FOR EVERYTHING IN ELECTRONICS

Wireless world

MAY 1983

80p

Forth microcomputer

UOSAT data and picture decoder

Microprocessor d.v.m.

Versatile accelerometer

Australia A$ 2.70
Canada C$ 3.25
Denmark DKR. 33.25
Germany DM. 7.00
Greece DRA. 190.00
Holland DFL. 8.50
Italy L 3700
New Zealand NZ$ 3.00
Norway NKR. 26.00
Singapore M$ 5.50
Spain PTS 275.00
Switzerland FR. 7.00
U.S.A. $ 3.75

Wireless world
FOR EVERYTHING IN ELECTRONICS

MAY 1983 VOL 89 NO 1568

A direct-from-the-screen photograph of an image generated using Advanced Electronic Design Inc software and a Dicoll AD767 colour graphics terminal.

NEXT MONTH

Microcomputer organ interface allows connection of a Nascom 2 Z80 micro to an electronic organ or a pipe organ with electric action. The micro will store and replay music played on the organ, and music can be typed on the Nascom keyboard.

Enigma was the name of the German World War II cypher machine. D. W. Rollema tells the story of the cracking of its code and examines the working of the machine.

A precision analogue voltmeter design, for audio and other purposes, offering many of the features found on digital instruments but without the ergonomic disadvantages.

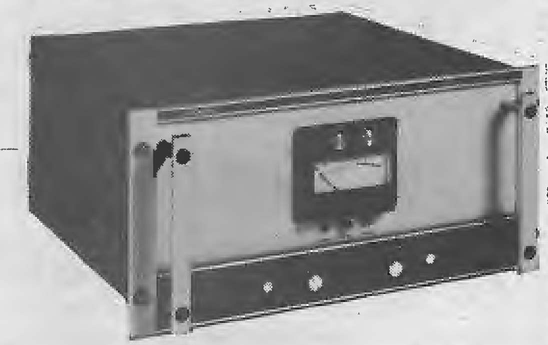
On-site calculation of antenna bearings for satellite tv broadcasts: a computer program to deal with some of the problems aerial installers will soon be facing.

Current issue price 80p, back issues (if available) £1, at Retail and Trade Counter, Units 1 & 2, Bankside Industrial Centre, Hopton Street, London SE1. Available on microfilm; please contact editor.
By post, current issue £1.23, back issues (if available) £1.80, order and payments to EEP General Sales Dept., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS Tel: 01-661 8668.
Editorial & Advertising offices: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS.
Telephones: Editorial 01-661 3614. Advertising 01-661 3130. See leader page.
Telex: 892084 BISPRS G.
Subscription rates: 1 year £14 UK and £17 outside UK.
Student rates: 1 year £9.35 UK and £11.70 outside UK.
Distribution: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. Telephone 01-661 3248.
Subscriptions: Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone: 0444 59188. Please notify a change of address.
USA: $44 surface mail, $98.30 airmail. Business Press International, Subscriptions Office, 205 E.42nd Street, NY 10017.
USA mailing agents: Expediters of the Printed Word Ltd, 527 Madison Avenue, Suite 1217, New York, NY 10022. 2nd class postage paid at New York.

ISSN 0043 6062.

amcron
INDUSTRIAL MUSCLE

★ POWER RESPONSE DC – 45KHz ± 1dB.
★ OUTPUT POWER IN EXCESS OF 1.5KW INTO 2.75 Ohm LOAD (CONTINUOUS R.M.S.)
★ D.C. OUTPUT 20 AMPS AT 100 VOLTS OR 2KVA.
★ HARMONIC DISTORTION LESS THAN 0.05% DC-20KHz AT 1kW INTO 6 OHMS.
★ PLUG-IN MODULES: CONSTANT VOLTAGE/CURRENT, PRECISION OSCILLATORS.
★ UNIPOLAR AND BIPOLAR DIGITAL INTERFACES, FUNCTION GENERATORS, AND MANY OTHERS.
★ OUTPUT MATCHING TRANSFORMERS AVAILABLE TO MATCH VIRTUALLY ANY LOAD.
★ FULL OPEN AND SHORT CIRCUIT PROTECTION GUARANTEED STABLE INTO ANY LOAD.
★ TWO UNITS MAY BE CONNECTED TO PROVIDE UP TO 4kW.
★ INTERLOCK CAPABILITY FOR UP TO EIGHT UNITS.
★ 3-YEAR PARTS AND LABOUR WARRANTY.
★ UNITS AVAILABLE FROM 100VA-12KVA.



Model — M600

For full details on all Amcron Products write or phone Chris Flack

P.O. BOX 3
ATTLEBOROUGH
NORFOLK NR17 2PF
Tel: 0953-452477

Analogue Associates

PROFESSIONAL INDUSTRIAL ELECTRONICS

WW – 012 FOR FURTHER DETAILS

D.I.L. MINIATURE ON-OFF SWITCHES
Gold-plated contacts. Sealed base. Ideal for programming. 6-position at less than half manufacturer's price
ONLY 75p
Will fit into 14-pin dil socket. Ten at 65p ea.; per 100 55p ea.

HONEYWELL PROXIMITY DETECTOR integral amplifier, 8v. D.C., £3.50 ea.
PHOTO CONDUCTIVE CELL, £1.25. High-power Cds cell, 600MW, for control circuits. Resistance 800 ohm to 4K. Max. volts 240. Size 1½ × ½in.
RIBBON MICROPHONE with pre-amp. on chassis, £1.75.

MULLARD MODULES
LP1171 IF. Strip — LP1179 AM, FM Front end
Pair £5.75
Complete with Data
LP1186 varicap £5.00 — LP1157 Med. & Long Tuner £2.50

CRYSTALS COLOUR TV
4.433619 mc/s £1.25
Miniature type sealed

ULTRA SONIC TRANSDUCERS 40KC/S. Complete on 18in. Screened cable, £1.75 each; pairs £2.95.
ULTRA SONIC TRANSMITTER. Complete unit (uncased requires 1.5V), £3.25.
FOSTER DYNAMIC MICROPHONES. 200 ohm impedance. Moving coil. Complete on chassis. £1.75 pair.

U.H.F. MODULATORS
Latest type, adjustable, ideal for computers. with data circuit
Size 3×2½×1 inch
Only £3.50
In screened case

LM380 Amplifier 85p
LM318N Hi-Slew Op. Amp. £1.50
LM323K, 5v. 3-amp, reg. £3.50
LM310N Volt, Follower Amp. £1.20
LM311H High Perf. Volt, Comparator £1.00
LM384N, 5-watt Amp £1.20
LM393N Dual Com. 60p
7905 Reg. –5v 75p

MINIATURE HIGH-QUALITY FANS
"Whisper Model" by Roton. Low-power consumption (less than 10 watts). Silent running. 115v. (two in series for 230v.). 50/60Hz. Size 4½ × 4½ × 1½in. ONLY £6.50 EACH incl. V.A.T.
BRAND NEW
50% less than manufacturer's price

STEREO CASSETTE
Mechanisms 6 or 12 volt. Complete with Heads + Erase and Solenoid. Brand new .... £5.50 ea.

TV CENDERGENCE POTS (LIN)
50 ohm
100 ,,
200 ,,
5K ,,
ALL 50p ea.

MINIATURE EDGE INDICATOR METER
With illuminated dial scale 0-10. F.S.D. 100 microamp. Size 1½ × 1½ × ½ deep. Only £1.65.

MONSANTO
Half-inch + 1 Display
High Intensity
£1 each
set of 4 £3.50
Common anode
14 Pin Dil Package

STEREO CASSETTE TAPE HEADS. Quality replacement for most recorders with mounting plate. Record/Replay £2.80
MARRIOTT TAPE HEADS
Quarter track.
Type
XRPS18 Record/Replay (each) £2.00
XRPS36 Record/Replay (each) £3.00
XES11 Erase (each) £1.00

HEWLETT-PACKARD DISPLAYS
5082-7650
HIGH EFFICIENCY AND VERY BRIGHT
Only £1.00 each
Set of 6 for £5
Half-inch red common anode will replace DL70/14-pin Dil.

EX-MOTOROLA 5 + 5-WATT CAR STEREO AMPLIFIERS
Complete and tested units. Medium and Long Wave. Supplied as two built units (5 × 2 × 2in.) with circuit and data. Only £5 pair. Includes pre-amp.

BRIDGE RECTIFIER
800-PIV 35 amps
1½×1½×½in. £3.50

NATIONAL
P.8080A Chips £2.95
8216 .... £1.75
IN4148 DIODES
Full spec. but no polarity band. Per 1,000 .... £10
MINIATURE MP.C. POTENTIOMETERS. Model M2. High-quality, 5% tolerance, 2-watt, with 1in. spindles. All values, 47 ohms-47k only 60p each per 10; 50p each per 100; 40p each.

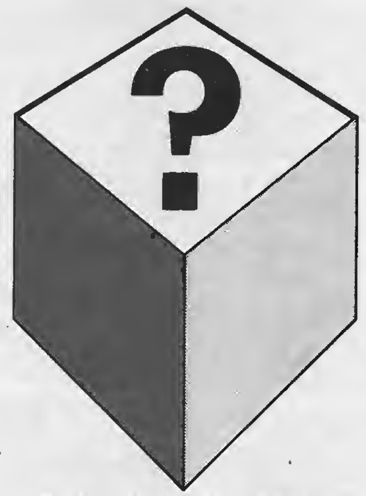
RECHARGEABLE BATTERIES
VARTA 3.6 volts DEAC, M/AH 225 .... £1.50

XTAL FILTER 10.7 mc/s. 12.5DB separation, 1½×1¼×1 inch £7.00
100KC/S + 1 meg. 3-pin £2.00

"CHERRY" ADD-ON KEYPAD
LIST PRICE £22.00
OUR PRICE ONLY £5.95 incl. V.A.T.
A compact 12-button keypad suitable for use with Keyboard extend its functions plus four extra keys.
Supplied brand new
A 3 × 4 non-encoded single mode keyboard

QUANTITY DISCOUNTS on *ALL* items (unless stated), 15% per 10, 20% per 50, 25% per 100. All items *BRAND NEW* (unless otherwise stated).
DELIVERY from stock – Add post 35p per order.

HENRY'S
EXPORT enquiries invited
TELEX 262284
Transonics
Mono 1400
01-723 1008/9
Callers to: 404 EDGWARE ROAD, LONDON W2 1ED
ALL MAIL ORDERS/EXPORT ENQUIRIES 11/12 PADDINGTON GREEN, LONDON, W2



WW – 024 FOR FURTHER DETAILS

INSTANT PRINTED CIRCUITS!!

Make your own – to professional standards – within minutes using either "Fotolak" Light-sensitive Aerosol Lacquer or Pre-coated board. No Darkroom or Ultra-violet source needed!

Fotolak aerosol £2.50 (30p)
Ferric Chloride £0.60 (45p)
Developer £0.30 (15p)
Acetate Sheet £0.15 (15p)

Copper-clad Fibre-glass Boards:
Single-sided .... £2 ft. sq. (45p)
Double-sided .... £2.25 ft. sq. (60p)

Pre-coated Fibre-glass Board:
8"x4½" .... £1.75 (25p) — 16"x9" .... £7 (60p) — 24"x18" ... £18 (£1.70)
8"x9" .... £3.50 (45p) — 24"x12" ... £13 (£1.20) — Eurocard £1.25 (25p)

Double-sided Board (all sizes) add 20%
Postage individual items in brackets. Maximum charge £2 per order

12V FLUORESCENT LIGHTING! FANTASTIC BARGAIN!

21" 13-watt Batten Type (complete with tube) £6 (£1.20)
Kit Form: .... £5 (£1.20). Inverter Transformers only: £1 (30p)

WHITE HOUSE ELECTRONICS PRAA SANDS, PENZANCE TR20 9TF
Telephone: Germoe (073-676) 2329

THE SOURCE....
of all good used test equipment

Electronic Brokers are Europe's leading Second User Equipment Company. We carry large stocks of the very latest test equipment which is refurbished in our own service laboratories and calibrated to meet the manufacturer's sales specifications. When you buy used equipment from Electronic Brokers, it can be yours in just days. No waiting for manufacturers lengthy production schedules. All equipment is fully guaranteed.

ANALYSERS

Dranetz
606-3 Line Disturbance Monitor **£2500.00**

Hewlett Packard
141T/8552B/8555A 10MHz-18GHz **£9300.00**
3582A Spectrum Analyser 0.02Hz-25.5KHz **£6350.00**
5004A Signature Analyser **£550.00**
5420A Digital Signal Analyser c/w Digital Filter 544708, A/D Converter 54410A **£21,000.00**
8407A/8412A Network Analyser **£1950.00**

Marconi
TF2337 Automatic Distortion Analyser **£250.00**

Solartron
1172 TFA **£4000.00**

Tektronix
AA501 opt 01. Distortion 10Hz — 100KHz to Less than 0.0025% **£1450.00**
DF1 Display Formatter For 7D01. **£850.00**
308 Portable 8 Channel 20MHz Data Analyser **£2100.00**
491 Spectrum Analyser 10MHz-40GHz **£7000.00**
492 [opt 01, 08] Spectrum Analyser 50KHz-220GHz **£13000.00**
492P [opt 01, 2, 3] Programmable Version of 492 .... **£20000.00**
7L5 Spectrum Analyser with opt 25 [Tracking Gen] and L3 [50Ω input] 20Hz — 5MHz **£7300.00**
7L12 Spectrum Analyser 100KHz-1.8GHz **£8000.00**
7L13 Spectrum Analyser 1KHz-1.8GHz **£7500.00**
7L14 Spectrum Analyser 10KHz-1.8GHz **£9450.00**
7L18 Spectrum Analyser 1.5GHz-60GHz **£9950.00**
TR502 Tracking Generator [for 7L12, 13 & 14] **£3200.00**
TR503 Tracking Generator [for 492/496 series] **£3250.00**
5L4N Spectrum Analyser 20Hz-100KHz **£2350.00**
7D01 16 Channel 100MHz Sample Rate **£2450.00**

BRIDGES

Marconi
TF1313A 0.1% LCR Bridge **£775.00**
TM4520 Set of Inductors **£350.00**

Wayne Kerr
B642 LCR 0.1% **£795.00**
SR 268 Source & Detector **£875.00**

DVM's AND DMM's

Datron
1059 Bench DMM 5 1/2 digit DC and True RMS AV volts and current + resistance **£700.00**

Fluke
8022A 3½ digit 0.25% Basic DC Accuracy 6 functions **£60.00**
8020A 3½ digit 0.1% Basic DC Accuracy 7 functions **£75.00**
THESE DMM'S ARE UNUSED — 90 DAY WARRANTY

Solartron.
7055 Microprocessor DMM. Scale Length 20,000. AC/DC volts, resistance. 1μV resolution **£495.00**

OSCILLOSCOPES

Hewlett Packard
1332A High Quality CRT Display 9.6×11.9cm **£1250.00**
1720A Dual Trace 275MHz with Delay T'Base and probe power **£2500.00**
1809A 100MHz 4 Channel Plug In **£2000.00**
1821A Timebase Plug In **£1000.00**

Philips
PM3232 Dual Beam 10MHz **£495.00**
PM 3234 True Dual Beam Storage Oscilloscope 10MHz New CRT .. **£1500.00**

Tektronix.
213 Miniscope/DMM Battery 1MHz **£975.00**
305 Portable battery scope/DMM, D T 5MHz **£975.00**
335 Dual Trace 35MHz Smal porteble with delay T'Base **£1200.00**
468 Dual Trace 100MHz with Digital Storage [10MHz] Delay T'Base . **£4950.00**
475 Dual Trace 200MHz Portable **£2200.00**
T922-01 15MHz DT Scope Diff. input **£515.00**
200C Trolley for 400 Series **£120.00**
7313 100MHz Storage Mainframe **£2225.00**
7603 100MHz Mainframe **£1850.00**
5223 Digital Storage 10MHz ... **£2000.00**
5440 50MHz Mainframe **£1000.00**
5441 50MHz Variable Persistence Storage Mainframe **£1800.00**
7104 1GHz Scope Mainframe **£11,500.00**
7704A Scope DC-200MHz Mainframe **£2500.00**
7613 Storage Scope Mainframe DC-100MHz **£2800.00**
7633 Multimode Storage Scope Mainframe DC — 100MHz **£4500.00**
7834 Storage Scope Mainframe DC-400MHz **£7200.00**
7844 Dual Beam 400MHz Mainframe **£7750.00**
7854 Waveform Processing Scope DC-400MHz **£8000.00**
7904 opt 02, 03 500MHz **£5350.00**
S1 Sampling Head. As New **£450.00**

Telequipment
DM63 Storage Oscilloscope Fitted with 2 × V4 Plug-ins to give 4 Trace 15MHz **£1350.00**
D1016A Dual Trace 20MHz 'As New' **£350.00**

SIGNAL SOURCES

Hewlett Packard.
608E 10-480MHz. AM or Pulse Modulation. Output 0.1μV-1V .. **£1000.00**
612A 450-1230MHz. AM or Pulse Modulation. Output 0.1μV-0.5V **£1500.00**
6168 1.8-4.2GHz int or ext PCM/FM 0.1μV-0.224V **£1000.00**
651B Test Oscillator. 10Hz-10MHz. 0.1mV-3.16V **£415.00**
3320A Frequency Synthesizer. 0.01Hz-13MHz **£885.00**
8690B Sweeper Mainframe with 8698B Plug In. 0.4 — 110MHz **£4000.00**

WW – 200 FOR FURTHER DETAILS

Marconi.
TF2000 20Hz-20KHz Low Distortion with 0-111dB Attenuator in 0.1dB steps **£575.00**
TF2002B with TF2170 Synchronizer 10KHz-88MHz AM/FM Modulation **£1700.00**
TF2120 0.0008Hz-100KHz Waveform Generator **£900.00**
TF2008 AM/FM 10KHz-510MHz built in sweeper. Output 0.2μV-200mV **£3500.00**
TF2016A + TF2173 Synchroniser AM/FM 10KHz-120MHz **£2000.00**
TF2169 Pulse Modulator for use with TF2015 or TF2016 .... **£200.00**

Philips.
PM6456 Stereo Generator. **£250.00**

Racal
9081 AM, FM, Phase and Pulse Synthesized 5-520MHz **£2200.00**

Radiometer
SMG1 Stereo Generator **£375.00**

TEKTRONIX PLUG INS

We stock a complete range of Plug Ins for use with 7000 and 5000 series Mainframes.

TEKTRONIX TM500 SERIES

AF501 Bandpass Filter/Amplifier . **£400.00**
AM501 Op Amp Gain 10,000 ... **£300.00**
AM502 Diff. Amp Gain 1 — 100K **£500.00**
DM502A True R M S 3½ digit DMM **£250.00**
DC503A 125MHz Counter **£475.00**
DC505A 225MHz Counter **£800.00**
FG501 Function Generator 0.001Hz-1MHz **£375.00**
FG501A Function Generator 0.002Hz-2MHz **£425.00**
FG502 Function Generator 0.1Hz-11MHz **£425.00**
FG503 Function Generator 1Hz-3MHz **£275.00**
PG505 Pulse Generator 1Hz-100KHz **£450.00**
SC502 15MHz Dual Trace Scope **£1000.00**
SC504 80MHz Dual Trace Scope **£1250.00**
SG503 Sinewave Generator 250KHz-250MHz **£950.00**
TG501 Timemark Generator **£850.00**
TM515 Mainframe [5 wide] **£350.00**

TEKTRONIX TV TEST EQUIPMENT

141A PAL Test Signal Generator **£1750.00**
148 PAL Insertion Test Generator **£4000.00**
1485C PAL/NTSC Dual Standard Waveform Monitor **£2950.00**
651HR 12" PAL Colour Monitor (Mint) **£3250.00**
655HR-1 TV Colour Picture Monitor [NTSC + PAL + RGB] **£3800.00**
656HR PAL/SECAM Monitor ... **£3900.00**
1411R TV Generator. Various Systems available .... **POA**

MISCELLANEOUS

Bruel & Kjaer
2209 Sound Level Meter **£975.00**

Ferrograph
RTS1 Test Set **£295.00**

Fluke
515A Portable Calibrator DC/AC and Resistance with DC Resolution 0.2μV **£1750.00**
883 AC/DC Differential **£615.00**
845 AB Null Detector **£610.00**
3010A Logictester. Self Contained. Porteble. Full Spec. on Request . **£8500.00**

Hewlett Packard.
5340A Counter 10Hz-18GHz 8 Digit **£3750.00**
8403A Modulator Fitted With 87328 PIN MODULATOR **£1500.00**
8482H Power Sensor 100KHz-4.2GHz. AS NEW **£250.00**
8745A S Parameter Test Set. Fitted with 11604A Universal Arms 0.1-2GHz **£2750.00**
59308A HP-IB Timing Generator. **£300.00**

Marconi.
TF2162 M.F. Attenuator. 0-111dB **£185.00**

Schaffner
NSG 509 5KV Insulation Tester .. **£785.00**

Tektronix
106 Square Wave Generator 1nS risetime 10Hz-1MHz without accessories . **£175.00**
832 Data Comms. Tester **£925.00**
833 Data Comms. Tester **£1350.00**
2701 Step Attenuator 50Ω 0.79dB in 1dB steps. DC to 2GHz **£295.00**
2901 Time-Mark Generator **£185.00**

Please note: Prices shown do not include VAT or carriage.

Electronic Brokers

Electronic Brokers Limited
61/65 Kings Cross Road
LONDON WC1X 9LN
Telephone: 01-278 3461
Telex: 298694 Elebro G

Accurate Digital Multimeters at Exceptional Prices

28 RANGES, EACH WITH FULL OVERLOAD PROTECTION

SPECIFICATION MODELS 6010 & 7030

* 10 amp AC/DC
* Battery: Single 9V drycell. Life: 200 hrs
* Dimensions: 170 x 89 x 38mm.
* Weight: 400g inc. battery.
* Mode Select: Push Button.
* AC DC Current: 200μA to 10A
* AC Voltage: 200mV to 750V
* DC Voltage: 200mV to 1000V
* Resistance: 200Ω to 2MΩ
* Input Impedance: 10MΩ
* Display: 3½ Digit 13mm LCD
* O/load Protection: All ranges

OTHER FEATURES: Auto polarity, auto zero, battery low indicator, ABS plastic case with tilt stand, battery and test leads included, optional carrying case.

NEW ANALOGUE METER WITH CONTINUITY BUZZER AND BATTERY SCALE

NEW HM 102 BZ SPECIFICATION

* DC Voltage: 0-25, 1, 2.5, 10, 25, 100, 250, 1000 volts 20,000 ohms/volt.
* AC Voltage: 0-10, 25, 100, 250, 1000 volts 10,000 ohms/volt.
* Decibels: -20 to +22dB
* DC Current: 0-50, 500μA, 0-5, 50, 500mA
* Ohmmeter: 0-6 Megohms in 4 ranges. 30 ohms Centre Scale
* Power Supply: One 1.5V size 'A' battery (incl)
* Size & Weight: 135 x 91 x 39mm, 280gr.

HM 101 POCKET SIZE MULTIMETER SPECIFICATION

* DC & AC Voltage: 0-10, 50, 250, 1000 volts, 2000 ohms/volts
* Decibels: -10 to +22dB
* DC Current: 0-100mA
* Ohmmeter: 0-1 Megohm in 2 ranges, 60 ohms Centre Scale
* Power Supply: One 1.5V size 'A' battery (incl)
* Size & Weight: 90 x 60 x 29mm, 92gr. incl. battery battery
* Price £5.50

Quantity discount for trade on application.

Add 15% to your order for VAT. P&P is free of charge.

Payment by cheque with order

Buy it with Access or BARCLAYCARD VISA accepted

ARMON ELECTRONICS LTD.

Cottrell House, 53-63 Wembley Hill Road, Wembley, Middlesex HA9 8BH, England

Telephone: 01-902 4321 (3 lines) TELEX No. 923985

WW – 042 FOR FURTHER DETAILS

Hitachi Oscilloscopes

performance, reliability, exceptional value and immediate delivery!

Hitachi Oscilloscopes provide the quality and performance that you'd expect from such a famous name, in a newly-extended range that represents the best value for money available anywhere.

V-152F	15MHz Dual Trace
V-202F	20MHz Dual Trace
V-203F	20MHz Sweep Delay
V-302F	30MHz Dual Trace
V-352F	35MHz Dual Trace
V-353F	35MHz Sweep Delay
V-134	10MHz Tube Storage Oscilloscope
V-650F	60MHz Dual Timebase, Trigger View (illustrated)
V-1050F	100MHz Quad Trace, Dual Timebase
V-209	20MHz Dual Trace, Mini-Portable
V-509	50MHz Dual Timebase, Mini-Portable

Prices start from around £250 (ex. V.A.T.) including 2 high-quality probes and a 2-year warranty. We hold the range in stock for immediate delivery.

For colour brochure giving detailed specifications and prices ring (0480) 63570.

Reltech Instruments, 46 High Street, Solihull, W. Midlands, B91 3TB

WW – 052 FOR FURTHER DETAILS

EASIBINDERS

Quick, neat and easy!

It's so easy and tidy with the Easibind binder to file your copies away. Each binder is designed to hold six issues and is attractively bound and blocked with the WIRELESS WORLD logo.
Price U.K. £4.30 including postage, packing and V.A.T.
Overseas orders add 35p per binder.
Nat. Giro No. 5157552.
Please allow 3/4 weeks for fulfilment of order.
Payment by ACCESS/BARCLAYCARD/VISA. Send coupon below detailing credit card no. and signature.
Why not place your order now? Send the completed coupon below with remittance payable to:

Easibind, 42 Hoxton Square, London N1 6NS

Order Form WIRELESS WORLD

I enclose P.O./cheque value.................................. for ....binders
Years required ....
BLOCK LETTERS PLEASE
Name ....
Address...
....
Date ....Registration No. 735718

IN VIEW OF THE EXTREMELY RAPID CHANGE TAKING PLACE IN THE ELECTRONICS INDUSTRY, LARGE QUANTITIES OF COMPONENTS BECOME REDUNDANT. WE ARE CASH PURCHASERS OF SUCH MATERIALS AND WOULD APPRECIATE A TELEPHONE CALL OR A LIST IF AVAILABLE. WE PAY TOP PRICES AND COLLECT.

BROADFIELDS & MAYCO DISPOSALS

21 Lodge Lane, N. Finchley, London, N.12. 5 mins. from Tally Ho corner

Telephone 445 2713/0749 (9461)

Announcing a MAJOR CATALOGUE from Electronic Brokers- Distributors of Philips Fluke Hameg Ice

Test & Measurement Equipment

WW 5/83

Electronic Brokers

Electronic Brokers Ltd, main distributors of Philips, Fluke, Hameg and ICE have just published a full colour catalogue containing illustrations, full technical specifications and prices on a wide range of electronic test and measurement equipment — all of which is ex-stock and available for immediate delivery! Electronic Brokers new catalogue is an absolute must for all engineers, designers and buyers. Send off the coupon for your FREE copy now.

To:
Electronic Brokers Ltd
61/65 Kings Cross Rd London WC1X 9LN
Tel: 01-833 1166 Telex: 298684 Elebro G
Please send me the new Test &Measurement Equipment catalogue
Name
Company
Position
Address

Tel

WATFORD ELECTRONICS

CARDIFF ROAD, WATFORD, HERTS, ENGLAND
MAIL ORDER, CALLERS WELCOME
Tel. Watford (0923) 40588. Telex: 8956095

ALL DEVICES BRAND NEW, FULL SPEC. AND FULLY GUARANTEED. ORDERS DESPATCHED BY RETURN OF POST. TERMS OF BUSINESS: CASH/CHEQUE/P.O.s OR BANKERS DRAFT WITH ORDER OR ACCESS. GOVERNMENT AND EDUCATIONAL INSTITUTIONS' OFFICIAL ORDERS ACCEPTED. TRADE AND EXPORT INQUIRY WELCOME. P&P ADD 50p TO ALL CASH ORDERS. OVERSEAS ORDERS POSTAGE AT COST. AIR/SURFACE. ACCESS ORDERS WELCOME.

VAT Export orders no VAT. Applicable to U.K. Customers only. Unless stated otherwise, all prices are exclusive of VAT. Please add 15% to the total cost including P&P. We stock thousands more items. It pays to visit us. We are situated behind Watford Football Ground. Nearest Underground/BR Station: Watford High Street. Open Monday to Saturday 9am to 6pm. Ample Free Car Parking space available.

ELECTROLYTIC CAPACITORS (Values in µF)

TAG-END CAPACITORS

POLYESTER CAPACITORS: Axial Lead Type

POLYESTER RADIAL LEAD CAPACITORS: 250V

TANTALUM BEAD CAPACITORS

MYLAR FILM CAPACITORS

SIEMENS pcb Type Miniature poly. Capacitors

FEED THROUGH CAPACITORS 1000pF/450V

POTENTIOMETERS

SLIDER POTENTIOMETERS

5KΩ-500KΩ single gang 70p
10KΩ-500KΩ dual gang 110p
Self Stick Graduated Bezel 40p

CERAMIC CAPACITORS 50V: Range: 0-5pF to 10nF **4p**. 15nF; 22nF; 33nF; 47nF **5p**. 100nF/30V **7p**. 200nF/6V **8p**

PRESET POTENTIOMETERS
0.1W 50Ω–5MΩ Miniature Vertical & Horizontal 7p
0-25W 100Ω–3-3MΩ horiz. larger 10p
0-25W 200Ω–4-7MΩ vert. 10p

ACCESS
Orders
Just phone your order through. We do the rest
Tel: 0923 50234

POLYSTYRENE CAPACITORS: 10pF to 1nF **8p**; 1.5nF to 12nF **10p**

SILVER MICA (Values in pF)
2, 3.3, 4.7, 6.8, 8.2, 10, 12, 15, 18, 22, 27, 33, 39, 47, 50, 56, 68, 75, 82, 85, 100, 120, 150, 180pF **15p** each;
200, 220, 250, 270, 300, 330, 360, 390, 470, 600, 800, 820 **21p** each
1000, 1200, 1800, 2200 **30p** each
3300, 4700pF **60p** each

RAM FOR BBC MICRO 4816AP 100ns 225p

MINIATURE TRIMMERS Capacitors 2-6pF, 2-10pF **22p**; 2-25pF, 5-60pF **30p**; 10-88pF **35p**

RESISTORS — Carbon Film High Stability. 5% Miniature.

	RANGE	VAL	1-99	100+
¼W	2Ω2–4M7	E24	2p	1p
½W	2Ω2–4M7	E12	2p	1p
1W	2Ω2–4M7	E12	6p	4p
2% Metal Film		E24	6p	4p
1% Metal Film		E24	8p	6p

100+ price applies to Resistors of each type not mixed.

RESISTORS Network S.I.L.
7 Commoned: (8 pins) 100Ω, 680Ω, 1K 2k2, 4K7, 10K, 47K, 100K **25p**.
8 Commoned: (9 pins) 150Ω, 180Ω, 270Ω, 330Ω, 1K, 2k2, 4K7, 10K, 22K, 47K, 100K **28p**.

DIODES

AA119	15
AA129	20
AAY30	15
BA100	15
BAX13	20
BY100	24
BY126	12
BY127	12
CRO33	250
OA9	40
OA47	12
OA70	12
OA79	15
OA81	20
OA85	15
OA90	8
OA91	8
OA95	8
OA200	8

BRIDGE Rectifiers

1A/50V	18
1A/100V	20
1A/400V	25
1A/600V	34
2A/50V	30
2A/200V	40
2A/400V	46
2A/600V	65
6A/100V	83
6A/400V	95
6A/600V	125
10A/200V	215
10A/600V	298
25A/200V	240
25A/600V	395
BY164	56

75 SERIES

75107/8	95
75110	90
75114/5	150
75121/2	130
75150	125
75154	150
75182/3	99
75188/9	55
75322	140
75324	360
75361/3	150
75365	150

ZENERS

SCR Thyristors

TRIACS

NOISE Diode

VARICAPS

COMPUTER ICs

68B54	780	8257-5	400	TMS9995	£12
1702	350	8259	395	ULN2003	75
1802CP	650	8271	£32	UPD7002	425
2114L-200n	95	8279	385	Z80CPU 2.5	299
2147	425	8282	450	Z80ACPU 4M	300
2532	300	8283	450	Z80 CTC	250
2564	£8	8284	350	Z80A CTC	260
2708	225	8285	365	Z80B	£11
2716-5V	225	8288	£10	Z80 DART	495
2732	350	8P8304BN	250	Z80A DART	550
2764	475	8T26A	99	Z80 DMA	675
3242	590	8T27	150	Z80 PIO	260
4116-150n	85	8T28A	120	Z80A PIO	275
4116-200n	80	8T31	350	Z80 SIO-1	850
4118-250n	325	8T95	90	Z80A SIO	£9
4164-200n	425	8T97N	90	ZN419	180
4532-3	350	9364AP	550		
4532-4	350	9602	220		
4816-100n	215	AM26LS31C	125		
5101-450	220	AM26LS32A	125		
6116-150n	350	AM26LS33A	125		
6116L-120	550	AY-3-1015	300		
6117-100n	490	AY-5-1350	388		
6502A	450	AY-5-2376	600		
6502CPU	325	COM8017	275		
6503	600	COM8116	700		
6504-250	550	DM8131	275		
6505	600	DS3691N	320		
6520PIA	100	DS88LS120N	275		
6522VIA	295	DS8820	110		
6530	£11	DS8830	110		
6532	570	DS8831	125		
6545RTC	899	DS8832	250		
6551ACIA	650	E9365	£38		
6592PC	£20	E9366	£38		
6800	220	FD1771	£15		
6802	250	FD1791	£22		
6803	850	FD1793	£23		
6804	180	FD1795	£28		
6805	670	FD1797	£28		
6808	520	FD1799	£28		
6809	630	IM6402	380		
6810	115	INS8060N	1050		
6821	110	INS8154N	£9		
6840	375	MC1488	55		
6843	£12	MC1489	55		
6845	650	MC14411	690		
6847	650				
6850	110				

LINEAR ICs

555CMOS	80
702	75
709C 8 pin	35
710	48
741 8 pin	14
747C 14 pin	65
748C 8 pin	38
753 8 pin	185
810	159
9400CJ	350
AD7581	£11
AY-1-1320	225
AY-1-5050	99
AY-1-5051	160
AY-1-6720	210
AY-3-1270	730
AY-3-1350	350
AY-3-8910	438
Booklet for AY-3-890	150
AY-3-8912	450
AY-5-1230	450
AY-5-1317A	630
AY-5-1350	388
CA3011	130
CA3012	175

TRANSISTORS

TTL 74

74LS

74C

74S

RF CHOKES Miniature PCB type

SWITCHES

TOGGLE 2A 250V
SPST 33p
DPDT 44p

SUB-MIN TOGGLE
SPST on/off 54p
SPDT c/over 60p
SPDT centre off 85p
SPDT biased both ways 105p
DPDT 6 tags 75p
DPDT centre off 88p
DPDT biased both ways 145p
DPDT 3 positions on/on/on 185p
3-pole 2 way 205p

SLIDE 250V
DPDT 1A 14p
DPDT 1A c/off 15p
DPDT ½A 13p

PUSHBUTTON 6A with 10mm Button
SPDT latching 99p
DPDT latching 145p
SPDT moment 99p
DPDT moment 145p

Mini Non Locking
Push to Make 16p
Push to Break 25p

DIL SWITCHES (SPST) 4-way **70p**; 6-way **85p**; 8-way **90p**; 10-way **145p**. (SPDT) 4-way **190p**.

ROTARY SWITCHES (Adjustable Stop type) 1 pole/2 to 12 way; 2p/2 to 6 way; 3 pole/2 to 4 way; 4p/2 to 3 way 45p

ROTARY: Mains DP 250V 4 Amp on/off 66p

ROTARY: (Mak-a-switch) Make a multi-way switch. Shafting assembly has adjustable stop. Accommodates up to 6 wafers. (max 6 pole/12 way — DP switch) Mechanism only 80p

WAFERS: (make before break) to fit the above switch mechanism 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6p/2 way 65p
Mains DP 4A Switch to fit 45p
Spacers **4p**. Screen **6p**.

ROCKER: 5A/250V SPST 28p
ROCKER: 10A/250V SPDT 38p
ROCKER: 10A/250V DPDT c/off 95p
ROCKER: 10A/250V DPST with neon 85p

THUMBWHEEL: Mini front mounting
Decade Switch Module 220p
B.C.D. Switch Module 275p
Mounting Cheeks (per pair) 75p

VEROBOARD 0.1in

	clad	plain
2½-3¼"	85p	–
2½-5"	100p	–
3¾-3¾"	100p	–
3¾-5"	115p	–
3¾-17"	390p	98p
4¾-17"	495p	275p

Pkt of 100 pins 55p
Spot face cuffer 150p
Pin insertion tool 185p

VQ Board 180p
DIP Board 350p
Vero Strip 95p

PROTO DECs
Veroblock 405p
S-Dec 350p
Eurobreadboard 520p
Bimboard 1 575p
Superstrip SS2 1350p

VERO WIRING PEN + Spool 340p
Spare Spool 75p
Combs 6p

DALO ETCH RESIST PEN Plus Spare Tip 80p

FERRIC CHLORIDE 1 lb bag Anhydrous 195p + 50p P&P

ULTRASONIC TRANSDUCER 40kHz 325 pr

COPPER CLAD BOARDS

Fibre glass	Single sided	Double sided	S.R.B.P. 9.5"x8.5"
6"x6"	90p	110p	95p
6"x12"	150p	195p	

DIL SOCKETS

	Low Prof	Wire Wrap
8 pin	8p	25p
14 pin	10p	35p
16 pin	10p	42p
18 pin	16p	52p
20 pin	20p	60p
22 pin	22p	65p
24 pin	25p	70p
28 pin	28p	80p
40 pin	30p	99p

EDGE CONNECTORS

	.1	.156
2×15 way	–	140p
2×18 way	180p	145p
2×22 way	199p	200p
2×23 way	175p	–
2×25 way	225p	220p
2×28 way	190p	–
2×30 way	245p	–
2×36 way	295p	–
2×40 way	315p	–
2×43 way	395p	–
2×75 way	550p	–

ETI PROJECTS We stock most of the parts

JUMPER LEADS (Ribbon Cable Assembly)

Length	14 pin	16 pin	24 pin	40 pin
Single ended DIP (Header Plug) Jumper				
24 inches	145p	165p	240p	325p
Double ended DIP (Header Plug) Jumper				
6 inches	185p	205p	300p	465p
12 inches	198p	215p	315p	490p
24 inches	210p	235p	345p	540p
36 inches	230p	250p	375p	595p

IDC Female Header Socket Jumper Leads 24"

	20 pin	26 pin	34 pin	40 pin
Single ended	160p	200p	260p	300p
Double ended	290p	370p	480p	525p

ANTEX SOLDERING IRON
C-15W 455p; CX17W 475p
CCN-15W 495p; CX25W 510p
Spare tips, assorted sizes 65p
Spare Elements 210p
Iron stand with sponge 185p

SIL Socket D.1" pitch 20 way 65p

TRANSFORMERS:

3-0-3V; 6-0-6V; 9-0-9V; 12-0-12V; 15-0-15V @ 100mA 99p

pcb mounting Miniature Split Bobbin
3VA: 2×6V-0.25A; 2×9V-0.15A; 2×12V-0.12A; 2×15V-0.1A 200p
6VA: 2×6V-0.5A; 2×9V-0.3A; 2×12V-0.25A; 2×15V-0.2A 270p

Standard Split Bobbin type
6VA: 2×6V-0.5A; 2×9V-0.4A; 2×12V-0.3A; 2×15V-0.25A 220p
12VA: 2×4.5V-1.3A; 2×6V-1A; 2×9V-0.6A; 2×12V-0.5A; 2×15V-0.4A; 2×20V-0.3A 295p (35p p&p)
24VA: 2×6V-1.5A; 2×9V-1.2A; 2×12V-1A; 2×15V-0.8A; 2×20V-0.6A 330p (60p p&p)
50VA: 2×6V-4A; 2×9V-2.5A; 2×12V-2A; 2×15V-1.5A; 2×20V-1.2A; 2×30V-0.8A 465p (60p p&p)
Specially wound for Multirail Computer PSUs 50VA: Outputs: +5V/5A; +12V; +25V; −5V, −12V×1A 575p (60p p&p)
100VA: 2×12V-4A; 2×15V-3A; 2×20V-2.5A; 2×25V-2A; 2×30V-1.5A; 2×50V-1A 920p
(75p p&p charge to be added over and above our normal postal charge).

VOLTAGE REGULATORS

1A T0220 Plastic casing

	+ve		−ve	
5V	7805	40p	7905	45p
12V	7812	40p	7908	60p
15V	7815	40p	7912	45p
18V	7818	40p	7915	45p
24V	7824	40p	7918	45p
			7924	45p

100mA T092 Plastic package

	+ve		−ve	
5V	78L05	30p	79L05	60p
6V	78L06	30p		–
8V	78L08	30p		–
12V	78L12	30p	79L12	60p
15V	78L15	30p	79L15	60p

LM300H 170p; LM304H 170p; LM305H 140p; LM309K 135p; LM317K 320p; LM317KP 99p; LM323K 450p; LM337 175p; LM723 Var. 36p; TAA550 50p
TDA1412 150p; 78HO5 +5V/5A 550p; 78H12 +12V/5A 580p; 78HG +5V to +25V/5A 599p; 79HG +2.25V to 24V5A 685p

SOLDERCON PINS Ideal for making SIL or DIL Sockets
100pins 75p
500pins 350p

ALUM BOXES

3x2x1"	85p
4x2½x2"	85p
4x2¾x2½"	103p
4x4x2"	105p
4x4x2½"	120p
5x4x1½"	99p
5x4x2½"	120p
5x2¾x1½"	80p
5x2¾x2½"	130p
6x4x2"	120p
6x4x3"	150p
7x5x3"	180p
8x6x3"	210p
10x4x3"	240p
10x7x3"	275p
12x5x3"	280p
24x8x3"	295p

IDC CONNECTORS

	PCB Plugs with latch Pins Strt	Pins Angle	Female Hdr. Plug	Female Card Edge Conn.
10 way	90p	99p	85p	120p
16 way	130p	150p	110p	–
20 way	145p	166p	125p	195p
26 way	175p	200p	150p	240p
34 way	205p	238p	160p	320p
40 way	220p	250p	190p	340p
50 way	235p	270p	200p	395p
60 way	–	–	230p	495p

EURO CONNECTORS

	Female Socket Strt Pins	Angle Pins	Male Plug Strt Pins	Angle Pins
DIN41617 31 way	170p	–	–	175p
DIN41612 2×32 A+B	275p	320p	220p	285p
DIN41612 2×32 A+C	295p	340p	240p	300p
DIN41612 3×32 A+B+C	360p	385p	260p	395p

DIL PLUG (Header)

	Solder	IDC
14 pin	40p	99p
16 pin	49p	105p
24 pin	88p	178p
40 pin	250p	255p

RIBBON CABLE price per foot — Grey / Colour

	Grey	Colour
10 way	15p	28p
16 way	25p	40p
20 way	30p	50p
24 way	40p	65p
34 way	60p	85p
40 way	70p	90p
50 way	100p	135p

ZIF DIL SOCKETS
24 pin 575p
28 pin 820p
40 pin 975p

D CONNECTORS: Miniature

	9 way	15 way	25 way	37 way
MALE				
Solder lugs	80p	105p	160p	250p
Angle pins	150p	210p	250p	365p
PCB pins	120p	130p	195p	295p
FEMALE				
Solder lugs	105p	160p	200p	335p
Angle pins	185p	215p	290p	440p
PCB pins	150p	180p	240p	420p
COVERS	90p	85p	90p	100p

IDC 25 way D Plug 365p; Socket 450p

25 way 'D' CONNECTOR (RS232)
Jumper Lead Cable Assembly
18" long, Single end, Male 495p
18" long, Single end, Female 525p
36" long, Double ended, M/M 1025p
36" long, Double ended, F/F 1050p
36" long, Double ended, M/F 995p

★ SPECIAL OFFER ★
2532 285p; 2764 550p; 6116 375p; 6522 280p

PANEL METERS

FSD 60×46×35mm
0.50µA, 0.100µA, 0.500µA, 0.1mA, 0.5mA, 0.10mA, 0.50mA, 0.100mA, 0.500mA, 0.1A, 0.2A, 0.25V, 0.50V AC, 0.300V AC, "S", "VU" 450p each

CRYSTALS

32.768kHz, 100kHz, 200kHz, 455kH, 1MHz, 1.008M, 1.28MHz, 1.6MHz, 1.8MHz, 1.8432M, 2.0MHz, 2.4576M, 3.278M, 3.5794M, 3.6864M, 4.0MHz, 4.032MHz, 4.19430M, 4.433619M, 4.80MHz, 5.0MHz, 5.185MHz, 5.24288M, 6.0MHz, 6.144MHz, 6.5536MHz, 7.0MHz, 7.168MHz, 7.68MHz, 8.0MHz, 8.08333M, 8.68723M, 9.00MHz, 10.0MHz, 10.24MHz, 10.7MHz, 12.0MHz, 12.528M, 14.31814M, 16.0MHz, 18.0MHz, 18.432M, 20.0MHz, 19.968MHz, 24.0MHz, 24.930MHz, 26.69M, 27.648M, 27.145M, 38.66667M, 48.0MHz, 100.0MHz, 116.0MHz

RELAYS

Miniature enclosed PCB mount
SINGLE POLE Changeover
RL6-91 205Ω Coil; 12V DC, 10V5 to 19.5V). 10A at 30V DC or 250V AC 185p
DOUBLE POLE Changeover. 6A 30V DC or 250V AC.
RL6-100 53Ω Coil, 6V DC (5V4 to 9V9) 190p
RL6-111 205Ω Coil, 12V DC (10V7 to 19V5) 195
RL6-114 740Ω Coil, 24V DC (22V to 37V) 200p

AMPHENOL PLUGS
IEEE 24 way 550p
Centronics Parallel 36 way solder 530p
Centronic Parallel 36 way IDC 495p

BUZZERS: miniature, solid-state 6V, 9V & 12V 70p
PIEZO TRANSDUCERS PB2720 55p

LOUDSPEAKERS
Miniature 0.3W 8Ω
2in, 3¼in, 2½in, 3in 80p
2½in 40Ω, 64Ω or 80Ω 80p

ASTEC UHF MODULATORS
Standard 6MHz 280p
Wideband 8MHz 480p

'WEMON' New Version WATFORD'S Ultimate Monitor IC
A 4K Monitor chip specially designed to produce the best from your Super board Series I & II. Enhanced Super board & UK101. As reviewed by Dr A. A. Berk in Practical Electronics, June 1981.
Only £10

BBC MICROCOMPUTER AND UPGRADE KITS

(Our BBC Micro Upgrade Kits will save you £££s . . .)
16K Memory (8×4816AP) £18
Printer User I/O Port Kit £8.20
Complete Printer Cable 36" £12
Disc Interface Kit £43
Analogue I/O Kit £6.75
Serial I/O Kit £7.50
Expansion Bus Kit £6.50
Complete Upgrade Kit from Model A to Model B £45
We supply complete range of BBC Plugs, Sockets, Leads, Peripherals, Software, etc. Send SAE for list.

CMOS

4000	10	4075	13	4543	70
4001	10	4076	50	4544	150
4002	12	4077	13	4548	40
4006	50	4078	15	4549	375
4007	14	4081	13	4553	245
		4082	13	4554	190
		4085	50	4556	35

OPTO Electronics

LEDs with Clips
TIL209 Red 10
TIL211 Green 14

COMPUTER CORNER

- **MX80FT/3 EPSON PRINTER.** 10" & Friction feed, 9 x 9 matrix, 80 column, Speed 80CPS, Bidirectional, Centronics Interface standard, Baud-rate 110-9600 (RS232), Hi-Res, Bit image graphics. Subscript & Superscript, Italics & Underlining facility plus 500 sheets of paper FREE **£324** (+£7 carr.)
- **MX100 EPSON** Printer, 136 Column, 15" carriage, plus all the features of MX80FT/3. Plus FREE 500 sheets of paper. **Only £425** (+ carr.)
- **SOFTY II.** An intelligent Eprom Programmer and Emulator. Accepts a 24 pin 5V Eprom. Has Memory Map TV Display. RS232 and Centronics I/P & O/P. Copies, Emulates and programs. RS 232 and centronics routines standard. PSU included **£169**
- **TEX** EPROM ERASER. Erases up to 32 ICs in 15-30 minutes **£33**
- **TEX** EPROM ERASER with a safety switch **£35**
- **TEX** EPROM ERASER plus our Solid State ELECTRONIC TIMER **£44**
- **ELECTRONIC TIMER.** Solid state, 15-30min. Connects directly to above Erasers. Protects your expensive Chips from overcooking. Our timer pays for itself in no time **£15**
- **SPARE** 'UV' Lamp bulb **£8**
- **POWER SUPPLY.** Regulated with Overload protection. Variable output, 5V to 15V at 4A. Professionally finished **£38**
- **MULTIRAIL POWER SUPPLY KIT.** Especially designed for Micros. Tested output: +5V/5A; +12V; +25V; −12V of 1A **£37**
- **C12 COMPUTER GRADE CASSETTES** in library cases **40p**
- **8½" and 9½"** Fan Fold paper (1000 sheets) .... **£7** (£1.50 carr.)
- **SEIKOSHA GP100A** 10" Tractor Feed, 80 Column. 30CPS, Normal and Double Width Char. Dot Res Graphics .... **£175** (£7 carr)
- **SEIKOSHA GP250X.** 10", 50 CPS, Normal and Double width and height Char. RS232 and Centronix Intrf. standard .... **£240** (£7 carr)
- Printer Cable for our printers and BBC **£12**

FLOPPY DISC DRIVES — TEAC — (BBC Compatible)

- **FD50A** – Uncased Single, 40 track, 5¼", S/S, 100K **£130**
- **CS50A** – Single Cased with PSU, 40 track, S/S, 100K **£180**
- **CD50A** – Twin Cased with PSU, 40 track, S/S, 200K, 5¼" **£350**
- **CS50E** – Single Cased with PSU, 80 track, 5¼", S/S 200K **£250**
- **CD50E** – Twin Cased with PSU, 80 track, 5¼", S/S, 400K **£475**
- **CS50F** – Single Cased with PSU, 80 track, 5¼", D/S, 400K **£330**
- **CD50F** – Twin Cased with PSU, 80 track, 5¼", D/S, 800K **£599**
- **Interface Cable** for BBC: .... Single **£8**; Double **£12**
- **10 Verbatim Diskettes** 5¼", SSSD (5 yrs warranty) **£20**
- **10 Verbatim Diskettes** 5¼", DSDD (5 yrs warranty) **£30**
- **10 Verbatim Diskettes** 8", SSDD (5 yrs warranty) **£28**
- **MITSUBISHI DISC DRIVE:** Uncased, Double Density, Double Track, 5¼" Slim Line, ONE MEGA-BYTES. Track density 96TPI. Track to Track access time 3msec .... Only **£249**

N.B. P&P on above items is extra.

NEC PC8023BE-C PRINTER

Europe's most popular printer
100CPS bi-directional, Logic seeking, 80 column, 7 x 9 Dot matrix head, true descenders on lower case, Superscript & Subscript & Underlining facility. Proportional spacing, Forward & reverse line feed, Tractor or friction feed, Hi-res & block graphics. Auto underlining. Plus FREE 500 sheets of Paper.
Price: Only £320 + £7 carr.

MONITORS

- **MICROVITEC 1431.** 14" Colour Monitor. RGB input (as used in BBC prog.) **£250**
- **ZENITH** 12" Green Monitor, Hi-Res. **£80**
- **AVT** 9" Green, Anti-glare filter, 12MHz **£95**
- **AVT** 9" B&W, Anti-glare filter, 12MHz **£89**
- **AVT** 9" Amber, Anti-glare filter, 12MHz **£98**

Carriage on all Monitors is £7 (Securicor)

ORIC – 1

16K and 48K RAM versions now available. Call in for a demonstration

JUPITER ACE Micro-computer

Uses Ultrafast FORTH 8K RAM. 32x24 Display .... **£78** (£2 car)

SINCLAIR ZX81 Micro-computer

Now available from stock **£43.45**

ULTIMUM

WATFORD'S own most versatile MICRO EXPANSION SYSTEM. Ideal for interfacing with APPLE, ATOM, DRAGON, PET, RESEARCH MACHINE, SPECTRUM, SUPERBOARD, VIDEO GENIE, ZX81, etc. Low cost, high spec. As published in Practical Electronics starting from November 1982.
Send SAE for details

WW-14

Start here for bigger profits in '83

Wembley Conference Centre April 26-28 1983...

The Computer Trade Show '83 is the most important annual event of its kind and there could be no better starting point on the route to achieving bigger profits from this expanding and lucrative market.

Held at one of the most accessible and popular exhibition centres in the United Kingdom and set in the heart of the biggest and most influential market region for computer systems, The Computer Trade Show '83 will provide you with the perfect opportunity to select equipment to meet your individual requirements from a wide selection of products to be shown by the major manufacturers and suppliers of computers and peripherals. First hand knowledge of new product lines will keep you ahead of market trends, and face to face contact with suppliers through a series of daily seminars will greatly assist your current purchasing power and ensure even bigger profits in the future.

Everything for every kind of retail, dealer or distribution outlet will be available at The Computer Trade Show '83 – minicomputers, microcomputers, small business systems, word processors and peripherals. Make a date now and complete the coupon below for your free tickets.

Organised by the organisers of COMPEC and sponsored by Computer Weekly, Practical Computing, Systems International, Software, and Micro Business.

The Computer Trade Show '83
Reed Exhibitions
Surrey House, 1 Throwley Way
Sutton, Surrey SM1 4QQ.

Please send ______ ticket(s) for The Computer Trade Show '83.

Name ______

Position in Company ______

Company ______

Address ______

THIS IS A TRADE ONLY SHOW, NOT FOR END-USERS

Please send me further details about the seminars ☐

BGW SYSTEMS Industrial/ Commercial Power Amplifiers

Specifications (Direct Output): BGW Model 620B

OUTPUT POWER:

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

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

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

Specifications (Direct Output): BGW Model 320B

OUTPUT POWER:

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

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

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

THEATRE PROJECTS

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

WW – 027 FOR FURTHER DETAILS

hi! performance hi! competitive hi!

FULL HOUSE OF MULTIMETERS

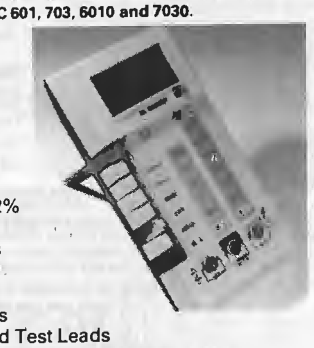
TRIO

Bench Models DL 705, 706, 720 and DF 760

- 3½ and 4½ digit LED
- Rugged and Reliable
- 2 YEAR GUARANTEE
- Simple Operation – Auto Ranging
- Mains or Battery
- 7 Digit Frequency Counter
- Resolutions 1 and 0.1 mV
- DCV, ACV, DCA, ACA and Ohms
- Basic accuracy 0.8, 0.25, 0.1 and 0.05%
- Prices from £92 include FREE batteries, hand book and Test Leads

HC

Hand Held Models HM101 and 102 Series, HC 601, 703, 6010 and 7030.



- 3½ digit LCD and Analogue
- Colour coded front panel and edge switches
- High impact ABS with Tilt stand
- Safety features meets UL 1244
- Basic accuracy 0.6 and 0.2%
- Full Range of DCV, ACV, DCmA, ACmA and Ohms
- Audio Continuity Tone Plus 10A capability.
- Switched HI and LO ohms
- FREE Battery, Manual and Test Leads
- Analogue from approx **£5** – Digital from approx **£34**

BBC GOERZ METRAWATT

MA1H, 2H, 3E and 5D. M2011, 2012, 2030, 2031 and 2032. Unigor 3N.

- Digital and Analog – Hand Held and Bench
- Huge LCDs – Many Safety Features
- Black, Rugged and Reliable
- 1 Year Guarantee
- 3½ and 4½ Digits
- Variable Viewing Angle – Hand free operation
- 20 Amp capability
- DCV, ACV, DCA, ACA, Ohms, Capacitance, Temp and Level in dBs
- Meet DIN 40050, 43780, 57410 or 57411 Requirements
- Prices from approx **£26** inc FREE Batteries, Manual and Test Leads

MIC

Hand Held Models 6000Z and 3300A

- 3½ digit LCD with easy single rotary control.
- 10 Amp., 1000V and 20M ohm capability.
- TRANSISTOR hFE measurement.
- Audible Continuity check and Diode Test.
- Optional accessories incl. Carry Case and Battery Eliminator.
- Fully Guaranteed for 12 months.
- Prices from approx. £39 include Free Battery, Manual and Test Leads.

Prices do not include VAT or P + D.

House of Instruments
Clifton Chambers, 62 High Street
Saffron Walden, Essex CB10 1EE
Tel: (0799) 24922 Telex: 818750

Extended CREDIT available

hi! House of Instruments Ltd.

hi! competitive hi!

hi! performance hi! service hi! reliability hi! competitive

hi! reliability hi! service hi! performance hi! competitive hi! performance hi! service hi! reliability hi! competitive

hi! reliability hi! service hi! performance hi! competitive hi! performance hi! competitive

WW – 033 FOR FURTHER DETAILS

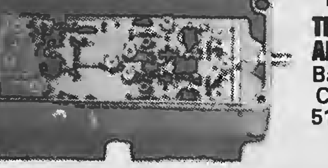
RF LINEAR POWER AMPLIFIERS

TYPE 9045

VMOS WIDEBAND LINEAR POWER AMPLIFIERS

4 watts and 20 watts max. RF output. Without tuning. Power gain 10 dB

TYPE 9045 10 KHz.-100 MHz. 4 watts....................£49.50+£2 p&p
TYPE 9050 20 MHz.-200 MHz. 4 watts....................£49.50+£2 p&p
TYPE 9066 10 KHz.-100 MHz. 20 watts....................£120.00+£4 p&p
TYPE 9064 As above with integral mains power supply unit....................£180+£8 p&p
TYPE 9067 20 MHz.-200 MHz. 20 watts....................£120+£4 p&p
TYPE 9065 As above with integral mains power supply unit....................£180+£8 p&p

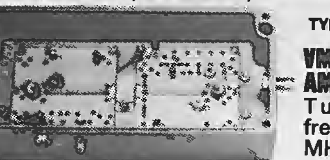


TYPE 9058

TELEVISION LINEAR POWER AMPLIFIERS

Bands IV or V.
Channel group 'A' 21-34, 'B' 39-51, or 'CD' 48-68

TYPE 9061 150mV. input, 10 mW. output. Adjustable gain....................£120.00+£4.00 p&p
TYPE 9052 10mW. input, 500mW. output. Adjustable gain....................£120.00+£4.00 p&p
TYPE 9059 500mW. input, 5 watts output....................£150.00+£4.00 p&p



TYPE 9054

VMOS LINEAR POWER AMPLIFIERS

Tuned to your specified frequency in the range 1-250 MHz.

TYPE 9054 200 mW. 2 watts input, 20 watts output. Gain adjustable 10-20 dB....................£120+£4 p&p
TYPE 9060 As above with integral mains power supply unit....................£180.00+£8.00 p&p
TYPE 9068 1-8 watts input, 80 watts output. Gain adjustable 10-20 dB £160.00+£4.00 p&p
TYPE 9057 As above with integral mains power supply unit....................£210.00+£8.00 p&p
TYPE 9082 FM TRANSMITTER. 88-108 MHz. 50 watts RF output....................£180.00+£4.00 p&p
TYPE 9083 As above with integral mains power supply unit....................£230+£8 p&p

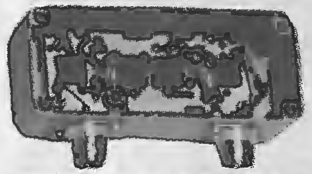
LOW NOISE GASFET PREAMPLIFIERS

TYPE 9008 in 9010

TWO STAGE GASFET STRIPLINE PREAMPLIFIERS

Television bands IV or V.
Channel group 'A' 21-34, 'B' 39-51, or 'CD' 48-68

TYPE 9008 Two stage Gasfet preamplifier. N.F. 0.7 dB. Gain 25 dB....................£65+£1.50 p&p
TYPE 9002 Two stage Gasfet preamplifier. N.F. 0.7 dB. Gain 10-35 dB. variable. High Q filter....................£85+£1.50 p&p
TYPE 9009 UHF two stage Gasfet preamplifier. N.F. 0.6 dB. Gain 25 dB. Aligned to your specified frequency in the range 250-500 MHz....................£65+£1.50 p&p
TYPE 9004 UHF TWO STAGE Gasfet preamplifier. N.F. 0.6 dB. Gain 10-35 dB. variable. Aligned to your specified frequency in the range 250-500 MHz. High Q filter....................£85+£1.50 p&p
TYPE 9012 Gasfet preamplifier mains power supply unit....................£24.50+£2.50 p&p
TYPE 9010 Masthead weatherproof unit....................£4.50+£1.50 p&p



TYPE 9026

GASFET/MOSFET RF PREAMPLIFIERS

Aligned to your specified frequency in the range 1-250 MHz.
Masthead/local use

TYPE 9026 N.F. 1.0 dB. Gain 10-40 dB. variable....................£39.50+£1.50 p&p
TYPE 9026 FM. As above. Band II 88-108 MHz....................£39.50+£1.50 p&p
TYPE 9006 Gasfet. N.F. 0.6 dB. Gain 10-40 dB. variable....................£65.00+£1.50 p&p
TYPE 9035 Mains power supply unit for above....................£19.50+£2.50 p&p

TYPE 9031

WIDEBAND RF PREAMPLIFIER

1 KHz-100 MHz without tuning

TYPE 9031 N.F. 3.0 dB Gain 40 dB....................£39.50+£1.50 p&p
TYPE 9056 1500 MHz PRESCALER. Divides 100-1500 Mhz by 10....................£59.50+£1.50 p&p
TYPE 8033 PHASE LOCKED SIGNAL SOURCE using low frequency reference crystal. Specify output in the range 1-600 MHz. Output 10 mW. + 10 dBm....................£64.50+£1.50 p&p

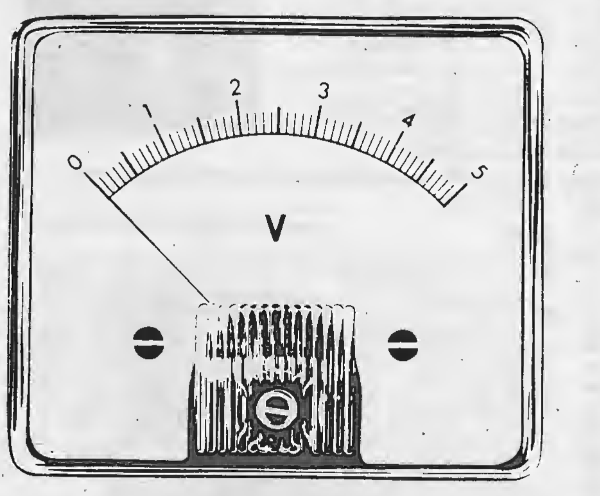
RESEARCH COMMUNICATIONS LTD.

UNIT 3, DANE JOHN WORKS, GORDON ROAD, CANTERBURY, KENT CT1 3PP
TELEPHONE: CANTERBURY (0227) 56489

PLEASE ADD 15% V.A.T. ON TOTAL

WW – 043 FOR FURTHER DETAILS

METER PROBLEMS?



137 Standard Ranges in a variety of sizes and stylings available for 10-14 days delivery. Other Ranges and special scales can be made to order.

Full Information from:

HARRIS ELECTRONICS (London)
138 GRAY'S INN ROAD, W.C.1
Phone: 01-837/7937
Telex: 892301

WW – 019 FOR FURTHER DETAILS

CLEF ELECTRONIC MUSIC

PIANOS

SPECIALISTS SINCE 1972
DOMESTIC OR STAGE
SIX OR 7¼ OCTAVES
KITS OR MANUFACTURED

The most advanced form of touch-sensitive action simulating piano key inertia by patented technique.

Four mixable voices for serious tone variation plus electronic chorus and flanger effects.

Component Kits include Keyboard.

Full Kits further contain: Cabinets, Harness, Power Amp and Speaker.

DOMESTIC PRICES

£	SIX	7¼
Comp	234	266
Full	398	442
MFD	620	695

Kit £314
Mfd £439

VOCAL & INSTRUMENTAL SOLOISTS!

BAND-BOX
An Electronic Backing TRIO. Drums, Bass & Chord Instrument. User Programmable for 50-100 scores, using microprocessor.

MASTER RHYTHM
User Programmable DRUM MACHINE. Twenty-four patterns. Eight parallel tracks. Twelve instruments sequence operation.

£79 KIT £119 BUILT

Write or Phone for full details of our range of high quality Kit and manufactured Electronic Musical Instruments. Prices include V.A.T., Carr., & Ins. and we operate Telephone BARCLAYCARD/ACCESS.
Competitive EXPORT Quotations given.

CLEF PRODUCTS (ELECTRONICS) LIMITED
Dept. W, 44a Bramhall Lane South
Bramhall, Stockport, Cheshire SK7 1AH
061-439 3297

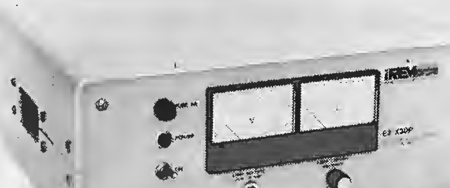
WW – 018 FOR FURTHER DETAILS

ELECTRONIC POWER UNITS

FOR XENON ARC AND MERCURY ARC LAMPS

UNITS AVAILABLE FOR LAMPS RANGING FROM 75 TO 6500 WATTS.

Lamp housings and lens systems manufactured as standard off the shelf models or to specific design.



iREM

K. T. Manners Design Ltd.
P.O. Box 936, London, W4 4NW Telephone: 01-994 7155. Telex: 28604

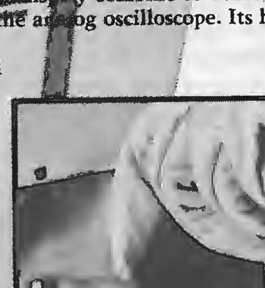
WW – 049 FOR FURTHER DETAILS

Bubble Machine.

This Nicolet digital scope can put a waveform in your pocket.

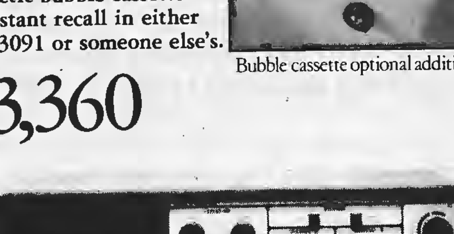
The two-channel 3091 offers the traditional advantages of a Nicolet digital storage oscilloscope in a compact portable package. The quartz crystal timing, precise A/D conversion and alphanumeric display combine to overcome the accuracy limitations of the analog oscilloscope. Its high resolution and 1MHz digitizing rate make it ideal for field calibration, fault diagnosis or transient analysis in mechanical, electrical, accoustical and biological applications.

The 3091 is a digital storage oscilloscope, a transient recorder and a chart recorder all in one, easy-to-use instrument. Important data can be stored on the optional magnetic bubble cassette for instant recall in either your 3091 or someone else's.



Bubble cassette optional addition £1,050

£3,360



Nicolet Instruments

Nicolet Instruments Limited. (A Nicolet Instrument Subsidiary).
Budbrooke Road, Warwick, England. CV34 5XH.
Telephone (0926) 494111 Telex 311135

WW – 050 FOR FURTHER DETAILS

Midwich

COMPUTER COMPANY LIMITED

1st choice for microcomputer components

BBC MICROCOMPUTERS

Model B	346.95
Model B +Disc Int.	441.95

BBC MICRO DISC DRIVES

BBC31 Single 100K	229.00
BBC32 Dual 100K	340.00
BBC34 Dual 400K	649.00

All disc drives include all Cables, Manual & Utilities Disc.

BBC MICRO UPGRADE KITS

BBCA2B Complete A TOB	44.75
BBC1 16K Memory	18.00
BBC2 Printer	7.50
BBC3 Disc	95.00
BBC4 Analogue	6.70
BBC5 Serial & RGB	7.30
BBC6 Bus	6.45

Fitting service available.

BBC MICRO CONNECTORS

BBC21 Printer Cable (not assembled)	13.00
BBC22 User Port Connector & Cable	2.46
BBC23 Cassette Lead	3.50
BBC24 7 Pin Din Plug	0.60
BBC25 6 Pin Din Plug	0.60
BBC26 5 Pin Din Plug	0.60

BBC MICRO ACCESSORIES

BBC45 Joysticks	11.30
BBC67 Eprom Programmer	57.95

BBC MICRO SOFTWARE

View Wordprocessor	52.00
1.0 M.O.S.	36.00

ACORNSOFT

Full range available. Please telephone for stock position.

MEMORIES

2114L-200NS	D1	0.80
2708 450NS	D2	2.95
2716 450NS	D1	2.45
2716 350NS	D1	4.95
2716 3 Rail	D1	7.25
2532 450NS	D2	3.45
2732 450NS	D1	3.45
2732 350NS	D1	5.45
2764 300NS	D1	7.95
4116 150NS	D1	0.85
4116 200NS	D2	0.80
4118 150NS	D1	3.25
5516 200NS	D2	9.45
6116 150NS	D1	3.30
6116 Low Power 150NS	D2	4.95
4164 200NS TI	D3	3.95
4164 200NS NEC	D3	3.95
4516/4816 100NS	D2	2.25
4532 200NS	D2	2.95

6800 FAMILY

6800	D7	2.25
6802	D5	2.50
6809	D6	6.30
6810	D1	1.15
6821	D3	1.00
6840	D4	3.75
6845	D5	6.50
6850	D2	1.10
68488	D2	7.30
68B00	D7	5.25
68B09	D6	12.00
68B10	D1	2.26
68B21	D3	2.20
68B40	D4	6.00
68B50	D2	2.20

Z80 FAMILY

Z80 ACPU	D2	2.99
Z80 BCPU	D2	9.00
Z80 ACTC	D1	2.60
Z80 BCTC	D1	9.00
Z80 ADART	D1	5.50
Z80 ADMA	D2	6.95
Z80 AP10	D1	2.75
Z80 BP10	D1	9.00
Z80 AS10	D4	9.00

8080 FAMILY

8085A	D4	3.50
8212		1.10
8216		1.00
8224		2.10
8228		3.27
8251A	D5	2.50
8253		4.00
8255A	D5	2.25

6500 FAMILY

6502	D3	3.25
6502A	D3	5.00
6520	D1	2.50
6520A	D1	3.16
6522	D5	3.00
6522A	D5	5.50
6532	D2	5.50

FLOPPY DISC CONTROLLERS

8271		36.00
FD1771	D5	15.00
FD1791	D6	22.00
FD1793	D6	23.00
FD1795	D6	28.00
FD1797	D6	28.00
WD1691	D2	12.00
WD2143-01	D2	6.99

INTERFACE DEVICES

6402		3.80
75107		0.47
75110		0.56
75150		0.64
75154		0.77
75160		2.56
75161		2.80
75162		3.95
75172		1.95
75173		1.44
75174		1.95
75175		1.44
75182		0.50
75183		0.50
75188		0.37
75189		0.37
75451		0.22
75452		0.22
75453		0.22
75454		0.22
75468		0.88
75491		0.31
75492		0.42
AY31015	D2	3.00
AY31270		6.47
AY38910	D6	4.40
AY53600	D2	6.70
DP8304	D1	2.50
MC1488	D1	0.37
MC1489	D1	0.37
NC3242A		6.30
MC3446	D1	2.50
MC3448A	D1	3.75
MC3480	D5	7.30
MC3487	D1	2.00
MC14411	D1	7.65
MC14412		9.45
RO32513L	D1	6.50
RO32513U	D1	6.50

UMF MODULATORS

UM1111	6MHZ	D1	2.60
UM1233	8MHZ	D1	3.90

BUFFERS

8IL595	0.80
8IL596	0.80
8IA597	0.80
8IL598	0.80
8T26A	0.90
8T28A	0.90
8T95	0.90
8T97A	0.90
8T98	0.90

LINEARS

L203	0.65
LF398N	4.75
LM301AN	0.24
LM308N	0.48
LM311P	0.50
LM319N	1.99
LM324N	0.30
LM348N	0.60
NE555P	0.16
NE556CP	0.45
TL010	0.39
TL061	0.29
TL062	0.49
TI064	0.98
TL066	0.29
TL071	0.29
TL072	0.47
TL074	1.00
TL081	0.26
TL082	0.46
TL084	1.58
TL091	0.40
TL092	0.58
TL094	1.34
TL487	0.62
TL489	0.62
TL494	1.63
TL496	0.60
TL507	1.33
725	1.60
741	0.14
747	0.48
748	0.27

REGULATORS

78L05	0.30
78L12	0.30
78L15	0.30
7805	0.40
7812	0.40
7815	0.40
7905	0.45
7912	0.45
7915	0.45
LM309K	1.20
LM317K	2.40
LM323K	4.50
LM338K	6.25

DATA CONVERTORS

UPD7002	D1	4.26
ZN425	D1	3.45
ZN426	D1	3.00
ZN427	D1	5.99
ZN428	D1	4.75
ZN429	D1	2.10
ZN432	D1	13.00
ZN449	D1	2.55

CRYSTALS

1MHZ	2.75
1.8432 MHZ	1.92
4MHZ	0.64
8MHZ	0.86

DIL SOCKETS

Pins	Tin	Gold	W/W
8	7	16	25
14	10	26	35
16	10	29	40
18	13	33	50
20	15	37	60
22	17	38	65
24	21	46	70
28	24	55	80
40	30	76	99

ZIF SOCKETS

24 Pin	5.75
28 Pin	8.20
40 Pin	9.75

Data sheets are available on items marked *D*. Prices are as follows

D1	0.75	D5	2.00
D2	1.00	D6	3.00
D3	1.25	D7	4.00
D4	2.00	D8	5.00

A full range of the following products is carried in stock and is listed in our FREE catalogue.

- 74LS Series TTC
- 4000 Series CMOS
- T.I. Bipolar Memories
- 9900 Series Micros
- Crystals
- IDC, Card Edge & D-Type Connectors
- Dip Jumpers
- Monochrome & Colour Monitors (NEC & KAGA)
- Eprom Programmers & Erasers
- Custom Cable Assemblies

SPECIAL OFFER! SPECTRUM 32K UPGRADE KIT £24.95

Carriage Orders up to £199 are sent by 1st class post, and £200+ by Securicor.
0-£100 0.50 £100-£199 1.25 £200+ 5.00 by Securicor.
Prices quoted (+ carriage charges) are exclusive of VAT and are subject to change without notice.
Quantity Discounts are available on many products, please ring for details.
Official Orders are welcome from Education Establishments, Government Bodies and Public Companies.
Credit Accounts are available to others subject to status. Payment is due strictly nett by the 15th of the month.
Credit Cards are accepted (Access and Visa) for telephone and postal order and NO SURCHARGE is made.
Out of stock items will follow automatically, at our discretion, or a refund will be given if requested.

THE ABOVE LIST SHOWS JUST A FEW OF THE ITEMS IN STOCK. PLEASE TELEPHONE YOUR REQUIREMENTS – OR BETTER STILL SEND FOR OUR FREE CATALOGUE

Please complete this coupon for a copy of our FREE catalogue.

NAME ____________
ADDRESS ____________
____
____
TEL. NO. ____________

MIDWICH COMPUTER COMPANY LIMITED
RICKINGHALL HOUSE, RICKINGHALL, SUFFOLK IP22 1HH
TELEPHONE (0379) DISS 898751

WW – 046 FOR FURTHER DETAILS

EP4000 *EPROM EMULATOR PROGRAMMER*

The microprocessor controlled EP4000 will emulate and program all the popular EPROMs including the 2704, 2708, 2716(3), 2508, 2758, 2516, 2716, 2532 and 2732 devices. Personality cards and hardware changes are not required as the machine configures itself for the different devices. Other devices such as bipolar PROMs and 2764 and 2564 EPROMs are programmed with external modules.

The editing and emulation facilities, video output and serial/parallel input/output provided as standard make the EP4000 very flexible to allow its use in three main modes:

- As a stand alone unit for editing and duplicating EPROMs.
- As a slave programmer used in conjunction with a software development system or microcomputer.
- As a real time EPROM emulator for program debugging and development (standard access time of the emulator is 300ns).

Data can be loaded into the 4k x 8 static RAM from a pre-programmed EPROM, the keypad, the serial or parallel ports and an audio cassette. Keypad editing allows for data entry, shift, move, delete, store, match and scroll, and a 1k x 8 RAM allows temporary block storage. A video output for memory map display, as well as the built-in 8 digit hex display allows full use of the editing facilities to be made.

Items pictured are: ● EP4000 Emulator Programmer – £545 + £12 delivery; ● BSC buffered simulator cable – £39; ● MESA 4 multi EPROM simulator cable – £98; ● 2732A Programming adaptor – £39; ● 2764 Programming adaptor – £64; ● 2564 Programming adaptor – £64; ● BP4 (TEXAS) Bipolar PROM Programming module – £190

Also available (not shown): ● VM10 Video monitor – £99; ● UV141 EPROM Eraser with timer – £78; ● GP100A 80 column Printer – £225; ● PI100 interface for EP4000 to GP100A – £65.

VAT should be added to all prices

DISTRIBUTORS REQUIRED ● EXPORT ENQUIRIES WELCOME

GP Industrial Electronics Ltd.

Tel: Plymouth (0752) 332961
Telex: 42513

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

WW – 039 FOR FURTHER DETAILS

P8000 – THE PRODUCTION PROGRAMMER THAT HANDLES ALL NMOS EPROMS

NEW PRODUCT

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

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

Write or phone for more details

DISTRIBUTORS REQUIRED ● EXPORT ENQUIRIES WELCOME

GP Industrial Electronics Ltd.

Tel: Plymouth (0752) 332961
Telex: 42513

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

WW – 040 FOR FURTHER DETAILS

Advanced fault finding and diagnosis is just one of the many projects undertaken with the ELE microelectronic and microprocessor teaching system.

A complete range of projects can be taught, from building simple electronic circuits to advanced engineering applications such as intelligent robotics.

Features

- **Expandable** - buy what you want when you want
- **Modular** - interchangeable components throughout
- **Structured** - provides a complete educational programme
- **Ready to use** - no extras to buy
- **Comprehensive** - 46 items of equipment in the system

How to find faults with our system

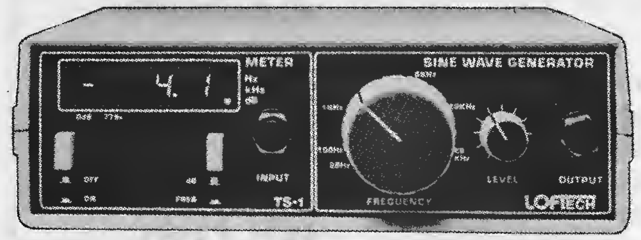
For further information and a free brochure, contact ELE at the address below:

ELE International Limited

ELE International
Eastman Way
Hemel Hempstead
Hertfordshire
HP2 7HB
England

Tel: (0442) 50221
Telex: 825239

WW – 044 FOR FURTHER DETAILS



Digital Audio Test Set

Imagine the ideal hand held test set. A minimum of controls. An oscillator that covers the audio spectrum in a single sweep. A level meter that measures directly in dBs over 74dBs. And a frequency counter that reads the oscillator or meter input.

Small enough to operate anywhere, and precise enough for any professional application.

The Loft TS1 is manufactured by the Phoenix Audio Laboratory Inc., and distributed exclusively by Turnkey.

It's price £249.00. Call us now for more information.

turnkey

Brent View Road LONDON NW9 7EL
01-202 4366

WW – 016 FOR FURTHER DETAILS

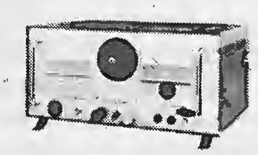
PRODUCTION TESTING

DEVELOPMENT

SERVICING

POWER UNITS

Now available with 3 OUTPUTS



Type 250VRU/30/25

OUTPUT 1: 0-30v, 25A DC
OUTPUT 2: 0-70v, 10A AC
OUTPUT 3: 0-250v, 4A AC

ALL Continuously Variable

Valradio

VALRADIO LIMITED, BROWELLS LANE, FELTHAM MIDDLESEX TW13 7EN
Telephone: 01-890 4242/4837

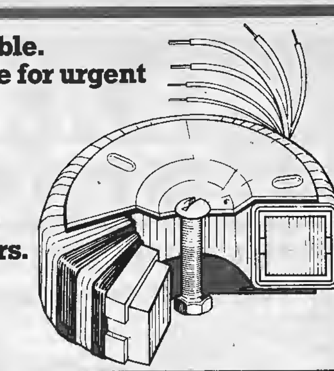
WW – 045 FOR FURTHER DETAILS

TOROIDALS

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

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

✱5 year no quibble guarantee.



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

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

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

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

The benefits of ILP toroidal transformers

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

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

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

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

For mail order please make your crossed cheques or postal orders payable to ILP Electronics Ltd. Barclaycard/Access welcome. Trade orders standard terms.

Post to: ILP Electronics Ltd, Graham Bell House, Roper Close, Canterbury CT2 7EP, Kent, England.
Telephone (0227) 54778. Telex 965780.

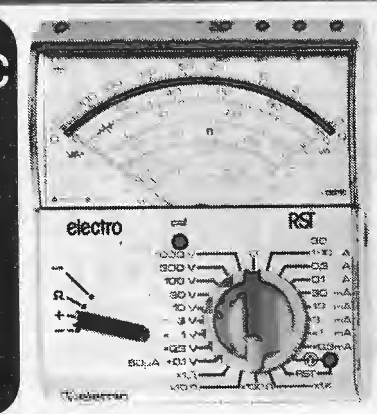
ILP TRANSFORMERS (a division of ILP Electronics Ltd)

WW – 009 FOR FURTHER DETAILS

LOW COST PROFESSIONAL TEST INSTRUMENTS

sabtronics
FREQUENCY METERS
100MHz, 600MHz, and 1GHz Models
from £67

Elemic
Hand Held Analogue and Digital Multimeters
16 Models from £18.75



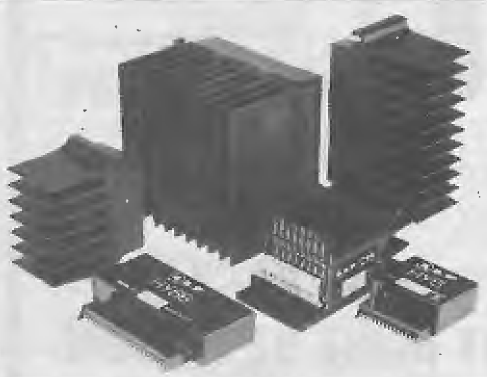
- ★ FREQUENCY METERS
- ★ ANALOGUE MULTIMETERS
- ★ DIGITAL MULTIMETERS
- ★ FUNCTION GENERATOR
- ★ OSCILLOSCOPES
- ★ POWER SUPPLIES
- ★ LOGIC PROBE
- ★ SCOPE PROBES

Write or phone for illustrated test instrument catalogue and price list
Black Star Ltd.
9A, Crown Street
St. Ives, Huntingdon
Cambs. PE17 4EB
Tel: (0480) 62440 Telex 32339

Black Star

WW – 010 FOR FURTHER DETAILS

GET BIG POWER



ILP Modular Amplifiers
the third generation

Due to continous improvements in components and design ILP now launch the largest and most advanced generation of modules ever.

WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.

BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	DISTORTION I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection: Full load line. Slew Rate: 15v/µs. Risetime: 5µs. S/N ratio: 100db.
Frequency response (−3dB) 15Hz — 50KHz. Input sensitivity: 500mV rms.
Input Impedance: 100K Ω. Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards
For ease of construction we recommend the **B6** for modules HY6—HY13 £1.05 (inc. VAT) and the **B66** for modules HY66—HY78 £1.29 (inc. VAT).

POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU.21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

Please note: X in part no. indicates primary voltage. Please insert "O" in place of X for **110V**, "1" in place of X for **220V**, and "2" in place of X for **240V**.

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	DISTORTION I.M.D. 60Hz/ 7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/µs. Rise time: 3µs. S/N ratio: 100db
Frequency response (−3dB): 15Hz — 100KHz. Input sensitivity: 500mV rms
Input impedance: 100K Ω. Damping factor: 100Hz >400.

'NEW to ILP' In Car Entertainments

C15
Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction. **£9.14 (inc. VAT)**

Mounts anywhere in car.

Automatic switch on.

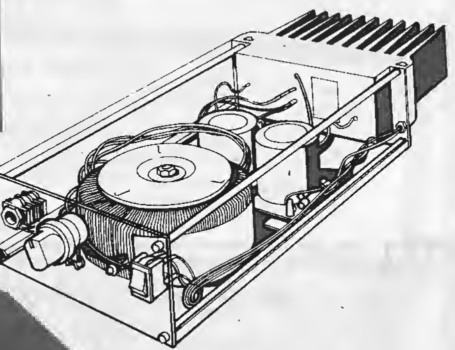
Output power maximum 22w peak into 4Ω
Frequency response (−3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω
Size 95 x 48 x 50mm, Weight 256 gms.

C1515
Stereo version of C15. **£17.19 (inc. VAT)**

Size 95 x 40 x 80. Weight 410 gms.

WITH A LOT OF HELP FROM ILP ELECTRONICS LTD

PROFESSIONAL HI-FI THAT EVERY ENTHUSIAST CAN HANDLE...



Unicase

Over the years ILP has been aware of the need for a complete packaging system for it's products, it has now developed a unique system which meets all the requirements for ease of assembly, adaptability, ruggedness, modern styling and above all price.

Each Unicase kit contains all the hardware required down to the last nut and bolt to build a complete unit without the need for any special tools.

Because of ILP's modular approach, "open plan" construction is used and final assembly of the unit parts forms a compact aesthetic unit. By this method construction can be achieved in under two hours with little experience of electronic wiring and mechanical assembly.

Hi Fi Separates

UC1 PRE AMP UNIT: Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

POWER AMPS: The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.

Power Slaves

Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

UNICASES

HIFI Separates					Price inc. VAT
UC1	Preamp				£29.95
UP1X	30 + 30W/4–8Ω	Bipolar	Stereo	HiFi	£54.95
UP2X	60W/4Ω	Bipolar	Mono	HiFi	£54.95
UP3X	60W/8Ω	Bipolar	Mono	HiFi	£54.95
UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4–8Ω	MOS	Mono	HiFi	£64.95
UP7X	120W/4–8Ω	MOS	Mono	HiFi	£84.95
Power Slaves					
US1X	60W/4Ω	Bipolar	Power	Slave	£59.95
US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
US3X	60W/4–8Ω	MOS	Power	Slave	£69.96
US4X	120W/4–8Ω	MOS	Power	Slave	£89.95

Please note X in part number denotes mains voltage. Please insert 'O' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

TO ORDER USING OUR FREEPOST FACILITY
Fill in the coupon as shown, or write details on a separate sheet of paper, quoting the name and date of this journal. By sending your order to our address as shown at the bottom of the page opposite, with FREEPOST clearly shown on the envelope, you need not stamp it. We pay postage for you. Cheques and money orders must be crossed and made payable to I.L.P. Electronics Ltd. if sending cash, it must be by registered post. To pay C.O.D. please add £1 to TOTAL value of order.

PAYMENT MAY BE MADE BY ACCESS OR BARCLAYCARD IF REQUIRED

ILP ELECTRONICS LTD

Post to: ILP Electronics Ltd., Freepost, 5 Graham Bell House, Roper Close. Canterbury. CT2 7EP. Kent. England.
Telephone: (0227) 54778.
Technical: (0227) 64723.
Telex: 965780.

Please send me the following ______
Total purchase price ______
I enclose Cheque ☐ Postal Orders ☐ Int. Money Order ☐
Please debit my Access/Barclaycard No. ______
Name ______
Address ______
______
Signature ______

WW — 008 FOR FURTHER DETAILS

REGD. TRADE MARK

TEONEX

TEONEX ELECTRONIC VALVES AND SEMICONDUCTORS

SERVING THE WORLD FOR 30 YEARS

We specialise in the supply of Industrial Valves of British, European and USA manufacture, and semiconductors from the Philips Group. Many types, including obsolete and obsolescent types, always available from stock.

For further details, contact Mrs. Janet Lowy.

T.O. SUPPLIES (EXPORT) LTD., 2A Westbourne Grove Mews, London W11 2RY.
Telephone: (01) 727 3421 Telex: 262256 Answerback TOSPLY G

WW – 011 FOR FURTHER DETAILS

Happy Memories

Part type	1 off	25-99	100 up
4116 200ns	.90	.81	.78
4116 250ns	.70	.63	.60
4816 100ns For BBC comp	2.20	1.95	1.85
4164 200ns	3.99	3.56	3.42
2114 200ns Low power	1.15	1.00	.90
2114 450ns Low power	.95	.85	.80
4118 250ns	3.35	3.00	2.85
6116 150ns CMOS	3.35	3.00	2.85
2708 450ns	2.60	2.25	2.10
2716 450ns 5 volt	2.35	2.10	2.02
2716 450ns three rail	5.75	5.00	4.65
2732 450ns Intel type	3.50	3.15	3.00
2532 450ns Texas type	3.70	3.30	3.00
2764 250ns	4.90	4.35	4.20

Z80A-CPU £3.95	Z80A-P10..........£2.99	Z80A-CTC..........£2.99
6522 PIA £4.90	7002 A-D...........£4.60	3691....................£2.75
88LS120 ....£2.20	7805 reg..................50	7812 reg..................50

Low-profile IC sockets:									
Pins	8	14	16	18	20	22	24	28	40
Pence	9	10	11	14	15	18	19	25	33

Soft-sectored floppy discs per 10 in plastic library case:

5-inch SSSD £17.00	5-inch SSDD £19.25	5-inch DSDD £21.00
	5-inch DSQD £26.35	
8-inch SSSD £19.25	8-inch SSDD £23.65	8-inch DSDD £25.50

74LS series TTL, large stocks at low prices with DIY discounts starting at a mix of just 25 pieces. Write or 'phone for list.

Please add 50p post & packing to orders under £15 and VAT to total Access & Visa welcome. 24-hr service on (054 422) 618 Government & Educational orders welcome, £15 minimum Trade accounts operated, 'phone or write for details

HAPPY MEMORIES (WW)
Gladestry, Kington
Herefordshire HR5 3NY
Telephone: (054 422) 618 or 628

RECHARGEABLE BATTERIES

PRIVATE & TRADE ENQUIRIES WELCOME

Full range available to replace 1.5 volt dry cells and 9 volt PP type batteries, SAE for lists and prices. £1.45 for booklet, "Nickel Cadmium Power," plus catalogue.

★ New sealed lead range now available ★

Write or call at:

SANDWELL PLANT LTD.
2 Union Drive, Boldmere
Sutton Coldfield, West Midlands, 021-354 9764
Southern Office: 0462 733254

WW – 032 FOR FURTHER DETAILS

RADFORD

Audio Measuring Instruments, Audio Amplifiers, Loudspeakers and Loudspeaker Components for the professional and enthusiast

RADFORD AUDIO LTD.
10 BEACH ROAD
WESTON-S-MARE, AVON BS23 2AU
TEL. 0934 416033

WW – 022 FOR FURTHER DETAILS

PRINTED CIRCUITS

FOR WIRELESS WORLD PROJECTS

Audio compressor/limiter—Dec. 1975—1 s.s. (stereo)	£4.25
Cassette recorder—May 1976—1 s.s.	£5.00
Audio compander—July 1976—1 s.s.	£4.25
Audio preamplifier—November 1976—2 s.s.	£8.50
Additional circuits—October 1977—1 s.s.	£4.00
Stereo coder—April 1977—1 d.s. 2 s.s.	£8.50
Low distortion disc amplifier (stereo)—September 1977—1 s.s.	£2.00
Low distortion audio oscillator—September 1977—1 s.s.	£3.50
Synthesized f.m. transceiver—November 1977—2 d.s. 1 s.s.	£12.00
Morsemaker—June 1978—1 d.s.	£4.50
Metal detector—July 1978—1 d.s.	£3.75
Oscilloscope waveform store—October 1978—4 d.s.	£18.00
Regulator for car alternator—August 1978—1 s.s.	£2.00
Wideband noise reducer—November 1978—1 d.s.	£5.00
Versatile noise generator—January 1979—1 s.s.	£5.00
200MHz frequency meter—January 1979—1 d.s.	£7.00
High performance preamplifier—February 1979—1 s.s.	£5.50
Distortion meter and oscillator—July 1979—2 s.s.	£5.50
Moving coil preamplifier—August 1979—1 s.s.	£3.50
Multi-mode transceiver—October 1979—10 d.s.	£35.00
Amplification system—Oct. 1979—3 preamp 1 poweramp	£4.20 each
Digital capacitance meter—April 1980—2 s.s.	£7.50
Colour graphics system—April 1980—1 d.s.	£18.50
Audio spectrum analyser—May 1980—3 s.s.	£10.50
Multi-section equalizer—June 1980—2 s.s.	£8.00
Floating-bridge power amp— Oct. 1980 — 1 s.s. (12V or 40V)	£4.00
Nanocomp 6802 or 6809 – Jan., July, 1981 – 1 d.s. 1 s.s.	£9.00
Cassette interface – July, 1981 – 1 s.s.	£1.50
Eprom programmer – Jan., 1982 – 1 d.s.	£4.50
Logic probe – Feb., 1981 – 2 d.s.	£6.00
Modular frequency counters – March, 1981 – 8 s.s.	£20.00
Opto electronic contact breaker (Delco) – April, 1981 – 2 s.s.	£4.00
CB synthesiser – Sept. – 1 d.s.	£6.00
Electronic ignition – March, 1982 – 1 s.s.	£4.00

Boards and glassfibre roller-tinned and drilled. Prices include VAT and UK postage. Airmail add 30%, Europe add 10%. Insurance 10%. Remittance with order to:

M. R. SAGIN, NANCARRAS MILL, THE LEVEL CONSTANTINE, FALMOUTH, CORNWALL

WW – 013 FOR FURTHER DETAILS

Toroidal Transformers

THE COTSWOLD "BUDGET RANGE" OFFERS BUILT-IN QUALITY COUPLED TO A RELIABLE DELIVERY SERVICE MOST TYPES FROM STOCK

IEC 65
VDE 0550
BS 415
TO ORDER

PHONE TELEX, WRITE FOR DATA SHEET AND PRICE LIST

Cotswold Electronics LTD.

Unit T1, Kingsville Road, Kingsditch Trading Estate, Cheltenham GL51 9NX

Tel: 0242-41313 Telex: 897106

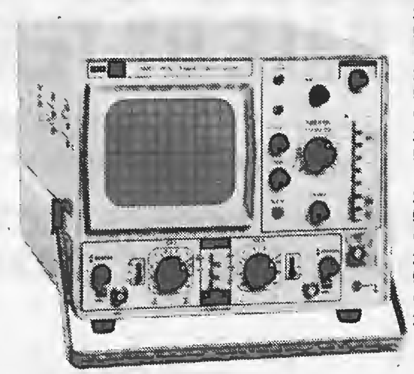
Sales Office in U.S.A.
AVEL LINDBERG INC.
Peacock Alley 116, 1 Padanaram Road, Danbury, CT 06810 U.S.A.
203-797-8698. Telex: 710-456-9984

WW – 053 FOR FURTHER DETAILS

Carstonbuy Carstonsell Carstonbuy

CROTECH Oscilloscopes

These are brand-new instruments



3030 15MHz 1 Trace 5mV built-in component tester	£150
3033 15MHz 1 Trace 5mV battery operation	£280
3034 15MHz 2 Trace 5mV battery operation	£360
3131 15MHz 2 Trace 5mV built-in component tester	£240
3337 30MHz 2 Trace 5mV with signal delay	£395
391 Battery eliminator	£32

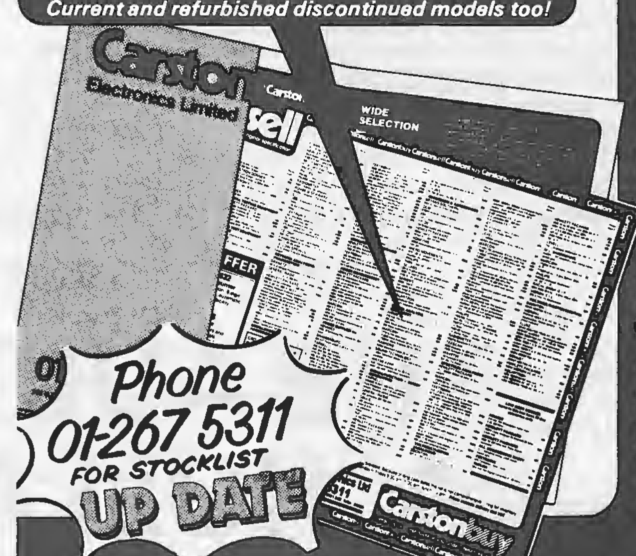
Prices exclude delivery and VAT.

Now, more than ever, the purchase of used test equipment can make more sense than buying new or even rental. Our wide choice, lower prices, and our guarantee arrangements can satisfy many of your urgent needs, NOW no waiting.
Although we also sell older models, a large proportion of our inventory is represented by manufacturers' currently listed models. Send for our full list.

Our current stock list includes:

AUDIO & ACOUSTIC	MULTI-METERS
ANALOGUE METERS	NETWORK ANALYSERS
BRIDGES	OSCILLOSCOPES
CHART RECORDERS	PHASE METERS
CALIBRATION EQUIPMENT	POWER METERS
CABLE TESTING	POWER SUPPLIES
COMMS. TEST EQUIPMENT	PULSE GENERATORS
COMPONENT TESTING	SIGNAL GENERATORS
COMPUTER EQUIPMENT	STORAGE OSCILLOSCOPES
DIGITAL TEST EQUIPMENT	SPECTRUM ANALYSERS
DIGITAL STORAGE SCOPES	SWEEP GENERATORS
DISTORTION METERS	T.V. TEST EQUIPMENT
DIGITAL METERS	TAPE RECORDERS
DATA LOGGERS	U.V. RECORDERS
DATACOM TESTING	VOLTAGE BREAKDOWN TESTERS
FREQUENCY COUNTERS	VIBRATION MEASUREMENT
FUNCTION GENERATORS	VOLTMETERS
LOGIC TESTING	WAVE ANALYSERS
MAINS SUPPLY TESTERS	X-Y RECORDERS *AND MORE*
MODULATION METERS	

Current and refurbished discontinued models too!



Phone 01-267 5311 FOR STOCKLIST UP DATE

Carstonsell

used, guaranteed test equipment, calibrated to manufacturers' original specification.

Carston Electronics Ltd., Shirley House, 27 Camden Road, London NW1 9NR. Tel: 01-267 5311. Telex: 23920 (Hours Monday to Friday 9.30 am to 5.00 pm – lunch 1-2 pm). Prices exclude delivery & VAT.

WW – 021 FOR FURTHER DETAILS

FOR EVERYTHING IN ELECTRONICS
Wireless world

Editor:
PHILIP DARRINGTON
01-661 3128

Deputy Editor:
GEOFFREY SHORTER, B.Sc.
01-661 8639

Technical Editor:
MARTIN ECCLES
01-661 8638

News Editor:
DAVID SCOBIE
01-661 8632

Drawing Office Manager:
ROGER GOODMAN
01-661 8690

Technical Illustrator:
BETTY PALMER

Advertisement Manager:
BOB NIBBS, A.C.I.I.
01-661 3130

BARBARA MILLER
01-661 8640

JULIAN BIDLAKE
01-661 8641

Northern Sales:
HARRY AIKEN
061-872 8861

Midland Sales:
BASIL McGOWAN
021-356 4838

Classified Manager:
BRIAN DURRANT
01-661 3106

IAN FAUX
01-661 3033

Production:
BRIAN BANNISTER
(Make-up and copy)
01-661 8648

Publishing Director
DAVID MONTGOMERY
01-661 3241

Impossible loyalties

A common assertion by those who have a vested interest in the retention by a company of engineering knowledge and skills is that engineers owe allegiance to the organization that employs them. Engineers, it is said, should preserve company secrets, even when it would be to the public good to disclose them, and should not behave in any way which would damage the organization, though it may be acting in an impossible manner. Engineers, in short, must be loyal to their organization.

This is a curious use of the world 'loyal'. Two prerequisites must be present in a relationship before loyalty can enter – the two parties concerned must be people and the loyalty must work both ways – neither of which conditions can apply between an employee and his organization.

Loyalty is normally regarded as existing between friends or among people who work together. It may be possible to display loyalty to a football team or to a school or any other group, but it is to the people in the groups that the loyalty is shown. An organization consists of people, but in the sense in which employees are exhorted to be loyal, it is the organization itself which claims the loyalty. In such a relationship, there is no personal link to stimulate loyalty, which is a moral attitude, impossible to attribute to an organization.

Loyalty to an organization is rendered more meaningless by the lack of any return in the attitude. An organization does whatever it must do in its own best interests, heedless of any benefits or harm to anyone. It is completely impersonal and cannot display loyalty to any person. The link between organization and employee is therefore one-way only and loyalty cannot exist.

Loyalty is considered to be a praiseworthy attitude, and it makes little sense to describe as loyal a person who acts in a less than praiseworthy manner to demonstrate his loyalty. Could one be loyal to a mass murderer, or to a group of terrorists? How, then, could an employee be loyal, even if one is to disregard all the foregoing, to an organization which makes profits from the sale of offensive weapons, or seeks to work in any way against the common good?

It is in this area, of the direction of responsibility, that engineering professionalism needs a close look. A professional considers the interests of his client (employer) before those of the rest of society, regarding, in the process, the results of his work as being the responsibility of his employer.

This is an anti-social attitude of mind, which in the perilous 1980s should be closely re-examined, particularly when the professionals concerned are engineers.

Data decoder for UOSAT

This high-performance correlation demodulator can decode data or picture information from the UOSAT spacecraft either directly off-air or from tape-recordings. It may be connected to a printer, v.d.u. or computer as the user wishes.

by J. R. Miller, B.Sc.

Since UOSAT's digital data is sent as 1200Hz or 2400Hz tones, a possible method of decoding it is to time the zero-crossings of the signal. Decoders based on this principle, however, are highly susceptible to noise and interference. Their performance depends on the audible signal-to-noise ratio, which is in turn directly dependent on the audio bandwidth; and the bandwidth cannot be reduced indefinitely without also attenuating the signal.

A more promising approach is to use a correlation decoder: this matches the incoming signal against synthesised replicas and in doing so extracts information much more effectively. In consequence its error performance is dependent only on the energy-density of the noise, which is independent of the audio bandwidth. In this way a signal can be decoded uncorrupted even though it seems to be buried in noise: for example, 45 baud data signals can be decoded without errors at a noise-to-signal ratio as poor as 5:1. This type of system is known as a matched filter.

The decoder described in this article comprises a channel filter, a 1200 baud demodulator, a 300 baud demodulator, a lock detector and a line-synchronization detector for the image data from UOSAT's c.c.d. television camera. Of these, the 1200 baud demodulator is central to the design; the other circuits may be omitted if the user does not require them. Alternative data-rates can be effected by changing timing components. The system does not include image display circuits since a design for these is available from AMSAT-UK[1].

Decoder outline

The decoder's task is to distinguish in the presence of noise between the two tones possible within a bit-period. The essential tool for this job is a correlator (Fig. 3). The signal to be detected is multiplied by its replica and the product is accumulated over a signal interval. Maximum output indicates a perfect match, zero output no match. Now, since 0 and 1 signals are mutually exclusive, the output of two such correlators may be compared to find the better match at the end of each bit-interval (Fig. 4). This is the matched filter. For timing, a bit rate clock is required, and must be extracted from the incoming signal; this rate may be either 1200 or 300 baud. The video line-sync code may best be detected using a window correlator. As the name suggests, this inspects a short sequence of the data-stream as it passes by, looking for a particular pattern. In the case of the line-sync code, the window would be 32 bits long with the correlator threshold set perhaps slightly below 32 'votes', giving some immunity from occasional corrupted bits.

Processing

Since the signal carries virtually no information in its amplitude, hard-limiting it will allow subsequent multiplications to be carried out by exclusive-or gates (Fig. 5). The two accumulators and the decision-tester described above are reconfigured here as a subtractor followed by a single accumulator. At the end of each bit-interval the decision is clocked into an output buffer and the integrator's output is zeroed in readiness for the next bit.

To generate the tone replicas (which may now be square waves) and to provide timing signals, a 1200Hz clock is extracted from the input signal using a phase-locked loop (p.l.l.). This acts on both tones, the contribution from the 2400 product being weighted half that of the 1200 product. A loop-gain of 1500 ensures that static phase errors are kept to a minimum; these might otherwise be troublesome because of oscillator drift or because of speed variations when decoding data recorded on tape. This gain corresponds to a voltage-controlled oscillator swing of 750Hz with respect to a nominal frequency of 1200Hz. With off-air signals the loop-bandwidth can be as little as 2Hz before acquisition of lock becomes inconveniently slow. However, during tape replay the bandwidth must be narrow enough to minimise the effects of signal noise though wide enough to accommodate speed variations in the tape machine, especially wow. With a cheap cassette machine the figure is likely to be about 20Hz.

A p.l.l. is merely a continuous correlator with feedback arranged to drive the phase of its replica to yield an average correlation of zero. This condition also occurs when the input is random noise; so it is useful to include a lock-detector. Lock can be indicated by a meter.

In synchronous 1200 baud mode, the bit-rate clock is by definition provided by the signal tones; however, at asynchronous rates (e.g. 300 baud) the clock must be extracted from the data itself. The data must therefore be detected first in some non-synchronous way, and for this a simple RC filter is sufficient (Fig. 6). The spectrum of this random data signal has a null at the bit-rate, but it does have energy at half the bit-rate. Thus if the data is squared, a spectral component will appear at the bit-rate with constant phase, which is what is required. A suitable way of doing this is to exclusive-or the data with itself delayed by half a bit-period. This generates a single cycle of bit clock for each data transition. This signal can be made continuous by another p.l.l., which can then be used to operate the data-correlator's dump-reset and so provide coherent detection.

Image line sync detection is effected by clocking the detected 1200 baud data into a 32-bit shift register (Fig. 7). The output from each stage is added or subtracted in an analogue summing circuit, according to whether the bit to be tested is a 1 or a 0. When all 32 bits are nestling in the 'memory' maximum output is obtained from the summation. A clipping threshold set at, say, 30 'votes' allows for up to two bit errors. It should be noted that since the line-sync code contains 16 bits repeated, there will be a half-amplitude correlation peak 16 time slots before and after the main peak. This is caused by the first block of code (hex 5BA4) passing through and matching the template provided for the second block, and vice-versa. If this peak were not present then the voting threshold could be set even lower. The code is not ideal.

Circuit notes

The complete circuit diagram is shown in Fig. 11. Although the system was designed for 12V operation, it will work with supplies between 6V and 18V. (For supplies above 15V, cmos devices numbered with a 'B' suffix should be used.) A half-V_{DD} bias is incorporated to 'float' the op-amps. Wire-wrap construction was used for the prototype, with components mounted on dil headers for easy experimentation. Layout is not particularly critical, though it would be prudent to keep the input circuits and the two p.l.ls apart to minimise stray pick-up.

The channel filter has a 3dB cut-off at 3000Hz and is a fifth-order Bessel type, with a very flat group delay (about 135 microseconds) which introduces no ringing or phase-distortion. Interstage a.c. coupling reduces the response below 300Hz. Equivalent noise bandwidth is

Data transmissions from UOSAT

The satellite can transmit a variety of data formats at a number of popular speeds, as directed by ground-station command. The data includes telemetry, news bulletins and camera images.

Telemetry information is sent in 12-bitASCII code: one start-bit, seven data, one even-parity and three stop-bits. A sample block is reproduced in Fig. 1. The first two lines are the 45 spacecraft status bits; the next six lines display 60 telemetry values, prefixed with identifiers 00-59. Translation of the three information digits is simple. For example, the right hand column gives temperatures of the six faces of the spacecraft, which convert as T=0.2×(474−N) degrees Celsius. A complete list is available through AMSAT-UK[1]. There are occasional variations to this format; explanations then accompany the data. The data rate is usually 1200 or 300 baud, although 45.45 baud (Baudot code), Morse code and 'Digitalker' synthetic speech are sometimes used.

News bulletins are sent as text and typically contain operational information, orbital data and acknowledgements of reception reports. The format is 11-bit ASCII with two stop-bits.

Image transmissions from the spacecraft's c.c.d. camera experiment have a 256×256 pixel format with a 16-level grey-scale (four bits). The ground area seen in an image is about 500km square[5].

The transmitted sequence is illustrated in Fig. 1b, and is sent in a line-synchronous manner, i.e. 256×4 bits for each line, and 256 lines. Each line is preceded by a line-sync code, and each frame by a frame header. The line-sync code is 32 bits,

01011011101001000101101110100100

(hex 5BA45BA4). Thus a line is 1056 bits long. The frame header consists of a shortened line composed of 31 line-sync codes, preceded by normal line-sync, and is 1024 bits long.

Pixels are coded 0000=black, 1111=white. MSB is sent first. A complete frame comprises 271360 bits, and at 1200 baud is transmitted in about 3.77 minutes.

Fig. 1a. Typical telemetry block from UOSAT. The two identical lines of status bits are followed by 60 telemetry values. These values may easily be decoded using the published calibration equations[1,4].

AMSAT	10100	10000	00000	00000	00100	00000	10101	11100	00000
AMSAT	10100	10000	00000	00000	00100	00000	10101	11100	00000
00440	01060	02698	03000	04000	05559	06750	07555	08447	09447
10140	11200	12000	13000	14027	15409	16822	17293	18448	19444
20170	21070	22672	23005	24007	25418	26422	27296	28496	29445
30330	31210	32665	33206	34013	35301	36374	37407	38510	39442
40140	41550	42699	43173	44041	45000	46003	47463	48486	49541
50180	51090	52283	53428	54609	55441	56015	57430	58507	59427

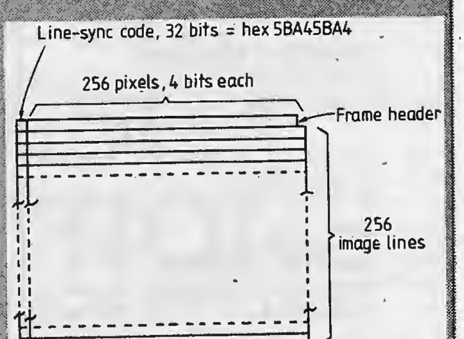


Fig. 1b. Data format of UOSAT's c.c.d. image transmissions. The frame-header is a shortened line comprising 31 line-sync codes plus the normal line-sync code and is 1024 bits long. Each of the 256 image lines is 1056 bits long in total.

Binary two-tone encoding

Data at 1200 bits per second is encoded as synchronous audio frequency-shift keying (a.f.s.k.) with one cycle of 1200Hz for 'mark' and two cycles of 2400Hz for 'space' (Fig. 2). This audio then frequency modulates the RF carrier, and may be detected using an ordinary amateur n.b.f.m. receiver, preferably with the de-emphasis reduced to about 50 microseconds so as to preserve correct phase relationships. Other baud rates use the same coherent tones, but bit transitions occur asynchronously; the modulation is inverted with respect to that used for 1200 baud.

Note that the ASCII polarities are: space=start=data 0, and mark=stop =data 1. For the c.c.d. image, 0=1200Hz and 1=2400Hz. The f.m. deviation is quite small: at 145MHz it is 600 and 1200Hz for the two tones, although at 435MHz it is somewhat wider. The maximum doppler shift for the 145MHz transmission is ±3.5kHz, with a rate-of-change reaching 50Hz/s on an overhead pass.

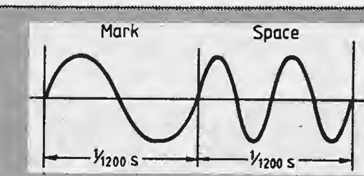


Fig. 2. Synchronous two-tone a.f.s.k. encoding. At 1200 baud, as shown here, data is synchronous. At other speeds, data is asynchronous and transitions occur at random phase angles within the tones. These audio-frequency tones modulate UOSAT's carrier on 145.825MHz or 435.025MHz.

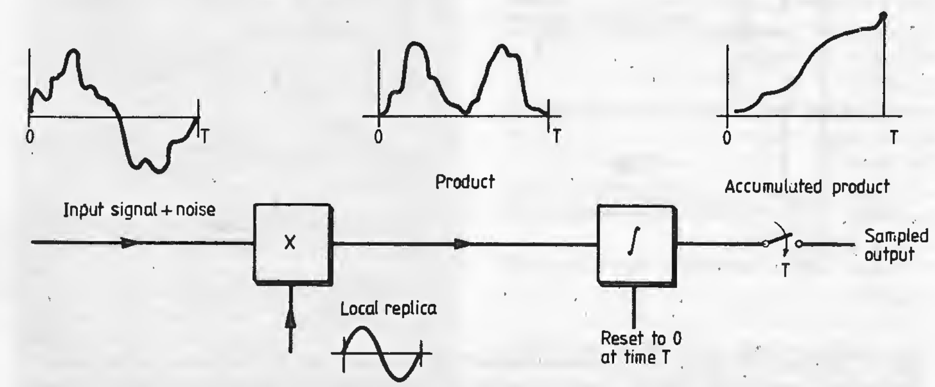


Fig. 3. Basic elements of a correlator. A (noisy) incoming signal is multiplied by a perfect local replica and the product is integrated. At the end of the data interval the resulting accumulation is tested. The accumulator is then usually reset and the process repeated. If the signal exactly matches the replica, the output is at a maximum.

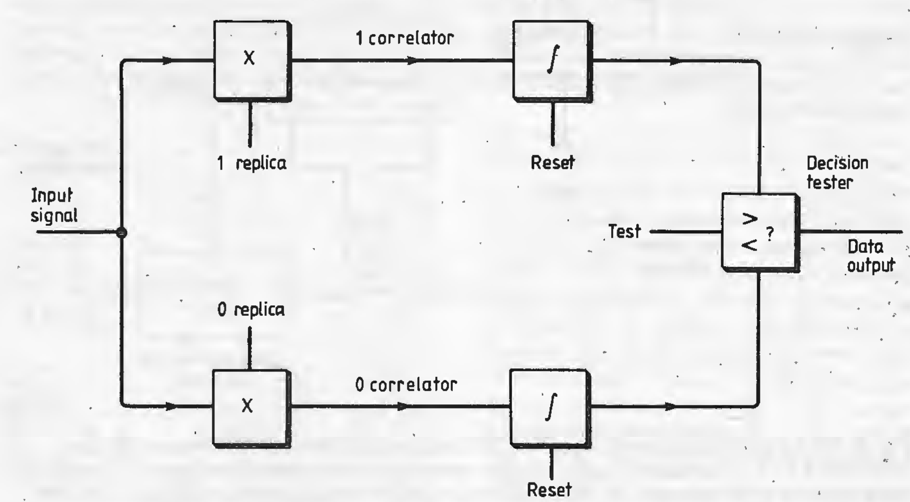


Fig. 4. A matched filter. The output of a pair of correlators is tested to find the better of the two matches. In the practical circuit, this decision is effected by a subtraction operation.

3300Hz. The filter is not essential when using de-emphasised signals from a typical f.m. receiver. However it must be used if wide-band noise is present during, for example, performance testing or with signals direct from the receiver's f.m. discriminator.

The limiter (IC_{1c}) will operate on a few millivolts of signal. The input polarity-invert switch S_2 is needed as receivers and tape-recorders will have arbitrary inversions built in, and the polarity of 1200 and 300 baud signals differs. The signal presented to the multipliers must be in the correct sense.

The main p.l.l. (IC_2, IC_3) operates at 19 200Hz. It is followed by a four-bit divider and some logic to generate the replicas $\overline{I:1200}$, $\overline{I:2400}$, Q:1200 and Q:2400 together with the synchronous integrate-and-dump timing. The circuit has a loop bandwidth of 20Hz.

An inspection of the waveforms entering the integrator (Fig. 8) shows that accumulation occurs only during the second and third quarters of the basic 1200Hz rhythm. (Because the tones have lost their sinusoidal character through limiting, it is only during this period that they differ.) Thus in synchronous 1200 baud operation the decision 'transfer to output buffer' can take place at the 3T/4 point, and the capacitor can be reset at leisure during the succeeding fourth and first periods. During asynchronous operation, however, 'dump-and-reset' can occur at random times and must be accomplished rapidly.

Acquisition of lock in the main p.l.l. is detected by summing the product of the signal with $\overline{I:1200}$ and $\overline{I:2400}$. Lock information is available during the first and fourth quarters; the analogue switch IC_{7c} admits only this energy to the op-amp RC smoother IC_{8b}. The circuit has a gain of 10 to emphasise marginal lock conditions and will 'end-stop' otherwise. A bistable output buffer (IC_{9b}) is used as, being on the same chip as the data output buffer, it will have the same threshold.

Extraction of non-coherent data is effected by the continuous correlator R_{23}, R_{24}, C_{14}. The time-constant or 'memory' should be short enough to avoid excessive inter-bit interference but long enough to smooth out noise. A value of a quarter to a half of a bit period is usual. The time-constant used introduces a quarter-bit lag, which is convenient for subsequent timing requirements. The asynchronous data may be used directly from this point if required, though its timing will be very ragged and the error rate somewhat high. The analogue switch IC_{7b} is only 'on' during the second and third quarters of each 1/1200s period: this keeps out non-information during the first and fourth quarters and at the same time prevents decay of the capacitor voltage and hence loss of information already stored.

James Miller, who is 38, pitched into electronics at an early age with a crystal set. Later he obtained a B.Sc.(Hons) in electronic engineering and then worked for Marconi and Sperry Gyroscope. Seven years ago he joined Cambridge Consultants to work on design and development in signal processing, electronics, computing, optics, non-impact printing and manufacturing technology. His interest in wireless continues through amateur radio (G3RUH), and a passion for satellites has to be shared with cooking and eating, opera and Wagner, the City of Cambridge and other fine things. He does not own a ZX81.

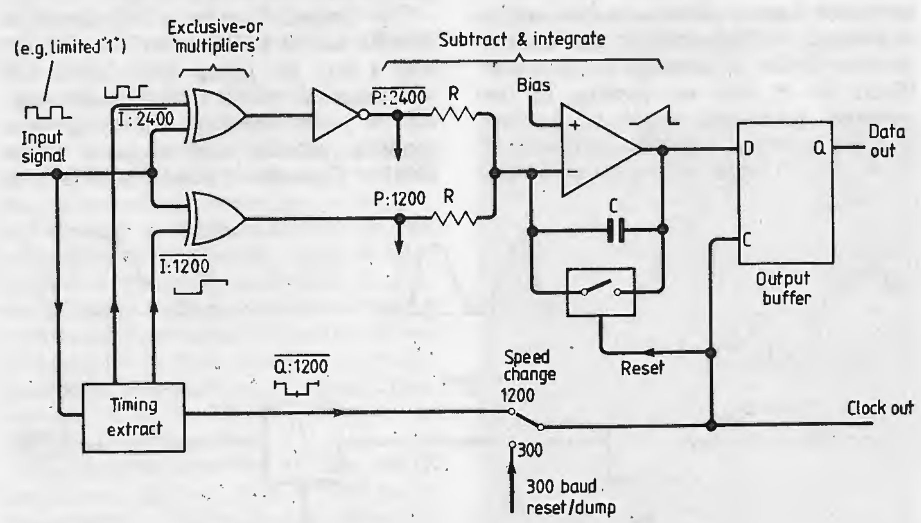


Fig. 5. Outline of the decoder. A phase-locked loop extracts the 1200Hz clock signal and generates the replica signals. The input signal is 'multiplied' by the replica signals in the exclusive-or gates; the op-amp compares the result by subtraction and integrates it.

To extract the asynchronous bit clock from the 300 baud stream, an eight-bit shift register IC_{10} is clocked at sixteen times the bit rate to provide a half-bit delay. The first and last stages are exclusive-or gated to generate a noisy bit clock which then feeds the second p.l.l., IC_{11} and IC_{12} (another correlator). A four-bit divider and logic provide the bit clock replica $\overline{I:300}$ and the carry is used to reset the data correlator as described above. Circuit values shown are for 300 baud; other rates require the values of C_{12}, C_{14}, C_{15}, C_{16} to be changed pro rata. The p.l.l. bandwidth is about 1Hz. A lock indication is obtained by multiplying the noisy bit clock by Q:300 and smoothing the result.

The c.c.d. line-sync detector is a 32-bit shift register and consists of IC_{9a} for the first bit and IC_{14}-IC_{17} for the remaining 31. On the circuit diagram, bits are shifted from right to left.

No output buffering is shown in the diagram: the user should add it as required. At the output, ASCII start-bit polarity and data 0 are high, stop and data 1 are low; image bits from the c.c.d. camera are 1 high and 0 low; data clock is significant on high-to-low transitions; lock and line-sync are high true and are synchronous with data output.

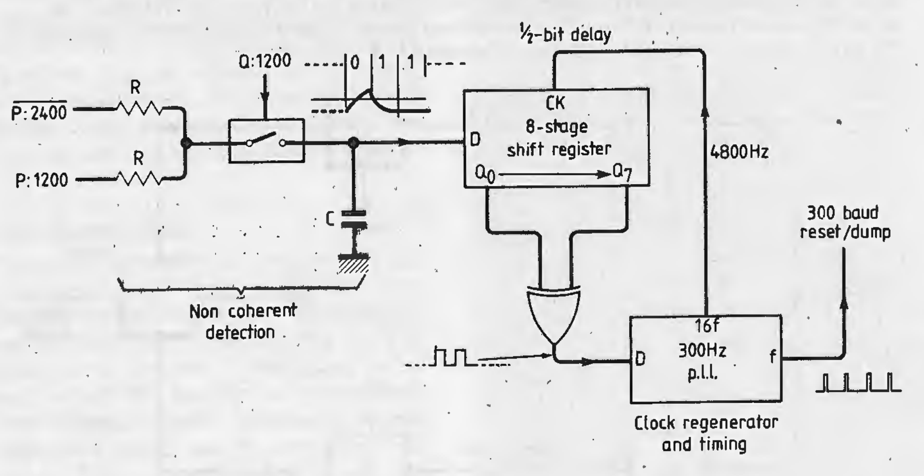


Fig. 6. 300 baud bit-clock extraction. The 300 baud signals are asynchronous and data transitions do not necessarily occur at zero-crossings of the transmitted tones. The data is multiplied by itself delayed, to give one cycle of 300Hz for each data transition. A narrow-bandwidth p.l.l. regenerates from this a steady 300Hz bit-clock which is used to drive the reset-dump section of the coherent detector in Fig. 5. Note that the non-coherent detector effectively is the same as the integrator of Fig. 5, with R replacing the reset switch.

Setting up

An accurate audio generator, oscilloscope and multi-meter will be needed, as well as a telemetry test data tape. To set up the line-sync detector it is necessary to have a c.c.d. data tape. These signal sources may be either recorded off-air or obtained via AMSAT-UK. (The data on the latter's tapes differs slightly from the format now transmitted by UOSAT. However, this does not affect their use.)

Main p.l.l.: apply noise to the signal input (noise from the receiver will do). Using R_{66}, adjust the v.c.o. of IC_2 to 19200Hz. If this cannot be effected change the timing capacitor C_{10}. Do not change resistors, as this will affect the p.l.l. performance characteristics. A 4:1 spread in nominal oscillation frequency of a 4046 chip is quite typical. Applying 0V and then V_{DD} to pin 9 of the p.l.l. chip IC_2 should result in a total frequency swing at the divide-by-16 output (IC_3 pin 15) of about 700Hz.

300 baud p.l.l.: adjust the centre frequency to 4800Hz with R_{67}; if necessary alter C_{16} to achieve this. Total frequency swing should be 600Hz at the divider output (IC_{12} pin 15).

Half supply voltage: still with noise applied to the input, switch to 1200 baud operation and adjust the half-supply-voltage control R_{65} until the output buffer bistable yields 1 and 0 with equal frequency. This may be easily observed by connecting an analogue voltmeter between the Q and $\overline{Q}$ outputs of IC_{9a}, pins 1 and 2. It should read zero.

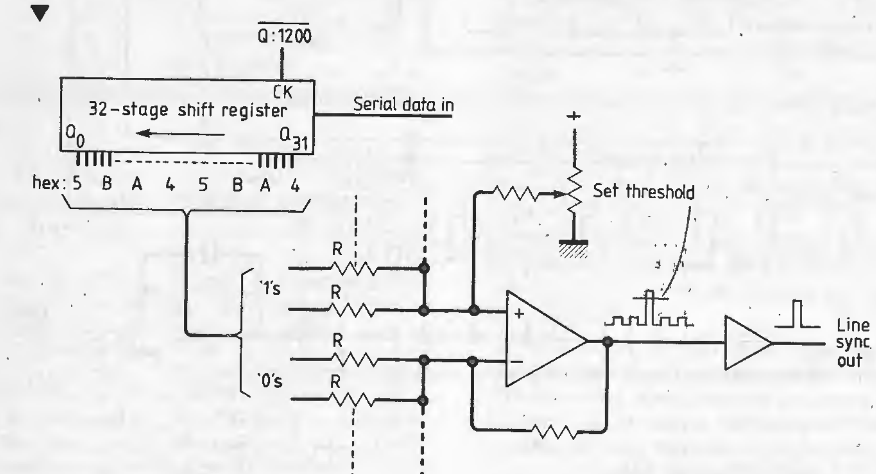
Performance checks: apply a 2400Hz tone to the input and verify that the main p.l.l. locks and continuous 1 data is output. Repeat for 1200Hz and observe continuous 0 data. Flip the input invert switch. There should be a momentary loss of lock-indication while the p.l.l. recovers.

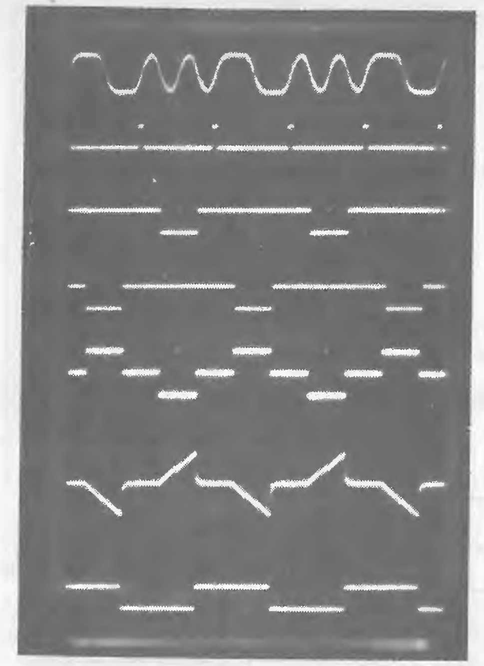
Now inject a 150Hz signal at the input to the 300 baud clock extractor IC_{10} pin 7. This simulates 101010.... reversals at 300 baud. Verify that the loop locks properly. Check for similar operation using 75Hz (11001100....), 50Hz (11100011100....), and so on. Lock should be maintained with 18.75Hz (1111111100000000....) input.

The system can now be checked out using test tapes, referring to the waveforms in Fig. 8 and Fig. 9.

Line-sync detector: play the c.c.d. camera test tape into the system, which should be set to 1200 baud. Observe the bit sync

Fig. 7. Line-synchronisation detector for UOSAT's c.c.d. image transmissions. A 32-bit window-correlator offers excellent immunity from corrupted code bits. When the code to be detected (hexadecimal 5BA45BA4) arrives in the shift-register, the output of the analogue summer reaches a maximum. If the threshold is set at, say, 30 votes out of the possible 32, errors in up to two bits will be tolerated.





(a) Input signal: (1)01010, IC_1 pin 10

(b) Extracted 1200Hz clock, IC_3 pin 15

(c) Signal × 0 replica, IC_5 pin 10 (P:1200)

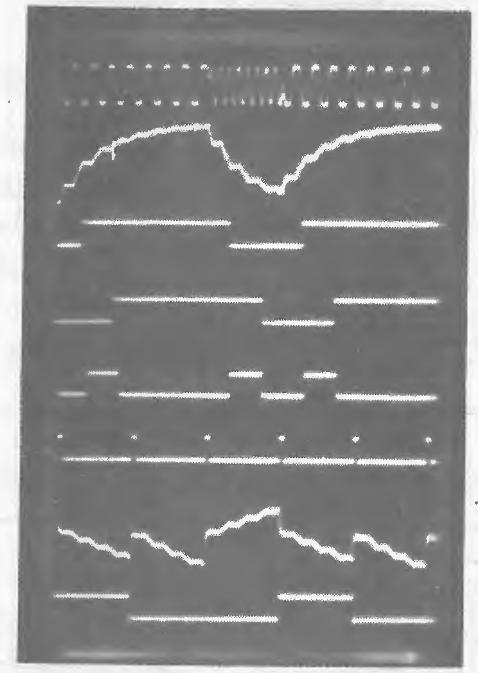
(d) Signal × 1 replica, IC_5 pin 11 (P:2400)

(e) P:2400 minus P:1200

(f) Integrator output, IC_8 pin 1

(g) Data out, 101010, IC_9 pin 1

Fig. 8. 1200 baud waveforms. Traces a to g show 5-bit noise-free signals from a test source. The horizontal scale is 417μs per division. When noise is present, the triangles in trace f become ragged and diminished.



(a) Input signal, (1)00100, IC_1 pin 10

(b) Incoherently-detected signal, IC_{10} pin 7

(c) Half-bit delay, first stage, IC_{10} pin 5

(d) Half-bit delay, last stage, IC_{10} pin 2

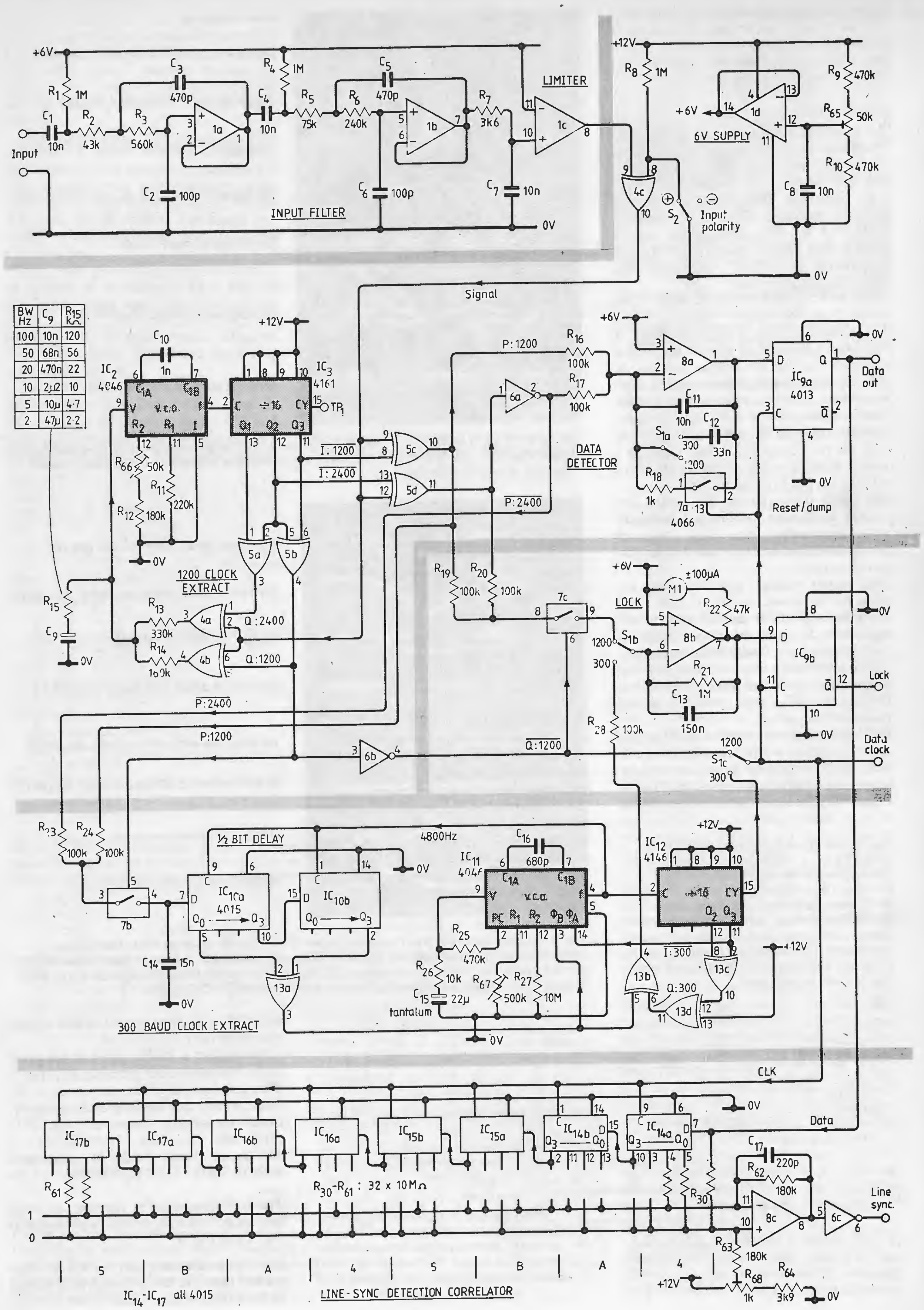
(e) After the exclusive-or gate, IC_{13} pin 3

(f) The extracted 300 baud clock, IC_{12} pin 15

(g) Output of the integrator, IC_8 pin 1

(h) Data output, 10010(0), IC_9 pin 1

Fig. 9. 300 baud waveforms. Horizontal scale is 1.67ms per division. Note that signal transitions of the input data are asynchronous with respect to the tones. Each transition in trace b gives rise to one proto-cycle of 300 baud clock, which is regenerated by a p.l.l. as in trace f. The total data-processing delay is equivalent to one bit-period.

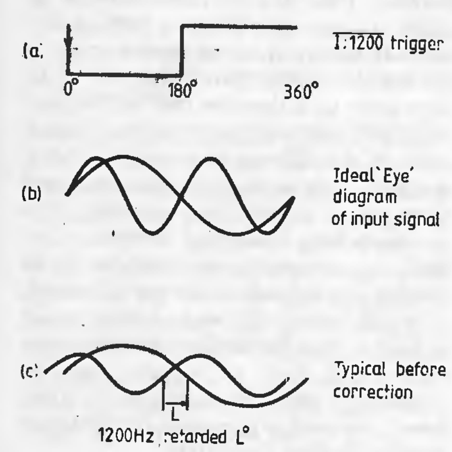


◄ ***Fig. 11.*** *The complete data demodulator. 1200 baud or 300 baud decoding is selected by S_1. Op-amps are TL084 or equivalent, exclusive-or gates are all 4070 and inverters 4069. C_2, C_3, C_5-C_7, C_{10}, and C_{16} are polystyrene, 5% tolerance.*

correlator output IC_8 pin 8. At the end of each line the 'peak' will be clearly visible, as will minor peaks. Now add noise to the input signal, sufficient to start creating data errors. The peak will be seen occasionally to drop by one or two votes as the noise is increased.

Adjust the threshold control R_{68} so that the peak just crosses the output buffer threshold on 32, 31 and 30 votes, but not on 29. (This is easier to do than describe!) There is little point in going lower: at a bit-error rate of 1 in 12 the image would be useless yet there would still be an even chance of sync detection.

Main p.l.l. loop bandwidth: the aim in selecting the loop bandwidth is to minimise the combined effect of noise and tape-recorder wow. To achieve this, record about ten minutes of 2400Hz sinewave tone on the recorder. An initial loop bandwidth of 20Hz should be used. Replay the tape and, triggering off the p.l.l. output, estimate the peak-to-peak timing jitter T_j seen on the input signal. Now input the 2400Hz tone directly from the audio oscillator. Gradually add noise until the data output at 1200 baud begins to give spurious zeros at a rate of about one per second. Measure the peak to peak jitter once again, T_n. The optimum bandwidth is roughly equal to $20 \times T_j/T_n$. Use the table to select new components for R_{15} and C_9. Replay the tape; peak to peak jitter should be less than about 40μs. If it is significantly larger, then the performance will be degraded.



Angle L/45°	CR μs
0.1	1260
0.2	622
0.3	404
0.4	293
0.5	223
0.6	173
0.7	134
0.8	102
0.9	70

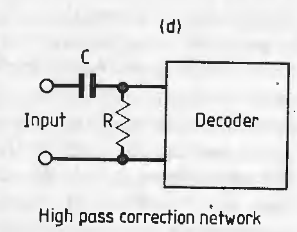
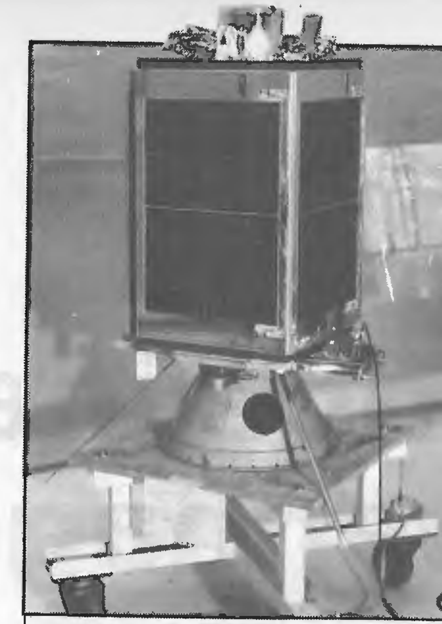


Fig. 10. *At the input, the 1200Hz tone will probably be retarded with respect to the 2400Hz tone. A suitable CR phase-compensation network can be selected from the table. If instead the 1200Hz tone is found to be advanced, R and C should be interchanged to give a low-pass network. The left-hand column of the table would then have to be re-labelled "1 – L/45".*



The amateur scientific satellite UOSAT, built at the University of Surrey, was launched by NASA on 6 October 1981. Its 515km-high polar orbit has a period of approximately 95 minutes. UOSAT's two main data beacons transmit on 145.825MHz and 435.025MHz; reception is possible during favourable passes on an ordinary amateur two-metre receiver with a quarter-wave whip aerial. A recorded news bulletin which also gives orbital predictions is available by telephone on Guildford (0483) 61202.

Phase problems

A correlation decoder is only as good as the assumptions implicit in its design. Most fundamentally, the input signal (limited) and the replicas should be identical. During the passage through the transmitter, receiver i.f., f.m. discriminator, de-emphasis, audio amplifier and possibly a tape recorder some relative phase shift of the 1200 and 2400Hz tones is inevitable. Full performance will only be realised if this is corrected.

To examine this, trigger the oscilloscope from the main p.l.l. I:1200 signal, one sweep per bit, and examine the input signal where 0 and 1 tones will be seen superimposed. The ideal is depicted (noiseless) in Fig. 10b; note the equal amplitudes and the crossover exactly in the middle.

Most likely it will be found that the 1200Hz tone is of larger amplitude, and slightly retarded (Fig. 10c). This can usually be cured with a CR high pass network at the system input (Fig. 10d). Adjust components until the crossover sits on the zero line as in Fig. 10b. If the 1200Hz tone is advanced then an RC low-pass network should be used.

Any problems (such as ringing) should be investigated and the source located. It may be found advantageous to bypass the receiver's audio stages. Signals could also be taken directly from the f.m. discriminator and separately de-emphasised.

Performance

If we define 'negligible errors' as an error rate of 1 in 10^5, for a data rate of 1200 bit/s and bandwidth 3300Hz the 'audible' signal to noise ratio should exceed 7.3:1, a signal at the receiver r.f. input of about 0.2 μV into 50Ω. So far as it is possible to measure this with precision, the figure is borne out in practice.

Excessive noise such as vehicle ignition spikes are a nuisance on weak 1200 baud signals; since they are typically of 1ms duration they can obliterate a whole bit. No add-on decoder can cope with this situation – it is a receiver problem, created in the f.m. de-emphasis network, which stretches noise that in the i.f. bandwidth once had a harmless duration of a few tens of microseconds. The problem is much reduced by taking signals direct from the discriminator.

At 300 baud the expected 6dB noise performance improvement over 1200 baud operation is realised (though at a quarter of the information rate). The decoder is virtually immune to ignition spikes, since a 1ms pulse will only squash about one-third of a bit, leaving the other two-thirds unaffected (albeit 2dB more vulnerable to other noises). The bit sync extractor will work quite satisfactorily on signals of only one bit in eight, at signal-to-noise ratios too small to be useful.

It should be remarked that the decoded data can be further processed by computer before display by a v.d.u. or printer. 12-bit ASCII (for example) contains five or six redundant bits, yet an error in any of these will cause a misprint of the true character. In fact, of the 6336 bits in a telemetry frame only 765 are information-bearing. Post-detection processing could obviate the effect of errors in the other 5571 bits.

For displaying the image data on a television screen, a converter design is available from AMSAT-UK; printed circuit boards will be offered when the commissioning of the c.c.d. camera has been completed. WW

References

1. AMSAT-UK, London E12 5EQ, England: UOSAT technical handbook, £3.00; 1200/300 baud data test tape, £3.50; c.c.d. camera simulation tape £3.50. Prices include packing and UK postage; overseas postage extra. A stamped addressed envelope should accompany enquiries. AMSAT-UK depends on donations.
2. Viterbi, A., "Principles of coherent communication". (McGraw-Hill, 1966).
3. Sweeting M. N., "UOSAT, an investigation into cost effective spacecraft engineering". *The Radio and Electronic Engineer* vol. 52 No. 8/9, August-September 1982 pp. 363-378. Whole issue devoted to UOSAT systems.
4. Mansi L. S. A. and Clarke R. A., "UOSAT telemetry system", ibid pp. 417-424.
5. Trayner C. P. and Jeans, T. G., "The development of a satellite-borne Earth imaging system for UOSAT", ibid pp. 398-402.

Acknowledgements

Thanks are due to my colleague Philip Howarth for his comments and co-operation during the evolution of this decoder, to Steve Temple for image processing, the University of Surrey spacecraft team, Cambridge Consultants Ltd for their indulgence, and to UOSAT itself.

A Heretic's Guide to Modern Physics

The doctrines of Copenhagen

The doctrines (literally, teachings) of the Copenhagen School served to detach the modern quantum theory from common sense. The key to the aberration was the diehard refusal to admit that the traditional field-theory concept of continuity, on which the wave theories are based, is incompatible with discrete and discontinuous quanta, or particles.

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

I have called much evidence in the *cause célèbre* of Physical Realism versus the Copenhagen School, but the evidence I have called is only a very small fraction of the physical evidence available. I have called no mathematical evidence at all, and indeed I have been careful to avoid mathematical argument of any kind. It is true, as Galileo said, that mathematics is the language of physics, but as far as I am concerned that is as far as it goes. It is not a particularly good language from a physicist's point of view and sometimes, as for instance when it is asked to handle simple matters like Fresnel diffraction or the length of the circumference of a planet's orbit, it can prove distinctly awkward and inelegant. Certainly Sir James Jeans was over-enthusiastic when he created God in his own image by claiming Him to have been a mathematician, but his attitude was perhaps not extreme for the 1930s era when most of the dubious doctrines were propounded. A prime difference between physics and mathematics is that physics is, or should be, subject to the strict discipline of the experimental method, whereas mathematics is not. The case that I must now summarize on behalf of the prosecution is a case in physics, not mathematics.

I believe there can be little doubt but that modern physics took a wrong turning in the 1930s. The outward and visible sign of the trouble was a denial of realism in natural philosophy and the espousal of a particular mysticism in its place. As far as I have been able to discern it was the result of a purely human whim, odd perhaps but understandable in that post-war period; for none of the reasons commonly advanced as causes of the philosophical revolution can stand up to a cold, scientific inquisition either together or severally. We can be reasonably sure, at any rate, that the real causes were not technical– It would therefore seem unprofitable to hazard guesses as to *why* it all happened, which is a question more for a psychologist or comparative theologian than for a physicist. Closer to home we can examine *what* went wrong and how it went wrong, as steps from which we may obtain hints toward our aim of eventual counter-revolution – that is, of trying to put modern physics back onto the intellectually honest philosophical road.

I have said enough about the three really glaring philosophical crimes of the Copenhagen School, their confusions of matter-waves with probability theory, of metaphysics with physics, and of measurement with fact, not to have to rediscuss them here. They were outstanding. However, there has always been a tendency to allocate to physical theories an importance of a more fundamental kind than they really warrant. One instance of this is the doctrinaire concept of the physical reality of the electromagnetic field. If we take note of what experiment actually says, as opposed to what we might prefer it to say, we find that light *in vacuo* is not influenced by electric or magnetic forces, and we may deduce from this that neither light waves nor photons can be of electromagnetic origin; it is *electrons* which are affected by such forces, not photons! The great Electromagnetic Theory appears as an analogy of Nature, sometimes as a very useful and accurate analogy, sometimes as a definite failure, but at no time does it seem to afford us a sound conceptual model of the working of the real, physical world.

Conceptual models are, in fact, of very great importance in physics. They enable one experience to be correlated with another so that the whole becomes greater than the sum of its parts and *scientific progress* is thereby made. Such models enable us to visualize the concepts within theories: the earth rotating, not the heavens; planetary electrons orbiting an atomic nucleus; the electron itself, a tiny torus of energy spinning mechanically at the speed of light. But during the 1930s there grew up a doctrine that the "master texts" of modern physics must lie in one or other of the differential equations of the quantum mechanics, and that one need never expect to be able to translate *those* equations into conceptual models – indeed, any attempt to do so tended to be derided as mechanistic and old-fashioned. (The real reason why such models cannot be built is that the mathematical concepts they would have to express, such as "symmetric and asymmetric wave functions", are neither physically plausible nor credible, in their application.)

In its most extreme form this doctrine of mathematical supremacy claims that the unprovable mathematics of the wave theory represents reality and that the physical world of our senses – and of our scientific instruments – is an illusion, a set of moving shadows on the wall of Plato's cave. Some people do actually believe this, but I assure you there is no experimental evidence of any kind to support it and it is the purest fancy. Its appeal is to the innate mysticism which haunts the depths of every human mind. In more practical form, but still fanciful, it becomes the doctrine of the New Mechanics, which says that the old-style mechanics of Newton and Galileo has been proved wrong and must be replaced by a new and correct mechanics, namely the "wave" or "quantum" mechanics. Two comments may be offered in reply to that self-aggrandising claim. The first is that experiments in microphysics have *not* shown the older mechanics to be wrong, but merely to be incomplete – and correctably so. The second is that according to the proposed new mechanics the motion of the earth in its yearly journey around the sun is not controlled by a force of gravity (Newton) or by spacetime curvature (Einstein), but by a system of matter-waves of frequency "perhaps" -10^{66} cycles per second – yes, negative, going the opposite way! – which *maintains its coherence precisely all around the orbit*. You and I do not have to believe such far-fetched imaginings.

In a way it is to our advantage to have such an obvious example of failure of the wave theory in front of us, because it encourages us to go ahead and to question some of its other doctrines. I would like to spend a few moments now on the doctrine of the Observer. This arose, you may recall, in an attempt to evade the consequences *inter alia* of the infinite phase velocity of de Broglie or Schrodinger-type "matter-waves" by declaring them to be "unobservable". It was argued that a physicist should not ask questions about anything that he could not observe, and in due course the doctrine became enshrined as a Principle of modern physics: "No quantity which cannot be 'observed' is of any concern to science".

Now that statement has a fine, "fundamental" ring to it, but its true meaning was that the physicists of the Copenhagen School were preparing to shirk some of the duties of their profession. It leads straight to the following:

> "An electron can be observed only when it interacts with matter or radiation: therefore it is of no concern to physics while it is in empty space".

The quotation is from Dirac, I believe; Bohr agreed with him. The argument was actually advanced to evade the problem of the indivisible electron in a "diffraction" experiment – ignore it and it may go away! A more conscientious view is that physics is the study of the workings of inanimate Nature, and that it should be concerned with *all physical phenomena whether we can observe them or not*. On this view the previous statement might read, with a more graceful humility:

> "We infer that an electron in free translational motion obeys the conservation laws, although we accept that we cannot confirm experimentally that it does so". (In fact, of course, within certain limits we can.)

The real danger of this doctrine of the observer does not lie in its assertion of the irrelevance to physics of "unobservable" fundamentals such as, for example, the mechanical structure of an electron as a physical particle, although by categorising them as improper questions it has in practice inhibited discussion of them for fifty years. Much more serious philosophically is the assertion that since we cannot "observe" an electron (or any other particle) between its interactions with other particles or radiation, the electron *may go wherever it pleases* between such interactions. The argument runs that as we cannot observe it during the interval we cannot prove that it obeys the conservation laws during the interval – or, more to the point, we cannot disprove the contrary, as in article 8 (page 62, April issue).

This has two very important illogical consequences. First, it renders the Copenhagen concepts of microphysics unimpeachable on internal grounds, because whenever these concepts call for violation of the conservation laws (as they frequently do) the defence has only to cry "unobservable" and the prosecution, however valid, must then collapse – *if* one accepts the magnificent, self-sustaining doctrine of the observer.

The second consequence is that the disciplines of physics and logic can now be bypassed with impunity: anybody henceforward can advance any "theory" without deference to physical discipline, except perhaps in the form of polite lip-service; for he has only to include one "unobservable" (or "virtual") quantity to ensure that his proposal cannot be disproved, either theoretically or experimentally. And if, like any other article of faith, it cannot be disproved, then one cannot in logic deny that it *might* be true. I am sure that my physicist colleagues will be able to call to mind at least half-a-dozen such pseudotheories in "modern physics" without assistance from me.

This variant of the observer doctrine is highly mystical, as it declares that a particle may pass from observed point A to observed point B without ever having to traverse the "unobservable" region in between. (The hard-headed layman will scarcely credit that this is the established doctrine of our modern physics, but I promise I'm telling the truth). The idea was first used publicly by Dirac in a mystical attempt to "explain" the positron (or positive electron), which did not require explanation anyway so much as acceptance. Dirac's proposal originated the "negative matter" concept which appears in some science fiction. (But if the mass of a positron were negative, as he was suggesting, then the energy released on "annihilation" would not be $2mc^2$ but zero!). A less startling application of the doctrine is found in the so-called tunnel effect, which is instructive enough to warrant an examination here. The story goes like this:

"Potential barriers", which prevent the free passage of electrons and other particles, seem to exist in a variety of situations in physics – surrounding the atomic nucleus, for example, or at a point of bad electrical contact between two conductors. A sheet of ordinary insulating material can be said to be a potential barrier in this sense. On the face of it no electron should be able to pass such a barrier unless it has enough energy – say several hundred electron-volts – to pass "over" it, as it were, by breaking down its insulation; yet experiments indicate that low-energy electrons, admittedly in very small numbers, do regularly appear at the far sides of such barriers. They must "tunnel" through them. How?

The wave theory waffles speciously about matter-waves which are in an "evanescent mode" while inside the barrier and which therefore (so conveniently!) are not *quite* like the waves of "real" particles; it does not explain how the electrons can appear at the far side of the barrier without having passed through it, but merely asserts that they do, "take it or leave it". We need not take it, because this is not just another Copenhagen *non-sequitur* but a simpler matter, more subtle and more significant. Consider the sand-fort built by children on the beach. Father fills it with sea-water for them from a bucket to within a few inches of its top. They paddle in it carefully for a while, without splashing. The energy of the water molecules is never sufficient to allow an appreciable number of them to pass over the barrier wall; yet half-an-hour later the outside of the wall is damp and the interior of the fort is empty. The principle is the same whether the process takes a microsecond or a thousand years.

The fallacy of the tunnel effect resides in the field-theory-type assumption that a potential barrier can properly be represented

continued on page 65

A catalogue of error and failure

"Mathematics is the language of physics", but it is not subject to the discipline of verification by physical experiment and it can indulge its fancies *ad libitum* among the "unobservables". Realistic physics may not. Confusions of matter-waves with probability theory, of metaphysics with physics, and of measurement with fact, lie at the root of our serious problems today. Physical theories are not to be regarded as expressions of Revealed Truth but as analogies, sometimes useful and almost correct, sometimes so badly wrong as to be positively misleading. Conceptual models also are important in physics; an inability to support a credible conceptual model may be taken as an indication of the imminent failure of a theory. The doctrine of the New Mechanics fails in this way. The doctrine of the Observer is particularly insidious because in fact, (if not explicitly) it removes from any new theory, hypothesis or postulate the need to comply with physical discipline; a fine example of the kind of error which ensues is afforded by the conventional, artificial argument of the "tunnel effect". The most glaring of the philosophical errors of the Copenhagen School was concerned with self-justification and the "completeness" of its pet theory: it was claimed that because its own particular, illogical amalgam of matter-waves and statistics could not cope with individual microphysical particles, it was impossible that any other theory could. That was an excessive claim, for there are alternative possibilities of a less mystical and more realistic kind. If Copenhagen cannot deliver the goods, let us shop around for another paradigm that can. (See "The structure of scientific revolutions" by Thomas S. Kuhn. Chicago 1970.)

IBM Selectric to TRS80 interface

This assembly language program, together with the inexpensive circuitry given in the April issue and a second-hand IBM Selectric typewriter, are all that is needed to produce a low-cost letter-quality printer

If you are not into assembly language programming then just skip this explanation, unless you want to learn a little about this powerful method of controlling your computer. I had to use assembly language because of the speed necessary in such a process as printing. Any other language would be out of the question. So let's jump right in.

Lines 100 to 330 as shown in the listing, which by the way is how the TRS editor-/assembler assembles a machine-language program, give some useful information. If you use this program alone, you have to be sure that the line printer control block is initialized to point to this particular program. Locations 16422 and 16423 can point to anywhere in memory, and it usually points to the print routine in rom, but we definitely want it to point to where our prgram starts. So we have to initialize it to point to where we want. Lines 240 and 250 show what to poke where. If your own program is in a different part of memory, you'll have to change these two bytes. I have some other programs running at the same time as this one, such as a keyboard debounce routine. What I usually do is to have these other small programs initialize these locations for me when I first load them. It is simple to do and you don't have to remember to do it all the time.

Line 330 indicates that this program uses an ANSI typing element, or typeball. This element has the special symbols 'greater than' and 'less than' as well as the crossed zero. The parts list gives the number of this unit, and can be ordered from IBM for around $20. If you use a standard element, the modified listing shows what lines have to be changed to get upper and lower case.

So now we can really get to the meat of the program. Line 360 tells the editor/assembler where the origin or beginning of this program is to be assembled from. If all the addresses that will be referred to in the program, such as absolute or relative jumps and subroutine addresses, are given symbolic names, then to assemble this program in a different location, the ORG is the only address that need be changed; a very handy feature. However, if you jump to a location in rom, you either have to give the address specifically or define a special word for it; but that is part of the assemblers job and we won't go into that now.

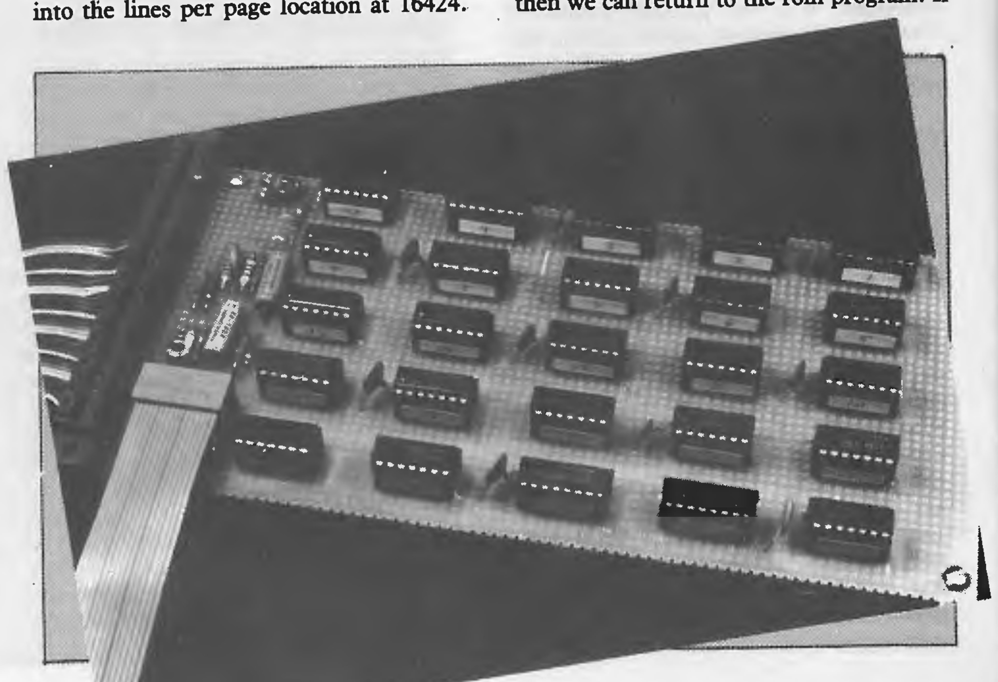
The rom has already put the character to be printed into the C register, so in line 370 the first thing to do is to put it into the A register, or accumulator, so that it can be worked on. The next instruction clears the flag register in case any computations have to be made. In line 390 we check for the ASCII character for top of form. This character can allow us to get to the top of a

by Anthony T. Scarpelli

form or page. It isn't used in our printing process, but is there just in case we need to use it some day. If it was that character, the program will jump to line 460. If not, we go to the next line, 410, which will check for a form-feed character. A form feed will allow line feeds to the end of a page. If it wasn't a form feed then the program will jump to line 530 which will output the character. Let's say it was a form feed, then in line 430 you see a fast way to zero the accumulator.

The line printer control block is initialized by rom. It normally puts the value 67 into the lines per page location at 16424. This is alright for continuous paper, but not very useful for single sheets of typing paper. So instead we have either poked the value 54 here, or have had another assembly language program initialize this section. The rom has also placed the printer control block address into the IX register, so in line 440, IX+3, which is the lines/-page value, is or-ed with the accumulator to be sure there is something there, if not, a null is printed. As there is something there, in line 460 this value is put into the accumulator and subtracted with the line counter, which has been incremented by one for each carriage return. The result is put into the B register. Next, in line 490, the character for a line feed is put into the accumulator and printed by calling the print subroutine. Line 510 is a very useful instruction which will decrement the B register and jump to the indicated address as long as the B register is not zero. All we are doing is to output line feeds until the end of the page, and when it is all finished the program jumps to line 610 which calls the change-page subroutine.

Line 530 prints the character, of course, and the next line checks for a carriage return. If it was some other character, this section of the program is finished, and then we can return to the rom program. If




```
                00100 ; PROGRAM NAME -- INTER
                00110 ;
                00120 ; INTERFACE PROGRAM FOR TRS-80 AND
                00130 ; IBM SELECTRIC I/O PRINTER
                00140 ;
                00150 ; CONVERTS ASCII CODE
                00160 ; TO IBM CORRESPONDENCE CODE
                00170 ;
                00180 ; USES HARDWARE TO DRIVE
                00190 ; SOLENOIDS FROM VARIOUS
                00200 ; PORTS LISTED BELOW
                00210 ;
                00220 ; THE FOLLOWING MEMORY LOCATIONS
                00230 ; MUST BE INITIIALIZED PRIOR TO USE:
                00240 ; POKE 16422,0 -- 00H (ORIGIN LO)
                00250 ; POKE 16423,126 -- 7EH (ORIGIN HI)
                00260 ;
                00270 ; PROGRAM CONTAINS A SUBROUTINE TO ALLOW A
                00280 ; CHANGE OF PAPER AFTER 54 LINES,
                00290 ; BUT BE SURE TO INITIALIZE LINE
                00300 ; COUNTER BEFORE LLISTING: POKE 16425,0
                00305 ; AND LINES/PAGE: POKE 16424,54
                00310 ; WHEN PRINTING STOPS, PRESS 'P' TO CONTINUE
                00320 ;
                00330 ; THIS PROGRAM USES ANSI ELEMENT
                00340 ;
                00350 ;
7E00            00360         ORG     7E00H          ;32256D
7E00 79         00370 BEGIN   LD      A,C            ;CHAR IS IN C-REG
7E01 B7         00380         OR      A
7E02 FE0B       00390         CP      0BH            ;TOP OF FORM?
7E04 280A       00400         JR      Z,L2           ;JUMP IF SO
7E06 FE0C       00410         CP      0CH            ;FORM FEED?
7E08 2016       00420         JR      NZ,L3          ;JUMP IF NOT
7E0A AF         00430         XOR     A              ;ZERO ACC.
7E0B DDB603     00440         OR      (IX+03H)       ;IX=4025H:LP CONT BLOCK
7E0E 2810       00450         JR      Z,L3           ;  IX+3 IS LINES/PAGE
7E10 DD7E03     00460 L2      LD      A,(IX+03H)     ;INTO ACC.
7E13 DD9604     00470         SUB     (IX+04H)       ;SUBTRACT LINE  COUNTER
7E16 47         00480         LD      B,A            ;INTO B-REG
7E17 3E0A       00490 L4      LD      A,0AH          ;LINE FEED
7E19 CDB77E     00500         CALL    ENTRY          ;OUTPUT LINE FEED
7E1C 10F9       00510         DJNZ    L4             ;CONT. UNTIL FINISHED
7E1E 1811       00520         JR      L5
7E20 CDB77E     00530 L3      CALL    ENTRY          ;OUTPUT CHAR
7E23 FE0D       00540         CP      0DH            ;CHECK FOR CARR. RET.
7E25 C0         00550         RET     NZ             ;RETURN IF NOT
7E26 DD3404     00560         INC     (IX+04H)       ;INC LINE COUNT IF CR
7E29 DD7E04     00570         LD      A,(IX+04H)     ;INTO ACC.
7E2C DDBE03     00580         CP      (IX+03H)       ;CHECK END OF PAGE
7E2F 79         00590         LD      A,C            ;GET CHARACTER AGAIN
7E30 C0         00600         RET     NZ             ;RETURN IF NOT END OF PG.
7E31 CDA37F     00610 L5      CALL    CHGPG          ;STOP TO CHANGE PAPER
7E34 00         00620         NOP
7E35 C9         00630         RET
                00640 ;
                00650 ; PORTS AND DELAY TIMES
                00660 ;
00F7            00670 CHRPRT  EQU     0F7H           ;CHARACTER PORT
00F8            00680 CMPRT   EQU     0F8H           ;CARR. MOVE. PORT
00F9            00690 PNTPRT  EQU     0F9H           ;PRINT PORT
00FA            00700 SHFPRT  EQU     0FAH           ;SHIFT PORT
00FB            00710 CRPORT  EQU     0FBH           ;CARR. RET. PORT
00FC            00720 INDPRT  EQU     0FCH           ;INDEX PORT
00FD            00730 SPCPRT  EQU     0FDH           ;SPACE PORT
                00740 ;
                00750 ;
                00760 ;
00FF            00770 DEL1    EQU     0FFH           ;DELAY TIMES
0005            00780 DEL2    EQU     05H
0001            00790 DELTIM  DEFS    01H            ;DELAY TEMP STORAGE
                00800 ;
                00810 ;ASCII TO CORRESPONDENCE TABLE
                00820 ;
7E37 FF         00830 TABLE   DEFB    0FFH           ;NUL (NULL)
7E38 FF         00840         DEFB    0FFH           ;SOH (START OF HEADING)
7E39 FF         00850         DEFB    0FFH           ;STX (START OF TEXT)
7E3A FF         00860         DEFB    0FFH           ;ETX (END OF TEXT)
7E3B FF         00870         DEFB    0FFH           ;EOT (END OF TRANSMISSION)
7E3C FF         00880         DEFB    0FFH           ;ENQ (ENQUIRY)
7E3D FF         00890         DEFB    0FFH           ;ACK (ACKNOWLEDGE)
7E3E FF         00900         DEFB    0FFH           ;BELL
7E3F FF         00910         DEFB    0FFH           ;BS (BACKSPACE)
7E40 FF         00920         DEFB    0FFH           ;HT (HORIZONTAL TAB)
7E41 FD         00930         DEFB    0FDH           ;LF (LINE FEED) (INDEX)
7E42 FF         00940         DEFB    0FFH           ;VT (VERT TAB) (TOP OF FORM)
7E43 FD         00950         DEFB    0FDH           ;FF (FORM FEED)
7E44 FC         00960         DEFB    0FCH           ;CR (CARR RET) (CR/LF)
7E45 FF         00970         DEFB    0FFH           ;SO (SHIFT OUT)
7E46 FF         00980         DEFB    0FFH           ;SI (SHIFT IN)
7E47 FF         00990         DEFB    0FFH           ;DLE (DELETE)
7E48 FF         01000         DEFB    0FFH           ;DC1 (DEVICE CONTROL)
7E49 FF         01010         DEFB    0FFH           ;DC2
7E4A FF         01020         DEFB    0FFH           ;DC3
7E4B FF         01030         DEFB    0FFH           ;DC4
7E4C FF         01040         DEFB    0FFH           ;NAK (NEGATIVE ACKNOWLEGE)
7E4D FF         01050         DEFB    0FFH           ;SYN (SYNCHRONOUS IDLE)
7E4E FF         01060         DEFB    0FFH           ;ETB (END OF TRANS BLOCK)
7E4F FF         01070         DEFB    0FFH           ;CAN (CANCEL)
7E50 FF         01080         DEFB    0FFH           ;EM (END OF MEDIUM)
7E51 FF         01090         DEFB    0FFH           ;SUB (SUBSTITUTE)
7E52 FF         01100         DEFB    0FFH           ;ESC (ESCAPE)
7E53 FF         01110         DEFB    0FFH           ;FS
7E54 FF         01120         DEFB    0FFH           ;GS
7E55 FF         01130         DEFB    0FFH           ;RS
7E56 FF         01140         DEFB    0FFH           ;US
7E57 FE         01150         DEFB    0FEH           ;SPACE
7E58 7F         01160         DEFB    7FH            ;!
7E59 6A         01170         DEFB    6AH            ;"
7E5A 5F         01180         DEFB    5FH            ;#
7E5B 67         01190         DEFB    67H            ;$
7E5C 6B         01200         DEFB    6BH            ;%
7E5D 6F         01210         DEFB    6FH            ;&
7E5E 2A         01220         DEFB    2AH            ;'
7E5F 43         01230         DEFB    43H            ;(
7E60 63         01240         DEFB    63H            ;)
7E61 4F         01250         DEFB    4FH            ;*
7E62 58         01260         DEFB    58H            ;+
7E63 0C         01270         DEFB    0CH            ;,
7E64 00         01280         DEFB    00H            ;-
7E65 1A         01290         DEFB    1AH            ;.
7E66 24         01300         DEFB    24H            ;/
7E67 66         01310         DEFB    66H            ;0
7E68 3F         01320         DEFB    3FH            ;1
7E69 1B         01330         DEFB    1BH            ;2
7E6A 1F         01340         DEFB    1FH            ;3
7E6B 27         01350         DEFB    27H            ;4
7E6C 2B         01360         DEFB    2BH            ;5
7E6D 0B         01370         DEFB    0BH            ;6
7E6E 2F         01380         DEFB    2FH            ;7
7E6F 0F         01390         DEFB    0FH            ;8
7E70 03         01400         DEFB    03H            ;9
7E71 6C         01410         DEFB    6CH            ;:
7E72 2C         01420         DEFB    2CH            ;;
7E73 6D         01430         DEFB    6DH            ;<
7E74 18         01440         DEFB    18H            ;=
7E75 5C         01450         DEFB    5CH            ;>
7E76 64         01460         DEFB    64H            ;?
7E77 5B         01470         DEFB    5BH            ;@
7E78 0E         01480         DEFB    0EH            ;A
7E79 01         01490         DEFB    01H            ;B
7E7A 0D         01500         DEFB    0DH            ;C
7E7B 2D         01510         DEFB    2DH            ;D
7E7C 29         01520         DEFB    29H            ;E
7E7D 1C         01530         DEFB    1CH            ;F
7E7E 3C         01540         DEFB    3CH            ;G
7E7F 21         01550         DEFB    21H            ;H
7E80 0A         01560         DEFB    0AH            ;I
7E81 38         01570         DEFB    38H            ;J
7E82 09         01580         DEFB    09H            ;K
7E83 25         01590         DEFB    25H            ;L
7E84 3E         01600         DEFB    3EH            ;M
7E85 19         01610         DEFB    19H            ;N
7E86 26         01620         DEFB    26H            ;O
7E87 28         01630         DEFB    28H            ;P
7E88 08         01640         DEFB    08H            ;Q
7E89 2E         01650         DEFB    2EH            ;R
7E8A 22         01660         DEFB    22H            ;S
7E8B 39         01670         DEFB    39H            ;T
7E8C 1D         01680         DEFB    1DH            ;U
7E8D 1E         01690         DEFB    1EH            ;V
7E8E 02         01700         DEFB    02H            ;W
7E8F 3D         01710         DEFB    3DH            ;X
7E90 20         01720         DEFB    20H            ;Y
7E91 3B         01730         DEFB    3BH            ;Z
7E92 79         01740         DEFB    79H            ;LEFT BRACKET, UP ARROW
7E93 42         01750         DEFB    42H            ;BACK SLASH, DOWN ARROW
7E94 6E         01760         DEFB    6EH            ;RIGHT BRACKET, LEFT ARROW
7E95 69         01770         DEFB    69H            ;UP ARROW, RIGHT ARROW
7E96 40         01780         DEFB    40H            ;LEFT ARROW, UNDERLINE
7E97 5A         01790         DEFB    5AH            ;ACCENT
7E98 0E         01800         DEFB    0EH            ;A LOWER CASE
7E99 01         01810         DEFB    01H            ;B L
7E9A 0D         01820         DEFB    0DH            ;C L
7E9B 2D         01830         DEFB    2DH            ;D L
7E9C 29         01840         DEFB    29H            ;E L
7E9D 1C         01850         DEFB    1CH            ;F L
7E9E 3C         01860         DEFB    3CH            ;G L
7E9F 21         01870         DEFB    21H            ;H L
7EA0 0A         01880         DEFB    0AH            ;I L
7EA1 38         01890         DEFB    38H            ;J L
7EA2 09         01900         DEFB    09H            ;K L
7EA3 25         01910         DEFB    25H            ;L L
7EA4 3E         01920         DEFB    3EH            ;M L
7EA5 19         01930         DEFB    19H            ;N L
7EA6 26         01940         DEFB    26H            ;O L
7EA7 28         01950         DEFB    28H            ;P L
7EA8 08         01960         DEFB    08H            ;Q L
7EA9 2E         01970         DEFB    2EH            ;R L
7EAA 22         01980         DEFB    22H            ;S L
7EAB 39         01990         DEFB    39H            ;T L
7EAC 1D         02000         DEFB    1DH            ;U L
7EAD 1E         02010         DEFB    1EH            ;V L
7EAE 02         02020         DEFB    02H            ;W L
7EAF 3D         02030         DEFB    3DH            ;X L
7EB0 20         02040         DEFB    20H            ;Y L
7EB1 3B         02050         DEFB    3BH            ;Z L
7EB2 3A         02060         DEFB    3AH            ;LEFT BRACE
7EB3 4B         02070         DEFB    4BH            ;VERTICAL
7EB4 3A         02080         DEFB    3AH            ;RIGHT BRACE
7EB5 4C         02090         DEFB    4CH            ;TILDE
7EB6 FF         02100         DEFB    0FFH           ;DEL (DELETE)
                02110 ;
                02120 ; MAIN PROGRAM
                02130 ;
7EB7 F5         02140 ENTRY   PUSH    AF             ;SAVE AF
7EB8 32CC7E     02150         LD      (CHAR+2),A     ;CHAR. INTO 7ECCH
7EBB C680       02160         ADD     A,80H          ;LEGAL CHAR.?
7EBD 3002       02170         JR      NC,START       ;JUMP IF SO
7EBF F1         02180         POP     AF
7EC0 C9         02190         RET
7EC1 C5         02200 START   PUSH    BC             ;SAVE ALL REGISTERS
7EC2 D5         02210         PUSH    DE
7EC3 E5         02220         PUSH    HL
7EC4 DDE5       02230         PUSH    IX
7EC6 DD21377E   02240         LD      IX,TABLE       ;LOOKUP TABLE
```

continued over page

it was a carriage return, the line count is incremented, and we get the line count and compare it to the lines/page value. In this case it is 54, either placed in this line as an assembly language instruction, or the value poked in the control block before the program was run. If the result turned out to be zero, the zero flag was set, then in line 590 we put the character back into the A register, because this is where the rom expects it to be. The next line will return to rom only if the zero flag was not set, otherwise we jump to the change page subroutine. Line 620 is skipped and we can now return; this part of the program is finished. All this was just to print one character, and it only takes a few hundred milliseconds. Any language other than assembly language simply would take forever.

Now let's continue with the rest of the program and see how it works. This first part, by the way, is basically the same as the program in rom, with a few of our own modifications so it will work for us. The rest of it comes partly from Mr Bateman's program, and from my own efforts. Lines 650 to 790 lists the names and numbers of the ports used, and the delay times for the delay sub-routines used in the program. Line 790 is the delay work area.

The ASCII correspondence table, from lines 830 to 2100, is a list of values that is to be interpreted by the program to be output to the printer. We'll see how that's done shortly. The table starts at address 7E37H. Remember, H means hexadecimal. Each address position from that point represents an ASCII character. ASCII character values go from 00H to 7FH, but we need to translate this into a value our printer can use, which is IBMs own peculiar code. So let's go to line 2140 where it all starts. This is the ENTRY subroutine that was called from the other part of the program, remember?

We start by saving the AF register pair, because these registers are to be used by this subroutine and so are PUSHed onto the stack. They will be retrieved just before this subroutine RETurns. Line 2150 needs some explanation. Look at line 2250. This address is labelled CHAR. Now look at the address 7ECAH, and notice that the hex number at this address is DD, 7ECB is 7E, and 7ECC is 00. Back to line 2150 and see that we are to load the ASCII character in the accumulator into CHAR+2, or in other words, 7ECA+2 or 7ECC. Thus, we have installed the ASCII

```
7ECA DD7E00   02250 CHAR    LD      A,(IX+0)      ;START OF TABLE+CHAR
7ECD FEFF     02260         CP      0FFH          ;NO CHAR.?
7ECF 281E     02270         JR      Z,ENDALL      ;JUMP IF SO
7ED1 FEFE     02280         CP      0FEH          ;SPACE?
7ED3 2005     02290         JR      NZ,CRLF       ;JUMP IF NOT
7ED5 CDF67E   02300         CALL    PRTSPC        ;PRINT SPACE SUBR.
7ED8 1815     02310         JR      ENDALL        ;FINISHED
7EDA FEFC     02320 CRLF    CP      0FCH          ;CR/LF?
7EDC 2005     02330         JR      NZ,INDEX      ;JUMP IF NOT
7EDE CD0F7F   02340         CALL    PRTCR         ;PRINT CARR RET SUBR
7EE1 180C     02350         JR      ENDALL        ;FINISHED
7EE3 FEFD     02360 INDEX   CP      0FDH          ;INDEX (LF)?
7EE5 2005     02370         JR      NZ,PRTCHR     ;JUMP IF NOT
7EE7 CD237F   02380         CALL    PRTIND        ;PRINT INDEX SUBR
7EEA 1803     02390         JR      ENDALL        ;FINISHED
7EEC CD3C7F   02400 PRTCHR  CALL    OUTCHR        ;PRINT CHAR.
7EEF DDE1     02410 ENDALL  POP     IX            ;RETURN REGISTERS
7EF1 E1       02420         POP     HL
7EF2 D1       02430         POP     DE
7EF3 C1       02440         POP     BC
7EF4 F1       02450         POP     AF
7EF5 C9       02460         RET
              02470 ;
              02480 ; PRINT SPACE SUBROUTINE
              02490 ;
7EF6 0EFD     02500 PRTSPC  LD      C,SPCPRT      ;GET SPACE PORT ADDR.
7EF8 ED79     02510         OUT     (C),A         ;LATCH SPACE PORT
7EFA 3E0A     02520         LD      A,0AH         ;SPACE DELAY
7EFC 32367E   02530         LD      (DELTIM),A
7EFF CD7D7F   02540         CALL    DELAY         ;DELAY FOR SOLENOID
7F02 3E00     02550         LD      A,0           ;ZERO ACC.
7F04 ED79     02560         OUT     (C),A         ;UNLATCH SPACE PORT
7F06 3E19     02570         LD      A,19H         ;SETTLING TIME
7F08 32367E   02580         LD      (DELTIM),A
7F0B CD7D7F   02590         CALL    DELAY
7F0E C9       02600         RET
              02610 ;
              02620 ;PRINT CR/LF SUBROUTINE
              02630 ;
7F0F 0EFB     02640 PRTCR   LD      C,CRPORT      ;GET CR ADDR.
7F11 ED79     02650         OUT     (C),A         ;LATCH CR PORT
7F13 3E10     02660         LD      A,10H         ;CR DELAY
7F15 32367E   02670         LD      (DELTIM),A
7F18 CD7D7F   02680         CALL    DELAY
7F1B 3E00     02690         LD      A,0           ;ZERO ACC.
7F1D ED79     02700         OUT     (C),A         ;UNLATCH CR PORT
7F1F CD8A7F   02710         CALL    CARMOV        ;DELAY FOR CAR. MOV.
7F22 C9       02720         RET
              02730 ;
              02740 ;PRINT LINE FEED (INDEX) SUBROUTINE
              02750 ;
7F23 0EFC     02760 PRTIND  LD      C,INDPRT
7F25 ED79     02770         OUT     (C),A
7F27 3E10     02780         LD      A,10H         ;INDEX DELAY
7F29 32367E   02790         LD      (DELTIM),A
7F2C CD7D7F   02800         CALL    DELAY
7F2F 3E00     02810         LD      A,0
7F31 ED79     02820         OUT     (C),A
7F33 3E19     02830         LD      A,19H
7F35 32367E   02840         LD      (DELTIM),A
7F38 CD7D7F   02850         CALL    DELAY
7F3B C9       02860         RET
              02870 ;
              02880 ;PRINT CHARACTER SUBR.
              02890 ;
7F3C 5F       02900 OUTCHR  LD      E,A           ;SAVE ACC.
7F3D CB77     02910         BIT     6,A           ;TEST FOR SHIFT
7F3F 280C     02920         JR      Z,PRINT       ;JUMP IF NO SHIFT
7F41 0EFA     02930         LD      C,SHFPRT      ;GET SHIFT PORT ADDR.
7F43 ED79     02940         OUT     (C),A         ;LATCH SHIFT PORT
7F45 3E14     02950         LD      A,14H         ;SHIFT DELAY TIME
7F47 32367E   02960         LD      (DELTIM),A
7F4A CD7D7F   02970         CALL    DELAY
7F4D 7B       02980 PRINT   LD      A,E           ;RETURN INFO
7F4E 0EF7     02990         LD      C,CHRPRT      ;GET CHAR PORT ADDR
7F50 ED79     03000         OUT     (C),A         ;INTO CHAR LATCH
7F52 3E10     03010         LD      A,10H         ;CHAR SOL DEL TIME
7F54 32367E   03020         LD      (DELTIM),A
7F57 CD7D7F   03030         CALL    DELAY
7F5A 0EF9     03040         LD      C,PNTPRT      ;GET PRINT PORT ADDR
7F5C ED79     03050         OUT     (C),A         ;LATCH PRNT PORT
7F5E 3E10     03060         LD      A,10H         ;PRINT DELAY TIME
7F60 32367E   03070         LD      (DELTIM),A
7F63 CD7D7F   03080         CALL    DELAY
7F66 0EF9     03090         LD      C,PNTPRT      ;GET PRNT PORT ADDR
7F68 3E80     03100         LD      A,80H         ;SET UP ACC.
7F6A ED79     03110         OUT     (C),A         ;UNLATCH PRNT PORT
7F6C 0EF7     03120         LD      C,CHRPRT      ;GET CHAR PORT ADDR
7F6E ED79     03130         OUT     (C),A         ;UNLATCH CHAR PORT
7F70 0EFA     03140         LD      C,SHFPRT      ;GET SHIFT PORT ADDR
7F72 ED79     03150         OUT     (C),A         ;UNLATCH SHIFT PORT
7F74 3E14     03160         LD      A,14H         ;SOL UNLATCH TIME
7F76 32367E   03170         LD      (DELTIM),A
7F79 CD7D7F   03180         CALL    DELAY
7F7C C9       03190         RET
              03200 ;
              03210 ;DELAY SUBROUTINE
              03220 ;
7F7D 06FF     03230 DELAY   LD      B,DEL1
7F7F C5       03240 TIM1    PUSH    BC
7F80 3A367E   03250         LD      A,(DELTIM)
7F83 47       03260         LD      B,A
7F84 10FE     03270 DL1     DJNZ    DL1
7F86 C1       03280         POP     BC
7F87 10F6     03290         DJNZ    TIM1
7F89 C9       03300         RET
              03310 ;
              03320 ;CARRIAGE MOVEMENT SUBROUTINE
              03330 ;
7F8A 0EF8     03340 CARMOV  LD      C,CMPRT       ;CARRIAGE MOVE. PORT.
7F8C 3E30     03350         LD      A,30H         ;WAIT TO CAPTURE MOVEMENT
7F8E 32367E   03360         LD      (DELTIM),A
7F91 CD7D7F   03370         CALL    DELAY
7F94 ED78     03380 CMLOOP  IN      A,(C)         ;OPEN PORT
7F96 CB4F     03390         BIT     1,A           ;CHECK FOR MOVEMENT
7F98 28FA     03400         JR      Z,CMLOOP      ;JUMP IF SENSED
7F9A 3E15     03410         LD      A,15H         ;SETTLING TIME
7F9C 32367E   03420         LD      (DELTIM),A
7F9F CD7D7F   03430         CALL    DELAY
7FA2 C9       03440         RET
              03450 ;
              03460 ;CHANGE PAPER SUBROUTINE
              03470 ;
7FA3 F5       03480 CHGPG   PUSH    AF            ;SAVE REGISTERS
7FA4 D5       03490         PUSH    DE
7FA5 C5       03500         PUSH    BC
7FA6 E5       03510         PUSH    HL
7FA7 CD897D   03520 PKEY    CALL    7D89H         ;CHECK FOR KYBD ENTRY
              03530                               ; CALL 002BH IF NO
              03540                               ; DEBOUNCE ROUTINE USED
7FAA FE50     03550         CP      50H           ;P FOR PAGE
7FAC 20F9     03560         JR      NZ,PKEY       ;JUMP IF P NOT ENTERED
7FAE DD360400 03570         LD      (IX+04H),0    ;ZERO LINE COUNT
7FB2 E1       03580         POP     HL            ;RETURN REGISTERS
7FB3 C1       03590         POP     BC
7FB4 D1       03600         POP     DE
7FB5 F1       03610         POP     AF
7FB6 C9       03620         RET
0000          03630         END
00000 TOTAL ERRORS

PKEY    7FA7              SPCPRT  00FD
CMLOOP  7F94              INDPRT  00FC
DL1     7F84              CRPORT  00FB
TIM1    7F7F              SHFPRT  00FA
PRINT   7F4D              PNTPRT  00F9
CARMOV  7F8A              CMPRT   00F8
DELAY   7F7D              CHRPRT  00F7
OUTCHR  7F3C              CHGPG   7FA3
PRTIND  7F23              L5      7E31
PRTCHR  7EEC              ENTRY   7EB7
PRTCR   7F0F              L4      7E17
INDEX   7EE3              L3      7E20
PRTSPC  7EF6              L2      7E10
CRLF    7EDA              BEGIN   7E00
ENDALL  7EEF
START   7EC1
CHAR    7ECA
TABLE   7E37
DELTIM  7E36
DEL2    0005
DEL1    00FF

00010 ; THE  FOLLOWING LINE NUMBERS SHOULD
00020 ; BE CHANGED WHEN USING THE NORMAL
00030 ; UPPER AND LOWER CASE TYPING
00040 ; ELEMENT:
00050 ;
01310           DEFB    23H        ;0
01480           DEFB    4EH        ;A
01490           DEFB    41H        ;B
01500           DEFB    4DH        ;C
01510           DEFB    6DH        ;D
01520           DEFB    69H        ;E
01530           DEFB    5CH        ;F
01540           DEFB    7CH        ;G
01550           DEFB    61H        ;H
01560           DEFB    4AH        ;I
01570           DEFB    78H        ;J
01580           DEFB    49H        ;K
01590           DEFB    65H        ;L
01600           DEFB    7EH        ;M
01610           DEFB    59H        ;N
01620           DEFB    66H        ;O
01630           DEFB    68H        ;P
01640           DEFB    48H        ;Q
01650           DEFB    6EH        ;R
01660           DEFB    62H        ;S
01670           DEFB    79H        ;T
01680           DEFB    5DH        ;U
01690           DEFB    5EH        ;V
01700           DEFB    42H        ;W
01710           DEFB    7DH        ;X
01720           DEFB    60H        ;Y
01730           DEFB    7BH        ;Z
```

character into the byte that represents the IX register's offset. Back to line 2160 for a minute. Here, we add a value to the accumulator that will be sure it is indeed an ASCII character, and if not, will return. Lines 2200 to 2230 make sure that nothing that was in the registers will be affected by our program, and then we are at line 2250.

This line will load the accumulator with whatever is at the address formed by adding the IX register with its offset, in this case the address of the table, 7E37H, and the value of the ASCII character. Now the accumulator holds the value of the correspondence code. Line 2260 checks to see if the accumulator holds a character we don't want to print, that is, an FFH. If it is, the program branches to line 2410. Line 2280 checks for a space and will jump to line 2320 it isn't, otherwise it will call the print space subroutine. The rest of this part of the program works the same, checking for various characters and then branching if it's not the right one. Lines 2410 to 2460 will return all of the registers to their original values and then return.

The print space subroutine at line 2500 is the first of our subroutines that actually will send something out to the printer. Here, in line 2500, we get the address of the port labled SPCPRT, and put it into the C register. The next line will then output whatever value is in the accumulator, in this case FEH, 1111 1110 in binary, to the port whose address is in the C register. This merely turns on the solenoid driver transistor, as indicated in the hardware section. Next, in line 2520, we load a delay value into the accumulator and then jump to the delay subroutine. On return, we zero-out the accumulator to release the solenoid in line 3560. Next we implement another delay so that solenoid has time to go back to a resting position. These delay times were chosen for my particular printer so that a firm pull-in is realized without multiple spaces being printed.

The next subroutine, print carriage return/line feed, is very similar, except that we jump to the carriage movement detection subroutine. Also, the print line feed subroutine works the same. IBM calls a line feed an index. The print character subroutine is a little more involved, so let's examine it. First, in line 2900, we save the character in the E register, then we test the sixth bit of the character to find out if it has a 1 or 0. A 1 indicates an upper-case letter. So in the next line, 2920, we will jump to line 2980 if there was no shift. Lines 2930 to 2970 is how we output a shift, which by the way has to stay latched until the printing of the character is completed. Now get our character back, line 2980, and latch the character-select solenoids on, 2990-3030, turn on the print solenoid, 3040-3080, turn off the print solenoid, 3100-3110, turn off the character-select solenoids, 3120-3130, and finally turn off the shift solenoid and add a delay, 3140-3190.

The delay subroutine is very simple, and is very handy, so let's look at it. First load into the B register a delay value of FFH, or 255D. This is temporarily PUSHed onto the stack, and then get the value we have been holding in our delay work area, and put it into the accumulator, line 3250. Transfer that value into the B register, and use that handy instruction to decrement the B register as many times as was in the DELTIM address. When that part is finished, POP out of the stack the DEL1 time, decrement it by one, and then jump back to do the whole thing over again. The delay times can be varied, and multiple delays can be implemented to give almost any delay that one desires. A very useful subroutine.

The carriage movement subroutine at line 3340 is used to check what is happening with the carriage movement detector. First get the port address, and then implement a short delay to give the detector a chance to operate; remember, the program goes through the instructions in microseconds, and the analogue operating detector takes time. Line 3380 inputs the data on the data bus into the accumulator from the port that is addressed by the C register. Line 3390 then tests bit number one, which was D1 in the hardware section, and if this line was low, inverted through the buffer, jump back to test the bit again to line 3380. As soon as a one is detected, we get another short delay and continue.

The change-paper subroutine shows that we can use some of the subroutines in rom if we want to. Lines 3480 to 3510 again saves our registers, and in line 3520 we jump to a subroutine which will input a character from the keyboard. This subroutine is located at 002BH in rom, but I have a subroutine that debounces my keyboard located in another section of memory, so this is where I have to access this subroutine. It deposites the character into the accumulator, so in line 3550 check to see if it is a P. If it isn't, jump back to line 3520 again and again until we have a chance to change the paper. As soon as we input the P from our keyboard, we zero the line counter in line 3570, and finish this part of the program.

That's the whole ball of wax, friends. You can now LLIST those Basic programs in letter-quality printing. However, to use this printer to its fullest, you have to be able to list assembly language programs from the editor/assembler, and do word processing. To do the first you have to modify the editor/assembler's print routine, and to do the second you have to have lower-case capability which means you have to modify your computer. You will also need a word-processor program. (I wrote this article using such a program in Basic which can be purchased from Computronics; it's free if you subscribe to their magazine.) The lower-case modification has been presented in a number of articles, and I won't repeat it here. The program modifications needed to debounce and modify the editor/assembler's print routine, and to allow normal typewriter-like input when using the lower-case modification, can be purchased from me for $3 to cover printing and mailing.

I want to make one last point about this interface. If you were to go out and purchase a word-processing system, you would surely spend around three to four thousands of dollars. A hobbyist usually can't justify spending this amount, so a lot of time, a desire to know your computer and the programs that make it work, and the perseverence to stay up 'til late at night chasing bugs, will reward you with a system that has many of the capabilities of the higher priced systems at a fraction of the price. It also can be the way to develop a little income for your efforts. This is helpful when you must justify your expensive hobby. When you have a typewriter that spouts poetry and love letters, you have a cupids arrow, right to your lover's heart.

Converting to other computers

Generally this interface can easily be used on other computers, but you need to know your system. You must be able to access the address and data bus of your computer as well as the signals that can produce the equivalent of an out, in, and reset. The out and in signals are usually a combination of the i/o signal and a read or write signal. You will also have to find a five volt supply, either in the computer or by purchasing or building one.

A Z80-based computer has these signals at the microprocessor as IORQ, RD and WR; they may or may not be combined and named as out or in. Other microprocessors have them as well, but their names may be different – check with your computer manual to find out where they are located. The printer port usually has data lines and some control signals, but generally they don't have address lines. Once you know the locations, the next step is to find a connector that will connect to your computers interface port. From this point on, the hardware is the same.

The software may be more difficult to convert. If you are not an assembly language programmer, you may have to find a friend who is. You should also have an editor/assembler program; without one, conversion may be a long process. A Z80 or 8080 computer will have little problems in conversion. But again, you should be familiar with your own system.

You should know where your normal printer driver is located, and it is essential that your computer is able to use another printer driver. If it can't, only with extreme difficulty and probably with much convoluted coding will you be able to use this interface. So the location that points to your present driver will have to be changed to point to this new one. If your system has a printer control block which holds this information, the driver address, lines per page count, etc., then there is no problem. If not, you'll have to create one.

Next you will have to be sure that the port addresses in the program will not conflict with any existing ports in your own system. If so, you will have to change some of the hardware logic decoding, but this is easy to do.

Next you'll have to find the routine that checks the keyboard. If you don't know where it is, you'll also have to create its equivalent. This is why you should be very familiar with the inner workings of your system, as well as be able to program in assembly language.

To use other microprocessor based computers requires re-writing all the code to do the same functions as the Z80 code. Here you need to know not only your own microprocessor's assembly language, but also the Z80 code. WW

LITERATURE RECEIVED

Gould Activair have issued data sheets describing a range of **zinc-air button cells** which are said to offer long life, high energy density, constant output and extended shelf-life. Suggested uses range from hearing-aids to security systems. Gould Activair UK, 11 Ash Road, Wrexham Industrial Estate, Wrexham, Clwyd LL13 9UF. WW400

The 1983 catalogue from Lambda describes the company's range of **power semiconductors** and d.c. power supplies. There are many pages of application notes. Lambda Electronics Co., Abbey Barn Road, High Wycombe, Buckinghamshire. WW401

The Zevac range of **desoldering tools** incuudes hand-held tools capable of removing multipin devices even from multi-layer printed circuit boards. For static-sensitive mos devices there is a low-voltage model powered via an isolating transformer. Further information from Tony Chapman Electronics, Electron House, Hemnell Street, Epping, Essex CM16 4LS. WW402

The latest edition of the **RS Components catalogue** has over 400 pages. Among many new products are a speech-synthesis system, a 13A mains plug incorporating an earth leakage circuit-breaker, ferrite cores for switch-mode power transformers, a wideband 50 ohm r.f. amplifier i.c. and an insulation-displacement wiring system. RS Components Ltd, P.O. Box 427, 13-17 Epworth Street, London EC2P 2HA. WW403

COMMUNICATIONS COMMENTARY

Cellular satellite

While the UK is planning the introduction of terrestrial, mobile, cellular-radio systems for areas of high population density, NASA has been petitioning the FCC to reserve frequencies and define conditions for a satellite-assisted cellular system that would be capable of covering large, thinly-populated rural areas using frequencies between 800 and 900 MHz. NASA, in association with the Canadian government, plans to launch an experimental MSAT-X in 1987 using 821-825 MHz and 866-870 MHz. This would have a 10-metre u.h.f. aerial providing six spot beams, four directed at Canada and Alaska, two at the USA

The satellite would augment urban terrestrial cellular-type systems, but it would be used only by mobiles outside the range of ground-based transmitters. The main data base in which mobile locations are stored would direct calls via satellite where appropriate. Terrestrial networks would have microwave feeder links with the satellite.

Japanese firms are beginning production of 900 MHz compact transceivers for the new "personal radio service", and one way and another it looks as though 800-900 MHz will soon be heavily used for mobile and personal radio systems.

Microwave or u.h.f.?

Where does the "microwave" spectrum begin? It is agreed internationally that the boundary between v.h.f. and u.h.f. falls at 300 MHz (1-metre), but most of us would consider that only systems above 1000 MHz (1 GHz or 30 cm wavelength) should be described as microwave systems.

My reason for raising this subject is not purely academic: I notice that Marconi Communications Systems proclaimed February 11, 1983 as the Golden Jubilee of "the world's first commercial microwave communications link". This was the 15-mile link between the Vatican and the summer residence of Pope Pius XI at Castel Gandolfo, opened in February 1933, following several years of investigation by Marconi of duplex telephony systems working on wavelengths below one metre.

This pioneering work was undoubtedly important and a notable world "first". But it has always been my understanding that these systems used wavelengths of about 50 cm, in other words about 600 MHz. Hence my quibble about "microwave", particularly in view of the similar anniversary two years ago of the STC (ITT) "microray" link across the English Channel. This was demonstrated in March 1931 using a wavelength of about 18 cm (about 1.7 GHz) – admittedly an "experimental" link. Perhaps, also, we should not forget that it was Barkhausen and Kurz whose work on electronic oscillators resulted in the early magnetrons that pioneered centimetric radio from about 1919. Nevertheless, in 1933 Marconi *did* achieve another "first" that proved of great importance in the study of v.h.f. and u.h.f. propagation. This was when he received 57 cm (525 MHz) transmissions at a distance of 168 miles and so conclusively demonstrated that tropospheric bending meant that signals on these frequencies were not, as previously believed, limited to the optical line-of-sight.

Higher radar

Today, for some applications, interest has shifted from microwave to millimetric systems. The ability to achieve highly directional beams with aerials only a few inches in diameter is leading to the development of 94 GHz radar systems for missile guidance, although details of American and British systems tend to be restricted. The attraction of frequencies between about 80 and 110 GHz is that they fall in the low-attenuation "window", and can penetrate fog and dusty atmospheres. But the hardware is not easy or cheap.

The U.S. services are also currently making a great bid for "new technology" in the form of multi-mode airborne radar that could be used as an advanced all-weather guidance control ("Joint Stars") for both fighter aircraft and multiple missiles for attacking scattered armoured formations. However US Congress has denied further funds for the tactical communications system "Seek Talk" claiming it overlapped with the alternative multi-billion-dollar (JTIDS) (Joint Tactical Information Display System).

Early digits

Most of us consider "spread-spectrum" techniques using digitally-encoded speech as one of the main communications development areas of the past few years. Spread-spectrum can offer anti-jamming, anti-interference, anti-intercept properties as well as selective addressing, accurate timing and high-resolution radar. It came as something of a shock, therefore, to read a recent account by William R. Bennett ("Secret telephony as a historical example of spread-spectrum communications" *IEE Trans on Communications* Vol Com 31, No 1, January 1983) of the American wartime system known as "Green Hornet" or Sigsaly" which provided secure digital speech over long-distance h.f. radio links during the latter part of World War 2. In this system, the bandwidth of the basic speech signal was first reduced by a vocoder, then the vocoder output was sampled and quantized to base six and a random, one-time, six-valued key stream added modulo six to obtain a public message that was conditionally secure against anyone not in possession of the key sources. The coding and decoding key sources consisted of identical disc records used once only and then destroyed. Each disc provided 15-minutes of speech and was delivered by courier. The terminals included a self-destruct feature and were installed at Washington DC, London, Paris and in North Africa, Hawaii, Australia and the Philippines. It was well known that German cryptanalysts succeeded in breaking the more conventional transatlantic scrambling system and listened to some of the Churchill/Roosevelt conversations, but Green Hornet was totally secure though clearly a costly system with its couriers and random, rather than pseudo-random, key streams.

Nevertheless Bennett shows that this 50 year-old system developed by Bell Telephone Laboratories achieved a remarkable string of "firsts": first unbreakable enciphered telephone; first quantized speech; first p.c.m. speech; first multilevel f.s.k.; first useful realisation of speech bandwidth compression; first use of f.s.k./f.d.m. as a viable transmission method over a fading medium; first use of multilevel "eye pattern" to adjust sampling intervals.

The vocoder was designed for male voices but the system coped with Eisenhower talking to his wife, though one notes from the transcripts that Winston Churchill was sometimes eager to hand over the phone to his secretary on the grounds of his increasing deafness!

AMATEUR RADIO

Hazards?

The National Radiological Protection Board has recently published a new Consultative Document containing proposals for common European limits for maximum exposure to non-ionizing radiation at e.l.f., r.f. and microwave frequencies. Comments have been invited by July 1, 1983.

Brian Johnson, G3LOX, has drawn attention to a potential fire hazard arising from the ageing of tightly-laced, multicable wiring harnesses using p.v.c.-insulated wires. It appears that after 15 to 20 years there is a tendency for the p.v.c. insulation to dry out, harden and become brittle with the result that the lacing may bite into the p.v.c. In this case, this caused a short-circuit of the 12-volt heater supply leads in a 1960s h.f. transceiver. This resulted in a small fire. Although this was quickly extinguished it could have been much more serious if the equipment had been unattended at the time. It is not uncommon practice, with older equipment, to switch on some time before it is used in order to overcome the initial, warm-up, frequency drift. There is still a lot of equipment in use over 15 years old.

Man-made problems

It is not only in the UK that amateurs are finding that the problem of operating a radio station in a residential or urban area appears to be returning to the levels experienced in the days of v.h.f. television in the 1950s and 1960s, with all the consequent social problems that ensue. The poor electromagnetic characteristics of the combined television set and video recorder, of unit audio, the greater sensitivity of viewers in the face of the large number of cases of interference caused by c.b. transmitters (still not far short of a 1000 per week), leaky cable tv systems, the difficulty of obtaining planning permission for aerial masts in some areas; all such factors are contributing to a growing feeling of unease. A recent editorial in the ARRL journal *QST* comments: "increasingly radio amateurs find themselves embroiled in legal action arising from zoning and radio interference conflicts. Within the past decade the number of local statutes seeking to restrict our right to erect antennas – and in some cases to operate at all – has increased manifold."

Some American amateurs are finding it necessary to resort to "invisible" or hidden aerials. One technique is to use thin (24 to 26 gauge) enamelled wire supported by nylon kite string to provide "hard to see" aerials. An alternative technique is to use a wire concealed in an innocent-looking clothesline or in a flag pole, or to use a television or v.h.f. aerial and its associated feeder cable as a long-wire aerial.

Here and there

The Home Office is seeking to reduce the chances of successful impersonation of candidates taking the amateur Morse test, whereby an experienced operator presents himself as the candidate. In future all candidates will be required to show a valid passport or produce some other positive means of identification when taking the test. That some other curious practices are coming into the hobby became apparent in 1981 when a much-publicised "DX-pedi tion" by an American amateur to St Felix Island (during which 800 contacts were made) has since been proved to have been an elaborate spoof, although supported by a number of carefully forged documents. It is now known that the amateur concerned never set foot on the island but operated from the Chilean mainland.

The use of lead-acid car batteries to power 12V solid-state transceivers from a fixed location normally involves the risk of damage caused by acid-spillage, as well as being a rather messy business. Many of the problems may be overcome when the Chloride company markets their Exide Torquestarter range of batteries in the U.K. These batteries, with built-in carrying handle, are already marketed in Australia and South Africa but seem unlikely to be available in the U.K. until next year. They are totally sealed, do not require topping up and cannot spill or leak acid. They use a "recombination electrolyte" with no free acid and with the electrolyte held in submicron glass wool. Frank Harris, G4IEY has been using one acquired in Australia and finds it a satisfactory, house-trained power source at lower cost than a heavy current mains power supply unit. It is kept charged from a simple, low-cost mains charger.

There were about 45,000 amateur licences in force in the UK at the end of 1982, compared with about 18,500 at the end of 1972. Main increase has come in the form of Class B v.h.f. only licences which do not require a Morse test. Whereas in 1972 there were approximately four Class A licences to every one Class B, there now appear to be significantly more Class B than Class A, and the gap is widening all the time.

In South Africa it has been the practice to restrict new amateurs to the use of c.w. for the first year of operation (as was done in the UK some thirty years ago). This rule is now being amended so that an amateur can use telephony after furnishing proof of establishing 200 contacts using Morse.

In brief

The newsletter of the "DX-TV" group of enthusiasts interested in long-distance television reception has been revived by Dave Launder (18 Burnside Close, Barnet, Herts EN5 5LN) and a copy is available on request provided that a stamped addressed envelope is sent to him. Among the topics covered in the Winter issue are the problem of interference to Band 1 reception caused by visual display units, the question of the future use of Band 1 frequencies, auroral propagation and the use of monitor receivers with scanning facilities . . . . A terrestrial linear transposer repeater, similar to those used on amateur satellites, has been tried at Dunedin, New Zealand. It can cope with several transmissions simultaneously (but involves power sharing) and is reported to result in less flutter on f.m. signals as well as handling s.s.b. transmissions . . . . The number of stations equipped for 144MHz earth-moon-earth "moonbounce" operation is increasing with contacts being made by stations having output down to about 100 watts. Clive Penna, G3POI recently became the second station in England to "work all continents" on 144 MHz as a result of using this mode . . . . The FCC is considering the elimination of all licensing for c.b. operation . . . . Trans-equatorial propagation during August 1982 result in a 144MHz two-way contact between ZC4G0 in Cyprus and Z22JV in Harare, Zimbabwe, a distance of about 4000 miles. Power at the Cyprus end was only 60 watts . . . . A new beacon on 28.208MHz with the callsign WA1IOB is located at Marlborough, Mass., U.S.A. and has an output of 20 watts to an omni-directional aerial . . . . Mobile rallies in May include: Maidstone Y Sportscentre, Melrose Close, Cripple Street, Loose Road, Maidstone on May 1; Lincolnshire Showground, 4 miles north of Lincoln (A15) on May 8; Northern Mobile Rally, Great Yorkshire Showground, Harrogate and the Swindon rally at Park School, Marlowe Avenue, Swindon both on May 15; Welsh Amateur Mobile Rally, Memorial Hall, Barry on May 22; East Suffolk Wireless Revival, Civil Service Sports Ground, Bucklesham, near Ipswich on May 29 . . . . The US Congress finally approved Treaty Document 97-21 at the end of 1982 thus making possible the ratification of the Radio Regulations as agreed at W.A.R.C. 1979.

PAT HAWKER, G3VA

Semiconductor noise analyser

Measures voltage and current noise densities of devices from 0.1Hz in decades to 10Khz.

by Ian Marshall and John Brydon

A brief summary of the noise sources is given here; for more detailed information the reader is referred to the literature contained in References 1 to 5. The three main sources are:

– Johnson noise, which arises from the thermal agitation of the charge carriers and leads to a noise voltage $v_n = \sqrt{4kTBR}$ in a bandwidth B across resistance R;

– shot noise, which is brought about by the discrete nature of the charge carriers giving rise to a noise current $i_n = \sqrt{2eIB}$ where e is the electronic charge and I is the mean current flow;

– flicker (1/f) noise, which dominates the low-frequency behaviour, its spectral noise density increasing as 1/f. It is largely due to surface defects in semiconductors.

In junction fets (Fig. 1(a)), there is Johnson noise in the resistive (source-drain) channel, of order $\sqrt{4kT/g_m}$ per root Hertz. There will also be shot noise in the gate current, $i_n = \sqrt{2eIg}$. Since Ig is typically a few pA, i_n is extremely small (0.01pA).

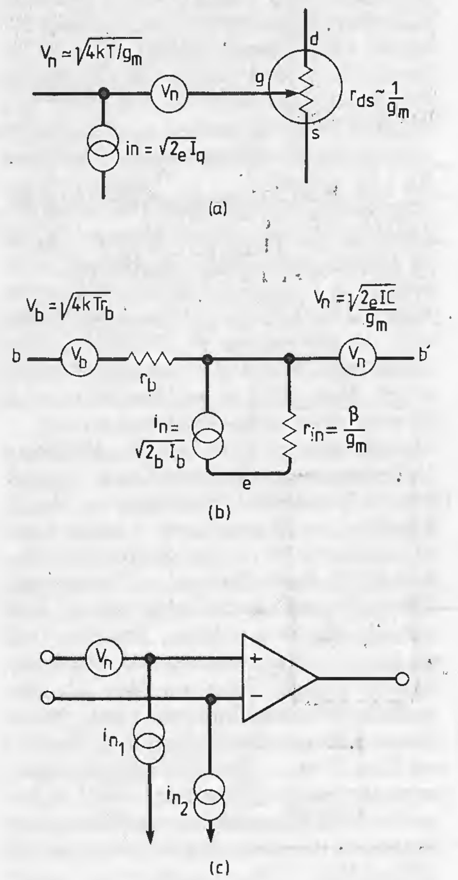


Fig. 1. Noise models of a fet(A), a bipolar transistor(b) and an op-am(c).

In bipolar transistors (Fig. 1(b)), shot noise in the base current is developed across the input resistance ($r_{in} = \beta/g_m = \beta r_e$) Shot noise in the collector current is represented by an equivalent noise voltage at the base ($v_n = i_n/g_m$), and there is a further contribution from Johnson noise in the base resistance r_b. At low frequencies (<100Hz) flicker noise becomes significant.

All resistors generate Johnson noise, and, apart from wirewound and bulk metal types, there is an additional contribution arising from the granular nature of the resistive material. This last contribution is expressed in microvolts per volt applied across the resistor, in a specified bandwidth.[6]

Both authors are in the Department of Medical Physics and Medical Engineering, Edinburgh Royal Infirmary.

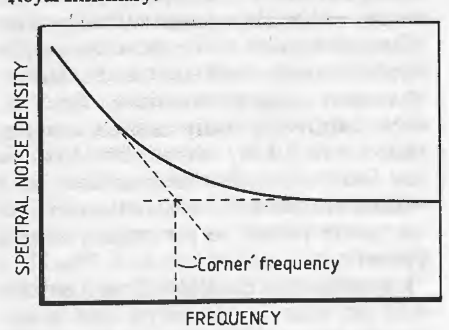


Fig. 2. Spectral noise density of typical op-amp.

Noise characterization

The information required for a full noise characterization of a semiconductor device is the spectral density as a function of frequency. The total noise is then found by integration of the spectral density over the relevant bandwidth. Unfortunately, these figures are not always readily available from manufacturers' data sheets. For example, it is quite common for a noise figure (in dB) to be given without clearly specifying the bandwidth or source impedance appropriate to the measurement.

Furthermore, a broadband figure intended for audio-frequency users can be highly misleading for low frequency (<100Hz) design calculations, as Fig. 2 illustrates.

This shows the form of the voltage (or current) spectral noise density (s.n.d.) of a typical op-amp (see also Fig. 1(c)). At higher frequencies, the s.n.d. is independent of frequency and relatively low in amplitude; this is referred to as the "white noise" region. However, at lower frequencies the s.n.d. rises as the frequency decreases, following a 1/f law. The intersection of the asymptotes, the "corner" frequency, should usually fall below the signal frequency: otherwise noise can become troublesome in critical applications. The lower the s.n.d. amplitude in the "white noise" region, and the lower the corner frequency, the better the op-amp can perform as a low-level amplifier.

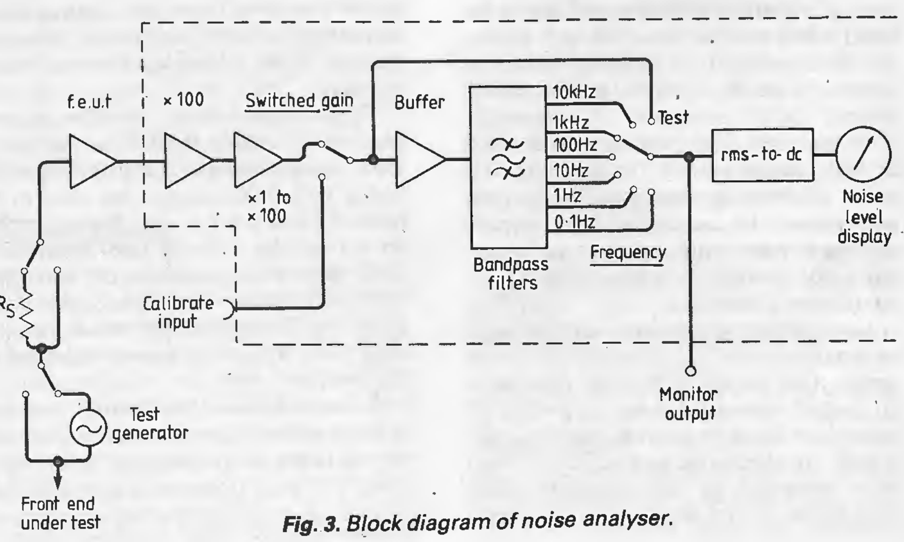


Fig. 3. Block diagram of noise analyser.

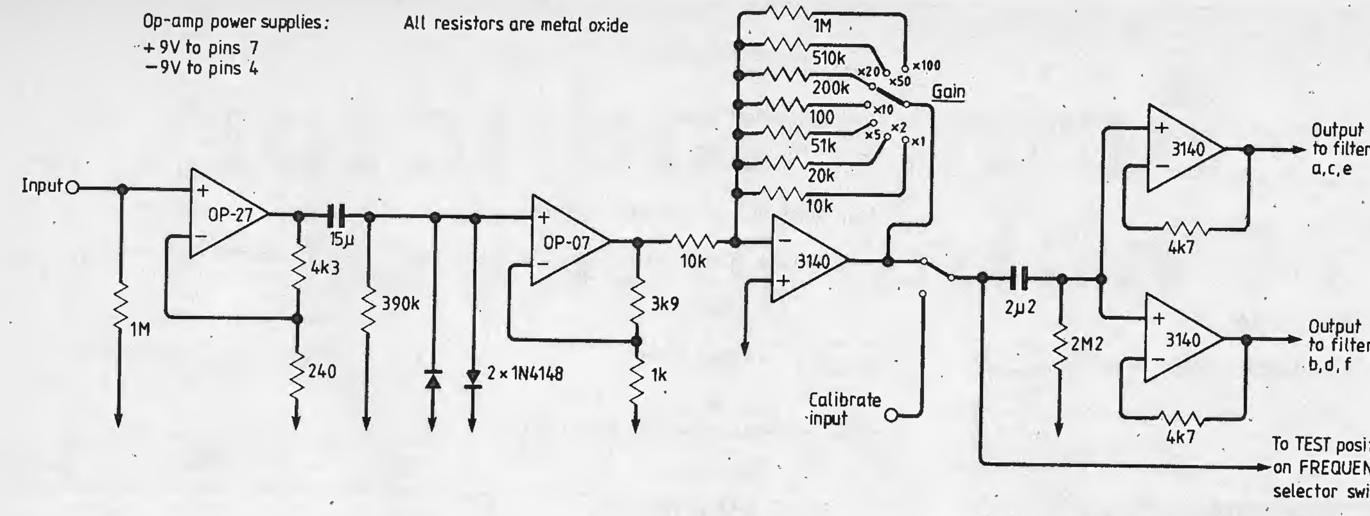


Fig.4. Three-stage preamplifier, gain-switchable from 100 to 10,000.

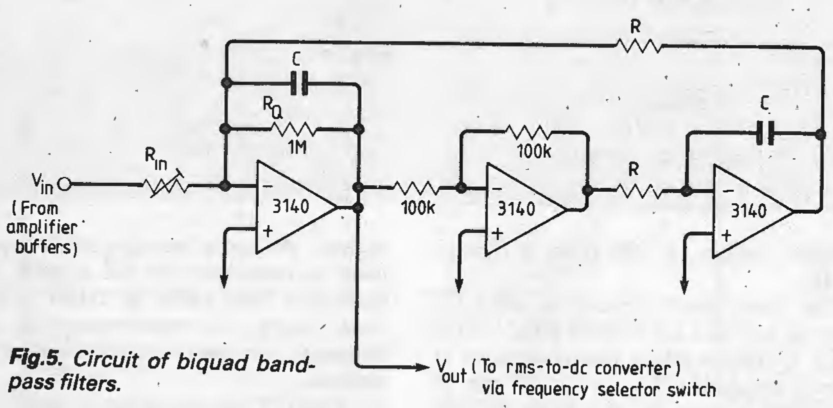


Fig.5. Circuit of biquad band-pass filters.

Typical figures are 20nV/√Hz and 30Hz (quoted by Signetics for the 741)[7] compared with 3nV/√Hz and 2.7Hz (the manufacturer's noise voltage for the OP-27)[8,9].

The noise analyser enables the s.n.d. to be measured at spot frequencies of 0.1Hz and decades to 10kHz. The circuit under test can be configured to allow its voltage noise and current noise to be studied separately.

Figure 3 shows the noise analysis system. Connected to the circuit under test, it consists of a low-noise preamplifier stage with fixed gain, followed by a switchable gain stage and a bank of band-pass filters feeding the r.m.s.-to-d.c. converter circuitry. The source resistance R_s may be shorted out to allow measurement of the front end noise voltage. With R_s in circuit, the resulting noise is the r.m.s. sum of voltage, current and resistor noise.:

$$V_r^2 = V_n^2 + i_n^2 R_s^2 + V_{Rs}^2 \qquad (1)$$

Circuit function

The test circuit output is taken to a pre-amp, shown in Fig. 4, which has as its first stage an OP-27 ultra-low-noise op-amp. This is followed by two further gain stages and buffers, which altogether provide a voltage gain switchable from 100 to 10,000 in 1,2,5 steps.

The amplified noise "signal" from the front end is passed to six "biquad" band-pass filters, having centre frequencies of 0.1 Hz, 1Hz and successive decades to 10 kHz. The bandwidths and passband gains of the filters are scaled such that the gains decrease as the square root of bandwidth; the requirement for equal amplitude outputs when fed with broadband white noise. To arrive at spectral noise density figures it is thus possible to divide all six outputs by the same constant and obtain directly readings in terms of nV/√Hz.

The filter outputs are selected as required by a rotary switch and applied to an r.m.s.-to-d.c. converter which drives a meter calibrated directly in spectral noise density, with a full scale of 100µV/√Hz. This reading is divided by the gain switched in (between 1 and 100) to arrive at the noise present at the noise analyser input socket.

A seventh position (TEST) of the frequency selector switch allows the noise from the preamplifier to pass directly to the r.m.s.-to-d.c. converter, bypassing the filters. A monitor output socket is provided to enable viewing, with an oscilloscope, of the signal reaching the meter drive circuitry.

Circuit description

Preamplifier. The first stage in Fig. 4 uses an OP-27 low-noise amplifier which, together with its input bias resistor, is the limiting factor in the measurement of test circuit noise. Its "white noise" voltage spectral density is typically 3nV/√Hz, extending right down to 2.7 Hz, whilst the integrated low-frequency voltage noise from 0.1 to 10 Hz is typically 90nV. To this must be added the current noise developed across the input bias resistance (R_{in}), and the thermal noise of the resistor itself. The 1MΩ resistor will normally be shunted by the (low) value of the output impedance of the front end; and the specification gives the equivalent noise for a grounded input.

In the second stage, a low-noise buffer with a gain of 5 is a.c.-coupled to the first stage and thus allows input offsets of up to ±250mV from the test circuit. The diodes limit excessive voltage swings and allow it to come out of saturation more quickly.

Type 3140 op-amps are used for the rest of the circuitry, the preamplifier being

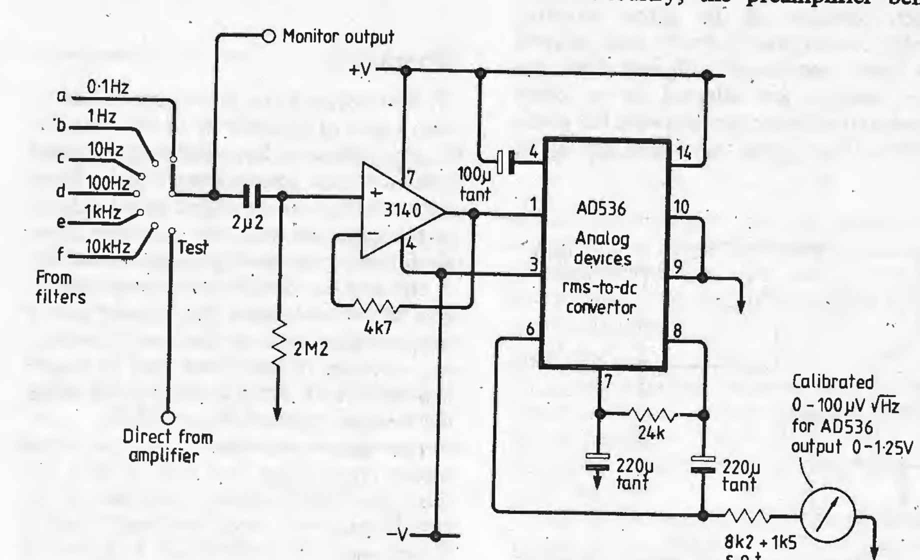


Fig.6. R.m.s-to-d.c. converter. Response is flat within 2% from 0.1Hz to 60kHz.

Specification

Input range for full output	100µV-10mV rms	broadband noise
Maximum input offset	±250mV	
Input impedance	1MΩ hard-wired; normally shunted	see text
Output reading	Full scale 100µV/√Hz (r.m.s.)	Divide by gain setting
Switchable gain	1,2,5,10,20,50,100	
Calibration input	(unity gain)	a.c.-coupled
Measurement frequencies	0.1 Hz and decades to 10kHz TEST: Broadband (-3dB at 21 kHz) (Full scale 1.25V r.m.s. in this mode)	
Monitor output	Input to r.m.s.-to-d.c. convertor brought out	
Internal preamp noise, input grounded	6nV/√Hz 8nV/√Hz 20nV/√Hz 80nV/√Hz	100Hz 10Hz 1Hz 0.1Hz
Power supply	Two "PP9" batteries	Current drain ~ ±100mA

completed by an inverting stage with gain switchable from 1 to 100 in 1,2,5 steps, and dual buffers after further a.c.-coupling to remove any d.c. offsets.

Bandpass filters. The biquad type of filter allows the various parameters to be easily selected. Referring to Fig. 5, the centre frequency, ω_0, is $\omega_0 = 1/RC$, the Q (−3dB) is R_Q/R and the passband gain G is R_Q/R_{in}. Each of the six filters comprises two integrators and an inverter in a loop, which combination behaves as a parallel tuned circuit with an artificial inductance L given by R^2C. The calculated Q (R_Q/R) gives the −3dB bandwidth as f_0/Q, and the effective bandwidth for white noise is $\pi/2$ times this (found by integration of the filter transfer function over all frequencies).[10]

Filter gains are set to assist in making spectral noise density measurements. The product of passband gain and square root of effective bandwidth is set at $100\sqrt{\pi/2} = 125$ for all six filters.

R.m.s.-to-d.c. converter. This is based around an Analog Devices AD536 chip, which contains all the active circuitry needed to compute the true r.m.s. value of the input waveform[11]. Signals from the filter outputs are selected by a rotary switch and buffered before being fed to the AD536. The circuit used here has a flat response within ± 2% from 0.1Hz to 60kHz.

The meter reads directly in µV/√Hz true r.m.s. with a full scale of 100µV/√Hz r.m.s. Output levels at the frequencies of interest are divided by the overall gain of the circuit on test and the noise analyser switched-gain stage (1 to 100), to arrive at the equivalent input noise density of the device under test (usually expressed in nV/√Hz for voltage noise and pA/√Hz for current noise).

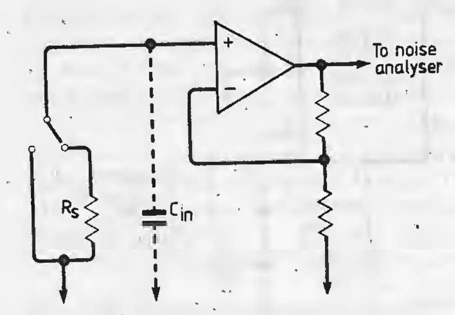


Fig.7. Measuring noise density of an op-amp.

Calibration

Each filter input resistor (R_{in} in Fig. 5) is made variable to aid calibration. If a broadband noise generator of known spectral noise density is available, then this can be used to set up the filters. Otherwise, the best method is to measure the −3dB points and then scale the peak gains accordingly: that is, Gain = $100/\sqrt{B_{-3dB}}$. The "CAL IN" socket provides buffered unity gain to the filters, the gain control being inoperative if this is selected.

Operation

(1) The device to be investigated is set up with a gain of typically 20 to 100. (see Fig. 7). For op-amps, the non-inverting configuration is most convenient since the source reistance (R_s) can be varied independently of the gain. As with any amplifier stage, the following precautions must be taken:

– the gain-bandwidth product of the device should not affect the selected gain at the measurement frequencies of interest;

– screening of the front end is recommended for all measurements, and essential for high values of R_s (>100kΩ);

– the input capacitance of the circuit layout (typically a few tens of pF) may limit the high-frequency response of the circuit under test when very high values of R_s are used. This effect can be tested by applying a sinusoidal signal in series with R_s, and sweeping through the frequency range to investigate the fall in gain. This factor can then either be taken into account during noise measurements, or measurements can be restricted to lower frequencies.

(2) Select R_s=0 by shorting the source resistor to ground. This enables the input noise voltage to be measured.

(3) To avoid overloading the first stage of the noise analyser, check with an oscilloscope that the broadband noise output is in the range 100µV-10mV (r.m.s.), and that the d.c. offset at the output is less than ±250mV.

(4) Connect the test circuit to the Input socket of the noise analyser, and switch the gain control to the minimum.

(5) At each selected frequency, the gain control is adjusted until the Monitor Output signal is in the range 1-4V pk-pk. It will then be necessary to wait about 20 seconds, the time constant of the AD536 circuit, before a reading can be taken. At 10Hz and below the reading will be seen to fluctuate due to the lower frequency components of the noise, and an average must be taken "by eye".

(6) This completes the readings necessary for an analysis of the noise voltage.

(7) Now switch in a source resistor R_s to obtain noise levels at least twice as large as before, and so enable separation of the voltage and current contributions: 100kΩ is suggested as an initial value. Devices with very low current noise (e.g. fet op-amps) will require larger values (but see precautions above regarding input capacitance). Wirewound resitors are recommended as they produce no significant component noise above the thermal contribution. The front end output offset should always be less then ±250mV, and it should be shielded to eliminate mains interference.

(8) Step 5 is repeated with R_s in circuit.

(9) Steps 7 and 8 can be repeated with different values of R_s as required.

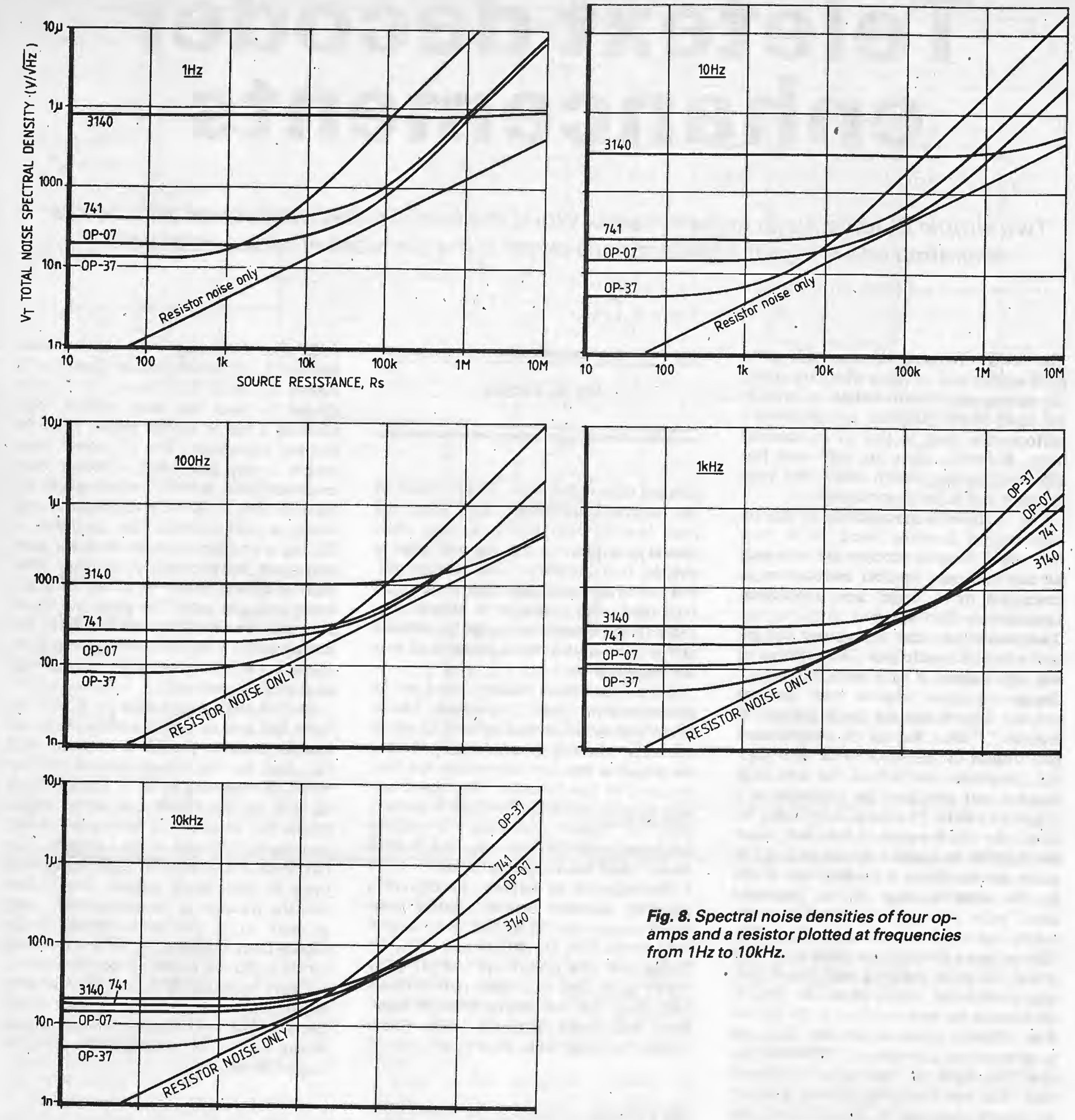


Fig. 8. Spectral noise densities of four op-amps and a resistor plotted at frequencies from 1Hz to 10kHz.

Analysis

Each meter reading of spectral noise density is referred to the input of the device under test by division by the noise analyser switched gain (1 to 100) and by the test circuit gain itself. For an example, an OP-37 with circuit gain 50, noise analyser gain 100, gave a reading of 20µV/√Hz at 10kHz.

V_n for OP-37 at 10kHz=

$$\frac{20\mu V/\sqrt{Hz}}{50\times100}=4nV/\sqrt{Hz}$$

This division is carried out on each of the readings made, to arrive at the spectral noise densities. The results with R_s=0 give the input noise voltage (v_n) directly*. With R_s switched in, the observed s.n.d. (v_T) is the r.m.s. sum of the voltage noise (v_n), the source noise (v_{Rs}) and the current noise (i_n) developed across R_s.

We take as the source noise (v_{Rs}) the thermal noise of a resistance, namely $\sqrt{4kTR_s}$ per root Hertz. At room temperature the following figures apply: 10k-ohm, 13nV/√Hz: 100k-ohm, 41nV/√Hz: 1M-ohm, 130nV/√Hz. Hence for a given R_s we perform the calculation

$$i_n=(v_T^2-v_n^2-v_{Rs}^2)^{1/2}/R_s$$

at each frequency to find the appropriate current noise spectral density.

Tabulated values of v_n and i_n may be plotted as in Fig. 1, or as described below under Results.

Results

The noise analyser has been used to characterise several commonly-used operational amplifiers. Values of v_n and i_n are measured as a function of frequency for each device.

One of the most useful forms of presentation of the results is as log-log graphs showing total noise voltage (v_T) versus

continued on page 47

*Neglecting the input noise of the noise analyser itself, which can be taken into account using the specification, if so desired, for critical measurements.

Teletext decoder enhancements

Two simple modifications to the Wireless World decoder are described which enhance its operation and brings the performance closer to the standard of commercial units.

by K. Drew

The W.W. Teletext Decoder still gives good service and, to those who have added the subsequent modifications to provide the more recent facilities, has provided a performance close to that of commercial units. However, there are still some features outstanding which could ease page selection and improve acquisition.

Fig. 1 shows a modification to the remote control decoding board (W.W. May '79) which simply removes the necessity for any new page number selection to be preceeded by a 'Page' key depression. Operation is then identical to that of the Time mode (in terms of numeric key entry) which is unaffected. The number of key depressions is thus reduced and, to change magazine number only involves two key depressions e.g. from 100 to 200 requires '2' then 'Reveal'. A 4 input nand gate detects the presence of the first digit (i.e. magazine number) of the new page number and simulates the reception of a 'Page' command by taking 314(6) high via 323(2) for the duration of the Data Allow clock pulse at 314(6). At the end of the pulse this condition is clocked into IC310 by the negative edge of the simulated e.o.c. pulse present at 323(6) which increments the write-address from 00 to 01. This is then followed by a pulse at 304(22) which clocks the received digit into IC312, and finally the e.o.c. pulse at 304(24) increments the write-address in the normal way. Thus reception of the first digit, say 1, gives rise to a display of P1XX and the next two digits are entered in the normal way. The two additional ICs required are IC322 (74LS20) and IC323 (74LS00) and are most conveniently mounted between the first two rows of ICs on the remote control board.

Fig. 2 shows a simple addition to the remote control decoding board which generates the following functions:-

(i) a 10 second cut-box pulse during row 0 following either any key depression (with the exception of TV) or upon detection of the selected (sub) page. This eases page selection since the normal tv picture may still be viewed whilst a new page or time is keyed in, and an indication is given when the page has been acquired. Also, by pressing 'Spare' for example, the status of the selected page, or real time clock, may be observed without intruding unduly into the tv picture.

(ii) a clear-page pulse is generated following the initial detection of a newly selected time-coded page. This is based on the general requirement that when the page headers stop rolling a clear cycle should take place before the new page is written into memory. This strategy enables us to initiate a page clear cycle in the time mode which cannot be simply provided by the normal clear page bit detector and is most useful when being used as a sub-page selector.

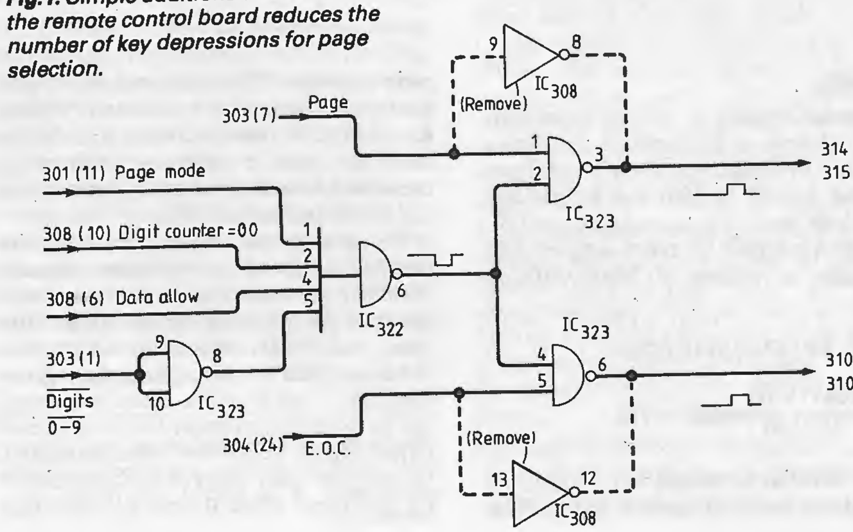
(iii) a sound mute facility, based on the remote control 'Spare' command. This is gated with the 10 second pulse of (i) which minimises the risk of accidentally muting the sound as two key depressions are then required for this function. The 'Spare' key may then be labelled 'S' which is pressed once for 'Status' (revealing the cut-box information of (i)) and twice for 'Sound Mute' which has a toggling action.

Operation is as follows. Receipt of a correctly decoded remote control command triggers the 10 second timer output (403,6) via (305,3), (402,3) and (401,10). Triggering also occurs via (402,2) when (78,6) goes high (i.e. stop roll headers), indicating that the newly selected page/time has been detected. The timer output is gated with Row 0 at (402,10) and, after buffering, sets the 'cut-box' latch at (51,10) which enables Row 0 to be viewed in the tv/Text mode. Tr 1 is included to reset the timer period, thus allowing a full 10 second display from the last key depression. The 10 second timer output is also gated with a 100ms spare command pulse at (402,4) which clocks the bistable (404,3). A buffered output is provided at (401,15) with the capability of driving a t.t.l input. In the author's unit, two spare open collector invertors were used to drive a green 'Mute on' led and a spare analogue gate. The pulse at (401,6) also sets the clear page latch (78,10) following either a remote control Clear command at (307,9) or when (78,6) goes high as described previously.

If a 556 dual timer is used for IC403, the spare half may be usefully employed in the astable mode to provide a constant 1600 Hz clock for the remote control decoder board, as suggested by R. T. Russell. Note the use of the 4049B hex buffer which avoids the necessity of having to replace existing IC's 51 and 78 by l.s types. The circuit of Fig 2 may be built on a small piece of vero board approx. 5cm×10cm and the number of interconnection, may be kept to 13 (including power) if the diodes from IC20 and IC306 are mounted on the underside of their respective i.cs.

I have found the WW Teletext decoder a useful and challenging project and would like to thank J. F. Daniels for the original design and all the other authors for their contributions.

***Fig.1.** Simple additions and removals from the remote control board reduces the number of key depressions for page selection.*



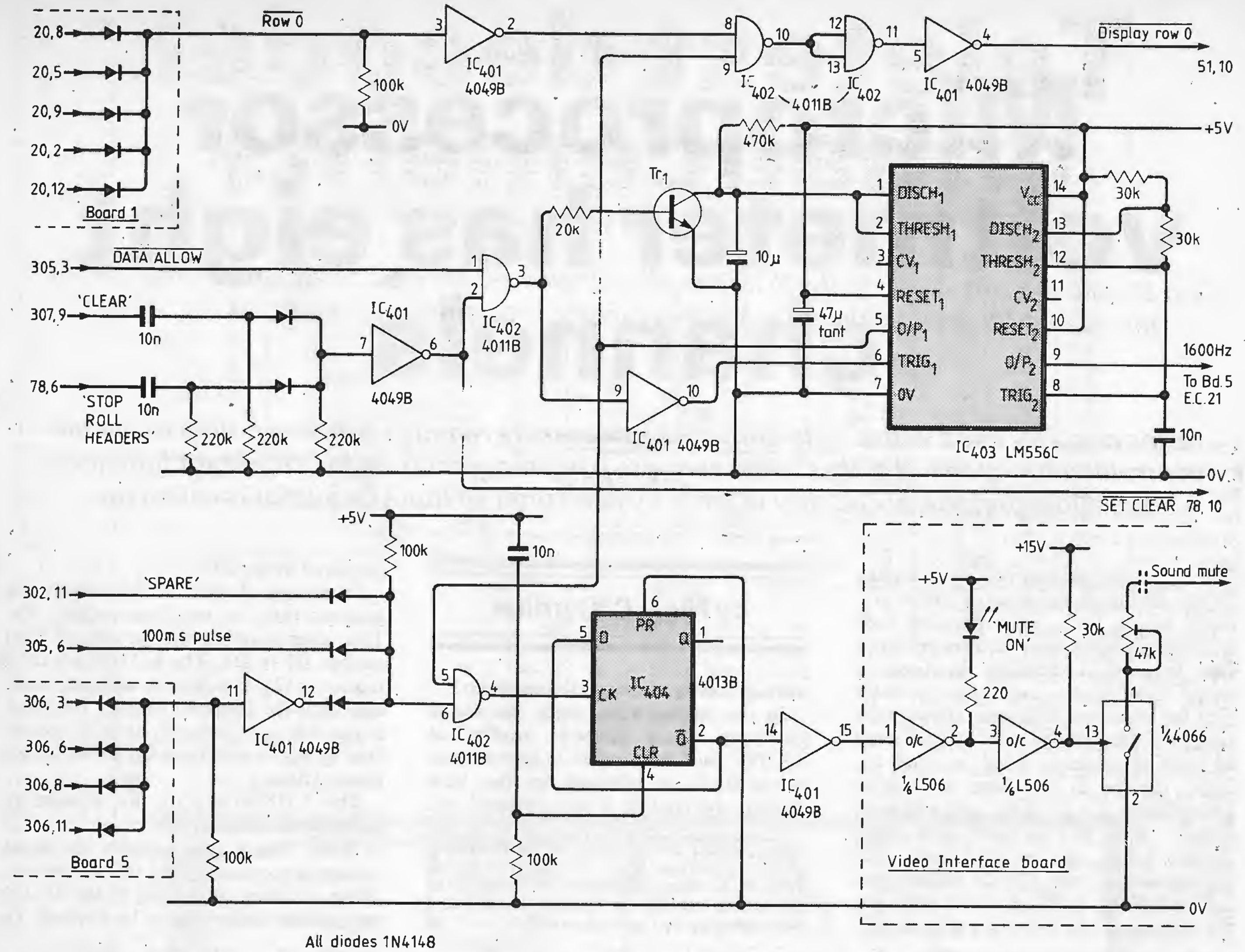


***Fig.2.** On the same board as Fig.1., these additions enable the viewing of the tv picture while the page is being selected; the generation of a clear-page pulse when the selected page is detected and the choice of a sound mute facility.*

continued from page 45

source resistance (R_s). One such graph is prepared for each measurement frequency, with v_T being calculated from the measured values of v_n and i_n using (1). Immediate comparisons are possible if the results from several devices are plotted on the same graph.

Reproduced below is a selection of graphs covering 1Hz to 10kHz, and comparing the following op-amps:

741, "Industry standard" bipolar input type.

3140, fet-input type. Very low current noise but poor voltage noise.

OP-07, low-noise bipolar type.

OP-37, ultra-low voltage noise, but poor current noise.

Using the graphs readily allows the best device to be chosen for a particular application (all other considerations being equal), or to see what trade-offs result from using alternative devices.

Specimen graphs

At low frequencies, the OP-37 has the lowest noise (approximately $10nV/\sqrt{Hz}$) for source resistances up to a few kilohms. Above this, the OP-07 is best until around 100 kilohms, when the 741 almost matches its performance. For R_s greater than 1Megohm, the 3140 fet-input comes into its own, contributing the lowest noise (~ $800nV/\sqrt{Hz}$).

There is less difference between the various devices at frequencies of 1kHz and above. The OP-37 still provides the best performance for R_s up to 20kΩ, after which the OP-07 and 741 are about equally good up to R_s=200kΩ. For source resistance greater than a few hundred kilohms, the 3140 once again becomes the best device, adding little significant noise to the thermal noise of the source itself.

At 10kHz, the OP-37 is still the lowest noise op-amp studied for R_s less than 20kΩ. The other three devices are all comparable for R_s up to 200kΩ, above which the fet-input of the 3140 once again provides the best performance.

For applications requiring low source resistances, say less than 10kΩ, the OP-37 can be used to advantage. For source resistances higher than a few 100kΩ, the 3140 has the best noise characteristic because of its fet input. Overall, the 741 performs very well, being almost as good as the OP-07 "low-noise" op-amp except at low frequencies.

References

1. Fisher, P. S. Electronic Noise. Clarendon Laboratory, University of Oxford (unpublished manuscript). January 1979.
2. Sherrin, J. Noise Specs Confusing? National Semiconductor Application Note 104, May 1974.
3. Soderquist, D. Minimization of Noise in op amp applications. Precision Monolithics Inc. Application Note 15, November 1979.
4. Bernardi, T. S. Designing low noise op-amp based systems. *Electronic Engineering*, July/August 1982.
5. Foord, A. Introduction to low-noise amplifier design. *Wireless World*, April 1982.
6. Instrumentation Amplifier-Resistor testing. *Electronic Design*, 10 June 1982.
7. 741 op-amp. Signetics Analogue Databook.
8. OP-27/OP-37 Data Sheet. Precision Monolithics Inc.
9. Op Amps tackle noise. *Electronic Design*, 20 Dec 1980.
10. Smith, K. L. Noise-confusion in more ways than one. Appendix B, *Wireless World*, April 1975.
11. AD536 Data Sheet. Analog Devices.

Microprocessor voltmeter has eight channels

Some circuitry used with single-chip microprocessors requires processor time to enable controlling functions. It makes more sense to use processor time for important functions and allow peripheral circuitry to work by itself until an input or output is called on.

The single chip microprocessor is finding its way into more and more of todays products and as such, some circuitry used with the microprocessor requires processor time to enable controlling functions. It would make more sense to use processor time for important functions, allowing the peripheral circuitry to work by itself until an input or output is called on. Such circuitry can be in the form of latching multiplexers, d.v.m. chips, and telephone diallers. With this in mind, this eight-channel d.v.m. was designed using a Z8 microprocessor with DG528 multiplexers and an LD120, LD121A d.v.m. chip set, the last-mentioned two chips relieving the

by Nigel C. Gardner

microprocessor of the a to d conversion.

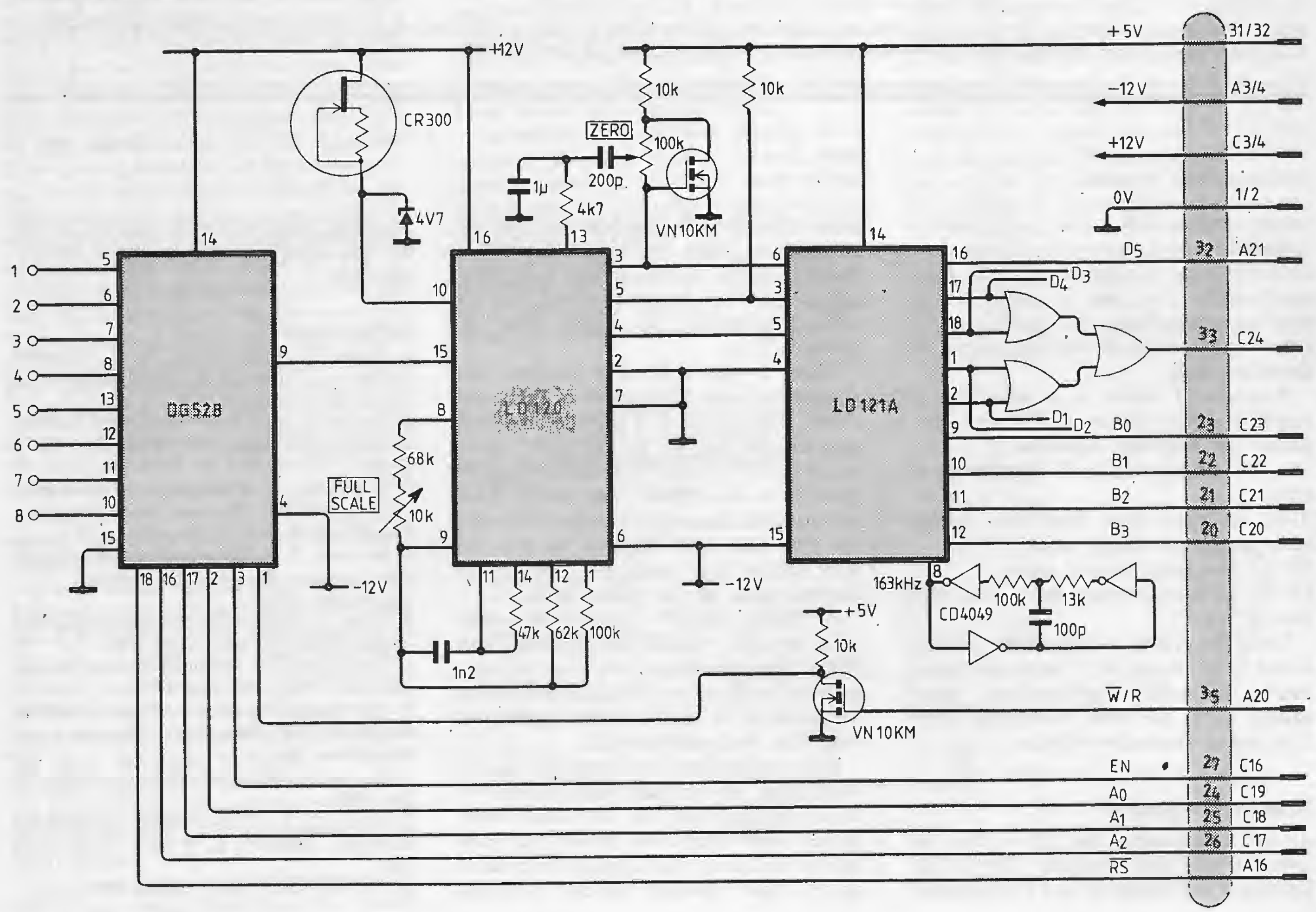
In the configuration used, the digital voltmeter has a full-scale reading of 1.9999V, but even when it over-ranges, indicated by a blinking on the local display, the reading is still obtained and

Nigel Gardner has an HNC in electrical/electronic engineering. After 7½ years with British Telecom, he joined Siliconix in 1979, initially as applications engineer on telecoms, but he's currently handling l.s.i. and r.f. as well.

displayed by the Z8.

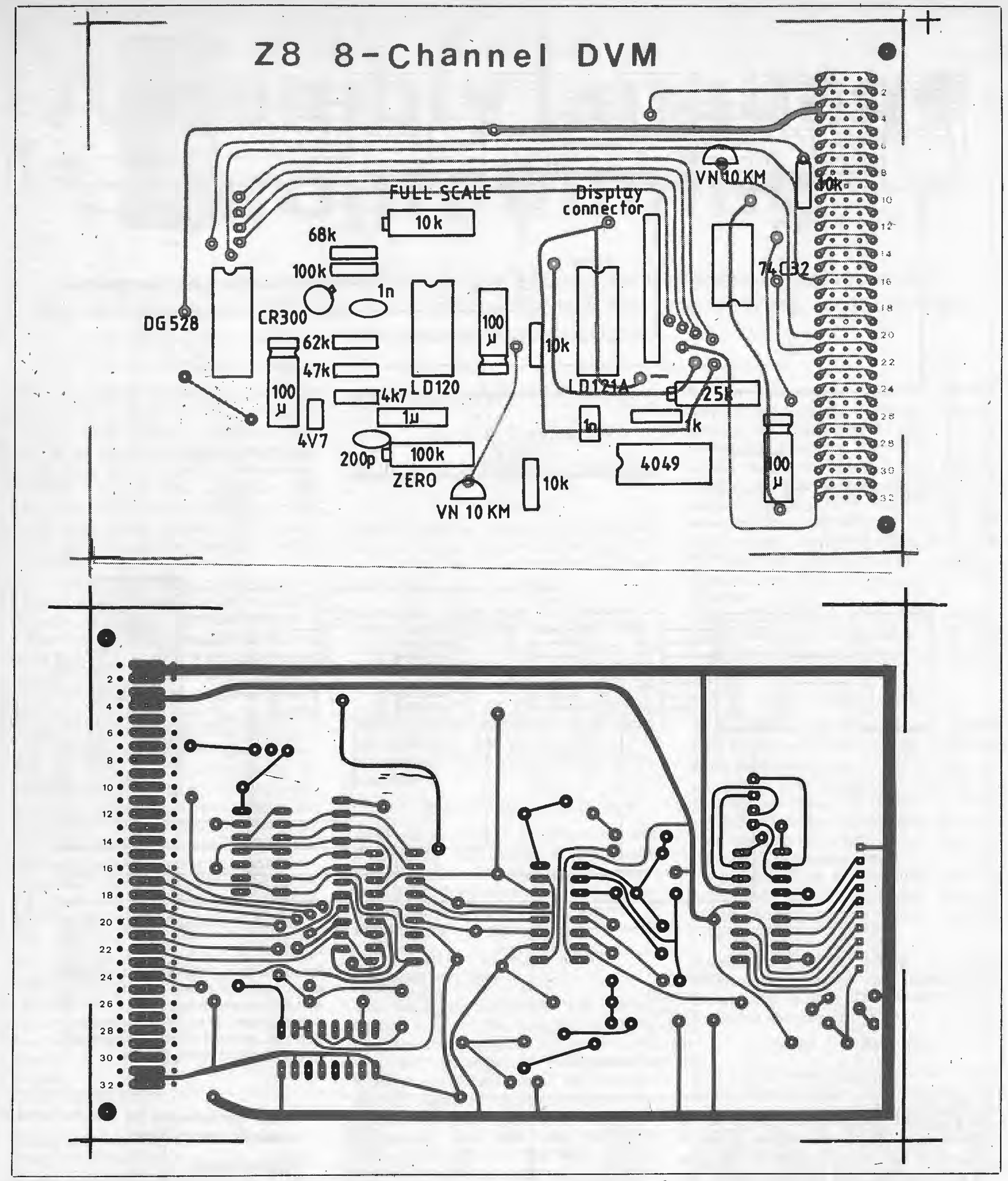
Interfacing of the LD121A to the Z8 is achieved with the use of one or-gate, IC_5. This gates together the outputs of digit strobes D1 to D4. The LD120, LD121A require ±12V and +5V to operate, available from the Z8 power supply. The clock required is approximately 163kHz, generated by IC_4 to save tying up one of the Z8 internal timers.

The LD120/LD121A are allowed to free-run and the start conversion pin is left to float. The d.v.m. samples the input voltage approximately ten times a second. When a reading is required by the Z8, the appropriate channel has to be selected. To



do this the channel number is sent via port 2, bits 4-7, to the address and enable lines of the DG528 (IC_1). This information can only be written into the DG528 when W/$\overline{R}$ is low. This is implemented by port 3_5 and the inverter. The sequence for the channel selection output information is:

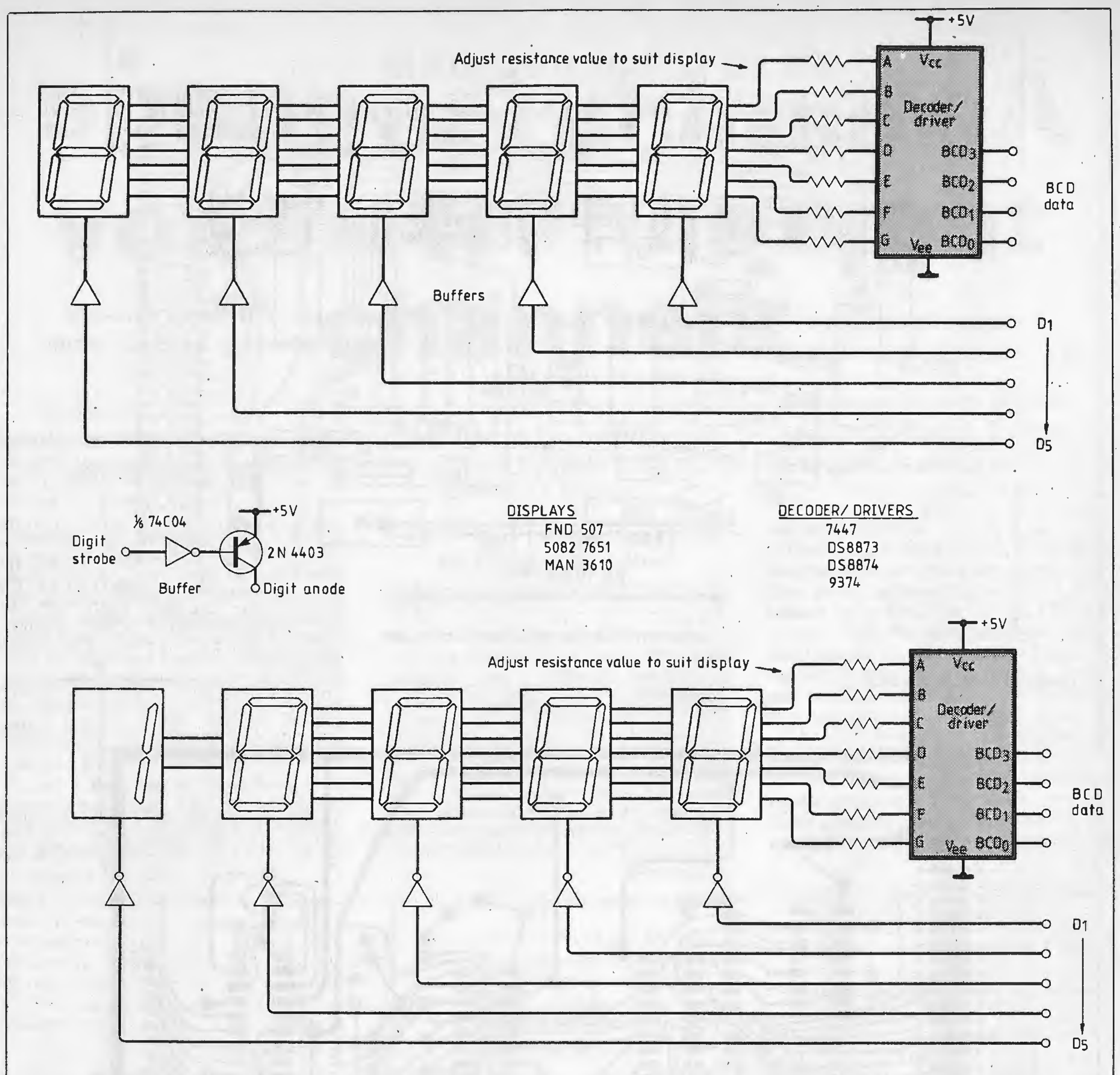
```
50 @ 2 = (channel number 0=0, 8-F=1-
   8)
55 @ 3 = A0 (sets W/R̄ (L))
55 @ 3 = 00 (resets W/R̄ (H))
60 @ 2 = 00 (clears reg. 2 for input of
   data)
70 W = W+L: IF W <15 then 70 (de-
   lay to allow reading to stabilize)
80 W = 0: GO @ %1400 (then take
   reading).
```



The machine code routine was loaded at %1400, but could be moved to another location if required. This machine code routine was required to enable the data from the LD121A to be loaded into the Z8 synchronously and at a higher speed than Basic will allow. The D5 pulse on port 3_2 signifies the start of data output to the display. The D0 to D4 pulses on port 3_3 signify the subsequent digits. Only when the D0 to D5 lines are high will data be read off the lines B0 to B3.

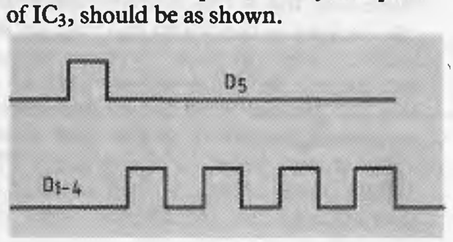
Setting up and testing

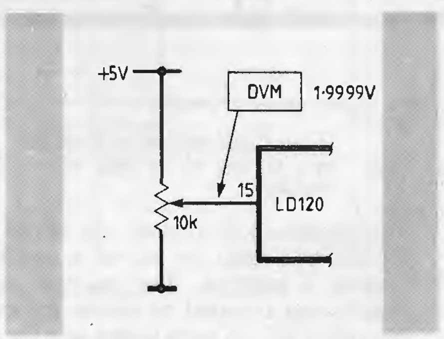
With only the d.v.m. board plugged into the backplace, check that the voltages are correct on board. If so, switch power off and place a short link between pin 15 of IC_2 and ground. With the remote display connected, reconnect power and a low value should show on the display. The 100kΩ potentiometer is then adjusted to give all zeros on the display. With the



Remote display interfacing circuits use either common anode led displays, giving ±28,672 counts maximum without blinking (top diagram), or common cathode displays, giving a maximum count of ±19,999 with blinking (bottom).

shorting link removed and the circuit as shown below, adjust the voltage on pin 15 to as close to 1.9999V as possible (the loan of a d.v.m. will help here) and adjust the 10kΩ preset to give the same reading on the remote display. If there is access to a scope, check the clock frequency, which should be approximately 163kHz, and also the waveforms on pin 6 of IC_5 and pin 16 of IC_3, should be as shown.





The d.v.m. board is now ready for interfacing to the Z8.

The appropriate Basic program can now be entered with the machine-code program, which when run will display the voltage appearing on the selected input if outside the preset values.

Applications

The application shown here uses the d.v.m. board to monitor eight channels, each given a fixed minimum and maximum in the program. This could be modified to allow the user to input the values when the program is executed. When a reading falls out of range, the minimum and maximum values are displayed on the terminal. An additional program for dialling up on a telephone line when the minimum and maximum values are exceeded could be incorporated, to send an alarm message to a host computer.

continued on page 58

Assembly language programming

Before writing assembly-language programs one must understand microprocessor instructions; but only a few of these need be learnt to start programming, as Bob Coates illustrates in his third tutorial.

by R. F. Coates

This section looks at 6805 microprocessor instructions and how they are represented. Each assembly-language instruction consists of an operation-code mnemonic, of which there are 61, which produces one machine-code byte when assembled. The instruction indicates the addressing mode to be used (which modifies the op-code byte) and may also require an operand giving either data or an address.

A one or two-byte data or address in the operand is added to the op-code to complete the instruction hence each assembled instruction will be between one and three bytes long. To be able to program in assembly language one has to learn how to use the various instructions and this is best done by trying them out in small programs on the Picotutor and seeing how the operations modify data. But it is not essential that you become familiar with every instruction before starting out; programs can be written using a small proportion of the instructions. Some instructions are used more than others, and some hardly at all. Emphasis here is placed on the most commonly used instructions; instruction tables published in the April issue of *Wireless World* or by Motorola in the MC68705P3 data sheet and MC68705P3(AC1) reference card are needed. Instruction functions fall into one of five categories.

register/memory
read/modify/write
control
branch
bit manipulation

Register/memory instructions

Instructions used in our previous example, LDA, STA, ADD and JMP, all fall into this category. With the exception of store and jump-type instructions, six different addressing modes can be used with each instruction mnemonic. The load accumulator instruction LDA is used here to demonstrate addressing modes; the principles are the same for all the other instructions.

Each addressing mode in the table has three columns indicating the op-code, which is machine code of the instruction mnemonic for the addressing mode specified, the number of bytes required (one for the op-code, any others for the operand) and the number of microprocessor clock cycles required to carry out the instruction. The six versions of LDA are as follows.

Immediate. Here the accumulator is loaded with a specified data byte which will follow the op-code byte in the machine-code instruction. This is written in assembly language as LDA #$F, the hash sign in the operand field indicating immediate addressing mode and the dollar sign indicating that the data byte 2F is hexadecimal. When assembled the instruction reads

```
A62F    LDA    #$2F
```

After the instruction is carried out the accumulator will contain 2F. With the addition of a software interrupt instruction, SWI, this program can be tried out on the Picotutor (use addresses between 24 and 6F).

```
A62F    LDA    #$2F
83      SWI
```

The interrupt instruction SWI passes control back to the monitor when the program run is completed in the same way as the JMP 80 instruction used earlier but it also places the contents of the processor A and X registers, condition codes and the address of the instruction following SWI in a temporary store called the stack. This information may then be retrieved and displayed on the Picotutor using the register function (reg) which is especially useful for program debugging since SWI interrupts may be placed anywhere in the program allowing the register status to be examined at each point.

Pressing the register key after such a break has passed control back to the monitor will display the condition codes as five bits (H, I, N, Z and C). If the letter is displayed the bit is set (1); if a dash is displayed on the bottom line the bit is clear (0). Pressing the step-up key will now result in the accumulator being displayed and pressing it again will display the index register indicated by letter H. Another step up will show the three-digit program counter value indicating the address of the instruction following the SWI interrupt which caused the break. A final step up returns the stack-pointer position which indicates the position before the interrupt was encountered*. This is because the stack pointer is moved down when the SWI interrupt stacks the c.p.u. registers. Pressing any key will return the dash prompt.

Direct. This version of the LDA instruction loads the accumulator with the contents of a memory location between 000 and 0FF as in

```
B680    LDA    $80
```

In this example the accumulator is loaded with the contents of address 80. Again two bytes are required, one for the op-code and one for the two hexadecimal digits of the page-zero address. The absence of a hash symbol or X in the operand field indicates that direct (or extended) addressing is to be used. Try running this instruction followed by SWI on the Picotutor, and the accumulator should be loaded with CC which is part of the eprom monitor program.

Extended. This is similar to direct addressing except that two address bytes are required to allow access to any location in the full memory map of 000 to 7FF, e.g.

```
C60080    LDA    $80
```

is the same instruction as in the direct-mode example above. As extended-mode addressing expects two bytes following the op-code byte, the full address must be specified. The assembly-language mnemonic and address are written in the same way for both direct and extended modes.

A computer assembler will look at the source code instruction to see first if direct addressing can be used. If it cannot, i.e. the address is above 0FF, extended-mode addressing will be used. The same principle applies when assembling by hand.

*If Picotutor does not display the stack pointer but returns the dash prompt after the program counter you have an early version of the software which only displays registers if SWI is not placed in a subroutine.

Table 1. A program for adding two 16bit numbers on the Picotutor using assembly-language mnemonics devised for the 6805 microprocessor.

030	B651	LDA	$51	Add least sig. bytes of the
032	BB53	ADD	$53	2 numbers, result in 55.
034	B755	STA	$55	
036	B650	LDA	$50	Add most sig. bytes of the
038	B952	ADC	$52	2 numbers and carry from
03A	B754	STA	$54	addition of least sig., result in 54.
03C	83	SWI		Return to monitor.

Table 2. Program for subtracting two 16bit numbers using 6805 mnemonics may be expanded to subtract numbers of any length in multiples of eight bits.

030	B651	LDA	$51	Subtract least sig. bytes of
032	B053	SUB	$53	the 2 numbers, result in 55.
034	B755	STA	$55	
036	B650	LDA	$50	Subtract most sig. bytes of
038	B252	SBC	$52	the 2 numbers and borrow from
03A	B754	STA	$54	1st operation, result in 54.
03C	83	SWI		Return to monitor.

Use direct mode wherever possible because it uses one less byte of memory space. In the previous example direct mode would be used although extended mode would work but with this example extended mode must be used

C607FE $7FE

Try running this (followed by SWI) and it will load the accumulator with 02, again part of the monitor program.

Three remaining addressing modes are all indexed types so to demonstrate their use with LDA we must first load the index register, X, using LDX. This operates in exactly the same way as LDA so

AE80 LDX #$80

will load the index register with 80. The operand for indexed addressing modes is written as (offset) ,X where ',X' indicates indexed addressing; which of the three variants is used is determined by the size of the offset. If no offset is required this assembles as

F6 LDA 0,X

Indexed, no-offset mode requires only the op-code byte, the effective address of the data or argument being held in the 8bit index register. This mode gives access to the first 256 memory locations from 000 to 0FF. It is often used to move a pointer through a table or to hold the address of a frequently used i/o location. Run this example,

```
AE80   LDX   #$80
F6     LDA   0,X
83     SWI
```

and then examine the registers. Index register X should contain 80 and the accumulator CC, the contents of memory location 80.

In the indexed, 8bit-offset mode the effective address is the sum of the contents of the index register and the offset byte following the op-code. This allows access to the first 511 memory locations from 000 to 0FE and two bytes are required for each instruction, e.g.

E601 LDA 1,X

The offset may be specified in the operand field as a decimal (1 to 255) or in hexadecimal (01 to FF). A computer assembler automatically converts decimal numbers to hexadecimal hence either of the following may be used

```
   E6FF   LDA   255,X
or E6FF   LDA   $FF,X
```

Try this example.

```
AE00   LDX   #0
E680   LDA   $80,X
83     SWI
```

It should give the same results as the previous example.

The indexed, 16bit-offset mode operates in a similar way to the 8bit-offset one but two extra bytes are required after the op-code to contain the 16bit offset, making three-bytes. A 16bit offset allows access to any location in the memory, e.g.

```
AE85     LDX   #$85
D60700   LDA   $700,X
83       SWI
```

should load the accumulator with AE, the contents of memory location 700+85 or 785 which is in the mask-programmed rom of the 68705P3 (programmed by the manufacturer).

Which of the three indexed modes to be used is not indicated directly in the assembly-language source code; which is used is determined by the offset size. A computer assembler will choose the mode which requires the least number of bytes and this applies when assembling by hand. The main use of the two indexed-with-offset addressing modes is when scanning tables of data in memory. Normally the base address of the table is the value of the offset and initially, zero is loaded into the index register to point to the first value in the table. If the index register is incremented repeatedly, access can be gained to the successive values of tables up to 256byte long. This now covers the six addressing modes that can be used with LDA.

Other instructions

The same basic principles apply to other instructions in section one of the instruction set, so for the other instructions we will just use one of the addressing modes to demonstrate their operation. LDX, the instruction for loading the index register, has already been covered.

Store accumulator, STA. This stores the contents of the accumulator in a memory location dictated by the addressing mode used, e.g.

```
AE40   LDX   #$40
E707   STA   $7,X
```

will store the accumulator contents in address location 40+7. The only exception is that immediate addressing cannot be used as this would imply storing in the byte following the op-code which is part of the program.

Store index register, STX. Identical to STA but used for the index register.

Add memory to accumulator, ADD. Contents of the accumulator are added to a memory location (or an immediate byte) according to the addressing mode, placing the result in the accumulator. If the result is greater than 8bit the carry bit (C) in the condition-code register (CCR) is set, if not the bit is cleared.

Continuing the instruction-set description, the next article covers logical functions, leading to the next group – read/modify/write instructions.

Table 3. 16bit addition and subtraction programs for 6800/6809 microprocessors. By coincidence, machine code for direct addressing on the 6805 processor is the same as for extended addressing on the 6800/6809 types.

16bit addition

1030	B61051	LDAA	$1051
1033	BB1053	ADDA	$1053
1036	B71055	STAA	$1055
1039	B61050	LDAA	$1050
103C	B91052	ADCA	$1052
103F	B71054	STAA	$1054
1042	7E7D97	JMP	START

16bit subtraction

1030	B61051	LDAA	$1051
1033	B01053	SUBA	$1053
1036	B71055	STAA	$1055
1039	B61050	LDAA	$1050
103C	B21052	SBCA	$1052
103F	B71054	STAA	$1054
1042	7E7D97	JMP	START

Table 4. 16bit addition and subtraction programs written in assembly language for the Z80 microprocessor. Add and subtract instructions cannot operate on memory directly so the HL register pair is used as a pointer.

16bit addition

2000	215320	LD	HL,$2053
2003	3A5120	LD	A,($2051)
2006	86	ADD	A, (HL)
2007	325520	LD	($2055) ,A
200A	2B	DEC	HL
200B	3A5020	LD	A, ($2050)
200E	8E	ADC	A, (HL)
200F	325420	LD	($2054) ,A
2012	C30000	JP	START

16bit subtraction

2000	215320	LD	HL, $2053
2003	3A5120	LD	A, ($2051)
2006	96	SUB	(HL)
2007	325520	LD	($2055) ,A
200A	2B	DEC	HL
200B	3A5020	LD	A, ($2050)
200E	9E	SBC	A, (HL)
200F	325420	LD	($2054) ,A
2012	C30000	JMP	START

Forth computer

With applications ranging from video games to research and process control this microcomputer combines the powers of Forth, a fast, threaded computer language/operating system, with an eight-bit processor having 16 bit internal architecture.

by Brian Woodroffe

Today a home or personal computer can more than match at lower cost the performance of a typical mid-1970s minicomputer. Then a minicomputer costing tens of thousands of pounds would have a memory of less than 32K words with a cycle time of about a microsecond and a Teletype terminal capable of ten characters per second. Disc-drive memory was rare and expensive and double-precision/floating-point instructions would be executed by software. This microcomputer design costing a few hundred pounds has a 48K read/write memory operating at 666ns, further 8Kbyte rom containing the operating system, a 100-character-per-second terminal and a 200Kbyte disc memory.

	Forth computer	1970s minicomputer
Memory size	56K (48K ram, 8K rom)	64K ram
Memory speed	666ns	960ns
C.p.u. 16-bit add time	4.6μs	1.96μs
Output peripherals	composite video RS232 8 ports	64 ports
Input peripherals	parallel keyboard RS232 8 ports	standard peripherals
Disc storage	200Kbyte/drive	5Mbyte/drive
Access time	333ms	35ms
Cost	£100-500	£10,000-100,000

The cost of developing control software and language application packages is the main reason why low-cost microprocessors have not destroyed the minicomputer industry. It will be a long time before any microprocessor has the software support of the PDP11! Further, when designing a home computer from the i.cs upwards one does not have the support of other computers to develop the software on and one cannot afford to develop the software alone. For these reasons the control program was chosen from those already available. This also applied to the choice of language; I was not willing to start from the bottom with machine code, for one sees too little reward for the effort of keying in programs on a hexadecimal keypad, nor was I prepared to design a 'bootstrap' rom that loaded the operating system in from disc, for I felt it an unnecessary commitment while the rest of the system was unproven.

Language/operating-system choice

The most popular operating system and language in the microcomputer field are CP/M and Basic respectively. Although Basic is readily available, in for example the INS8298 rom for the 8080, I was not prepared to use the language for reasons too many to mention but summed up by Dijkstra[1] who said "It is practically impossible to teach good programming to students that have had prior exposure to Basic." He seems equally impressed by most other languages, including Fortran, PL/1, Cobol, APL and Ada.

My first choice would have been Pascal but for this application Forth appeared to be the best choice. Besides being a language, Forth forms the basis of an operating system and the Forth Interest Group[2] have made FIG Forth a public-domain product. The language is efficient, which is important when using a processor with a limited address range of 64K and it is interactive, avoiding the traps of edit-compile/load-run phases which are a left over of batch-processing systems. FIG Forth is a single-operator, single-task operating system but it has 'hooks' which allow it to be expanded into a multi-operator, multi-task system. It promotes good programming habits in that its programs are structured in blocks and work from top to bottom.

The language has drawbacks – unfamiliar notation, no file structure and poor data structures – but it is readily available and has more advantages than disadvantages. The power and flexibility in Forth allows the operator to expand the language and add any desired feature, and a new version of Forth may be placed on disc by editing and compiled using the resident language to give a completely user-defined version.

Forth

Details of Forth and how it operates are available (ref. 3) and the following is a brief summary. Forth uses 16bit arithmetic and reverse Polish notation, which implies the use of a data stack. Control between executable statements, referred to as a word, is accomplished by the use of indirect-threaded code and a control stack which is separate from the data stack. Features of Forth not found in Basic are virtual memory, compiling, extensibility and vocabularies. These features make better use of the processor resources and a program written in Forth will use less memory and run faster than its Basic equivalent, often by a factor of ten or more in both cases. As Forth compiles the 'English' program into a form readable by the processor (threaded code) the operating speed will always be faster than when using Basic which stores the program as text. Memory space taken up by compiled code is much smaller than would be taken up by its equivalent in English text so larger programs are possible in a limited memory space.

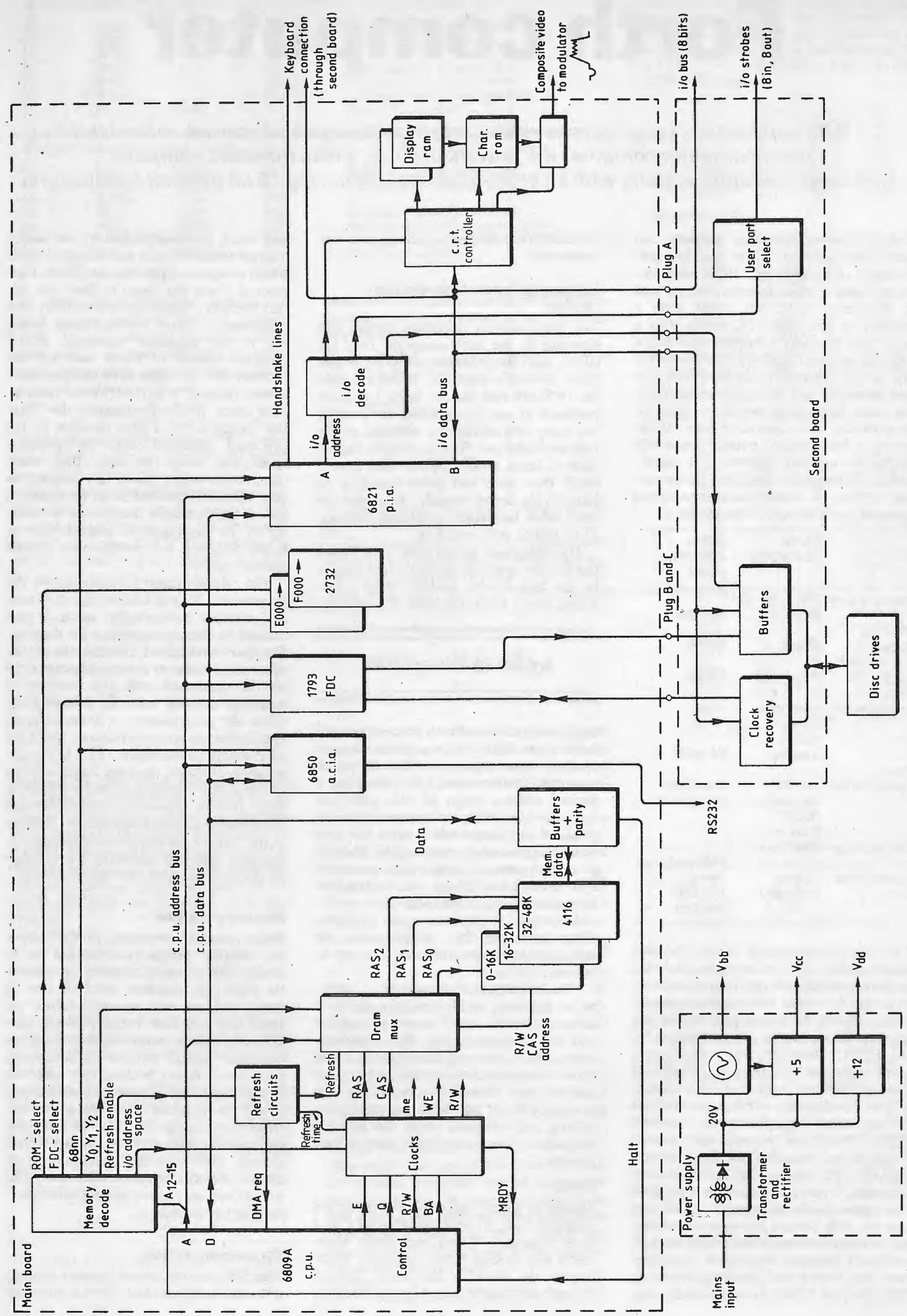
The virtual-memory feature allows the programmer to treat disc storage as processor memory so memory space is not limited by the processor but by the disc. Data is moved to and from the disc by the operating system so the programmer need not be concerned with the problem of mapping the disc memory. Vocabularies allow the programmer to keep different application programs in memory which are physically concurrent but logically separate. Further, there are features found in Forth that are not generally available in Basic such as recursion, extensibility and self-compiling. Recursion allows a portion of the code to use itself more than once at the same time and extensibility is the ability of Forth to define new control words.

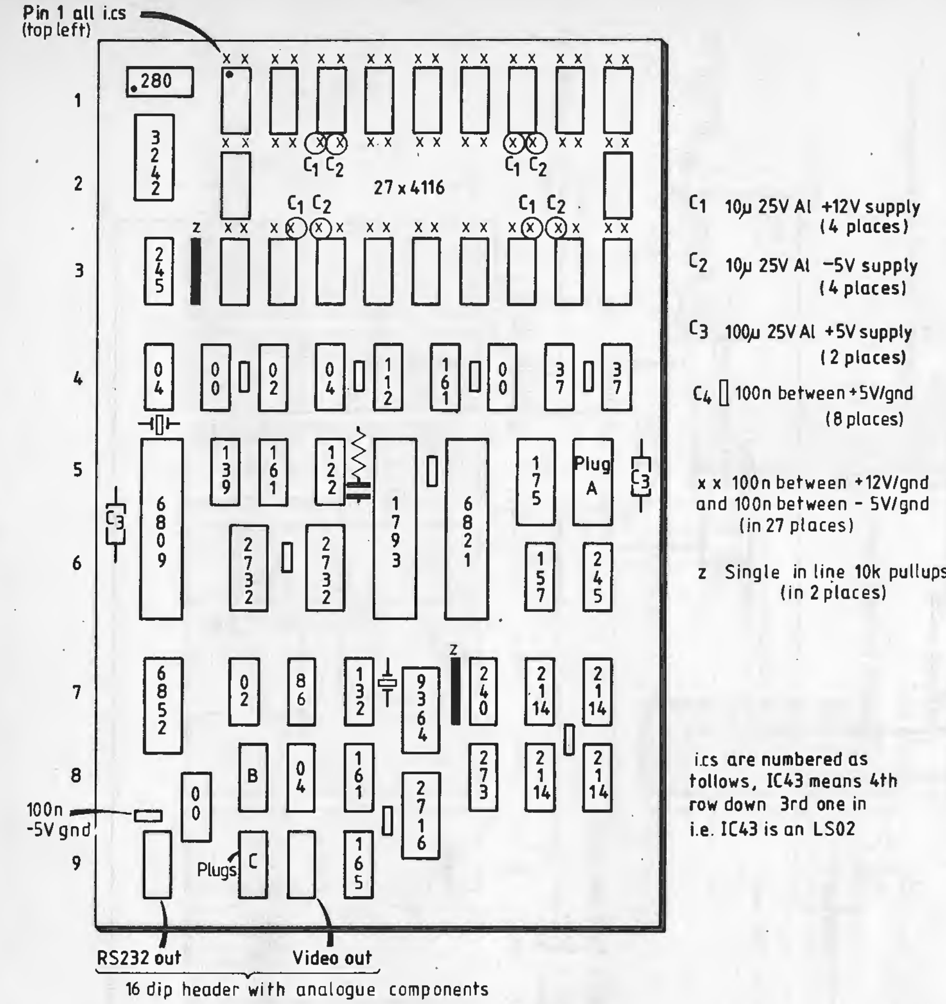
Memory choice

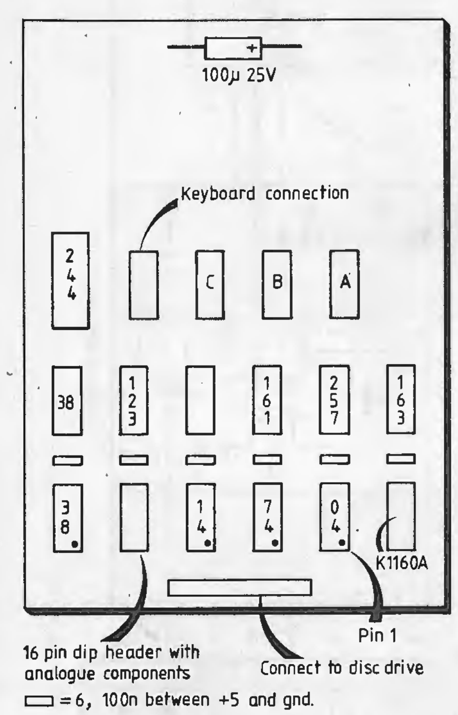
Before selecting a processor for the computer, another design decision has to be made. This concerns memory, in particular what type and how much to use. In time, memory will always become too small and too slow because of the programmer's rising expectations of what the computer should do[4], so 4116 dynamic rams were chosen because they offer the best performance in terms of cost, size and power consumption when compared with static rams such as the 2114. This decision does present some problems in that refresh circuits and three-rail supplies are required. Because dynamic rams are prone to 'soft' errors, parity-checking circuits are included in the design.

Processor choice

The Z80 microprocessor contains dynamic ram refresh circuits and CP/M is written in







Complete Forth computer system has a 48K memory, floppy disc storage and memory-data parity checking but the system may be used with 16K ram and without disc storage and parity checking to reduce costs. Wire wrapping allows the computer to be built on one relatively small board with a minimum of bus buffering. A further small board holds the disc controller and i/o-port hardware. The system can be set to read most disc formats.

Z80 machine code which surely explains why it is the most widely sold processor, but to use Forth, the most suitable 8bit microprocessor is the 6809. Although most of Forth is written in Forth, the computer must execute some machine code to interpret the most primitive Forth instructions. The 6809 has indexed addressing modes (see "6809 evaluation system" by R. Coates, *Wireless World* July 1980) which suit stack operations and as said earlier, Forth uses two stacks. These examples of stack addition illustrate the merits of the 6809; they represent code of the Forth word '+' for various processors.

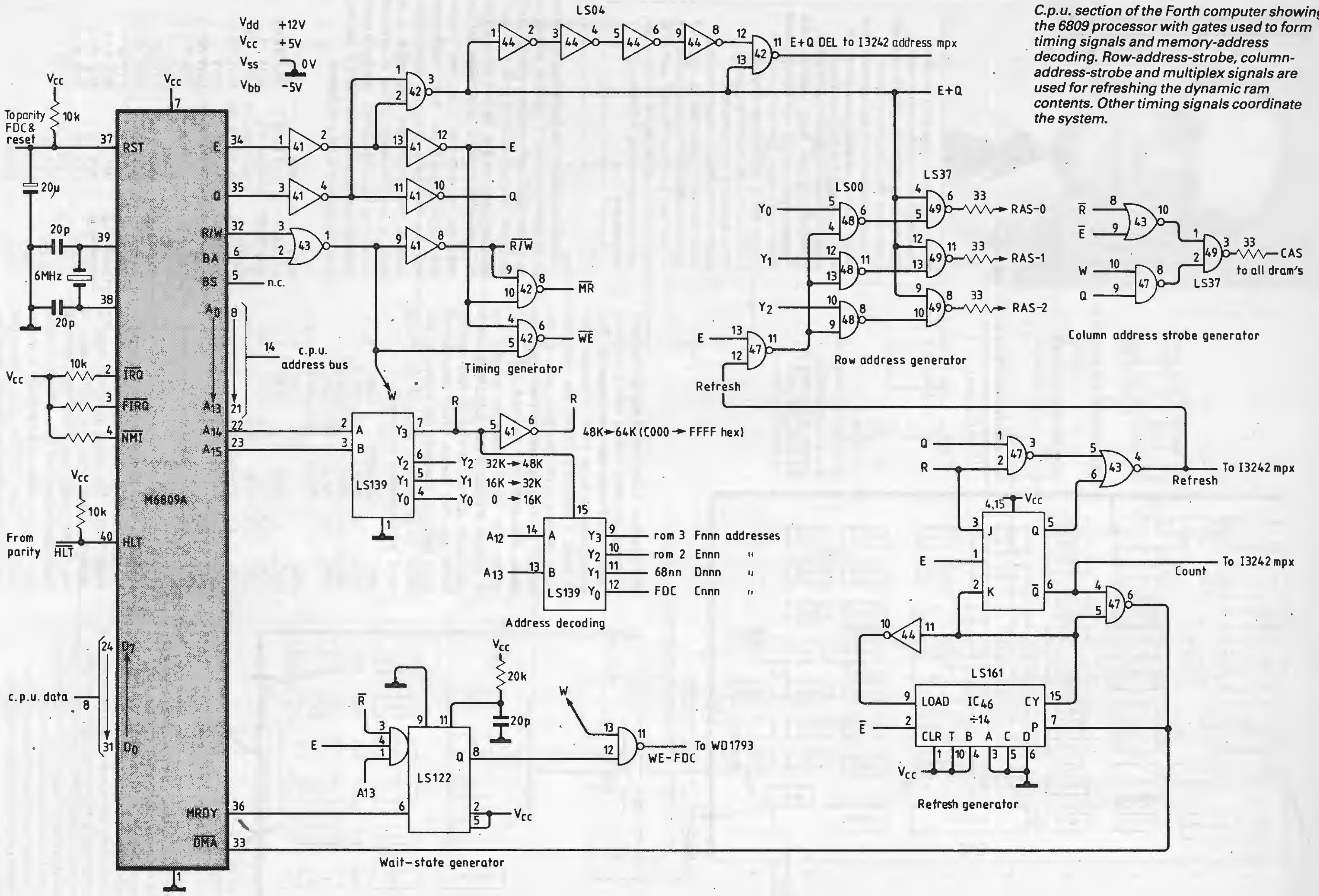
```
6809            Z80/8085        6800
PULU   D        POP     D       PULB
ADDD   0,U      POP     H       PULA
STD    0,U      DAD     D       TSX
                PUSH    H       ADDB  1,X
6502                            ADCA  0,X
CLC             8088            STB   1,X
LDA    0,X      POP     AX      STA   0,X
ADC    2,X      POP     BX
STA    2,X      ADD AX,BX
LDA    1,X      PUSH    AX
ADC    3,X
STA    3,X
INX
INX
```

Secondly, the 6809 instruction set is particularly suited to code the crucial Forth word 'next'. The speed at which 'next' is executed determines the performance of the Forth system since this word controls the indirect-threaded code. 'Next' is called the inner (or address) interpeter to distinguish it from Forth's text interpreter which performs the function of a compiler.

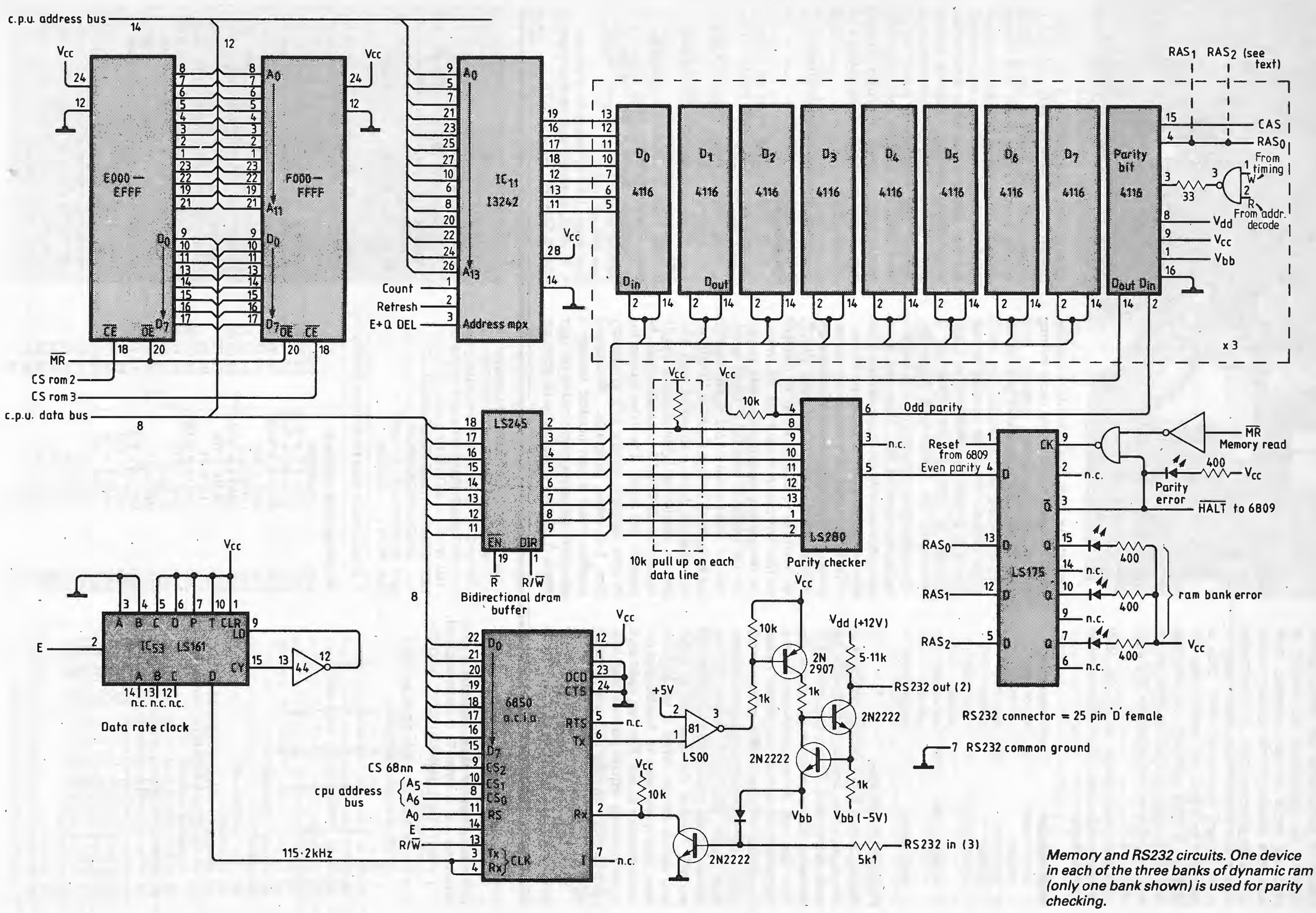
Having worked in Hewlett Packard's production and systems-engineering departments, Brian Woodroffe currently works with the company's South Queensferry research and development group and has recently been involved with designing the microprocessor control section of the HP3724/25/26A baseband analyser. Brian obtained a BA degree in engineering and economics at Downing College, Cambridge in 1970 and an MA in 1975. His computing interests include real-time control, languages and microprocessor graphics but outside electronics, his main interest – rifle shooting, in which he has represented Scotland in full bore – has been curtailed through part-time studies for an M.Sc degree in computer systems engineering at Edinburgh University.

Machine code in the computer emulates Forth operation, the Y register taking on the role of the Forth program counter, and the Forth instruction-fetch cycle is a 'next' machine-code routine. So you can see that the processor choice is dominated by the speed and memory cost of the 'next' operation. Equivalent Forth 'next' operations for some microprocessors are listed below. Because the 6809 'next' operation is so short, it may be copied in line as required resulting in improved performance through avoiding the JMP NEXT instruction required for most processors.

```
6809            8088            6502
LDX 0,Y++       JMP NEXT        JMP NEXT
JMP [0,X]       LODS AX         LDY #1
(4.11)          MOV BX,AX       LDY [IP],Y
                MOV DX,BX       STA W+1
Z80/8085        INC DX          DEY
JMP NEXT        JMP WORD        LDY (IP),Y
LDAX B            PTR (BX)      STA W
INX B           (3.19)          CLC
MOV L,A         6800            LDA IP
LDAX B          JMP NEXT        ADC #2
INX B           LDX IP          STA IP
MOV H,A         INX             BCC $+4
MOV E,M         INX             INC IP+1
INX H           STX IP          JMP W-1
MOV D,M         LDX 0,X         (1.25)
XCHG            STX W
PCHL            LDX 0,X
(1.37)          JMP 0,X
                (1)
```



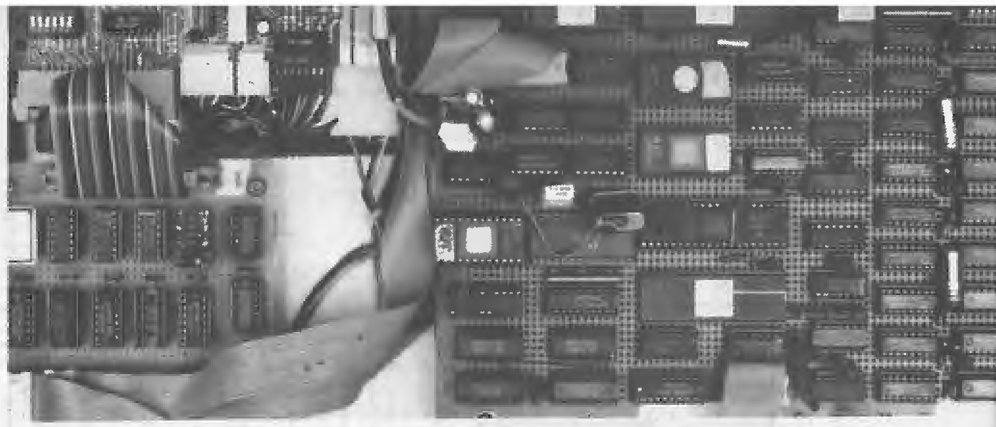
C.p.u. section of the Forth computer showing the 6809 processor with gates used to form timing signals and memory-address decoding. Row-address-strobe, column-address-strobe and multiplex signals are used for refreshing the dynamic ram contents. Other timing signals coordinate the system.



Memory and RS232 circuits. One device in each of the three banks of dynamic ram (only one bank shown) is used for parity checking.

Values in parentheses are merit figures obtained by multiplying the number of processor cycles by the processor cycle time then dividing by the memory-access time in the processor cycle. It is interesting to note that the 6809 fares better than the more recently introduced 8088. This is especially so when one realises that the 8088 has a 16bit arithmetic unit whereas the 6809 in common with the other processors noted has an 8bit arithmetic and logic unit (a.l.u.).

Finally, the register set of the 6809 exactly matches that which is required to operate Forth.



6809 register		Forth operation	
S	system stack pointer	RP	return stack pointer
U	user stack pointer	SP	data stack pointer
Y	index register	IP	instruction pointer
X	index register	W	code field pointer
D	accumulator		accumulator

Peripheral devices

Having chosen Forth and the processor to run it on, other design requirements are easily determined. These were selected to maximize the number of peripheral devices that can be easily driven. First a floppy disc was included to provide a modest amount of non-volatile memory with much faster operation than tape recorders. Mini floppy discs were chosen for two reasons, firstly because they are cheap and secondly because the data rate of eight-inch double-density drives is too high for most microprocessors to handle without direct-memory access. Further, eight-inch drives normally require phase-locked loop clock-recovery circuits and also a mains supply.

Three-inch disc drives from Sony were investigated but the data transfer rate is high so that only single-density recording could be used, which would mean wasting half of the data-storage capacity. Both these drives and eight-inch types can be used with the system, provided they run in single density. Processor memory in this system is greater than 40Kbyte so a disc capacity of greater than 400Kbyte is reasonable; one double-sided floppy-disc drive meets this requirement. It is interesting to note that the BBC Micro and Atom computer can only use single-density 5¼in disc drives because of data-rate problems.

Different types of terminal are accommodated. Operating-system words for terminals, KEY, TERMINAL and EMIT, are vectored so that they may be changed on-line between terminal types. At switch-on the system automatically sets vectors for the available terminals. These terminals are either serial RS232 or 8bit parallel for a keyboard such as the RCA VP601/611 and integral video compatible with 625-line tv, displaying 1,024 characters in 16 lines (the EF96364B controller may be used for 525 lines). The video section has its own memory, leaving 48K of memory free for other programs. Bit-mapped graphics video is best handled through a secondary processor connected to the user ports. A number of definable i/o ports are spare to allow for expansion of the system.

Certain design features were included to reduce cost. By keeping the computer system down to one board, bus drivers necessary to overcome capacitance encountered in larger systems are avoided. Another reason for avoiding these buffers is that they cause delays which eat into the access time available from communicating devices. The switch-mode power supply used means that a readily obtainable transformer with a single secondary winding may be used to provide all three rails (+12, +5 and −5V). WW

Next article describes computer circuitry.

References

1. E. W. Dijkstra, How do we tell truths that might hurt? ACM Sigplan notices, vol. 17 no 5, May 1982, p.14.
2. Forth Interest Group (FIG), PO Box 1105, San Carlos, CA94070, USA.
3. L. Brodie, Starting Forth. Prentice Hall, 1981.
B. Allan, Forth: a threaded interpretive language, *Wireless World* Nov. 1982 p.74.
G. Feierbach, Forth – the language of machine independance, Computer Design, June 1981 pp.117-121.
Byte, August 1980 for various Forth articles.
4. W. Wulf, Compilers and Computer Architecture, *Computer*, July 1981 p.41.

continued from page 50

Z8 Basic listing for eight-channel a to d converter (@ ≡ byte, % ≡ hexadecimal)

```
   1 PRINT "SILICONIX LD120/121A TO Z8
     INTERFACE"
   2 PRINT "HIT ANY KEY TO RUN";: GO
     @%61,%07:R=USR(%54)
   5 A =  (      ) : B =  (      )
  10 C =  (      ) : D =  (      )
  15 E =  (      ) : F =  (      )
  20 G =  ( see* ) : H =  ( see* )
  25 I =  (      ) : J =  (      )
  30 K =  (      ) : L =  (      )
  35 M =  (      ) : N =  (      )
  40 O =  (      ) : P =  (      )
  45 N =1 : Z=%80
  50 @2=Z
  55 @3=%A0:03=00
  60 @2=%00 .
  70 W =W+1:IFW<15 THEN 70
  80 W =0:GO@%1400 (m.c. routine for
     collection of data)
  85 IF N=1 THEN X=A: Y=B: GO TO 130
  90 IF N=2 THEN X=C: Y=D: GO TO 130
  95 IF N=3 THEN X=E: Y=F: GO TO 130
 100 IF N=4 THEN X=G: Y=H: GO TO 130
 105 IF N=5 THEN X=I:  Y=J: GO TO 130
 110 IF N=6 THEN X=K: Y=L: GO TO 130
 115 IF N=7 THEN X=M: Y=N: GO TO 130
 120 IF N=8 THEN X=0:  Y=P: GO TO 130
 125 GO TO 45
 130 Z=Z+%10
 135 V=@%26+@%25×10+@%24×100
     +@%23×1000+@%22×10000
 140 IF V>X THEN PRINT "CHANNEL";
     N;"OVERRANGE";:GO TO 1000
 145 IF V<Y THEN PRINT "CHANNEL";
     N;"UNDERRANGE";:GO TO 1000
 150 N=N+1: GO TO 50
1000 GO@%61,%07:PRINT @%22;".";
     @%24;@%25;@%26;
1010 PRINT"MAX";X;"MIN";Y
1020 N=N+1 : GOTO50
```

*Limits entered here for process monitoring.

Machine code routine

Line	Assembler	Hex
200	LD % F7, # % 41	E6 F7 41
210	LD % F6, # % 0F	E6 F7 0F
220	AND 3, # % 04	56 03 04
230	JRZ, * 220	6B FB
240	LD % 22, 2	E4 02 22
250	AND 3 # % 04	56 03 04
260	JR N2, * 250	EB FB
270	CLR % 21	B0 21
280	AND 3 # % 08	56 03 08
290	JRZ, * 270	6B FB
300	PUSH 2	70 02
310	INC % 21	20 21
320	CP % 21, # 4	A6 21 04
330	JRZ 2, * 350	6B 07
340	AND 3, # 08	56 03 08
350	JR N2 * 320	EB FB
360	JR * 270	8B EB
370	POP % 26	50 26
380	POP % 25	50 25
390	POP % 24	50 24
400	POP % 23	50 23
410	RET	AF

Using the Z8 microprocessor

The potential of the Zilog Z8 microcomputer for low-volume or one-off applications has not been well publicised. Introduced in 1981, the chip includes all the blocks that you would find in a standard computer system including c.p.u., ram, i/o and a rom containing Tiny Basic. In addition there are two timers, one for serial i/o, the other available to the user. External memory of 60K can be added for program storage together with 60K of data storage. The evaluation kit used in this was supplied by Ambit International and posesses a comprehensive monitor, enabling machine-code routines to be written in Assembler and stored in eprom. The Tiny Basic name does not reveal the full potential of itself, and with an 8MHz clock driving the Z8, it executes most of the instructions in 1.5 to 2.5µs.

LETTERS

CABLE AND AMATEURS

As our very good friend Pat Hawker (G3VA) has mentioned on more than one occasion the question of cable tv (c.a.t.v.) being installed for tv links and its possible QRM (interference) to the amateur bands between 5MHz and possible infinity (GHz?) is looming.

With the notification of the RFI Bill 5.929 last September, it would appear that 'we' as the amateur population are dragging our feet somewhat.

Hopefully, as I ask you to publish these few words, someone somewhere, here in the UK at least, will take note to realise that if c.a.t.v. is to progress without (?) problems then parties must get together quickly.

It not only affects the amateur and/or industry-at-large but in some cases the s.w.l. and domestic listener/viewer.

Bear in mind that radio amateurs throughout the world form a substantial part of the balance of payments of varying countries, and after all, not every firm depends on MOD contracts. The naive idea that amateurs 'do not count' according to some professional engineers must be looked at in the light of future and past developments in both radio and tv. In short, what works in theory doesn't always work in practice, so consequently the need for liaison between interested parties, notably the RSGB on the one hand and industry and the Home Office on the other. The RSGB and others are aware of this problem regarding c.a.t.v. and it should not be allowed to drift.

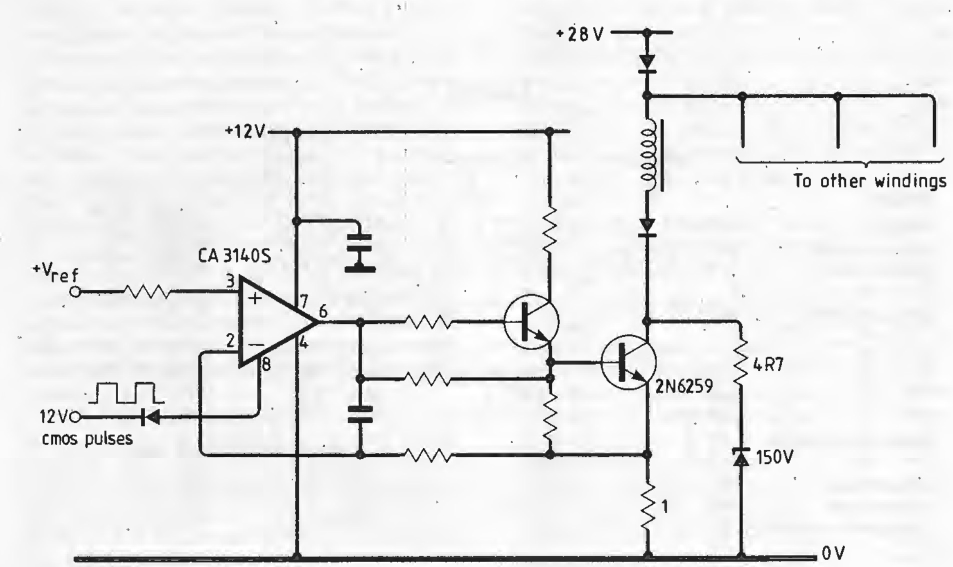
J. A. Holmes, G4LRS
Chingford
London

STEPPER MOTOR DRIVE

The 'Stepper motor driver circuit' article (*WW* February 1983) describes as novel a system which is certainly not new. A t.t.l. chopper drive circuit, while efficient, was found to cause excessive radiated interference (up to 400MHz) when fitted to an aircraft, so I designed a pulsed constant-current circuit using exactly the same principles as in Mr Bailey's article. A simplified circuit is shown below; it is a standard high-power current sink set at one amp. per volt of V_{ref}., and gated by the pulse train to pin 8. One circuit is required for each phase of the motor which in this case is a large V.R. type.

This circuit has been in use since early 1977; I had no reason to suppose it was novel then.

B. S. Beddoe
Wimborne
Dorset



HERETICAL PHYSICS

Those of us who are approaching the age of 80 can hardly bear to wait a month to find out what kind of Newer Physics is going to turn up in the *WW* "Letters". Some of the ideas are so oddly fascinating that it seems a real pity that they cannot all be right.

Attractive though this is, I cannot help remembering the professor of physics who reminded his students that what happened on the lab. bench was real, whereas what went on inside human heads was mostly fantasy, and often pathological fantasy at that.

P. C. Smethurst,
Bishop's Stortford, Herts.

ELECTROMAGNETIC DOPPLER

In your March 1983 issue, your correspondant J. Kennaugh asks how the Doppler shift is produced in electromagnetic waves. Specifically he quotes the relaticistic Doppler equation as:

$$\frac{f_o}{f_s} = \left(\frac{c-v}{c}\right)\left(\frac{1}{\sqrt{1-v^2/c^2}}\right)$$

and asks "what is the physical mechanism which produces the first term?". The "physical mechanism" is the velocity, v.

J. K says that if the wave propagation velocity is the same to both observers then the only possible variable is time. I don't understand why J.K. says this. If two objects are travelling away from each other then the distance between them is increasing.

If one of these objects generates something – say "wave crests" – at regular intervals, and if these wave crests travel through space to the other object, then each successive crest has further to travel and consequently takes longer over the journey. The frequency of arrival is lower than the frequency of departure. If we take the transmission frequency to be f_s and the received frequency to be f_o, the relative velocity between the objects as v and the propagation velocity as c, then for "modest" v a moment's work with pencil and paper gives:

$$\frac{f_o}{f_s} = \frac{c-v}{c}$$

In this equation f_o, f_s, c and v are all measured by the same observer. J.K. says that (c-v) is the velocity of light relative to the observer. Not true. (c-v) is the difference between the rate at which light (or radio waves) cross the gap (c) and the rate at which the gap is increasing (v).

Note that this last equation arises naturally from the definitions of velocity and frequency – no obscure "physical mechanism" is needed.

Another point. If both objects transmit at identical tramsmitter frequency then each will receive a lower frequency (Doppler shifted) than they transmit. At object A, the transmitter frequency f_A is higher than the received frequency from B (f_B) – $f_A>f_B$; at B, by the same process $f_B>f_A$. There is a sense in which $f_A>f_B$ *and* $f_A<f_B$. If you think that this "doesn't conform to the laws of mathematics" then you have three (not two) choices: reject the Doppler effect; reject maths; or find an error in your "deduction".

S. Hobson
Hampton
Middlesex

I have been unable to find the answer to what is superficially a straightforward question: what is the mechanism by which Doppler shift is produced in the case of electromagnetic waves?

In acoustics, when two observers in relative motion observe the same sound wave they measure different frequencies because the wave is passing each at a different relative velocity. If V_{R1} and V_{R2} represent the velocities of observers 1 and 2 relative to the wave then

$$f_1\lambda = f_2\lambda \qquad (1)$$

$$\text{or } \frac{f_1}{f_2} = \frac{VR_1}{VR_2} = \frac{V-v_1}{V-v_2} \qquad (2)$$

Equation (2) is the derivation of the more familiar form of the equation where the relative velocity of wave and observer is expressed in terms of the velocity of propagation in the medium V, and the velocity of the observers relative to the medium V_1 and V_2.

The e.m. Doppler shift equation (3) can be verified experimentally to a high degree of accuracy.

$$\frac{f_o}{f_s} = \frac{c-v}{c} \qquad (3)$$

Now if, as I have seen stated, "similar principles apply" one can deduce two things.

(1) that the velocity of light relative to the observer is c-v, which is in direct opposition to the postulate of relativity which insists that the velocity of light is always c independent of relative motion between source and observer;
(2) that the velocity of light is constant relative to the source, which would provide an ade-

quate explanation of the null result of the Michelson-Morley experiment and would support the corpuscular/photon model of light, photons being "shot" out of matter at constant "muzzle" velocity.

A further piece of evidence supporting (2) is that of star aberration. In 1729 Bradley showed that the apparent direction of a star is actually the vector sum of velocity of the light from the star and that of the earth. It would seem that there is at least some evidence to support the view that the velocity of light is constant with respect to the source and that this would resolve the dilemma presented to physics by the Michelson-Morley experiment. As physics has not accepted this path one can logically assume that there must be overwhelming evidence to the contrary which supports the postulate that the velocity of light is always constant independent of the velocity of the source. I have looked in vain for such evidence: most books seem to manage without any, the only evidence I have found being de Sitters' observation of double stars. If the whole of modern physics is based only on that I think we should all be worried.

The standard technique seems to be to ignore Doppler and aberration, to fudge the evidence in respect of the postulate and dive straight into the mathematics of relativity.

From this appear the relativistic Doppler shift equation and aberration equation. Thus having shown that both are embraced by relativity one never has to ask the questions I have raised. Now the relativistic Doppler equation may be written.

$$\frac{f_o}{f_s} = \left(\frac{c-v}{c}\right)\left(\frac{1}{\sqrt{1-v^2/c^2}}\right)$$

The second term is time dilation, which for modest values of v is equal to unity. My question is what is the physical mechanism which produces the first term which appears to be the ratio of two velocities. If the velocity of the wave is the same to both observers there is effectively only one other possible variable and that is time (note distance can be defined as the distance travelled by a light beam in unit time) so that if the first term is not due to a difference in velocity of wave it must be due to a time difference or time dilation. Both observers observe the same wave. They both observe that it is travelling at the same velocity yet they disagree as to its frequency because their clocks are ticking at a different rate. But whose clock is ticking faster. It depends on which observer is sourcing the beam of light. If both send a beam to the other simultaneously then we get the mathematical absurdity.

$T_A > T_B$ and $T_A < T_B$ – both true.

This type of "paradox" has been mentioned in *WW* before, but surely either the result must be rejected because it doesn't conform to the laws of mathematics, or the laws of mathematics are wrong, in which case the derivation of the result must be rejected as being based on faulty mathematical laws.

I would welcome any suggestions as to where I am going wrong.

Appendix
Double Stars

For those unfamiliar with this piece of evidence the idea is that if the velocity of light was constant with respect to the source then the light from a star in a binary system which is travelling towards us would tend to overtake that from the star going away from us with the result that their observed orbits would seem irregular. De Sitter observed double stars and no orbital irregularity. I have yet to find out when or where these observations took place, the magnitude of the expected irregularity, de Sitter's measurement accuracy, and why he didn't get a Nobel prize for this obviously vital work.

J. Kennaugh
Cornwall

DIMENSIONS

The arguments which appear in the letters to Wireless World month by month on the validity and meaning (if any), of D and B, E and H, the products of μ and ε and the ratio of μ and ε, seem never ending. As a student in the late 1940s I was obliged to learn such formulae and their "dimensions" in e.m. units, e.s. units and Gaussian units from the famous text books of S. G. Starling. The apparent duality of e.m.u. and e.s.u. systems and their quaint skew symmetry appealed to the mystics who mused on the inner meaning of the symmetries. At that time the main practical use to me was as a means of checking half-remembered formulae in examinations!

With the introduction of S.I. units, the theory of dimensions seems to have fallen into disuse or was considered 'not quite decent', except in the pages of *Wireless World*.

In the early 1950s, while designing and testing waveguide components, I was very impressed with the frequency with which the expression $(\sqrt{\mu/\epsilon}) = Z_o$ appeared in texts dealing with waveguides and aerials and the concept that Z_o was the characteristic impedance of free space for plane e.m. waves appealed to me. I remember noticing that if one listed such properties as charge, "magnetic pole", electric field, B and D, E and H and so on, with their e.m.u. and e.s.u. dimensions in separate columns, most of the e.m.u. dimensions occured in powers of $\epsilon^{1/2}$ or $\epsilon^{-1/2}$ while the e.s.u. dimensions of that property was usually expressed in corresponding powers of $\mu^{-1/2}$ or $\mu^{+1/2}$.

I then made up a third column in which the dimensions were the geometric means of the dimensions in the e.m.u. and e.s.u. columns, expecting to find an inconsistency, but to my surprise I found this was also a self-consistant system of dimensions in which the "4th dimension" was $(\sqrt{\mu/\epsilon})$, which I have denoted by Z in Table 1. Symmetry was greatly improved. The skew symmetry between e.m.u. and e.s.u. dimensions of analogous magnetic and electric properties had now vanished, so far as ML and T were concerned, and only appeared as opposite sign in the index of Z. I therefore added a 4th column in M,L,T and Y, where $Y=Z^{-1}$. The skew symmetry now reappears, but with no mystery, as *WW* readers have been considering the duality of networks expressed in terms of impedance and admittance for a very long time!

It would now seem that the duality of magnetic phenomena and electric phenomena has a very close affinity to that duality used in networks expressed in Z and Y. At this stage, I discovered that Fitzgerald had known about the M,L,T,Z system of dimensions in the late 19th Century but was unable to identify Z which he regarded as a "slowness" or "retardation" of some kind. So Fitzgerald abandoned the concept. The Z system of dimensions does not derive logically from inverse square laws of forces between magnetic poles and electric charges which many people regard as impossible experiments, anyway.

So far, I have never found any inconsistencies in the Z system outlined here and would be obliged to readers who can point any out to me. I have unfortunately now lost the reference to Fitzgerald's paper which may have appeared in an early series of *Proc. Roy. Soc.* or *Phil. Mag.* in the 1890s. Can anyone help?

It is well-known that despite similarity in the mathematical methods from which they are derived, resistance and reluctance are not analogous electric and magnetic phenomena. This is demonstrated in Table 1 in e.m.u., e.s.u. and also in Z systems of dimensions. I am inclined to believe that more attention should be paid to the nature of Z and the dynamic properties of e.m. radiation, following Maxwell, rather than tackling static properties like μ + ε, derived from impractical hypothetical experiments. A change from mass to 'spin' or 'action' is also interesting for simplifying charge and 'magnetic pole', B + D and flux.

Whether the Z system will throw any light on the problems of your correspondents is incalculable; all I can hope is that by throwing yet another pebble into the pond perhaps some other obscuring ripple may be temporarily cancelled out, allowing a momentary glimpse of the underlying physics before too much mud is stirred up!

E. F. Dawson
Melton Mowbray
Leicestershire

TABLE 1

Property	Dimensions in ESU	Dimensions in EMU	Geometric mean of ESU & EMU $Z=\sqrt{\mu/\epsilon}$	$Y=Z^{-1}$
charge	$M^{1/2}L^{3/2}T^{-1}\epsilon^{1/2}$	$M^{1/2}L^{1/2}T^{0}\mu^{-1/2}$	$M^{1/2}L^{1}T^{-1/2}Z^{-1/2}$	$M^{1/2}L^{1}T^{-1/2}Y^{1/2}$
magnetic pole	$M^{1/2}L^{1/2}T^{0}\epsilon^{-1/2}$	$M^{1/2}L^{3/2}T^{-1}\mu^{1/2}$	$M^{1/2}L^{1}T^{-1/2}Z^{1/2}$	$M^{1/2}L^{1}T^{-1/2}Y^{-1/2}$
electric field E	$M^{1/2}L^{-1/2}T^{-1}\epsilon^{-1/2}$	$M^{1/2}L^{1/2}T^{-2}\mu^{1/2}$	$M^{1/2}L^{0}T^{-3/2}Z^{1/2}$	$M^{1/2}L^{0}T^{-3/2}Y^{-1/2}$
magnetic field H	$M^{1/2}L^{1/2}T^{-2}\epsilon^{1/2}$	$M^{1/2}L^{-1/2}T^{-1}\mu^{-1/2}$	$M^{1/2}L^{0}T^{-3/2}Z^{-1/2}$	$M^{1/2}L^{0}T^{-3/2}Y^{1/2}$
B	$M^{1/2}L^{-3/2}T^{0}\epsilon^{-1/2}$	$M^{1/2}L^{-1/2}T^{-1}\mu^{1/2}$	$M^{1/2}L^{-1}T^{-1/2}Z^{1/2}$	$M^{1/2}L^{-1}T^{-1/2}Y^{-1/2}$
D	$M^{1/2}L^{-1/2}T^{-1}\epsilon^{1/2}$	$M^{1/2}L^{-3/2}T^{0}\mu^{-1/2}$	$M^{1/2}L^{-1/2}T^{-1/2}Z^{-1/2}$	$M^{1/2}L^{-1}T^{-1/2}Y^{1/2}$
μ	$M^{0}L^{-2}T^{2}\epsilon^{-1}$	$M^{0}L^{0}T^{0}\mu^{1}$	$M^{0}L^{-1}T^{1}Z^{1}$	$M^{0}L^{-1}T^{1}Y^{-1}$
ε	$M^{0}L^{0}T^{0}\epsilon^{1}$	$M^{0}L^{-2}T^{2}\mu^{-1}$	$M^{0}L^{-1}T^{1}Z^{-1}$	$M^{0}L^{-1}T^{1}Y^{1}$
electric resistance R	$M^{0}L^{-1}T^{1}\epsilon^{-1}$	$M^{0}L^{1}T^{-1}\mu^{1}$	$M^{0}L^{0}T^{0}Z^{1}$	$M^{0}L^{0}T^{0}Y^{-1}$
capacitance	$M^{0}L^{1}T^{0}\epsilon^{1}$	$M^{0}L^{-1}T^{2}\mu^{-1}$	$M^{0}L^{0}T^{1}Z^{-1}$	$M^{0}L^{0}T^{1}Y^{1}$
inductance	$M^{0}L^{-1}T^{2}\epsilon^{-1}$	$M^{0}L^{1}T^{0}\mu^{1}$	$M^{0}L^{0}T^{1}Z^{1}$	$M^{0}L^{0}T^{1}Y^{-1}$
magnetic reluctance	$M^{0}L^{1}T^{-2}\epsilon^{1}$	$M^{0}L^{-1}T^{0}\mu^{-1}$	$M^{0}L^{0}T^{-1}Z^{-1}$	$M^{0}L^{0}T^{-1}Y^{1}$

AERIALS AT SEA

Regarding Wiseman's articles on marine radio, it is unfair to compare Soviet merchant practice with the West's since all Soviet ships are quasi-military and under strict government control, hence "proper" aerials.

I agree that some of the installations are quite appallingly bad and have been neglected, but the root cause is the short aerial, and lack of radiation resistance. Since we cannot emulate the BBC's "big T" at Droitwich within the confines of a ship another solution must be found, and I suggest that the helically loaded glass-fibre whip is the answer. Glass-fibre poles are freely available (pole vaulters use them). Such poles are about twenty feet long and would accommodate around one hundred metres of 16 s.w.g. copper wire. Since these aerials could be manufactured to have a driving-point impedance equal to that of the feeder, insulation losses would be minimal.

Regarding the durability of glass-reinforced plastics, cheap g.r.p. is based on polyester resin, which is hygroscopic and does deteriorate in the space of a few years. G.r.p. reinforced with epoxy resin does not appear to suffer in this way although it is more costly.

Finally if anyone is enterprising enough to make such an aerial, he must be sure to avoid a carbon fibre reinforced pole.

D. Benyon
Bude
Cornwall

HERETICS GUIDE TO MODERN PHYSICS

I would have thought that authors prepared to advertise their Ph.D., B.Sc., and so on would show a more up-to-date knowledge and greater scientific integrity than that displayed in October 1982 *WW* by Dr Scott Murray.

The 'Photon' article revolves round and leads to a conclusion that a special test experiment on counting single photons should be done, and the author confidently predicts the result that individual photons passing through an apparatus would not show interference. I'm afraid that Scott Murray is out of date by 50 years or more; the experiment has been done many times, since photon counters (able to detect single photons) have been available for a long time. And the result – individual photons produce interference fringes just as more intense light does.

I cannot offer an explanation, since apart from using quantum mechanics (which is a mathematical description) there is no explanation in mechanistic terms of what happens. The problem strains our imagination to its limits, but explanation or not, it is a hard experimental fact. I do not think that this can be passed off as a subjective assessment as implied by John W. T. Smith, September, 1982 *WW* letters), since the photomultiplier either does, or does not register photons at certain position along the interference fringe pattern. This experiment has been repeated by many workers, since the topic is of great significance, yet always the same result.

I think therefore Scott Murray should review the contents of any subsequent articles on this theme if they rely on his incorrect anticipation of the photon experiment. A good description of this experiment occurs in Richard Feynman's Book – The Character of Physical Law (BBC Publications 1966).

To further confound Scott Murray, electrons also show wave/particle duality and give interference fringes too; this is also described in Feynman's book.

One further point, articles of a scientific nature, whether 'heretical' or not, are improved by less use of emotive terms like 'dogma', 'mysticism' 'doctrine'. It would seem that the only person with a dogmatic view is Scott Murray himself who has decided to shun the facts and invent his own 'nature'.

B. J. C. Burrows
Benson
Oxford

In the article from the series by Dr Murray which appeared in the December issue he refers to Compton's calculation of the way in which the energy of a gamma ray scattered by a free electron varies with the angle of scattering, though for some reason he describes the scattered gamma ray as a second gamma radiated from the point of impact. He claims correctly that Compton's calculation was based on the model of a billiard ball collision between the gamma ray photon and the electron, but neglects to mention that this model is quite unable to account for the experimental observations of the angular distribution of the scattered photons about the direction of the incident photons. Eventually Klein and Nishina succeeded in deriving an expression for this distribution which is accurate up to and beyond energies of 10 MeV, but they made use of wave mechanics. So much for his assertion that there is 'no indication of wavelike properties of either electrons or photons'.

He goes on to discuss the photo-electric effect. This effect, in which an incoming gamma ray is completely absorbed by a single atom, which then emits a single electron carrying the excess energy, has been studied for many years. Characteristically the electron has a distribution about the direction of the gamma ray which extends over a wide range of angles, and an energy which falls short of that of the gamma ray by an amount which has a series of discrete values determined by the atom from which it is ejected[1]. Thus the process observed experimentally bears little resemblance to the results of Dr Murray's calculation, since according to him 'the direction of the electron's motion must be at right angles to the incident photon's path to within a few hundredths of an angular degree'. Even if one were to take Dr Murray's calculations at their face value, and to accept that they would apply to the photons associated with electromagnetic waves, a 'Murray photon' hitting a vertical dipole aerial would be equally likely to eject an electron from its parent atom so that it moved towards the top, bottom, or sides of the aerial rod, giving zero net induced current!

In general a photon will interact collectively with electrons in an area of the wave front with linear dimensions of at least one wavelength. For the optical photo-effect, in which a photon of visible light ejects a single electron from a suitably prepared surface, the wavelength is some tens of interatomic spacings, so that despite the end result the effect cannot be explained in terms of the interaction of the photon with an isolated electron or atom. A 300 MHz photon, whose energy is some 10^{-9} eV only, would interact collectively with electrons over the whole length of a dipole aerial tuned to that frequency, though I doubt whether individual quantum phenomena as such have been observed at frequencies below 300 GHz. This is hardly the behaviour of a classical particle, and it is not surprising that Dr Murray turned his discussion rather quickly from photons and electromagnetic waves to the consideration of much higher energy photons.

The articles in the series so far have either been written tongue in cheek, or betray a failure to grasp the basic ideas of quantum mechanics and a very limited knowledge of the experimental results which confirm some of its most radical predictions. It is rather unfortunate that *Wireless World* should be propagating this 'disinformation' at the very time when experiments are coming down solidly in favour of one of the most mind-blowing of these predictions, one which is at variance even with the simpler versions of Special Relativity[2].

C. F. Coleman
Grove
Nr. Wantage
Oxfordshire

References

1. C. M. Davisson, 'Interaction of γ-Radiation with Matter', from 'Alpha-, Beta-, and Gamma-Ray Spectroscopy', Ed K. Siegbahn, North Holland, Amsterdam 1965.
2. A. Aspect, P. Grangier and C. Roger, *Phys. Rev. Letters* 47 (1981) 460. R. D. Mattuck, *Eur. Jrn. Phys.* 3 (1982) 107.

Dr Scott Murray (Quantization and quantization, Jan. 83) regards the idea that light seems to consist sometimes of waves and sometimes of particles to be mysticism of the most blatant kind. Indeed it would be if one believes that light 'consists' of waves and particles, since these two entities have mutually exclusive properties.

The idea that any physical phenomenon 'is' or 'consists' of either waves or particles is surely the root of the problem. The concept of wave and of particle are pure abstractions. They summon up in each case a set of mathematical relationships which define what we mean by these abstractions. A bullet or a billiard ball do not 'consist' of particles, nor do ripples on a pond or vibrations in a plank of wood 'consist' of waves. That the abstract set of ideas associated with waves is useful in describing and predicting certain physical events, like the movement of a violin string is true. Similarly, the set of ideas associated with particles is clearly of value in other areas. That light has some properties for which the wave concept is more useful, and other properties for which the particle concept is of greater value presents no contradiction. It simply demonstrates that we have yet to devise a unified, internally consistent set of ideas which are paralleled in the physical world by all of light's manifestations.

M. M. Gleave
Whitstable
Kent

I have an increasing sense of bewilderment on reading Dr W. A. Scott Murray's series of articles so far.

I may be simple-minded, but I am unable to see that certain of Dr Murray's remarks have the remotest connexion with any physical phenomena (". . . prediction is foreign to Nature . . .", ". . . living matter . . . does this (build enzymes etc. for its own convenience) by decreasing entropy locally . . .").

Now Dr Murray unveils what seems to be his fundamental physical paradigm, of "discrete physical entities having real, free-standing existence independently of each other and of any observer, human or deputy." Such a paradigm fails to provide any account even of the simplest interactions between such "entities", and I am afraid it suffers the same fate as all other attempts to explain the obscure in terms of the more obscure.

Indeed, this must be the fate of all attempted explanations which may be produced in accordance with Dr Murray's own criterion of demarcation between physics and mysticism (physical phenomena to be physically explained). Thus, any such attempted physical explanation will involve physical phenomena; but the criterion demands that these be explained physically, and so we either end up with an infinite regress (or a circularity) of physical explanations, or finish after all with something that is not explained at all, or at least not physically! I think we need a better criterion than what Dr Murray has proposed!

In summary, I am afraid that Dr Murray seems to show basic confusion about what is and is not capable of being meant and explained by a physical theory. I am unable to say what is the essence of a better approach to making, using and understanding theories, but anybody who would like to arrive at such an approach could do very well, I believe, to consider the views of Sir Isaac Newton. I quote his refusal to speculate on the nature and origin of the interactions involved in the phenomena of universal gravitation, for which he had provided his celebrated mathematical account: (Concerning such matters) 'I frame no hypotheses; for whatever is not implied by the phenomena is to be called an hypothesis; and hypotheses, whether physical or metaphysical, whether of occult things or mechanical, have no place in experimental philosophy.'.

Newton's 'experimental philosophy' is none other than what we now call science. I suggest that 'hypotheses, whether physical or metaphysical . . .' also have no place in a scientific journal such as *Wireless World*.

Terry Stancliffe
Wimbledon
London SW19

The author replies:

Readers' letters in response to the "Heretic's Guide" series so far have fallen into two categories: the interested and constructive ones have mostly been addressed to me privately and some of them have initiated encouraging correspondence, while the critical and sometimes personally-abusive ones have tended to be addressed to the Editor of *Wireless World* – occasionally even taking him to task too for allowing such nonsense to be published in his magazine! That pattern was predictable and I have no fault to find with it.

One of the recurring topics is the suggestion that the interference of light might disappear at a sufficiently low light level or photon density. What is a "low" photon density? How long is a photon? (A. H. Winterfield, Letters, January). I know of several standard "experimental" answers to that second question, all of them wrong in that they are in conflict with other experimental results. Mr B. J. C. Burrows' letter may be quoted as representing the majority view on this issue. He says that "Scott Murray is out of date by 50 years or more . . . individual photons produce interference fringes just as more intense light does . . . This experiment has been repeated by many workers, always with the same result."

Now the interesting point about this quote is that what Mr Burrows says, although straight down the centre of the established duality doctrine, is not in fact true. Two Russian experimenters, Dontsov and Baz' (Soviet Physics JETP, translated, 25, pp. 1-5, 1967) reported that "photons in light beams are correlated to a considerable degree and cannot be considered statistically independent as a rule . . . the impinging beams contained 'bunches' of photons"; and *after they had dealt with* this bunching (their choice of word, independently of mine), "the beam of statistically independent photons passed through the interferometer without producing an interference pattern."

One part of this experiment was quickly repeated by G. T. Reynolds of Princeton and reported at a symposium at Imperial College in 1969. Reynolds did *not* observe any deterioration of his interference fringes, but although he had attempted to reproduce the Russians' apparatus exactly he used a different kind of light source and his experiment was not performed in quite the same way. The most important difference was that Dontsov and Baz' had taken particular care to quantify photon bunching and to minimize its incidence, but Reynolds and his colleagues simply *assumed* that their photons were statistically independent at the light levels they used.

Therefore, despite Mr Burrows' disagreement, in view of this conflict of experimental findings I still feel that it would be worthwhile to perform at least one more experiment of this general type, taking special anti-bunching precautions and using photon-detection techniques effectively 100 times more sensitive than those of Dontsov and Baz', and Reynolds.

To reply fully to Mr C. F. Coleman would require a letter of at least article length, so instead let me pick out one representative passage for comment. In his third paragraph he says,

"In general a photon will interact collectively with electrons in an area of wave front with linear dimensions of at least one wavelength. For the optical photo-effect, in which a photon of visible light ejects a single electron from a suitably prepared surface, the wavelength is some tens of interatomic spacings, so that despite the end result the effect cannot be explained in terms of the interaction of the photon with an isolated electron or atom."

Once more this is *ex cathedra* doctrine, faithfully reproduced.

Comment one. The terms photon, wave-front and wavelength appear without differentiation in that single first sentence. Here we have Duality supreme: none of the "sometimes behaves like particles" and "sometimes behaves like a wave system" of the doctrine's more cautious apologists. Here light *is* both at the same time. Even among Copenhagen's adherents, not every one will support this extremist line in public.

Comment two. The photon is said to interact collectively with electrons over a linear dimension of at least 10 inter-atomic spacings; given one free electron per lattice atom there will be 100 of them per square wavelength, or up to 1000 of them would be involved if the photon were to penetrate into the material to a depth of just one wavelength. Now, if some 100 to 1000 electrons are interacting with one incoming photon, why is it that *only one* of these electrons is ejected by the photon's impact – and what physical mechanism determines *which* of the electrons is to be ejected? (Please don't tell me that it is ejected from the material by a "probability"!) This was the very argument that in Einstein's hands in 1905 denied the possibility of a statistical mechanism for the photoelectric effect and led directly to the photon hypothesis. Are we to go back on that hypothesis now? (I don't say we shouldn't – I just ask the question).

Comment three. The first sentence in the quotation makes a flat statement of what happens in a photon/photocell interaction, all cut and dried as if it were factually true. How wide is a photon, please? If we knew the answer to that we might be able to "explain the effect" in line with "the end result". Many answers have been proposed to that question, all different and mutually conflicting: it is conventional nowadays to regard the question as "improper" and refuse to recognise it. But in that case perhaps I may reasonably ask instead for a reference to the report of the experiment which measured the diameter of a photon and supports the statement that it is "at least one wavelength" across? I believe there is no such reference; that is one of the fundamental experiments that I have suggested ought now to be done.

Other comments could be made, but perhaps I have said enough. There are many things in the arena of modern physics that none of us understand, and it doesn't help progress for people to insist that we know it all when in fact we don't. It is more seemly to be humble when discussing such difficult problems. Several correspondents such as N. M. Gleave, John W. T. Smith and Professor D. A. Bell have written in a very civilized way on the theme that ". . . we have yet to devise a unified, internally consistent set of ideas which are paralleled in the physical world . . ." (with which I wholeheartedly agree), and that it may never prove possible to devise one because the scope of human thought-processes may be too limiting. There is as yet no evidence of this either way, but it suits my temperament to be optimistic. What I don't go along with is the idea that one should give up trying to understand such things simply because the Copenhagen School, having themselves failed to reach understanding of them, arrogantly pronounced them to be non-questions, unsuitable for the attention of physicists. It is just possible that the Copenhagen School and their followers may have been wrong on that point, as they have been on quite a few others.

I move that we should re-examine our current physical concepts carefully and conscientiously in the light of a few realistic principles ("acceptable paradigms", if you will, *pace* Mr Terry Stancliffe!), and go on trying.

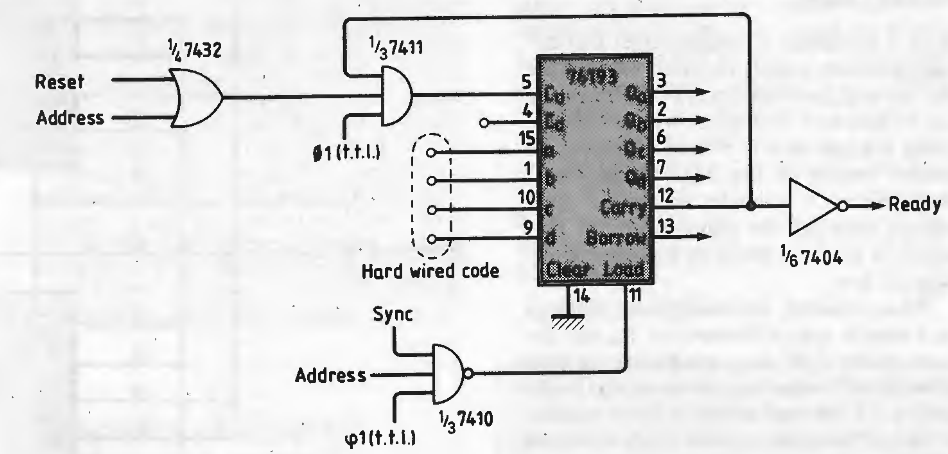
SATELLITE TV SYSTEM

Dr Tomlinson, no doubt, will correct me if I am wrong but his "original method" of digital/analogue modulation (*WW* January 83, pp28,29) seems to me to be a development of the ADAM modem which Freddie Court of SRDE devised, in 1971/72, during his work on SKYNET.

Working from memory, I believe ADAM stood for "Amplitude, Dipolar Angle Modulation".

G. R. Miller
Orpington,
Kent.

Using the 8080 with slow memories



Forcing the 8080A microprocessor to enter an adjustable wait state when addressing slow memory devices, this circuit compensates using a 74193 up/down counter. When the system starts up, the reset signal is forced high for a short period by the reset button. This period is long enough to allow 16 clock pulses (φ1 t.t.l.) to be passed to the C_U input of the 74193 counter if the carry input of the counter is in the high state, i.e. the data output is not in the F (hexadecimal) state.

These clock pulses drive the counter to the F state when the carry output goes low. This sends the counter C_U input low and sets the ready signal to the 8080. Clocking the counter while resetting the system gives the same results as starting up the system with F as the counter-data output.

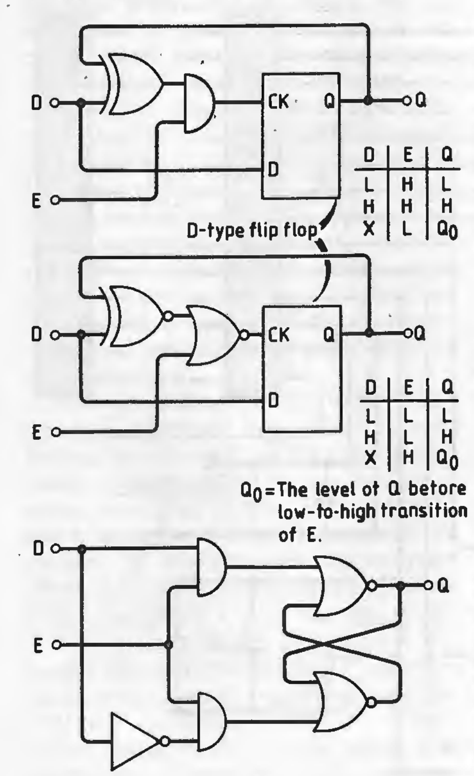
When the 8080A c.p.u addresses slow memory devices, the address is sent during the first state of the current machine cycle and decoded as an active-high line which drives the converter. At the start of the second machine cycle, the counter load input goes low, causing a hard-wired word at the counter data input to be loaded. Through loading of this word (which should not be F) C_U goes high, resetting the ready signal and driving the processor into a wait state. From the third machine cycle, the counter is incremented by one until the output is F, when carry goes low and sets the ready line. Depending on the hard-wired word, the wait state can be extended between one and 15 machine cycles.

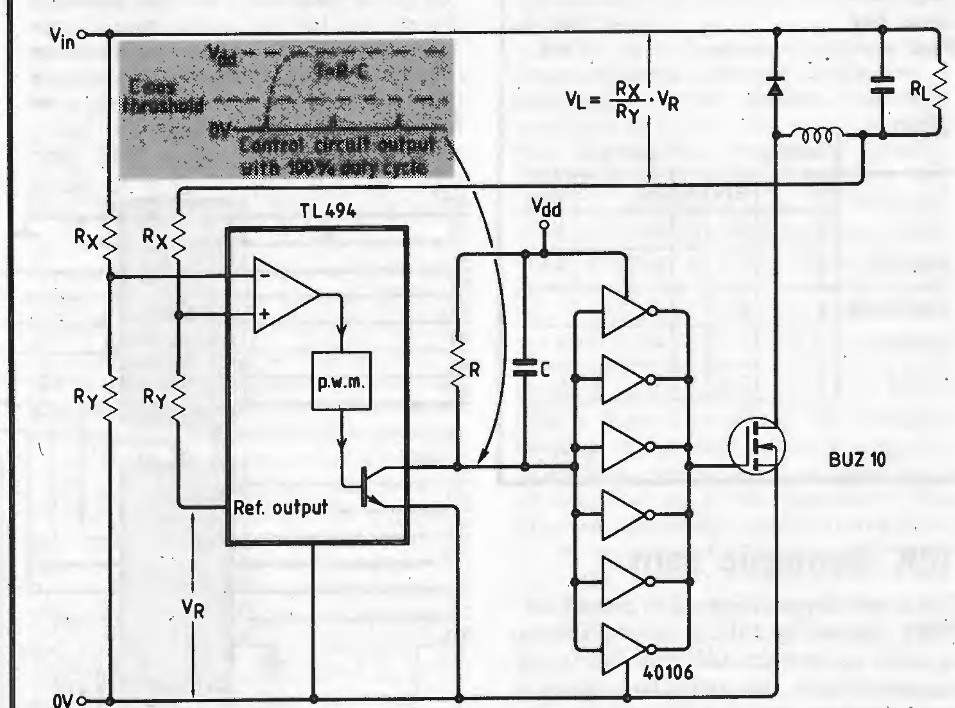
G. A. M. Labib
Heliopolis
Egypt

Alternative latches

Logic circuits often have spare gates. Where latches are required, these two circuits may help to reduce the number of i.cs in a given design. Their standard equivalent is also shown.

Y. Pang
Worthing
W. Sussex





Switching regulator with 0-100% duty cycle

Designed for low-voltage battery-powered systems, this efficient switching regulator relies on a power mosfet's low drain-source resistance. Controllers available have duty cycles less than 95% so the switching element cannot fully conduct with low input voltages. This circuit uses an RC pulse stretcher to give a 100% duty cycle.

Multiple cmos gates provide sufficient power to drive an n-channel fet with low $R_{ds(on)}$. To include this device, the standard switch-mode circuit is inverted. Care must be taken not to exceed the common-mode range of the control-circuit op-amp.

Bryan Inkster
Egersund
Norway

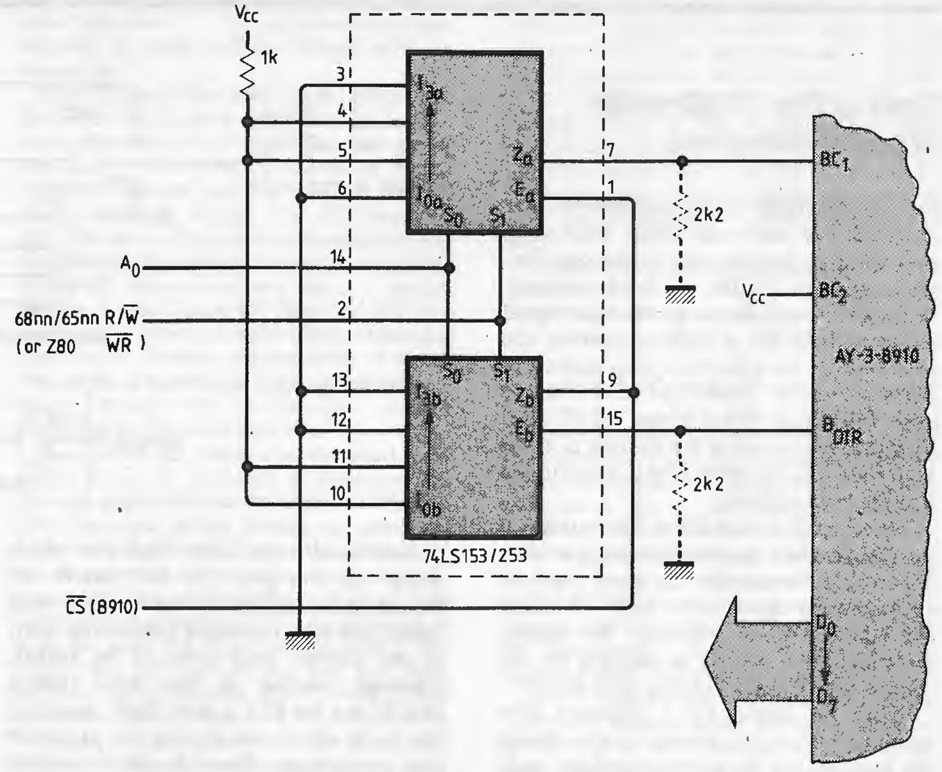
Sound-generator interface

With a minimum of components, this circuit produces signals required to interface the General Instruments AY-3-8910 sound i.c. to standard 8bit microprocessor buses using a single m.s.i. – t.t.l. device, The output enable of the 74153 dual 4-to-1 multiplexer i.c. provides an inactive bus-control state for the sound-generator i.c., which is disabled when its bus-control inputs are low.

When selected, the multiplexer behaves as a simple rom addressed by A_0 and the state of the R/$\overline{W}$ line, producing outputs determined by the logic levels on the 74153 inputs. In use, one writes the port address to an odd location and one reads or writes data from an even location.

Resistors shown are pull-downs required if a 74LS253 is used, as this is a three-state output device. A version using a 74LS253 has successfully been used on a 4MHz Z80A system where it was mapped as an i/o port, the auto-wait state feature of the Z80 i/o request ensuring that the timing of signals is longer than the minimum specified in the data sheet. Another has been built into an M6809 system.

M. James
Herne Bay
Kent



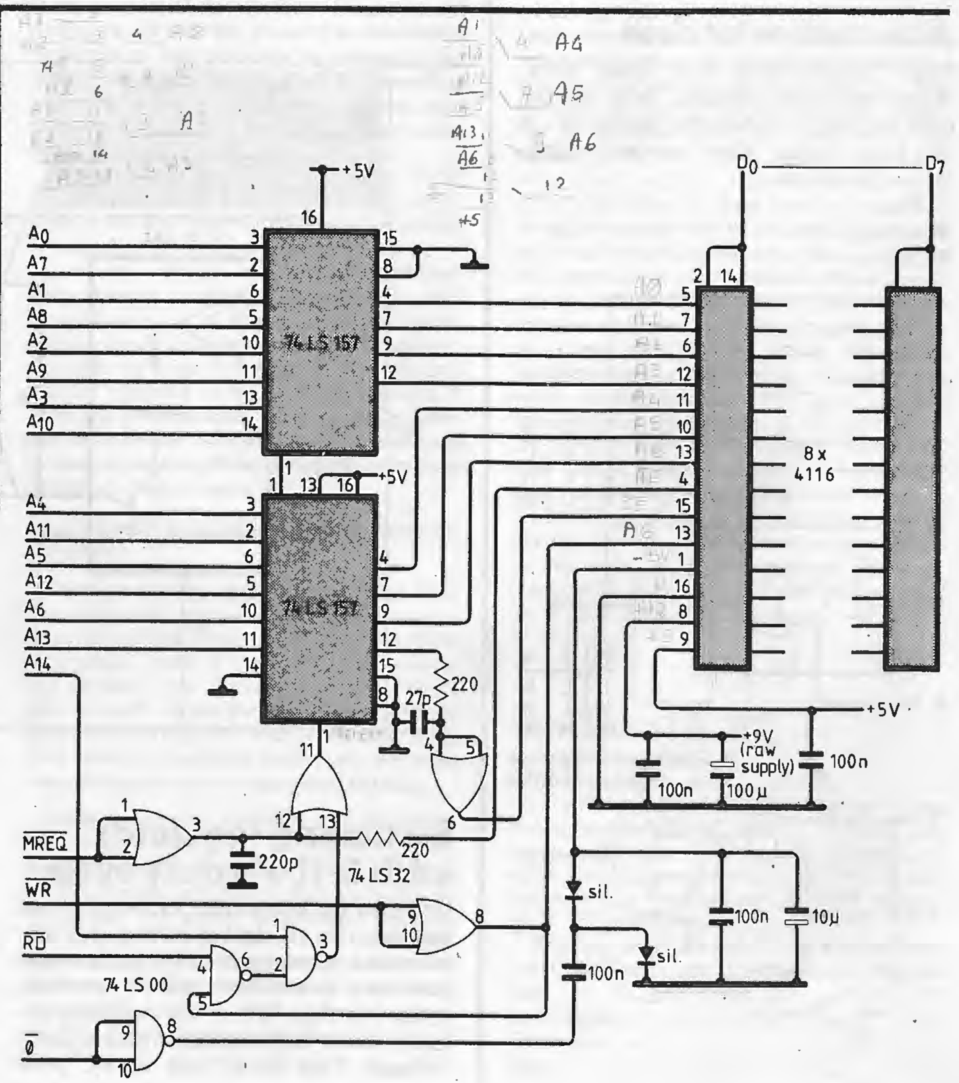
	INPUTS			OUTPUTS	
	$\overline{CS}$	R/W	A_0	BC_1	B_{DIR}
	1	X	X	0	0
Write date	0	0	0	0	1
Write address	0	0	1	1	1
Read data	0	1	0	1	0
Inactive	0	1	1	0	0

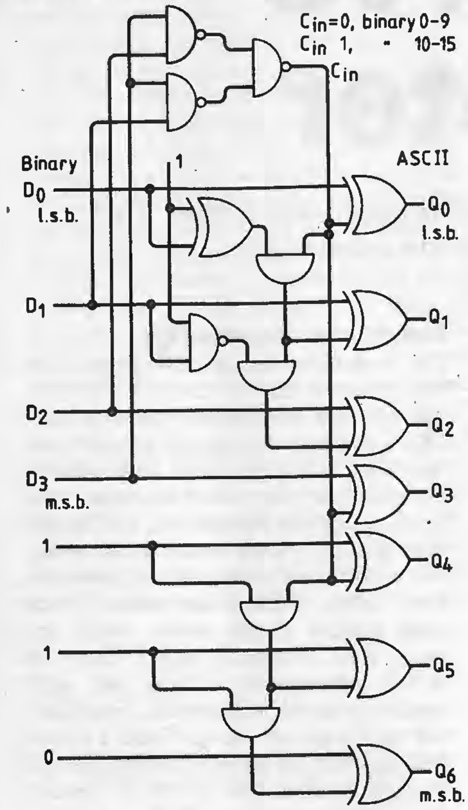
16K dynamic ram

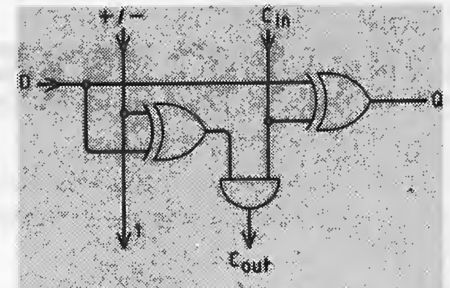
Cost of this circuit, designed to expand the ZX81 memory by 16K, is around £10 as opposed to between £25 and £50 for a commercial unit. Illustrating how easy it is to use dynamic ram, this memory may be used with any Z80 system with only slight modifications. I did not need a case since my computer is in a large box.

Negative bias, generated by a NAND gate, capacitor and diodes, is only around 3V but this is sufficient. Positive supply to pin 8 of the 4116 rams is taken from the raw supply, hence the 100µF smoothing capacitor.

D. G. Jones
Leamington Spa
Warwickshire







Function	C_{in}	+/−	C_{out}
Q = D	0	0 or 1	0
Q = D+1	1	0	carry
Q = D−1	1	1	borrow

Cascadable one-bit arithmetic module

The module shown adds one, subtracts one or transfers the input to the output. Cascaded modules, with C_{out} connected to C_{in} of a more-significant module, operate with binary-weighted inputs giving

$$Q_0 2^0 + \ldots Q_Z 2^Z = D_0 2^0 + \ldots D_Z 2^Z + N$$

where N is plus one, minus one or zero.

There are two control inputs, C_{in} which selects add/subtract or transfer, and +/− which selects add or subtract. When operation is limited to +/− = 1, $gate_1$ may be any inverter and when +/− is limited to zero, $gate_1$ may be omitted. The binary-to-ASCII circuit uses +/− = 1 for bits zero to two and +/− = zero for bits four to six.

R. Merson
Taunton
Somerset

Dividing by fractions. Some readers have found the 4722 timer used in this circuit idea (Jan 1983) difficult to obtain. The 4722 may be replaced by an XR-2240 (Exar) or a µA2240 (Texas) without circuit modifications. An XR2212, XR215 or NE565 may be used in place of the p.l.l.

continued from page 35

in terms of continuity – that the potential can always be described in terms of position by means of a smooth, broadly-generalized mathematical curve. A barrier of this type must obviously be completely leak-proof, *but this is not what is observed in Nature*. The concept may sometimes suffice to describe the behaviour of matter in bulk, but it fails to take into account the essential granularity of matter on the microphysical scale. These barriers are composed of *particles*. The often-quoted tunnel effect is not to be explained as a manifestation of matter waves, mystically, but by a down-to-earth study of the physical properties of the particles involved *as particles*, and of the real, physical forces that act between them. The insulator is not quite impervious to current, nor the radioactive nucleus quite stable, given time. That is what the quantum hypothesis implies, and its realisation defines the coverage required of any successful quantum theory of matter.

Now the failure of the wave theory which is evidenced here is a conceptual failure, far more serious than any expositional or mathematical failure. Instead of being just wrong the theory is seen to be *utterly* wrong, because it is based on the concept of continuity in microphysics which although mathematically convenient is by experiment a false concept. It has failed, in fact, for the same reason that caused electromagnetic theory to fail when faced with Planck's quantization (type one) and its obverse, the photoelectric effect. Moreover there would seem to be no prospect of recovery in either case, because continuity and discontinuity are diametrically opposed in logic: any true quantum theory must therefore be the antithesis of any field theory.* But whereas electromagnetic theory often provides good and useful analogies, the wave theory of matter consistently offers bad ones. Over and over again we have been misled by it. It has proved to be a bad habit. Should we not consider giving it up?

★ ★ ★

Probably the most insidious of all Copenhagen doctrines is the doctrine of Completeness, which was concocted from the doctrine of the Observer with the aid of a liberal sprinkling of Indeterminacy. The idea was that *as* Nature is indeterminate and essentially statistical, and *as* (quoting Landé before his conversion) it is "unphysical" to dwell on situations that can never be observed, *it followed* that the Copenhagen quantum theory, which incorporates these restrictions, must be "complete" – the Ultimate Theory of microphysics. Einstein challenged this doctrine on general grounds on its first formulation, but the argument was side-tracked by Bohr into a discussion of the "correctness" of the wave-mechanics (which we can now see to have been an irrelevant issue), and the challenge, thus evaded, was eventually allowed to drop.

*The point may be paraphrased and repeated in view of its philosophical importance. The so-called quantum theory of Copenhagen, involving as it does the concept (and mathematical equations) of waves in a continuous medium, is *essentially a field theory*. As such, it can by approximation describe the behaviour of matter in bulk, but it is intrinsically unable to cope with any discontinuity or "quantum" – electron or photon. This logical contradiction, both as an expression of and as the root of the duality concept of Niels Bohr, lies at the very heart of the Copenhagen abberration.

Earlier in the present sequence, and from a different standpoint to Einstein, I have argued that the premise of the indeterminacy of Nature was almost certainly false and that the observability premise was never more than a doctrinaire, and arbitrary, attitude of mind. Nevertheless, on those very dubious premises the Copenhagen doctrine of completeness claimed, grandiosely, that as this particular, peculiar, probabilistic "quantum theory" cannot explain the fundamental phenomena in microphysics, *no theory can*. Pulling itself up by its own bootstraps, it had the gall to offer a "logical proof" of this arrogance based on its own misguided self-restriction to statistical treatments. (I am referring to an argument by J. von Neumann). The One True Faith being unable to pronounce on the structure of the electron, it would be *sacrilegious* for any other theory to presume to try. Such effrontery was amazing, especially when one remembers that Niels Bohr himself had been forced to admit,

> "The quantum mechanics deals not with the properties of micro-objects as such but, rather, with nothing more than the relationships between the observable, large-scale phenomena".

One can only suggest, with moderate diffidence, that a theory which was not confined essentially to macroscopic, statistical relationships might be better able to handle the encounters of individual micro-objects, while a theory that took the reality of the physical world more seriously might prove more successful in describing it. This cannot be the end of the road. WW

Low-cost servo accelerometer

A design simple enough for home construction, yet capable of an accuracy better than 0.1% of full-scale. It can also be used as a precision force balance

by Neil Pollock

In recent years analogue and digital electronics have advanced very rapidly and it is now possible to perform complex manipulations of electrical signals at low cost. Unfortunately these advances in electronics have not been paralleled by similar advances in the design of the transducers required to convert other physical quantities into electrical signals. It is particularly frustrating for an amateur to have a project which he can easily handle electronically but which is stopped by the high cost of suitable transducers.

The acceleration transducer described here was developed as part of an automotive acceleration and braking performance measuring instrument. Other potential uses include an angle-of-heel indicator for a yacht, a precision level, an earthquake detector, a vibration-type car theft alarm and a home intruder-alarm based on measuring the deflections and accelerations of the floor structure. The transducer can also be used to measure forces up to 0.1 newton (0.02lb) directly, or higher values if a suitable lever system is added. In addition to the obvious application to weighing machines the force measurement capability could also be useful for the measurement of low velocity air flows, where the drag of a small vane could be sensed, and for pressure measurements, where a flexible diaphragm could be used to convert the pressure to a force.

Operating principle

The accelerometer described is based on the servo-balance or force-balance principle. A mass is suspended by a system of flexures which constrain it to move relative to the transducer body only in the direction of the acceleration to be measured (Fig. 1). When the transducer body is accelerated along the sensitive direction the mass will obey Newton's first law of motion and remain at rest. This will produce a relative movement between the mass and the body which is sensed by the displacement detector. The detector output is amplified and applied to an electromagnetic force generator which returns the relative movement between mass and body to zero. The net effect of this feedback loop is that the force generator always applies the appropriate force to the mass to produce an acceleration which is identical to that of the transducer body. Since, according to Newton's second law of motion, the acceleration is directly proportional to the force producing it, the force output of the electromagnetic generator will be an accurate measure of the acceleration. Further, since for small displacements a moving coil force generator exhibits a highly linear relationship between current and force, the current flowing in the coil will be an accurate measure of the acceleration. This current is conveniently measured by sensing the voltage drop across a resistor in series with the coil. It can be seen that an external force applied directly to the moving mass will be measured in exactly the same way as an applied acceleration.

This simple system would tend to oscillate at a frequency determined by the size of the mass and the effective stiffness of the feedback system. To ensure stability it is necessary to include some mechanical or electrical damping. It is common practice to produce at least some of the damping electrically by incorporating a phase-lead network in the servo amplifier. The servo loop should have the highest possible gain to produce the greatest effective stiffness and therefore the highest frequency response and smallest movement of the suspended mass. Minimum movement of the mass is important because the linearity of all practical force generators deteriorates with displacement. The highest gain that can be used is usually limited by stability considerations.

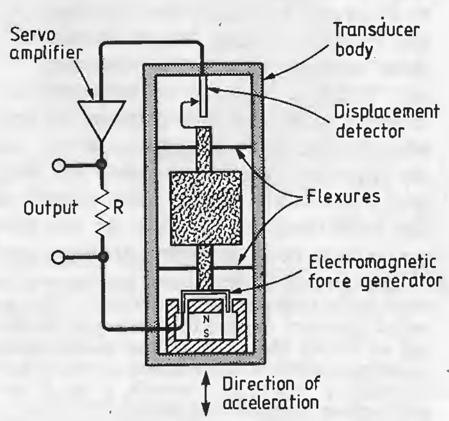


Fig. 1. Outline of the force-balance accelerometer. The e.m.f. generator acts to cancel movement of the mass resulting from acceleration of the transducer body.

Transducer construction

The transducer design was prompted by the realisation that the magnet and voice-coil out of a loudspeaker make an ideal force generator. An optical isolator/interrupter of the type used for limit switches and end-of-tape indicators was selected for the displacement detector and the flexures were fabricated from a steel guitar string. The remainder of the transducer was made from scraps of aluminium sheet, double sided printed circuit board, solder and epoxy glue. Figures 2 and 3 show the overall arrangement. Since the loudspeakers available to potential constructors will vary in size and design detail, a general description of the construction process will be given rather than a set of detailed drawings.

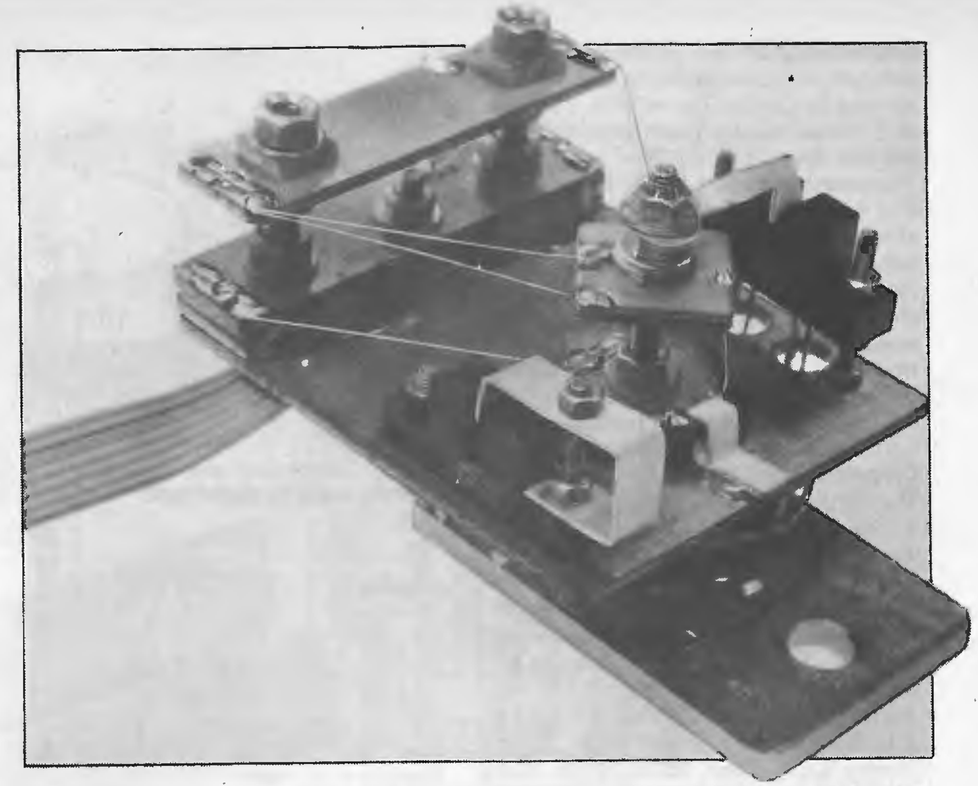
The most suitable type of loudspeaker is the sort used in pocket transistor radios. The one chosen for the various prototypes had a cone diameter of about 56mm (2.25 inch), a voice coil diameter of 13mm (0.5 inch) and a resistance of 8Ω. In preparing it for use, the first step is to dismember the speaker to obtain an undamaged voice coil and magnet (Fig. 4). To do this, the braided connecting leads should be unsoldered from the voice coil leads where they join the cone. Then the majority of the cone can be cut away using a razor blade and small nail scissors. The corrugated diaphragm normally hidden by the cone can then be cut with a sharp razor blade. The voice-coil can then be lifted clear of the magnet and the remains of the cone and diaphragm cut away. If drilling or cutting is necessary to separate the magnet from the speaker frame, it is a good idea to stick adhesive tape over the magnet gap to prevent the ingress of metal chips. When the magnet is removed all the metal chips, filings and whiskers which will inevitably find their way into the gap must be carefully cleaned out using a needle and a compressed air hose. If everything has been done correctly the voice-coil should drop cleanly into and out of the magnet without sticking.

The next step is to construct the flexure assembly (Fig. 2 and Fig. 5). The moving mass consists of two squares of double-sided printed circuit board slightly larger than the voice-coil diameter, joined together with a countersunk brass screw. For the flexure mounting, two rectangular pieces of the same board are joined with two screws. A clearance hole for fixing is drilled in the centre of the lower piece of board. On the upper surface of both boards of the moving mass and mounting assembly, the copper coating should be cut back from the screw holes and insulating washers used under the nuts so that the two surfaces are isolated from each other. Next, the moving mass and mounting assemblies should be placed face down on a flat surface so that the flexures, which are cut from a 0.2mm (0.008 inch) steel guitar string, can be soldered in place. The voice-coil can then be glued to the bottom of the moving mass and its two leads connected to the same surfaces as the flexures.

The base board is cut from double sided printed circuit board. This board requires a clearance hole for the voice-coil, a hole for the flexure assembly attaching screw and holes for the mounting screws and lead wires of the two opto-interrupters (Fig. 2 and Fig. 3). The magnet can then be glued to the base board with the magnet gap concentric with the voice-coil clearance hole. The flexure assembly can now be mounted with a spacer of appropriate thickness between it and the base board so that the voice coil is axially centred in the magnet gap with the flexures undeflected. The spacer thickness may be determined by measuring the various pieces prior to assembly.

Mating the flexure assembly to the base is the most critical operation in the transducer construction and the following instructions should be followed closely. Glue the spacer to the base board, then carefully lower the coil into the magnet gap. Insert the screw which secures the flexure assembly to the base and tighten it just enough to prevent the two parts sliding with respect to one another. Make small movements of the flexure mounting until the coil moves freely in the magnet without scraping. When the correct setting is achieved the moving mass will vibrate freely when the base board is stood vertically and gently shaken. At this stage the flexure mounting and base are permanently fixed together by applying a non-shrinking glue around the edges, *not* by tightening the screw because this will inevitably spoil the alignment and probably damage the coil.

At this stage the hardest part is over and final assembly can proceed. Two stops bent from thin aluminium sheet should be glued in place to limit the movement of the mass to about ±0.5mm (±0.02 inch) from the flexure-undeflected position. A suitable mounting bracket can be glued to the bottom of the magnet and then the two



▲
Fig. 3. Completed servo accelerometer. Potential uses include precision levels, earthquake detectors, car theft alarms and home intruder alarms. Opto-interrupter on right acts as a displacement detector; the other is for temperature compensation.

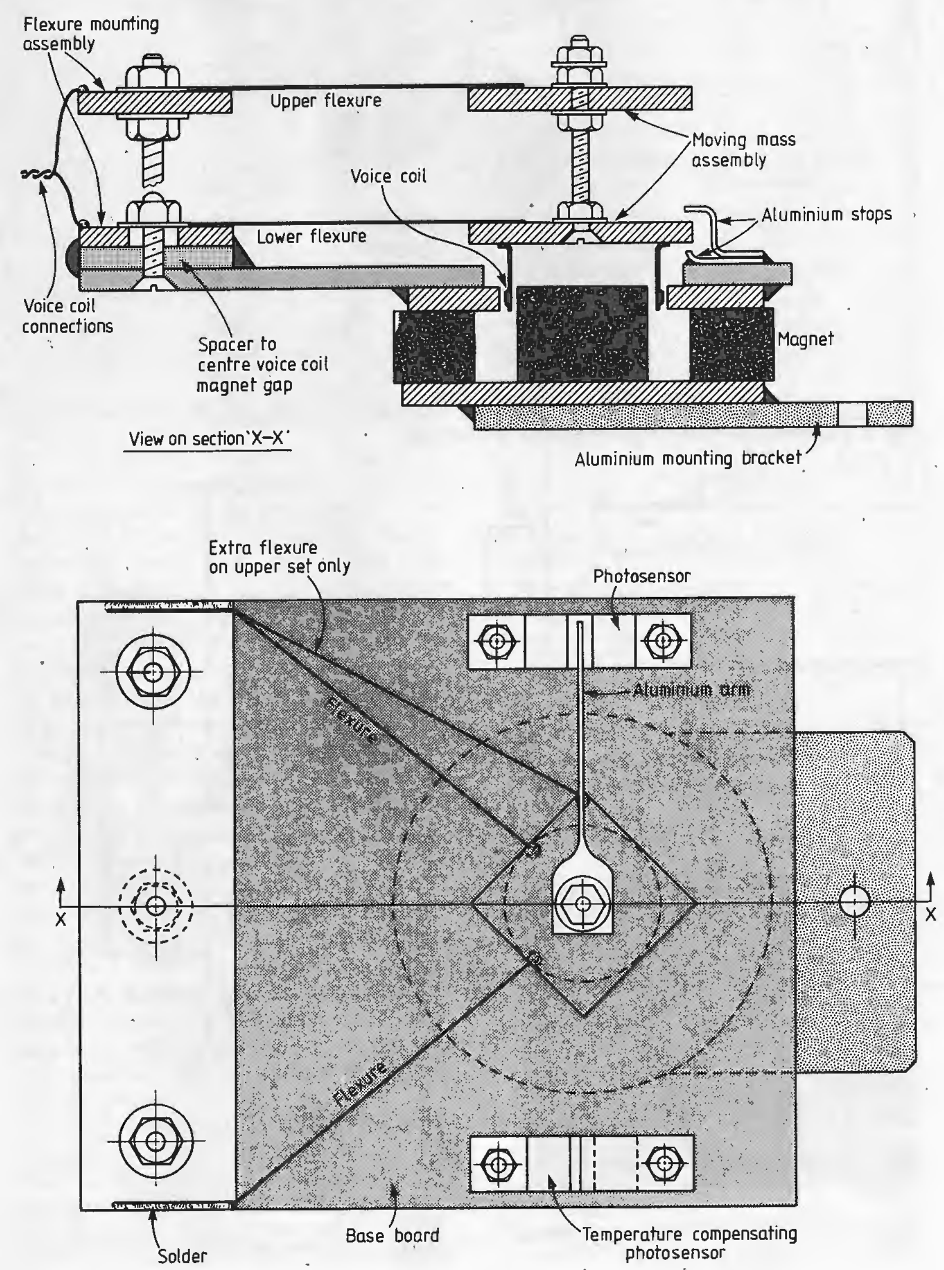


Fig. 2. Mechanical arrangement of transducer. The e.m.f. generator is adapted from a cheap loudspeaker unit of the type used in pocket radio sets.

opto-interrupters can be fitted. The temperature compensation opto-interrupter is screwed to the base board with a presettable cut-off shutter made from thin aluminium sheet (Fig. 3). The active opto-interrupter is mounted on long screws so that its height above the base board can be altered easily. A thin aluminium flag attached to the centre screw of the moving mass (by tightening the nut *gently* and then glueing it) extends to the gap in the active sensor. When in use the transducer should be enclosed in a box, both to exclude ambient light and to prevent metal particles finding their way into the magnet gap.

Circuit description

The circuit diagram for the servo-amplifier is shown in Fig. 6. The two opto-interrupter outputs are applied to unity gain buffers which drive a unity-gain differential amplifier. This amplifier feeds a passive lead-lag compensation network formed by C_1, R_8, C_2 and R_9 which in turn feeds a variable gain (0 to 30) amplifier. The output from this amplifier passes via Link 1 to a bridge-connected power stage. By removing Link 1 and adding Link 2, an additional amplifier can be brought into the circuit: the function of this amplifier is described below in the section on compensation. A circuit board pattern and component layout are presented in Fig. 7 and Fig. 8. It is possible to mount the circuit board either adjacent to or remote from the transducer, according to the requirements of the application. The system output, which is the voltage drop across R_{22}, is floating and not referenced to ground; a floating meter or a differential amplifier must therefore be used to measure this voltage.

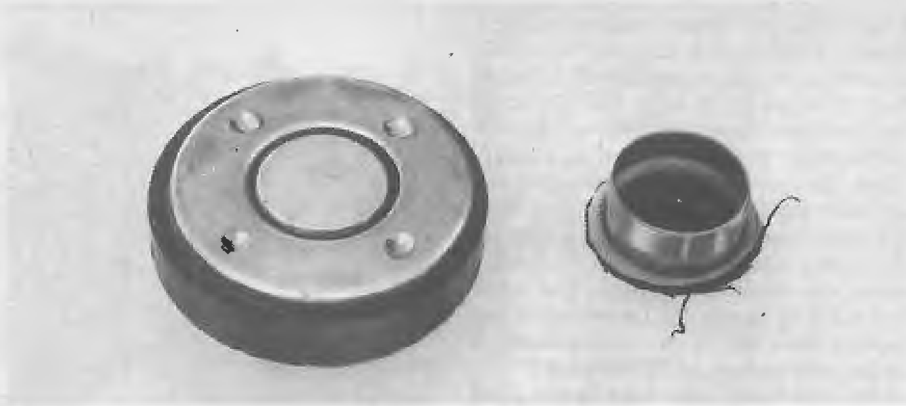


Fig. 4. *Loudspeaker unit is prepared by separating the voice-coil from the magnet and cutting away the paper cone.*

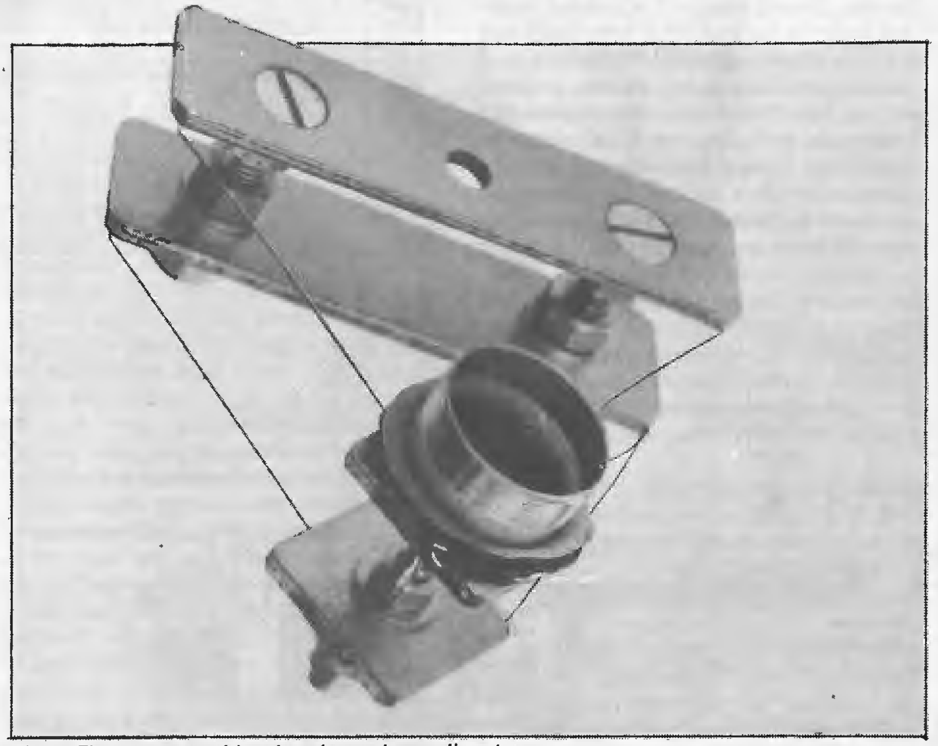


Fig. 5. *Flexure assembly, showing voice- coil on top.*

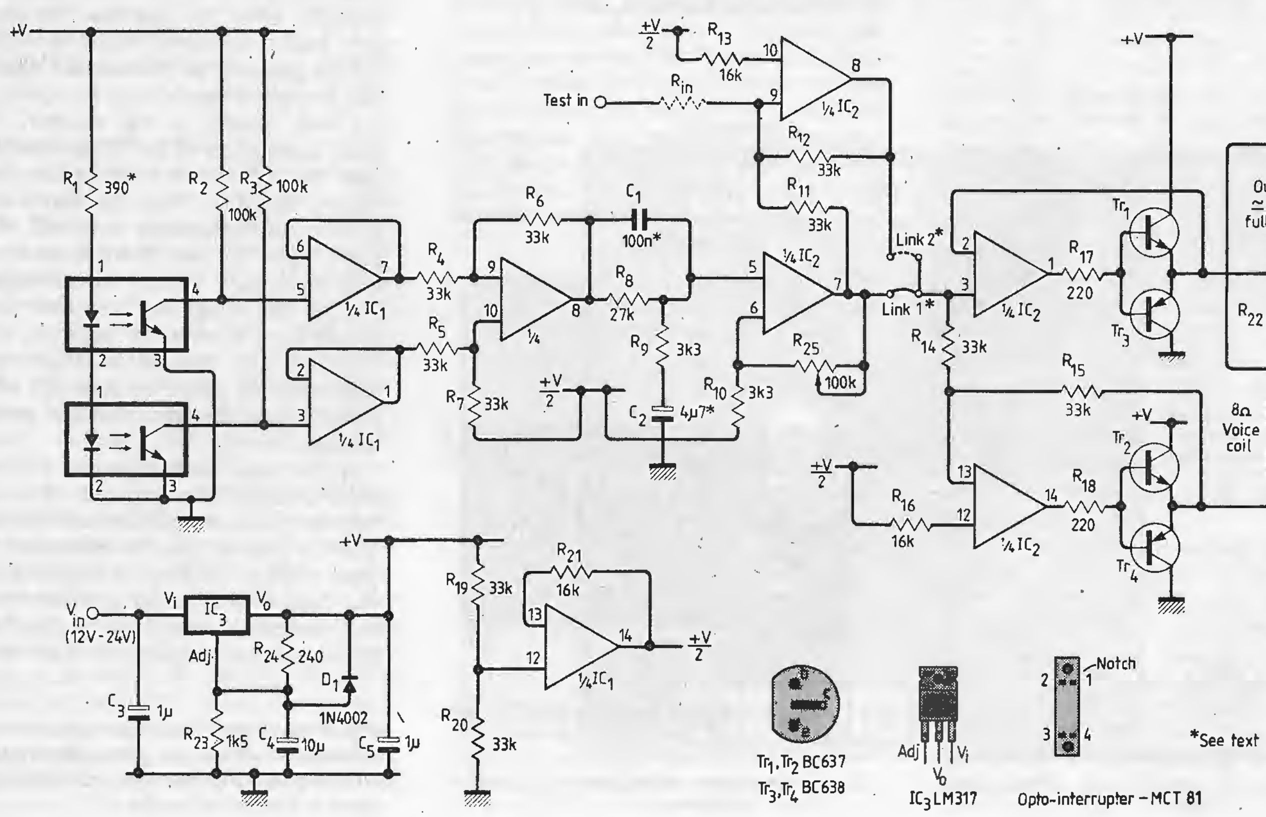


Fig. 6. *Circuit diagram of the servo-amplifier. IC_1 and IC_2 are quad op-amps, type LM324 or equivalent. Suitable alternatives for opto-interrupter include TIL143, TIL144 and MCT8. C_2-C_5 are tantalum types.*

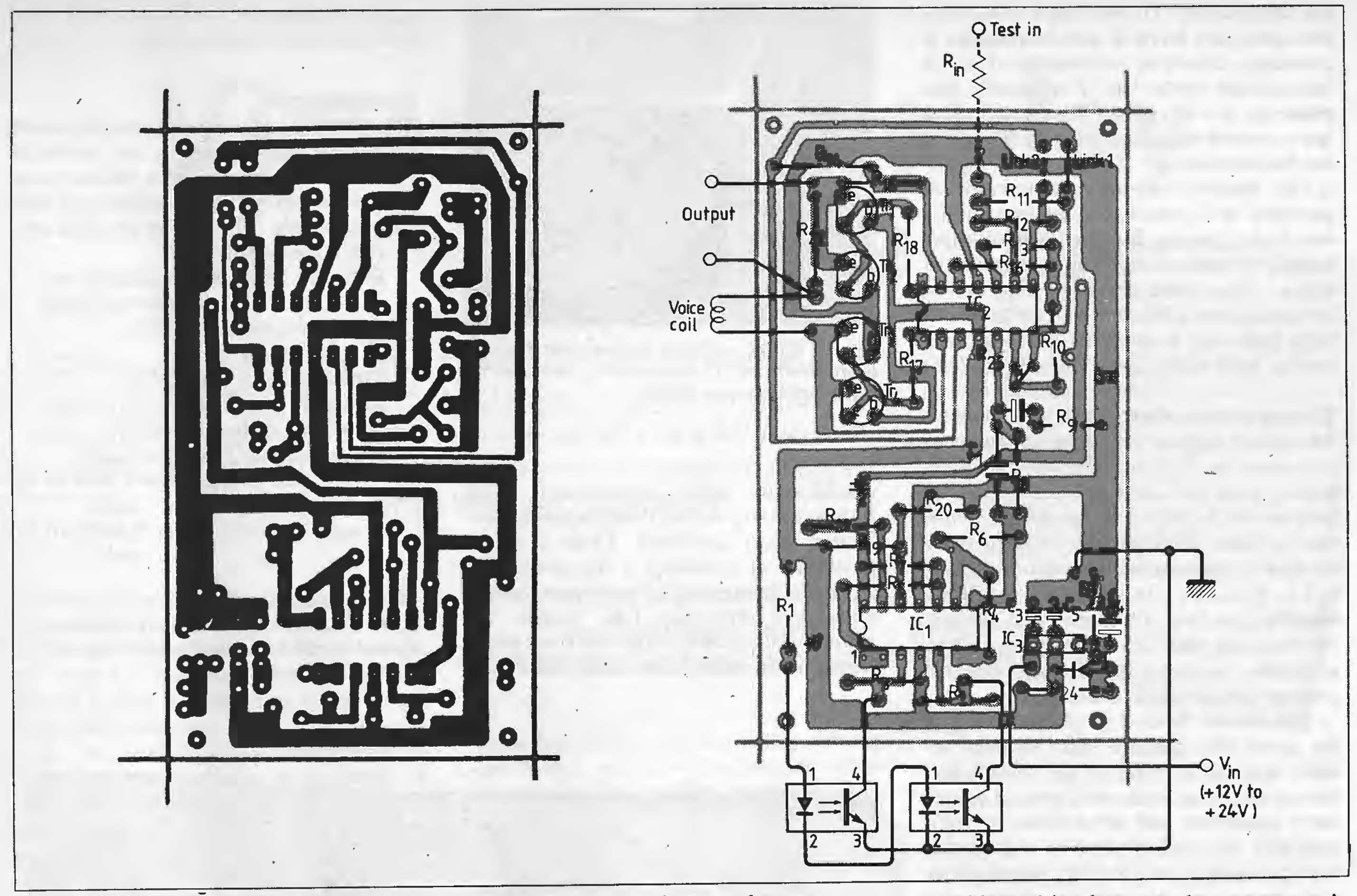


Fig. 7. *Circuit-board pattern for servo-amplifier, viewed from track side.*

Fig. 8. *Component layout for servo-amplifier.*

Since the opto-interrupters have widely varying current gains it is necessary to select the value of R_1 for the specific components used. To do this connect the opto-interrupters as shown in Fig. 6 before mounting them on the transducer. With the optical path of the sensors unobstructed, find the maximum value of R_1 for which the output voltage on pin 4 of the less sensitive of the two sensors is less than 0.3V (measured with a meter with an input impedance of at least 1MΩ). The value of R_1 found in this way is the appropriate one to use. The output voltage of the more sensitive sensor will be lower than the less sensitive one. To avoid damage to the sensors R_1 should not be less than 200Ω. The sensor with the higher gain should be used as the temperature compensator and the one with the lower gain, and therefore the greater linear range of operation, for the moving mass position sensor.

When R_1 has been selected the two sensors can be mounted on the transducer and connected to the servo-amplifier. The cut-off of the temperature compensation sensor should be adjusted so that the voltage on pin 4 is near 4V. The height of the position sensor above the base-board can then be adjusted so the voltage on pin 4 is approximately 4V at mid-travel of the moving mass.

With R_{25} set to zero, connect the voice-coil and then slowly increase R_{25}. If the mass moves to either stop and stays there, the sign of the feedback is incorrect and the voice-coil connections must be reversed. If all is well the mass will assume a stable position between the two stops. As R_{25} is further increased the moving mass will probably start to oscillate, emitting an audible tone at 100 to 200Hz. R_{25} should then be reduced until the oscillation just ceases and then approximately halved in value. If necessary the height of the position sensor can be adjusted to centre the moving mass between its stops. If the arrangement of the transducer is similar to the one described this procedure should produce a system with good stability and performance. If the design is altered significantly the compensation network may require changing.

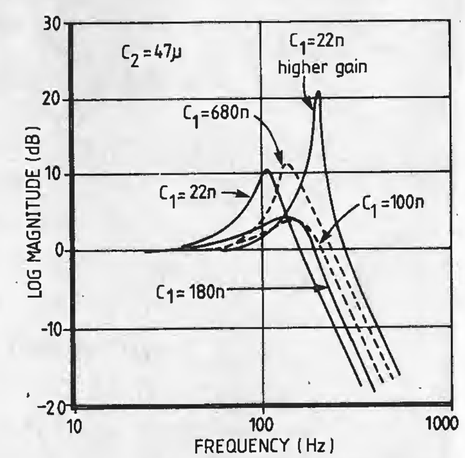


Fig. 9. *Altering the value of the lead-compensation capacitors affects the stability and frequency-response of the system.*

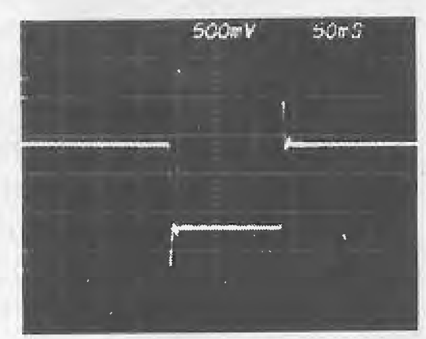


Fig. 10. *Step-response of the system with C_1=180nF. A degree of overshoot is visible.*

The prototype transducer had a full scale range of ±2G, or ±0.1 newton (±0.02lb) when used to measure forces. This range was selected so that accelerations of ±1G could be measured while allowing reasonable headroom to accommodate the electrical damping introduced by the phase-lead network. To increase the transducer range R_{22} should be reduced, taking care not to exceed the voice-coil dissipation limit. To reduce the transducer range R_{22} can be increased or the moving mass increased in size.

Compensation

The stability of a transducer such as this depends critically on the gain and phase-angle versus frequency characteristics of the servo-amplifier. This problem is dealt with in great detail by books on control system theory. In simple terms the amplifier must produce a phase-lead near the transducer resonant frequency to produce damping. Unfortunately all the networks which produce a phase-lead also introduce a rising gain with increasing frequency and this can lead to unacceptably low gain at low frequencies. To overcome this problem some gain boost at low frequencies is provided, inevitably accompanied by a destabilizing phase-lag. Fortunately this phase-lag is not critical since the system has a considerable margin of stability at low frequencies.

The desired lead-lag compensation is provided by C_1 and R_8 for the lead and C_2 and R_9 for the lag. Two methods of arriving at appropriate compensation networks will be described, the first of which is suitable for constructors without access to test equipment. Leaving R_8 and R_9 at their normal values set C_1 to a low value (22nF) to provide some minimal damping and C_2 to a large value (47μF) so the lag compensation only has effect at very low frequencies. Increase R_{25} until audible oscillation occurs, or if it fails to do so increase the gain further by reducing R_{10}. When oscillation occurs determine its frequency by comparing the note with a piano. Select C_1 and C_2 such that $1/2\pi R_8C_1$ is about half the observed resonant frequency and R_9C_2 is between six and ten times R_8C_1. Then adjust R_{25} to about half the value which produces the onset of oscillation.

The second method of compensation is for those who desire a more detailed insight into the stability of the system and have access to an audio oscillator or square wave generator and an oscilloscope. To optimize the performance of a feedback system it is necessary to apply sinusoidal or step inputs and observe the system response. A summing amplifier has been provided which can be inserted before the power stage by removing link 1 and inserting link 2 (Fig. 6). Since this amplifier inverts, the connections to the voice coil must be reversed when it is in circuit. Any signal (Test in) applied to this amplifier through a suitable resistor (R_{in}) will force a current in the voice coil which will have an identical effect to an applied acceleration. Under these circumstances the voltage 'Test in' can be regarded as an input acceleration, and the system output effectively appears at pin 7 of IC_2. With the aid of an oscillator and an a.c. voltmeter or oscilloscope it is possible to measure the system frequency response. To examine the step response of the system, a square-wave generator and oscilloscope are needed. Frequency response measurements carried out on the prototype system with various values of lead-compensation capacitor C_1 are plotted in Fig. 9. For comparison the step response for two of the cases shown in Fig. 9 are reproduced in Fig. 10 and Fig. 11. The aim is to select a value for C_1 which produces an acceptable response overshoot at the highest possible frequency. When changing C_1 it will be necessary to vary R_{25}, remembering that increasing gain increases the resonant frequency and reduces the effective damping of the resonance. When a suitable value of C_1 has been determined, C_2 (which should have been initially set to a large value) should be reduced until the measured response just starts to deteriorate. The effect of large excursions of the moving mass should be checked by deflecting it to one of its stops and then releasing it. This is necessary because it is possible to have a

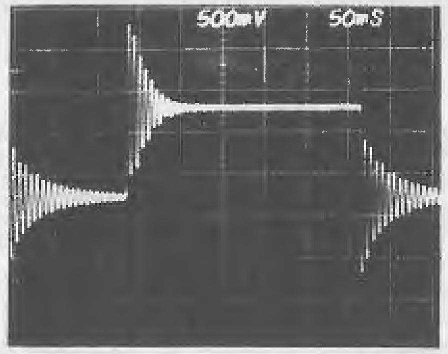


Fig. 11. *With C_1=680nF the servo is grossly under-damped. The value of C_1 selected for the prototype was 100nF.*

conditionally stable arrangement which bursts into stop-to-stop low frequency oscillation when disturbed. There is also a possibility of instability if the mechanical resonant frequency of any part of the transducer structure falls within the operating frequency range. All these problems can be sorted out with the aid of careful measurements, time, and a good book on control system theory.

Performance

The following performance measurements have been carried out on two prototype transducers using precision masses to apply forces and a digital voltmeter to measure the output. The results obtained are:

Full scale output ±4V
Full scale input ±2G, acceleration
±0.1 newton, force
Resonant frequency 150Hz
Damping ratio ≈0.3
Linearity better than 0.1%
Zero drift ≈0.01%/°C
Sensitivity drift <0.01%/°C
Resolution (set by output noise)
with d.c.-100Hz filter 0.03% of full scale
with d.c.-10Hz filter 0.003% of full scale

Background reading

H. K. P. Neubert, Instrument Transducers. Oxford at the Clarendon Press 1963, pp.363-381.

DESIGN COMPETITION

This is the third month of our competition 'Design an electronic device to help the disabled'. Already, registrations are coming in, and the competition seems certain to bring out some extremely useful equipment to enable physically handicapped people to lead a more independent and fuller life.

This is a worthwhile spare-time activity. The prizes are attractive and the outcome could be more than just a clever design exercise: it could be the means of assisting someone to speak, read, move about or even 'see'.

The rules are set out on page 88: they are few and quite simple. All you need to do in the first place is to register with WW your intention to enter the competition. Think about it – but not for too long, because time is running out.

Viewdata display module

Colour text and graphics in 'level one' teletext format are provided and the display is controlled by either a serial or parallel link from the host computer. With the addition of a modem, the display module can be programmed to display data directly from a viewdata computer.

by Dennis N. Pim

Photograph shows display module described in April and May issues together with ViCom experimental videotex computer by Deaconhouse Ltd. In its teletext application GIM decoder chip AY-3-7910 is added to the display module. Telesoftware can then be captured into one of the page stores and "dumped" using command 28 to the host computer for execution/processing. The display module is suitable for the 'level one' standard of Prestel, but other display standards can be catered for by changing the display module as appropriate chips become available.

Information received by the display module can be divided into two categories: the first is data transferred directly to one of the rams for immediate display, and the second is data decoded as a command to the display processor.

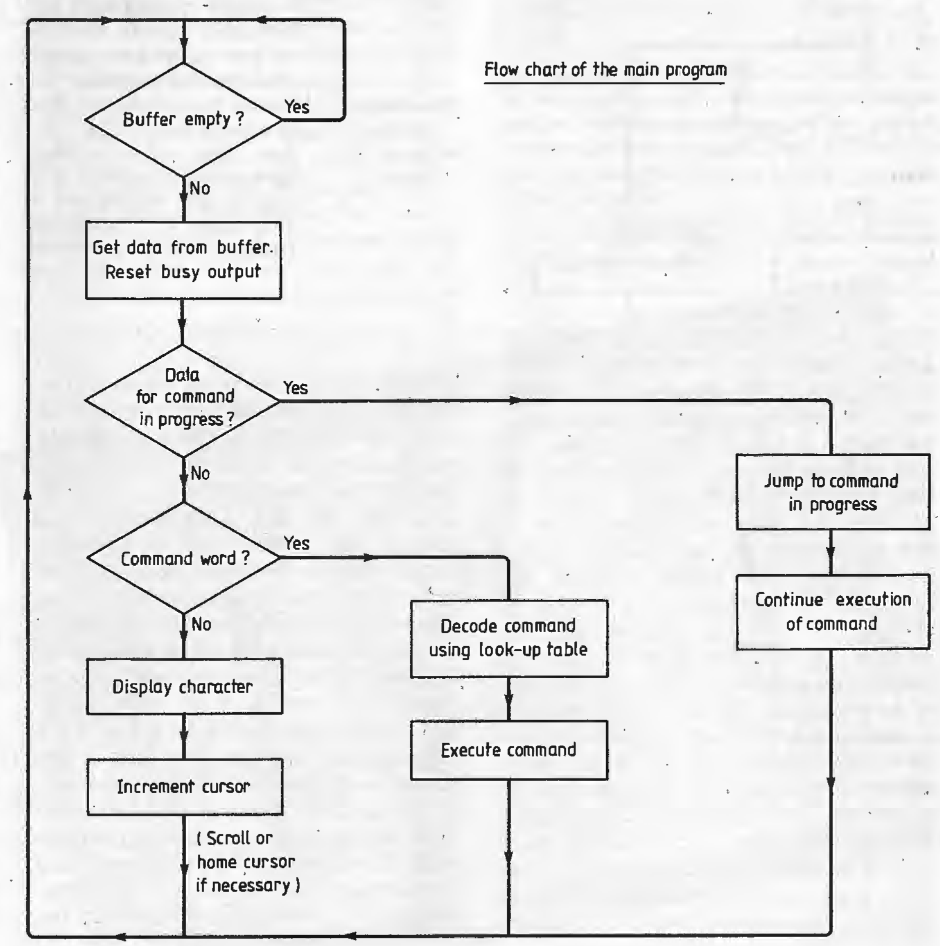
As the module is software-controlled there is great flexibility in its mode of operation. For this reason the following descriptions of the commands available and software required only apply to my prototype where the module was designed to be connected to a host computer and receive/send data serially at 4800baud. This should demonstrate the capabilities of the module and provide sufficient detail for it to be adapated to other applications.

In the prototype therefore when a data word is received from the host computer, its most significant bit is examined. If it is logic one then the data is treated as a command, if it is logic zero the data is stored directly in the current cursor location of the currently addressed store (which is not necessarily the one being displayed at that instant), and the cursor is moved to the next location in the store. Thus ordinary strings of characters for display (including teletext control commands such as colour/-graphics controls) can be sent to the module without intervening commands and will be stored correctly, ready for display.

For commands (most significant bit=1) the first five bits of the data are decoded with the aid of a look-up table, and the particular command is then executed. This gives 32 possible commands some of which use the two remaining spare bits of the data word (bits 5 and 6) to provide variations in the particular command.

To preserve compatibility with the codes used in viewdata transmissions, commands such as carriage return and line feed have their usual ASCII codes (only the most significant bit, 7, is set to 1 to indicate a command). Table 1 lists the commands implemented in the prototype. The software required for these fits neatly into the 1K of program rom available in the 8048 processor. Notice that some of the commands require a second or third data word from the host processor before the command can be executed. Notice also that some commands produce output data to be sent to the host computer, although the module will never output data unless instructed to do so. The commands shown demonstrate the sort of functions that can be performed within the display module to reduce the need of the host computer from having to perform some of the more common display processes.

For specific applications, there are many other display functions that could be implemented in the display module, such as a simple block move routine. This is of course at the expense of some of the other



Flow chart of the main program

commands as only 1K of program rom is available.

Software

It would not be instructive to provide a complete assembly language listing of the program as it stands in the prototype; not only is it very lengthy and it contains many complicated programming tricks to reduce the memory requirement to fit into the 1K of program rom available, but it has also been specifically developed to meet my requirements. The software must be tailored to each individual application. However, it is worth explaining the subroutines which access the display rams and send commands to the video generator, as these would be required in any implementation of the display module. A knowledge of 8048 assembly language is assumed in the explanation of these routines.

Firstly though, consider the overall structure of the whole program, see flowchart. When idling, the processor continually looks at the input buffer waiting for commands or display data. This buffer, consisting of 24 of the ram locations within the 8048, is supplied with data as it arrives from the host processor by the interrupt routine which decodes the serial/parallel data and stores it in the next free buffer location. (Software decodes the serial data stream.)

When the main program detects that a new data word is available it is loaded from the buffer. If this data is not the second or third byte of a multiple byte command, in which case execution of the command in progress continues using the new data received, its most significant bit is tested. If this is zero, the data is assumed to be a character for display and is therefore directly stored at the cursor position in the currently-addressed page store. The cursor position is then incremented by one, which may involve homing the cursor or scrolling the display if the cursor was positioned in column 40 of row 24. If the most significant bit of the data word is set to one, it is a command and the first five bits of this word are used in a look-up table to transfer processing to the required command execution routine. After execution of the command, or displaying the character and incrementing the cursor as necessary, processing is returned to the start of the main program again.

Apart from the scrolling operation, and the clear page function (which requires at least one video frame of 20ms), most of the commands and data display are executed within 800µs. This time is less than the stop bit time of serial data at 1200baud so the module can directly display data from a viewdata computer if required.

I didn't specifically consider the execution time of the program during development and it seems likely that the 800µs time could be reduced by careful program design. There is, however, some unavoidable time wastage of up to 64µs (the time for one video line) each time the processor has to access the display memories. This occurs three times each time a character is stored, once to store the character and clear the cursor bit, once to read the data at the new cursor position, and once to add the cursor bit at this new location without altering the character stored there. However, I am working on a version which combines the last two operations into one line-flyback interval.

In any implementation of the display module, the subroutines to read and write to the page stores during line flyback, and the subroutine to send commands to the video generator will be required. So the operation of these is described next; refer to assembly language subroutine illustration.

The setup subroutine performs two functions. Firstly, it finds the next line sync pulse and secondly it sets up the various registers required for the read or write operations. The timing of this subroutine is carefully arranged so that the *next* line flyback interval (56µs after the start of the previous line sync pulse, the time at which the video generator frees the address and data buses) occurs immediately after execution of the RET instruction.

On entry into the subroutine, the current cursor address is held in the two memory locations addressed by the contents of registers R0 and R1 (low-order eight bits addressed by R0). Register R6 contains the port 2 mask so that when the high-order address lines are set up on bits 0 and 1 of port 2, the currently-addressed page bits (port 2 bits 2 & 3) are set up correctly, the address latch output is enabled (port 2 bit 4 is set low) and none of the other bits of port 2 are altered.

The flow chart of the subroutine describes its operation. The second test for the line sync pulse is required in case an interrupt occurred after the first test and before the interrupt was disabled (a time window of about 5µs). If this happens the interrupt is enabled again and the processor waits for the next line sync pulse after servicing the interrupt. For the processor to execute past the second line sync test, the pulse must be 10µs wide, set by the monostable timing components R_3 and C_4.

If the host processor starts to send a data word during a read or write operation there may be up to 64µs delay before the 8048 responds, as the interrupt has to be disabled. This won't affect the correct decoding of data at 4800 baud or less and the possibility has been accounted for in the arrangement of the sampling points of the decoding software. Alternatively, for faster rates, or parallel input, the data output line (port 2 bit 7) can be set low during a read or write operation to indicate that the 8048 is busy and cannot accept a new data word.

Operation of the read and write subroutines is comparatively straightforward. After calling the setup subroutine, the read subroutine sets the address, page and address latch output enable outputs on port 2 (data and address buses are now free) and uses an external move instruction (MOVX) to read the currently-addressed display ram (the low-order display address held in R0 is automatically latched in IC_3 during execution of the MOVX instruction). Bits 0 to 4 of port 2 are then set to their high impedance state again so that the video generator can have access to the data and address buses again. The resulting data is then inverted, as the video generator uses inverted logic data, the in-

SETUP subroutine

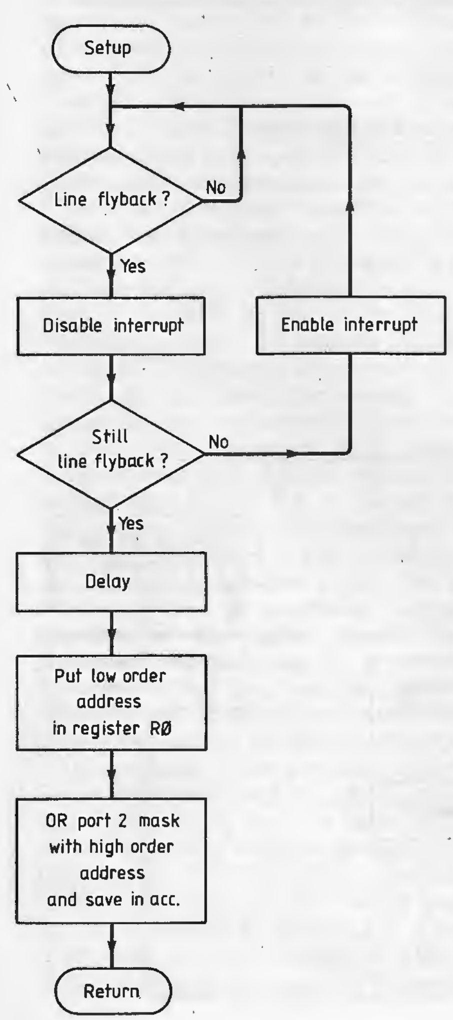
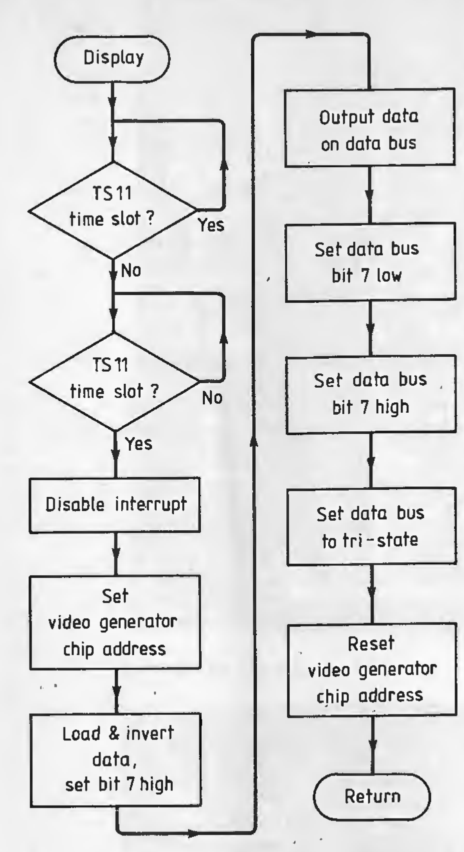


Table 1. Commands available in prototype.

Command	Function
0 Send status	The flag status register in the display module is transmitted. Eight bits interpreted as 0 – scrolling on/off, 1 – scrolling down/up, 2 & 3 – currently addressed store, 4 – cursor on/off, 5 – reveal/conceal control codes at the cursor position[1], 6 & 7 – currently-displayed store.
1 Scroll	Currently-addressed store scrolled (if scrolling is on).
2 Reset	Display module reset and screen cleared.
3 Read display address	Current cursor row and column position transmitted.
4 Read display memory	Character at cursor position in currently-addressed store transmitted.
5 Write to display memory	Next data word received stored at the current/cursor position (cursor not incremented). mented).
6 Read port	Current state of parallel port (port 1 in the 8048) transmitted.
7 Write port	Next data word received used to set 8 bits of parallel port (serial input only).
8 Backspace	Cursor moved one location backwards[2].
9 Cursor forward	Cursor moved one location forward[2].
10 Cursor down	Cursor moved one row downwards[2].
11 Cursor up	Cursor moved one row upward[2].
12 Clear screen	Two variations: – whole screen cleared and cursor homed – screen cleared from and including cursor position to end of screen (cursor position unchanged).
13 Carriage return	Cursor moved to the start of current row.
14 Select store	Next data word received determines new store to be addressed, displayed or addressed and displayed. Options determined by settings of bits 5 & 6 in command word.
15 Set display controls	Next data word received sent to display controller to provide half-page expansion and other display options (see Table 2).
16 Set scrolling	Scrolling up and down and on/off flags set. Bits 5 & 6 determine new settings.
17 Cursor on	Flashing underline cursor displayed.
18	No action.
19	No action.
20 Cursor off	Flashing underline cursor not displayed.
21	No action.
22 Set reveal	Reveal control-codes flag set or reset.
23	No action.
24 Cancel	The current row is cleared from and including cursor position to end of row.
25	No action.
26	No action.
27	No action.
28 Dump	Portions of the currently-addressed page store are transmitted from cursor position – to end of page – to end of current row – until match is found with next data word received (or end of page if encountered first). – until number of bytes specified in next data word received have been sent (or end of page if encountered first).
29	No action.
30 Cursor home	Cursor moved to row 1 column 1.
31 Set cursor	Next two data words received define new row and column position of cursor.

1. This function involves replacing a control code by a space character whilst the cursor remains positioned on such a character.
2. Scrolling, if required, is performed automatically.

DISP subroutine



Components

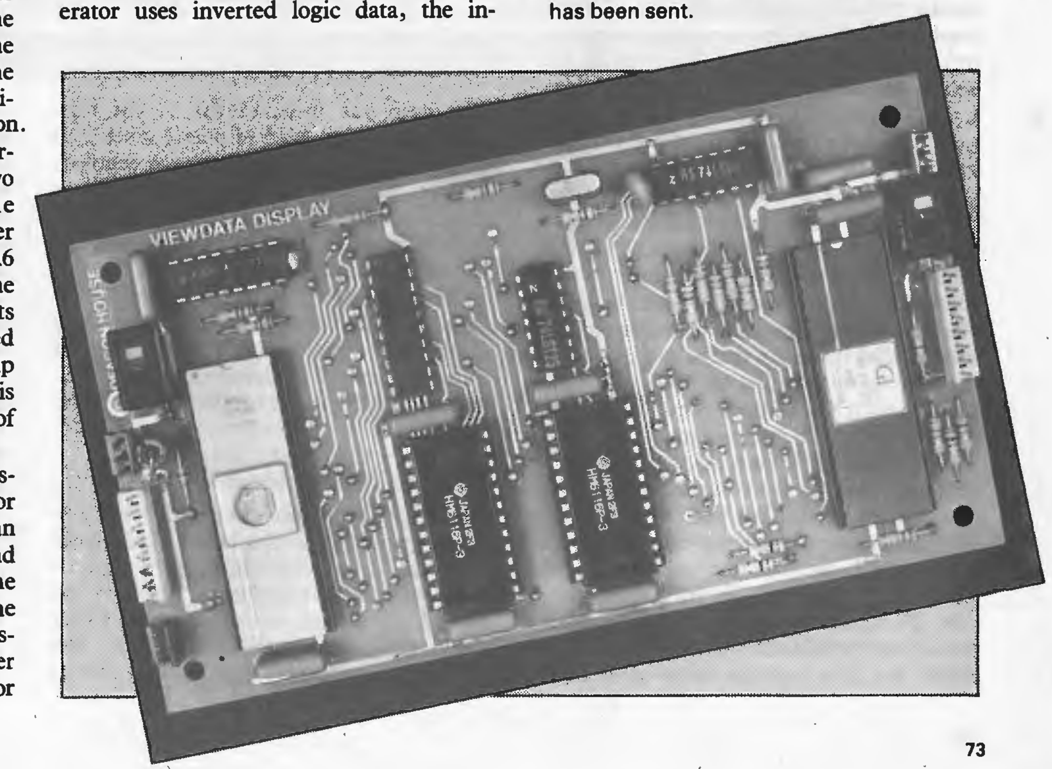
IC_1	8048 microcomputer (8748 eprom version)
IC_2	74LS123
IC_3	74LS373
IC_4, IC_5	2K×8 static ram (e.g. Fujitsu MB8416)
IC_6	74LS125
IC_7	74LS04
IC_8	9735 video generator*
D	1N4148
R_1, R_2	1kΩ all 5%, ¼ watt
R_3	27kΩ
R_4, R_5	1kΩ
R_6, R_7	10kΩ
R_8, R_9	10kΩ
R_{10} to R_{12}	22kΩ
R_{13}	10kΩ
R_{14}	4.7kΩ
R_{15}	10kΩ
R_{16}	22kΩ
R_{17} to R_{19}	100Ω†
R_{20}	10kΩ
R_{21}	330Ω
R_{22}	100Ω†
C_1	0.1µF
C_2	1µF 10V electrolytic
C_3	220pF
C_4	1nF
C_5 to C_9	0.1µF

* GIM tell us they are unable to supply the video generator i.c. An equivalent device, type MR9735, should be available through Plessey distributors or from Deaconhouse.
† Incorrectly labelled in circuit diagram.

Table 2. Video generator command words – see AY-3-9735 data sheet for full list.

Display function	Hex value
PICTURE ON & PAGE 0	C8
TEXT & SYNC ON	D1
(These commands should be sent in this order on power-up)	
CURSOR ON	A1, B1*
CURSOR OFF	A1, B4*
CLEAR ADDRESSED PAGE	94†
HALF-PAGE EXPANSION (Cycles top, full, bottom, full etc)	D3
DISPLAY FUNCTION	HEX VALUE
REVEAL/CONCEAL	D2
MIX mode	E2
ROUNDING (in interlace mode) & FLASHING OFF (for printing etc)	D9
SELECT DISPLAYED PAGE	C0 to C3 (page 0 to 3)
SELECT ADDRESSED PAGE	80 to 83 (page 0 to 3)

* These two command words must be sent in the given order in the same TS11 time slot (the DISP subroutine has a second entry point which bypasses the TS11 tests so that the second word can be sent in the same time slot).
† The display rams should not be accessed for one video frame after this command has been sent.



```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;
;       READ SUBROUTINE
;
;       READS ONE CHARACTER FROM
;       THE CURRENTLY ADDRESSED
;       DISPLAY RAM
;
;       ON ENTRY - (R0)=CURSOR ADDRESS LOW
;                - (R1)=CURSOR ADDRESS HIGH
;                - (R6)=PORT 2 MASK
;
;       ON EXIT  - (A)=CHARACTER READ FROM RAM
;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

READ:   CALL    SETUP   ;FIND LINE SYNC EDGE &
                        ;SET UP ADDRESS REGISTERS
        OUTL    P2,A    ;SET ADDRESS HIGH, PAGE SELECT
                        ;OUTPUTS & ENABLE ADDRESS LATCH
                        ;OUTPUTS
        MOVX    A,@R0   ;READ DISPLAY RAM
        ORL     P2,£1FH ;RESET PORT 2 OUTPUTS
        EN      I       ;ENABLE INTERRUPT (INTERRUPT
                        ;DISABLED IN SETUP)
        RET             ;RETURN


;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;
;       WRITE SUBROUTINE
;
;       STORES ONE CHARACTER AT THE
;       CURSOR POSITION IN THE CURRENTLY
;       ADDRESSED DISPLAY RAM
;
;       ON ENTRY - (R0)=CURSOR ADDRESS LOW
;                - (R1)=CURSOR ADDRESS HIGH
;                - (A) =CHARACTER FOR DISPLAY
;                - (R6)=PORT 2 MASK
;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
WRITE:  CPL     A       ;INVERT DATA FOR VIDEO
                        ;GENERATOR
        MOV     A,R3    ;SAVE CHARACTER IN R3
        CALL    SETUP   ;FIND LINE SYNC EDGE &
                        ;SET UP ADDRESS REGISTERS
        OUTL    P2,A    ;SET ADDRESS HIGH, PAGE SELECT
                        ;OUTPUTS AND ENABLE ADDRESS LATCH
                        ;OUTPUTS
        MOV     A,R3    ;LOAD CHARACTER FROM R3
        MOVX    @R0,A   ;STORE CHARACTER IN DISPLAY RAM
        ORL     P2,£1FH ;RESET PORT 2 OUTPUTS
        EN      I       ;ENABLE INTERRUPT (INTERRUPT
                        ;DISABLED IN SETUP)
        RET             ;RETURN
```

Deaconhouse Ltd, of 57 Guildford Street, Chertsey, Surrey (tel 09328 66015) say they will supply the 85 × 155mm double-sided printed board shown opposite.

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;
;       SETUP SUBROUTINE
;
;       FINDS THE NEXT LINE SYNC
;       PULSE AND SETS THE CURSOR
;       ADDRESS LOW IN R0, THE
;       CURSOR ADDRESS HIGH AND
;       CURRENTLY ADDRESSED PAGE
;       IN ACCUMULATOR AND RETURNS
;       AT THE START OF THE NEXT
;       LINE FLYBACK INTERVAL
;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

SETUP1: EN      I       ;ENABLE INTERRUPT AGAIN
SETUP:  JT0     SETUP   ;WAIT UNTIL NEXT LINE
                        ;SYNC PULSE
        DIS     I       ;DISABLE INTERRUPT
SETUP2: JT0     SETUP1  ;JUMP IF LINE SYNC
                        ;PULSE NOT STILL THERE
        MOV     A,£3    ;SET DELAY
SETUP3: DEC     A       ;DECREMENT ACCUMULATOR
        JNZ     SETUP3  ;JUMP UNTIL (A)=0
        MOV     A,@R0   ;LOAD CURSOR ADDRESS LOW
        MOV     R0,A    ;SAVE IN R0
        MOV     A,R6    ;LOAD PORT 2 MASK
        ORL     A,@R1   ;ADD CURSOR ADDRESS HIGH
        RET             ;RETURN


;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;
;       SUBROUTINE DISP
;
;       SENDS A DISPLAY COMMAND TO THE
;       VIDEO GENERATOR
;
;       ON ENTRY - (A)=COMMAND CODE TO BE SENT
;
;       ENTRY POINT "DISP2" ALLOWS A
;       COMMAND TO BE SENT DIRECTLY
;       WITHOUT WAITING FOR THE NEXT
;       TS11 TIME SLOT - USED FOR
;       CURSOR ON/OFF COMMANDS
;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

DISP:   JT1     DISP    ;WAIT UNTIL NOT TS11
                        ;TIME SLOT
DISP1:  JNT1    DISP1   ;WAIT UNTIL START OF
                        ;NEXT TS11 TIME SLOT
        DIS     I       ;DISABLE INTERRUPT
DISP2:  ANL     P2,£0DFH ;SET VIDEO GENERATOR
                        ;ADDRESS OUTPUT
                        ;(PORT 2 BIT 5 LOW)
        CPL     A       ;INVERT COMMAND CODE
                        ;FOR VIDEO GENERATOR
        ORL     A,£80H  ;SET BIT 7 HIGH
        OUTL    BUS,A   ;SET COMMAND ON DATA BUS
        ANL     A,£07FH ;SET BIT 7 LOW
        OUTL    BUS,A   ;SET STROBE BIT LOW ON DATA BUS
        ORL     A,£80H  ;RESET BIT 7 HIGH
        OUTL    BUS,A   ;SET STROBE BIT HIGH ON DATA BUS
        ORL     A,0FFH  ;SET ALL BITS HIGH
        OUTL    BUS,A   ;SET DATA BUS TO TRI-STATE AGAIN
        ORL     A,£20H  ;RESET VIDEO GENERATOR
                        ;ADDRESS OUTPUT
        EN      I       ;ENABLE INTERRUPT
        RET             ;RETURN
```

terrupt is enabled, and the subroutine returns.

The write subroutine operates in a similar fashion except the character to be displayed (held in the accumulator on entry) is inverted and stored in register R3 before execution of the setup subroutine. It is then loaded into the accumulator again just before execution of the MOVX instruction to store the character.

The subroutine to send commands to the video generator, called DISP, operates as follows; the first two instructions find the rising edge of the 8048 T1 input – this represents the start of the TS11 time slot when the video generator can receive commands. The interrupt is disabled and bit 5 of port 2 is set low to complete the 1111XX0XXXX address required for the video generator to respond to a command. The command data to be sent to the video generator, held in the accumulator, is then inverted for the DATA bus of the display chip. The most significant bit which acts as a strobe is set high and the data placed on the bus by the OUTL BUS,A instruction. The most significant data bit is then pulsed low (minimum pulse width 4µs) to strobe the data into the video generator. The data bus then returns to the high impedance state, bit 5 of port 2 is set high impedance again, the interrupt is enabled, and the subroutine returns. Table 2 shows the hex values of the command data required by the video generator to achieve the various display facilities.

These three subroutines are the only ones that would have to be used in any application of the display module. The rest of the program is determined by the application and the functions required of the module.

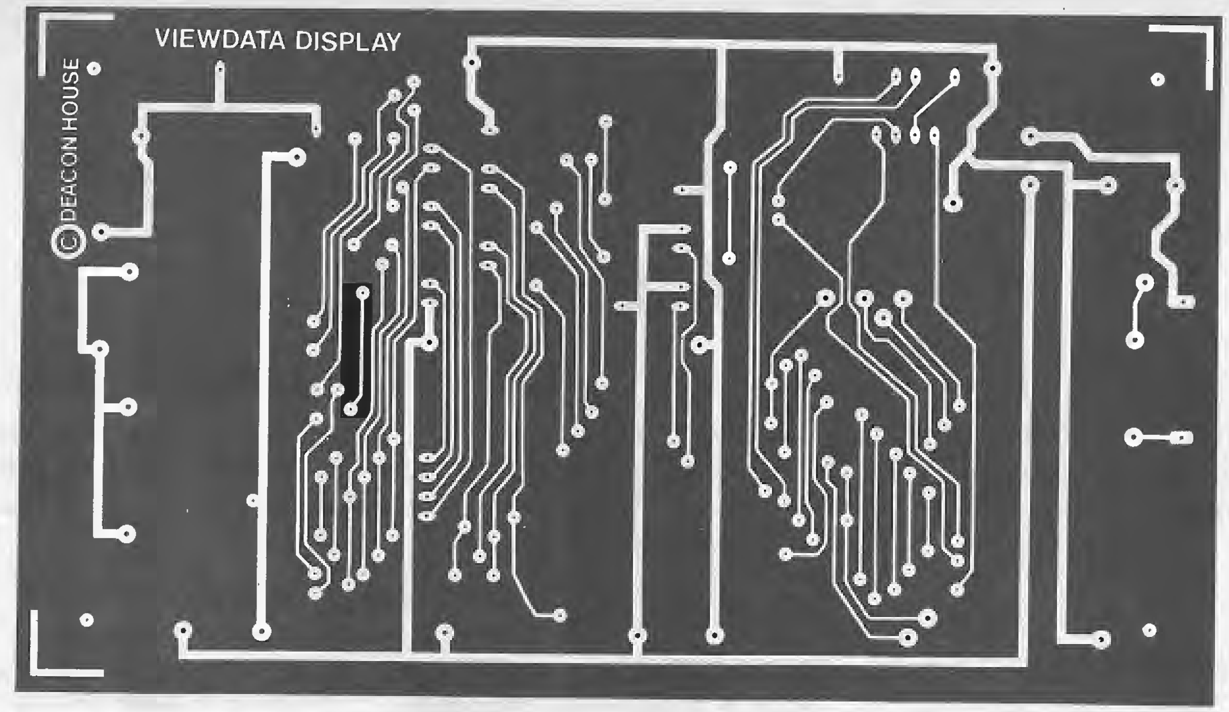
Constructional notes

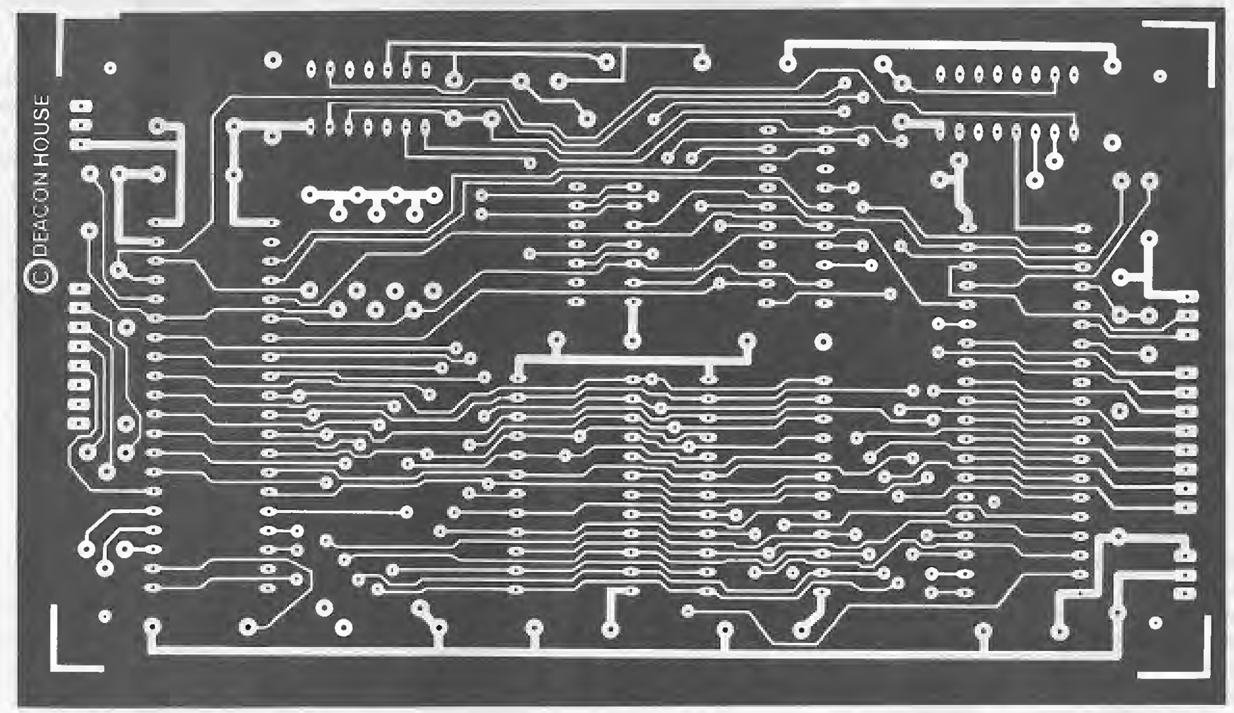
The original was constructed on a half-Eurocard prototype wiring board. Apart from the usual considerations as to the placement of the decoupling capacitors no special precautions were taken with either the component or the wiring layouts. The only hardware problem met so far is that the video generator i.c. sometimes does not power-up correctly. On the software side, I recently used different versions of the display generator – one which automatically displays the cursor when initially set to the text mode and one which does not. Both problems appear to stem from the use of pre-production prototype display generators, and I do not envisage these occurring with production i.cs.

Stand-alone viewdata decoder

The following notes are intended as a guide to those who wish to use the module to directly decode the 1200baud serial data arriving from a viewdata computer. I have not tried these modifications.

The first consideration is whether the module can be constructed and programmed to transmit 75baud data to the viewdata computer as well as receive the





1200baud data. It is possible to connect a keyboard with a parallel ASCII output to the parallel port on the module, and use the data out line (port 2, bit 7) as the 75baud data line. The most significant bit of the parallel port could be used as a keyboard strobe (the strobe pulse width should be arranged to be less than the transmit time of one 75baud character, but longer than the transmit time of one 1200baud character, i.e. between about 10ms and 100ms. This ensures that the strobe will be recognised even if it occurs whilst a character is being received). The problem with this method is that if a character is received whilst one is being transmitted, the transmitted character will be corrupted because the processor will be interrupted by the incoming character. To ensure full duplex operation therefore, it may be wiser to employ a separate uart to generate the 75baud signal.

On the software side, the following changes would have to be made.

– Change the software delays in the interrupt routine to decode 1200 baud data rather than 4800.
– Change the serial transmit routine delays to send 75baud data (if port 1 is used to connect the keyboard).
– Perform a parity check on the incoming data using the most significant bit and display the parity error character (7F hex) if an error occurs.
– Change the command look-up table to perform only the required viewdata cursor controls (such as back space, carriage return, clear screen, etc).
– Set a flag on receipt of an ESC code.
– If the ESC flag is set convert the next received character (if it is between 40 hex and 60 hex) to a teletext control code (clear bit 7 of the character) and display it, or ignore it if it is not in the above range. The ESC flag is then cleared.
– On receipt of the ENQ character (05 hex) to send the required log-on data (which should be programmed into the 8748 rom).

To have enough program space to incorporate these changes would require the deletion of some of the editing facilities described in Table 1, such as scrolling, part clear, or dump.

A modem would of course be required in any stand-alone application of the display module to transmit/receive the correct f.s.k. signals. WW

Digital filter design procedure

These examples of the design of a simple digital filter and, in contrast, that of a digital version of a fourth-order Butterworth filter, show how laborious mathematics may be simplified and the "recurrence formula" for the filter written without having to solve a fourth order equation.

Many digital filters can be designed simply on their own merits. But in the case of the digital equivalent of an analogue filter, such as the Butterworth filter, the situation is complicated by the need to use a bilinear transformation, resulting in laborious algebra. This can be largely avoided for a fourth-order filter by following this procedure, substituting cut-off and sampling frequency values, and by using the tabular form suggested.

The end product of filter design procedure is the recurrence formula in a form which can readily be entered into the computer or micro processor program that constitutes the filter. In addition it is desirable to plot the j ω frequency spectrum in terms of the sampling frequency to check that the filter has the desired characteristics.

Two starting points are considered:

– where the z-transfer function and hence the z-plane diagram can be formulated from a comparatively simple requirement. The example described is the digital equivalent of a simple tuned circuit.

– where the z-transfer function and the z-plane diagram have to be derived from an analogue filter using a bilinear transformation. The example chosen is the digital equivalent of a Butterworth low-pass filter.

by J. T. R. Sylvester Bradley

The two examples are worked in full. In the second example the algebra is laborious and unavoidable but some short cuts are suggested. It shows that if a digital filter is designed as an equivalent to an analogue filter, coefficients are generated which in most cases require sophisticated arithmetic in the microprocessor. It is often preferable to design a digital filter so that the coefficients can be kept as simple as the hardware requires. (In the Butterworth filter fractional coefficients with a required accuracy of 3 decimal places are unavoidable.)

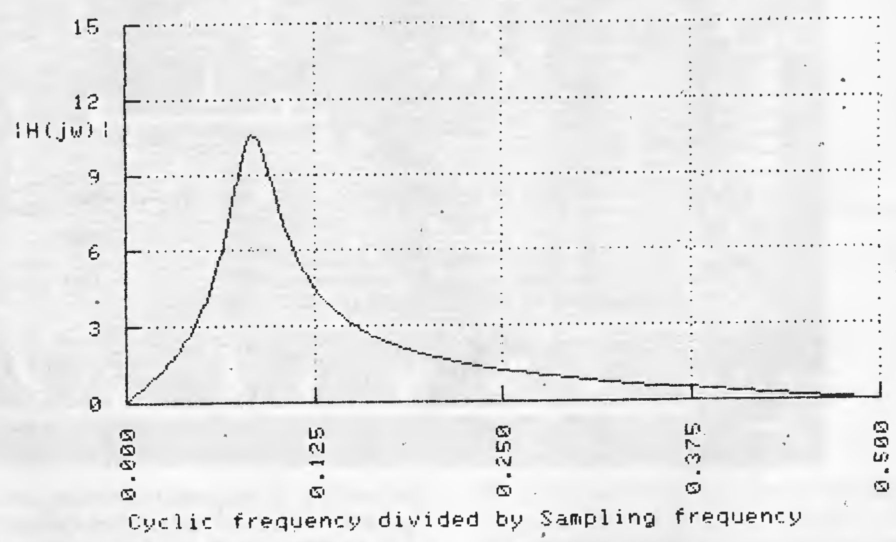


***Fig. 2.** Response |H(jω)| of the filter in Fig. 1 is plotted against frequency divided by sampling frequency.*

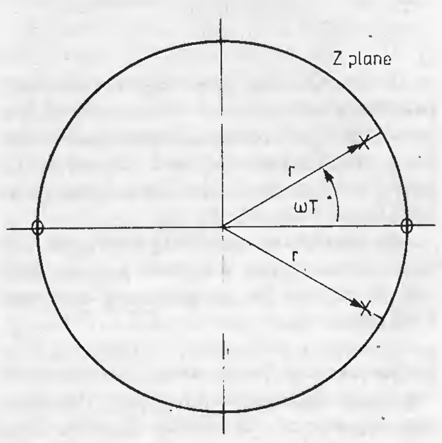


***Fig. 1.** Z-plane diagram of the digital equivalent of a tuned circuit. Angle represents the resonant frequency and is 1/12 of the sampling frequency, which is represented by one revolution round the unit circle.*

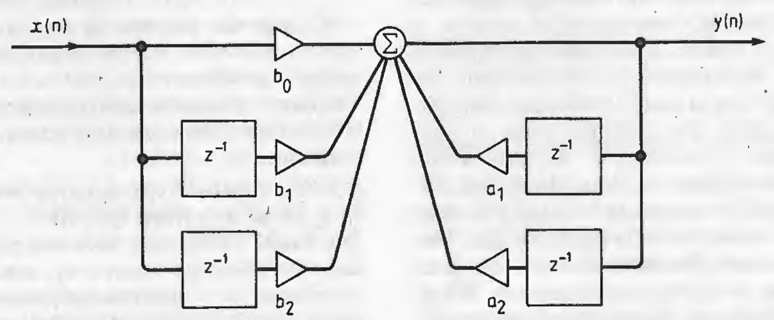


***Fig. 3.** Realization diagram shows how the microprocessor performs the signal processing. Boxes labelled z^{-1} are delays of one clock pulse and the small triangles are multipliers (or dividers) by the coefficients shown. x(n) is the input sample at the instant "now" or "n", and y(n) is the output sample at the same instant.*

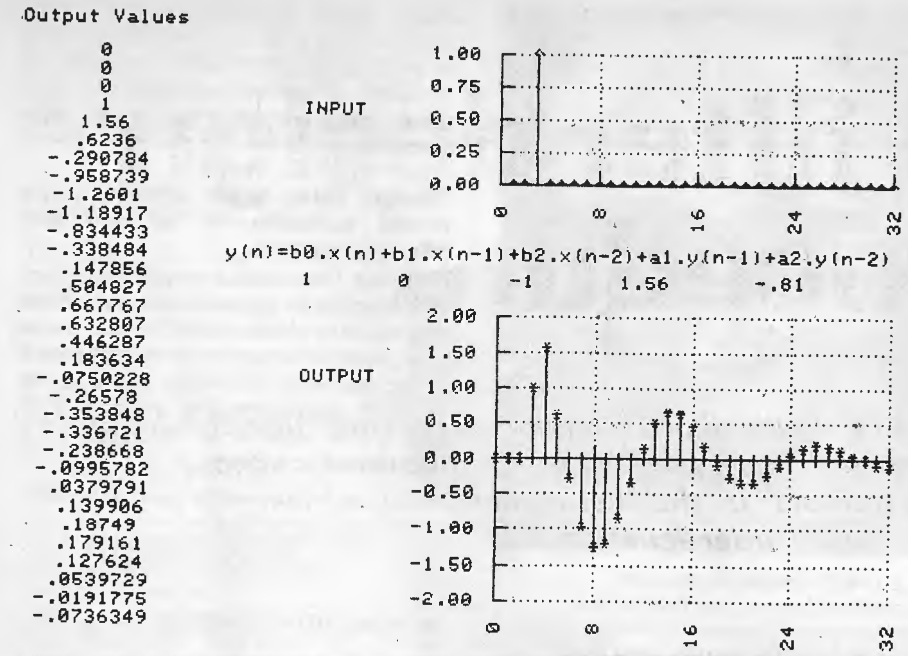


***Fig. 4.** Input of 32 samples is shown with the corresponding output as (a) a column of values on the left and (b) as a diagram, for the filter whose recurrence formula is shown between the input and output diagrams. A single pulse is shown as the input, resulting in a decaying oscillation at 1/12 of the sampling frequency.*

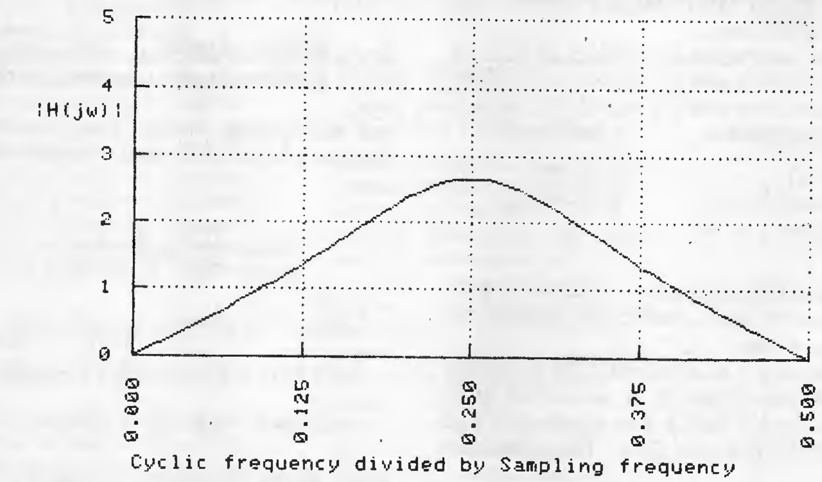


***Fig. 7.** Flatness or low Q shown in the response curve is a result of choosing very simple arithmetic.*

Method

The process for the design of a digital filter is

– choose a suitable transfer function

– derive the recurrence formula from the transfer function

– write the recurrence formula into the program for the relevant hardware (computer or microprocessor) that will be used to make the filter.

Of these it is the choice of transfer function that causes difficulty. Often a z-plane diagram can be drawn as a step toward the choice of transfer function. In addition a j ω frequency spectrum is needed so that one can see whether the filter will meet the requirements of bandwidth and so on; this is derived from the z-plane diagram. In the first, simple case the design almost begins and ends with the z-plane equivalent of an analogue circuit, whereas in the second example, in which a digital version of Butterworth filter is designed, the z-plane diagram and frequency spectrum are derived from a Butterworth s-plane diagram involving a bilinear transformation, and the algebra is more involved.

The recurrence formula is usefully illustrated as a realization diagram, shown for each example. Finally, in each case the operation of each filter is demonstrated by generating the impulse response using a desk-top computer and a simple Basic program to give input and output signal diagrams.

Design digital filter equivalent to a parallel tuned circuit

The tuned circuit will have one pole-pair only, at its resonant frequency, and we can assume zeros at zero frequency and at infinity. To be stable, the poles must lie within the unit circle on the z-plane. (In other words the analogue circuit must contain some resistance.) The position of the poles is dictated by the resonant frequency in relation to the sampling frequency, and to the Q required.

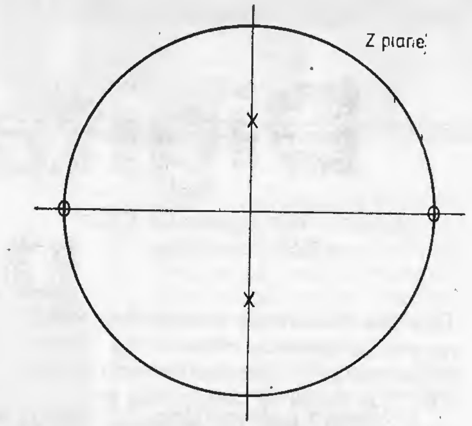


***Fig. 5.** Z-plane diagram has been chosen with very simple ratios to simplify arithmetic in the microprocessor.*

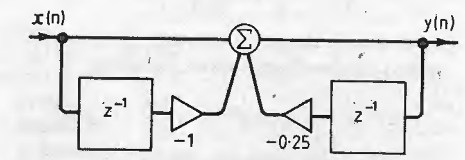


***Fig. 6.** Realization diagram only contains one multiplier with a coefficient of 1/4, so the arithmetic in the microprocessor is very simple.*

Two examples are worked, one with pole positions chosen arbitrarily with the resonant frequency any value less than half the sampling frequency, and the other with pole positions chosen for arithmetic simplicity with a simple microprocessor in mind (e.g. the MMD1).

Step 1 – draw the z-plane diagram. Suppose the sampling frequency has already been chosen as $12 \times f_o$, where f_o is the required resonant frequency of the tuned circuit. The digital filter is designed by locating a pole on the z-plane at an angle of 1/12 of a revolution, as one complete revolution of the z phasor represents the sampling frequency. There will automatically be another pole at an angle of −1/12 of a revolution, as the poles come in conjugate pairs. The radius of the poles (exp σT) has been chosen arbitrarily as 0.9 to give an adequately peaky response, without instability. Two zeros are added, at zero frequency and at maximum frequency (½ the sampling frequency) to correspond with zeros at zero frequency and infinite frequency for the analogue circuit, Fig. 1. The jω spectrum or cyclic frequency response |H(jω)| is found directly from the z-plane diagram and is shown at Fig. 2.

Because the transfer function H(z) is zero when z=+1 or −1 (the zeros) and is infinite where z=r. exp jωT (the poles), the transfer function can be written down directly as

$$H(z)=\frac{(z+1)(z-1)}{(z-r\exp j\omega T)(z-r\exp -j\omega T)}.$$

Step 2 – find the recurrence formula.

$$H(z)=\frac{Y(z)}{X(z)}=\frac{z^2-1}{z^2-2r\,z\cos\omega T+r^2}$$

$$\therefore Y(z).z^2-Y(z).2rz\cos\omega T+Y(z).r^2=X(z)\,.\,z^2-X(z).$$

This can be directly transformed to the recurrence formula, since if the present output sample is y(n) then the next sample y(n+1) is found by multiplying by z (one clock pulse), and the previous sample y(n−1) by dividing by z. Thus

Y(z)	y(n)
Y(z) . z	y(n+1)
Y(z) . z^2	y(n+2)
Y(z) . z^{-1}	y(n−1)

and so on. So the equation becomes

$$y(n+2)-2r.\cos\omega T.y(n+1)+r^2.y(n)=z(n+2)-x(n).$$

The present output sample y(n) in terms of present and previous input samples, x(n), x(n−1) etc can be found by dividing z^2, and putting r=0.9 and ωT=30° gives y(n)=

$$1.56.y(n-1)-0.81.y(n-2)+x(n)-x(n-2).$$

The recurrence formula in this form can be used as the digital filter within a suitable program.

The general form of the recurrence formula for a second-order filter is

$$y(n)=b_0.x(n)+b_1.x(n-1)+b_2\times x(n-2)+a_1.a_1y(n-1)+a_2.y(n-2)$$

Its realization diagram is shown in Fig. 3, and in this example the coefficients are

J. T. R. S. Bradley is currently principal lecturer and head of the telecommunications technology group in the School of Signals, Blandford Camp, a post he has held since 1975. Graduating from Corpus Christi College, Cambridge, he served in the Royal Corps of Signals from 1942 to 1966, when he retired (as a major) to become a lecturer at the School of Signals, then at Catterick Camp in Yorkshire.

x coefficients	y coefficients
$b_0=1$	$a_1=1.56$
$b_1=0$	$a_2=-0.81$
$b_2=-1$	

The x-coefficients relate to the zero positions, while the y coefficients relate to the pole positions.

The output is of course a list of sample values, which has to be converted to an output signal with a d-to-a convertor and (usually) a low-pass filter. The values and output signal in sampled data form are shown at Fig. 4 for a single unit input, and is the impulse response of the filter. As expected, the output oscillates at 1/12 of the sampling frequency and decays exponentially.

Design filter with simple arithmetic suitable for a primitive microprocessor

Sampling frequency, resonant frequency, and damping factor must be chosen so that they relate by simple ratios. In this case the pole positions are chosen so that they are at ½ the maximum frequency (i.e. at an angle of 90 degrees) and at a radius of ½, Fig. 5. The poles are at +j0.5 and −j0.5, the zeros are at +1 and −1.

$$H(z)=\frac{z^2-1}{z^2-2r^2z\,.\,\cos\omega T+r^2}$$

as before but r=0.5 and cosωT=cos 90°=0

$$\therefore H(z)=\frac{z^2-1}{z^2+.25}.$$

Alternatively this could be found by describing the transfer function in terms of the poles and zeros as follows:

$$H(z)=\frac{\text{position of zeros}}{\text{position of poles}}=\frac{(z+1)(z-1)}{(z+j0.5)(z-j0.5)}$$

and multiplying it out. The recurrence formula is obtained from the transfer function:

$$H(z)=\frac{Y(z)}{X(z)}=\frac{z^2-1}{z^2+0.25}$$

$$\therefore Y(z).z^2+0.25Y(z)=X(z).z^2-X(z)$$

$$\therefore y(n+2)+0.25y(n)=x(n+2)-x(n)$$

$$\therefore y(n)=x(n)-x(n-2)-0.25y(n-2).$$

Fig. 6 shows the realization diagram, Fig. 7 the spectrum and Fig. 8 the impulse response. The filter was designed with the very simple arithmetic of a primitive microprocessor in mind, limiting the processes to addition, subtraction and multiplication or division by two only. The result is a response curve which is too flat, Fig. 7. Of course a sharper response can be obtained with only a modest improvement in the arithmetic, as in the first example in which the coefficients are 1.56 and −0.81.

To be concluded with fourth-order Butterworth filter design.

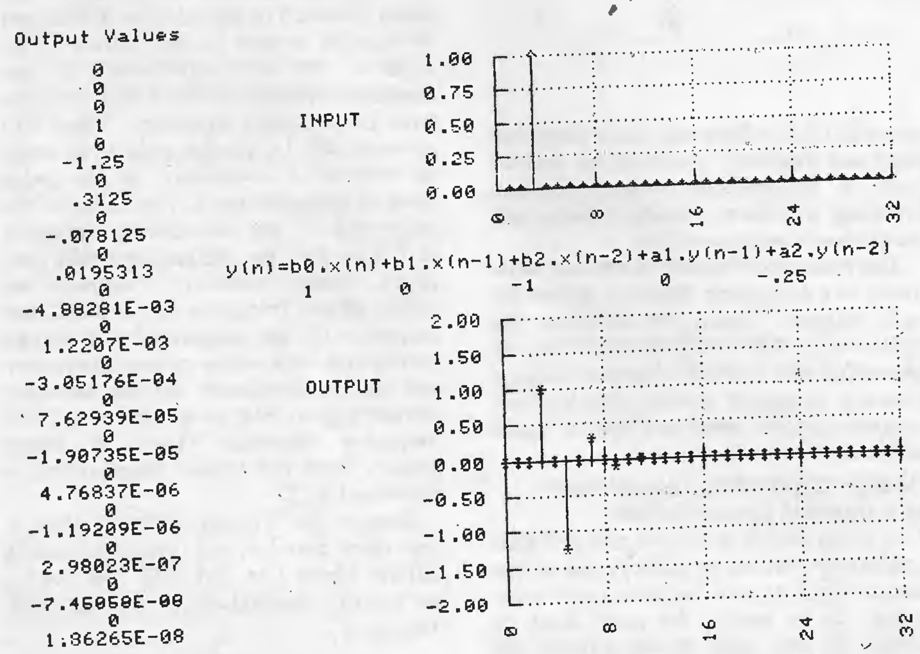


Fig. 8. Oscillation caused by the impulse at the input soon dies away, as one would expect from a low-Q circuit.

NEW PRODUCTS

POWER ANALYSIS

Three displays are available on the 636 multifunction power analyser. The first two display voltage and current but the third shows a function selected from a push-button panel. The selected function may be watts, watthours, vars, varhours, volt-ams, power factor, phase angle and frequency.

The resolution of the instrument is 0.01% of full scale with an error of ±0.05% of full scale. It will give true r.m.s. readings of sinusoidal or distorted waveforms at a frequency range of 40 to 400Hz.

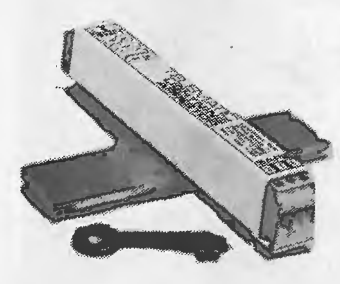
Voltage and current inputs are fully isolated with voltage ranges from 15 to 600V in six ranges with five significant figures; current is measured in nine ranges from 25mA to 55A.

A wide range of applications are possible with the instrument. They include calibration standards for meters and transducers; measurement of losses in transformers, inductors and motors; non-destructive testing of soft magnetic materials; power factor measurement in reactive loads; measuring phase; checking line-frequency stability; measuring the efficiency of lighting and heating circuits. Wessex Electronics Ltd, 114-116 North Street, Downend, Bristol BS16 5SE. **WW301**

LIGHTNING ARRESTED

According to many sources, lightning strikes can generate up to 200A of surge current lasting for, typically 5μs to 1ms, in an overhead line. The SA series of surge arrestors form Telematic are capable of withstanding 5kA peaks for over 10ms. While this is happening at the 'line' side of the arrestor, the 'safe' end remains at predetermined levels, safe for semiconductor circuitry. In the event of a surge greater than the design of the device, a 'fail-safe' mechanism will short circuit the input and isolate any series elements.

Thus modems, duplexers, two-wire transmitters, control loops, exchanges and all data transmission ports are fully protected. The arresters are approved for use with British Telecom equipment. Physically small, 168mm long, the arrestor is bolted to an earthed busbar by a single bolt. Several arrestors can be mounted together and for outdoor use, weatherproof boxes are available. Telematic Ltd, 49 Hazelwood Drive, St Albans, Herts AL4 0UP. **WW302**



TAPE NOISE REDUCTION

A tape compatibility unit, the TCU 3000a, is the first product of a new British company, Tardis Ltd. It claims to eliminate tape hiss entirely. The circuit is a two-to-one compander using an averaging system with treble pre- and de-emphasis. It is based around the Signetics NE570N dual compander chip, which can be switched to encode or decode.

High-frequency noise pumping, which is a problem with most compansion systems, is minimized by boosting the components of the signal above 2kHz by 12dB prior to encoding. Low-frequency pumping is reduced by a -12dB attenuation filter in series with the variable gain cell.

Tape saturation is avoided both by the two-to-one compansion system and by the introduction of a bandpass filter.

The performance figures claimed for the machine include a 40dB noise reduction, total harmonic distortion of 0.1% over the whole encode/decode cycle with a frequency response level between 30Hz and 30kHz. The dynamic range is claimed to be doubled.

The unit is connected between an amplifier and a tape recorder by phono plugs and it is not suitable for DIN level machines. It may only be used in one direction at a time – either record or replay – and so may not be used in a monitor mode for, say, a three-head recorder. The manufacturers have said that a two-way unit is to be made. Input from the amplifier is preset through a hole in the back of the case and once set does not need to be adjusted further. In the other direction there is no input control for the level from the tape deck, so it is necessary to use a deck with an output level control. Input and output levels are indicated on two p.p.ms, one for each channel. After the input level is set the only controls used are three push buttons on the front panel: power switch, record or replay and unit switched in or out. This last control by-passes the unit so that the amplifier is connected directly to the tape deck.

Auditioning a pre-production unit, we found that the unit worked very well on music with no audible background noise at all. Some pumping was discernible on speech which was not evident as noise as much as a peculiar change in perspective between presence or absence of sound. The unit costs £149.50 inclusive and is available from the manufacturer, Tardis Ltd, Unit 3, Sunningdale Road, South Park Industrial Estate, Scunthorpe, South Humberside. **WW303**

MULTI-WAVE GENERATOR

A number of user-defined waveforms may be stored in the memory of the waveform generator from 3D. Function generators can normally supply square, sinusoidal, triangular or other regular waveforms but if any special function is required, it may take much adaptation of filters and shaping circuitry to get the required form. This generator interfaces with a microcomputer which can store up to 32 different waveforms. The frequency can be easily controlled up to 500kHz., with an output voltage of up to 10V r.m.s. and frequency sweeps, amplitude or frequency modulation are possible. A number of standard waveforms; sine, triangular, square, pulse etc. are already programmed into the generator's internal rom; others can be programmed and stored in eprom if they are to be used regularly. Applications cited by the manufacturer include component testing, vibration testing and the testing of the reaction to stimulus of muscles and nerve tissue subject to the influence of various medicines. The generator is one of a series of Inlab modules and shares the same interface system which can be connected to a wide range of microcomputers through the IEEE-488 instrumentation bus, or may be configured to work with many others. Digital Design and Development, 18-19 Warren Street, London W1P 5DB **WW304**

UV FOR P.C.Bs

An exposure unit for photosensitive coated copper boards or labels from Electronic Assistance includes four 15V actinic u.v. fluorescent tubes controlled by a precision timer. The UV-800 has an exposure area of 800cm² and boards are clamped against the exposure window by a flame-retardant foam pressure pad in the lid. A microswitch prevents u.v. emission reaching the operator when the lid is raised. The exposure unit costs £85 (+ v.a.t.) and there is a smaller unit, UV-300, without the timer but with the same safety features, for £35 (+ v.a.t.). Electronic Assitance Ltd, Unit 1, Brunberth Industrial Estate, Rhayader, Powys LD6 5EN. **WW305**

LCDs WORK IN THE COLD

Operating temperatures of -45° up to +85°C are claimed for the Survivor range of liquid crystal displays. At the lowest temperature there is a response time of 1.1s. The l.c.ds are sealed with contact protection to allow the displays to work in 95% relative humidity and are also protected against shock and vibration to make them suitable for all sorts of hostile environments. Manufactured in Canada by Data Images Inc, they are available in the UK through Antech Electronics Ltd, Grenfell Place, Maidenhead, Berks SL6 1HL. **WW306**

NEW PRODUCTS

UNINTERRUPTABLE SWITCH-MODE POWER

Pmos high-speed switching transistors are used in a range of 125W power units, the SMM series from Elba Electric GMBH. Several models are available with up to five isolated outputs. One output may be used to charge a 24V battery, which can take over the power supply in the event of a mains failure.

Inputs may be 115 or 230V alternating or 24V direct. Outputs offered are 5V at 20A, 5 to 18V at 3A, -5 to -15V at 1A, 12 to 24V at 2.5A and 24 to 27.5V at 1A for battery charging. Outputs are short circuit protected. All this fits into a space 300 × 125 × 75mm. The units comply with standard safety regulations and are available in the UK through Dome Electronics, 1A Junction Road, Andover, Hants.
WW307

FORTH COMPUTER ON A BOARD

Designed for system control applications, the TDS 900 is based on the Hitachi HD6301P 8/16-bit microprocessor and has an on-board Forth interpreter. Fitting on a standard Eurocard, the TDS900 is provided with 10K of ram and 8K of rom. Either or both of these can be easily extended by the addition of TDS940 extension cards to give 160K-bytes of ram or 640K-bytes of rom. An RS232C connector is incorporated and can be connected to a v.d.u. and to an eprom programmer.

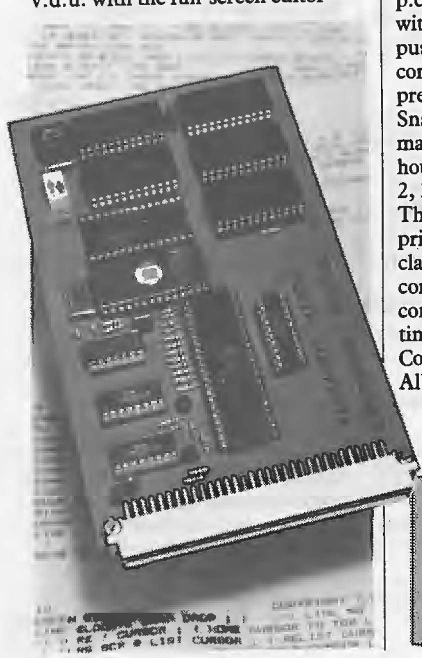
The computer is intended chiefly for installing into equipment and a typical development cycle is to programme the computer using a v.d.u. with the full-screen editor included in the on-board software. The program is entered in Forth, which is then compiled into the Forth dictionary format. The program may be run and tested (debugging is inherent in the Forth language) and then output to a prom programmer. The eprom may then be plugged in to the computer which thus becomes dedicated to that task. Even when it is installed in the equipment, the computer can be connected to a v.d.u. and its operation may be monitored and corrected if necessary.

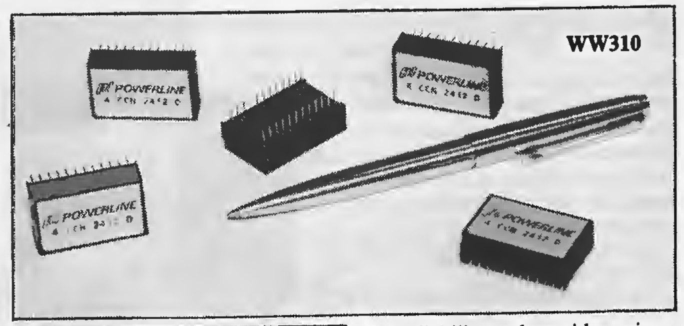
A large variety of input/output interfaces may be connected to the computer including a-to-d or d-to-a converters, control signals to triacs or other switches, printers, keyboards, or displays.

Standard Fig-Forth language is used with additional commands for the screen editor and for some functions, for example timing. Any function not included can, of course, be added by the user.

One application developed by the manufacturer was a sound-operated switch which could be used by the severely handicapped to operate up to ten appliances such as switching on or off lighting, the tv, radio, etc. or for summoning assistance.

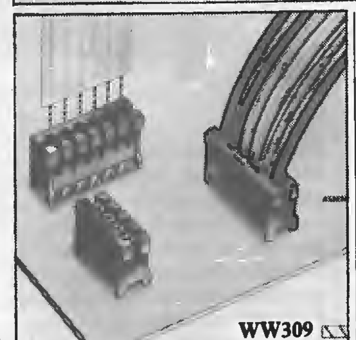
The computer is produced in different versions: cmos for battery-powered operation or the cheaper n-channel version: there are also lower cost versions with less ram. The full memory cmos model costs £179.95 for one-off, less for quantity orders. Triangle Digital Services Ltd, 23 Campus Road, London E17 8PG.
WW308





WW310

the reliability and provides twice as much output power as discrete component versions of a similar size. Powerline Electronics Ltd, 5 Nimrod Way, Reading, Berks RG2 0EB.
WW310



WW309

EDUCATIONAL KIT

Thirty-one different experiments and applications are possible with the experimental electronics kit from Cambion. Two years of planning have gone into the development of the kit which comes complete with teacher's notes and a series of worksheets. The electronic components plug into a breadboard and may be re-used in different configurations.

Designed for use in schools, the kit is equally useful in industrial schemes for training apprentices. It costs just under £30 from Cambion Electronics Products Division, Midland Ross Corporation, Castleton, Sheffield S30 2WR.
WW311

D.C. TO D.C.

The first of a series of d.c.-to-d.c. converters are thick-film hybrids in 24-pin d.i.ps with up to 4W of output power in both regulated and unregulated versions. Output voltages of 5, 12, 15, -12 and -15V are derived from models with input voltages nominally of 5, 12, 24, 28 and 48V. The makers claim that the use of thick film techniques increases

FLAT CABLE TERMINALS

Connectors which are soldered to a p.c.b. can have the flat cable inserted with no force. The housing is then pushed down to effect the connection. No special tools or cable preparation are necessary with the Snap-mate connectors and the cables may be easily released by lifting the housing. Connectors are available for 2, 3, 4, 5 and 6-conductor cables. The gas-tight high-pressure contact principle used in the terminals is claimed to offer as reliable connections as in gold-plated contacts while using the lower cost tin alloy plating. Burndy Ltd, Connector House, Colney Street, St Albans, Herts AL2 2ED. **WW309**

WW311

If you would like more information on any of the items featured here, enter the appropriate WW reference number(s) on the mauve reply-paid card.

01-452 1500 TECHNOMATIC LTD 01-450 6597

BBC Micro Computer

Please phone for availability

BBC Model B **£399** (incl. VAT) Carr £8/unit
Model A to Model B upgrade kit **£50**
Fitting charge **£15**
Individual upgrades also available

TELETEXT ADAPTOR £195
PRESTEL ADAPTOR £90
2nd PROCESSOR 6502 £170
2nd PROCESSOR Z80 £290

WORD PROCESSOR 'VIEW' 16K ROM £52

ACORN SOFT/BBC SOFT/GAMES PADDLES IN STOCK

FLOPPY DISC INTERFACE

incl. 1.2 Operating System
£95 & £20 installation

Phone or send for our BBC leaflet

BBC FLOPPY DISC DRIVES

Single Drive 5¼" 100K £235+£6 carr.
Double Drive 5¼" 800K £799+£8 carr.

BBC COMPATIBLE DRIVES

These are drives with TEAC FD50 mechanism and are complete with power supply
SINGLE: 100K £190; 200K £260; 400K £340
DUAL: 200K £360; 400K £490; 800K £610
DRIVE CABLES: SINGLE £8 DUAL £12

OFFICIAL BBC DEALER

CASSETTE RECORDER

BBC Compatible Cassette Recorder with Counter and Remote Control
£26.50 + £1.50 carr.
Cassette Leads £3.50
Computer Grade Cassettes £0.50 each. £4.50 for 10 + £1 carr

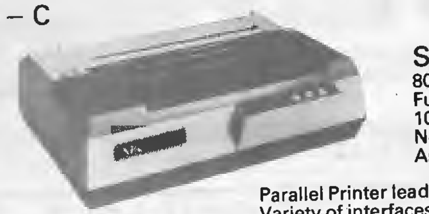
MONITORS

MICROVITEC 1431 14in Colour Monitor £249+£8 carr
MICROVITEC 2031 20in Colour Monitor £319+£8 carr
KAGA 12in RGB Monitor £255+£8 carr
Lead for KAGA RGB £10
SANYO Hi Res Green Monitor £99+£6 carr

ACORN ATOM

Basic Built £135. Expanded £175
(Carr £3 per unit)
Atom Disc Pack £299+£6 carr
3A 5V Regulated PSU £26+£2 carr
Phone or send for our BBC Atom list

NEC PC 8023 BE – C



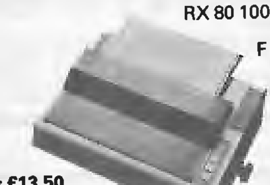
100CPS, 80 cols
Logic Seeking, Bi-directional,
Forward and Reverse Line Feed,
Proportional Spacing,
Auto Underline,
Hi-Res and Block Graphics, Greek Char. Set.
Only £345 + £8 carr.

PRINTERS

SEIKOSHA GP 100A

80 cols 30 CPS
Full ASCII & Graphics
10" wide paper
Now only £180 + £6 carr.
Ask for details on GP 250A

EPSON RX 80 and FX 80



RX 80 100CPS 80 col Tractor Feed
FX 80 160CPS 80 cols
F & T Feed Logic seeking, bi-directional,
Bit Image Printing,
9×9 Matrix
Auto Underline
Centronix 8, Bit Parallel Interface as standard
RX 80 £298 FX 80 £438
(£8 Carr/Printer)

Parallel Printer lead for BBC/Atom to most printers £13.50
Variety of interfaces, ribbons in stock.
2,000 fan fold sheets 9½"×11" £13.50+£3 p&p

RUGBY ATOMIC CLOCK

This Z80 micro controlled clock/calendar receives coded time data from NPL Rugby. The clock never needs to be reset. The facilities include 8 independent alarms and for each alarm there is a choice of melody or alternatively these can be used for electrical switching. A separate timer allows recording of up to 240 lap times without interrupting the count. Expansion facilities provided.
See July/August '82 ETI for details.
Built and tested £145+£2 p&p.

CONNECTOR SYSTEMS

ID CONNECTORS (Speedblock type)

No of ways	Header Plug	Receptacle	Edge Conn
10	90p	85p	120p
20	145p	125p	240p
26	175p	150p	300p
34	200p	160p	380p
40	220p	190p	550p
50	235p	200p	600p

JUMPER LEADS

24" Ribbon Cable with Headers

	14pin	16pin	24pin	40pin
1 end	145p	165p	240p	380p
2 ends	210p	230p	345p	540p

24" Ribbon Cable with Sockets

	20pin	26pin	34pin	40pin
1 end	160p	210p	270p	300p
2 ends	290p	385p	490p	540p

Ribbon Cable with D. Conn. 25-way Male 500p. Female 550p

AMPHENOL CONNECTORS

36 way Solder Type Plug (centronix type)	550p
36 way Solder Socket (centronix type)	550p
36 way IDC Plug (centronix type)	500p
24 way Solder Plug (IEEE type)	500p
24 way Solder Socket	500p
24 way IDC Plug	485p

RIBBON CABLE (Grey)

10 way	60p
14 way	80p
16 way	90p
20 way	105p
26 way	140p
34 way	220p
40 way	265p
50 way	330p
64 way	370p

MICROTIMER

6502 Based Programmable clock timer with
★ 224 switching times/week cycle
★ 24-hour 7-day timer
★ 4 independent switch outputs directly interfacing to thyristor/triacs
★ 6 digit 7 seg. display to indicate real time, ON/OFF and Reset times
★ Output to drive day of week switch and status LEDs.
Full details on request. Price for kit £57

D CONNECTORS

No. of ways	9	15	25	37
MALE				
Solder	90p	130p	160p	250p
Angled	160p	230p	285p	425p
FEMALE				
Solder	110p	160p	210p	350p
Angled	175p	240p	310p	500p
Hoods	95p	95p	95p	125p

RS 232 CONNS (25 way D)

24" Single end Male	£5.50
24" Single end Female	£6.00
24" Female-Female	£11.00
24" Male-Male	£10.00
24" Male-Female	£11.50

DIL HEADERS

	Solder Type	IDC Type
14pin	40p	100p
16pin	50p	110p
24pin	100p	150p
40pin	200p	225p

EURO CONNECTORS (Indirect Edge Conn.)

DIN STD	Plug	Skt.
41617 21 way	170p	170p
41617 31 way	180p	180p
41612 2×32 way	250p	320p
Angled 2×32 way	325p	375p
41612 3×32 way	275p	380p
Angled 3×32 way	–	400p
2×32 way IDC a+c	–	525p

(for 2×32 way specify a+b or a+c)

EDGE CONNECTORS

	0.1"	0.156"
2×18 way	–	140p
2×22 way	200p	170p
2×23 way	210p	–
2×25 way	225p	220p
1×43 way	260p	–
2×43 way	395p	–
2×50 way	–	–
1×77 way	700p	–
S100 Conn.	–	600p

MICRODOCTOR £295

This is not a logic analyser or an oscilloscope. It tests a microsystem and gives a printed reprint on RAM, ROM and I/O – it will print memory map, search for code, check dataline shorts and operates peripherals.
Microdoctor complete with psu, printer probe cable and two configuration boards.

SOFTY II INTELLIGENT PROGRAMMER

The complete microprocessor development system for Engineers and Hobbyists. You can develop programs, debug, verify and commit to EPROMs or use in host computer by using softy as a romulator. Powerful editing facilities permit bytes, blocks of bytes changed, deleted or inserted and memory contents can be observed on ordinary TV. Accepts most +5v Eproms.
Softy II complete with PSU, TV Lead and Romulator lead £169

★ SPECIAL OFFER ★

2114L	80p
2716 (+5v)	250p
2532	350p
4116-2	80p
4164-2	450p
6116P	350p

UV ERASERS

UV1B up to 6 Eproms £47.50
UV1T with Timer £60
UV140 up to 14 Eproms £61.50
UV141 with Timer £78
(Carr £2/eraser)
All erasers are fitted with mains switches and safety interlocks.

'WIRELESS WORLD' PROJECTS

Semiconductors inc. I.Cs., Transistors, Displays, Connectors and Sockets for most projects are stocked by us

BOOKS

(No VAT p&p £1)

CMOS Cook Book	£7.75
CRT Controller H/Book	£6.50
Programming the Z80	£11.50
Z80 Microcomp Handbook	£6.95
Programming the 6502	£10.25
6502 Assy. Lang	£12.10
6502 Applications	£10.20
6502 Software Design	£9.05
6502 Games	£10.25

Large selection of databooks, interfacing books, books on BBC, etc in stock.
Ask for our list.
WW-12

NEW COMPREHENSIVE CATALOGUE AVAILABLE PLEASE SEND FOR PRICE LIST

74 SERIES

Type	Price
7400	11p
7401	11p
7402	11p
7403	12p
7404	12p
7405	15p
7406	18p
7407	18p
7408	14p
7409	14p
7410	14p
7411	16p
7412	14p
7413	16p
7414	18p
7416	18p
7417	18p
7420	14p
7421	18p
7422	20p
7423	18p
7425	18p
7426	18p
7427	18p
7428	18p
7430	14p
7432	18p
7433	22p
7437	22p
7438	22p
7439	25p
7440	15p
7441	55p
7442A	30p
7443	70p
7444	70p
7445	50p
7446A	50p
7447A	36p
7448	45p
7450	15p
7451	15p
7453	15p
7454	15p
7460	15p
7470	30p
7472	25p
7473	25p
7474	18p
7475	22p
7476	25p
7480	48p
7481	120p
7482	65p
7483A	38p
7484A	60p
7485	60p
7486	18p
7489	170p
7490A	20p
7491	35p
7492A	25p
7493A	24p
7494	35p
7495A	35p
7496	35p
7497	90p
74100	80p
74104	50p
74105	55p
74107	22p
74109	25p
74110	30p
74111	55p
74112	170p
74116	50p
74118	55p
74119	60p
74120	60p
74121	25p
74122	30p
74123	36p
74125	30p
74126	30p
74128	36p
74132	30p
74136	28p
74141	55p
74142	175p
74143	200p
74144	200p
74145	40p
74147	75p
74148	60p
74150	50p
74151A	36p
74153	36p
74154	50p
74155	36p
74156	40p
74157	30p
74159	75p
74160	40p
74161	40p
74162	40p
74163	40p
74164	45p
74165	45p
74166	48p
74167	150p
74170	120p
74172	250p
74173	50p
74174	55p
74175	50p
74176	40p
74177	45p
74178	70p
74179	70p
74180	40p
74181	115p
74182	40p
74184	90p
74185A	90p
74186	470p
74188	250p
74190	45p
74191	45p
74192	45p
74193	45p
74194	40p
74195	40p
74196	40p
74197	40p
74198	80p
74199	80p
74221	55p
74251	45p
74259	100p
74265	45p
74273	120p
74276	90p
74278	100p
74279	40p
74283	50p
74284	160p
74285	160p
74290	75p
74293	80p
74298	100p
74351	150p
74365A	30p
74366A	30p
74367A	30p
74368A	30p
74376	100p
74390	75p
74393	90p
74490	95p

74LS SERIES

Type	Price
74LS00	11p
74LS01	11p
74LS02	11p
74LS03	12p
74LS04	12p
74LS05	12p
74LS08	12p
74LS09	12p
74LS10	12p
74LS11	13p
74LS12	12p
74LS13	15p
74LS14	25p
74LS15	12p
74LS20	12p
74LS21	12p
74LS22	12p
74LS26	12p
74LS27	13p
74LS28	14p
74LS30	12p
74LS32	13p
74LS33	14p
74LS37	14p
74LS38	15p
74LS40	12p
74LS42	30p
74LS47	36p
74LS48	45p
74LS51	14p
74LS54	14p
74LS55	14p
74LS63	120p
74LS73	18p
74LS74	16p
74LS75	18p
74LS76	17p
74LS83	36p
74LS86	16p
74LS90	22p
74LS91	66p
74LS92	32p
74LS93	22p
74LS95	40p
74LS96	50p
74LS107	20p
74LS109	27p
74LS112	20p
74LS113	20p
74LS114	22p
74LS122	28p
74LS123	34p
74LS124	90p
74LS125	24p
74LS126	25p
74LS132	34p
74LS133	25p
74LS136	25p
74LS138	27p
74LS139	27p
74LS145	70p
74LS148	75p
74LS151	40p
74LS153	40p
74LS154	60p
74LS155	30p
74LS156	36p
74LS157	25p
74LS158	30p
74LS160	36p
74LS161	36p
74LS162	36p
74LS163	36p
74LS164	40p
74LS165	50p
74LS166	60p
74LS168	85p
74LS169	85p
74LS170	70p
74LS173	55p
74LS174	40p
74LS175	40p
74LS181	90p
74LS183	120p
74LS190	36p
74LS191	36p
74LS192	36p
74LS193	36p
74LS194	35p
74LS195	35p
74LS196	45p
74LS197	45p
74LS221	50p
74LS240	55p
74LS241	55p
74LS242	55p
74LS243	55p
74LS244	50p
74LS245	70p
74LS247	50p
74LS248	55p
74LS249	55p
74LS251	30p
74LS253	30p
74LS256	150p
74LS257	30p
74LS258	35p
74LS259	55p
74LS261	138p
74LS260	20p
74LS266	20p
74LS273	60p
74LS275	225p
74LS279	30p
74LS280	100p
74LS283	40p
74LS290	45p
74LS293	40p
74LS295	90p
74LS297	900p
74LS298	90p
74LS299	180p
74LS321	150p
74LS323	160p
74LS324	150p
74LS348	90p
74LS352	60p
74LS353	60p
74LS356	250p
74LS363	140p
74LS364	140p
74LS365	27p
74LS366	27p
74LS367	27p
74LS368	27p
74LS374	55p
74LS375	45p
74LS377	60p
74LS378	60p
74LS390	45p
74LS393	45p
74LS395	90p
74LS399	160p
74LS445	100p
74LS490	200p
74LS467	90p
74LS540	90p
74LS541	80p
74LS610	£19
74LS624	90p
74LS626	150p
74LS628	150p
74LS629	90p
74LS640	100p
74LS641	100p
74LS643	100p
74LS644	100p
74LS645	100p
74LS668	120p
74LS669	120p
74LS670	140p
74LS678	550p
74LS682	400p
74LS684	400p
74LS687	400p

74S SERIES

Type	Price
74S00	30p
74S02	30p
74S04	30p
74S05	60p
74S08	60p
74S10	40p
74S11	50p
74S20	40p
74S22	50p
74S30	40p
74S32	70p
74S37	60p
74S74	75p
74S85	450p
74S86	90p
74S112	90p
74S113	90p
74S114	90p
74S124	300p
74S132	110p
74S133	60p
74S138	120p
74S139	120p
74S157	260p
74S158	195p
74S163	300p
74S174	250p
74S175	320p
74S194	320p
74S195	500p
74S225	510p
74S241	300p
74S244	300p
74S251	250p
74S257	250p
74S258	250p
74S260	70p
74S261	300p
74S262	850p
74S373	400p
74S374	400p

74C SERIES

Type	Price
74C244	160p
74C245	180p
74C373	160p
74C374	160p

4000 CMOS

Type	Price
4000	10p
4001	10p
4002	12p
4006	50p
4007	14p
4008	36p
4009	24p
4010	24p
4011	11p
4012	16p
4013	20p
4014	48p
4015	40p
4016	20p
4017	32p
4018	45p
4019	25p
4020	48p
4021	40p
4022	45p
4023	13p
4024	32p
4025	13p
4026	80p
4027	20p
4028	40p
4029	45p
4030	15p
4031	125p
4032	80p
4033	125p
4034	140p
4035	45p
4036	275p
4037	110p
4038	110p
4039	290p
4040	40p
4041	40p
4042	40p
4043	40p
4044	40p
4045	105p
4046	50p
4047	45p
4048	50p
4049	24p
4050	24p
4051	45p
4052	60p
4053	50p
4054	90p
4055	90p
4046	90p
4059	450p
4060	55p
4063	90p
4066	27p
4067	225p
4068	14p
4069	14p
4070	14p
4071	14p
4072	14p
4073	14p
4075	14p
4076	48p
4077	16p
4078	16p
4081	14p
4082	15p
4086	55p
4089	125p
4093	24p
4094	90p
4095	75p
4096	70p
4097	290p
4098	90p
4099	100p
4500	575p
4502	60p
4503	45p
4504	75p
4505	400p
4506	35p
4507	35p
4508	130p
4510	45p
4511	45p
4512	48p
4514	120p
4515	110p
4516	55p
4518	40p
4520	50p
4521	90p
4522	120p
4526	60p
4527	60p
4528	50p
4532	70p
4534	400p
4536	270p
4538	90p
4539	70p
4543	75p
4553	245p
4555	35p
4556	35p
4557	300p
4560	120p
4566	160p
4568	250p
4569	170p
4572	30p
4583	90p
4584	40p
4585	75p
40014	40p
40085	90p
40097	45p
40102	140p
40103	170p
40105	110p
40106	40p
40109	100p
40110	275p
40163	60p
40174	50p
40175	75p
40193	75p
40244	160p
40245	180p
40257	160p
40373	160p
40374	160p
14495	300p
14500	700p
14599	290p

COUNTERS

Type	Price
74C925	£4
74C926	£5
74C928	£6
7216B	£20
ZN1040	670p

DIL SWITCHES

Type	Price
4-way	90p
8-way	120p
6-way	£105p
10-way	150p
4116-20	80p

Most items despatched by return of post

Ask for our detailed price list

LINEAR ICs

Type	Price
AD7581	1150p
ADC0808	990p
AN103	200p
AY1-0212	700p
AY1-1320	225p
AY1-5050	99p
AY3-1270	750p
AY3-1350	350p
AY3-8910	450p
AY3-8912	625p
AY5-3600	600p
AY5-4007D	£8
CA3028A	120p
CA3019	80p
CA3046	70p
CA3048	220p
CA3059	285p
CA3060	350p
CA3080E	70p
CA3086	48p
CA3089E	200p
CA3090AQ	400p
CA3130E	90p
CA3130T	110p
CA3140E	50p
CA3140T	90p
CA3160E	100p
CA3161E	150p
CA3162E	450p
CA3189E	300p
CA3240E	110p
CA3280G	200p
D7002C	420p
DAC0800	£2
DAC0808	£2
HA1366	195p
HA1388	270p
ICL7106	700p
ICL7660	200p
ICL7611	95p
ICL8038	300p
ICM7216B	£16
ICM7217	750p
ICM7555	60p
ICL7611	90p
LC7120	300p
LC7130	325p
LC7137	270p
LF347	150p
LF351	48p
LF353	95p
LF356P	95p
LF357	110p
LF13331	100p
LM10C	325p
LM1011	480p
LM301A	25p
LM308N	75p
LM310	120p
LM311	70p
LM318	150p
LM319	215p
LM324	30p
LM334Z	90p
LM335Z	140p
LM339	50p
LM348	65p
LM358P	60p
LM377	175p
LM380	75p
LM381AN	180p
LM382	120p
LM386	90p
LM387	120p
LM389	95p
LM391	150p
LM392N	60p
LM393	100p
LM394CH	300p
LM709	36p
LM710	50p
LM711	70p
LM725	300p
LM733	60p
LM741	18p
LM747	70p
LM748	35p
LM1014	150p
LM1801	300p
LM1830	250p
LM1871	450p
LM1872	450p
LM1886	700p
LM1889	350p
LM2917	200p
LM3302	75p
LM3900	50p
LM3909	85p
LM3911	125p
LM3914	200p
LM3915	200p
LM3916	225p
LM13600	110p
MS1513L	230p
MS1516L	500p
MB3712	200p
MB3730	450p
MC1310P	150p
MC1413	75p
MC1445	250p
MC1458	36p
MC1493	150p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3401	50p
MC3403	75p
MF10	350p
MK50240	900p
MK50398	700p
ML920	800p
MM57160	620p
MM58201A	600p
NE531	140p
NE544	150p
NE555	16p
NE556	45p
NE564	420p
NE565	120p
NE566	150p
NE567	140p
NE570	410p
NE571	400p
NE592	60p
NE5532	130p
NE5533	140p
NE5534P	110p
NE5534AP	120p
PLL02A	500p
RC4136	60p
S566B	225p
SAA1900	£16
SAD1024A	£9
SFF96364	800p
SN76131	125p
SN76477	450p
SN76488	450p
SN76660	120p
SN87489	400p
SN76495	400p
SP8515	750p
TA7120	150p
TA7130	160p
TA7204	200p
TA7205	90p
TA7222	150p
TA7310	150p
TBA641BX1	£4
TBA800	80p
TBA810	100p
TBA820	80p
TBA920	200p
TBA950	225p
TC9109	900p
TCA210	350p
TCA220	350p
TCA270	350p
TCA940	175p
TCA965	120p
TDA1004A	£3
TDA1008	320p
TDA1010	200p
TDA1022	500p
TDA1024	120p
TDA1170	300p
TDA2003	325p
TDA2006	350p
TDA2020	320p
TL064	100p
TL071/81	25p
TL072/82	45p
TL074	100p
TL083	75p
TL084	90p
TL094	200p
TL170	50p
TL430C	70p
TMS1601	1200p
UA1003-3	935p
UA2240	150p
UAA170	170p
ULN2003A	75p
ULN2004	75p
ULN2068	290p
ULN2802	200p
ULN2804	150p
UPC575	275p
UPC592H	200p
UPC1156H	£3
UPC1185H	£5
XR2206	300p
XR2207	375p
XR2211	575p
XR2216	675p
XR2240	120p
ZN134	£23
ZN414	80p
ZN419C	180p
ZN423E	130p
ZN424E	130p
ZN425E	350p
ZN426E	300p
ZN427E	590p
ZN428E	410p
ZN1034E	200p
ZN1040E	670p
ZNA234	850p

VOLTAGE REGULATORS

FIXED PLASTIC

1A	+ve		-ve	
5V	7805	40p	7905	45p
6V	7806	40p	7906	45p
8V	7808	40p	7908	45p
12V	7812	40p	7912	45p
15V	7815	40p	7915	45p
18V	7818	40p	7918	45p
24V	7824	40p	7924	45p
5V 100mA	78L05	30p	79L05	45p
6V 100mA	78L06	30p		
8V 100mA	78L08	30p		
12V 100mA	78L12	30p	79L12	60p
15V 100mA	78L15	30p	79L15	60p

OTHER REGULATORS

LM309K 1A 5V	140p	78P05	900p
LM317K T03	250p	78HGKC	600p
LM317T	200p	78H05KC	550p
LM337T	225p	78GUIC	200p
LM323K 3A 5V	450p	79GUIC	225p
LM350T	375p	79HGKC	700p
LM723N	30p	ICL7660	250p
TL494	300p	LM305AH	250p
TL497	600p	78H12	600p
78S40	225p	SG3524	300p

OPTO ELECTRONICS

2N5777	40p	TIL32	55p
OCP71	180p	TIL78	55p
ORP12	120p	TIL31A	120p
ORP60	120p	TIL81	90p
ORP61	120p	TIL100	75p

OPTO ISOLATORS

ILD74	130p	TIL111	70p
MCT26	100p	TIL112	70p
MCS2400	190p	TIL113	70p
MOC3020	150p	TIL116	70p
ILQ74	240p		

LEDS

0.125"		FND357	120p
TIL209 Red	10p	FND500	90p
TIL211 Gr	12p	FND507	90p
TIL212 Yel	15p	MAN3640	200p
0.2"		MAN4640	200p
TIL220 Red	10p	NSB5881	570p
TIL222 Gr	12p	TIL311	600p
TIL228 Yel	15p	TIL312/3	110p
Rectangular LEDs(R,G,Y)	20p	TIL321/3	130p
		TIL330	140p
		7750/60	200p
		Bargraph	225p

DISPLAYS

DL704	140p
DL707 Red	140p

DRIVERS

9368	250p
9370	300p

COMPUTER COMPONENTS

CPUs

Type	Price
1802CE	650p
2650A	£12
6502	350p
6502A	500p
6800	225p
6802	250p
6805E2L	£18
6809	650p
68B09	£12
6809E	£12
8035	350p
8039	300p
8080A	250p
8085A	350p
8088	£18
8748	1800p
INS8060	£11
TMS1601	£12
TMS9980	£20
TMS9995	£12
Z8	£24
Z80	250p
Z80A	320p
Z80B	£9
8288	£11
8755	£16
9902	£3
TMS4500	£14
TMS9928	£30
Z80P10	250p
Z80AP10	280p
Z80CTC	250p
Z80ACTC	280p
Z80ADART	700p
Z80ADMA	£9
Z80SI 0/1/2	£9

SUPPORT DEVICES

Type	Price
3242	800p
3245	450p
6520	280p
6522	350p
6522A	550p
6532	550p
6551	650p
6821	100p
68B21	220p
6829	£12.50
6840	375p
68B40	600p
6850	110p
68B50	220p
6852	250p
6854	700p
68B54	600p
6875	570p
8154	950p
8155	350p
8156	350p
8205	225p
8212	110p
8216	100p
8224	110p
8226	250p
8228	270p
8243	280p
8250	850p
8251	250p
8253	390p
8255	250p
8256	£36
8257	400p
8259	400p
8271	£36
8279	440p
8284	350p

MEMORIES

Type	Price
2101-4A	400p
2102-3L	120p
2107B	500p
2111A	300p
2112-A	300p
2114-2L	100p
2147	450p
4027-3	300p
4116-15	120p
4116-20	90p
4118-3	450p
4164-2	400p
4816AP-3	270p
5101	300p
5516	750p
6116-3	420p
6116LP-3	550p
6514-45	200p
6810	120p
74S189	150p
74S201	350p
74S289	150p
93415	600p
93425	600p

ROMs/PROMs

Type	Price
74S188	325p
74S287	350p
74S288	225p
74S387	325p
74S471	650p
74S473	850p
74S474	650p
74S570	650p
74S571	650p
74S573	950p

EPROMs

Type	Price
2516(+5v)	250p
2532	375p
2532-30	700p
2564	£8
2708	250p
2716(+5v)	250p
2764-25	£5
TMS2716	£7

CRT CONTROLLER

Type	Price
CRT6545	900p
CRT5027	£18
CRT5037	£18
EF9365	£45
EF9366	£45
MC6845	650p
MC6845SP	£12
MC6847	650p
SFF96364	£8
TMS9918	£60
TMS9927	£18
TMS9928	£20
TMS9929	£20

INTERFACE ICs

Type	Price
AD558CJ	775p
AD561J	£14
AD7581	1150p
AM25S10	350p
AM25LS2521	£2
AM26LS31	125p
AM26LS32	125p
D7002	480p
DAC80	£28
DM8131	275p
DP8304	250p
DS3691	300p
DS8830	140p
DS8831	140p
DS8832	250p
DS8833	225p
DS8836	150p
DS8838	225p
LF13201	450p
MC1488	55p
MC1489	55p
MC3418	950p
MC3446	250p
MC3480	850p
MC3486	500p
MC3487	300p
MC4024	325p
MC4044	325p
MC14411	675p
MC14412	750p
75107	90p
75110/12	160p
75114/15	160p
75121/22	140p
75150P	120p
75154	140p
75182	90p
75365	150p
75451/2	72p
75453/4	72p
75491/2	65p
8T26	120p
8T28	120p
8T95/96	90p
8T97/98	90p
81LS95/96	80p
81LS97/98	80p
88LS120	350p
9602	220p
9637AP	160p
ZN425E-8	350p
ZN426E-8	350p
ZN427E	£6
ZN428E-8	450p

DISC CONTROL ICs

Type	Price
8271	£26
8272	£20
FD1771	£20
FD1791	£22
FD1793	£23
FD1795	£28
FD1797	£28
FD2793	£42
FD2797	£42
WD1691	£15
WD2143	550p

CHARACTER GENERATORS

Type	Price
RO3-2513	
U.C.	750p
L.C.	700p
DM86564	£12
MC66760	750p
SN74S262AN	£10

KEYBOARD ENCODER

Type	Price
AY5-2376	700p
74C922	500p
74C923N	500p

BAUD RATE GENERATORS

Type	Price
MC14411	700p
COM8116	800p
4702B	750p

UARTs

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

ZIF SKTS (TEX TOOL)

Type	Price
24 pin	600p
28 pin	800p
40 pin	£10

MODULATORS

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

CRYSTALS

Freq	Price
32.768KHz	100p
100KHz	250p
200KHz	280p
Freq in MHz	
1.0	290p
1.008	275p
1.8432	210p
2.00	225p
2.45760	210p
2.5	250p
2.662	250p
3.276	150p
3.5795	100p
3.686	300p
4.00	150p
4.194	200p
4.43	110p
4.608	250p
4.915	250p
5.0	175p
5.068	£2
6.0	150p
6.144	150p
7.0	150p
7.168	175p
8.00	175p
8.86	175p
10.00	175p
10.5	250p
10.7	150p
12.00	150p
14.318	175p
14.756	250p
15.00	200p
16.00	200p
17.7	200p
18.00	200p
18.432	150p
19.968	150p
20.00	200p
24.00	£2
26.690	150p
27.145	200p
38.6667	175p
48.0	175p
55.5	400p
116	300p
145.80	250p

REAL TIME CLOCK

Type	Price
MK3805	£TBA
MM58174	700p
MSM5832	500p

TELETEXT DECODER

Type	Price
SAA5020	600p
SAA5030	700p
SAA5041	£16
SAA5050	900p

LOW PROFILE SOCKETS BY TI

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

WIRE WRAP SOCKETS BY TI

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

TRANSISTORS

Type	Price
AD161/2	45p
BC107/8	13p
BC109C	14p
BC117	20p
BC147/8	9p
BC149	10p
BC157/8	10p
BC159	11p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	16p
BC461	25p
BC477/8	30p
BC516/7	40p
BC547B	14p
BC548C	12p
BC549C	16p
BC557B	14p
BC559C	16p
BCY70	18p
BCY71	22p
BD131	75p
BD132	50p
BD135/6	40p
BD139	40p
BD140	40p
BD189	60p
BD232	60p
BD233	75p
BD235	85p
BD241	60p
BD242	60p
BD379	60p
BD380	60p
BD677	40p
BF244B	35p
BF256B	50p
BF257/8	32p
BF337	30p
BF339	25p
BFR40/1	25p
BFR79	25p
BFR80/1	25p
BFR96	180p
BFX29	40p
BFX30	27p
BFX84/5	40p
BFX66/7	27p
BFX88	27p
BFX89	180p
BFY50	24p
BFY51/2	24p
BFY56	33p
BFY90	80p
BRY39	45p
BSX19/20	24p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
BUX80	600p
BUY69C	350p
E310	50p
MJ802	400p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJ4502	400p
MJE340	60p
MJE2955	100p
MJE3055	70p
MPF102	40p
MPF103/4	30p
MPF105	30p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSA93	40p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	45p
TIP32A	45p
TIP32C	40p
TIP33A	70p
TIP33C	80p
TIP34A	90p
TIP34C	120p
TIP35A	120p
TIP35C	140p
TIP36A	140p
TIP36C	150p
TIP41A	50p
TIP41C	55p
TIP42A	60p
TIP42C	65p
TIP54	160p
TIP120	75p
TIP121	75p
TIP122	80p
TIP142	120p
TIP147	120p
TIP2955	78p
TIP4055	70p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX452	45p
ZTX500	15p
ZTX502	16p
ZTX504	18p
ZTX552	55p
ZTX652	60p
ZTX752	70p
VN66AF	72p
VN10KM	60p
VN66	80p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	25p
2N2222A	25p
2N2369A	17p
2N2484	25p
2N2646	40p
2N2904/5	25p
2N2906A	25p
2N2907A	25p
2N2926	9p
2N3053	25p
2N3054	55p
2N3055	35p
2N3442	140p
2N3553	240p
ZN3584	250p
2N3643/4	48p
2N3702/3	10p
2N3704/5	10p
2N3706/7	10p
2N3708	10p
2N3773	200p
2N3819	20p
2N3820	40p
2N3823	30p
2N3866	90p
2N3902	700p
2N3904	15p
2N4037	65p
2N4123/4	27p
2N4125/6	27p
2N4401/3	25p
2N4427	90p
2N4871	50p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5245	40p
2N5401	60p
2N5459	30p
2N5460	60p
2N5485	36p
2N5875	250p
2N6027	30p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1969	150p
2SC2028	80p
2SC2029	200p
2SC2078	160p
2SC2335	200p
2SC2612	200p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	200p
40290	250p
40361/2	75p
40408	90p
40409	100p
40410	100p
40594	120p
40595	120p
40673	75p
40871/2	100p

DIODES

Type	Price
BY127	12p
BYX36300	20p
OA47	8p
OA90/91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5404/5	14p
1N5404/7	19p
IS920	9p

BRIDGE RECTIFIERS

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

TRIACS PLASTIC

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

THYRISTORS

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

PCB MOUNTING RELAYS

6 or 12V DC Coil SPDT 2A 24V DC 160p
6 or 12V DC Coil DPDT 5A 24V DC 240V AC 200p
6 or 12V DC Coil SPDT 10A 24V DC 240V AC 225p

ZENERS

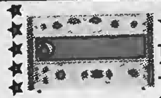
2.7V-33V
400mW 9p
1W 15p

TECHNOMATIC LTD

MAIL ORDERS TO: 17 BURNLEY ROAD, LONDON NW10 1ED
SHOPS AT: 17 BURNLEY ROAD, LONDON NW10
(Tel: 01-452 1500, 01-450 6597. Telex: 922800)
305 EDGWARE ROAD, LONDON W2

PLEASE ADD 40p p&p & 15% VAT
(Export: no VAT, p&p at Cost)
Orders from Government Depts. & Colleges etc. welcome.
Detailed Price List on request.
Stock items are normally by return of post.

★ **MARCONI SIGNAL GENERATORS** ★



TF2002A/S (illustrated) 10kHz-72MHz. AM/FM. **£750**
TF2002. As above but AM only. **£450**
MARCONI TF1066B/1. AM/FM Generator. 10-470MHz. 0.2uV-200mV output. FM Deviation up to ±100kHz. **£550**
MARCONI TF995A/5. AM/FM Generator. Narrow deviation model 995 covering 1.5-220MHz. **£450.** TF995B/5 **£525.**
MARCONI TF1064B/5. AM/FM Signal generator covering in three ranges 68-108, 118-185 and 450-470MHz. FM fixed deviations of 3.5 & 10kHz. AM fixed 30%. **£225**

★ **'DOLBY' NOISE WEIGHTING FILTERS** ★

Cat. No. 98A. Noise weighting filters for CCIR/ARM signal-to-noise ratio measurements. As new units. **£40** each (+£1 p&p).

BECKMAN TURNS COUNTER DIALS

Miniature type (22mm diam.). Counting up to 15 turn "Helipots". Brand new with mounting instructions. Only **£2.50** each.

★ **'VARIACS' — SPECIAL PURCHASE** ★

We now have a stock of used but excellent condition, fully tested, variable (0-260V) transformers at the following ratings.

BERCO (enclosed) 2A	£12.50+£1.50 pp
BERCO (non-enclosed) 8A	£25.00+£2.50 pp
BERCO (non-enclosed) 10A	£28.00+£2.50 pp
ZENITH (enclosed) 8A	£26.00+£2.50 pp

Also available, small quantity of Heavy Duty and 3 Phase Variacs. P.O.A.

★ **AUDIO WATTMETERS** ★

Switchable 1W & 10W FSD. Internal 3.5 & 8 Ohm load impedances. Housed in grey enamelled case 6×6×3". Large easy to read 3" sq. meter. Scope output provision. **£10** (+£1).
HEATHKIT Model AW-IU. Internal load switchable 3, 8, 15 & 600 Ohm. Meter scaled 0-50W (+dB scale). 5 Ranges from 5mW-50W FSD. Mains powered. **£25** (+£1).
MARCONI TF893A. 1mW-10W Full scale in 5 ranges. Impedances 2.5-20K Ohm in 48 steps. Direct calibration in Watts and dBm. **£85** (+£2).

GPO JACK SOCKET STRIPS. 20-WAY Type 320 (3-pole) **£2.50** ea. Type 520 (3-pole with switching contacts) **£4** ea. Please include 35p each for postage on these. GPO type 316 jack plugs for above **20p** ea. (10+ post free). Plus VAT please. Also recent stock of new, mint condition 720 Type, £6 each.

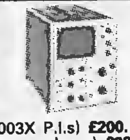
★★ **PHILIPS RF SIGNAL GENERATOR** ★★

As new condition Philips PM 5326. AM/FM RF Signal generator covering 0.1-125MHz. Integral 5 digit Frequency display. Mod AM & FM + Sweep facilities. 1 only available.

P. F. RALFE ELECTRONICS

10 CHAPEL STREET, LONDON, NW1 TEL: 01-723 8753

'ADVANCE' 'SCOPES — SPECIAL OFFER



A bulk purchase of Advance series 'scopes enables us to offer the following fully reconditioned, guaranteed units as follows.

OS2000 20MHz dual-beam. 10mV/cm. (2002Y & 2003X P.I.s) **£200.**
OS2100 30MHz dual-beam. 10mV/cm. (plug-in units as above) **£230.**
OS2200 25MHz dual-beam. 10mV/cm STORAGE. 2005X plug-in **£316.**

N.B. All these prices INCLUDE 15% VAT. Securicor despatch if required + £10 ea. We also have in stock various optional plug-in units such as Differential (50uV) Y-amp., Sweep-delay X-amp, etc. Please call for details. For full spec SAE please.

ADVANCE VM77D Millivoltmeters. 15Hz-4.5MHz. 1mV Full scale —300V AC **£55**
WOELKE ME104C. Wow & Flutter Meter **£95**
AVO Type 1 LCR Component Bridge.
WAYNE KERR AF Signal Generator Type S121 **£75**
AIRMEC Wave Analysers Models 853 and 248A.
CENTRONICS P1 Printer, one only. AND Type 663 Printer.
ROHDE & SCHWARZ SDR Signal Generator. 300MHz-1GHz.
HEWLETT PACKARD 608C Signal Generator. 10-480MHz AM.
MARCONI Component Bridge Model TF2700. (LC&R).
OKIDATA CORP Series 3300 Hard-Disc Drives.
TALLY Model 220 Line Printers.

BELL & HOWELL MICROFICHE VIEWERS

Type SR5. Screen size 9×5". Recent small quantity now avail. **£55**

★ **DISC CARTRIDGES** ★

BASF 12-Segment Single Hard Disc Cartridges. Brand new surplus stock.

★ **SWEEPERS** ★

TELONIC Sweep generator system type 2003. Fitted with Marker, attenuator, Detector plug-in units and Generator covering 800-1500MHz. **£325**

★ **MUIRHEAD FACSIMILE UNITS** ★

MUFAX 'COURIER' facsimile receiver type K441-CH and transmitters K400 AMCH in stock in excellent condition.

PLEASE NOTE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessery. It is sold in first-class operational condition and most items carry s three months' guarantee. For our mail order customers we have a money-back scheme. Repairs and servicing to all equipment at very reasonable rates. PLEASE ADD 15% VAT TO ALL PRICES.

★ **DC POWER SUPPLIES** ★

1. APT.10459/8. Stabilised Regulated supplies. New stock arrival hence LOWER PRICES. Available in preset output voltages between 6 and 30V DC (state requirements) ±4V approx. Three sizes available, 5A, 7½A & 10A. Prices **£20, £25 & £30** respectively (plus postage £2, £2.50 and £4).
2. Mullard Dual supplies. Pos/Neg 12V @ 1A & 0.4A. Dimensions 9×4×5". **£10** ea. (+£1 p&p).
3. Farnell Current limited. 13-17V DC @ 2A. **£15.** 27-32V DC @ 1A. **£15** (+£1 p&p).
4. Lambda LXS Series supplied 110V AC Input. 5V @ 14A. **£20** (+£2.50 p&p). Various other voltages available from stock in small quantity.
5. Coutant 5/6V @ 5A. Small size (7×5×3"). **£20** (+£1).
6. Variable 0-30V @ 1A. Volt-metered. **£30.**
7. Farnell 5V Switching. 60A. **£85.**

★ **RF SIGNAL GENERATORS** ★

ADVANCE Type E2. 100kHz-100MHz. Internal AM & Audio O/P. 1uV-100mV output. Price each **£50** inc. VAT.
TAYLOR Type 68A/M. 100kHz-240MHz. Internal Modulation. **£60** inc. VAT.
All of these units are in full working condition and carry our usual 90-Day Warranty. In both cases please add £2 each for carriage.

★ **MILLI-VOLT MEASUREMENT, ANALOGUE** ★

MARCONI TF2600. Twelve ranges 1mV-300V FSD. Wide-band to 10MHz.
MARCONI TF2603. Frequency range 50kHz-1.5GHz. High Sensitivity from 300uV.
MARCONI TF2604. Electronic Multi-meter. AC/DC 300mV Full scale to 300V (1kV DC). Resistance ranged. AC Frequency range 20Hz-1500MHz.

★ **BRUEL & KJOER** ★

Model 2006 Heterodyne Voltmeter. AM/FM/Voltage measurements to 240MHz.

★ **CLAUDE LYONS 240V AC REGULATORS** ★

Small quantity available of constant voltage mains regulators. Continuous current rating 5A. Model no. CVR-1200. Input 204-252V. Output adjustable 200-254V AC± 0.3%. 45-65Hz. Condition as new. (Dims— 11"×7"×6". Weight 20Kgs). **Price £95 ea. + Carriage £5.**

★ **ROTRON INSTRUMENT COOLING FANS** ★

Supplied in excellent condition, fully tested.
115V, 4.5×4.5×1.5" **£4.50.** 230V **£5.** 115V. 3×3×1.5" **£4** + postage ea. 35p.
Also brand new 230V at **£6** ea. WW-10

Sowter Transformers

With 40 years' experience in the design and manufacture of several hundred thousand transformers we can supply:

AUDIO FREQUENCY TRANSFORMERS OF EVERY TYPE

YOU NAME IT! WE MAKE IT!

OUR RANGE INCLUDES

Microphone transformers (all types), Microphone Splitter/Combiner transformers. Input and Output transformers, Direct Injection transformers for Guitars, Multi-Secondary output transformers, Bridging transformers, Line transformers, Line transformers to G.P.O. Isolating Test Specification, Tapped impedance matching transformers, Gramophone Pickup transformers, Audio Mixing Desk transformers (all types), Miniature transformers, Microminiature transformers for PCB mounting, Experimental transformers, Ultra low frequency transformers, Ultra linear and other transformers for Transistor and Valve Amplifiers up to 500 watts, Inductive Loop Transformers, Smoothing Chokes, Filter, Inductors, Amplifier to 100 volt line transformers (from a few watts up to 1,000 watts), 100 volt line transformers to speakers, Speaker matching transformers (all powers), Column Loudspeaker transformers up to 300 watts or more.

We can design for RECORDING QUALITY, STUDIO QUALITY, HI-FI QUALITY OR P.A. QUALITY. OUR PRICES ARE HIGHLY COMPETITIVE AND WE SUPPLY LARGE OR SMALL QUANTITIES AND EVEN SINGLE TRANSFORMERS. Many standard types are in stock and normal dispatch times are short and sensible.
OUR CLIENTS COVER A LARGE NUMBER OF BROADCASTING AUTHORITIES, MIXING DESK MANUFACTURERS, RECORDING STUDIOS, HI-FI ENTHUSIASTS, BAND GROUPS, AND PUBLIC ADDRESS FIRMS. Export is a speciality and we have overseas clients in the COMMONWEALTH, E.E.C., USA, MIDDLE EAST, etc. Send for our questionnaire which, when completed, enables us to post quotations by return.

E. A. Sowter Ltd.

Manufacturers and Designers

E. A. SOWTER LTD. (Established 1941) : Reg. No. England 303990
The Boat Yard, Cullingham Road, Ipswich IP1 2EG, Suffolk
P.O. Box 36, Ipswich, IP1 2EL, England
Phone: 0473 52794 and 0473 219390
Telex 987703G Sowter

WW — 023 FOR FURTHER DETAILS

HBED

6FT. PARABOLIC DISHES

FROM ONLY £85 PLUS V.A.T.

6ft. dia. dishes, feed horns and electronics for use in 4GHz satellite reception. GaAs Fet transistors, SMA connectors, P.T.F.E., etc. available.
Please send s.a.e. for full details and data sheets.

Harrison Bros.
Electronic Distributors

22 Milton Road, Westcliff-on-Sea, Essex SS0 7JX
Tel. Southend (0702) 332338

WW — 059 FOR FURTHER DETAILS

Weighing in at only 35 grams, and sitting lightly on the ears, the Danavox HMT 808 is probably the most comfortable headset on the market.

Particularly as it can be worn either over the head, or under the chin.

And for such an advanced piece of equipment, it's also remarkably easy on the pocket.

It has a multiple version microphone, either magnetic or electret, with a noise cancelling feature and pre-amp for matching into communications systems.

Servicing and repairs are readily available, as the components are all easily replaced.

And naturally, Danavox quality means it carries the Danavox guarantee.

If you'd like to hear more, contact John Carter.

Danavox

Danavox (Great Britain) Limited, 1 Cheyne Walk, Northampton, NN1 5PT
Tel: Northampton (0604) 36351 Telex: 312395

WW — 069 FOR FURTHER DETAILS

A COMPETITION OPEN TO ALL WIRELESS WORLD READERS WITH £8000 IN CASH PRIZES

Design an Electronic Device to help the Disabled

Could you design a piece of equipment to help a disabled person? If so, you would — in addition to undertaking this worthy task — be eligible to win a substantial cash prize.

Our competition is open to individuals or groups resident in the UK. You register your entry using the form below, sending it to the Editor to arrive at his office not later than June 30th 1983. The designs themselves must be submitted to his office by 1st October 1983.

Entries, which will be judged by a group of eminent engineers and doctors, must consist of the following:- a statement of the design objectives; an overall description of the device; detailed circuit descriptions and diagrams; a model of the device or a model of a unique aspect of the design sufficient to demonstrate its feasibility.

The finalists will be invited to London to talk over their entries with the judges and be awarded their prizes. The prizes are:

1st prize £2,500
2nd prize £1,500

and the 4 runners up will be awarded prizes each of £1,000

To make sure you have the maximum time to undertake your design, return your entry form now!

"DESIGN AN ELECTRONIC DEVICE TO HELP THE DISABLED"
LIST OF RULES

1. The competition is open to U.K. residents only.
2. Entrants can be individuals or groups.
3. All participants must register their interest in entering the competition on the form provided which must be returned to the Wireless World Editorial Department by the 30th June 1983.
4. All entrants agree to give Wireless World first serial publication rights to an article describing the entry.
5. All entrants indemnify Wireless World from any liability in respect of injury to people or damage to property arising from the use of the design.
6. All submitted designs must be the original work of the entrant or entrants and must not infringe the rights of third parties in anyway.
7. All submissions should consist of:
   a) **A statement of design objectives**
   b) **An overall description of the device**
   c) **Detailed circuit descriptions and diagrams**
   d) **A model of the device or the unique aspect of the design sufficient to demonstrate its feasibility.**
8. The design will be judged on:
   a) **Originality and benefit to the handicapped**
   b) **Potential for production**
   c) **Elegance of engineering design**
   d) **Electronics content**
   e) **Design reliability**
   f) **Simplicity of operation**
   g) **Freedom from excessive maintenance**
   h) **Safety.**
9. Software only solutions are not accepted.
10. The judges' decision is final.
11. All designs must be submitted to the Wireless World Editor by the 1st October 1983.
12. Shortlisted entrants must be prepared to travel to a venue in London sometime during November and December 1983 to demonstrate their design. All costs will be paid by the journal.
13. Employees of Business Press International are not allowed to enter this competition.

wireless world **COMPETITION ENTRY FORM**

"Design an electronic device to help the disabled"

Name of competitor ____________________

Address ____________________

____

Telephone (home) ____________________

(business) ____________________

I intend to enter the competition and to abide by the rules as laid down in the May 1983 issue of Wireless World.

I understand that, in order to qualify, my entry must be in the hands of the judges by 1st October, 1983.

Signature ____________________

Date ____________________

Please send this form, as soon as possible, to:

The Editor, WIRELESS WORLD
Room L302, Quadrant House, The Quadrant
Sutton, Surrey SM2 5AS.

Receipt of the form will be acknowledged.

LANGREX SUPPLIES LTD

Climax House, Fallsbrook Rd., Streatham, London SW16 6ED

RST Tel: 01-677 2424 Telex: 946708 **RST**

SEMICONDUCTORS

AA119	0.10
AAY30	0.17
AAY30	0.17
AAZ13	0.15
AAZ15	0.15
AAZ17	0.15
AC107	0.55
AC125	0.25
AC126	0.25
AC127	0.25
AC128	0.30
AC141	0.28
AC141K	0.35
AC142	0.28
AC142K	0.35
AC176	0.30
AC187	0.28
AC188	0.28
ACY17	1.30
ACY18	1.15
ACY19	1.10
ACY20	1.10
ACY21	1.15
ACY39	2.50
AD149	0.75
AD161	0.35
AD162	0.35
AF106	0.35
AF114	0.75
AF115	0.75
AF116	0.75
AF117	0.75
AF139	0.33
AF186	1.00
AF239	0.39
AFZ11	4.00
AFZ12	4.00
ASY26	1.40
ASY27	0.90
ASZ15	1.20
ASZ16	1.10
ASZ17	1.00
ASZ20	2.30
ASZ21	2.50
AU113	2.50
AUY10	3.00
AUY10	3.00
BA145	0.13
BA148	0.15
BA154	0.10
BA155	0.11
BA156	0.10
BAW62	0.05
BAX13	0.06
BAX16	0.06
BC107	0.16
BC108	0.16
BC109	0.16
BC113	0.15
BC114	0.15
BC115	0.18
BC116	0.19
BC117	0.23
BC118	0.18
BC125	0.18
BC126	0.18
BC135	0.15
BC136	0.19
BC137	0.19
BC147	0.12
BC148	0.12
BC149	0.13
BC157	0.13
BC158	0.13
BC159	0.13
BC167	0.11
BC170	0.11
BC171	0.11
BC172	0.11
BC173	0.11
BC177	0.28
BC178	0.28
BC179	0.28
BC182	0.11
BC183	0.11
BC184	0.11
BC212	0.11
BC213	0.11
BC214	0.11
BC237	0.11
BC238	0.11
BC301	0.33
BC303	0.34
BC307	0.11
BC308	0.11
BC327	0.12
BC328	0.12
BC337	0.12
BC338	0.12
BCY30	1.25
BCY31	1.50
BCY32	1.50
BCY33	1.10
BCY34	1.00
BCY39	3.40
BCY40	2.80
BCY42	0.30
BCY43	0.30
BCY58	0.19
BCY70	0.17
BCY71	0.18
BCY72	0.17
BCZ11	1.75
BD115	0.42
BD121	1.70
BD123	2.80
BD124	2.00
BD131	0.44
BD132	0.48
BD135	0.40
BD136	0.40
BD137	0.40
BD138	0.48
BD139	0.48
BD140	0.50
BD144	2.00
BD181	1.20
BD183	0.80
BD2137	0.54
BD238	0.54
BDX10	0.91
BDX32	2.00
BDY20	1.50
BDY60	2.75
BF115	0.35
BF152	0.16
BF153	0.16
BF154	0.17
BF159	0.17
BF160	0.17
BF167	0.24
BF173	0.30
BF177	0.35
BF178	0.35
BF179	0.35
BF180	0.28
BF181	0.28
BF182	0.30
BF183	0.28
BF184	0.28
BF185	0.30
BF194	0.14
BF195	0.12
BF196	0.13
BF197	0.14
BF200	0.40
BF224	0.25
BF244	0.28
BF257	0.27
BF258	0.27
BF259	0.28
BF336	0.34
BF337	0.33
BF338	0.36
BFS21	4.00
BFS28	2.25
BFS61	0.20
BFS98	0.20
BFW10	0.97
BFW11	0.96
BFX84	0.30
BFX85	0.30
BFX87	0.30
BFX88	0.30
BFY50	0.25
BFY51	0.25
BFY52	0.25
BFY64	0.30
BFY90	0.95
BSX19	0.27
BSX20	0.27
BSX21	0.29
BT106	1.20
BTY79/400R	2.00
BU205	1.30
BU206	1.50
BU208	2.00
BY100	0.40
BY126	0.13
BY127	0.14
BZX61 Series	0.17
BZY88 Series	0.10
CRS1/40	0.60
CRS3/40	0.75
CRS3/60	0.90
GEX66	3.00
GEX541	5.00
GJ3M	1.50
GM0378A	1.75
KS100A	0.45
MJE340	0.60
MJE370	0.73
MJE371	0.71
MJE520	0.47
MJE521	0.73
MJE2955	1.30
MJE3055	1.10
MPF102	0.35
MPF103	0.35
MPF104	0.35
MPF105	0.35
MPSA06	0.26
MPSA56	0.28
MPSU01	0.53
MPSU06	0.65
MPSU56	0.69
NE555	0.45
NKT401	3.50
NKT403	2.50
NKT404	2.20
OA5	1.20
OA7	0.60
OA10	0.55
OA47	0.12
OA70	0.25
OA79	0.12
OA81	0.17
OA85	0.17
OA90	0.08
OA91	0.08
OA95	0.08
OA200	0.15
OA202	0.15
OA211	1.50
OAZ200	1.50
OAZ201	1.50
OAZ206	1.50
OAZ207	1.50
OC16	2.50
OC20	2.50
OC22	2.50
OC23	4.00
OC24	3.00
OC25	1.00
OC26	1.50
OC28	2.00
OC29	2.00
OC35	1.50
OC36	1.50
OC41	0.90
OC42	0.90
OC43	1.50
OC44	0.85
OC45	0.65
OC71	0.55
OC72	1.00
OC73	1.00
OC74	0.70
OC75	0.65
OC76	1.00
OC77	1.00
OC81	0.65
OC81Z	1.20
OC82	0.90
OC83	0.80
OC84	0.80
OC122	2.75
OC123	2.00
OC139	3.00
OC140	4.00
OC141	4.25
OC170	1.25
OC171	1.25
OC200	1.50
OC201	2.50
OC202	2.75
OC203	3.00
OC204	3.00
OC205	2.75
OC206	2.75
OC207	2.50
OCP71	2.00
ORP12	1.00
R2008B	2.00
R2009	2.25
R2010B	2.00
T1C44	0.27
T1C226D	1.20
T1L209	0.16
T1P29A	0.43
T1P30A	0.45
T1P31A	0.33
T1P32A	0.36
T1P33A	0.54
T1P34A	0.67
T1P41A	0.44
T1P42A	0.42
T1P2955	0.70
T1P3055	0.56
T1S43	0.43
ZS140	0.25
ZS170	0.21
ZS178	0.54
ZS271	0.23
ZS278	0.57
ZTX107	0.12
ZTX108	0.12
ZTX109	0.12
ZTX300	0.13
ZTX301	0.14
ZTX302	0.18
ZTX303	0.18
ZTX304	0.20
ZTX311	0.13
ZTX314	0.25
ZTX500	0.14
ZTX501	0.14
ZTX502	0.18
ZTX503	0.19
ZTX504	0.21
ZTX531	0.24
ZTX550	0.25
1N914	0.05
1N916	0.09
1N4001	0.06
1N4002	0.06
1N4003	0.06
1N4004	0.07
1N4005	0.09
1N4006	0.11
1N4007	0.12
1N4009	0.07
1N4148	0.04
1N5400	0.13
1N5401	0.13
1S44	0.04
1S920	0.08
1S921	0.09
2G301	1.00
2G302	1.00
2G306	1.00
2N404	1.30
2N696	0.32
2N697	0.32
2N698	0.32
2N705	1.25
2N706	0.25
2N708	0.25
2N930	0.25
2N1131	0.30
2N1132	0.30
2N1302	1.20
2N1303	0.80
2N1304	1.20
2N1305	1.00
2N1306	1.50
2N1307	1.10
2N1308	1.75
2N1309	1.20
2N1613	0.32
2N1671	5.00
2N1893	0.32
2N2147	4.00
2N2148	3.75
2N2218	0.32
2N2219	0.32
2N2220	0.20
2N2221	0.20
2N2222	0.20
2N2223	4.25
2N2368	0.25
2N2369A	0.25
2N2484	0.25
2N2646	0.50
2N2904	0.32
2N2905	0.32
2N2906	0.21
2N2907	0.21
2N2924	0.26
2N2925	0.22
2N2926	0.15
2N3053	0.26
2N3054	0.55
2N3055	0.65
2N3440	0.70
2N3441	0.85
2N3442	1.25
2N3614	2.20
2N3702	0.11
2N3703	0.11
2N3704	0.11
2N3705	0.11
2N3706	0.11
2N3707	0.11
2N3708	0.10
2N3709	0.11
2N3710	0.10
2N3711	0.10
2N3771	1.40
2N3772	1.60
2N3773	1.80
2N3819	0.30
2N3820	0.39
2N3823	0.60
2N3866	1.00
2N3904	0.17
2N3905	0.17
2N3906	0.17
2N4058	0.20
2N4059	0.20
2N4060	0.16
2N4061	0.16
2N4062	0.16
2N4124	0.16
2N4126	0.16
2N4286	0.15
2N4288	0.18
2N4289	0.18
2N5457	0.32
2N5458	0.32
2N5459	0.32
2S017	10.00
2S019	12.00
2S026	25.00
2S103	1.50
2S302	2.00
2S303	1.50
2S322	3.50
2S324	3.50
2S701	2.00
2S745A	0.95
2S746A	0.95

VALVES

A1834	9.00
A2087	13.50
A2134	17.50
A2293	16.00
A2426	18.75
A2521	22.50
A2900	22.50
A3343	45.00
AZ31	2.75
AZ41	2.60
BK448	114.90
BK484	155.35
BS90	58.00
BS452	60.00
BS810	60.00
BT5	58.95
BT17	151.00
BT19	44.05
BT29	349.15
BT69	354.80
BT95	129.00
CBL31	4.00
CL33	4.00
CY31	3.00
C1K	20.00
C3A	22.00
C3JA	22.00
DA41	25.00
DA42	18.70
DAF91	1.75
DAF96	1.75
DET22	35.00
DET24	49.00
DF91	1.75
DF96	1.75
DK91	1.75
DK92	2.00
DK96	1.75
DL92	2.00
DL94	1.75
DL96	1.75
DLS10	14.00
DLS15	12.50
DLS16	12.50
DLS19	12.50
DM70	2.00
DM71	2.00
DM160	4.75
DY87	1.50
DY802	1.50
E55L	22.00
E80CC	8.81
E80CF	11.27
E80F	13.58
E80L	13.37
E81CC	8.00
E81L	12.57
E82CC	8.10
E83CC	8.40
E86C	8.25
E88C	8.25
E88CC	8.00
E90CC	8.61
E90F	9.90
E91H	6.25
E92CC	8.75
E99F	9.10
E130L	18.50
E180CC	10.50
E180F	9.90
E182CC	13.25
E186F	11.50
E188CC	8.25
E280F	22.51
E283CC	12.00
E288CC	17.50
EA52	32.25
EA76	2.50
EABC80	1.25
EAC91	3.50
EAF42	2.50
EAF801	2.00
EB41	4.00
EB91	1.50
EBC33	2.50
EBC41	2.50
EBC81	1.50
EBC90	1.25
EBF80	1.50
EBF83	1.75
EBF89	1.50
EBL31	6.00
EC90	1.25
EC91	8.00
EC92	1.75
EC157	325.40
ECC33	4.50
ECC35	4.50
ECC40	4.50
ECC81	1.75
ECC82	1.75
ECC83	1.75
ECC84	1.75
ECC85	1.75
ECC86	2.50
ECC88	2.10
ECC89	2.00
ECC91	8.93
ECC189	2.10
ECC807	1.75
ECC808	3.50
ECF80	1.55
ECF82	1.50
ECF86	2.50
ECH35	3.00
ECH42	3.50
ECH81	3.00
ECH83	2.50
ECH84	2.50
ECL80	1.50
ECL81	1.75
ECL82	1.50
ECL83	3.00
ECL84	1.50
ECL85	1.50
ECL86	1.75
EF37A	5.00
EF39	2.75
EF40	5.00
EF41	3.50
EF42	4.50
EF50	2.50
EF54	5.00
EF55	3.50
EF80	1.75
EF83	4.00
EF85	1.75
EF86	1.75
EF89	2.50
EF91	2.95
EF92	6.37
EF93	1.50
EF94	2.50
EF95	5.99
EF98	2.00
EF183	2.00
EF184	2.00
EF804S	12.00
EF805S	9.80
EH90	1.75
EK90	1.50
EL32	2.50
EL33	4.00
EL34MUI	3.00
EL36	2.50
EL41	2.80
EL42	2.50
EL81	5.25
EL83	6.00
EL84	2.25
EL86	2.75
EL90	2.25
EL91	9.69
EL95	2.00
EL156	25.00
EL360	8.50
EL500/504	3.00
EL509	7.00
EL821	13.00
EL822	13.97
EM34	5.00
EM80	2.50
EM81	2.50
EM84	2.00
EM85	2.75
EM87	2.50
EN32	17.46
EN91	7.50
EN92	6.96
EY51	2.75
EY81	2.50
EY83	2.50
EY84	9.24
EY86	1.75
EY88	1.75
EY500A	3.00
EY802	1.75
EZ35	1.75
EZ40	2.50
EZ41	2.50
EZ80	1.50
EZ81	1.50
EZ90	2.00
FW4-500	3.50
FW4-800	3.50
G1.371K	35.00
G551K	12.00
G180.2M	17.50
G240.2D	12.00
G400.1K	17.50
GN4	9.00
GN4A	9.00
GS16	16.00
GT1C	15.00
GU50	20.00
GU51	20.00
GXU1	15.35
GXU2	30.00
GXU3	25.00
GXU4	44.50
GXU50	20.00
GY501	3.00
GZ32	2.50
GZ33	4.75
GZ34	3.00
GZ37	4.75
KT61	5.00
KT66	8.00
KT88	11.00
KTW61	2.50
KTW62	2.50
KTW63	2.50
M8079	12.34
M8080	8.25
M8081	9.82
M8082	9.69
M8083	8.58
M8091	10.43
M8096	6.80
M8097	8.10
M8098	6.15
M8099	8.00
M8100	9.52
M8136	10.23
M8137	10.23
M8140	6.00
M8141	6.50
M8142	8.75
M8144	7.50
M8149	6.50
M8161	9.35
M8162	10.40
M8163	8.25
M8190	5.00
M8195	10.85
M8196	7.50
M8204	7.05
M8212	11.37
M8223	6.00
M8224	6.30
M8225	4.50
M8248	14.03
MD2901	60.00
MU14	2.50
MX119	55.00
MX123	72.00
MX145	56.70
MX151	17.25
MX152	131.25
MX161	152.25
MX163	20.25
MX164	25.52
MX166	147.00
MX168	48.00
N78	15.00
OA2	3.25
OA3	2.50
OA4	6.00
OB2	4.35
OB3	2.50
OC2	4.35
OC3	2.50
OD3	2.50
OZ4	3.50
PC86	2.50
PC88	2.50
PC95	1.75
PC97	1.75
PC900	1.75
PCC84	1.50
PCC85	1.50
PCC88	2.00
PCC89	1.75
PCC189	2.50
PCC805	1.60
PCC806	1.60
PCE82	2.00
PCF80	2.00
PCF82	1.50
PCF86	2.50
PCF87	2.00
PCF200	3.25
PCF201	3.25
PCF801	2.50
PCF802	2.50
PCF805	1.70
PCF806	1.70
PCF808	1.70
PCL82	2.00
PCL83	3.00
PCL84	2.00
PCL85	2.50
PCL86	2.50
PCL805/85	2.50
PD500	6.00
PE06-40N	30.00
PFL200	2.50
PL36	2.50
PL81	1.75
PL81A	2.00
PL82	1.50
PL83	2.50
PL84	2.00
PL504/5	2.50
PL508	2.50
PL509	6.00
PL519	6.00
PL801	1.50
PL802	6.00
PY33	2.50
PY81	1.75
PY82	1.50
PY83	2.50
PY88	2.00
PY500A	3.00
PY800	1.50
PY801	1.50
QQV02-6	16.50
QQV03-10	14.00
QQV03-20A	48.38
QQV06-40A	48.38
QQV07-50	66.90
QQZ06-40A	62.20
QU37	12.50
QV03-12	6.80
QV04-7	3.50
QV08-100	136.85
QY3-65	54.26
QY3-125	60.40
QY4-250	73.15
QY4-400	76.80
QY5-500	175.00
QY5-3000A	335.00
QZ06-20	32.70
R10	6.00
R17	3.00
R18	3.00
R19	9.24
R20	2.50
RG3-250	32.68
RG3-250A	32.68
RG3-1250	59.50
RG4-1250	61.60
RG4-3000	99.45
RR3-250	40.00
RR3-1250	45.75
S11E12	65.00
S130	6.00
S130P	6.00
STV280-40	14.00
STV280-80	21.00
SU41	5.00
SU42	10.00
TD03-10	35.00
TD03-10F	35.00
TT15	35.00
TT21	23.00
TT22	23.00
TT100	60.00
TY2-125	60.00
TW4-400	71.40
TY4-500	98.35
TY5-500	175.00
TY6-800	188.00
TY6-5000A	375.00
TY6-5000B	395.00
TY6-5000W	325.00
TY7-6000A	374.00
TY7-6000W	303.60
TZ40	25.00
U18-20	3.50
U19	13.75
U25	2.50
U26	2.50
U37	12.00
UABC80	1.25
UAF42	2.50
UB41	3.00
UBC41	2.25
UBF89	1.50
UCC84	1.75
UCC85	1.85
UCF80	2.00
UCH42	2.50
UCH81	2.50
UCL82	1.75
UCL83	2.75
UF41	2.00
UF42	2.10
UF80	1.75
UF85	1.75
UF89	2.00
UL41	3.50
UL84	1.75
UM80	2.00
UY41	2.25
UY85	2.25
VLS631	15.00
XG1-2500	45.80
XG2-6400	141.90
XG5-500	26.60
XG2-6400	162.00
XR1-1600A	53.75
XR1-3200	81.97
XR1-3200A	
XR1-6400	102.00
YD1120	395.00
YD1240	351.00
Z759	25.00
ZM1000	8.00
ZM1001	8.00
ZM1020	9.00
ZM1021	9.00
ZM1022	9.00
ZM1023	9.00
ZM1040	19.36
ZM1041	16.66
ZM1042	17.77
1B3GT	3.00
1B24	25.00
1B35A	48.00
1B63	64.00
1R5	1.75
1S5	1.75
1T4	1.75
2AS15	11.50
2C39A	60.00
2C43	70.00
2D21	3.25
2E26	8.25
2J42	98.00
2J55	175.00
2J70A	383.00
2J70B	336.00
2K25	125.00
3-400Z	85.00
3-500Z	85.00
3A5	3.00
3B24	11.00
3B28	15.35
3B29	20.00
3B240M	17.50
3B241M	17.50
3C23	25.00
3C45	24.50
3CX100A5	47.00
3E29	45.00
3S4	2.00
3V4	1.75
465A	60.00
4-125A	60.00
4-250A	80.00
4-400A	87.00
4B32	20.00
4C35	78.00
4CX250B	40.00
4CX350A	73.00
4X150A	60.00
4X150D	56.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5J180E	1650.00
5R4GY	3.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	7.10
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.00
6AN5	4.75
6AN8A	3.50
6AQ5	2.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BC4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	85.00
6BL7GT	4.50
6BM6	115.00
6BN6	2.00
6BQ7A	3.50
6BR7	6.00
6BR8A	3.50
6BS7	6.00
6BW6	6.00
6BW7	1.50
6BX7GT	5.00
6BZ6	2.75
6C4	1.25
6CB6A	2.50
6CD6GA	5.00
6CG7	2.50
6CH6	13.00
6CL6	3.75
6CW4	8.00
6D2	1.50
6DK6	3.00
6DQ6B	4.75
6EA8	3.00
6EB8	2.50
6EW6	2.25
6F6	3.00
6F23	1.60
6F28	1.60
6F33	33.50
6H1	14.00
6H2N	2.75
6H3N	2.75
6H6	3.00
6J4	5.50
6J6	8.93
6J7	4.75
6K4N	2.50
6K6GT	2.75
6K7	3.00
6K8	3.00
6KD6	7.00
6L6G	3.00
6L6GA	2.25
6L6GT	2.25
6L6GC	2.50
6L7	2.50
6N2P	2.50
6N3P	2.50
6N7	3.00
6P25	4.00
6Q7	3.75
6R7	3.25
6SA7	3.00
6SC7	2.75
6SF7	2.50
6SH7	3.00
6SJ7	3.25
6SK7	3.50
6SK7GT	3.00
6SN7GT	3.00
6SQ7	3.40
6SR7	4.00
6SS7	2.75
6U5G	3.50
6U8A	2.25
6V6GT	2.25
6X4	2.00
6X5GT	1.75
7B7	2.50
7C5	4.00
7C6	2.50
7H7	4.00
7R7	4.25
7S7	3.50
7Y4	2.25
7Z4	2.00
11E3	55.00
12AH8	5.00
12AT6	1.50
12AT7	1.75
12AU6	2.50
12AU7	1.75
12AV6	2.50
12AV7	3.50
12AX7	1.75
12AY7A	4.00
12B4A	3.50
12BA6	2.50
12BE6	2.50
12BH7	1.50
12BY7	3.00
12E1	20.00
12E11TT	170.00
12E14	35.00
13E1	20.00
19H4	27.50
19H5	47.50
24B9	67.25
30C15	2.00
30C17	2.00
30C18	2.00
30F5	1.60
30FL1/2	1.38
30FL12	1.80
30FL14	2.00
30L1	1.50
30L15	2.00
30L17	2.00
30P4	2.50
30P19	2.50
30PL1	3.00
30PL14	1.80
30PL15	1.80
35W4	1.00
50C5	1.50
75B1	6.05
75C1	3.50
85A1	7.50
85A2	4.45
90AG	12.96
90AV	12.96
90C1	6.00
90CG	14.54
90CV	15.45
92AG	12.96
92AV	12.96
95A1	8.45
150B2	6.50
150B3	8.35
150C2	3.25
150C4	6.00
211	35.00
723AB	125.00
803	25.00
805	45.00
807	3.75
811A	18.33
812A	18.33
813	125.86
833A	193.16
866A	20.03
872A	20.00
922	6.00
931A	18.52
1624	4.00
1625	3.50
2050	17.46
4212E	300.00
4212H	300.00
5544	81.97
5545	102.00
5551A	114.90
5552A	155.35
5642	9.00
5654	3.00
5651	4.45
5670	4.50
5675	28.00
5687	6.00
5696	4.50
5718	7.50
5725	5.50
5726	11.37
5727	7.05
5749	2.50
5751	4.00
5763	4.50
5814A	4.00
5840	4.00
5842	12.00
5876A	31.50
5879	5.00
5886	12.50
5963	2.50
5965	3.50
6005	2.25
6021	4.50
6057	10.23
6058	12.34
6059	6.00
6061	6.00
6063	3.75
6064	8.58
6067	10.23
6072	6.00
6080	14.00
6097A	235.00
6097B	200.00
6146A	8.25
6146B	8.25
6159B	19.00
6189	9.55
6201	11.40
6442	20.00
6883B	17.54
6973	4.00
7025	3.00
7551	6.25
7586	12.00
7587	18.50
7609	56.00
7868	6.00
7895	12.00
8005	110.49
8068	14.00
8122	90.00
8136	2.50
8417	6.00
18042	11.53
18045	10.49

Tested Ex-Equipment

4CX250B	6.50

BASES

B7G unskirted	0.22
B7G skirted	0.30
B9A unskirted	0.22
B9A skirted	0.30
Int Octal	0.35
Loctal	0.55
Nuvistor base	0.75
8 pin DIL	0.15
14 pin DIL	0.15
16 pin DIL	0.17
Valve screening cans all sizes	0.30

CRTs

2AP1	8.50
2BP1	9.00
3BP1	12.00
3DP1	5.00
3EG1	10.00
3FP7	6.00
3GP1	6.00
3JP1	8.00
3JP2	8.00
3JP7	10.00
3KP1	15.00
3RP1	35.00
3WP1	20.00
5ADP1	35.00
5BP1	10.00
5CP1	10.00
5CP1A	40.00
5FP15A	15.00
5UP7	25.00
DG7-5	63.32
DG7-31	58.07
DG7-32	58.07
DH3-91	56.83
DH7-11	113.12
VCR97	12.00
VCR138	12.00
VCR138A	12.50
VCR139A	8.00
VCR517A	10.00
VCR517B	10.00
VCR517C	10.00

Tube Bases Prices on application

INTEGRATED CIRCUITS

7400	0.16
7401	0.17
7402	0.17
7403	0.17
7404	0.18
7405	0.18
7406	0.43
7407	0.43
7408	0.20
7409	0.20
7410	0.17
7412	0.29
7413	0.32
7416	0.32
7417	0.32
7420	0.18
7422	0.20
7423	0.33
7425	0.30
7427	0.30
7428	0.43
7430	0.17
7432	0.30
7433	0.40
7437	0.32
7438	0.32
7440	0.32
7441	0.90
7442	0.72
7447AN	1.17
7450	0.18
7451	0.18
7453	0.18
7454	0.18
7460	0.18
7470	0.38
7472	0.33
7473	0.38
7474	0.38
7475	0.54
7476	0.42
7480	0.56
7482	0.75
7483	1.00
7484	1.05
7486	0.39
7490	0.60
7491	0.82
7492	0.60
7493	0.60
7494	0.82
7495	0.73
7496	0.82
7497	3.15
74100	1.54
74107	0.45
74109	0.73
74110	0.51
74111	0.71
74116	1.85
74118	1.00
74119	1.54
74120	0.83
74121	0.43
74122	0.62
74123	1.18
74125	0.58
74126	0.58
74128	0.63
74132	0.72
74136	0.51
74141	0.89
74142	2.30
74143	2.60
74144	2.60
74145	1.00
74147	2.00
74148	1.76
74150	1.80
74151	0.94
74154	1.80
74155	0.90
74156	0.90
74157	0.75
74159	2.20
74170	2.40
74172	4.40
74173	1.42
74174	1.60
74175	1.02
74176	1.16
74178	1.36
74179	1.36
74180	1.20
74190	1.90
74191	1.90
74192	1.90
74193	1.90
74194	1.25
74195	1.20
74196	1.35
74197	1.35
74198	2.70
74199	2.30
76013N	1.76
TAA570	2.30
TAA630S	3.50
TAA700	3.90
TBA480Q	1.84
TBA520Q	2.30
TBA530	1.98
TBA540Q	2.30
TBA550Q	3.22
TBA560CQ	3.22
TBA673	2.20
TBA700	1.52
TBA720Q	2.30
TBA750Q	2.07
TBA800	1.20
TBA920	2.90
TBA920Q	2.90
TBA990Q	2.90
TCA270Q	2.90
TCA760A	1.38

Terms of business: CWO. Postage and packing valves and semiconductors 50p per order. CRTs £1.50. Prices excluding VAT, add 15%. Price ruling at time of despatch.
In some cases prices of Mullard and USA valves will be higher than those advertised. Prices correct when going to press.
Account facilities available to approved companies with minimum order charge £10. Carriage and packing £1.50 on credit orders.
Over 10,000 types of valves, tubes and semiconductors in stock. Quotations for any types not listed. S.A.E.

Telephone 01-677 2424/7
Telex 946708
E. & O.E.
Open to callers Monday-Friday 9 a.m.-5 p.m.

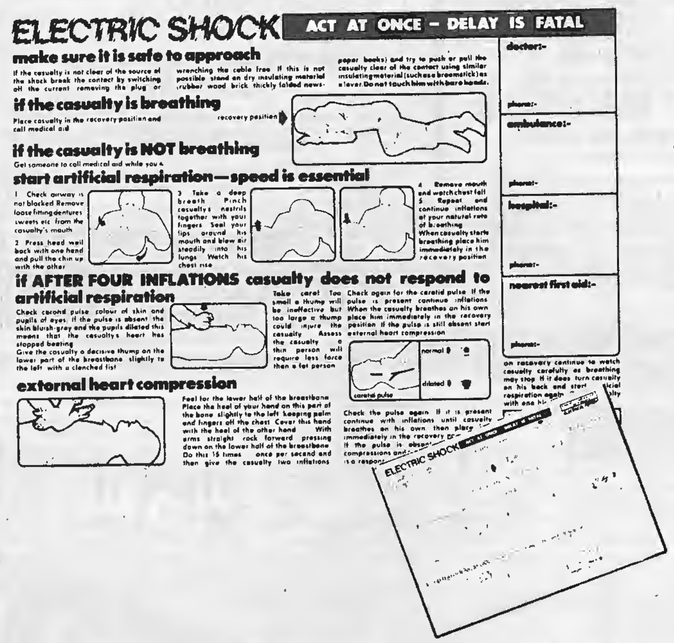
WW-11

WW – 036 FOR FURTHER DETAILS

ELECTRIC SHOCK

2 WAYS TO RECOVERY

ACT AT ONCE – DELAY IS FATAL



1 Display the ELECTRICAL REVIEW shock first aid chart (356x508mm) supplied in thousands to destinations world-wide. Recent deliveries include consignments to companies in Papua New Guinea, Dubai, United Arab Emirates, The Philippines, apart from UK commercial and industrial, educational, Central Government, Local Authorities' orders.

2 Carry the ELECTRICAL REVIEW pocket-size shock card (92x126mm) designed to help safety and training officers, medical and welfare personnel; all who might find themselves called to save a life. Always pocket your card; there's a useful two-year calendar on the back.

GET IT – READ IT – PRACTISE 1-4

BE READY TO SAVE A LIFE.
SOMEONE MIGHT SAVE YOURS.

ACT AT ONCE—DELAY IS FATAL!

To Electrical-Electronic Press
General Sales Department
Room 205
Quadrant House
Sutton SM2 5AS
Surrey
England

Company Registered Number: 151537 (ENGLAND)
Registered Office: Quadrant House, The Quadrant
Sutton, Surrey SM2 5AS

Please send......copy/copies as indicated

- Pocket Card @ 70p each inc VAT ☐
- Paper Chart @ £1.00 each post free ☐
- Card Chart @ £2.00 each post free ☐
- Plastic Chart @ £3.00 each post free ☐

Discounts: 100+ copies 10%
500+ copies 15%

(Overseas surface and air mail rates supplied on application.)

EX-STOCK TRANSFORMERS

Despatch by return

OVER 150 TYPES OF TRANSFORMER STOCKED

MAINS ISOLATORS

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

Ref.	VA (Watts)	£	P&P
07★	20	5.32	1.50
149	60	8.84	1.60
150	100	10.06	1.84
151	200	13.69	2.12
152	250	16.31	2.64
153	350	20.34	2.12
154	500	25.02	2.90
155	750	35.91	OA
156	1000	45.89	OA
157	1500	60.52	OA
158	2000	72.43	OA
159	3000	101.12	OA
161	6000	203.65	OA

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

30 VOLT RANGE 2×15V sec

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

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

(AMPS)

SCREENED MINIATURES Pri 240V

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

12 or 24-VOLT RANGE

2×12V windings Pri 220-240V

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

(AMPS)

60 VOLT RANGE

Pri 0-120V×2

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

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

(AMPS)

AUTO TRANSFORMERS

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

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

50 VOLT RANGE 2×25V

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

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

(AMPS)

CASED AUTOS

240V cable input USA 115V outlets

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

400/440V ISOLATORS

400/440 to 200/240V

VA	Ref.	£	P&P
60	243	8.11	1.50
250	246	16.07	OA
350	247	19.88	OA
500	248	24.77	OA
1000	250	50.53	OA
2000	252	74.79	OA
3000	253	104.86	OA
6000	254	207.92	OA

BURGLAR ALARMS
Ultrasonic portable, robust, looks like a speaker. No installation cost. £99. P&P £4.50 + VAT 15%.
- Powerful electric siren
- Exit and Entry delays
- Low cost

LOW COST SOLDERING IRONS TO BS SPEC
240V £1.75. Also 12V £1.90 + 30p P&P + VAT 15%.

Constant Voltage Transformers for spike-free and stable mains supply
250VA £157.36
500VA £219.91
1kVA £308.80
+ VAT 15% + P&P

INVERTERS
12- or 24-volt d.c. input; 240v. a.c. output
100W £49.50
250W £121.50
500W £286.00
1kW £240.40 (24V input)
Continuous rating + carriage at cost + V.A.T. 15%

EDUCATIONAL METERS. 75×78mm free-standing finger screw connection. i) 0-10A; ii) 0-30V; iii) 0-2A 75×78mm £4.50+66p p&p+VAT 15%

Specialist transformer winding services for batch production

BRIDGE RECTIFIERS

200v	2A	45p	200v	4A	65p
400v	2A	55p	400v	4A	85p
100v	25A+	£2.10	400v	6A	£1.40
100v	35A	£2.60	500v	12A	£2.85

P&P 20p. VAT 15%

OTHER PRODUCTS

CASING SERVICE
We can now case all open transformers listed in sturdy grey metal ventilated boxes (with mounting flange) for safety and protection. Cable in and out. USA 3 pin or 13 amp sockets to order, phone or write for quotes.

AVO & MEGGERS

8 Mk. 5 latest Model	£122.10
71 (Handy	£49.30
73 Portable Size)	£68.90
MM5 Minor	£43.60
DA211 LCD Digital	£58.50
DA212 LCD Digital	£81.90
DA116 LCD Digital	£131.30
DA117 Autorange LCD	£157.00
Megger 70143 500V	£101.50
Megger Battery BM7	£11.60

P&P £1.60 – VAT 15%

Industrial Standard Toroidals
15vA to 4kVA, made to order. Send or phone specification for quotes. Vacuum varnish impregnated. Split primaries, copper screens.

BUDGET METER
Sensitivity: 2,000Ω/V. Voltage to 1000v AC/DC. Resistance 0-200K with inst batt 5KΩ Centre Scale. DC current to 100ma. Size 95×65×30mm. Complete with leads, battery and instructions, small enough to slip in a pocket. £6.04 + 80p p&p + VAT 15%.

ANTEX SOLDERING IRONS 15W CCN240 or C250 £5. Safety stand £1.75 25W X25 £5.30. 12V 25W car soldering iron kit £5.30 P&P 50p + VAT 15%

Precision De-Solder Pumps for one hand working. Large £6.23. P&P 35p + VAT. Small £5.42. P&P 30p + VAT.

Cable: Coax, mains, multicore, screened, equipment, wire.

PANEL METERS'
43×43 mm ...£6.70 0.50μA, 0.500μA, 0.1mA + VAT
82×78 mm ...£7.37 0.30V, 100nA, 100mA, 1A, 5A, 10A, 15V, 100V available + VAT

MAINS BATTERY ELIMINATORS
Ready to plug into 13A socket. 3, 4.5V, 6, 7.5V, 9, 12V DC @ 300mA £5.10 + £1.20 P&P + VAT 15%.

¼W METAL OXIDE RESISTORS £1/100
Special Offer TR4 5% Electrosil (100s only). 47Ω - 75Ω - 180Ω - 360Ω - 390Ω - 430Ω - 470Ω - 510Ω - 560Ω - 820Ω - 1K - 1K2 - 1K3 - 1K6 - 1K8 - 2K - 2K4 - 3K - 16K - 20K - 22K - 24K - 27K - 47K - 82K - 100K - 110K - 120K - 130K - 180K - 220K - 270K - 300K. P&P 30p + VAT

PLUGS – SOCKETS – BOOKS – SEMI-CONDUCTORS – VALVES

Barrie Electronics Ltd.
3 THE MINORIES, LONDON EC3N 1BJ
TELEPHONE 01-488 3316/7/8
NEAREST TUBE STATIONS: ALDGATE & LIVERPOOL ST.
WW-6

Prices correct at time of print

OVERSEAS ENQUIRIES WELCOMED

WW – 037 FOR FURTHER DETAILS

TOTAL CONCEPT SPEAKERS

dB

HIGH QUALITY KITS FOR THE HOME CONSTRUCTOR

We are told that some ready-made speakers – at twice the price – sound as good as the dB range – but we doubt it!

Four models supplied with prefinished solid African Walnut panels and grille foam, plus two economy models with simulated woodgrain finish and grille fabric.
No veneering – no varnishing – no soldering – no electronic or woodworking skill required. All cabinet components are accurately machined from smooth MDF for easy assembly.
Kits contain all drive units, assembled crossover networks with leads, wadding, foam/grille fabric, screws, bolts, nuts etc. Optional purpose-designed stands (as illustrated).
Models suitable for 10–200 watts per channel.

Prices range from £35.95 – £212 per pair.

Details of the dB range (and many others) are contained in our new catalogue – £1.50 post free (cheque, P.O., or phone with your credit card number).

WILMSLOW AUDIO
The firm for Speakers

☎ 0625 529599

35/39 Church Street, Wilmslow, Cheshire SK9 1AS

WW – 062 FOR FURTHER DETAILS

MicroSight

Microsight 1, a complete vision system including software and full documentation for only:

£495 + vat

DIGITHURST

Digithurst Ltd.
Leaden Hill, Orwell, Royston,
Herts. SG8 5QH
Telephone: (0223) 208926

WW – 064 FOR FURTHER DETAILS

HF ANTENNAS SMC

★ MODE; Full half wave operation.
★ BANDS; Up to 4 spot frequencies.
★ POWER; Receive to 800W (PEP).
★ SWR; Better than 1.5:1 on channel.

From £135

THE SMC TRAPPED DIPOLE ANTENNA

has been developed to satisfy the needs of commerical and military users. It is capable of operation between 2 and 30 MHz on as many as four spot frequencies — each capable of accommodating many channels. Excellent matching and efficiency with a single coaxial feed is offered by the use of SMC H1Q traps and the incorporation of a ferrite balun in a full half wave design. NB: Power absorbing terminating resistors are not employed. The antenna may be deployed using one or two support masts, installation (incorporating SMC light duty portable masts) can be easily effected by two people in half an hour.

HF SSB TRANSCEIVER

TM180 "PIONEER" HF SSB TRANSCEIVER. 1.8-18MHz, 6 channels 100 watts RF output measuring only 95(H) x 240(W) x 310(D)mm and weighing 6kg. May be operated as a base or mobile transceiver, complementing our trap dipole and HW4 mobile aerials. **Prices start at £600,** making this unit not only very attractive but highly competitive.

SOUTH MIDLANDS COMMUNICATIONS LTD.

SM HOUSE
OSBORNE ROAD, TOTTON
SOUTHAMPTON SO4 4DN

Telex: 477351 SMCOMM G
Tel: Totton (0703) 867333

WW – 041 FOR FURTHER DETAILS

FYLDE

TRANSDUCER and RECORDER
AMPLIFIERS and SYSTEMS

reliable high performance & practical controls. individually powered modules—mains or dc option single cases and up to 17 modules in standard 19" crates small size—low weight—realistic prices.

FYLDE

Fylde Electronic Laboratories Limited.

49/51 Fylde Road Preston
PR1 2XQ
Telephone 0772 57560

WW – 020 FOR FURTHER DETAILS

PM COMPONENTS LTD
VALVE & COMPONENTS SPECIALISTS

INTEGRATED CIRCUITS

AN124 2.50
AN214Q 2.50
AN240P 2.80
AN612 2.15
AN7150 2.95
BA521 3.35
ETT6016 1.75
HA1366W 1.95
LA1230 1.15
LA4031P 2.70
LA4102 2.95
LA4400 4.15
LA4422 2.50
LC7120 3.25
LC7130 3.50
LC7131 5.50
LC7137 5.50
LM324N 0.45
LM380N 0.95
LM383T 2.95
LM390N 1.95
M51513L 2.30
M51515L 2.95
M83712 2.00
MC1307P 1.00
MC1310P 1.50
MC1327 0.95
MC1327Q 0.95
MC1330P 0.76
MC1349P 1.20
MC1350P 0.95
MC1351P 1.50
MC1352P 1.25
MC1357 2.35
MC1358 1.58
MC1495 3.00
MC1496 1.25
MC14011BCP 0.32
MC145106P 7.95
MC1723 0.50
MC3357 2.75
ML231B 1.75
ML232B 1.75
ML237B 1.95
ML238B 4.20
ML920 4.12
MSM5807 8.75
PLL02A 5.75
SAA1025 7.25
SAA5000A 3.05
SAA5010 6.35
SAS560S 1.75
SAS570S 1.75
SAS580 2.85
SL901B 4.85
SL917B 6.85
SL1310 1.80
SL1327 1.10
SL1327Q 1.10
SN76003N 1.95
SN76013N 1.95
SN76013ND 1.95
SN76023N 1.65
SN76033N 1.65
SN76110N 0.89
SN76131N 1.30
SN76226DN 1.55
SN76227N 1.05
SN76532N 1.40
SN76533N 1.65
SN76544N 1.65
SN76650N 1.15
SN76660N 0.80
SN76666N 0.70
TA7061AP 3.95
TA7108P 1.00
TA7120P 1.65
TA7130P 1.50
TA7146 2.95
TA7203 2.95
TA7204P 2.15
TA7205AP 1.50
TA7222AP 1.80
TA7227P 4.25
TA7310P 1.80
TA7313AP 2.95
TA7611AP 2.95
TAA550 0.25
TAA570 1.95
TAA661B 1.20
TAA700 1.70
TAA6305 3.50
TBA120B 0.95
TBA120S 0.70
TBA120SA 0.70
TBA120SQ 0.70
TBA120T 1.05
TBA120U 1.00
TBA231 1.25
TBA395 1.50
TBA396 0.75
TBA440N 2.55
TBA480Q 1.25
TBA510 2.50
TBA510Q 2.50
TBA520 1.10
TBA520Q 1.10
TBA530 1.10
TBA530Q 1.10
TBA540 1.25
TBA540Q 1.35
TBA550Q 1.45
TBA560C 1.45
TBA560CQ 1.45
TBA570 1.00
TBA641A12 2.50
TBA641BX1 3.00
TBA651 1.75
TBA720A 2.45
TBA750Q 2.65
TBA800 0.89
TBA810AS 1.35
TBA820Q 1.45
TBA890 2.50
TBA920 1.65
TBA920Q 1.65
TBA950 2.35
TBA950/2X 2.35
TBA990 1.49
TBA990Q 1.49
TBA1441 2.15
TCA270 1.10
TCA270SQ 1.10
TCA650 2.50
TCA800 2.15
TCA830S 1.40
TCA940 1.65
TDA440 2.20
TDA1004A 2.20
TDA1006A 2.50
TDA1010 2.15
TDA1035 2.50
TDA1037 1.95
TDA1170 1.95
TDA1170S 1.95
TDA1190 2.15
TDA1270Q 3.95
TDA1327 1.70
TDA1352B 1.43
TDA1412 0.85
TDA2002 1.95
TDA2020 2.45
TDA2030 2.80
TDA2522 1.95
TDA2523 1.95
TDA2524 1.95
TDA2530 1.95
TDA2532 1.95
TDA2540 1.95
TDA2541 2.15
TDA2560 2.15
TDA2581 2.25
TDA2590 2.95
TDA2591 2.95
TDA2593 2.95
TDA2600 3.50
TDA2610 2.50
TDA2611A 1.95
TDA2640 2.60
TDA2690 1.35
TDA3560 3.95
TDA3950 1.95
UPC566H 2.95
UPC575C2 2.75
UPC1001H 2.50
UPC1025H 2.50
UPC1028H 1.95
UPC1156H 2.75
UPC1167C2 1.15
UPC1181H 1.25
UPC1182H 2.95
UPC1185H 3.95
UPC1350C 2.95
UPC2002H 1.95
ZTK33B 0.30
555 0.35
556 0.42
723 0.50
741 0.35
747 0.50
748 0.35
4042 0.50
7805 0.60

SEMICONDUCTORS

AAY12 0.25
AC126 0.22
AC127 0.20
AC128 0.20
AC128K 0.32
AC141 0.28
AC141K 0.34
AC142K 0.30
AC176 0.22
AC176K 0.31
AC187 0.25
AC187K 0.25
AC188 0.25
AC188K 0.37
AD142 0.90
AD143 0.82
AD149 0.70
AD161 0.39
AD162 0.39
AD161/2 0.90
AF115 0.75
AF124 0.34
AF125 0.35
AF126 0.32
AF127 0.32
AF139 0.40
AF150 0.42
AF239 0.42
AU106 2.00
AU107 1.75
AU110 2.00
AU113 2.95
BC107 0.10
BC107A 0.11
BC107B 0.11
BC108 0.10
BC108A 0.11
BC108B 0.12
BC109 0.10
BC109B 0.12
BC109C 0.12
BC114 0.11
BC116A 0.15
BC117 0.19
BC119 0.24
BC125 0.25
BC140 0.31
BC141 0.25
BC142 0.21
BC143 0.24
BC147 0.09
BC147B 0.09
BC148A 0.09
BC148B 0.09
BC149 0.09
BC157 0.12
BC158 0.09
BC159 0.09
BC160 0.28
BC161 0.28
BC170B 0.15
BC171 0.09
BC171A 0.10
BC171B 0.10
BC172 0.10
BC172B 0.10
BC172C 0.10
BC173B 0.10
BC174 0.09
BC174A 0.09
BC177 0.15
BC178 0.15
BC182 0.10
BC182LB 0.10
BC183 0.10
BC183L 0.09
BC184LB 0.09
BC204 0.10
BC207B 0.13
BC208B 0.13
BC212 0.09
BC212L 0.09
BC212LA 0.09
BC213 0.09
BC213L 0.09
BC214 0.09
BC214C 0.09
BC214L 0.09
BC237 0.09
BC237A 0.09
BC237B 0.09
BC238 0.09
BC239 0.12
BC251A 0.12
BC252A 0.15
BC258 0.25
BC258A 0.39
BC284 0.30
BC300 0.30
BC301 0.30
BC303 0.26
BC307 0.09
BC307A 0.09
BC307B 0.09
BC327 0.10
BC328 0.10
BC337 0.10
BC338 0.09
BC347A 0.13
BC461 0.35
BC478 0.20
BC527 0.20
BC547 0.10
BC548 0.10
BC549A 0.08
BC550 0.08
BC557 0.08
BC557A 0.08
BC557B 0.08
BC558 0.10
BCY33A 1.60
BD115 0.30
BD116 0.60
BD124P 0.59
BD131 0.32
BD132 0.35
BD133 0.40
BD135 0.30
BD136 0.30
BD137 0.32
BD138 0.30
BD139 0.32
BD140 0.30
BD144 1.10
BD159 0.65
BD166 0.55
BD179 0.72
BD182 0.70
BD201 0.83
BD202 0.65
BD203 0.78
BD204 0.70
BD222 0.48
BD223 0.59
BD225 0.48
BD232 0.35
BD233 0.35
BD234 0.35
BD236 0.49
BD237 0.40
BD238 0.40
BD241 0.40
BD242 0.50
BD246 0.60
BD376 0.32
BD410 0.55
BD434 0.65
BD437 0.50
BD438 0.60
BD506 0.50
BD508 0.40
BD520 0.65
BD538 0.65
BD597 0.75
BD697 1.50
BD698 1.10
BD707 0.90
BDX32 1.50
BF115 0.35
BF127 0.24
BF154 0.12
BF158 0.22
BF160 0.27
BF167 0.25
BF173 0.22
BF177 0.38
BF178 0.29
BF179 0.34
BF180 0.29
BF181 0.29
BF182 0.29
BF183 0.29
BF184 0.28
BF185 0.28
BF194 0.11
BF195 0.11
BF196 0.11
BF197 0.11
BF198 0.16
BF199 0.14
BF200 0.40
BF241 0.15
BF245 0.30
BF246 0.28
BF256/LC 0.28
BF257 0.29
BF258 0.28
BF259 0.28
BF271 0.26
BF273 0.13
BF336 0.34
BF337 0.29
BF338 0.32
BF355 0.37
BF362 0.38
BF363 0.38
BF371 0.20
BF394 0.19
BF422 0.32
BF423 0.25
BF457 0.32
BF458 0.28
BF459 0.36
BF595 0.23
BF597 0.25
BFR39 0.23
BFR40 0.23
BFR41 0.28
BFR88 0.30
BFR90 1.50
BFR91 1.75
BFT42 0.28
BFT43 0.28
BFW92 0.85
BFX29 0.30
BFX84 0.26
BFX85 0.32
BFX86 0.30
BFX88 0.25
BFY50 0.21
BFY51 0.21
BFY52 0.25
BFY90 0.77
BR100 0.26
BR101 0.30
BRC4443 0.85
BT106 1.22
BT108 1.22
BT116 1.20
BT119 1.65
BT120 1.65
BU105 1.22
BU108 1.69
BU124 1.25
BU125 1.25
BU126 1.60
BU204 1.55
BU205 1.30
BU208 1.39
BU208A 1.52
BU326 1.20
BU326A 1.42
BU326S 1.90
BU407 1.24
BU500 2.25
BU526 1.90
BUY69B 1.70
MJ3000 1.98
MJE340 0.40
MJE520 0.48
MPSA12 0.20
MPSA13 0.29
MPSA92 0.30
MRF450A 13.50
MRF453 13.50
MRF454 17.50
MRF475 2.90
MRF477 10.00
OC23 1.50
OC42 0.55
OC44 0.55
OC45 0.55
OC70 0.45
OC71 0.45
OC81 0.50
R2008B 1.70
R2010B 1.70
R2322 0.58
R2323 0.66
R2540 2.48
RCA16334 0.90
RCA16335 0.80
SKE5F 1.45
TIP29 0.40
TIP29C 0.42
TIP30C 0.43
TIP31C 0.42
TIP32C 0.42
TIP33B 0.75
TIP34B 0.75
TIP41A 0.45
TIP41C 0.45
TIP42C 0.47
TIP47 0.65
TIP120 0.60
TIP125 0.65
TIP142 1.75
TIP146 1.75
TIP161 2.95
TIP2955 0.80
TIP3055 0.55
TIS91 0.20
TV106/2 1.50
2N2219 0.28
2N2905 0.40
2N3053 0.40
2N3054 0.59
2N3055 0.52
2N3702 0.12
2N3703 0.12
2N3704 0.12
2N3705 0.12
2N3706 0.12
2N3708 0.12
2N3773 1.75
2N3792 1.35
2N4427 1.50
2N4444 1.15
2N5294 0.42
2N5296 0.48
2N5298 0.60
2N5496 0.65
2SA715 0.60
2SC495 0.80
2SC496 0.80
2SC1096 0.80
2SC1172Y 2.20
2SC1173 1.15
2SC1306 1.00
2SC1307 1.50
2SC1449 0.80
2SC1678 1.25
2SC1945 2.10
2SC1953 0.95
2SC1957 0.80
2SC1969 1.95
2SC2028 1.15
2SC2029 1.95
2SC2078 1.45
2SC2091 0.85
2SC2166 1.95
2SC2314 0.80
2SD234 0.50
3N211 1.50

DIODES

AA119 0.08
BA102 0.17
BA115 0.13
BA145 0.16
BA148 0.17
BA154 0.06
BA155 0.13
BA156 0.15
BA157 0.30
BAX13 0.04
BAX16 0.06
BB105B 0.30
BT151 0.79
BY126 0.10
BY127 0.11
BY133 0.15
BY164 0.45
BY176 1.20
BY179 0.63
BY184 0.35
BY199 0.40
BY206 0.14
BY208-800 0.33
BY210-800 0.33
BY223 0.90
BY298-400 0.22
BY299-800 0.22
BYX10 0.20
BYX36-150R 0.20
BYX38-600R 0.60
BYX55-600 0.30
BYX71-600 0.60
BZY95C30 0.35
OA47 0.09
OA90 0.05
OA91 0.06
OA95 0.08
OA202 0.10
IN914 0.04
IN4001 0.04
IN4002 0.04
IN4003 0.04
IN4004 0.05
IN4005 0.05
IN4006 0.06
IN4007 0.06
IN4148 0.02
IN4448 0.10
IN5401 0.12
IN5402 0.14
IN5403 0.12
IN5404 0.12
IN5405 0.13
IN5406 0.13
IN5407 0.16
IN5408 0.18
ITT44 0.04
ITT923 0.15
ITT2002 0.10

74LS SERIES Prices available on request

CRT TUBES

A selection available. Prices on request.
3BP1 £13.50 D10-210GH £45
DG7-32 £42 DH7-91 £59
DP7-6 £35 DP7-11 £35
SE4DP7 £45 95447 £135
M17-151GVR £220

DATA & EQUIV. BOOKS

Transistor Data Books including Japanese types. Two books, £8.50 pair.

I.C. DATA BOOKS
LIN 1 covering Op Amps
LIN 2 covering Regulators
£4.95 each

PHONE 0474 813225 3 LINES

P. M. COMPONENTS LTD
SELECTRON HOUSE, WROTHAM ROAD
MEOPHAM GREEN, MEOPHAM, KENT DA13 0QY

TELEX 966371 PM COMP

A SELECTION FROM OUR STOCK OF BRANDED VALVES

A1714 18.50
A1998 11.50
A2087 11.50
A2134 14.95
A2293 6.50
A2426 17.50
A2521 21.00
A2599 37.50
A2900 11.50
A3042 24.00
A3283 24.00
AC/HL/DD 4.00
ACP 4.00
AC/THI 4.00
AC/VP2 4.00
AH221 39.00
AH238 39.00
AL60 6.00
ARP12 0.70
ARP34 1.25
ARP35 2.00
AZ31 2.00
BL63 2.00
BS450 67.00
BT5 49.50
BT19 32.50
BT79 12.50
CIK 18.00
C3JA 18.00
C1108 55.00
C1134 17.50
C1148A 80.00
C1149/1 89.00
C1534 32.00
CBL31 2.00
CCA 2.80
CL30 2.00
CL33 2.00
CMG25 9.00
CV Nos Prices on request
D63 1.20
DAF91 0.45
DAF96 0.65
DC70 1.75
DC90 1.20
DCX4-1000 12.00
DCX4-5000 25.00
DET10 6.00
DET22 28.00
DET24 39.00
DET25 22.00
DF91 0.70
DF92 0.60
DF96 0.65
DH63 1.00
DH77 0.90
DH79 0.56
DH149 2.00
DK91 0.90
DK92 1.20
DK96 2.50
DL35 1.00
DL63 1.00
DL70 2.50
DL73 2.50
DL91 1.50
DL92 0.80
DL93 1.00
DL96 2.50
DLS10 8.00
DLS16 10.00
DM70 1.10
DM160 2.75
DY51 1.00
DY80 1.20
DY86/87 0.55
DY802 0.65
E1T 9.00
E80CC 7.50
E80CF 7.50
E80F 9.50
E80L 11.50
E81CC 3.50
E81L 12.00
E82CC 3.50
E83CC 3.50
E83F 3.50
E86C 9.50
E88C 7.95
E88CC 2.50
E90CC 5.00
E90F 7.95
E91H 4.50
E92CC 2.25
E99F 6.99
E130L 14.50
E180CC 6.50
E182CC 9.00
E186F 8.50
E280F 19.50
E283CC 12.00
E288CC 13.50
E810F 16.00
E1148 1.00
EA50 1.00
EA76 1.95
EA79 1.95
EAA91 0.60
EABC80 0.68
EAC91 2.50
EAF42 1.20
EAF801 1.40
EB34 1.50
EB41 3.00
EB91 0.52
EBC33 2.50
EBC41 1.95
EBC81 0.85
EBC90 0.75
EBC91 0.75
EBF80 0.50
EBF83 0.50
EBF85 0.95
EBF89 0.70
EBF93 0.95
EBL1 1.50
EBL21 2.00
EBL31 3.95
EC52 0.75
EC70 1.75
EC80 4.25
EC81 4.50
EC86 1.00
EC88 1.00
EC90 0.70
EC91 7.00
EC92 1.50
EC93 0.80
EC95 7.00
EC97 1.10
EC8010 6.00
ECC32 3.00
ECC33 2.50
ECC35 3.50
ECC40 3.00
ECC81 0.85
ECC81 Mullard 1.10
ECC82 0.55
ECC82 Philips 1.10
ECC83 0.85
ECC83 Mullard 1.10
ECC83 Philips 1.10
ECC84 0.50
ECC85 0.60
ECC86 1.45
ECC88 0.75
ECC91 2.00
ECC180 0.72
ECC189 0.95
ECC801S 3.50
ECC803S 3.50
ECC804 0.60
ECC807 2.50
ECC808 2.95
ECC2000 12.00
ECF80 0.72
ECF82 0.60
ECF86 1.70
ECF200 1.85
ECF201 1.85
ECF801 0.85
ECF804 6.00
ECF805 2.50
ECH35 2.50
ECH42 1.00
ECH81 0.58
ECH83 0.78
ECH84 0.69
ECH200 1.50
ECL80 0.80
ECL82 0.85
ECL83 2.50
ECL84 0.75
ECL85 0.69
ECL86 0.74
ECL805 0.80
ECLL800 16.00
ED500 15.00
EF37A 2.00
EF39 1.00
EF41 3.50
EF42 3.50
EF50 1.50
EF55 2.25
EF71 1.50
EF72 1.50
EF73 1.00
EF80 0.55
EF83 3.50
EF85 0.60
EF86 1.50
EF86 Special quality 2.50
EF89 0.85
EF91 1.25
EF92 2.50
EF93 1.00
EF94 0.85
EF95 0.80
EF97 0.90
EF98 0.90
EF183 0.65
EF184 0.65
EF731 1.80
EF732 1.80
EF800 11.00
EF804S 9.85
EF805S 9.85
EF806S 9.85
EF812 0.65
EFL200 1.50
EH90 0.72
EK90 0.85
EL32 0.95
EL33 4.00
EL34 1.95
EL34 Mullard 2.95
EL36 1.50
EL37 9.00
EL38 6.00
EL41 2.25
EL42 2.00
EL81 3.95
EL82 0.58
EL84 0.89
EL85 0.60
EL86 0.85
EL90 1.25
EL91 6.00
EL95 0.80
EL183E 3.50
EL183P 3.50
EL360 7.95
EL500 1.40
EL504 1.40
EL508 1.90
EL509 5.25
EL519 5.50
EL802 3.65
EL821 10.35
EL822 10.35
EM1 9.00
EM4 9.00
EM34 7.50
EM80 0.70
EM81 0.70
EM84 0.75
EM85 1.10
EM87 2.50
EN10 8.00
EN32 13.50
EN91 1.80
EN91(SQ) 2.50
EN92 4.50
ES1100 115.00
ET1 11.00
EY51 0.80
EY81 0.80
EY83 1.50
EY84 9.00
EY84W 10.00
EY86/87 0.50
EY88 0.55
EY91 5.50
EY500A 1.50
EY802 0.70
EZ35 0.75
EZ40 1.25
EZ41 1.25
EZ80 0.70
EZ81 0.80
EZ90 0.96
FW4/500 2.00
FW4/800 2.00
G1/371K 30.00
G55/1K 9.00
G180/2M 9.00
G240/2D 9.00
G400/1K 14.00
GC10B 17.50
GC10/4B 17.50
GC10/4E 17.50
GC12/4B 17.50
GD86W 6.00
GDT120M 5.00
GE10 9.00
GN4 6.00
GN10 15.00
GR10G 4.00
GR10J 4.00
GS10C 12.00
GS10H 12.00
GS12D 12.00
GT1C 17.50
GT1C S/S 13.00
GTE175M 8.00
GTR150W 1.00
GU20 70.00
GU50 15.00
GXU1 15.00
GXU3 24.00
GY501 1.20
GY802 1.00
GZ30 1.00
GZ31 1.00
GZ32 1.00
GZ33 4.50
GZ34 2.15
GZ37 4.50
HAA91 1.00
HABC80 0.90
HBC90 0.75
HBC91 0.80
HF93 0.75
HF94 0.60
HK90 1.05
HL2K 3.50
HL23DD 4.00
HL41 3.50
HL41DD 3.50
HL42DD 3.50
HL90 0.70
HL92 1.50
HL133/DD 3.50
HR2 4.00
HY90 1.00
HVR2 3.00
KT8C 7.00
KT33C 3.50
KT36 3.00
KT41 4.00
KT44 4.00
KT45 4.00
KT63 2.00
KT66 USA 8.00
KT66 GEC 9.95
KT67 15.00
KT77 Gold Lion 9.50
KT81 7.00
KT88 USA 7.00
KT88 Gold Lion 12.50
KTW61 2.00
KTW62 2.00
KTW63 2.00
KTZ41 2.00
L63 1.00
L102/2K 6.95
L120/2K 12.00
LCF801 1.35
LCH200 1.35
LF184 1.00
LFL200 1.35
LY500A 1.75
M502A 135.00
M537A 180.00
M5143 155.00
M8079 6.00
M8082 7.50
M8083 3.25
M8091 7.50
M8096 3.00
M8098 3.00
M8099 4.00
M8100 2.85
M8136 4.00
M8137 5.50
M8161 5.50
M8162 5.50
M8163 3.65
M8190 3.65
M8195 3.00
M8196 3.25
M8204 2.00
M8223 2.00
M8224 2.00
M8225 2.00
ME1400 4.00
ME1401 29.50
ME1402 29.50
ME1501 14.00
MH4 3.00
MS4B 5.50
MU14 1.50
N37 13.50
N78 14.95
OA2 0.85
OA2WA 1.50
OA3 1.50
OB2 0.85
OB2WA 1.25
OC2 1.50
OC3 1.50
OD3 1.50
OM4 1.00
OM5B 3.00
OM6 1.75
OM9 4.00
ORP43 3.95
ORP50 3.95
P41 2.50
PABC80 0.50
PC86 0.75
PC88 0.75
PC92 1.50
PC97 1.10
PC800 1.10
PC900 0.75
PCC84 0.40
PCC85 0.55
PCC88 0.70
PCC89 0.70
PCC189 0.70
PCC805 0.70
PCC806 0.80
PCE800 0.85
PCF80 0.65
PCF82 0.60
PCF84 0.65
PCF86 1.20
PCF87 0.40
PCF200 1.35
PCF201 1.35
PCF800 0.40
PCF801 0.75
PCF802 0.60
PCF805 1.48
PCF806 1.25
PCF808 1.25
PCH200 1.10
PCL82 0.80
PCL83 2.50
PCL84 0.75
PCL85 0.80
PCL86 0.85
PCL200 1.60
PCL800 0.80
PCL805 0.80
PD500 3.50
PD510 3.65
PEN4DD 2.50
PEN25 2.00
PEN45 3.00
PEN45DD 3.00
PEN46 2.00
PFL200 1.25
PL21 2.50
PL33 1.25
PL36 0.95
PL38 1.50
PL81 0.72
PL81A 0.72
PL82 0.60
PL83 0.52
PL84 0.80
PL95 1.00
PL302 1.00
PL345 12.50
PL500 0.95
PL504 0.95
PL508 1.95
PL509 4.85
PL519 4.95
PL802 3.50
PL820 2.95
PY32 0.80
PY33 0.50
PY81 0.70
PY82 0.70
PY83 0.70
PY88 0.52
PY500A 1.79
PY800 0.75
PY801 0.69
Q13-110BA 28.00
QB3-300 30.50
QEO3-10 3.50
QE08-200 130.00
QP25 1.00
QQEO2-5 12.75
QQEO3-12 6.50
QQEO3-20 27.00
QQEO6-40 39.50
QQVO2-6 12.75
QQVO3-10 5.50
QQVO3-20 18.50
QQVO3-20A 17.00
QQVO6-40A 16.00
QQVO7-50 63.50
QQZO3-20 42.50
QQZO6-40A 46.25
QS72/20 1.50
QS75/40 2.50
QS92/10 5.00
QS95/10 4.85
QS108/45 4.00
QS150/15 5.00
QS150/30 1.15
QS1200 3.95
QS1202 3.95
QS1203 4.15
QS1205 3.95
QS1206 1.05
QS1207 0.90
QS1208 0.90
QS1209 2.00
QS1210 1.50
QS1211 1.50
QS1212 3.20
QS1213 5.00
QS1215 2.10
QS1218 5.00
QU37 11.50
QV03-12 3.50
QVO5-25 1.75
QVO6-20 29.50
QVO8-100 118.50
QY3-125 54.95
QY4-250 85.00
QY4-400 71.95
QY5-500 115.00
QZ06-20 32.50
R10 4.00
R16 12.00
R17 1.50
R18 2.50
R19 6.95
R20 1.20
RG1-125 4.95
RG1-240A 14.50
RG3-250A 25.00
RG3-1250A 52.50
RK2K25 62.50
RG4-1000 10.00
RK-20A 12.00
RL16 1.50
RPL16 12.00
RPY13 2.50
RPY43 2.50
RPY82 2.50
RR3-250 37.00
RR3-1250 65.00
RS613 45.00
RS685 54.95
RS686 52.15
S6F17 5.95
S6F33 28.95
S11E12 38.00
S30/2K 12.00
S104/1K 10.00
S109/1K 15.00
S130 5.95
S130P 5.95
SC1/800 5.00
SC1/1200 15.00
SC1/1400 12.00
SC1/2000 9.00
SP2 5.00
SP41 5.00
SP42 3.00
ST11 1.50
STV280/40 11.95
STV280/80 19.95
SU42 4.95
TB2.5/3000 60.00
TB2-300 45.00
TD1-100A 19.00
TDO3-10F 28.00
TD3-12 4.00
TP25 1.00
TSP4 7.00
TT11 1.50
TT15 34.95
TT21 19.50
TT22 18.50
TY2-125A 45.00
TY4-400 85.00
TY6-800 185.00
TY7-6000A 365.00
TY8-600W 365.00
TYS2/250 375.00
U18-20 2.75
U19 11.95
U22 1.00
U24 2.00
U25 0.90
U26 0.90
U37 9.00
U41 0.70
U50 1.00
U54 4.50
U82 3.00
U191 0.70
U192 1.00
U193 0.65
U251 1.00
U291 0.60
U301 0.65
U801 0.75
UABC80 0.85
UAF42 1.00
UBC41 1.75
UBC81 1.50
UBF80 0.60
UBF89 0.60
UBL21 1.75
UC92 1.20
UCC84 0.70
UCC85 0.60
UCF80 1.00
UCH21 1.20
UCH42 1.80
UCH81 0.65
UCL82 0.60
UF41 1.15
UF42 1.50
UF80 1.00
UF89 2.50
UL41 3.50
UL84 0.85
UU5 2.00
UU7 8.00
UY41 3.50
UY85 0.70
V339 3.50
VLS631 10.95
VP2B 2.50
VP4A 4.50
VP4B 4.50
VP6 2.50
VP41 2.50
VP133 2.00
VR37 1.50
VR75/30 3.00
VR91 1.50
VR101 2.00
VR105/30 1.50
VR150/30 1.05
VT52 2.50
VU39 1.50
VX5120 5.00
VX9133 5.00
VX9181 5.00
W77 5.00
W729 1.00
W739 1.50
X24 1.00
X79 3.50
XC12 1.50
XC15 1.50
XC25 0.50
XC900 1.35
XE3P 2.50
XFW47 1.50
XFW50 1.50
XG5-500 22.50
XL1-5V 4.50
XL509 4.95
XNP12 2.50
XNP28 2.50
XP1002 29.00
XR1-1600A 49.50
XR1-3200A 79.50
XR1-6400A 99.50
XSG2-0 3.00
Y63 1.50
Y602 12.00
YJ1060 285.00
YL1020 29.00
YL1070 115.00
YL1071 109.00
YL1370 5.50
YL1371 8.50
Z77 1.20
Z300T 5.00
Z302C 10.00
Z303C 9.00
Z505S 15.00
Z520M 4.00
Z521M 8.00
Z700U 3.00
Z749 0.60
Z759 19.85
Z800U 3.00
Z801U 3.00
Z803U 18.95
ZA1000 9.00
ZA1001 1.50
ZA1002 1.50
ZC1040 8.00
ZM1000 7.50
ZM1001 5.00
ZM1005 8.00
ZM1020 8.00
ZM1021 8.00
ZM1022 8.00
ZM1023 7.95
ZM1041 14.00
ZM1050 14.00
ZM1080 12.50
ZM1082 9.00
ZM1084 10.00
ZM1177 9.00
ZM1202 56.00
ZM1263 4.00
ZM1264 4.00
2T1011 29.00
1AC6 1.20
1B3GT 1.50
1B5 2.50
1B22 10.00
1B24 14.95
1C1 1.20
1C5GT 1.00
1D5 1.20
1FD1 0.90
1G3GT 1.00
1L4 0.60
1L6 1.00
1LA6 1.50
1N5GT 2.50
1S2 0.95
1T4 0.45
1U5 1.00
1X2B 1.15
2AS15A 10.00
2C21 1.00
2C39A 23.50
2C39WA 29.50
2C40 37.00
2C40A 55.00
2C42 29.50
2C43 29.50
2C51 5.00
2C53 32.00
2B7 1.50
2D21 0.95
2D21W 2.50
2E26 7.95
2J42 93.00
2K25 24.95
3A/147J 7.50
3A/167M 10.00
3A2 3.95
3A3A 3.95
3A4 1.10
3A5 6.50
3AL5 0.95
3AT2 1.95
3AW2 3.35
3B2 3.00
3B7 4.50
3B24 7.50
3B28 12.00
3C4 1.00
3C45 17.50
3CN3A 2.50
3CX3 2.50
3D21A 29.50
3D22 19.50
3J187E 398.00
3J187G 398.00
3W4GT 2.50
4B551B 115.00
4-65A 59.00
4-250A 85.00
4C27 25.00
4C28 25.00
4CX250B 37.50
4CX250R 48.50
4CX350A 63.75
4GS7 2.25
4GV7 2.25
4X150A 18.95
5A152M 9.00
5A163K 10.00
5A170K 8.25
5AN8 1.20
5AQ5 2.00
5AU4 1.50
5B.110M 10.00
5B-254M 14.50
5B-255M 14.50
5B-257M 9.00
5B-258M 14.50
5C22 40.00
5R4GB 2.80
5R4GY 2.80
5U4G 2.00
5U4GB 2.50
5V4G 0.75
5Y3GT 0.80
5Z4GT 0.85
6/30L2 0.70
6A/203K 9.00
6A8G 1.50
6AB7 1.00
6AB8 0.80
6AC7 2.00
6AF4A 2.50
6AG5 1.50
6AG7 1.95
6AH6 1.50
6AJ4 2.00
6AJ7 2.00
6AK5 1.00
6AK6 2.50
6AL5 0.52
6AM4 3.25
6AM5 8.00
6AM6 1.20
6AN5 3.95
6AN8A 2.50
6AQ5 1.20
6AQ8 0.85
6AR5 1.50
6AR8 2.00
6AS6 1.50
6AS7G 7.50
6AT6 0.75
6AU4 2.00
6AU6 0.65
6AV6 0.72
6AW8A 2.95
6B8G 0.80
6BA6 0.60
6BA8A 3.50
6BC8 1.00
6BD6 1.00
6BE6 0.72
6BF5 1.00
6BG6G 1.25
6BH6 1.50
6BJ6 1.30
6BK4 4.00
6BK7A 1.95
6BM8 0.85
6BN4 1.65
6BN6 1.65
6BN8 2.75
6BQ5 0.69
6BQ7A 0.72
6BL7GTA 3.95
6BL8 0.65
6BR7 4.15
6BR8 2.15
6BR8A 2.15
6BS7 4.50
6BS8 4.50
6BW4 5.35
6BW6 5.35
6BW7 1.50
6BX6 0.48
6BX7GT 3.50
6BZ6 2.00
6BZ7 2.95
6BZ8 0.95
6C4 0.80
6C5 1.95
6C6 0.50
6C8G 0.80
6C11 2.50
6C15 2.50
6C18 2.50
6CA4 0.60
6CA7 4.50
6CB6 1.50
6CD6GA 4.50
6CF6 1.50
6CH6 10.35
6CL6 3.50
6CL8A 2.00
6CM5 1.60
6CS6 0.75
6CW4 7.25
6CY5 1.00
6DC6 2.50
6DK6 1.65
6DQ5 2.30
6DQ6B 2.00
6DT6 1.50
6EA8 1.50
6EB8 1.50
6EH7 1.75
6EU8 1.75
6EW6 1.75
6F1 2.00
6F6G 2.00
6F12 1.50
6F13 1.50
6F14 1.00
6F15 2.75
6F17 1.75
6F18 1.50
6F19 0.48
6F21 0.70
6F22 0.70
6F23 0.70
6F24 1.25
6F25 1.25
6F28 1.25
6F32 17.00
6FG5 1.95
6GH8A 0.80
6GK5 1.50
6GK6 2.00
6GV7 2.50
6H3N 1.10
6H6 1.20
6H6GT 1.10
6J4 1.10
6J5 1.95
6J5G 0.75
6J6 0.55
6JB6A 3.95
6JE6C 3.50
6JS6A 3.50
6JS6C 3.50
6K7G 0.70
6KD6 4.50
6L1 2.50
6L19 3.50
6L6GC 2.75
6L6GT 1.75
6L7G 0.75
6LD20 0.60
6LF6 2.95
6LQ6 2.95
6N7GT 1.50
6P15 0.80
6P25 1.50
6P28 2.00
6Q7 1.20
6S4A 1.20
6SA7GT 1.00
6SC7 1.50
6SH7 1.50
6SJ7GT 1.50
6SK7 1.50
6SK7GT 1.20
6SL7GT 0.72
6SN7GT 0.69
6SQ7 0.80
6SS7 1.95
6U4GT 1.75
6U5G 1.95
6U8 1.50
6U8A 1.50
6V6GT 1.00
6X2N 1.00
6X4 0.96
6X5GT 1.00
6X5GTY 2.25
6X8A 2.00
7A7 1.75
7AD7 1.75
7B7 1.40
7C5 2.00
7C6 2.50
7H7 2.00
7Q7 1.00
7S7 2.50
7Y4 1.95
10C1 5.50
10C2 0.70
10D2 1.25
10F1 0.75
10GK6 1.95
10P14 2.50
10P18 0.75
10LD11 1.00
10LD12 0.65
11E2 16.50
11E3 55.00
12A6 0.85
12AQ8 1.50
12AL5 1.00
12AT6 0.59
12AT7 0.85
12AT7WA 2.50
12AU6 1.50
12AU7 0.55
12AV6 0.80
12AX4GT 1.00
12AX7 0.65
12AX7WA 2.50
12AY7 4.00
12AZ7A 1.95
12B4A 3.50
12BA6 0.90
12BE6 1.05
12BH7 1.50
12BH7A 1.50
12BL6 0.70
12BY7A 2.75
12CX6 1.20
12E1 17.95
12E14 28.00
12GN7 3.95
12HG7A 3.95
12J7GT 0.70
12K5 1.00
12K7GT 0.60
12K8 1.10
12Q7GT 0.50
12SA7GT 1.00
12SH7 1.00
12SK7 1.00
12SJ7 0.60
12SN7GT 1.65
12U7 1.50
13D3 3.20
13D7 3.20
13E1 115.00
14S7 1.00
15E 1.00
17DW4A 1.75
17JZ8 2.75
18D3 1.60
19AQ5 0.75
19H4 23.95
19Q9 9.00
20A2 10.50
20D1 0.70
20D4 1.75
20LF6 3.50
20L1 1.95
20P1 0.55
20P3 0.60
20P4 1.05
20P5 1.15
211 32.50
25L6GT 1.75
25BQ6 1.75
29C1 19.50
30A5 1.00
30C1 0.40
30C15 0.40
30C17 0.40
30C18 1.48
30F5 0.95
30FL1 1.10
30FL2 1.10
30FL12 0.95
30FL13 1.10
30FL14 1.25
30L1 0.45
30L15 0.60
30L17 0.80
30P4MR 1.00
30P12 1.00
30P18 0.60
30P19 1.00
30PL1 2.50
30PL13 1.00
30PL14 1.75
31JS6A 2.95
35A5 4.50
35L6GT 2.00
35W4 0.70
35Z3 1.85
38HE7 4.50
40KD6 4.50
47 6.00
50B5 1.50
50C5 0.95
50CD6G 1.15
52KU 2.00
61SPT 4.50
75B1 1.50
75C1 1.50
76 1.50
83A1 7.00
84 3.00
85A1 6.50
85A2 2.00
90AV 10.00
90C1 2.70
90CG 13.50
91AG 9.00
92AG 11.85
92AV 11.85
95A1 6.50
108C1 1.50
150B2 3.95
150C2 1.50
150C4 2.15
155UG 25.00
185BT 12.00
205F 12.00
257A 6.00
307 5.00
329 5.00
388A 17.50
408A 4.00
425A5 8.00
431U 2.00
572B 35.00
705A 8.00
708A 8.00
715A 6.00
715C 45.00
801A 2.00
803 14.95
807 1.50
810 55.00
811A 12.95
813 18.50
813 USA 59.50
833A 115.00
866A 3.95
872A 16.00
873 60.00
884 5.50
954 0.50
955 0.90
958A 0.80
1299A 0.80
2050 8.95
3545 4.00
4313C 0.50
5642 8.50
5651 3.20
5654 1.95
5670 3.50
5675 23.50
5687 3.50
5692 3.50
5696 3.50
5718 6.50
5725 2.50
5726 2.50
5727 2.50
5749 2.50
5750 2.00
5751 3.50
5763 3.50
5814A 3.25
5840 3.50
5842 6.50
5879 3.90
5881A 4.50
5894 39.50
5899 4.50
5963 2.00
5965 2.25
5993 8.00
6005 1.95
6012 6.00
6021 3.95
6057 2.50
6059 3.75
6060 2.25
6062 4.50
6063 2.00
6064 3.25
6067 1.95
6072 4.25
6080 5.75
6080WA 8.50
6096 2.85
6132 10.00
6136 2.50
6146A 4.95
6146B 6.95
6201 6.95
6211 2.50
6267 1.50
6350 2.00
6360 4.50
6386 14.50
6545 8.50
6550 7.00
6550A 7.00
6870 11.50
6883B 13.95
6973 3.75
7025 2.50
7027A 4.85
7058 2.00
7059 2.50
7189 2.50
7199 3.20
7247 2.00
7360 7.50
7475 5.00
7551 4.50
7558 11.50
7581A 3.00
7586 9.00
7591A 3.95
7868 3.95
8012 4.20
8136 1.00
8298A 4.95
8417 5.95
9001 0.90
9006 0.90
18042 10.00
18045 10.00

WIREWOUND RESISTORS

PREFERRED VALUES

4 Watt: 4R7-1K8 0.15; 2K2-6K8 0.18; 10K 0.24
7 Watt: R47-4K7 0.18; 5K6-12K 0.19; 15K-22K 0.20
11 Watt: 1R-10K 0.20; 15K-22K 0.24
17 Watt: 1R-10K 0.26; 15K-22K 0.28

WW-2

BASES ETC.

B7G 0.15
B7G Skirted 0.30
B8G 0.70
B9A 0.20
B9A Skirted 0.30
B10B 0.18
B13B 0.50
8 Pin DIL 0.10
14 Pin DIL 0.12
14 Pin DIL/Q 0.30
16 Pin DIL 0.15
OCTAL 0.35
CANS 0.27
B9A PCB 0.15
B5 0.75
B9G 0.38

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 51V 56V 68V 75V

BZY88 0.07
2V7 3V 3V3 3V6 3V9 4V3 4V7 5V1
5V6 6V2 6V8 7V5 8V2 9V1 10V 11V
12V 13V 15V 18V 20V 24V 27V 30V

THERMISTORS

VA1040 0.23
VA1056S 0.23
VA1104 0.70
VA8650 0.45
VA1097 0.25

BATTERIES

7V Power Mike batteries TR175 £1.40 ea other prices on request

CALLERS WELCOME

★ ENTRANCE ON A227
50 YDS SOUTH OF MEOPHAM GREEN
CAR PARKING AVAILABLE
OPEN MONDAY TO FRIDAY 9a.m.-5.30p.m.
★ 24 HOUR ANSWERPHONE SERVICE ★
ACCESS AND BARCLAYCARD ORDERS WELCOME
★ MANY OTHER ITEMS AVAILABLE ★

UK ORDERS P&P 50p PLEASE ADD V.A.T. AT 15%

EXPORT ORDERS WELCOME. CARRIAGE/POST AT COST

WW – 051 FOR FURTHER DETAILS

To obtain further details of any of the coded items mentioned in the Editorial or Advertisement pages of this issue, please complete one or more of the attached cards entering the reference number(s). Your enquiries will be passed on to the manufacturers concerned and you can expect to hear from them direct in due course. Cards posted from abroad require a stamp. These Service Cards are valid for six months from the date of publication.

Please Use Capital Letters

If you are way down on the circulation list, you may not be getting the information you require from the journal as soon as you should. Why not have your *own* copy?

To start a one year's subscription you may apply direct to us by using the card at the bottom of this page. You may also apply to the agent nearest to you, their address is shown below.

OVERSEAS SUBSCRIPTION AGENTS

Australia: Gordon & Gotch (Australasia) Ltd, 380 Lonsdale Street, Melbourne 3000, Victoria

Belgium: Agence et Messageries de la Presse, 1 Rue de la Petite-ILE Brussels 7

Canada: Davis Circulation Agency, 153 St. Clair Avenue West, Toronto 195, Ontario

Cyprus: General Press Agency Ltd, 131 Prodromou Street, P.O. Box 4528, Nicosia

Denmark: Dansk Bladdistribution, Hovedvagtsgade 8, Dk. 1103 Kobenhavn.

Finland: Rautakirja OY, Koivuvaarankuja 2, 01640 Vantaa 64, Finland.

France: Dawson-France S.A., B.P.40, F-91121, Palaiseau

Germany: W. E. Saarbach GmbH, 5 Koln 1, Follerstrasse 2

Greece: Hellenic Distribution Agency, P.O. Box 315, 245 Syngrou Avenue, Nea Smyrni, Greece.

Holland: Van Ditmar N.V., Oostelijke Handelskade 11, Amsterdam 1004

India: International Book House, Indian Mercantile Mansion Ext, Madame Cama Road, Bombay 1

Iran: A.D.A., 151 Khiaban Soraya, Tehran

Israel: Steimatzky's Agency Ltd, Citrus House, P.O. Box 628, Tel Aviv

Italy: Intercontinental s.a.s. Via Veracini 9, 20124 Milano

Japan: Western Publications Distribution Agency, 170 Nishi-Okubo 4-chome, Shinjuku-Ku, Tokyo 160

Lebanon: Levant Distributors Co., P.O. Box 1181, Makdesi Street, Halim Hanna Bldg, Beirut

Malaysia: Times Distributors Sdn. Bhd., Times House, 390 Kim Seng Road, Singapore 9, Malaysia.

Malta: W. H. Smith Continental Ltd, 18a Scots Street, Valleta

New Zealand: Gordon & Gotch (New Zealand) Ltd, 102 Adelaide Road, Wellington 2

Nigeria: Daily Times of Nigeria Ltd, 3 Kakawa Street, P.O. Box 139, Lagos

Norway: A/S Narvesens Kioskompani, Bertrand Narvesens vei 2, Oslo 6

Portugal: Livaria Bertrand s.a.r.l Apartado 37, Amadora

South Africa: Central News Agency Ltd, P.O. Box 1033, Johannesburg

Spain: Comercial Atheneum s.a. Consejo de Ciento, 130-136 Barcelona 15

Sweden: Wennegren Williams A B. Fack S-104, 25 Stockholm 30

Switzerland: Naville & Cie SA, Rue Levrier 5-7, CH-1211 Geneve 1
Schmidt Agence AG, Savogelstrasse 34, 4002 Basle

U.S.A.: John Barios, Business Press International, 205 East 42nd Street, New York, N.Y. 10017

CUT HERE

Postage will be paid by Licensee

Do not affix Postage Stamps if posted in Gt Britain, Channel Islands, N Ireland or the Isle of Man

2

BUSINESS REPLY SERVICE
Licence No 12045

WIRELESS WORLD
Reader Enquiry Service
Oakfield House
Perrymount Road
Haywards Heath
Sussex RH16 3DH
England

CUT HERE

Enquiry Service for Professional Readers

WIRELESS WORLD Wireless World, May 1983 WW 8365

WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....

Please arrange for me to receive further details of the products listed, the appropriate reference numbers of which have been entered in the space provided.

Name ....

Name of Company ....

Address ....

....

Telephone Number ....

PUBLISHERS USE ONLY			A/E		

Position in Company ....

Nature of Company/Business ....

No. of employees at this establishment ....

I wish to subscribe to Wireless World ☐

VALID FOR SIX MONTHS ONLY

CUT HERE

Wireless World: Subscription Order Form

To become a subscriber to Wireless World please complete the reverse side of this form and return it with your remittance to:

Subscription Manager,
Business Press International Ltd,
Oakfield House, Perrymount Road,
Haywards Heath, Sussex RH16 3DH,
England

Enquiry Service for Professional Readers ONLY.

WIRELESS WORLD Wireless World, May 1983 WW 8365

WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....

Please arrange for me to receive further details of the products listed, the appropriate reference numbers of which have been entered in the space provided.

Name ....

Position in Company ....

Name of Company ....

Address ....

....

Telephone Number ....

Nature of Company/Business ....

No. of employees at this establishment ....

VALID FOR SIX MONTHS ONLY

CUT HERE

Postage will be paid by Licensee

Do not affix Postage Stamps if posted in Gt Britain, Channel Islands, N Ireland or the Isle of Man

BUSINESS REPLY SERVICE
Licence No 12045

2

WIRELESS WORLD
Reader Enquiry Service
Oakfield House
Perrymount Road
Haywards Heath
Sussex RH16 3DH
England

CUT HERE

Wireless World Subscription Order Form Wireless World, May 1983 WW 8365

UK subscription rates
1 year: £14.00

Overseas ***1 year:*** £17.00

USA & Canada subscription rates
1 year: $44.00

Please enter my subscription to Wireless World for 1 year

I enclose remittance value .... **made payable to**
BUSINESS PRESS INTERNATIONAL Ltd.

Name ....

Address ....

....

Company Registered No: 151537 (ENGLAND)
Registered Office: Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS

CUT HERE

OVERSEAS ADVERTISEMENT AGENTS

Hungary Mrs. Edit Bajusz, Hungexpo Advertising Agency, Budapest XIV, Varosliget – Telephone: 225 008 – Telex: Budapest 22-4525 INTFOIRE

Italy Sig. C. Epis Etas-Kompass, S.p.a. – Servizio Estero, Via Mantegna 6, 20154 Milan – Telephone 347051 – Telex: 37342 Kompass

Japan Mr. Inatsuki, Trade Media – IBPA (Japan), B212 Azabu Heights, 1-5-10 Roppongi, Minato-Ku, Tokyo 106 – Telephone: (03) 585-0581

United States of America Ray Barnes, *Business Press International 205 East 42nd Street, *New York*, NY 10017 – Telephone: (212) 689 5961 – Telex: 421710
Mr. Jack Farley Jnr., The Farley Co., Suite 1548, 35 East Wacker Drive, *Chicago*, Illinois 60601 – Telephone: (312) 6 3074
Mr. Victor A. Jauch, Elmatex International, P.O. Box 34607, Los Angeles Calif. 90034 U.S.A. Telephone: (213) 821 8581 Telex: 18 – 1059.
Mr. Jack Mentel, The Farley Co., Suite 605, Ranna Building, Cleveland, Ohio 4415 – Telephone: (216) 621 1919
Mr. Ray Rickles, Ray Rickles & Co., P.O. Box 2008, *Miami Beach, Florida* 33140 – Telephone: (305) 532 7301
Mr. Jim Parks, Ray Rickles & Co., 3116 Maple Drive N.E., Atlanta, Georgia 30305. Telephone: (404) 237 7432
Mike Loughlin, Business Press International, 15055 Memorials, Ste 119, Houston, Texas 77079 – Telephone: (713) 783 8673

Canada Mr. Colin H. MacCulloch, International Advertising Consultants Ltd., 915 Carlton Tower, 2 Carlton Street, Toronto 2 – Telephone (416) 364 2269

*Also subscription agents

Test Instruments from Sifam

These instruments have all the features, accuracy and reliability you would expect from professional-quality equipment at less than you might expect them to cost.

3½-DIGITAL MULTIMETERS

Both these instruments have the following features:

- Only two input terminals, common to all functions.
- Overload protection, autozero, autopolarity, over-range and low battery indications.
- Basic 0.3% DCV accuracy.
- Supplied with test leads, spare fuse, 9V battery and operator's manual.

DMM2500

(bench model)

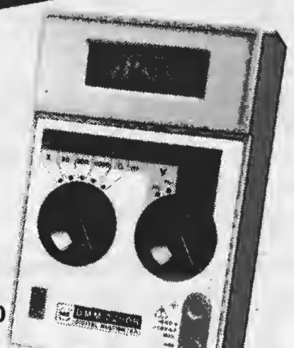
Push-button operation providing 24 ranges in 5 modes.
±2A A.C./D.C.
±1000V A.C./D.C.
200Ω to 20MΩ resistance
Re-settable overload circuit breaker
2000 hours operation from 9V battery
Size: 155x120x57mm

£85.95 incl.VAT plus p&p at £1.00

DMM2200B

(hand-held model)

2 Teflon-bushed rotary switches providing 21 ranges in 5 modes.
±2A A.C./D.C.
±1000V A.C./D.C.
2000Ω to 20MΩ resistance
1000 hours operation from 9V battery
Size: 165x110x43mm



£49.95 incl.VAT plus p&p at £1.00

DIGITAL LOGIC PROBE DLP50

- Wide frequency range: DC to 50 MHz
- Minimum detectable input pulse width of 10 nsec.
- High input impedence of 10 megohms
- Compatible with DTL, TTL and CMOS in a wide range of power supply voltages of 4.5 to 30V D.C.
- Protected up to ±120V D.C./A.C. in input signal plus audible warning function
- Rugged, modern plastic-housed unit supplied packaged in a de-luxe moulded plastic carrying case, with ground lead, IC-clip lead and operator's manual
- Size: 195x26x16mm with 800mm power lead

£44.95 incl.VAT plus p&p at £1.00

All these instruments are guaranteed against defective parts/workmanship for 12 months. If not satisfied, please return within 14 days for full refund.

The telephone number for Access/Barclaycard orders, enquiries and literature is 0803 63822. Ext.8.

Post to: **Sifam Ltd.**, Woodland Road, Torquay, Devon TQ2 7AY

Please send me ______ Total purchase price ______
Please debit my Access/Barclaycard No. ______ I enclose Cheque ☐ Postal Order ☐
Name ______ Int. Money Order ☐
Address ______
Signature ______

Please allow up to 28 days for delivery. Official orders accepted from colleges, schools, companies, etc.

WW – 074 FOR FURTHER DETAILS

NEW! ICOM ICH2 SYNTHESIZED FM HANDPORTABLE

The ICH2 is the first of a new breed of synthesized hand-held radio transceivers. Being synthesized, it requires no crystals to be set on to frequency. All that is required is to lift a recessed panel on the top of the set and cut the correct diodes to program the set to one or two channels. Duplex or simplex is obtained in the same way. This really is a boon to the busy dealer and convenient for the customer who wants those extra few sets "yesterday".

The ICH2 is very versatile, coming complete with a rechargeable ni-cad pack, small mains charger, rubber helical antenna, earphone and strong spring belt clip. Optional extras include: A speaker/microphone, cigarette lighter plug 12V charging lead, 12V convertor to operate direct from the car supply, leather and leatherette cases, various different types of slide on/off battery packs both rechargeable and dry and a desk charger that fast charges some of the battery packs in 1 to 1½ hours. The battery packs slide on and off very easily, enabling a spare to be carried in your pocket and an exchange made in the field. Sizes are 6.5"H × 2.6"W × 1.4"D, weighing 1.1lb. Power output is 1-3 watts and covers a frequency range of 164.975-174.975Mhz, duplex or simplex.

Retail price is 269 pounds each plus VAT. We are also looking for dealers for general distribution. More details from

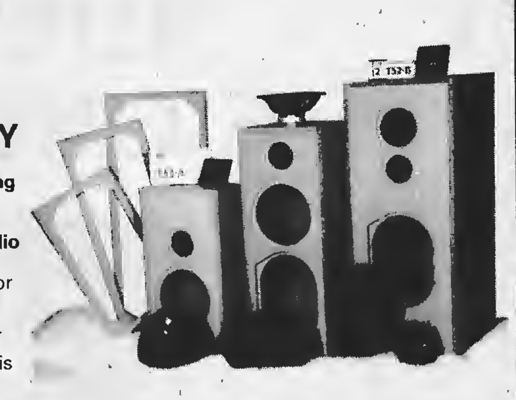
Thanet Electronics ICOM
143 Reculver Road, Herne Bay, Kent
Tel: 02273 63859. Telex 965179

WW – 048 FOR FURTHER DETAILS

KEF Constructor Series Speakers

IT'S SO EASY

Have fun, save money, building a Kef design with a Wilmslow Audio CS Total kit.



No electronic or woodworking knowledge necessary and the end result is a proven top-quality design that you'll be proud of.

Each kit contains all cabinet components, accurately machined for easy assembly, speaker drive units, crossovers, wadding, grille fabric, terminals, nuts, bolts, etc.

The cabinets can be painted or stained or finished with iron-on veneer or self adhesive woodgrain vynil.

Easy foolproof assembly instructions supplied. Set of constructor leaflets sent free on receipt of large S.A.E.

Prices:		
CS1 (As 101)	**£110** pr. inc. VAT, plus carr./ins.	£ 5.50
CS1A (simplified LS3/5A)	**£103** pr. inc. VAT, plus carr./ins.	£ 5.50
CS3 (as 103.2)	**£129** pr. inc. VAT, plus carr./ins.	£10.00
CS5 (as Carlton II)	**£192** pr. inc. VAT, plus carr./ins.	£15.00
CS7 (as Cantata)	**£250** pr. inc. VAT, plus carr./ins.	£18.00

WILMSLOW AUDIO The firm for Speakers

0625 529599

35/39 Church Street, Wilmslow, Cheshire SK9 1AS

Catalogue — £1.50 post free

Lightning service on telephoned credit card orders!

WW – 061 FOR FURTHER DETAILS

COMPUTER WAREHOUSE

THE 'ALADDIN'S' CAVE OF COMPUTER AND ELECTRONIC EQUIPMENT

HARD DISK DRIVES

Fully refurbished Diablo/DRE Series 30 2.5 mb hard disk drive for DEC RKO5, NOVA, TEXAS etc.
Front load £550.00 – Top load £295.00
PSU type ME3029 for 2 drives £125.00
DRE 44A/4000A/B 10 mb 5+5 all configurations from £995.00. Call sales office for details.

5 AMP MAINS FILTERS

Cure those unnerving hang ups and data glitches caused by mains interference. Matchbox size – Up to 5 amp 240 v load. As recommended by the ZX81 newsletter. Suppression Devices SD5A £5.95.

DISTEL©

The UK's **FIRST** free of charge, 24 hr. public access data base. Get information on **1000's** of stock items and order via your computer and credit card. On line now, 300 baud. CCITT tones, full duplex, fully interactive.

DON'T MISS THOSE BARGAINS CALL NOW, IT'S FREE!

01-683 1133 7 days per week 24 hrs. per day
8 BIT WORD – NO PARITY

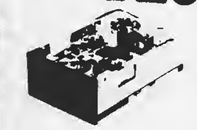
COMPUTER 'CAB'

All in one quality computer cabinet with integral switched mode PSU, Mains filtering, and twin fan cooling. Originally made for the famous **DEC PDP8** computer system costing thousands of pounds. Made to run 24 hours per day the PSU is fully screened and will deliver a massive +5v DC at 17 amps, +15v DC at 1 amp and –15v DC at 5 amps. The complete unit is fully enclosed with removable top lid, filtering, trip switch, 'Power' and 'Run' LEDs mounted on Ali front panel, rear cable entries, etc. etc. Units are in good but used condition – supplied for 240v operation complete with full circuit and tech. man. **Give your system that professional finish** for only £49.95 + Carr. Dim. 19" wide 16" deep 10.5" high. Useable area 16"w 10.5"h 11.5"d. Also available **LESS PSU** with internal dim. 19"w, 16"d, 10.5"h, £19.95". Carriage & insurance £9.50.

COOLING FANS

Keep your hot parts COOL and RELIABLE with our range of **BRAND NEW** professional cooling fans.
ETRI 99XUOI Dim. 92 x 92 x 25 mm. Miniature 240 v equipment fan complete with finger guard. **£9.95.**
GOULD JB-3AR Dim. 3" x 3" x 2.5" compact very quiet running 240 v operation. **NEW £6.95**
BUHLER 69.11.22. 8-16 v DC micro miniature reversible fan. Uses a brushless servo motor for extremely high air flow, almost silent running and guaranteed 10,000 hr life. Measures only 62 x 62 x 22 mm. Current cost £32.00. **OUR PRICE ONLY £12.95 complete with data.**
MUFFIN-CENTAUR standard 4" x 4" x 1.25" fan supplied tested EX EQUIPMENT 240 v at £6.25 or 110 v at £4.95 or BRAND NEW 240 v at £10.50. 1000's of other fans Ex Stock. Call for Details. Post & Packing on all fans £1.60

8" FLOPPY DISK DRIVES



Unbelievable value the DRE 7100 8" floppy disk drives utilise the finest technology to give you 100% bus compatibility with most drives available today. The only difference being our **PRICE** and the superb manufacturing quality!! The 7100 single sided and 7200 double sided drive accept hard or soft sectoring IBM or ANSI standard formats giving a massive 0.8 MB (7100) 1.6 MB (7200) of storage. Absolutely SHUGART, BASF, SIEMANS etc. compatible. Supplied BRAND NEW with user manual and full 90 day warranty. Carriage and insurance £9.75.

7100 Single sided £225.00 + Carr. **7200 Double sided £295** + Carr.

Optional accessories: Full technical manual £20.00 alone. £10.50 with drive. Refund of difference on drive purchase. DC and AC power connector and cable kit £8.45. 50 way IDC connector £5.50. 50 way ribbon cable £3.20 per metre.

RECHARGEABLE BATTERIES

CYCLON type D001 sealed lead acid maintenance free 2v 2.5 ah. will deliver over 300 amps on short circuit!! Brand new at only £2.95

SUPER DEAL? NO — SUPER STEAL!!

The FABULOUS 25CPS TEC Starwriter
Daisy wheel printer at a fraction of its original cost.
BRAND NEW AT ONLY £499 + VAT

Made to the very highest spec the **TEC Starwriter FP1500-25** features a heavy duty die cast chassis and DIABLO type print mechanism giving superb registration and print quality. Microprocessor electronics offer full DIABLO/QUME command compatability and full control via CPM Wordstar etc.
Many other features include bi directional printing, switchable 10 or 12 pitch, full width 381 mm paper handling with upto 163 characters per line, friction feed rollers for single sheet or continuous paper, internal buffer, standard RS232 serial interface with handshake.
Supplied absolutly **BRAND NEW** with 90 day guarantee and **FREE** daisy wheel and dust cover. Order **NOW** or contact sales office for more information.
Optional extras: RS232 data cable **£10.00**. Tech manual **£7.50**. Tractor feed **£120.00**. Spare daisy wheel **£3.00**. Carriage & Ins. (UK Mainland) **£10.00**.

TELETYPE ASR33 I/O TERMINALS

FROM £195 + CAR. + VAT

Fully fledged industry standard ASR33 data terminal. Many features including ASCII keyboard and printer for data I/O auto data detect circuitry. RS232 serial interface. 110 baud, 8 bit paper tape punch and reader for off line data preparation and ridiculously cheap and reliable data storage. Supplied in good condition and in working order
Options: Floor stand *£12.50* + VAT
KSR33 with 20ma loop interface *£125.00* + Sound proof enclosure *£25.00* + VAT

SOFTY 2

The amazing SOFTY 2. The complete "toolkit" for the open heart software surgeon. Copies, Displays, Emulates ROM, RAM and EPROMS of the 2516, 2532 variety. Many other features include keyboard, UHF modulator. Cassette interface etc. Functions exceed capabilities of units costing 7 times the price! Only *£169.00* pp £1.95 *Data sheet on request*

VIDEO MONITORS

12" CASED. Made by the British KGM Co. Designed for continuous use as a data display station, unit is totally housed in an attractive brushed aluminium case with ON-OFF, BRIGHTNESS and CONTRAST controls mounted to one side. Much attention was given to construction and reliability of this unit with features such as, internal transformer isolated regulated DC supply, all components mounted on two fibre glass PCB boards – which hinge out for ease of service, many internal controls for linearity etc. The monitor accepts standard 75 ohm composite video signal via SO239 socket on rear panel. Bandwidth of the unit is estimated around 20 Mhz and will display most high def graphics and 132 x 24 lines. Units are secondhand and may have screen burns. However where burns exist they are only apparent when monitor is switched off. Although unguaranteed all monitors are tested prior to despatch. Dimensions approx. 14" high x 14" wide by 11" deep. Supplied complete with circuit. 240 volt AC operation. *ONLY £45.00 PLUS £9.50 CARR.*

24" CASED. Again made by the KGM Co with a similar spec as the 12" monitor. Originally used for large screen data display. Very compact unit in lightweight alloy case dim. 19" H x 17" D x 22" W. All silicon electronics and composite video input make an ideal unit for schools, clubs, shops etc. Supplied in a used but working condition.
ONLY £55.00 PLUS £9.50 CARR. & INS.

14" COLOUR superb chassis monitor made by a subsidiary of the HITACHI Co. Inputs are TTL RGB with separate sync. and will plug direct into the BBC micro etc. Exceptional bandwidth with good 80 col. definition. Brand new and guaranteed. Complete with full data & circuit. 240 v AC working. Dim. 14" x 13" x 13".
ONLY £199.00 PLUS £9.50 CARR.

DATA MODEMS

Join the communications revolution with our range of EX TELECOM data modems. Made to most stringent spec and designed to operate for 24 hrs per day. Units are made to the CCITT tone spec. With RS232 i/o levels via a 25 way 'D' skt. Units are sold in a tested and working condition with data. Permission may be required for connection to PO lines.
MODEM 13A compact, async, same size as telephone base. Up to 300 baud, full duplex over 2 wires, but call mode only **£75.00**
MODEM 2B/C Fully fledged, up to 300 baud async, ANSWER & CALL modes, auto answer, auto switching, ideal networks etc. Just 2 wire connection to comms line. **£85.00**
MODEM 20-1 Compact unit for use with PRESTEL or full duplex 2 wire link. 75 baud transmit – 1200 baud receive. Auto answer. **£130.00**
MODEM 20-2 same as 20-1 but 75 baud receive 1200 baud transmit. **£130.00**
MODEM 20-3 Made for data rates up to 1200 baud in full duplex mode over 4 wire circuit or half duplex mode over 2 wires. **£130.00**
Carriage. 13A £4.50. 2B/C & 20 £9.50.
DATA PUMP MODEM compact unit upto 1200 baud full duplex over 4 wires or half duplex over 2 wires. BELL specification with data i/o via RS232 25 way D socket, remote test etc. 240 v operation. Supplied complete with data **£65.00** carr. £4.50.

For more information or details of other types of ex. stock modems contact sales office.

D.C. POWER SUPPLY SPECIALS

Experimentors PSU Ex-GPO unit all silicon electronics. Outputs give +5v @ 2 amps. +12v @ 800 ma. -12v @ 800 ma. +24v @ 350 ma. 5v @ 50 ma. floating. Dim 160 x 120 x 350 mm. All outputs fully regulated and short circuit proof. Removed from working equipment, but untested. Complete with circuit. Transformer guaranteed. Only *£14.50* +£2.50 pp.
CUSTOM POWER CO55 5v @ 3 amp. Very compact unit dim. approx 60 x 90 x 190 mm. Semi open chassis, full crowbar overvoltage protection. Tested Ex Equipment. *£11.95* + pp £1.25
FARNELL 5 Volt 40 amps. Type number G6-40A this miniature switching psu measures only 160 mm wide, 175 mm deep and 90 mm high!! Fully regulated and smoothed with over voltage protection etc. 120 or 240 volts AC input. Supplied BRAND NEW and boxed with circuit and fixing screws at a fraction of the current list price. Only *£130.00* + £3.00 carr. & ins.
PERIPHERAL SYSTEM SUPPLY. Fully cased unit supplied in a Brand new or little used condition. Outputs give 5v @ 11 amps, "+" 15-17v @ 8 amps. "–" 15-17v @ 8 amps and "+" 24v @ 4 amps. All outputs are crowbar protected and the 5 volt output is fully regulated. Fan cooled. Supplied tested, with circuit *£55.00* + £8.50 carr.
MAIN FRAME SUPPLY. A real beefy unit designed for MINI or MAINFRAME use outputs give 5 volts @ 50 amps. +12v @ 5 amps. -12v @ 10 amps. All output are fully regulated with crowbar overvoltage protection on the 5v output. Supplied with circuit and tested. Ex-Equip. 110v AC input. Only *£49.95* + carr. £10.50.

SEMICONDUCTOR 'GRAB BAGS'

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 manufacturer's markings, fully guaranteed, 50+ *£2.95* 100+ *£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 100+ mixed "mostly TTL" grab bags at a price which two or three chips in the bag would nnormally cost to buy. Fully guaranteed all I.C.'s full spec. 100+ *£6.90* 200+ *£12.30* 300+ *£19.50*

66% DISCOUNT ELECTRONIC COMPONENTS & EQUIPMENT

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. surlplus 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 play plus we always include something from our ads. for unbeatable value!! Sold by weight.

2.5kls *£4.25* + pp £1.25 — 5kls *£5.90* + pp £1.80
10kls *£10.25* + pp £2.25 — 20kls *£17.50* + pp £4.75

OLIVETTI TE300

REDUCED TO CLEAR

Complete input output terminal with integral 8 hole paper tape punch and reader. Unit operates at 150 baud in standard ASCII. Ideal as a cheap printer for a MICRO etc. 120 columns, Serial data i/o. Supplied complete with data, untested, unguaranteed *£65.00* + £11.50 carr.

ALL PRICES PLUS VAT

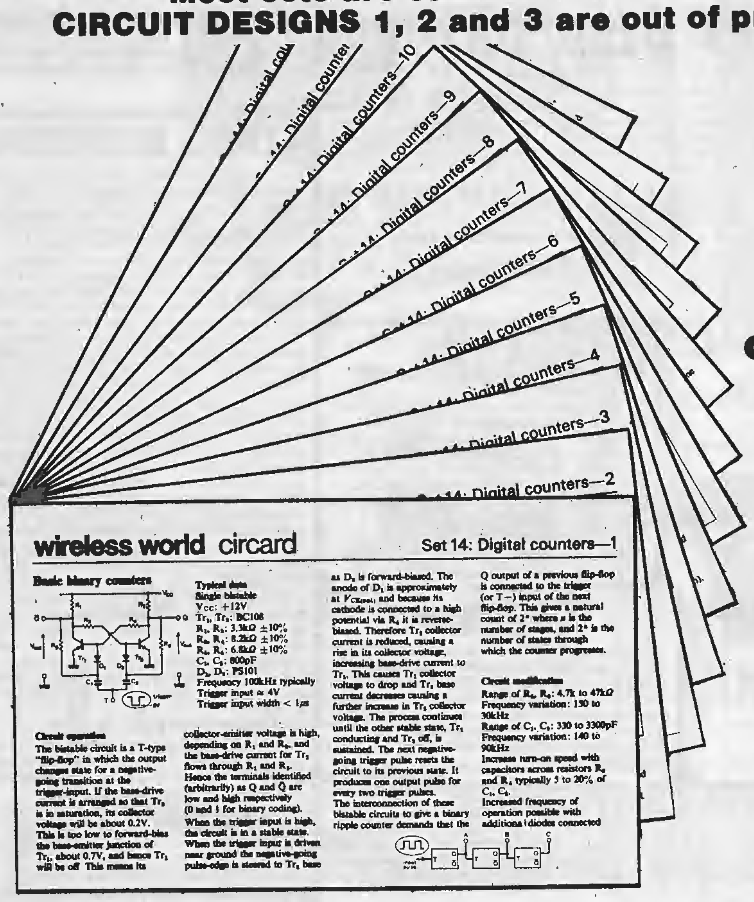
All prices quoted are for U.K. Mainland, paid cash with order in Pounds Stirling PLUS VAT. Minimum order value *£2.00*, Minimum Credit Card order *£10.00*. Minimum BONA FIDE account orders from Government depts., Schools, Universities and established companies *£20.00* Where post and packing not indicated please ADD **60p + VAT** Warehouse open Mon-Fri 9.30 — 5.30. Sat. 10.15 — 5.30. We reserve the right to change prices and specifications without notice. Trade, Bulk and Export enquiries welcome.

DISPLAY -ELECTRONICS- 64-66 Melfort Road, Thornton Heath, Near Croydon, Surrey
01-689 7702 — 01-689 6800 Telex 27924

WW – 073 FOR FURTHER DETAILS

MARK 1983 WITH GAPS IN CIRCUIT FILES WELL-PLUGGED

WIRELESS WORLD CIRCARDS last year benefited many 'new generation' readers who bought at 1976 bargain prices + 10% discount for 10 sets! Most sets are still available although companion volumes CIRCUIT DESIGNS 1, 2 and 3 are out of print (CIRCARDS sets 1 to 30).



The Offer stands, so order now your sets of 127 × 204mm cards in plastic wallets. These unique circuit cards normally contain descriptions and performance data of 10 tested circuits, together with ideas for modifying them to suit special needs.

1 Basic Active filters 2 Switching Circuits, comparators and Schmitts (But these gaps cannot be filled) * 6 Constant current circuits 7 Power amplifiers 8 Astable circuits 9 Optoelectronics 10 Micro power circuits 11 Basic logic gates 12 Wideband amplifiers 13 Alarm circuits 14 Digital Counters 15 Pulse modulators 16 Current differencing amplifiers – signal processing 17 Current differencing amplifiers – signal generation 18 Current differencing amplifiers – measurement and detection 19 Monostable circuits 20 Transistor pairs 21 Voltage-to-frequency converters 22 Amplitude modulation and detection 23 Reference circuits 24 Voltage regulators 25 RC oscillators – 1 26 RC oscillators – 2 27 Linear cmos – 1 28 Linear cmos – 2 29 Analogue multipliers 30 Rms/log/power laws 31 Digital multipliers 32 Transistor arrays 33 Differential and bridge amplifiers 34 Analogue gate applications – 1 35 Analogue gate applications – 2.

*Photocopies only: 3 Waveform generators 4A.C. measurement 5 Audio circuits @ £3.20 each set.

To Electrical-Electronic Press
General Sales Department
Room 108
Quadrant House
Sutton
Surrey SM2 5AS

Please send me the following sets of Circards..£2 each, £18 for 10 post free.
Remittance enclosed .... payable to BUSINESS PRESS INTERNATIONAL LIMITED

Name (Please print) ....

Address (Please print).......................................

....

Company Registered Number: 151537 (ENGLAND). Registered Office: Quadrant House, The Quadrant Sutton, Surrey SM2 5AS

OPUS SUPPLIES SPECIAL OFFERS

SCOOP PURCHASE

DISC DRIVE DISCOUNTS

★ **FD 514 – 8in. S/S D/D DRIVE FORMATTED 600KBYTE £149**

★ **FD 650 – 8in. D/S D/D DRIVE FORMATTED 1.2 MBYTE £199**

★ **CASE TO HOLD TWO DRIVES WITH COSSOR POWER SUPPLY FAN AND CARRYING HANDLES – BRAND NEW – ONLY £99.95**

A Special Purchase allows us to offer a limited quantity of these items at this remarkable price. The drives are manufactured by Pertec – are Shugart compatible and have a 90-day warranty.

5¼in. DISC DRIVES

CANNON S/S D/D 40-TRACK Formatted 175kByte - ONLY £129.95
TEAC 55F D/S 80-TRACK - Formatted Single density 400k - double density 800k ONLY £229

★ Ideal for use with BBC and other leading micros
★ Full warranty
★ Slimline latest technology

★ See us at Midland Computer Fair 28-30 April – Stand 508 ★ Bingley Hall, Birmingham

★ A DAISYWHEEL PRINTER ONLY £499 ★

The TEC Starwriter FP1500-25
Serial Printer - Diablo type
Print Mechanism - 25 C.P. Second

NEW

THE MAGIC BOARD

STOP PRESS

Add-on memory for your BBC MICRO

Simply plug into a spare Eprom socket – fits inside your micro. Gives up to 16k of additional ram – 64k of Eprom. Takes the following 2716/2732/2764/6116/5516. Supplied with full software instructions. **ONLY £29.95**

To order add carriage at the following rates: Monitor £10, Drives and Case £7, Board free; and V.A.T. at 15% to total; send your order to: OPUS SUPPLIES, 10 BECKENHAM GROVE, SHORTLANDS, KENT

TELEPHONE: 01-464 5040 or 01-464 1598

WW – 072 FOR FURTHER DETAILS

pantechnic — THE POWERFET SPECIALISTS

POWERFET AMPLIFIER MODULES

MODEL	POWER RANGE (Continuous RMS)	TYPICAL LOADS	PRICES (one off)
PFA 100	50W-150W	4Ω, 8Ω	£17.35
PFA 200	100W-300W	4Ω, 8Ω	£23.87
PFA 500	250W-600W	2Ω, 4Ω, 8Ω	£42.00
PFA HV	200W-300W	4Ω, 8Ω, 16Ω	£34.30

Key features:

- RELIABLE – Powerfet freedom from thermal runaway and secondary breakdown
- LINEAR – TID zero, IM/THD < 0.01% full power (mid-band THD down to 0.0015%)
- FAST – Slew rate >30V/μS (45V/μS typical)
- QUIET – Signal to noise ratio 120dB
- BRIDGEABLE – Without extra circuitry
- STABLE – Unconditionally
- LOW COST – 10 watts to 20 watts per £, depending on model and quantity

As they stand these modules suit most P.A. and industrial applications and satisfy all foreseeable audiophile requirements. (The HV is aimed at digital audio.) Where aspects of performance fail to meet specific requirements (e.g. in speed or power) low-cost customising is often a possibility. Alternatively entirely new boards can be produced.

ALSO–
PAN 20 – Ultra-low-noise/distortion, mono preamp board, **£6.76**
PAX 2/24 – 2-way active crossover board (24dB/octave) plus regulators, **£9.70**
THE HEAT EXCHANGER – New, super-efficient heatsink; handles 300W or 1.2kW when blown; 7in. × 4in. × 2¼in., **£7.50**

This is just a fraction of the new products available from Pantechnic – check us out!

Prices exclude V.A.T. *Carriage 75p*

Price and Delivery
PANTECHNIC (Dept. WW5)
17A WOOLTON STREET
LIVERPOOL L25 5NH
Tel: 051-428 8485

Technical Enquiries contact Phil Rimmer on 01-800 6667

WW – 068 FOR FURTHER DETAILS

MANUFACTURERS & DISTRIBUTORS

MATSUSHITA. High quality 6 volt d.c. cassette drive motors. Size 30mm dia. x 20mm. high. Driveshaft 7mm long x 2mm dia. approx. No load current 40 m/a. £13.50 for 50 + VAT, £24 for 100 + VAT, £108 for 500 + VAT, £190 for 1,000 + VAT. Sample 10 for £3 + £1 p&p (£4.60 inc. VAT).

STEREO CASSETTE FRONT LOADING REPLAY MECHANISM for in-car entertainment, complete with motor and preamplifier. Manufactured in U.K. under licence of Staar, S.A. £45 for 10 + VAT, £205 for 50 + VAT, £375 for 100 + VAT. Sample for £5 + £1.50 p&p (£7.48 inc. VAT).

MATCHED PAIR DYNAMIC/STEREO MICROPHONES AND STANDS. Wired into one 3-pin 180° Din plug, approx. 2m separation, 200ohms. £20 for 10 + VAT, £90 for 50 + VAT, £162 for 100 + VAT, £730 for 500 + VAT, £1,400 for 1,000 + VAT. Sample sent for £2.50 + 50p p&p (£3.45 inc. VAT).

MONO DYNAMIC MICROPHONE & STAND. 3.5mm J plug fitted to approx. 1m lead. £7 for 10 + VAT, £32 for 50 + VAT, £60 for 100 + VAT, £270 for 500 + VAT, £500 for 1,000 + VAT. Sample sent for £1 + 50p p&p (£1.38 inc. VAT).

CAR STEREO SHELF-MOUNTING SPEAKERS. Moulded black plastic cabinet for vertical or horizontal mounting. Imp. 8ohms power handling, 5 watts (nom.) 8 watts (max.). Dims. 152mm x 222mm x 85. £25 for 10 pr + VAT, £115 for 50 pr + VAT, £210 for 100 pr + VAT, £390 for 200 pr + VAT, £900 for 500 pr + VAT. Sample pair sent for £3 + 75 p&p (£4.32 inc. VAT).

MINIATURE ROUND SPEAKER. 2¼'' 8 ohms ¼ watt, £35 for 100 + VAT, £165 for 500 + VAT, £315 for 1,000 + VAT, £600 for 2,000 + VAT. Sample 10 sent for £4 + £1 p&p (£5.75 inc. VAT).

CHERRY SUB-MINIATURE MICRO SWITCHES. 3 contacts, i.e. common no-nc. Rated at 5 amps on 125-250V a.c. Contacts gold plated for long life. £15 for 100 + VAT, £67.50 for 500 + VAT, £125 for 1,000 + VAT, £550 for 5,000 + VAT. Sample 10 for £2 + 50p p&p (£2.88 inc. VAT).

150 WATT HINCHLEY TRANSFORMERS. 220/240V a.c. input, 30-0-30V output + 14V. Tap size 96mm x 80mm, weight approx. 2.7 kgs. £75 for 10 + VAT, £350 for 50 + VAT, £620 for 100 + VAT, £2,800 for 500 + VAT. Sample sent for £9 + £2 p&p (£12.65 inc. VAT).

6V.A. MINIATURE TRANSFORMER. 240V a.c. input, 12-0-12V output. P.C. mounting + internal thermal overload protection. £2.50 for 10 + VAT, £115 for 50 + VAT, £210 for 100 + VAT, £950 for 500 + VAT. Sample sent for £3 + 75p p&p (£4.31 inc. VAT).

Terms c.w.o. Please add 5% to all orders for carriage plus 15% V.A.T. Export enquiries welcome. We find it impossible to advertise all we stock. Please telephone or write for further enquiries. Personal callers always welcome.

ELECTRONIC EQUIPMENT CO.
SPRINGFIELD HOUSE
TYSSEN STREET, LONDON E8
TEL: 01-249 5217
TELEX: 8953906 EECO.G

WW – 066 FOR FURTHER DETAILS

Advertisements accepted up to 12 noon Tuesday, May 3rd, for June issue, subject to space available.

DISPLAYED APPOINTMENTS VACANT: £15.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £3 per line, minimum £20 (prepayable).
BOX NUMBERS: £3 extra. (Replies should be addressed to the Box Number in the advertisement, c/o Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS).
PHONE: IAN FAUX, 01-661 3033 (DIRECT LINE)
Cheques and Postal Orders payable to BUSINESS PRESS INTERNATIONAL LTD. and crossed.

ecm

ALWAYS AHEAD WITH THE BEST!

£5,000-£18,000

- ★ **Experienced in:** Mini/Microprocessor Hardware or Software; Digital and Analogue circuitry; RF and Microwave techniques?
- ★ **Where does your interest lie:** Image Processing; Automation; Datacomms; Radar; Nav-Aids; Video; Medical: Telemetry; Simulation; Satcom; Local Area Nets; Computers; Weapons; Communications?
- ★ **There are opportunities in:** Design; Test; Service: Sales; Systems; Production; Quality and Research for Engineers and Managers.
- ★ **First call:** MIKE GERNAT or JOHN SANDERS on 076 384 676/7.

ELECTRONIC COMPUTER AND MANAGEMENT APPOINTMENTS LIMITED (1926)
148-150 High St., Barkway, Royston, Herts SG8 8EG.

Junior Radio Officers

The Royal Fleet Auxiliary has a number of vacancies for Junior Radio Officers. These appointments are for short term engagements of 6 months duration, (with the possibility of extension) and offer recently qualified personnel the opportunity to gain the required seatime.
Minimum qualifications: MRGC and DTI Radar Maintenance Certificate.
Apply, in the first instance, by telephone to:— Dave Poynter, RFA Personnel Office, (Radio), on 01-385 1244 ext. 3041.

ROYAL FLEET AUXILIARY RFA

(2071)

ITN

SENIOR ENGINEER

ENG/OB Maintenance

Salary in the range £14,000-£17,800

Independent Television News Limited has a vacancy for a Senior Engineer in their ENG/OB Maintenance Section at ITN House, London W1.

The successful candidate would join the specialist team responsible primarily for the maintenance of ENG equipment including Sony BVU series U-matics, Sony BVP330 cameras, TBCs and associated portable equipment. The section is also responsible for the long-term maintenance of our two camera OB unit.

The work may occasionally involve travel with ENG teams to remote locations.

Previous maintenance experience with U-matic equipment and/or lightweight cameras is essential.

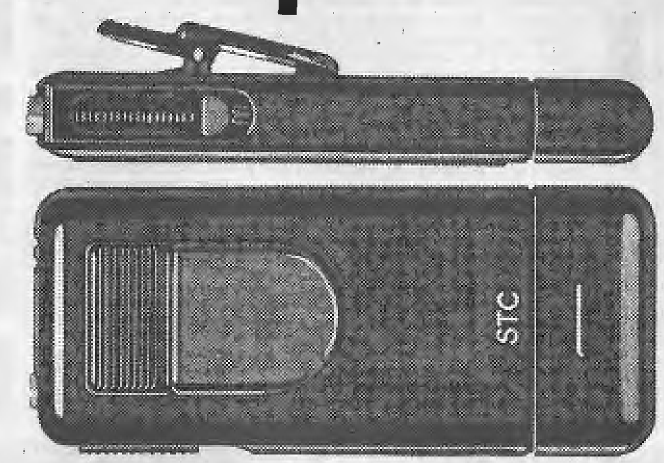
Generous pension scheme, free life assurance.

Please telephone the Personnel Office on 01-637 3144 quoting reference number 303005.

(2074)

ELECTRONICS PROFESSIONALS

The 1980s herald a new era in personal communications development.



With a respected pedigree of world leadership in advanced communications, STC are breaking new ground in the exciting and fast expanding field of personal communications. Achievements in this high technology area have already earned recognition with the 1982 Design Council Award for the STC Radiopager — one of the smallest and most highly attractive pagers on the market. We are determined to build on this success by taking our micro engineering expertise through into a new era of personal communications.

To continue innovation in this challenging field, we intend to strengthen our successful team by appointing a select number of talented professionals.

Our salary package is first-class and is further enhanced by a full range of valuable benefits including life, health and pension schemes, and, where appropriate, generous assistance with relocation to our location on the fringe of London's northern green belt. Future career prospects are excellent with progression being on a 'dual ladder' basis, where both technical and management abilities achieve equal recognition.

So join the STC team and help lead our drive into a new era of personal communications technology. For more information, please write or better still telephone: **Vaughan Hartridge, Standard Telephones and Cables plc, Oakleigh Road South, New Southgate N11 1HB. Tel: 01-368 1234, ext. 2215.**

We're determined to turn state-of-the-art theory into world-class quality products. Join our team now!

Section Head

a demanding role for a mature and very determined professional to lead a design team creating our next generation of successful products. You'll need to be a senior electronic engineering professional who has progressed through to management via technical achievement.

Senior Software Engineer

to be closely involved in all aspects of new product development from planning through to realisation of software. A minimum of 5 years' experience with microprocessors and software engineering is essential.

Senior Digital Engineer

who must be capable of taking a lead responsibility for the hardware design of the digital section of our product range. A broad experience of digital circuit design including microprocessors is essential.

STC Telecommunications (2085) **STC**

CUT THIS OUT!

Clip this advert and you can stop hunting for your next appointment. We have a wide selection of the best appointments in Digital, Analogue, RF, Microwave, Microprocessor, Computer, Data Comms and Medical Electronics and we're here to serve *your* interests.

Call us now for posts in Design, Sales, Applications or Field Service, at all levels from £6,000-£16,000.

Technomark
Engineering & Technical Recruitment
11 Westbourne Grove, London W2. Tel: 01-229 9239.

1935

ITN TRAINEE BROADCAST ENGINEERS

Vacancies exist at ITN for Engineering Trainees which could provide the opportunity to start a career in Broadcast Television Engineering with ITV.

Firstly, a firm interest in persuing a career in the technical branch of broadcasting is necessary.

Then you should have completed or expect this year to complete, theoretical training in Electronic Engineering with a bias towards Television or Audio applications. Qualifications most suitable are T.E.C. Higher Technical Diploma, T.E.C. Higher Technical Certificate or the HND/HNC equivalent.

Initially, you would be involved in a familiarisation period by a rotational attachment to our four maintenance areas and the Projects Department. This lasts for up to 15 months.

After successful training you would be employed on the maintenance or operation of a wide range of broadcast equipment in our Central London Studios near Oxford Circus, from which the ITN national news programmes are networked.

Successful applicants will join ITN in early September, 1983. Starting salaries would lie within the range of £5,642 (at 18) rising to £7,109 at age 20.

If you have the qualifications and the drive to work with us in a busy lively environment, then call us on 01-637 3144 or write to:

The Personnel Manager
Independent Television News Limited
ITN House
48 Wells Street
London
W1P 4DE

for an application form quoting reference number 0476007.

(2054)

BROADCAST ENGINEER

Required by the Broadcast Division of The Services Sound and Vision Corporation, who provide broadcast television and radio services to H.M. Forces and their dependants abroad.

Candidates (preferably aged 22-35) should be educated to HND/HNC standard in electrical or electronic engineering and have work experience in the broadcasting industry.

Their work (mostly overseas) includes the installation, operation, repair and maintenance of the full range of professional radio studio equipment and MW and VHF broadcast transmitters.

A tax free salary in the range of £7,914 to £9,994 is paid overseas, plus generous tax-free overseas allowances and other fringe benefits. There are promotion prospects to higher grades, and opportunities for training and transfer to the Television Division.

Please apply in writing to:

Personnel Manager,
The Services Sound and Vision Corporation
Chalfont Grove, Gerrards Cross
Bucks SL9 8TN

(2052)

ADVANCED TELECOMMUNICATIONS:

careers with extensive scope at Cheltenham

Join the Government Communications Headquarters, one of the world's foremost centres for R & D and production in voice/data communications ranging from HF to satellite – and their security. Some of GCHQ's facilities are unique and there is substantial emphasis on creative solutions for solving complex communications problems using state-of-the-art techniques including computer/microprocessor applications. Current opportunities are for:

Telecommunication Technical Officers

Two levels of entry providing two salary scales: £5980-£8180 and £8065-£9085

Minimum qualifications are TEC/SCOTEC in Electronics/Telecommunications or a similar discipline or C & G Part II Telecommunications Technicians Certificate or Part I plus Maths B, Telecommunications Principles B and either Radio Line Transmission B or Computers B or equivalent: ONC in Electrical, Electronics or Telecommunications Engineering or a CIE Part I Pass, or formal approved Service technical training. Additionally, at least four years' (lower level) or seven years' (higher level) appropriate experience is essential in either radio communications or radar, data, computer or similar electronic systems. At the lower entry level first line technical/supervisory control of technicians involves "hands-on" participation and may involve individual work of a highly technical nature. The higher level involves application of technical knowledge and experience to work planning including implementation of medium to large scale projects.

Radio Technicians

£5232-£7450

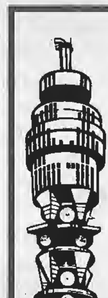
To provide all aspects of technical support. Promotion prospects are good and linked with active encouragement to acquire further skills and experience. Minimum qualifications are a TEC Certificate in Telecommunications or equivalent plus two or more years' practical experience.
Cheltenham, a handsome Regency town, is finely-endowed with cultural, sports and other facilities which are equally available in nearby Gloucester. Close to some of Britain's most magnificent countryside, the area also offers reasonably-priced housing. Relocation assistance may be available.

For further information and your application form, please write to

Recruitment Office
GCHQ Oakley, Priors Road
Cheltenham, Gloucestershire GL52 5AJ
or phone 0242 21491, Ext. 2269.

(1998) **GCHQ**

CAPITAL APPOINTMENTS LTD



THE UK's No. 1 ELECTRONICS AGENCY

If you have HNC/TEC or higher qualifications and are looking for a job in design, test, customer service, technical sales or similar fields:

Telephone now for our free jobs list
We have vacancies in all areas of the UK
Salaries to £15,000 pa

01-637 5551 or 01-636 9659
(24 hours)

Or if you prefer send a FULL CV to:

CAPITAL APPOINTMENTS LTD
29-30 WINDMILL STREET, LONDON W1P 1HG

(291)

RF Engineers & Senior Engineers

Our Client is an internationally successful Company that you'll both know and respect. A world-renowned force in advanced communications products, they have a track record of technological innovation and commercial success that is second to none.

The Company's achievements in the fast expanding personal communications market are considerable – and their product range continues to receive wide acclaim – both in the market and also within the industry. Now to maintain this momentum of success, they intend to lead the way in developing the next generation of advanced, high technology personal communications products.

They therefore wish to strengthen their highly talented, integrated design and development teams by appointing several key Engineers – at Senior and Middleweight levels.

The need is for experienced professionals to become immediately involved in projects which will fully exploit the latest state-of-the-art technology in the ever-advancing field of circuit integration. You will initiate designs for large sections of a major project workload – and when you are ready for more responsibility, there are opportunities in both project and man-management.

To be considered, you must have an HND/Degree in electronics together with between 2-7 years' experience in analogue circuit VHF/UHF design and application. A background in mobile, military or airborne radio would be an advantage – but most importantly, you must demonstrate the ability to liaise with related engineering disciplines, manufacturing and marketing.

We recognise that we are looking for a "rare breed" of Engineer – and the remuneration package will reflect the importance of your role. Initial salaries will be highly attractive and individually negotiable, further enhanced by a full range of benefits. As far as the future is concerned, there are opportunities for very positive career progression within this successful and dynamic organisation.

Find out the full story about the Company of the future in RF technology. Please telephone Kevin Long on 01-636 5538 in complete confidence or write with a c.v. to him at:
Moxon Dolphin & Kerby Ltd., 178-202 Great Portland Street, London W1N 5TB, quoting ref: KL/980/W.

In the race to develop the next generation of personal communications products...

MOXON DOLPHIN & KERBY LTD

...Join the Company that will win!

(2084)

Royal Marsden Hospital,
Fullham Road, London SW3

Medical Physics Technician

MPT2

required in the Physics and Radiotherapy Departments. The appointed person will be responsible for the supervision of a pleasantly situated, well-equipped electronics workshop and the maintenance and service of an interesting variety of radiotherapy equipment.

The Department has 3 cobalt treatment machines, 150kv and 300kv X-ray units, a Philips 10mv linear accelerator and a simulator. Current developments include the installation of a Philips 5mv linear accelerator and caesium Selectron unit.

Applicants should hold ONC, HNC or similar qualification in electrical engineering or (preferably) in electronics, and have relevant technical experience particularly with Philips linear accelerators. To be appointed on to the MPT2 scale applicants should have served at least 2 years as MPT3 or equivalent. Salary scale from 1st April 1983 £8,383-£10,209 per annum.

Application form and job description available from the Personnel Department, Royal Marsden Hospital, at the above address. Tel: 01-352 8171 Ext. 446/447.

(2053)

VIDEO ENGINEERS

Rediffusion Consumer Manufacturing Ltd is seeking intermediate and senior video engineers with OND, HND or similar qualifications, together with a knowledge of analogue and digital circuits, to join a small team working on a wide variety of projects associated with video cassette recorders, video cameras, disc players, colour TV receivers and monitors.

In addition to analysis of performance and long term reliability factors, assessment reporting is an important part of the team's function and the ability to express oneself verbally and in writing is essential.

Our laboratories are situated at Chessington within easy commuting distance of the Surrey countryside.

Attractive salaries and the usual big company benefits are offered to suitably qualified and experienced engineers. If you believe you can make an effective contribution to our future video projects please write to or phone:

Mr Harry Brearley
Rediffusion Consumer Manufacturing Ltd.
Fullers Way South
Chessington, Surrey KT9 1HJ
Telephone: 01-397 5411

REDIFFUSION

(2070)

Civil Aviation Gollege (Gulf States) Doha, Qatar

requires for September 1983:

INSTRUCTOR AVIATION ELECTRONICS

University Degree and Professional qualifications in Aviation Electronics, qualified and experienced in installation and maintenance of Modern Radio Systems

Must have minimum ten years' experience with three years' instructional experience at an ICAO recognised Training Centre.

Salary and Allowances up to US$3400 per month

Applications to:

The Principal
Civil Aviation College (Gulf States)
P.O. Box 4050
Doha
State of Qatar

(2088)

UNIVERSITY OF ABERDEEN

Department of Bio-Medical Physics and Bio-Engineering

ELECTRONIC OFFICER

required for well-equipped Electronics Section (staff 15) of internationally known Department to be associated with design, servicing and maintenance of modern medical electronic equipment in hospitals and laboratories. The Officer will be expected to guide technicians and help actively research in bio-medical applications of electronics. Additional experience desired in one or more relevant areas of instrumentation — eg vacuum, lasers, high voltage, high frequency.

Salary within the Grade 1A scale for Other Related Staff (£6,375-£11,105 per annum) with appropriate placing.

Further particulars and application forms from The Secretary, The University, Aberdeen, with whom applications (two copies) should be lodged by 10 May, 1983.

(2072)

Manor Studios

Require a full-time

MAINTENANCE ENGINEER

Based in Oxfordshire, duties will include work at the Manor Studio and on location with the mobile. For details please ring:

PAUL WARD – 08675 77551

(2067)

Botswana

Assistant Force Communications Officer

Up to £16,470 p.a. substantially tax-free

A challenging post with the Police in a democratic, multi-racial developing country in southern Africa.

Candidates, preferably aged between 30 and 45, must possess City and Guilds Part II or equivalent and have at least five years' experience in police or armed forces communications with HF, SSB and VHF (FM) communications equipment.

Duties include the maintenance, installation and fitting of communications equipment and the training of junior technicians for C & G examinations.

Benefits include free passages, generous paid leave, children's holiday visit passages and education allowances. Basic salary attracts 25% tax-free gratuity on completion of three year contract.

For further details and application form ring Linda Mitchell on 01-222 7730 extension 3714 or write quoting YX/1013/WW.

Crown Agents

The Crown Agents for Oversea Governments & Administrations, Recruitment Division, 4 Millbank, London SWIP 3JD

(2081)

THIS IS ENGINEERING PAR EXCELLENCE

An opinion of our client company shared by the highest in the land – yes, a Queen's Award winner 1982

DESIGN ENGINEERS

are required to augment this exceptionally talented team who have achieved the following:

Launched a video graphic product for broadcast TV in 1978 which still has no rival in the British or European television industry. Not surprising – modern bit slice technology designed for maximum reliability, rugged environment and artistic appearance.

Designed a second generation product which has burgeoned into a whole family of new products including devices for graphic animation. Teletext peripherals, encoding and data logging products for future TV applications.

Have the next generation of products in the pipeline – confidential of course – however, one look around the laboratory and you can bet they will be one of the first into 32 bit micros and mega-byte rams.

Created an extremely pleasant working environment and attractive financial package for their staff. Salary is above average, also BUPA, life assurance and subsidised canteen.

Graduates with relevant experience, don't sit around, ring or send your C.V. to their chosen agents.

Charles Airey Associates

Tempo House, 15 Falcon Road, Battersea, London SW11 2PJ
Telephone: 01-223 7662 or 228 6294

(2061)

BORED ?

Then change your job!

1) Test Equipment Controller
Plan and procure test equipment and control a team of test equipment engineers. To £12,670 – Hants.

2) Maintenance Engineer
Start an in-house test of communications equipment – then move to field service when fully conversant. To £8,000 + car – London.

3) Service Engineer
Analogue and digital detection and alarm systems. Middx-Essex – to £8,000.

4) Test Engineer
In-house work on modems and data communications systems. To £7,500 – Bucks.

5) Service Personnel
(RAF, RN, Army)
We have many clients interested in employing ex-service fitters and technicians at sites throughout the UK. Phone for details.

6) £500 per week
We are paying very high rates for contract design and test engineers who have a background in RF, MICROWAVE, DIGITAL, ANALOGUE or SOFTWARE, at sites throughout the UK.

Hundreds of other Electronic and Computer Vacancies to £12,500

Phone or write:
Roger Howard, C.Eng.M.I.E.E., M.I.E.R.E.
CLIVEDEN CONSULTANTS
87 St. Leonard's Road, Windsor, Berks.
Windsor (07535) 58022 (5 lines)

(1646)

CLIVEDEN

UNIVERSITY OF YORK

Department of Electronics

Applications are invited for the post of

Senior Technician

(GRADE 5)

in the central workshop of the new Department of Electronics. The workshop staff are responsible for the maintenance of electronic instruments and for the development and construction of electronic equipment for teaching and research purposes.

Applicants are expected to have an appropriate qualification and considerable experience of electronic engineering, preferably including computers. The salary scale is currently £6,009-£7,016 p.a.

Applications giving full details of age, education and experience, together with the names and addresses of two referees, should be sent to Mr D. Rymer, Assistant Bursar, University of York, York YO1 5DD by Tuesday, May 3, 1983.

(2075)

Appointments

Hospital Medical Equipment Technicians

C. £15,400* Tax Free + substantial benefits in Saudia Arabia

As a leading international healthcare company, staffing and managing several hospital projects in the Middle East, the efficient maintenance of medical equipment is a vital part of our operation. Consequently we are seeking additional male technicians with the following experience to join us at one of these hospitals in the Kingdom of Saudi Arabia.

You must hold an HNC in Medical Electronics or Electronic Engineering and have at least 3 years' post qualification experience of hospital medical equipment including microprocessor controlled patient monitoring or X-ray equipment.

The substantial tax free salary offered (*paid in US dollars and converted in this instance at a rate of US$ 1.55=£1.00) is supported by the wide range of benefits outlined below:

The Whittaker Benefits Package

* Choice of 1 or 2 year contracts * 7 weeks holiday * Mid-year holiday allowance * Return air fare * Comprehensive insurance cover * Free local transport * End-of-contract bonus * Storage allowance * Free recreation facilities * Free, furnished, fully-equipped, air-conditioned accommodation.

You'll be ideally placed to make the most of your holidays, travelling even further afield–to Nairobi, Singapore, Hong Kong or Bangkok for example.

If you hold a UK or Irish passport and are interested in a 1 or 2 year renewable, single status contract, phone Irene Cooper or Michelle Chudley on 01-434 1081 reversing the charges and quoting ref: E360. Alternatively, write to Whittaker Life Sciences Limited, Freepost 35, London W1E 5QZ.

DEDICATED TO A WORLD OF HEALTH
Whittaker
LIFE SCIENCES LIMITED

(2093)

INNER LONDON EDUCATION AUTHORITY
Learning Resources Branch
Television Centre
Thackeray Road
Battersea SW8 3TB

ENGINEER – ELECTRONIC MAINTENANCE

Salary range: (ST2) £7,035 to £7,974 plus £1,284 London Weighting Allowance.

The ILEA's Television Centre produces a wide range of educational programmes on video and audio cassettes.

The Maintenance section numbers four persons and a vacancy has arisen for an engineer with a sound knowledge of the principles of colour television, and preferably a working experience of maintaining broadcast type TV equipment. Applicants must wish to specialise on the video side (cameras, vision mixers, telecine, etc.), and will receive appropriate training.

An engineering degree, TEC or other equivalent qualifications are desirable.

Application forms from the Education Officer (EO/Estab. 1B), Room 365, The County Hall, London SE1 7PB. Please enclose a stamped and addressed foolscap envelope. Completed forms to be returned by May 4, 1983.

ILEA is an equal opportunities employer.

(2066)

RADIO ENGINEER

To work as a technical adviser with a Latin American organisation for education by radio, with 40 affiliated radio stations in 17 countries.

The engineer will initially be based in Quito, Ecuador and will later travel to radio stations in other countries. The job consists of planning and running training courses for local technicians in maintenance of mainly small, short and medium wave transmitters, aerials and studios.

Applicants should have radio engineering experience, gained in a broadcasting environment: the post will demand skills in training people with non-technical backgrounds and in planning and improvising equipment. Spanish speakers especially welcome, but language training can be provided.

The post is initially for three years on a basic salary. Because of extensive travel, it is unlikely to suit applicants with families. CIIR will provide orientation and language training, insurance, air-fares and various allowances.

For a job description and application form, please send a brief cv to CIIR Overseas Programme, 22 Coleman Fields, London N1 7AF, quoting ref WW/1.

(2087)

TRAINEE ASSISTANT PICTURE EDITORS

Television News

Assistant Picture Editors will work with film and ENG on all programmes produced by Television News. Trainee Assistant Picture Editors will be given a comprehensive training to enable them to progress to Assistant Picture Editors and eventually to compete for posts as Picture Editors. Most duties involve shift working, including nights.

Candidates with an Arts or Engineering based background and at least 'O' level standard in Maths, English and a Science subject, preferably Physics, will be considered and they will be required to demonstrate an ability and potential to undertake the necessary technical training. Higher qualifications in either Arts or Science subjects would be an advantage. Candidates should be able to work under pressure, react quickly to changing circumstances and have normal hearing and colour vision, with an informed and lively interest in News and Current Affairs.

Initial salary will be £6734 which includes a continuing shift allowance. (General salary review due in April). Based West London. Relocation expenses considered.

Contact us immediately for application form (quote ref. 1283/WW and enclose s.a.e.): **BBC Appointments, London, W1A 1AA. Tel. 01-580 4468 Ext. 4619.**

We are an Equal Opportunities employer

BBC tv

A NUMBER OF THINGS YOU SHOULD KNOW ABOUT COMMUNICATIONS TECHNOLOGY

Those 'things you should know' are the opportunities available to people with experience in high technology areas of the communications industry. Below are a sample. Telephone Paul Hecquet on Lewes (07916) 71271 to discuss these and many more.

Video (Image Processing) Design Engineer — **c £15,000** — **Home Counties**

Experience in fields such as slowscan would be desirable. Ref: 3/80.

RF Senior Development Engineer — **c £11,000** — **West Country**

Design and Development on advanced range of signal processing (High frequency) components. Ref: 4/13.

Cabel TV Systems Engineer — **c £16,000+** — **Home Counties**

To work on cable TV proposals involving total systems (turnkey) design. Ref: 5/79.

RF Circuit Design — **c £9,000** — **Home Counties**

Design and Development RF circuitry for commercial mobile radio systems. Ref: 3/28.

RF/ATE Group Manager — **c £20,000**

Responsible for Design/Development and manufacture of RF/ATE. Ref: 6/48.

(2079)

The Electronics Recruitment Company
Temple House
25/26 High Street, Lewes
East Sussex BN7 2LU
Tel: Lewes (07916) 71271

SOUTHERN DERBYSHIRE HEALTH AUTHORITY

MANOR HOSPITAL, UTTOXETER ROAD DERBY DE3 3NB

ENGINEERING ELECTRONICS TECHNICIAN III

To carry out maintenance, repair and modification of electronic equipment used in medical and engineering applications. The successful applicant will be expected to undertake necessary training to enable him/her to maintain medical gas equipment. A current driving licence and possession of a car are essential. Applicants should be qualified to O.N.C. or equivalent standard and have at least three years' experience in a similar position of responsibility.

Application form and further details from: Mr. D. Hargreaves, Assistant District Works Officer (Engineering). (Ref. No. 895).

(2057)

Filter Engineer

An opportunity has arisen for a professional filter engineer experienced in the specification and design of complex passive filters. Experience in active and SAW filters or other areas of electronics would be advantageous. This is a permanent, senior position in an expanding company

Apply to:
WIRELESS WORLD
BOX NO. 2077
for further details

(2077)

Broadcast/ Data Comms Engineers

HNC standard for both permanent and contract positions.

Tel. Camberley 0276 62466
Jenrick (agy) (2083)

LOGEX ELECTRONICS RECRUITMENT

Specialists in Field & Customer Engineering appointments, all locations and disciplines.

Logex House, Burleigh, Stroud Gloucestershire GL5 2PW

0453 883264 & 01-290 0267

(24 hours)

CV Services

The Professional CV people

★ Quick
★ Efficient
★ Confidential

We prepare top-quality résumés at a price you can afford

For further information write/phone:
CV Services, 10 Wilton Road, Hitchin, Herts SG5 1SS. Tel: Hitchin (0462) 31836
(2073)

R & D OPPORTUNITIES. Senior level vacancies for Communications Hardware and Software Engineers, based in West Sussex. Competitive salaries offered. Please ring David Bird at Rediffusion Radio Systems on 01-874 7281. (1162

SITUATIONS VACANT

Telecommunications Technicians

Up to £9403

The posts available are varied, but broadly they fall into 2 groups at 3 different locations.

HANSLOPE PARK (MILTON KEYNES) and CENTRAL LONDON

for installation, maintenance and other work associated with HF communications equipment, VHF, UHF and microwave links and associated test equipment; teleprinters, telephone subscribers' apparatus, PMBXs, PAXs, PABXs and ancillary equipment including that using analogue and digital techniques and voice frequency telegraph.

CROWBOROUGH, SUSSEX

for maintenance and operation of high power, medium and short wave broadcasting transmitters and associated equipment.

Applicants should normally have 4 years' relevant experience, and must hold one or more of the following:

★ ONC in Engineering (with pass in Electrical Engineering 'A')
★ ONC in Applied Physics
★ TEC/SCOTEC certificate
★ City & Guilds Telecommunications Technicians Certificate Part II (Course No. 271) or Part I plus Maths 'B', Telecommunications Principles 'B' and one other subject.
★ a pass in the Council of Engineering Institutions Part I examination
★ an equivalent or higher relevant qualification.

Ex-Service personnel who have had suitable training and at least 3 years' appropriate service (as Staff Sergeant or equivalent) will also be considered.

Salary: £5983-£8183; London £1220 more. Starting salary may be above minimum for those with additional relevant experience. Promotion prospects are good.

Relocation assistance may be available.

For an application form (to be returned by 19 May) write to: Foreign & Commonwealth Office, Hanslope Park, Hanslope, Milton Keynes MK19 7BH, or telephone Milton Keynes (0908) 510444 Ext. 232. Please quote reference YHU/TT2/83.

Foreign & Commonwealth Office

(2065)

Electronics Design Engineers

Communications

R/F VHF UHF Systems
R/F HF Systems
Microwave Equipment
Analogue Digital Circuitry
Message Circuit Switching
Cryptographic Systems

Marconi Space and Defence Systems, Communications Division, are rapidly expanding their civil and military projects. Additional experienced staff qualified to PhD/Degree/HND/HNC are required at all levels of responsibility for software/hardware development in the above areas. Our salary scales match the high standards of qualifications, experience and ability demanded. We offer a comprehensive range of benefits together with relocation assistance if required.

Phone Portsmouth 674019 for further information and an application form. Alternatively, you can write to Jack Burnie, Marconi Space and Defence Systems Limited, Browns Lane, The Airport, Portsmouth, Hants, quoting ref: BL 25.

(All posts are open to men and women)

Marconi
Space & Defence Systems

Telecommunications Engineer

£9,504-£10,071

The responsibilities will cover the design, construction and installation of purpose-built telecommunications equipment and modifications to installed equipment subject to CAA approval. The successful applicant will also be required to assist other members of the Telecommunications Section in the maintenance and repair of equipment within the Telecommunications Department.

Applicants should be educated to at least HNC or equivalent in Electronics and have a minimum of five years' practical experience in fields including RF, AF and Digital Techniques.

Generous relocation expenses are payable in appropriate cases and temporary housing accommodation may be available.

Application forms, returnable by May 6th, 1983, may be obtained from the Personnel Department, Town Hall, Luton LU1 2BQ. Tel: Luton 31291 ext 2300.

Luton International Airport

(2090)

EVTR

is looking for a young Video Engineer

EVTR is a broadcast television facilities company specialising in the use of computer editing equipment.

We need a qualified electronics person who is willing to work a shift system and gain experience of broadcast, video tape recording and operational engineering.

Please telephone Andy Thompson on 01-631 4421
21 Great Tichfield Street
London, W.1

(2063)

ARTICLES FOR SALE

Word Processor Clearance Sale. BDP/Qume Daisy-wheel printer, 2 discs; £595. Adler SE2000-Golfball printer, single disc; £450. Kalle Infortec 7000-Golfball printer. Single tape; £350. All + VAT. Autotype, Haywards Heath (0444) 414484 and 454377. (2017)

BILLINGTON VALVES, Electronic valve specialists (also bulk suppliers of transistors). SAE-/IRC for quotation on your requirements. We offer an unrivalled service supplying rare/obsolete valves. Send 25p + L.S.A.E. For our valve listing (Includes money off voucher). 23 Irwin Drive, Horsham, RH12 1NL. No callers. (2069)

SITUATIONS VACANT

BROADCAST ENGINEER

REQUIRED FOR VIDEO FACILITIES COMPANY

to service and maintain Sony 330 cameras, Sony and Ampex one inch "C" format recorders, colour monitors and a large range of broadcast ancillary equipment. Due to the nature of the business, the pace is fast, but the work is interesting and the people friendly.

The applicant will need to be educated to HND, HNC or higher tech level. Salary is in accordance with ACTT rates.

Please apply in the first instance to:

R. G. Gold, Managing Director, Samuelson Video Limited, 303 Cricklewood Broadway, London NW2 6PQ. 01-452 8090.

(2076)

SERVICE & INSTALLATION ENGINEERS

London & Home Counties Area

British subsidiary of French X-Ray Company requires service and installation engineers to work on modern X-ray equipment in National Health and Private Hospitals.

The work involves an unusual blend of high-voltage plus analogue and digital technologies. Successful candidates will be qualified to BSc or HND level, be practically minded and have the initiative to cope with problem solving in the field.

Company car provided, salary negotiable, expenses paid.

Please write, enclosing CV for interview to M W Ridgeon, Asst. Service Manager, 01-572 1431.

CGR Medical Limited

Astronaut House, Hounslow Road
Feltham, Middx.

(2092)

ARTICLES WANTED

SURPLUS

Top prices paid for surplus, redundant and obsolete test equipment, factories cleared.
Also quantities of components.
Immediate settlement. We will call anywhere in the United Kingdom.

TIMEBASE
94 Alfriston Gardens
Sholling, Southampton SO2 8FU
Telephone: (0703) 431 323

(1852)

WANTED

Redundant test equipment – receiving and transmitting equipment – valves, plugs and sockets – synchros etc.

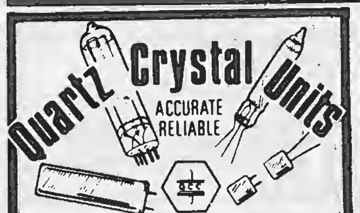
Phone: Johns Radio
0274 684007
84 Whitehall Road
East Birkenshaw
Bradford BD11 2ER

(2049)

TURN YOUR SURPLUS Capacitors, Transistors, etc., into cash. Contact COLES-HARDING & CO., 103 South Brink, Wisbech, Cambs. 0945 584188. Immediate settlement. We also welcome the opportunity to quote for complete factory clearance. (9509

WANTED: Design and possible manufacture of complete unit for transmitting a narrow beam of Microwave in the low Gigahertz range. Also complete unit for transmitting high-power 25kHz Ultrasound. Write for further information to Burrabella Pty. Ltd., 5 Moon Street, East Burwood, Victoria 3151, Australia. (2082

ARTICLES FOR SALE



Private enquiries, send 13p in stamps for brochure

THE QUARTZ CRYSTAL CO. LTD.
Q.C.C. WORKS, WELLINGTON CRESCENT
NEW MALDEN, SURREY 01-942 0334 & 2988

(8493)

LINSLEY HOOD DESIGNS

75 watt and 100w amps
Audio signal generators
75 watt amp pcd £2.30
100 watt Mosfet pcb £4
(pp 50p)
SAE for leaflets

TELERADIO ELECTRONICS
325 Fore Street, London N9 0PE

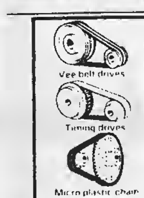
(1762)

ANTIQUE RECEIVING VALVES

Unused and boxed
In large quantity

Tsutom Yoshihara
C1-105, Deguchi-cho 34
Suita-shi, Osaka 564
JAPAN

(2055)



NEED QUALITY LIGHT MECHANICAL DRIVE COMPONENTS . . . FAST?
WE HAVE WAYS OF HELPING YOU OUT!
We offer the U.K.'s widest stock range, and can also produce "specials" at competitive prices for volume orders. Materials include aluminium, various plastics, steel & cast-iron.
Send £2 for comprehensive catalogue/drive design manual
Trade enquiries invited.

Gould Pulleys & Drives Ltd
(formerly Aluminium Pulleys Ltd)
Albert Street, Chipping Norton, Oxon
Telephone (0608) 3311 Telex 837066
Keeping the wheels turning for OEM's, Bearing Distributors, Designers and you

SUPER VALUE CATALOGUE NOW AVAILABLE – A NEW WORKING DESIGN AID

(2062)

ARTICLES FOR SALE

TO MANUFACTURERS, WHOLESALERS BULK BUYERS, ETC.

LARGE QUANTITIES OF RADIO, TV AND ELECTRONIC COMPONENTS FOR DISPOSAL

SEMICONDUCTORS, all types, INTEGRATED CIRCUITS, TRANSISTORS, DIODES, RECTIFIERS, THYRISTORS, etc. RESISTORS, C/F, M/F, W/W, etc. CAPACITORS, SILVER MICA, POLYSTYRENE, C280, C296, DISC CERAMICS, PLATE CERAMICS, etc.

ELECTROLYTIC CONDENSERS, SPEAKERS, CONNECTING WIRE, CABLES, SCREENED WIRE, SCREWS, NUTS, CHOKES, TRANSFORMERS, etc.

ALL AT KNOCKOUT PRICES – Come and pay us a visit ALADDIN'S CAVE

TELEPHONE: 445 0749/445 2713
BROADFIELDS & MAYCO DISPOSALS
21 Lodge Lane, North Finchley, London, N.12
(5 minutes from Tally Ho Corner)

(1613)

1983 RADIO AMATEURS HANDBOOK

by ARRL Price: £10

WORLD RADIO TV HANDBOOK 1983 £12.00
ROBOTS AND ROBOTOLOGY by Warring, R.H. Price: £7.95
INTERNATIONAL DIGITAL I/L SELECTOR by Towers, T. D. Price: £11.00
PRACTICAL DESIGN OF DIGITAL CIRCUITS by Kampel, I. Price: £10.95
DIGITAL ELECTRONICS CIRCUITS and systems by Morris, N. Price: £5.50
THE ART OF ELECTRONICS by Horowitz, P. Price: £15.95
MICROPROCESSOR DATA BOOK by Money, S. Price: £17.00
HANDBOOK OF ELECTRONIC CALCULATIONS by Kaufman, M. Price: £31.00
MICRO COOKBOOK Vol. 1 FUNDAMENTALS, Lancaster, D. Price: £13.75
UNIX THE BOOK by Banahan, M. Price £7.50

★ ALL PRICES INCLUDE POSTAGE ★

THE MODERN BOOK CO.

BRITAIN'S LARGEST STOCKIST of British and American Technical Books

19-21 PRAED STREET
LONDON W2 1NP

Phone 01-402 9176
Closed Saturday 1 p.m.
Please allow 14 days for reply or delivery

(2023)

RACAL COMMUNICATION RECEIVERS

500kc/s to 30mc/s in 30 bands 1mc/s wide, **RA17 MK11** £100, **RA17L** £150, **RA117E** £225. New metal louvred cases for above £25 each. All receivers are air tested and calibrated in our workshop. Supplied with manual and dust cover, in fair used condition. **RACAL SYNTHESISERS** (Decade frequency generator) **MA350B** Solid state for use with MA79 – RA117 – RA217 – RA1217 ETC, £100 to £150. **MA250** 1.6mc/s to 31.6mc/s £100 to £150. **MA259G PRECISION FREQUENCY STANDARD** 5mc/s, 1mc/s 100khz £100 to £150. **EDDYSTONE RECEIVER TYPE EC964/7K** Solid state, single channel, SSB, mains or battery powered, 1.6 to 27.5mc/s and 400, 535khz £100 with manual. **REDIFON SSB RECEIVER TYPE R499** Solid state, 10 fixed channels, range 1.5 to 30mc/s and 255khz to 525khz, power mains or battery, complete with ISB adaptor ARU10A, £100 with manual. **REDIFON TT11 AUDIO TELEPRINTER CONVERTOR** Solid state, tested with circuit £25. **CREED TYPE 75 TELEPRINTER** 50 and 75 bauds for use with above convertor £25.

OSCILLOSCOPES

COSSOR CDU150 35mc/s, twin beam, solid state £195 with manual. **TEKTRONIX 422** Solid state, portable with internal battery pack, 15mc/s, dual trace £350. **CT436 DUAL BEAM** Ooscilloscope, 6mc/s £75. **TEKTRONIX 647A** 100mc/s, dual trace, solid state £350 with manual. **MARCONI TF995 SIGNAL GENERATORS** From .2mc/s or 1.5mc/s to 220mc/s. AM-FM. **A2M** £100, **A3** £100, **A5** £150, **B5** £250 with manuals. **TF2005R** Two tone signal source audio £150. **TF2606 DIFFERENTIAL DC VOLT METER** 0 to 1100volts £100. **TF2002 AM SIGNAL GENERATOR** 10kc/s to 72mc/s £400. **TF2002AS** FM and AM signal generator, 10kc/s to 72mc/s – £600. **TF2172B DIGITAL SYNCHRONIZER** For above £350. **TF1066B/6 FM-AM SIGNAL GENERATOR** 10cm/s to 470mc/s £300. **TF1245 CIRCUIT MAGNIFICATION METER** and TF1246 Oscillator £200. **H.P. SIGNAL GENERATOR 620A** 7 to 11 gigs £100. **H.P. SIGNAL GENERATOR 608** 10-420mc/s – £70. **MARCONI AF WATT METER CT44 NO1** Absorption, 200 microwatts to 6 watts, in 10 ranges switched, 2.5ohms to 20K ohms £45. **TF893A AF WATT METER** 1 milliwatt to 10 watts 2.5ohms to 20K ohms in 48 steps £65. **THYRISTOR TEST SET, CT558** Voltages up to 2KV £100. **TEKTRONIX 4002A GRAPHIC COMPUTER TERMINAL** with joystick £1200. **TEKTRONIX 4601** Hard copy unit for use with above £450. Both units for £1550. **RACAL DIGITAL COUNTERS, TYPE 801M** – 125mc/s £50. **RACAL 836 COUNTER** 35mc/s £50.

VAT AND CARRIAGE ON ABOVE ITEMS EXTRA

All items are bought direct from H.M. Government, being surplus equipment. Price is ex works

SAE for all enquiries. Phone for appointment for demonstration of any item.

JOHN'S RADIO, WHITEHALL WORKS, 84 WHITEHALL ROAD EAST, BIRKENSHAW, BRADFORD BD11 2ER
TEL: (0274) 684007

(848)

Kastler Integrated Circuit prototype/production equipment, including binocular microscope, U.V. source, exposure control, mechanical positioning, etc. £375. TAC Automation X-Y/Z Electronic Probing Control System, 24 gold probes, probe control arms, pre-selected positioning, 000.0 thousandths of an inch, etc. £290. Buyfield 2-channel Ultrasonic Generator £79. Stabilised 1.7KV, 7.A. PSU £75. Integrated Circuit Tester £125. Brandenburg PSU, 0-500, -1000, -1500, -2000, -2500v, £75. B&K. Deviation Bridge, RCL, £29. ½kW mains stabilisation transformer £49. 7½ hp 3-phase motor £45. Pye Lynx Video camera £29 ea. Centrifuge £49. Two weatherproof vehicle/outdoor speakers £15. Sweep generators £79. Wow/flutter meter £75. Megohmmeter VDR, piezo tests, etc. £45. Ferrograph tape recorder £35. Stabilised +5/0/-5 psu's £20. 24v stab. psu £18. 7-track recorder £98. Dawe Vibration Analyser £85. Valradio Converter 250-110/250 AC, 50-60 c/s, £35. Hatfield AC PSU 290-550 c/s, 0-120v output, mains input £65, etc., etc.

040 376236

(2016)

· THE SCIENTIFIC WIRE COMPANY

P.O. Box 30, London, E.4

ENAMELLED COPPER WIRE

SWG	1lb	8oz	4oz	2oz
8 to 29	2.76	1.50	.80	.60
30 to 34	3.20	1.80	.90	.70
35 to 40	3.40	2.00	1.10	.80
41 to 43	4.75	2.60	2.00	1.42
47	8.37	5.32	3.19	2.50
48 to 49	15.96	9.58	6.38	3.69

SILVER PLATED COPPER WIRE

SWG	1lb	8oz	4oz	2oz
14 to 30	6.50	3.75	2.20	1.40

TINNED COPPER WIRE

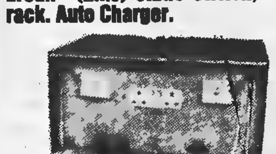
SWG	1lb	8oz	4oz	2oz
14 to 30	3.38	2.36	1.34	.90

Prices include P&P, VAT and Wire Data. SAE for list. Dealer enquiries welcome.
Reg Office: 22 Coningsby Gardens

(9063)

INVERTERS

High-quality DC-AC; also "no break" (2ms) static switch, 19in. rack. Auto Charger.



COMPUTER POWER SYSTEMS –

Interport Mains-Store Ltd.
POB 51, London, W11 3BZ
Tel: 01-727 7042 or 0225 310916

(9101)

ENCAPSULATING EQUIPMENT FOR coils, transformers, components, degassing silicone rubber, resin, epoxy. Lost wax casting for brass, bronze, silver, etc. Impregnating coils, transformers, components. Vacuum equipment, low cost, used and new. Also for CRT regunning metallising. Research & Development. Barratts, Mayo Road, Croydon CR0 2QP. 01-684 9917. (9678)

AUTOMATIC PCB TESTERS. 23 units plus jigging, suitable for production line. 16 different tests. Recently used on tape recorder PCBs but modular design is easily modified. Circuit diagrams available. S.H. Electronics, 5 St. Josephs Park, Ballycruttle, Downpatrick. Tel: (0396) 5135. (2080

STOCK SALE. 30% off all items. Scopes, multimeters, frequency meters, function generators, power supplies, logic probes, audio and RF generators, etc. SAE for list: **A.E. ELECTRONICS, 149 London Road, WARRINGTON, Cheshire WA4 6LG. Tel: (0925) 68339.** (2062)

COURSES

oxford polytechnic

B.Sc. DEGREE IN ELECTRICAL AND ELECTRONIC ENGINEERING

Obtain a degree by part-time study over four years.

The course includes study of Microelectronics, Microprocessors, Telecommunications and Control.

TEC HC/HD OR HNC ENTRY

CONTACT:
P. T. Moran, Engineering Department
Oxford Polytechnic, Headington, Oxford OX3 0BP
Tel: (0865) 64777, ext. 384

(2086)

SERVICES

CIRCOLEC
THE COMPLETE ELECTRONIC SERVICE

Artwork, Circuit Design, PCB Assembly, Test & Repair Service, Q.A. Consultancy, Prototypes, Final Assembly.

Quality workmanship by professionals at economic prices.

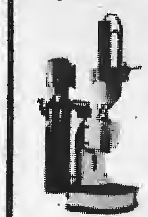
Please telephone **01-646 5686** for advice or further details.
Unit 4, Windmill Trading Estate
Commonside East, Mitcham

(1391)

ARTICLES FOR SALE

HYDROKIT

Hydraulic Flypress Conversion



Complete Hydraulic Kits comprising: Power Pack, Control Valve, Ram, Hoses and Fittings. Suitable for many applications including Flypress Conversions. Working pressure 2,000 p.s.i. 2-10 tons. Stroke 4in. Adjustable relief valve. Power pressure and return.

PRICE FROM £428

"HYDROKITS" ARE COMPLETE
Just remove arm of press and operate screw shaft, fit hydraulic ram assembly with manual valve (all supplied), fill with hydraulic oil and connect to power source, 13 amp or 3-phase. Send details of press or ask for questionnaire.

TAVISHELM HYDRAULICS INTERNATIONAL LIMITED

Hypress House, Station Close, Potters Bar, Herts. EN6 1TL. Tel. Potters Bar (0707) 43434

(1735)

FOR THE BEST PCB SERVICE AVAILABLE

★ Circuit Design & Development
Digital and Analogue

★ Artwork Layout
Work of the highest standard by experienced draughtsmen. No minimum charge.

★ Board Manufacture
Prototype to semi-production, excellent rates, 24-hour prototype service from filmwork.

★ Wiring & Assembly
PCB assembly, wiring and cable forming by qualified staff.

★ Test
Full test facilities available.

One or all services available, no order too small. Please telephone Chelmsford (0245) 357935, or write to HCR Electronics, The Industrial Unit, Parker Road, Chelmsford.

(1169)

williams

P.C.B. Artworks

FAST TURNROUND

To ensure immediate turnround of your artwork contact JULIAN WILLIAMS
WILLIAMS ARTWORK, GRAYS LANE
MORETON-IN-MARSH, GLOS.
Tel: MORETON-IN-MARSH 51444
(or Evesham 840121)

PCB/ELECTRONIC ASSEMBLY

to sample or drawing. Short or continuous runs. Any quantity. 100% inspected. Special rates for small companies or large quantities. Fast turnaround and local deliveries if required.

AUTRONICS, 23 Regency Gardens
Yardley Wood, Birmingham B14 4JS
021-474 4638

(2020)

PRINTED CIRCUIT BOARDS

Manufacturers from A/W or film, small or large quantities, average turnaround two weeks.

MAYLAND PCB CO. LTD.
Maylandsea
Chelmsford, Essex CM3 6AB
Tel. (0621) 741560

(2051)

ELECTRONIC KIT. 100 assorted resistors, capacitors, fuses, etc. £3.75 inc. P&P. Matsushita Electrolytics, thousands at trade prices, 50p brings lists, trade enquiries welcomed, cash with order. Ball and Rogers, 4 The Slore, Beccles, Suffolk NR34 9AR. (2058)

VALVES, PROJECTOR Lamps, 6000 types, list 75p, world wide export. Cox Radio (Sussex) Ltd., The Parade, East Wittering, Sussex. Phone (024 366) 2023. (1991)

DON'T MISS OUR VALVE LIST! Send 25p + L.S.A.E. Today; Billington valves, 23 Irwin Drive, Horsham, RH12 1NL. 10p + Sae for component clearance list. (No callers). (2068)

LAMPS AND CABLE. Large amount of lamps and cable for sale – all types and sizes, domestic and industrial. Telephone MIRAGE LIGHTING on HITCHIN (0462) 733388 between 10am-7pm. (1809)

PROTOTYPE PLASTIC CASINGS, vacuum formed to your requirements. Four-D Ltd., 25 Burnett Park, Harlow, Essex. Phone 0279 29246. (1725)

BRIDGES, waveform/transistor analysers. Calibrators, Standards. Millivoltmeters. Dynamometers. KW meters. Oscilloscopes. Recorders. Signal generators – sweep, low distortion, true RMS, audio, FM, deviation. Tel. 040 376236. (1627

TENDERS

County Surveyor's Milton Keynes Link Road Southern

Provision of a Site Radio Telephone System

Applications are invited from companies wishing to be considered for the supply and maintenance of a site radio telephone system on the basis of a medium-term hire contract. The equipment is to be used for a period of approximately fifteen months on the above-mentioned contract.

Companies wishing to be considered should apply to:

The County Surveyor, County Hall, Cauldwell Street, Bedford MK43 9AP. Telephone: Bedford (STD 0234) 63222 Extension 8.

Bedfordshire
COUNTY COUNCIL

(2091)

ARTICLES WANTED

WANTED

Test equipment, receivers, valves, transmitters, components, cable and electronic scrap, and quantity. Prompt service and cash. Member of A.R.R.A.

M & B RADIO
86 Bishopsgate Street
Leeds LS1 4BB
0532 35649

WANTED

Scrap and re-usable mainframe computer and industrial electronic equipment.

E.M.A. Telecommunications Engineers, Orford, Woodbridge, Suffolk. Tel. 039-45 328.

(1720)

WANTED

Redundant/surplus electronic components and equipment. Telephone and computer spares.

Prompt service and payment.

J. B. PATTRICK
(Electronics)
191/193 London Road
Romford, Essex
Romford 44473

(1979)

CAPACITY AVAILABLE

TW ELECTRONICS LTD

THE PCB ASSEMBLERS

More and more companies are investigating the advantages of using a professional subcontractor. Such an undertaking requires certain assurances.

TW are able to satisfy all of them – quality, competitive pricing, firm delivery and close co-operation with the customer.

Assembled boards at 100% inspected before flow soldering and reinspected after automatic cropping and cleaning.

Every batch of completed boards is issued with a signed certificate of conformity and quality – our final assurance.

For further details, contact us at our new works:

Blenheim Industrial Park
Bury St. Edmunds
Suffolk IP33 3UT
Telephone: 0284 3931 (1466)

SERVICES

DESIGN SERVICES. Electronic design development and production service available for digital and analogue instruments. RF Transmitters and receivers, telemetry and control systems. 20 years' experience. R.C.S. Electronics, Wolsey Road, Ashford, Middlesex. Phone Mr Falkner 53661. (8341

TURN YOUR SURPLUS Capacitors, transistors, etc, into cash. Contact COLES-HARDING & CO., 103 South Brink, Wisbech, Cambs. 0945-4188. Immediate settlement. We also welcome the opportunity to quote for complete factory clearance. (9509

SMALL BATCH PCBs produced from your artwork. Also DIALS, PANELS, LABELS. Camera work undertaken. FAST TURNAROUND. Details: Winston Promotions, 9 Hatton Place, London EC1N 8RU. Tel. 01-405 4123/0960. (9794)

DESIGN AND DEVELOPMENT. ANALOGUE, DIGITAL, RF AND MICROWAVE CIRCUIT AND SYSTEM DESIGN. Also PCB design, mechanical design and prototype/small batch production. – Adenmore Limited, 27 Longshot Estate, Bracknell, Berks. Tel: Bracknell (0344) 52023. (656)

ELECTRONIC DESIGN SERVICE. Immediate capacity available for circuit design and development work, PC artwork, etc. Small batch and prototype production welcome. – E.P.D.S. Ltd., 1A Eva Road, Gillingham, Kent. Tel: Medway (0634) 577854. (9667

BATCH PRODUCTION wiring and assembly to sample or drawings. McDeane Electricals Ltd, 19b Station Parade, Ealing Common, London W5. Tel: 01-992 8976. (169

BATCH PRODUCTION PC assembly to sample or drawings, any quantity. Stagecraft (Electronics) Ltd, Unit 7, Carew Street Industrial Estate, Camberwell SE5 9DF. Tel: 01-737 1422. (1942)

BATCH PRODUCTION PC assembly to sample or drawings, any quantity. Stagecraft (Electronics) Ltd, 3, Churchfield Rd, Acton W3 6BH. Tel: (01) 993 3660. (2059)

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 102-111

PAGE

OVERSEAS ADVERTISEMENT AGENTS

France & Belgium: Norbert Hellin, 50 Rue de Chemin Veat, F-9100, Boulogne, Paris.

Hungary: Ms Edit, Bajusz, Hungexpo Advertising Agency, Budapest XIV, Varosliget. Telephone: 225 008 – Telex: Budapest 22-4525 INTFOIRE

Italy: Sig C. Epis, Etas-Kompass, S.p.a. – Servizio Estero, Via Mantegna 6, 20154 Milan. Telephone: 347051 – Telex: 37342 Kompass.

Japan: Mr. Inatsuki, Trade Media – IBPA (Japan), B.212. Azabu Heights, 1-5-10 Roppongi, Minato-ku, Tokyo 106. Telephone: (03) 585 0581.

United States of America: Ray Barnes, Business Press International Ltd, 205 East 42nd Street, *New York*, NY 10017 – Telephone (212) 867-2080 – Telex: 238327.
Jack Farley Jnr., The Farley Co., Suite 1584, 35 East Walker Drive, *Chicago*, Illionois 60601 – Telephone (312) 63074.
Victor A. Jauch, Elmatex International, P.O. Box 34607, *Los Angeles*, Calif. 90034, USA – Telephone (213) 821-8581 – Telex: 18-1059.
Jack Mantel, The Farley Co., Suite 650, Ranna Building, *Cleveland*, Ohio 4415 – Telephone (216) 621 1919.
Ray Rickles, Ray Rickles & Co., P.O. Box 2028, *Miami Beach*, Florida 33140 – Telephone (305) 532 7301.
Tim Parks, Ray Rickles & Co., 3116 Maple Drive N.E., *Atlanta*, Georgia 30305. Telephone (404) 237 7432.
Mike Loughlin Business Press International, 15055, Memorial Ste 119, *Houston*, Texas 77079 – Telephone (713) 783 8673.

Canada: Colin H. MacCulloch, International Advertising Consultants Ltd., 915 Carlton Tower, 2 Carlton Street, Toronto 2 – Telephone (416) 364 2269.

* Also subscription agents.

Printed in Great Britain by QB Ltd, Sheepen Place, Colchester, for the proprietors, Business Press International Ltd, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS. © Business Press International Ltd 1983. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Services Ltd; Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd; William Dawson & Son (SA) Ltd. UNITED STATES: Eastern News Distribution Inc., 14th Floor, 111 Eighth Avenue, New York, NY 10011.

TRADE PRICES

from

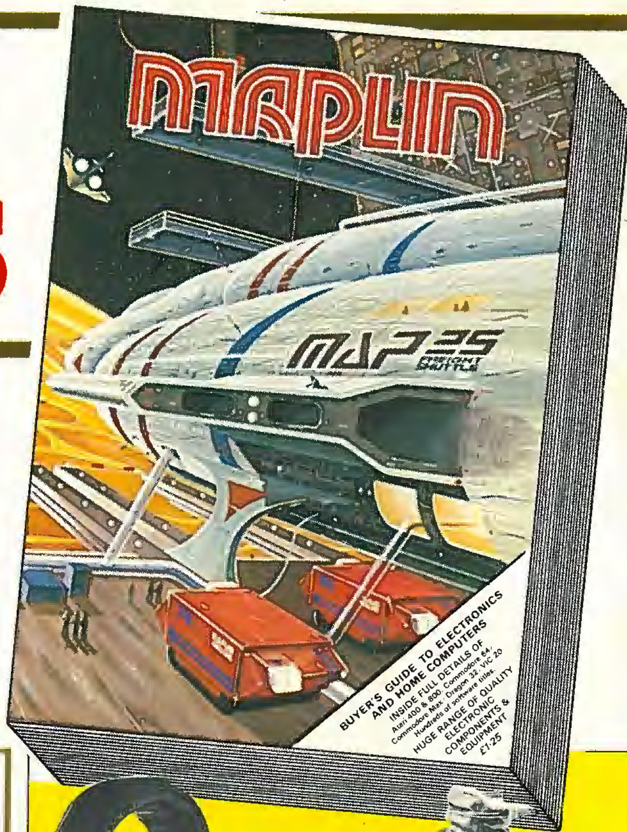
MAPLIN

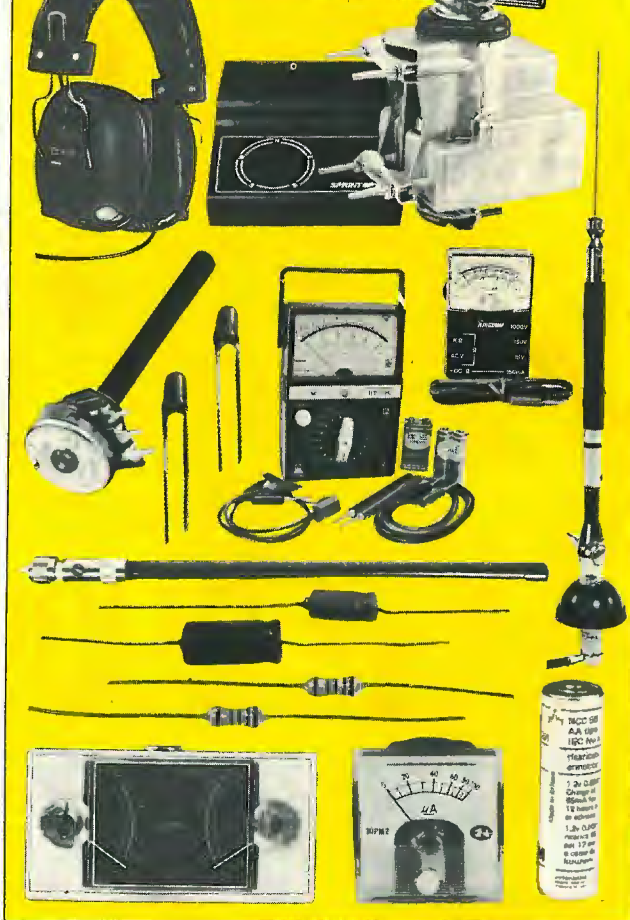
Look at these examples from our huge range.

Code	Description	Cat. Page	Retail Price Incl. VAT	Min. Trade Qnty.	Price Each for Min. Tr. Quantity excl. VAT
XB54J	Aerial Rotator	25	£39.95	5	£29.00
YG00A	Ni-Cad AA 500mAh	26	£1.25	50	75p
FB15R	Electrolytic 2.2uF 63V	90	10p	500	4.5p
FB22Y	Electrolytic 10uF 25V	90	9p	1000	3.5p
FB49D	Electrolytic 100uF 25V	90	14p	500	6.5p
FB73Q	Electrolytic 470uF 25V	90	30p	250	12p
FB83E	Electrolytic 1000uF 25V	90	40p	250	17p
FB96E	Electrolytic 4700uF 25V	90	£1.25	50	58p
YG41U	27MHz Rubber Duck	99	£4.75	25	£2.95
XG13P	1.5m CB Aerial	99	£13.95	5	£8.45
LB72P	2-Station Intercom	102	£8.75	10	£4.95
HF85G	¼in. Jack Plug plastic barrel	142	19p	500	9p
HF88V	¼in. Jack Plug stereo plastic barrel	142	28p	250	15p
HF87U	¼in. Jack Plug metal barrel	142	39p	250	22p
HF89W	¼in. Jack Plug stereo metal barrel	142	45p	250	28p
RW67X	13A nylon Mains Plug British	157	79p	100	45p
WL27E	LED 0.2in. Red	182	12p	500	6p
WL28F	LED 0.2in. Green	182	19p	500	10p
WL29G	LED 0.2in. Orange	182	33p	250	19p
WL30H	LED 0.2in. Yellow	182	17p	500	9p
RK07H	Panel Meter 100uA	197	£2.95	25	£1.95
RK09K	Panel Meter 1mA	197	£2.95	25	£1.95
RK19V	Panel Meter VU	197	£2.95	25	£1.95
YQ47B	Dual VU Meter	197	£3.90	25	£2.30
YR84F	Professional Plugblock	201	£6.95	10	£4.95
RX96E	20mm Fuse Holder	250	45p	250	24p
M10R-M1M	Metal Film 0.4W 1% Resistor	262	2p	1000	1p
FW00A-FW09K	Rotary Potentiometers linear	265	45p	250	32p
FW21X-FW29G	Rotary Potentiometers log	265	45p	250	32p
QL80B	1N4148	270	4p	1000	2p
QL22Y	741C 8-pin DIL	270	23p	500	12p
QH66W	NE555	270	21p	500	12p
QQ06G	4164 64K dynamic RAM	271	£5.99	100	£3.84
BL18U	DIL Socket 14-pin	336	11p	500	7.5p
BL17T	DIL Socket 8-pin	336	9p	1000	4.5p
WF14Q	Stereo Headphone with slide volume controls	342	£7.99	10	£4.95
FH00A	Sub-min Toggle Switch SPDT	347	70p	100	45p
FH04E	Sub-min Toggle Switch DPDT	347	99p	100	59p
FF73Q-FF76H	Rotary Switch break before make	348	74p	100	46p
FH42V-FH45Y	Rotary Switch make before break	348	70p	100	42p
YW93B	1000 ohm per volt Multimeter	362	£4.85	25	£2.95
YW68Y	20,000 ohm per volt Multimeter with Transistor Tester	363	£16.25	5	£10.45
BR75S	Box-joint Insulated 4½in. Cutters	370	£6.93	10	£4.45
BR78K	Box-joint Insulated 4½in. Pliers	371	£5.72	10	£3.95

Retail prices guaranteed until 4th May 1983. Quantity prices shown are subject to change without notice. Please check with us before ordering.

Most items in our catalogue are available at competitive trade prices; the bigger the quantity the better the price. If you find the example prices attractive, then contact us now with your requirements for a quotation. Phone Southend (0702) 552911 or write to us at P.O. Box 3, Rayleigh, Essex, SS6 8LR. Please ask for trade sales desk.





Copies of our catalogue are available in all branches of W.H. Smith, price £1.25. In case of difficulty, send £1.50 to our mail-order address. Overseas price £1.90.

Maplin Electronic Supplies Ltd.

All mail to P.O. Box 3, Rayleigh, Essex SS6 8LR. Tel. (0702) 552911.
Shops at 159 King St., Hammersmith, W6. Tel. 01-748 0926.
Lynton Square, Perry Barr, Birmingham. Tel: 021-356 7292.
284 London Road, Westcliff-on-Sea, Essex. Tel. (0702) 554000.
Shops closed all day Monday.

WW5/83

WW–003 FOR FURTHER DETAILS