**QV* MODULES FOR COST-CONSCIOUS CONSTRUCTORS**

**STIRLING SOUND** policy is to ensure customer satisfaction by designing and making their products in their own factory in Essex and selling direct. Production control-checked throughout. All QV Modules are compatible within the range and with much other equipment.

**PRE AMP/TONE CONTROL MODULES**

**UNIT ONE**

Combined pre-amp with active tone-control circuits. 15dB at 10kHz treble and 30Hz bass. Stereo. Vol balance treble bass. 200mV out for 50mV in. Takes 10-16V. £7.80

**SS100** Active tone control. £1.60

**SS101** Pre-amp for ceramic cartridges, radio, tape. Stereo. Passive tone control circuit shown in data supplied. £1.60

New style for power amps SS105, SS110 and SS120

**POWER AMPLIFIERS FROM 3 TO 100 WATTS R.M.S.**

**THE NEW SS1100**

Delivers 100 watts r.m.s. into 4 ohms using 70 volt supply. Heavy duty, ruggedly constructed module complete with output capacitor and heatsink-type mounting bracket. Size approx. 140 x 76 x 32mm. Just the job for disco or P.A. use. £9.45

Large Heatsink. £1.00

**SS103**

3 watt r.m.s. mono I.C. with built-in current, short, and thermal protection. £1.75

**SS103-3** Stereo version of above. £2.25

**SS105** 5 watts r.m.s. into 4 ohms, using 12V. (SS312 for example). £2.25

**SS110** 10 watts r.m.s. using 24V and 4 ohm load. Use SS324 as the power supply. £2.75

**SS120** 20 watts r.m.s. into 4 ohms, using 34V. Use SS324 for your power supply. £3.25

Modules SS105, SS110, SS120 all measure 89 x 50 x 19mm. Suitable power supplies will be found in the accompanying range. VAT for power supplies ordered with amps SS103-SS120 becomes 12%

**FM TUNING MODULES**

**SS201** Front end tuner, slow geared drive, two gang A.F.C. facility. Tunes 88-108MHz. £5.00

**SS202** I.F. amplifier. £2.65

**SS203** Stereo decoder for use with the above or other FM mono tuners. A LED may be fitted. £3.85

Appropriate technical data with all modules

*THE BUILT-IN QV FACTOR*

means Stirling Sound's guarantee of QUALITY AND VALUE to give you today's best value all round.

**TODAY'S BEST VALUE IN Power Supply Units**

with 13-15V take-off points

**7 MODELS TO CHOOSE FROM**

All the following are supplied assembled complete with mains transformers and low volt take-off points except SS312. Complete with mains transformers (except SS310). All at 8% VAT rate. Add 12% for any model except SS310.

**SS312** 12V/1A £3.75

**SS318** 18V/1A £4.15

**SS324** 24V/1A £4.60

**SS334** 34V/2A £5.25

**SS345** 45V/2A £5.60

**SS350** 50V/2A £5.90

**SS300** Stabilised power supply with variable output from 10 to 50V/2A. With built-in protection against shorting. £11.95

WHEN ORDERING

Add 35p for p/p unless stated otherwise. VAT add 12% to total value of order unless price is shown *†* when the rate is 8%. Make cheques, etc., payable to Bi-Pre-Pak Ltd. Every effort is made to ensure correctness of information at time of going to press. Prices subject to alteration without notice.

Stirling Sound

A member of the Bi-Pre-Pak group

220-224 WEST ROAD, WESTCLIFFE-ON-SEA, ESSEX SS0 9DF

Telephone Southend (0702) 46344

PERSONAL CALLERS WELCOME
CONSTRUCTIONAL PROJECTS

SOLAR HEATING CONTROLLER  by G. I. Williams
An automatic controller for a circulating pump  98

RADIO CONTROL SYSTEM—2  by G. D. Southern
The decoder and final adjustments  102

MILLIVOLTMETRE  by D. W. Easterling
A battery-powered a.c./d.c. instrument  120

SEVEN-SEGMENT DISPLAY FOR OSCILLOSCOPES  by L. M. Newell
An inexpensive unit generating numerals 0-9  126

I. C. SNAP  by P. D. Scargill
A simple card game goes electronic  132

GENERAL FEATURES

MEMORIES—2  by A. Briar
This final article discusses Read Only Memories and Charge Coupled Devices  108

SEMICONDUCTOR UPDATE  by R. W. Coles
A look at some recently released devices  119

NOISE SOURCES  by D. Maynard
Investigating possible causes and ways of keeping noise down to a minimum  134

INGENUITY UNLIMITED
Polyphonic Keyboard System—Automatic Car Aerial—Car Overheat Indicator—Over-Voltage Protector—Digital Logic Checker—Percussion Effects—Simple Compressor—Clock Display—Head or Tails  136

NEWS AND COMMENT

EDITORIAL—The Sunny Side  97

POINTS ARISING
Cine/Tape Synchroniser—Random Tone Generator  101

BOOK REVIEWS
Selected new books we have received  106

SPACEWATCH  by Frank W. Hyde
Asteroid Numbered 1976 UA—Largest Radio Telescope—Pluto—Mars  107

COMPUTER HOBBIES in the U.S.  by Roger Woolnough
A report on this new pastime for amateur electronics constructors in the States  115

NEWS BRIEFS
Amateur Tape Award—Permanent Magnet Machine—Scanner  116

MARKET PLACE
Interesting new products and catalogues  124

INDUSTRY NOTEBOOK  by Nexus
What's happening inside industry  130

MICROPROCESSOR FORUM FOR CONSTRUCTORS
Details of a P.E., National and Marshall's joint sponsored event  131

PATENTS REVIEW
Thought provoking ideas on file at the British Patents Office  145

READOUT
A selection of readers' letters  146

Our March issue will be on sale on Friday, February 11, 1977
(for details of special Free wallchart and other contents, see page 125)
Join the Digital Revolution

Understand the latest developments in calculators, computers, watches, telephones, television, automotive instrumentation... Each of the 5 volumes of this self-instruction course measures 11½ x 8½” and contains 60 pages packed with information, diagrams and questions designed to lead you step-by-step through number systems and Boolean algebra, to memories, counters and simple arithmetic circuits, and on to a complete understanding of the design and operation of calculators and computers.

Design of Digital Systems

£6.00
plus 60p packing and surface post anywhere in the world.
Payments may be made in foreign currencies.
Quantity discounts available on request:
VAT zero rated.

Also available—a more elementary course assuming no prior knowledge except simple arithmetic.
Digital Computer Logic and Electronics

£4.20
plus 60p P. & P.
Offer Order both courses for the bargain price £9.75, plus 80p P. & P.

Designer
Manager
Enthusiast
Scientist
Engineer
Student

These courses were written so that you could teach yourself the theory and application of digital logic. Learning by self-instruction has the advantages of being quicker and more thorough than classroom teaching. You work at your own speed and must respond by answering questions on each new piece of information before proceeding to the next.

Guarantee—no risk to you
If you are not entirely satisfied with Design of Digital Systems or Digital Computer Logic and Electronics, you may return them to us and your money will be refunded in full, no questions asked.

LEKTROPACKS

17 Turnham Green Terrace, Chiswick, London, W.4 Tel: 01-994 2784
*NEW* FULLY GUARANTEED COMPONENT PACKS * FULL SPEC. SEMI-
CONDUCTORS * AVAILABLE IN LOW COST PACKS OF TEN * ALL PRICES INCLUDE
VAT AND U.K. POSTAGE * NO HIDDEN EXTRAS * TEN PACKS LESS 15%.

Price per 10
Product Description
Price per 10
AC129 E1-20 BD132 £3.50 TIPS8 £3.35 2N2906 £2.50
AC130 E1-20 BD132 £3.50 OA242 £2.90 TIPS8 £3.35 2N2906 £2.50
AC131 E1-20 BD132 £3.50 OA271 £2.90 TIPS8 £3.35 2N2906 £2.50
AC132 E1-20 BD132 £3.50 OA242 £2.90 TIPS8 £3.35 2N2906 £2.50
AC133 E1-20 BD132 £3.50 OA271 £2.90 TIPS8 £3.35 2N2906 £2.50

*delete as applicable
No need to use a stamp—just print FREEPOST on the envelope. PE21

Doram kits

DORAM KITS CONTAIN EVERYTHING DOWN TO THE LAST NUT

TEST BENCH AMPLIFIER 1W

£4.59
+ S

For use in fault finding, development work and testing equipment without its own audio output stage. This available portable equipment may be used with its own built-in speaker or with an extension loudspeaker. Screw terminal input connections.

Subject to availability

O'w's orders—add 15% for P + P. All items offered for sale subject to the Terms of Business as set out in Doram Edition 3 catalogue, price E4.59 + S (order code 991-495).
SPEAKERS
Baker Group 25, 3, 8 or 15 ohm £13.90
Baker Group 35, 3, 8 or 15 ohm £11.50
Baker Group 5012 8 or 15 ohm £14.50
Baker Group 5015 8 or 15 ohm £18.00
Baker Deluxe 124, 8 or 15 ohm £17.90
Baker Major 3, 8 or 15 ohm £15.90
Baker Superb 8 or 15 ohm £20.00
Baker Regent 12in 8 or 15 ohm £16.80
Baker Auditorium 12in 8 or 15 ohm £16.80
Baker Auditorium 15in 8 or 15 ohm £19.40
Fane Crescendo 15/125. 8 or 16 ohm £9.28
Fane 120 Mk II horn £9.28
Fane HPX1 crossover 200W £19.99
Fane 13 x 8in, 15W dual cone £5.50
Fane 801T 8in d/c, roll surr. £9.95
Fane 120 12in £15.00
Fane 130 15in £18.00
Fane Crescendo 15/100A. 8 or 16 ohm £8.95
Fane Axient 100 £12.90
Fane Axiom 402 8 or 15 ohm £18.00
Fane Twinaxialom 8, 8 or 15 ohm £20.00
Fane Axiom 102 £8.95
Fane Axiom 120 £8.95
Fane Axiom 120 2528 £18.98
Fane Axiom 12 £8.95
Fane Axiom 152 £9.95
Fane 150P £16.90
Fane 180P £13.90
Fane Hilites 750P £19.80
Fane 5in midrange £9.95
Decca London ribbon horn £5.85
Decca London CD/100 £4.95
Decca DCB/P ribbon horn £9.55
Decca CO/1/8 crossover (DCB) £9.55
EMI 14 x 8in bass 8 ohms, 14A770 £11.95
EMI 8 x 5in, 10W, d/c, roll surr. £10.50
EMI 6in d/cone, roll surr., 8 ohm £8.95
EMI 8in roll. bass surf. £9.55
EMI 5in mid range £19.95
Elec 59RM 109 (15 ohm), 59RM114 (8 ohm) £29.95
Elec 8in d/c, roll surr., 8 ohm £19.95
Elec 10in 16RM39, 8 ohm £24.95
Eagle FRA £5.95
Eagle FRA5 £11.95
Eagle FRA6 £8.95
Eagle FRA8 £14.00
Eagle FRA10 £29.95
Eagle H112 £9.95
Eagle H12 £29.95
Eagle H1210 £4.95
Eagle FB28 Multicell. horn £9.95
Fane Pop 15, 8 or 15 ohm £9.75
Fane Pop 50T, 8 or 16 ohm £9.75
Fane Pop 50, 8 or 16 ohm £29.95
Fane Pop 55, 8 or 15 ohm £29.95
Fane Pop 70, 8 or 16 ohm £39.95
Fane Pop 100, 8 or 16 ohm £39.95
Fane Crescendo 12, 8 or 16 ohm £49.95
Fane Crescendo 12BL, 8 or 16 ohm £44.95
Fane Crescendo 15/104A, 8 or 16 ohm £64.95
Fane Crescendo 15/125, 8 or 16 ohm £64.95

SPEAKERS
Tannoy 12in Monitor HPD £86.00
Tannoy 15in Monitor HPD £99.95
Wharfedale Super 10 RS/DD 8 ohm £13.90

SPEAKER KITS
Baker Major Module 3, 8 or 15 ohm each £13.90
Fane Made One Mk II 15W each £10.35
Fane D40 Discio Kit each £19.95
Goodmans DIN 20 4 or 8 ohm each £16.75
Goodmans Mezzo Twin Kit pair £51.95
Helme XLK 30 pair £29.95
Helme XLK 35 pair £26.75
Helme XLK 40, pair £38.50
Kefkit 1 pair £53.50
Kefkit III each £49.90
Peerless 1050 pair £54.00
Peerless 11710 each £46.50
Peerless 1120 each £54.00
Peerless 2050 pair £39.50
Peerless 2060 each £53.00
Richard Allan Triple assembly each £13.95
Richard Allan Triple 8 each £25.75
Richard Allan Triple 12 each £25.95
Richard Allan Super Trio pair £29.50
Richard Allan RA6 pair £37.80
Richard Allan RA82K Kit pair £59.40
Richard Allan RA82L Kit pair £58.70
Wharfedale Denton 2XP kit pair £83.25
Wharfedale Lynx 3XP kit pair £28.00
Wharfedale Glendale3XP kit pair £48.50

HI-FI ON DEMONSTRATION in our showrooms:
Axi, Armstrong, Bowers & Wilkins, Castle, Celestion, Dual, Goodmans, Kef, Leak, Pioneer, Radford, Richard Allan, Rotel, Tandberg, Trio, Videotone, Wharfedale, etc.—ask for our HI-FI discount price list.

THIS MONTH'S SPECIALS!
(Price £6.50, Carr. £2.50)

Rotel RA8 £79.95
Rotel RX202 £79.50
Sansui SC2000/2002 £149.70
Videotone Minimax II £43.00
Pioneer SX46 £116.00

ALL UNITS GUARANTEED NEW AND PERFECT

Carnage and Insurance: Speakers up to 12in 60p; 12in £1; 15in £1.50; 18in £2.50. Kits £1 each (£2 per pair). Tweeters and Crossovers 30p each.

Complete kits in stock for Radford Studio 90, Radford Monitor 180, Radford Studio 270, Radford Studio 360, HI-FI Answers Monitor (Rogers), Hi-Fi News No Compromise (Frisky), Hi-Fi News State of the Art, Wireless World Transmission Line (Bailey), Practical HI-FI and Audio Monitor (Giles), Practical HI-FI and Audio Triangle (Giles), Popular HI-FI (Colloms), etc.

On dem. Answers Monitor, State of Art, etc.

Construction leaflets for Radford, Kef, Jordan Watts, Tannoy, HI-FI Answers Monitor, free on request.

P.A. amplifiers, microphones, etc., by Shure, Linear, Eagle, Beyer, AKG, etc.

FREE with orders over £10—"HI-FI Loudspeaker Enclosures" book.

WILMSLOW AUDIO
Dept PE
Loudspeakers, Mail order and export: Swan Works, Bank Square, Wilmslow.
Hi-Fi, Radio and TV: Swift of Wilmslow, 5 Swan Street, Wilmslow, Cheshire.
PA, HI-FI and Accessories: Wilmslow Audio, 10 Swan Street, Wilmslow, Cheshire.

Telephone: Loudspeakers, mail order and export—Wilmslow 29959, HI-FI, Radio, etc.—Wilmslow 28213.

Access and Barclaycard orders accepted by phone.
DOLOMITI
20kΩ/V a.c. and d.c.

A NEW HIGH SENSITIVITY MULTIMETER WITH ALL THE FEATURES YOU WILL EVER NEED

Accuracy: d.c. ranges, ±2.0%; a.c. and Ω ranges ±2.5%.
39 ranges: d.c. V: 0-150mV, 500mV, 1.5V, 5V, 15V, 50V, 150V, 500V, 1kV; a.c.: 1, 0-50µA, 500µA, 5mA, 50mA, 500mA, 5A; a.c. V: 5V, 15V, 50V, 150V, 500V, 1kV; a.c.: 1, 5mA, 50mA, 500mA, 5A; dB -10 to +65 in 6 ranges, Ω 0-5kΩ, 5kΩ, 50kΩ, 500kΩ, 5MΩ, 50MΩ, 5pF, 50pF, 500pF.

Automatic overload protection and high current range fusing.
Scale mirror and fine pointer for accuracy of reading. Single knob main range switching and all panel controls. C.E.I. Class 1 movement with sprung jewel bearings. Extended 92mm scale length for extra clarity. Compact ABS case 125 x 125 x 37mm. Weight 650g with batteries. Supplied complete with carrying case, fused leads, hand-book and full 12-month guarantee. Optional 30kV d.c. probe available.

Meter £45-90 incl. VAT (£1 P. & P.)
30kV Probe £12-85 incl. VAT

CHINAGLIA
PRESENT THE

FROM THE BIGGEST RANGE OF GOOD QUALITY MULTIMETERS

WELBROOK STEREO
This new hi-fi amplifier from Welbrook is the result of painstaking design incorporating 5 I.C.s 22 transistors plus 10 diodes and offers outstanding value for money to the discerning enthusiast.
30W RMS per channel into 8 ohms load. Total harmonic distortion less than 0.1% at all power levels.
Hum/Noise:
- 80dB Tape/Tuner
- 65dB Disc (Magnetic Input)
Complete unit comprising power supply, pre-amplifier with filter networks, two power amplifiers and loudness control all in teak finished cabinet only £88 plus VAT.

As above but without filters and loudness control only £79 plus VAT.

Also available in module form complete with front panel but without cabinet—easily assembled by the average enthusiast.

Send for details and price list to:

Welbrook Engineering & Electronics Ltd
Brooks Street, Hillgate
Stockport SK1 3HT
CASIO

fx-911P (Illus.)
10 digit or 8 digit, 2 Exp. 120 Functions Degree Rad. Un. conditional jump and manual jump as well as indirect address, subroutine, etc. The programme function allows you to handle any type of calculation, under any condition

fx-602P
The world's first fractional calculator. 10 digits or 8 plus 2 Exp. Trig, Inverse common & Natural logs. Reciprocals. Sexagesimal, Pi entry. Statistical calc. incl. 2 kinds of Standard deviation and other applications.

fx-603P
8 digit or 6 plus 2 Exp. Trig. inverse trig. All log functions. Sor rows. Reciprocals. Sexagesimal/Decimal conversions, 2 kinds of Standard Deviation and other applications.

fx-605P
12 stages can be programmed for maths, engineering, statistical, financial and navigation.

L.C.D.

KLC3
C. Constant display Shows Hrs, Mins, Secs + pulsating secs. Chrome finish with Stainless Steel back and FREE Adjustable S/Steel strap

$24.50
Gold Plate $26.45

KLC3
Constantly shows hrs, mins, and clock. Command button for minute & date. Press again for seconds. May be set to alternate hrs & mins & date every 2 sec. to time. 4 yr cal.

$139.95
Gold Plate $42.40
FREE matching bracelets with each.

KLC3
U.S. Module
Continuous hrs, mins, and clock +Command button for minute & date. Press again for seconds. Setting for alternating hrs & mins & date every 2 sec. Auto-reset 4 yr.

Note Life $37.90

KLC3
LADIES DIGITAL
The IDEAL PRESENT!
An elegant 6-function window display shows Hrs, Mins, Secs, Mth & Date, Day of week in letters. Single button. Auto hold & Fade-out. 4 yr. calendar. Case in Heavy Rhodium on Brass + S/Steel back. FREE matching S/Steel adjustable bracelet

$29.95
Gold Plate $33.95

KLC3
PLUCK Monthly & Day of the Week in Letters! Shows Hrs, Mins, Secs, Mth & Date. Ideal for wearing when indulging in Steak and Tiptoe. Polar rectangular co-ordinates. 2-store mem. Mean and Standard Deviation

$64.95
FREE matching bracelets with each.

L.E.D.

KEDY

KEDY Fantastic 6-Functions window display shows Hrs, Mins, Secs, Mth & Date. Day of week in letters. Single button. Auto hold & Fade-out. 4 yr. calendar. Case in Heavy Rhodium on Brass + S/Steel back. FREE matching S/Steel adjustable bracelet

$29.95
Gold Plate $33.95

KEDY

KEDY amazing 6-Functions window display shows Hrs, Mins, Secs, Mth & Date. Day of week in letters. Single button. Auto hold & Fade-out. 4 yr. calendar. Case in Heavy Rhodium on Brass + S/Steel back. FREE matching S/Steel adjustable bracelet

$29.95
Gold Plate $33.95

CBM

4190R (Illus.)
10-digit, 2 Exp. 90 function pre-programmed. Metric conversions. Extra functions to the 4140R. Perms and combinations. Gamma, Pearson and Binomial distributions. Factorial, complex numbers, hyperbolic functions, linear regression and integration of y = f(x).

(R)£36.95

7919D
8-digit or 5-digit + 8 Exp. Full trig and log functions. So root. Reciprocal x, x ± 1, x ± 1, Polar rectangular co-ordinates. 2-store mem. Mean and Standard Deviation

(R)£26.95

4140, 10 digit + 2 Exp. Full log and trig function. X, X ± 1, X ± 1. Pole, rectangular co-ordinates. 2-store mem. Mean and Standard Deviation

(R)£20.95

NOVUS

4640 (Illus.)
10 digit or 8 digit, 4 functions, 4 level roll stack, 3 fully addressable memories. Logs, Trigs, Sine and Metric conversions.

(R)£42.95

4690

(R)£27.50

4625
12 or 10 digit. Extra Swap, RPN Full log and trig. X, Y Exchange. Mem. 120 Functions. Additional programs in the 100 step

(R)£34.95

4515
100 step prog version

(R)£31.95

6035, 100-step programmable Statis- tician, Reciprocals

(R)£34.95

6039, 100-step programmable Reciprocals, Reciprocal

(R)£34.95

6041
12 stages can be programmed for maths, engineering, statistical, financial and navigation.

(R)£29.95

ULTRAVOX

2630
12 stages can be programmed for maths, engineering, statistical, financial and navigation.

(R)£29.95

ULTRAVOX

2632
12 stages can be programmed for maths, engineering, statistical, financial and navigation.

(R)£29.95

ROCKWELL

4190R (Illus.)
12-digit or 8-digit + 2 Exp. Additional to the 4190. Polar rec. co-ordinates. Log trig, and square root.

$24.50

4190M
3-digit or 2 Exp. Green Display. Store. 8 digit. To the 618R less factorials. Stainless Steel Simulated, Green display. In beautiful leatherette wallet + pen, note pad and credit card (all included). Full memory. Click buttons. Reciprocals. Rechargeable. Including rechargeable

(R)£21.95

ALL ITEMS CARRY 1 YEAR GUAR. PRICES INCLUDE V.A.T.

Free B.S.I. adaptor. (R) Free recharge

DECIMO DIGITAL CLOCK RADIO

Oxford 300
Larger version of above.

£13.90

DECIMO DIGITAL CLOCK RADIO

Oxford 300
Larger version of above.

£13.90

SINCLAIR

CAMBRIDGE SCIENTIFIC

5-digit or 3 Exp. + C, CE key. S/Steel or plastic, each

(R)£89.95

224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-

(R)£224 programme steps. 20 inde-
Build yourself this high quality touch-sensitive piano. The design also features the new transpose control which is an external tuning control—this tunes the entire keyboard higher or lower than the concert pitch by one whole octave. Two models are available: TS50 which is a straight piano and TS53 has piano, honky tonk, harpsichord, and fast and slow tremolo effects. These professional pianos can be built in just 12 hours.

**Parts List**

- **ESU/4 Dividers and Touch-Sensitive Keyer Unit**
  1 x AV-1-6551 i.c. divider £1.20
  25 x resistors 2.2M £0.01
  10 x transistors 2N3703 £0.02
  5 x capacitors 3.3uF 25V £0.02
  48 x resistors 470 ohm £0.01
  12 x terminal pins (mp each) £0.01
  1 x C.C. board drilled £0.00
  2 x 0-21 (5p each) £0.01
  3 x 0-21 (4p each) £0.01
  Total Price (only one unit required) £9.86

- **ESU/4 Dividers and Touch-Sensitive Keyer Unit**
  1 x AV-1-4271/5 £1.30
  5 x resistors 5,600 ohm £0.01
  2 x capacitors 3.3uF 105V £0.02
  12 x terminal pins (5p each) £0.02
  1 x C.C. board drilled £0.00
  4 x 0-21 (5p each) £0.01
  Total Price (only one unit required) £13.96

**Power Supply**

- 3 x mains main cable (10 yard) £3.90
- 1 x mains transformer 20-0-20 1A £4.45
- 1 x mains plug and socket £0.76
- 2 x fuse holders (20p each) £0.40
- 2 x fuses 1A (5p each) £0.10
- 4 x rectifier diodes (5p each) £0.76
- 1 x elect. caps 1,000uF 25V £0.50
- 3 x resistors 5W £0.12
- 1 x neon lamp £0.25
- 1 x pot with switch £0.50
- 1 x switch £0.50
- 10 x capacitor clamps £0.50
- 1 x chassis £6.00
  Total Price (only one unit required) £8.01

- 1 x voltage regulator £1.75
- 5 x octave keyboard C-C or F-F £32.00
- 1 x cabinet, front plate and fittings £26.00
- 1 x jack socket £0.50
- 1 x switched jack socket £0.50
- 1 x stereo jack plug £0.50
- 4 x rocker switches (2p each) £1.16
- 1 x headphone amp, built and tested £2.89
- 1 x loud and soft pedal £0.50
- 1 x tremolo unit for TS53 only £3.50
- 1 x toneforming unit for TS50 only £3.50
- 1 x variable capacitor, 10 turns £0.50
- 1 x GU500 built and tested, M.T.G. £14.05
- 2 x yards gold wire (50 yard) £1.17
- 1 x yards rigid card £0.01
- 3 x yards 25 core cable £0.10
- 1 x terminal pins (5p each) £0.76
- 1 x switch for 1550 only £1.95
  Total Price £168.81 + £21.10 VAT £190.91

**TS50 Complete Kit**

- £168.81 + £21.10 VAT £190.91

**TS53 Complete Kit**

- £172.22 + £21.59 VAT £193.81

Carnage on Kit Complete (£6.00). Wide range of Electronic Organ Kits available, i.a. Mayfair Mk. II Portable Organ—4 octave keyboard, 4 pitch, 10 voices, sustain, vibrato, split keyboard, transpose control. Price £186.00 VAT, carriage £6.00 (U.K. only). Overseas customers C.I.F. at cost. Also available from stock, a huge quantity of specialised I.C.s and components. Send 60p for Data Sheets for organ I.C.s 25p

---

**Elevato**

**Electronic Musical Instruments**

**Showroom:** 12 Brett Road, Hackney, London E8 1JP. Tel. 01-985 8485

**Component Shop:** 40a Dalston Lane, Dalston Junction, London E8 2AZ. Tel. 01-249 5624

---

**ambit INTERNATIONAL**

The acknowledged RF and tuner specialists have applied a little wireless experience to metal locators.

The Bionic-Ferret 300

A new VCO differentiating metal locator, with the power to locate a 'hp at 8 inches. Featuring: Automatic tuning stabilization, two levels of sensitivity, meter output, continuous or variable tone operation, low battery drain, stylish plastic housing, shielded coil, headphone or speaker outlets.

Available at the low price (in kit form) of £149.95 (ex VAT) £175.00.

---

**LOW, LOW PRICES ON BRANDED COMPONENTS.**

- All 'big name' manufacturers
- Same day service
- Money back guarantee

---

**Terms:** 2% and 6% VAT on domestic and 17.5% VAT on overseas delivery. Discounts etc. plus 2% postage and packing.

---

**Rownsgem Ltd.**

The acknowledged RF and tuner specialists have applied a little wireless experience to metal locators.
MONO DISCO MIXER
WITH AUTO FADE


Max output 3V RMS.

Specification.
Deck inputs-50mV into 'IMO;
Deck Tone Controls-treble total range 36dB at 15kHz-Base total range 36dB at 50Hz. Mic input -200 ohms upwards 2mV into 220. Mic Tone Control-Total range 40dB at 15kHz. Tape input-10OrnV into 200 ohms. Power requirements 20-50 volts d.c. at 50mA RI A.A. comp mag inputs available 75p extra.

PANEL SIZE 18 x 44in. DEPTH 3in.

STEREO DISCO MIXER
T/S SWITCHING, etc.
£115.00

4 CHANNEL SOUND TO LIGHT SEQUENCE CHASER-4LSMI
RCA IA Trlace
1000W per channel
Fully suppressed and fused
Switched master control for sound operation from 4W to 125W
Full wave control
Speed control for fixed rate sequence from 8 per minute to 50 per second
Full logic integrated circuitry with optical isolation for amplifier protection
218.75
±2 easy connections
Patents applied for

Model 501 500W per channel as above without sound triggering
02.25

FRONT PANEL FOR LIGHTING EFFECT MODULES (complete with switches, hooks and knobs) as illustrated
Size: 8 x 44
For S1LMB
26.50
Size 64" x µ"
For 4LSM1
25.50
41 For S1LMB combined with 3SDM1
27.50

THE PIEZO SUPER HORN
NEEDS NO CROSS-OVER NETWORK
FREQUENCY RESPONSE 4.000-30,000Hz
3dB
PATENTED MOMENTUM DRIVE PRINCIPLE
NO VOICE COILS OR MAGNETS
HIGH INTERNAL IMPEDANCE
ADAPTS TO ANY SYSTEM
HIGH ACCOUSTIC OUTPUT
MANY CAN BE CONNECTED IN SERIES TO FORM AN ARRAY-INCREASED OUTPUT
POWER HANDLING CAPACITY
25 volts RMS-see chart

POWER HANDLING GUIDE
System
Impedance
Capacity
2 ohms
312 watts
4 ohms
156 watts
8 ohms
78 watts
16 ohms
39 watts

To order by post
Make cheques/P.0.5 payable to TUAC LTD (PE 27 or quote Access/Barclaycard No and post to TUAC LTD. IPE27). 119 Chalmont Road, London SW17 9AB. We accept phone orders from Access/Barclaycard Holders. Phone 01-672 9080.
PLASTIC BOXES IN 5 SIZES
Easily drilled or punched, grey ABS boxes incorporate slots for 1.5mm PCBs with lid fixing screws running into integral brass bushes.

100x50x25mm £0.98 (1-9) £0.90
112x62x31mm £0.99 (1-9) £0.92
120x65x40mm £1.12 (1-9) £1.04
150x80x50mm £1.33 (1-9) £1.20
190x110x60mm £1.83 (1-9) £1.70

Polystyrene version
Plain inside, no integral bushes

112x61x31mm £0.35 (1-9) £0.32

Add 25p per £1 order value for Post & Packing.

TYPE A NEON INDICATORS
Held in 8mm hole by plastic bezel
150mm wire leads

Red, Amber, Clear, Opal
19p each
Green
28p each

TYPE MP NEON INDICATOR
150mm leads, held in 6.4mm hole by nut

Red, Amber, Clear, Opal
20p each

On all orders quote reference PE/2/77.

THE NEW MW BREADBOARD accepts Transistors, LED's, Diodes, Resistors, Capacitors and all DIL packages with 6 to 40 pins.

Includes slot-in Component Support Bracket and has over 400 individual sockets, plus Vcc & Ground Bus Strips
Price £9.72 (includes VAT & P.P.)

POWERFUL 12 VOLS MINI HAND DRILL
Ideal for drilling PCBs, chassis and model-making

Supplied with 2 collets that accept drills, and tools with up to 2.4mm dia. shanks
Price £7.56 (includes VAT & P.P.)

SEVEN SEGMENT DISPLAYS
Economy Quality - Only 66p
0.3" - Red
Common Anode - Left Decimal
Full specification displays also available
Red, Green and Yellow
£1.35 each inc. data

P.P. Note: Unless included in price add 25p Post & Packing for orders totalling under £1.

Prices include VAT and are valid in UK only for 2 months from journal issue date.

Michael Williams Electronics
47 Vicarage Av., Chaddesly Hulme, Cheshire SK8 6JP

EYE CATCHING INSTRUMENT CASE
Removable Red, Orange or Grey covers
Black chassis with support brackets
Overall size 250x167x68mm
Price £13.18 (includes VAT & P.P.)

CRAM KITS CONTAIN EVERYTHING DOWN TO THE LAST NUT

DORAM KITS

DORAM KITS CONTAIN EVERYTHING DOWN TO THE LAST NUT

SIGNAL GENERATOR
Subject to availability

Ideal for audio testing this handy portable unit is excellent value for money, giving an audio frequency signal variable in amplitude and frequency between 20Hz and 20KHz.

£2.99+5 (order code 991-906)

O'seas orders—add 15% for P + P. All items offered for sale subject to the Terms of Business as set out in Doram Edition 3 catalogue, price 60p. The Doram Kit brochure is also available, price 25p. Combined price only 75p which also entitles you to 2 x 25p vouchers, each one usable on any order placed to the value of £1.00 or more (ex. VAT). DORAM ELECTRONICS LTD P.O. Box TR8, Wellington Road Industrial Estate, Leeds LS12 2UF. An Electrocomponents Group Company
Bring 'scope' to your interest.

'There's only one way to master electronics... to see what is going on and learn by doing.'

This new style course will enable anyone to have a real understanding of electronics by a modern, practical and visual method. No previous knowledge is required, no maths, and an absolute minimum of theory.

You learn the practical way in easy steps mastering all the essentials of your hobby or to further your career in electronics or as a self-employed electronics engineer.

All the training can be carried out in the comfort of your own home and at your own pace. A tutor is available to whom you can write, at any time, for advice or help during your work. A Certificate is given at the end of every course.

1 Build an oscilloscope.
As the first stage of your training, you actually build your own Cathode ray oscilloscope! This is no toy, but a test instrument that you will need not only for the course's practical experiments, but also later if you decide to develop your knowledge and enter the profession. It remains your property and represents a very large saving over buying a similar piece of essential equipment.

2 Read, draw and understand circuit diagrams.
In a short time you will be able to read and draw circuit diagrams, understand the very fundamentals of television, radio, computers and countless other electronic devices and their servicing procedures.

3 Carry out over 40 experiments on basic circuits.
We show you how to conduct experiments on a wide variety of different circuits and turn the information gained into a working knowledge of testing, servicing and maintaining all types of electronic equipment, radio, t.v. etc.

All students enrolling in our courses receive a free circuit board originating from a computer and containing many different components that can be used in experiments and provide an excellent example of current electronic practice.

To find out more about how to learn electronics in a new, exciting and absorbing way, just clip the coupon for a free colour brochure and full details of enrolment.

Write to:- British National Radio & Electronics School, P.O. Box 156, Jersey, Channel Islands.

NAME

ADDRESS

---

Practical Electronics  February 1977
SEMICONDUCTORS
POSTAGE AND PACKING
Please add 25p. Overseas
add extra for airmail.
Minimum order £1.

2nd
GREAT WINTER
SALE!

TRANSDISTORS

<table>
<thead>
<tr>
<th>Type</th>
<th>Price</th>
<th>Type</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC128</td>
<td>10p</td>
<td>OC44</td>
<td>12p</td>
</tr>
<tr>
<td>AC153K</td>
<td>10p</td>
<td>OC45</td>
<td>12p</td>
</tr>
<tr>
<td>AC175</td>
<td>25p</td>
<td>OC71</td>
<td>5p</td>
</tr>
<tr>
<td>AC176K</td>
<td>22p</td>
<td>OC72</td>
<td>14p</td>
</tr>
<tr>
<td>AC187K</td>
<td>22p</td>
<td>OC81</td>
<td>14p</td>
</tr>
<tr>
<td>AC188K</td>
<td>22p</td>
<td>ZTX107</td>
<td>6p</td>
</tr>
<tr>
<td>AC198K</td>
<td>22p</td>
<td>ZTX108</td>
<td>6p</td>
</tr>
<tr>
<td>BC107</td>
<td>6p</td>
<td>ZTX109</td>
<td>6p</td>
</tr>
<tr>
<td>BC108</td>
<td>6p</td>
<td>ZTX110</td>
<td>6p</td>
</tr>
<tr>
<td>BC109</td>
<td>6p</td>
<td>ZTX111</td>
<td>6p</td>
</tr>
<tr>
<td>BC118</td>
<td>10p</td>
<td>ZTX112</td>
<td>6p</td>
</tr>
<tr>
<td>BC154</td>
<td>10p</td>
<td>ZTX113</td>
<td>6p</td>
</tr>
<tr>
<td>BC147</td>
<td>10p</td>
<td>ZTX114</td>
<td>6p</td>
</tr>
<tr>
<td>BC148</td>
<td>10p</td>
<td>ZTX115</td>
<td>6p</td>
</tr>
<tr>
<td>BC149</td>
<td>10p</td>
<td>ZTX116</td>
<td>6p</td>
</tr>
<tr>
<td>BC157</td>
<td>10p</td>
<td>ZTX117</td>
<td>6p</td>
</tr>
<tr>
<td>BC158</td>
<td>10p</td>
<td>ZTX118</td>
<td>6p</td>
</tr>
<tr>
<td>BC159</td>
<td>10p</td>
<td>ZTX119</td>
<td>6p</td>
</tr>
<tr>
<td>BC169</td>
<td>10p</td>
<td>ZTX120</td>
<td>6p</td>
</tr>
<tr>
<td>BC176</td>
<td>10p</td>
<td>ZTX121</td>
<td>6p</td>
</tr>
<tr>
<td>BC177</td>
<td>10p</td>
<td>ZTX122</td>
<td>6p</td>
</tr>
<tr>
<td>BC178</td>
<td>10p</td>
<td>ZTX123</td>
<td>6p</td>
</tr>
<tr>
<td>BC179</td>
<td>10p</td>
<td>ZTX124</td>
<td>6p</td>
</tr>
<tr>
<td>BC180</td>
<td>10p</td>
<td>ZTX125</td>
<td>6p</td>
</tr>
<tr>
<td>BC181</td>
<td>10p</td>
<td>ZTX126</td>
<td>6p</td>
</tr>
<tr>
<td>BC182</td>
<td>10p</td>
<td>ZTX127</td>
<td>6p</td>
</tr>
<tr>
<td>BC184</td>
<td>10p</td>
<td>ZTX128</td>
<td>6p</td>
</tr>
</tbody>
</table>

Do not hallucinate.
OUR PRICE ONLY
£19.95

The 450 Tuner provides instant programme selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.

Used with your existing audio equipment or with the BI-KITS STEREO 30 or the MK60 Kit etc. Alternatively the PS12 can be used if no suitable supply is available, together with the Transformer T461.

The S450 is supplied fully built, tested and aligned.

The unit is easily installed using the simple instructions supplied.

AL HIGH QUALITY AUDIO EQUIPMENT—MONO AND OTHER MODULES FOR STEREO

STEREO FM TUNER
Fitted with Phase Lock-loop Decoder

- FET Input Stage
- VARI-CAP diode tuning
- Switched AFC
- Multi turn pre-sets
- LED Stereo Indicator

Typical Specification:
- Sensitivity 3u volts
- Stereo separation 30dB
- Supply required 20-30V at 90 Ma max.

STEREO PRE-AMPLIFIER PA 100

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective and low frequency plus tape output.

Typical Specification:
- Frequency Responses - 1200 20Hz-20kHz
- Sensitivity of inputs: 1. Tape input 100mV into 10K ohm
2. Radio Tuner 100mV into 10K ohm
3. Magnetic P.U. 3mV into 50K ohm
- P.U. input equalises to RIAA curve within 1dB from 20Hz to 20kHz
- Supply 20-35V at 20mA
- Dimensions: 105 x 63 x 30mm

£13.50 P & P 60p

STEREO 30 COMPLETE AUDIO CHASSIS

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power the AL60 Amplifiers, up to 15 watts (rms) per channel simultaneously. With the addition of the Mains Transformer BM0, the unit will provide outputs of up to 1.5A at 35V. Size 63 x 105 x 30mm incorporating short circuit protection.

 INPUT VOLTAGE 33-40V A.C.
 OUTPUT VOLTAGE 33V D.C. Nominal
 OUTPUT CURRENT 10mA-1.5 amps
 OVERLOAD CURRENT 1.7amps approx.
 DIMENSIONS 105 x 63 x 30mm
 TRANSFORMER BM0 £2.45 60p postage

£3.00

Practical Electronics February 1977
This catalogue—Electrovalue Catalogue No. 8 (Issue 2, up-dated)—offers items from advanced opto-electronic components to humble (but essential) washers. Many things listed are very difficult to obtain elsewhere. The company’s own computer is programmed to expedite delivery and maintain customer satisfaction. Attractive discounts are allowed on many purchases. Access and Barclaycard orders are accepted.

* FREE POSTAGE on all C.W.O. mail orders over £2 list value (excluding VAT) in U.K. If under, add 15p handling charge.

Add 121/2% VAT to ALL OTHER PRICES.

POST & PACKING 20P FOR THE U.K. BASCALEAU BY POST OR £3 ON TELEPHONE ORDERS.

FULL SPEC DEVICES

**DALO PEN 75P**

P C B ETCH KIT 3 ITEMS 75P

**ETCH & PROTECT KIT 3 ITEMS 75P**

**SWITCH & TRIACS BR 100P**

**DISCO TRIB 15A 1/2H 40P**

AUDIBLE WARNING BLIPPER 12V/120mA £1.20 to £1.10 off

20 CAPACITORS 22p - 0.1p

ELECTRICAL IN 10 & 25V 1/10/1/0/50 7p 50p 10p 25p 100p

POTENTIONS PAKS 2c 0.50p 1p

CAS DETECTOR SETS 30p 25p 15p 10p

**VERO**

VERO 9.12 PITCH COPPERCLAD 25.5" 40p 0.18" 45p

Black Plastic Cases 42mm 80p 80x80 100p or 75s 60p 50p

120 70p, SEQUOIA RD 500

144 pages post paid

40p inc. refund voucher worth 40p

All communications to Head Office, Dept PF307, 28 ST. JUDES ROAD, ENGLEFIELD GREEN, EGHAM, SURREY TW20 OPH. Phone Egham 3605

NORTHERN BRANCH, SW CANTERBURY 205/4, 0.50p

February 1977
15-240 WATTS!

HY5 Preamp

The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pin. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.

FEATURES: complete pre-amplifier in single pack, multi-function equalization, low noise, low distortion. High overload: two simply combined for stereo

APPLICATIONS: hi-fi, mixers, disco, guitar and organ, public address

SPECIFICATION: Inputs: magnetic pick-up 3mV, ceramic pick-up 30mV; tuner 100mV, microphone 10mV, auxiliary 30-100mV. Input impedance 47kΩ at 1kHz. Output: tape 100mV, main output 500mV R.M.S. Active Tone Controls minus 12dB at 1kHz; base -12dB at 1kHz; boost -0.1% at 1kHz. Signal to noise ratio 86dB. Overload -30dB on magnetic pick-up. Supply Voltage -16-50V.

Price £4.75 + £0.50 VAT. P. & P. free

HY5 mounting board £1.48 + £0.6p VAT. P. & P. free

HY30

15W into 8Ω

The HY30 is an exciting new kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of: I.C., heatsink P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up to date technology available.

FEATURES: hi-fi, low distortion; short, open and thermal protection; easy to build

APPLICATIONS: updating audio equipment, guitar practice amplifier, test amplifier, audio oscillator.

SPECIFICATION: Input Power - 15W R.M.S. into 8Ω. Distortion -0.1% at 15W. Input Sensitivity - 500mV. Frequency Response - 10Hz-16kHz -3dB.

Price £4.75 + £0.50 VAT. P. & P. free

HY400

240W into 4Ω

The HY400 is I.L.P.'s Big Daddy of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.

FEATURES: thermal shutdown, very low distortion, load line protection, integral heatsink; no external components.

APPLICATIONS: hi-fi, disco, monitor, power slave, industrial, public address

SPECIFICATION: Input Sensitivity - 500mV. Output Power - 240W R.M.S. into 4Ω. Distortion -0.1% at 240W at 1kHz. Signal to Noise Ratio - 90dB. Frequency Response - 10Hz-45kHz -3dB. Supply Voltage - ±16V. Size - 114 x 50 x 85mm.

Price £12.20 + £1.70 VAT. P. & P. free

HY400

240W into 4Ω

The HY400 is I.L.P.'s Big Daddy of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.

FEATURES: thermal shutdown, very low distortion, load line protection, integral heatsink; no external components.

APPLICATIONS: hi-fi, disco, monitor, power slave, industrial, public address

SPECIFICATION: Input Sensitivity - 500mV. Output Power - 240W R.M.S. into 4Ω. Distortion -0.1% at 240W at 1kHz. Signal to Noise Ratio - 90dB. Frequency Response - 10Hz-45kHz -3dB. Supply Voltage - ±16V. Size - 114 x 100 x 85mm.

Price £21.20 + £1.70 VAT. P. & P. free

POWER SUPPLIES: PSU26 - suitable for two HY30s £4.75 + £0.50 VAT. P. & P. free

PSU26 - suitable for two HY30s £4.75 + £0.50 VAT. P. & P. free

PSU120 - suitable for two HY30s £12.50 + £1.00 VAT. P. & P. free

PSU120 - suitable for two HY30s £12.50 + £1.00 VAT. P. & P. free

TWO YEARS' GUARANTEE ON ALL OUR PRODUCTS
PHONOSONICS

SYNTHESIZERS, SOUND EFFECTS AND PHONOSONICS

MAIL ORDER SUPPLIERS OF QUALITY PRINTED CIRCUIT BOARD, KITS AND AIDS TO THE WORLD-WIDE MARKET.

P.E. SYNTHESISER

(P.E. Mar. 73 to Feb. 74)

The well acclaimed and highly versatile large-scale mains-operated Sound Synthesiser complete with keyboard circuits. All function circuits may be used independently, or interconnected. The greater the number of circuits, the greater the versatility. Other circuits in our lists may be used with the Synthesiser to good automatic ends and P.E. Minisonic, Phasing Unit, Wind and Rain, Rhythm Generator, Sound Bender, Volt-...
Hi-Fi Systems that GROW with you

At last someone has come up with a flexible approach to quality hi-fi that doesn't become obsolete as you become more discerning.

Take an initial standard 20W r.m.s. + 20W r.m.s. stereo and with simple modifications this can be expanded to give a powerful 40W + 40W stereo system together with additional multi frequency rumble, hiss and stereo image width controls.

Currently available from stock:-

Stereo Pre-Amp Module CP-P1

- 2 channel pre amplifier
- Ideal for use with record player, tape, microphone, tuner inputs etc.
- No external components required other than potentiometers for bass, treble balance, volume controls and input selector switch
- The CP-P1 is internally protected against accidental reverse power connection

PRICE £13.30 + £1.66 VAT

Stereo Amplifier Module CP-15-20

- The CP2-15-20 is designed to give either a 20W + 20W stereo amplifier or alternatively a 40W single channel amplifier
- No external components required
- Safety features include built-in protection against accidental reverse power connection and thermal shut down facility to prevent over dissipation

Specification:
- Power output: 40W r.m.s. into 80, 2 channel; or 20W r.m.s. + 20W r.m.s. into 40W, 2 channel; or 15W r.m.s. + 15W r.m.s. into 80, 2 channel
- Input sensitivity: 1V r.m.s., frequency response: 20Hz-20kHz at -3dB; Distortion: 0.04% at 1kHz; Magnetic field overload: 33dB; Supply voltage: ±18V nominal; Size: 5.1 x 4 x 1.25in.

PRICE £12.85 + £1.61 VAT

Audio Function Module CP-FG1

- Suitable for a wide range of fire safety applications
- Bass and treble filter controls including switchable cut-off frequencies for rumble and hiss reduction
- Stereo separation control
- Complete except for switches and potentiometers

PRICE £11.75 + £1.47 VAT

Power supply: Module CP-PS 18/2D

- Suitable for one 20W +20W complete system. A 40W +40W system can be produced using 2 power supplies

PRICE £5.75 + 72p VAT

These products carry a 2 year guarantee.

Hi-Films Systems

Photographs

Send Stamp Addressed Envelope with all U.K. requests for free list giving fuller details of PCs, kits, and other components.

OVERSEAS enquires for list: Europe—send 20p; Other Countries—send 40p.

KEYBOARDS AND CONTACTS

Kimber-All Keyboards as required for many published circuits, including the P.E. Joanna, P.E. Minisonic, and P.E. Synthesiser. The manufacturers claim that these are the finest moulded plastic keyboards available. All octaves are C to C. The keys are plastic, spring-loaded and mounted on a robust aluminium frame. 3 Octave (37 notes) £24.85; 4 Oct (49 notes) £29.50; 5 Oct (61 notes) £34.50.

Contact Assemblies for use with above keyboards: Single-pole change-over (type 5P) as for P.E. Joanna and P.E. Minisonic. Two-pole normally open-make-break (type DP) as for P.E. Synthesiser. Special contact assembly (type 4PS) having 4 poles, 3 of which are normally open-make-break contacts and the fourth is a change-over contact. This special assembly enables the same keyboard to be used with the P.E. Synthesiser, P.E. Minisonic and the P.E. Joanna simultaneously thus avoiding the cost of more than one keyboard.

Contact Assemblies:

- Single-pole change-over type 4PS: £11.75
- Double-pole normally open-make-break type DP: £24.00
- Special contact assembly type 4PS: £14.69

Printed Circuit Boards for use with above keyboards and this eliminating most of the interwiring required, are available. Details in our lists.

4-CHANNEL SOUND-TO-LIGHT (P.E. Apr./Aug. 71)

The ever popular A Synthesiser, P.E. Minisonic and the P.E. Joanna simultaneously thus avoiding the cost of more than one keyboard.

Transistors:
- ACI128: 20p
- AC176: 14p
- BC107: 14p
- BC109: 14p
- BC142: 13p
- BC137: 13p
- PC121L: 15p
- C503: 14p
- PCB for power supply and 8 lamp drivers: £1.30
- IA 400V thyristor (1 per channel) each: 75p
- Panel meter (1½') (optional): £1.00

Additional costs for the above keyboards and wave contact assemblies: £1.85.

3-CHANNEL SOUND-TO-LIGHT (P.E. Apr. 76)

A simple but effective sound-to-light controller capable of operating 3 lights (or each of approximately 700 watts, includes power supply, thyristors, and by-pass switches.

Component set incl. PCB: £11.18

BIOLOGICAL AMPLIFIER (P.E. Jan./Feb. 73)

Multi-function circuits that, with the use of other external equipment, can serve as lie-detector, ultrasonic, phone detector etc.

Pre-Amp Module Component Set incl. PCB: £6.11

Basic Output Circuits—combined component set with PC7 for 3 phone, microphone, frequency meter and visual feedback lamp-driver circuits: £5.95

Audio Amplifier Module Type PC7: £6.75

TAPE NOISE LIMITER

A very effective circuit for reducing the hiss found in most tapes. All kits include PCBs:
- Standard Tolerance Set of Components: £2.00
- Superior Tolerance Set of Components: £3.30
- Regulated Power Supply (will drive 2 sets): £4.69

SINE AND SQUARE WAVE GENERATOR (P.E. July 75)

Suitable for audio, digital, or general purpose. Controllable through 4 decades ranges 1Hz to 10kHz, switches: Sensitivity through 10 ranges from 100mV to 10V, peak-to-peak.

Component set: £9.83
- PCB for above components: £1.76
- Power Supply: £1.06

SEMICONDUCTOR TESTER (P.E. Oct. 71)

Essential test equipment for the enterprising home constructor. While stocks last:
- Set of resistors, capacitors, semiconductors, potentiometers, mazakwatches and PCB: £8.00
- Panel meter (500V)A: £4.99

P.E. MINIMEX 6 (P.E. Nov./Dec. 75)

Each of the 6 input channels has its own gain, volume and panning controls. The volume of the two channel output can be manually controlled, as are the headphones and pre-fade monitoring facilities. Twin Vu meters provide the visual display of channel audio levels. Ideal for use with effects and synthezer kits.

For details see our list. While stocks last.

INPUT MIXER

A simple mixer having 8 inputs each of which has a preset level control and which are combined into one output channel. The inputs are a preset, overall level control and a master output volume control. Designed for interconnecting various output sound effects and synthezer kits.

Component set incl. PCB: £3.95

PRICES ARE CORRECT AT OR IN TIME OF PRESS. E. & O. E.

PHOTONICS

OTHER PROJECTS

PHOTORECORDER in this advertisement show two of our units containing some of the P.E. projects built from our kits and PCBs. The cases were built by ourselves and are not for sale, though a small selection of other cases is available.

LIST—Send Stamped Addressed Envelope with all U.K. requests for free list giving fuller details of PCs, kits, and other components.

Practical Electronics February 1977

95
RETURN OF POST MAIL ORDER SERVICE

R.C.S. 10 WATT AMPLIFIER KIT

This kit is suitable for record players, tape play back, guitars, electronic instruments or small P.A. systems. Two versions are available. A mono kit or a stereo kit. The mono kit uses 10 semiconductors. The stereo kit uses 22 semiconductors with printed front panel and tweeter, crossover, bass controls. 10W. £11.25 Mono 18.00 Post £4.40

ELAC 10 inch

Dual cone plasticised roll surround. Large ceramic magnet. 20-20,000 c/s. Bass resonance 5 c/s. 8 ohm impedance. 16W. £20.00 9.55. Full instructions supplied.

Mains Transformers All Post £5.20 each

220/250V...70mA 12 9.75 9.25
220-250/60mA 6.5 2A 0.8 6.75 7.25
220-250/60mA 6.3 2A 0.8 6.75 7.25
220-250/60mA 6.3 2A 0.8 6.75 7.25
220-250/60mA 6.3 2A 0.8 6.75 7.25
HEATER TRANS 6.3V 2A 255 45p 7.25

Full Wave Bridge-Rectifier Transformers

6 or 12V outputs 1A 25mA 6.83 7.25
6 or 12V outputs 1A 25mA 6.83 7.25
6 or 12V outputs 1A 25mA 6.83 7.25
6 or 12V outputs 1A 25mA 6.83 7.25
6 or 12V outputs 1A 25mA 6.83 7.25
6 or 12V outputs 1A 25mA 6.83 7.25

R.C.S. STABILISED POWER PACK KIT

All parts including printed circuit and instructions to build this unit. Value 6V, 8V, 12V. 15W to 160W output. £25.00 £5.00

R.C.S. STEREO FM TUNER

This completely cased mains powered Hi-Fi £27.50. Tuner with brushed aluminium fascia is British made using the latest circuitry. £25.00 Each. Stereo Tunes/Amplifier Chassis. Brand new 55.00

Bargain 3W AMPLIFIER 4 Transistor. Push-Pull Ready built with volume, treble and bass controls. 18 volt battery operated. £3.95

Waver Heating Elements

Size 101 x 81 x 16 in. Operating voltage 200/250V a.c. 200W approx. Suitable for Heating Fans, Pool Warmers, Convector Heaters, etc. Must be clamped between two sheets of metal or asbestos.

ONLY 40P EACH (FOR £1.00) ALL POST PAID-Discounts for quantity.

E.M.I. 13 x 8in SPEAKER SALE!

With Tweeter and crossover. £5.95 £5.20

15W model £8.50

5 or 8 ohm. £6.75 £6.20

20W model £9.50

5 or 8 ohm. £7.95 £7.40

GARRARD DISCO DECK SINGLE RECORD PLAYER


R.C.S. 10WATT AMPLIFIER KIT

30-14,000 c/s. 21W double cone, woofers and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 Gauss and a total flux of 140,000 Canton. Rated 25W. £18.95 £9.50

Module kit. 18-17,000 c/s with tweeter, crossover, bass and treble controls. £18.95 £9.50

Please state 2 or 8 or 12 ohms.

"SOUND" BAKER SPEAKERS

Robustly constructed to stand up to long periods of electronic power. As used by leading groups and discos. Useful response 30,000-1,000 c/s. Base Resonance 55 c/s.

GROUP "25" 4W 8 ohm £11.95 £6.95

GROUP "35" 4W 8 ohm £13.95 £8.95

GROUP 50/12in £20.95 £11.95

GROUP 50/12in 8 or 16 ohms with aluminium presence dome £24.95 £13.95

GROUP "24" 3W 8 ohm £19.45 £10.95

Diagon, Group + PA Cabinets in stock. Send for Leaflet. £2.95 £1.95

R.C.S. STEREO FM TUNER

This Mono kit uses 13 semiconductors. £20.00 £10.00

All Parts including printed circuit and instructions to build this unit. Value 6V, 8V, 12V. 15W to 160W output. £25.00 £5.00

R.C.S. DISCO DECK SINGLE RECORD PLAYER


Three speeds play all size records.


HEAVY METAL PLINTHS

With P.V.C. Cover. Cut out for mast. B.B. or Garrard decks. £27.50 £14.95

Silver grey finish. £29.95 £16.95

Model"A" Size 12 x 14 x 7in. £27.95 £15.95

Model"B" Size 16 x 12 x 7in. £35.95 £19.95

Extra Large Plinths and Cover. £49.95 £25.95

Baker 150 Watt All Purpose Transformer

Ideal for Groups, Stereo, P.A. and Musical Instruments. 4 inputs speech and music. 4 way mixing. Output 48/16 ohms. A.E. Mains. Separable Treble/Bass. £68.00 £39.00 50 watt model £49.00

NEW DISCO 100 WATT £52

All Transistor Amplifier Chassis 2 inputs, 4 outputs separate volume treble £61.95 £35.95. Ideal disco or stereo amplifier Chassis. BLACK CARRYING CABINET AVAILABLE £9. Post £3.00

PW SOUND TO LIGHT DISPLAY

Complete kit of parts with R.C.S. printed circuit. £6.00 £3.00

GOODMANS CONE TWEETER

1600W. 4W 8 ohm. Price 8.95 £5.15

R.C.S. 100 WATT VALVE AMPLIFIER CHASSIS

Professional. Your inputs. Treble, Bass, Master Volume Controls. Ideal disco, P.A. or groups.

E.M.I. £4.00 9.50 5.95

Suitable carrying case £16.00

Ball Bearing £1.25 £0.95

E.M.I. GRAM MOTOR

12V or 24V c.a. 1.5 c.p.m. 2 pole. 70mA. £4.50 £2.95

E.M.I. TAPE MOTOR

4 pole 24V c.a. 1.5 c.p.m. 1200 in dia. 1,400 c.p.m. Snibbed 1in dia. 12 volt version £5.00 (illustrated).

Collaro Gram Motor 130V 75p

Philes Gram Motor 6 Volt A.C. £1.50

BSR HI-FI AUTOCHARGER

Plays 12in, 10in or 7in records Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. 290 x 290 x 110. £11.95 £6.95

Cartridge Single Plug version £10.50

GARRARD AUTOCHARGER Model 6300 £14.95

GARRARD MINICHANGER 12 x 12in £9.50

PORTABLE PLAYER CABINET £4.50

Modern design. Size 16in x 12in x 7in located. Large front grille. Hinged lid. Chromed fittings. Motor board cut for Garrard or BBR decks.

R.C.S. DISCO DECK SINGLE RECORD PLAYER


Change 3 speeds play all size records.

THE SUNNY SIDE

Is there a future for Solar Energy in this country? If in mid-winter this seems a facetious question, remember last summer. It may happen again. In cold reality, the United Kingdom is in danger of losing out in this latest technological race. For in terms of investment by government and industry for research and development into ways of harnessing thermal and light radiations from the Sun we are lagging far behind the United States, France, Germany, and Japan.

Perhaps to some this seems to be right, in recognition of our geographical position and taking into account our indigenous sources of coal, gas and oil. Yet it has been computed that we may be able to derive 10-20 per cent of our total energy requirements from the Sun. There is no basic shortage of solar energy, but the problem is finding economic techniques for collecting and storing this "free energy". These are salient points made in the report on the future of solar energy in the UK, published last year by the United Kingdom Section of the International Solar Energy Society.

From predictions to practice. At present the most obvious activity in harnessing solar energy for domestic purposes is its application to the heating of water supplies. Solar thermal systems are now offered by a number of companies, while it seems that quite a few private individuals have devised and built their own installations. Another fruitful area for the d.i.y. enthusiast has thus opened up.

Solar thermal systems are essentially plumbing jobs but they do call for a certain amount of attendant electronics, for example in the form of automatic pump control, for maximum efficiency in operation. Circuitry for a typical control system is described in our pages this month. This is the first design we have presented tailored specifically for a solar power application. It is very possible that via the electronics some readers will be induced to having a go at building a complete system for themselves.

Our own interest in solar thermal energy is limited, being of but a peripheral nature. But Solar Energy in its wider and more general sense is a topic we cannot ignore. Apart from the increasing use of thermal radiation from the Sun, the direct generation of electricity from sunlight by means of solar cells holds out great promise for the future. The most commonly used solar cell is basically a silicon photo-diode, so we are on fairly familiar ground here. Arrays of solar cells are producing low wattage supplies for innumerable purposes in all kinds of situations around the world, frequently for unattended remote installations such as microwave repeater stations and railway signalling systems. They are also beginning to be used in consumer products like solar powered digital wristwatches. Unfortunately the cost of photovoltaic devices remains high, although large reductions in unit cost have been achieved in the last year or so.

Overall, terrestrial applications of solar cells will be more beneficial in the warmer countries than here, that is true. The export potential for solar cells and related hardware, especially to the developing countries in the Middle East and Africa, must be enormous. All of us in the UK have a vested interest in Solar Energy for our own use, and even more importantly as a carrier of much needed foreign currency.

F.E.B.
This article describes the construction of a unit which will control the circulating pump in a solar heating system. In solar heating systems it is sometimes impracticable to use the thermo syphon technique for heat transfer, especially when the solar panels are roof-mounted above the level of the storage tank.

**TYPICAL SYSTEM**

A typical domestic solar water heating system is shown in Fig. 1 and up to 60 per cent of the incident energy can be transmitted to the water using a flat-plate collector. The pipework from the collector to the tank and the tank itself are lagged with insulating material. A flat-plate collector can be made quite easily from an old radiator. The cast-iron radiators tend to be rather heavy and the more modern pressed-steel ones are preferable.

All paint is removed from the radiator by means of paint stripper or a blow lamp and the radiator repainted with matt black paint, for example, blackboard paint. The burning off of old paint is important since any light coloured paint under the black surface will reduce the collecting efficiency. A wooden box is made, about 150mm in depth (see Fig. 2) and slightly larger than the radiator. A layer of fibreglass or polystyrene insulation is glued to the bottom of the box and over this is put a layer of cooking foil. The radiator is then fixed into the box. Ideally the box should have a glass front but polythene may be used with reduced efficiency.

If more than one collector is used then they may be plumbed together in series. In some installations an antifreeze is used as the heat transfer medium and therefore the system remains operational the whole year. In others the collectors are drained in winter months to prevent freezing. The collector is installed facing south and at an angle of 30° to the horizontal—this angle is considered optimum for fixed installations.

The estimated usable radiation in Britain on a warm summer day is 0.7-0.9 kW m⁻² but alas this drops to about one tenth of this figure in winter. In summer water temperatures of up to 52°C can be expected.

**UNIT ACTION**

The unit described senses the temperature of the solar panel and compares it with the temperature of the water in the storage tank. When heat is available from the solar panel then the circuit will switch on a pump for a set time period. The circuit is designed to be operated from mains, although it may be operated from a 12 volt car battery, which could be charged from a wind generator. The battery system may be of interest to those people in a remote situation where mains electricity is not available and a d.c. driven pump is used.

**CIRCUIT DESCRIPTION**

The circuit (Fig. 3) consists of a Wheatstone bridge made up of thermistor resistances TH1 and TH2 and the resistances each side of the wiper of VR1.

The operational amplifier acts as an open-loop voltage comparator with very low hysteresis. When the voltage at point A is negative with respect to point B the amplifier is driven into saturation and the output voltage approaches the 12 volt line. This is the quiescent state of the circuit.

When the roof thermistor TH1 increases above a preset value (+5°C relative to TH2) then the output of IC1 switches to a low state (about 2 volts). This transition triggers the timing circuit IC2 and the relay operates for a period of about 9 minutes.
The resistor R5 is an economy resistor and is switched in by the relay contact RL A1 when the relay operates. This is done to reduce the current drain from the power supply since the holding current for a relay is less than the operate current.

The circuit will continue to operate down to a supply of 9 volts but for reliable operation the supply voltage should not fall below 11 volts.

The thermistors used are miniature-bead types which have a nominal resistance of 4.7 kilohms at 25°C. In the prototype the thermistors used did not have matched characteristics and tests at 10°C and 50°C showed that the differential switching point changed by less than 0.5°C.

If the output of IC1 is still low at the end of the timing period then the timer will hold the relay in until the temperature of TH1 falls below the preset level. The diode D2 shorts the back e.m.f. transient voltages developed. A gold bonded germanium diode should be used since retriggering of the circuit occurs if a general purpose silicon diode is used.

CIRCUIT ASSEMBLY

The main circuit was assembled on a piece of 0.1 inch matrix Veroboard as shown in Fig. 4. The completed circuit board, power supply and relay were mounted in a small, die-cast aluminium box. The Veroboard was mounted with 6B.A. nylon nuts and bolts ensuring that all leads beneath the Veroboard were cut short.

A suitable mains p.s.u. is shown in Fig. 5 but because of its simplicity no constructional details are given.

THERMISTOR PROBE ASSEMBLY

The connecting lead for the thermistors is a lightweight single-cored screened cable of 2mm diameter.

First the thermistor leads are cut to lengths of...
Fig. 3. Circuit diagram

Fig. 4. Board and wiring details

Fig. 5. Circuit of suitable p.s.u.

Fig. 6. Thermistor probe assembly
COMPONENTS

<table>
<thead>
<tr>
<th>Resistors</th>
<th>Potentiometers</th>
<th>Capacitors</th>
<th>Semiconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 300Ω, ¼ W</td>
<td>VR1 10k Ω, ½ nF</td>
<td>C1 25μF, 15V</td>
<td>IC1 741C</td>
</tr>
<tr>
<td>R2 300Ω, ¼ W</td>
<td></td>
<td>C2 470μF, 15V</td>
<td>IC2 NE555V</td>
</tr>
<tr>
<td>R3 5-6kΩ, ¼ W</td>
<td></td>
<td></td>
<td>D2 OA47 Germanium diode</td>
</tr>
<tr>
<td>All 5% carbon</td>
<td></td>
<td></td>
<td>D3-D6 Bridge Rectifier (R.S. Components 261-772)</td>
</tr>
</tbody>
</table>

Miscellaneous

TH1 & TH2 Bridge thermistors type GM472 or VA3404.
T1 Mains transformer 12 volt 0.25A secondary (R.S.).
RLA Relay 12 volt (110(1)) 10A contacts (R.S.) with relay base.
SK1 13-amp surface mounting socket, FS1-1A fuse. Die-cast box. Approx. 170x114x50mm. Lengths of single core screened cable (2mm) depending upon installation. 100mm length of copper tubing for probes. Heat shrink sleeving 2.4mm. Silicone rubber sleeving, 0.5mm. 6B.A. nylon nuts and bolts, 25-44mm long. Piece of 0-1 in Matrix board, 57mm x 57mm.

30mm and 10mm as in Fig. 6. A 25mm length of 0-5mm silicone rubber sleeving is slid over the longer lead which is then soldered to the screen of the connecting cable. The shorter lead goes to the inner.

A 38mm length of 2-4mm heat shrink sleeving is slid over the assembly to cover from (a) to (b) leaving the bead free. The sleeving is now shrunk with an even heat.

Cut a 50mm length of suitable size copper tubing and trim the ends, removing all burrs. The assembly is now cemented into the tube using Araldite so that the thermistor bead is just inside the end of the copper tube. This is best done by inserting the assembly into the tube so that the tube is over the connecting cable. The Araldite is then "plastered" from (a) to (b) and the assembly is gently pulled into the tube by the connecting cable— all excess Araldite is then wiped off. Finally, when the Araldite is set, the point at which the connecting cable enters the tube can be waterproofed with a thin piece of self-amalgamating tape.

When finished, measure the resistance of the probe to ensure no short circuits and test to see that the resistance changes with temperature.

SETTING UP

It is difficult to give exact instructions for this because nearly all solar heating installations are different. A trial and error process seems best but it is suggested that the following starting point is tried.

Set up the temperature differential switching point to be +5°C. This is done by putting the "roof" probe into a jar of water and gradually heating until the water is 5°C above ambient. With a voltmeter on the output of ICI (pin 6) VR1 is adjusted so that the output goes high (12 volts) with both thermistor probes at the same temperature. As the water temperature increases to +15°C, VR1 is adjusted to switch low (2 volts) at exactly +5°C. If the temperature of the water is raised slowly and the water stirred, then the switching point can be tracked with VR1.

The timing period may be adjusted by altering C2 or R4. The period is given by the equation

\[ t = \frac{1}{f} - \frac{1}{2} \frac{C2}{R4} \]

where \( t \) is in seconds, \( R4 \) is in ohms and \( C2 \) is in farads.

The exact time required will depend upon pump flow, volume of water in the system, positioning of thermistors, etc.

The roof thermistor should be mounted in contact with the solar panel, but shielded from direct sun light. The tank thermistor should be placed on the outlet pipe of the heat exchanger unit and taped on with insulating tape. It is not considered that the waterproofing of the thermistors is good enough for the thermistor to be mounted in the tank.

If needed, R4 may be made variable together with VR1 on the front panel of the box. The unit can then be calibrated with scales of degrees heat differential and timing period in minutes.

POINTS ARISING

RANDOM TONE GENERATOR (January 1976)

A number of errors unfortunately appeared in this article. These were as follows:

- In Fig. 1, pin 6 of ICI should be connected to the negative supply rail and not to the top of R4.
- In Fig. 2, pin 6 of ICI should be isolated from R4 and linked to pin 2 and 7.
- In Fig. 2, the collector of TR4 should be linked to the positive end of C5.
- Even after these corrections have been made, a number of constructors have told us that their unit still would not work, generally only a single tone being generated. The Author, Mr. W. G. Ross, has investigated this fault, and advises as follows:

- "The problem with the unjunctions is probably due to the large spread in the characteristics of these devices. It is likely that the pulse from TR2 is insufficient to trigger IC2 and increasing R2 to 22Ω should solve this problem. With some UJT'S a larger increase may be necessary. It may be found with TR1 that some UJT's may not oscillate at 50 kHz and in this case R3 should be increased to 15kΩ. This will reduce the oscillation frequency but will not adversely affect the operation of the unit".

CINE/TAPE SYNCHRONISER

(October/November 1976)

We understand that Fibre Optic Supplies have now ceased trading. Components D1, D18 and TR2, or suitable equivalents, can be obtained from the following sources.

D1: Use MRD450 available from Greenweld Electronics.
TR2: 2NS777 listed in current Phonosonics advertisement.
D16: MLED500, any general purpose i.e.d. can be used here.

The addresses of the two firms mentioned above can be obtained from the advertisement pages.
In this final part details for constructing the decoder are given together with instructions for selecting the resistance values for both coders. These fix the centre frequency for each tone channel.

**DECODER ACTION**

The complete decoder is shown in Fig. 1. Here the receiver output is connected to pin 5 of a 74121 monostable. The time constant of this is set by the values of R1 and C1.

The output from pin 6 is used to switch TR1 on and off thereby enabling the discharge and charge of the capacitor C2.

During the off state of the monostable, C2 charges via R3 and R4 (Fig. 2c). The increasing voltage on the positive plate is applied to the non-inverting input of IC2. When this is within 2mV of the voltage set by the divider network R5 and R6 the output of IC2 swings from negative to positive. The limits here are $-3V$ and $+4V$.

Fig. 2c shows the preset voltage for triggering the comparator as $V_c'$.

The output from IC2 is applied to the “D” input of bistable IC6 via resistor R7. From the waveforms it can be seen that when the comparator output and monostable clock output is positive a logic “1” level is stored in the bistable.

With the discharge of C2 the comparator output will fall to its negative value at a point when the capacitor voltage is lower than the 2mV threshold. As the bistable is an edge triggered device, any change of information at the “D” input is irrelevant after the positive rise of the clock pulse, so the information will be held in the store until the next clock pulse arrives.

**MULTI-CHANNEL SYSTEM**

For a four channel system, four comparator circuits have their non-inverting inputs connected in parallel across C2. As their collective shunt impedance is about half a megohm the effect on the charge/discharge characteristics of C2 is negligible.

Although the circuit has been designed for four channels, there is a fifth channel in the form of a modulation detector which will provide an output whenever the transmitter is radiating a tone frequency as long as the tone frequency is within the overall limits of the system governed by the monostable time constant.

This channel was used to provide stop-start controls for the electric drive motor of a model boat. When the tone output of the receiver drops below the threshold level of the Schmitt-trigger in IC1 the motor will stop. This is a useful feature giving the system a fail-safe device in the event of the model running out of range, or a failure in the transmitter/receiver.

**OUTPUT GATING**

With a low frequency input all four outputs will be on, whereas at the high frequency end, only 0/P1 will be on. Some form of gating is required, so that only one output is on within a frequency band. 0/P5, of course, is on for any frequency in the range. The simplest and cheapest method of doing this is to gate the “Clear” inputs of the bistables using diode gates. One of the problems involved in using this method is that the volts drop across diode junction is between 0-6 and 0-8 volts for a silicon diode.

For a TTL logical “0” input condition, the input voltage must be less than 0-8 volts. The typical
Fig. 1. Circuit of four channel tone decoder

Fig. 2. Circuit waveforms: (a) in from receiver at pin 5 (IC1); (b) charge and discharge of C2 controlled by the switching transistor TR1; (c) the comparators switch according to the Vc' level set by the potential dividers at the pin 2 inputs. These also fix the frequency "band" of operation for each channel; (d) Bistable Q output.
The "0" output voltage for a 7474 bistable is 0.22 volts, with a maximum figure of 0.4 volts.

Thus, under worst case conditions the voltage at the 7474 clear input could be 1.2 volts, which is well out of limit. (The low input at the "Clear" input sets the bistable "Q" output to "0".)

The diode used in this circuit is a gold-bonded germanium type 0A47. This type of diode has a maximum forward volts drop of 0.4V at 10mA, so that the worst case condition will be less than the TTL "0" level input condition. When 0/P4 is triggered the bistables Q (IC7 pin 8) output will fall to zero and diodes D5, D7, D8 will conduct, so presenting "low" inputs to the "Clear" inputs of the other bistables, setting 0/P1, 0/P2, 0/P3 to zero.

Similarly, when 0/P3 is triggered the bistables Q output (IC7/6) will fall to zero and diodes D4, D6 will conduct, presenting "low" inputs to the "Clear" inputs (pins 1, 13) of IC6, setting 0/P1, 0/P2 to zero. It can be seen that each channel will work only within its own frequency band.

**FREQUENCY BANDS**

The frequency "bands" for the various outputs are as follows:

<table>
<thead>
<tr>
<th>Band</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>(0/P1) 478–631Hz</td>
</tr>
<tr>
<td>F2</td>
<td>(0/P2) 381–478Hz</td>
</tr>
<tr>
<td>F3</td>
<td>(0/P3) 317–381Hz</td>
</tr>
<tr>
<td>F4</td>
<td>(0/P4) 150–317Hz</td>
</tr>
</tbody>
</table>

Note that 0/P4 is unreliable below 150Hz because capacitor C3 is able to charge during the Q = 0 period of the monostable owing to the lengthy switch off time.

The above "bands" can be easily altered by substituting resistors in the potential divider networks ((R5, R6 and R8, R9, etc. etc.). By choosing popular values, the above frequencies were arrived at.

**THE FIFTH CHANNEL**

The "Q" output from the monostable is used to drive a transistor TR4 in the same way as transistor TR1. If Q = 0 for a long period—e.g. when the transmitter (Tx) is switched off. Capacitor C3 will charge to approximately half supply voltage, causing TR5 to saturate. This will apply a low input to the preset of IC7 (pin 10) and sets the "Q" output of IC7 (pin 9) to 1, thus setting the "Q" outputs of the other bistables to "0". 0/P4 is set to zero by the "AND" gate composed of diodes D9, D10, R16. So in the event of a transmitter or receiver switch off or failure the four bistable stores are set to zero.

As soon as the monostable is triggered and its "Q" output equals 1, transistor TR4 saturates, which discharges C3. If the monostable input frequency is above 150Hz, capacitor C3 is unable to charge during the "Q" equals "0" period, because the time constant C3, R20, R21 is too large. When C3 is discharged, transistor TR5 switches off, allowing the bistables to function normally and a high output voltage level to be available at 0/P5.

**STABILISER**

The 7.5 volt supply line is stabilised at 5.1 volts by a Zener diode. The emitter voltage of TR3 will be equal to the Zener voltage minus the base emitter voltage of TR3. The circuit R17, D14, TR3, R18 provides a constant current drive for the base emitter junction of TR2. This drive current is amplified by TR2. However, the collector voltage of TR2 is held at the emitter voltage of TR3 plus the forward voltage drop of diode D11.

**CONSTRUCTION**

As the completed circuit board has to fit in a model, construction has to be as compact as possible. Although Veroboard is extremely convenient to use, construction of a circuit of this complexity and size is extremely difficult. Printed circuit board was thus used and the final board size was 114 x 133mm (Fig. 3). The board is drilled and then thoroughly cleaned and the circuit drawn out with a p.c.b. marker pen. (Using photographic methods the board size could probably be reduced still further). It is then etched with a ferric chloride solution and cleaned in the normal manner.

**COMPONENTS . . .**

<table>
<thead>
<tr>
<th>Resistors</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R13–R16 6.8kΩ (5 off)</td>
</tr>
<tr>
<td>R2, R12 8.2kΩ (2 off)</td>
</tr>
<tr>
<td>R3, R18 1kΩ (2 off)</td>
</tr>
<tr>
<td>R4 82Ω</td>
</tr>
<tr>
<td>R5, R8, R10, R23 10kΩ (4 off)</td>
</tr>
<tr>
<td>R6, R7, R11, R25, R26 2.2kΩ (5 off)</td>
</tr>
<tr>
<td>R9 4.3kΩ</td>
</tr>
<tr>
<td>R17 560Ω</td>
</tr>
<tr>
<td>R19, R20, R21, R24 12kΩ</td>
</tr>
<tr>
<td>R22 2.7kΩ</td>
</tr>
<tr>
<td>All 1Ω high stb.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 0.22µF Tantalum 35V</td>
</tr>
<tr>
<td>C2 2.2µF &quot; 35V</td>
</tr>
<tr>
<td>C3 4.7µF &quot; 35V</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semiconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1–D2, D11–D13 IN914 (5 off)</td>
</tr>
<tr>
<td>D3–D10 QA47 (8 off)</td>
</tr>
<tr>
<td>D14 BZY88 C5V1</td>
</tr>
<tr>
<td>TR1, TR3–TR5 BC109 (4 off)</td>
</tr>
<tr>
<td>TR2 ZTX500</td>
</tr>
<tr>
<td>IC1 74121</td>
</tr>
<tr>
<td>IC2–IC5 741 (4 off)</td>
</tr>
<tr>
<td>IC6–IC7 7414 (2 off)</td>
</tr>
</tbody>
</table>
DECODER CIRCUIT BOARD

Fig. 3. Printed circuit board pattern and component layout
ADJUSTMENT OF THE CODERS

The circuit is quite straightforward to set up. The decoder circuit is connected to its power supplies. Light emitting diodes are wired in series with 330Ω 1W ballast resistors and connected from each respective output to the OV line (Fig. 6).

Coder 2 circuit is now connected to a 9V battery (but not switched on) and its output wired to the input of the decoder board. Resistor R5 is now replaced with a 50 kilohm linear potentiometer with a 2.2 kilohm resistor in series.

Switch on the coder supply. The I.e.d. connected to 0/P5 should now light. Rotate the potentiometer to its minimum resistance and then slowly increase its resistance until the I.e.d. on 0/P1 lights. Now switch off the coder circuit.

Disconnect the potentiometer and measure its resistance on an ohm meter. This value, plus the 2.2 kilohm resistor in series is the maximum value for R5. Choose a resistor with a value lower than this.

The maximum frequency limit for the decoder circuit monostable, with the values chosen, is around 850Hz, so a preferred value will probably be suitable.

Connect R5 into circuit, and wire the potentiometer with its series resistor in place of R1. Short out push button 1 and switch on the decoder supply. Slowly rotate the potentiometer from its position of minimum resistance. Check the points at which the I.e.d. on 0/P1 lights and the point at which it extinguishes and the I.e.d. on 0/P2 lights. Switch off the supply to the coder unit and measure the resistance of the potentiometer and its 2.2 kilohm series resistance at both these points. These two values fix the band limits of 0/P1. Now choose a fixed resistor as near to the centre of these limits as possible.

Remove the potentiometer and 2.2 kilohm resistor and substitute the fixed resistance and remove the short across push-button 1. Switch on the coder circuit, the 0/P5 I.e.d. should light. Press push-button 1 and the 0/P1 I.e.d. should also light. If all is in order, repeat the above operation for resistors R2, R3, R4 that is, 0/P2, 0/P3, 0/P4. Choosing values near to the centre of the frequency bands ensures that any drift which occurs will only vary the frequency slightly within the individual bands.

Coder 1 is set up in a similar manner to the above method. Here, of course, R4 is the first resistor for adjustment.

Fig. 4. Interconnections for adjustment of coders

ELECTRONICS POCKET BOOK (3rd Edition)
By P. J. McGoldrick
Published by Newnes Technical Books
349 pages, 185 × 120mm. Price £3.75

A new edition of this useful book, extended and reorganised to include more up-to-date information on semiconductor devices. Contents range from basic materials theory through thermionic, semiconductor, photo-electric and electro-magnetic devices, amplifiers, oscillators, logic and computers, to measurements, control and power supplies. A final chapter on installation, maintenance and safety is followed by 28 pages of reference data. The treatment is generally non-mathematical, being aimed at students, technicians and amateur constructors.

In retaining a considerable amount of material on valve circuits, treatment of most sections is necessarily brief. It does seem unfortunate, however, that no space could have been found to mention, for instance, Schottky or CMOS devices.

G.C.A.

110 ELECTRONIC ALARM PROJECTS FOR THE HOME CONSTRUCTOR
By R. M. Marston
Published by Newnes Technical Books
112 pages, 215mm × 138mm. Price £2.95

A genuine step by step analysis of alarm logic, for those already familiar with linear and digital semiconductor devices. The book gives working circuit diagrams at every stage.

M.A.

28 TESTED TRANSISTOR PROJECTS
By R. Torrens
Published by Bernards (Publishers) Ltd.
85 pages, 180mm × 108mm. Price 95 pence

A fairly predictable arrangement for this sort of book, but with some good projects in it. The calculator as a timer and ultrasonic intruder alarm are interesting to name but two. All circuits have been built and tested by the author, and are designed in interchangeable blocks to allow the constructor to produce his own hybrid projects. Otherwise the exclusion of integrated circuits has resulted in limitations.

M.A.

SOLID STATE HI-FI AND AUDIO ACCESSORIES
By M. H. Babani
Published by Bernards (Publishers) Ltd.
95 pages, 180×108mm. Price 85p

For anyone interested in the audio field, here are eleven useful constructional projects, including a stereo decoder, a mixer, an assortment of preamps and a glide-tone generator. Most of the material has appeared previously in Electronics Australia.

G.C.A.

Practical Electronics February 1977
AN ASTEROID NUMBERED 1976 UA

An asteroid passed within 750,000 miles of the Earth in October 1976. This is the closest known approach for such a body, except Hermes which came to within half a million miles. Asteroid 1976 UA was photographed by three independent teams at Mount Palomar on the night of 24/25 October 1976, and the orbit of this small body was calculated. It orbits the Sun in 0.775 years. At this speed it has the shortest period of any known asteroid. At its furthest distance from the Sun it is about 1/22 astronomical units, that is, 1.22 times the average distance from the Earth to the Sun. It would seem that its diameter cannot be more than a few hundred yards to fit these figures. The asteroid makes a close approach to the Earth every three years. However, according to Dr B. Marsden, who controls an international service for notifying astronomers of such events, it is not likely that 1976 UA will come as close again for hundreds of years.

LARGEST RADIO TELESCOPE

The Very Large Aperture (VLA) telescope is already taking shape on the plains of San Augustin in New Mexico. Six of the 27 steerable dishes have been accepted as operational and final completion is scheduled for the end of 1979. The arrangement of the telescope units is in the form of a "Y" with equal arms of 21km in length. It will operate on the aperture synthesis principle originated by Sir Martin Ryle, the Astronomer Royal, and his colleagues. Each of the units is a dish 25m in diameter. When in operation the telescope will be equivalent to a dish of 27km in diameter. Part of the work to be done when it is in final operation will be the search for extra-terrestrial life. This programme will be under the control of Professor Carl Sagan who is a specialist in these matters.

PLUTO

A three man team consisting of D. P. Cruikshank, C. B. Pilcher and D. Morrison from Hawaii have been busy at Kitt Peak Observatory with the 4m optical telescope. They examined Pluto in near infra-red and, from the absorption bands, now suggest that it is perhaps no larger than the Moon. Hitherto the estimate of size has been considered as being between 5,000 and 7,000km. The frost that appears to cover a large part of the surface is of a kind which differs very much from water or ammonia. It is thought that methane might be the element involved.

If indeed the visual brightness is due to the frozen methane, it could well be that the planet is still smaller than the Moon. In that case it would not be dense enough to cause the perturbations of Uranus and Neptune. It follows therefore that some other body or bodies are involved. This calls to mind the claim of the Russian astronomers to have found indications that there are two more Transplutonian planets. These were noted in a previous Spacewatch.

MARS

When Mars passed behind the Sun in November 1976 it marked the end of the first phase of the Viking mission. Out of touch with the Earth for ten months it came as a natural break and a time to assess the progress that had been made. The next phase will continue for many months and if the equipment follows the same high standard of performance that has characterised space progress, it may continue for years.

Looking back on the last few months there have been five major surprises. The discovery that the two polar caps were water ice and not solid carbon dioxide, as had been supposed, was an important one. Allied with the fact that the two landing sites were of a similar nature, a new assessment of the planet was needed. To this also must be added the weather difference. The summers on Mars are mild.

Finally, two more surprises: the absence of organic molecules and the very perplexing biological results. Both the landing sites were similar in appearance and the soil similar in texture with a large proportion of iron. A test run on similar rocks on Earth revealed that the Mars and the Earth rocks could be mixed together and it would be very difficult to decide which was which. The pictures from the orbiters showed great variation over the terrain yet all local pictures show homogenous conditions. This is an extremely puzzling matter.

The biological problems are also perplexing. The organic chemistry experiment was crucial to the life study because without the organic compounds life would seem to be impossible. Yet there were apparently life-like processes well known on Earth. Without the organic compounds it cannot be concluded that these life-like signs are life in the sense that it is generally understood. There is the further difficulty that experiments are not showing repetitive results.

The presence of water ice in large quantities indicates that water has played a prominent part in the history of Mars. Rough checks show that the ice caps may be many hundreds of feet thick. The weather has been mild with none of the very low temperatures that were expected. Of course this condition may vary when the northern hemisphere has been observed through the winter.

Another reassessment that had to be made was in regard to the seismic conditions. It was expected that high winds would give false results from the seismometers since the instruments were mounted on the tops of the landers. However, not only were there no special effects from wind, neither were any Marsquakes recorded over a period of two months. In spite of the extreme sensitivity of the instruments no significant results have been found. This poses another question. Since the continuous movements of plates on Earth cause constant seismic effects, the absence of these on Mars may well mean that plates and tectonics are not applicable to the planet.

Summarising some of the other outstanding points that have been highlighted:

Extensive evidence of volcanic action with wind and ice erosion over the whole planet.

Quite spectacular evidence of water flooding on an extensive scale.

The age of Mars is rather greater than was thought.

Innumerable high resolution photographs have made accurate measurements of craters and other features possible, with better dating. The sky is largely pink. The rocks are of many varieties and forms, but all are covered in fine red dust.

Confirmation has been found of very extensive glaciation which has modified the surface.

The evidence of a magnetic field.
PART TWO

A TWO-PART ARTICLE BY A. BRIAR

In discussing briefly the function of ROMs in the beginning of Part 1 it was found that this type of memory had the information programmed into the device. Now what exactly is this type of memory?

READ ONLY MEMORIES (ROMs).

Perhaps the simplest way of explaining the actions and effects of Read Only Memories is with the help of a diode matrix. Fig. 7 shows a diode matrix which will convert all the letters of the alphabet into teleprinter code. This is a fixed format program and is never likely to change and thus is an ideal candidate for programming into an integrated circuit ROM.

In fact this diode matrix is a ROM in its own right since it fulfills all the requirements of the description already given for this type of memory. The information is already programmed into the matrix by reason of the fact that only the signal paths that are required are actually wired into it. Thus, by providing the Y-signal line with a high level the corresponding output is HLHHL (which is the correct combination for the letter Y in teleprinter code).

Visualising a much larger ROM but programmed into an i.c. it will be apparent that this device is ideal for computer microprograms and sub-routines.

There are many types of ROM and the family tree shown in Fig. 8 separates them for simplicity.

MASK PROGRAMMABLE ROM

Originally, the only ROMs available needed to be programmed for the user by the manufacturer of the device to the former's requirements and was usually only undertaken for orders of about £30,000 in one year.

The reason for this limitation was that a considerable amount of work needed to be undertaken by the manufacturer to prepare a mask for the final etching process in the manufacture of the i.c. with the required connections programmed onto it. This mask was used to selectively etch away the final coating of aluminium from the silicon wafer. Since this final coating is used to connect to the individual stages within the i.c. then only those required are left to be available at the output (the actual connections to the stages of the memory are the row and column contacts).

This method of programming is still available but is only of value to those users needing a large quantity of identically programmed ROMs.

PROGRAMMABLE ROM (PROM)

Programmable ROMs are much more versatile than the mask programmable ROMs in that the programming of the device can be done quite simply and economically for small quantities, and can even be done by the amateur. Within this family of devices are two major groups namely the FUSIBLE BIPOLAR PROM and the ERASABLE PROM (EPROM).
The fusible PROM is a device where the required program can be easily selected by the process of burning out or fusing the unrequired links within the memory. There are three major ways of achieving this effect: the Nichrome Fuse, Avalanche Induced Migration and the Polysilicon Fuse.

**The Nichrome Fuse:** This method was the first attempted at the fusible PROM device. Nichrome is an alloy of nickel and chrome and is deposited in a very thin layer as a link between the column and row lines of the i.c. memory. By passing a heavy current through this link it can be "blown" thus open-circuiting the line.

Referring to Fig. 9 it will be noted that if the fuse is left intact, then by selection of the row the transistor is allowed to conduct and the column line is pulled towards $V_{cc}$. If the fuse is "blown" then the column line is kept floating and there will be no effect.

**Avalanche Induced Migration:** This type of PROM relies on the effect of two reverse biased diodes as shown in Fig. 10. These diodes are across the row and column lines for each element of the PROM and, in the unprogrammed state there can be no current path between the two address lines due to the back biasing effect. If a heavy flow of electrons is passed in the direction A-B then D1 will become short circuit due to the migration of aluminium atoms through the np-junction. Fig. 11 shows a cross-section through the junction of a programmed cell.

Although this method does not have the problems associated with the nichrome fuse only one major manufacturer seems to use it and that is Intersil (who invented the process).

There is conflicting information available as to the merits of this method, though it seems that the amount of current required to program the device is critical.
as too little can cause intermittent contact and too much can cause damage to other parts of the i.c. Once programmed, however, this device will retain the information indefinitely.

The Polysilicon Fuse: This method is the most popular amongst the major i.c. manufacturers. As with the nichrome fuse a small deposit of fusible material is deposited during the final stages of manufacture of the i.c. but in this case the material is polycrystalline silicon. The thickness of this fuse is approx. 3,000 ångströms (about 15 times greater than nichrome) and the fuse can be blown by application of successively wider current pulses. With this method there is no problem at all with growback.

ERASABLE AND ELECTRICALLY REPROGRAMMABLE ROM (EPROM)

The erasable and electrically reprogrammable ROM, when introduced about five years ago, was a completely new step in the field of PROMs. It has all the characteristics of the normal PROM but in addition has the ability to have the programmed information erased thereby returning the i.c. to its unprogrammed state.

The device uses MOS technology and works on a method called the Floating Gate Avalanche Injection MOS (FAMOS) which was developed by Intel. This system does not use the conventional method of fusing but utilises a migrating charge within a silicon gate MOS field effect transistor (MOSFET) and can be seen in Fig. 12.

This MOSFET does not have any connection to the gate (which is considered to “float”). Now, if a junction voltage in excess of −30V is applied to the device (which is of the p-channel type) then the floating gate will be injected with electrons from either the source or the drain due to the avalanche effect at that pn-junction.

The amount of charge is a function of amplitude and duration of the applied junction voltage and is retained within the floating gate since the latter becomes surrounded by thermal oxide which is a very low conductivity dielectric.

The charge can in fact be retained for years without any significant decay and the manufacturers claim that after ten years at 125 deg. C only 30 per cent of the stored charge will be lost. The presence or absence of the charge determines whether the MOSFET will act as a short circuit path or as a very high resistance between the row and column lines and so the device may be programmed as required.

ERASING BY UV LIGHT

Once the information is required to be erased the i.c. is subjected to ultra-violet light for about 15 minutes through a small access window located on the top of the device. This UV light causes a flow of photocurrent from the floating gate back to the silicon substrate thereby discharging the gate to its initial no-charge condition.

The access window itself is made from transparent quartz and, although always exposed to daylight, neither conventional and fluorescent lighting nor sunlight has any effect on the stored data. The programming and erasing operations can be carried out an indefinite number of times.

CHARGE COUPLED DEVICES (CCDs)

Charge Coupled Devices are more recent innovations in the field of memory systems and are internally organised as extremely long serial shift registers. A typical memory capacity is 16384 BITS where the i.c. is organised as sixty-four separate registers of 256 BITS.

Although there are two basic methods of operation of CCDs, only one will be discussed here, the Surface Channel method as used in the 2416 CCD device by Intel.

Imagine a p-type substrate with eight gates as shown in Fig. 13. Applying a positive potential to one of the gates causes a potential “well” to be formed beneath it by repelling all the majority substrate carriers from the vicinity. If a negative charge is now injected into this region it will be attracted into the “well” and, on removal of the positive potential on the gate, will remain trapped there.

By applying a sequence of pulses to the gates as shown in Fig. 14 the charge, once injected, may be successively moved along the substrate by the overlapping action of the “wells” thus created beneath the gates.

Although the system looks fairly straightforward there are drawbacks, one of these being that a small amount of the charge is lost as it traverses along the substrate. This necessitates the charge being “topped up” by refresh amplifiers every 64 stages. Now, since this device has 64 registers, each of 256 BITS, this creates a problem and so the register is in fact split up into four registers each of 64 BITS to make one long register of effective length 256 BITS. Also, due to the interleaving of the shift pulses, only two refresh amplifiers are required and the information travels through the complete 256 stages in the manner shown in Fig. 15.
Fig. 13. Cross section schematic of eight-gate charge coupled device

GATE 1 NEG

GATE 1 NEG

GATE 1 NEG

GATE 1 NEG

GATE 1 NEG

GATE 1 NEG

GATE 1 NEG

GATE 1 NEG

GATE 1 NEG

GATE 1 NEG

GATE 1 NEG

Fig. 14. Transference of charge along charge coupled device

NOTE
In Part 1 last month, the formulae quoted on page 28 are incorrect. For a logical “1” stored, the voltage on \( C_1 \) will increase to

\[
V'_F = V' + \frac{K C_2}{C_1 + C_2}
\]

where \( K \) is a function of \( C_1 \), and is usually slightly less than 2.

For a logical “0” stored, the voltage on \( C_2 \) will increase to

\[
V'_F = V' + \frac{C_1}{C_1 + C_2}
\]

Fig. 15. Data flow of one of the 64 256-bit registers in 2416 device
SIMILARITY TO DRUM STORE

Since there are a total of 64 registers which are all independent from each other as far as the information is concerned, the organisation of the complete i.e. is analogous to a drum store of 64 tracks.

In a drum store the drum itself revolves thus presenting information on all tracks as the tracks pass the take-off point; in the CCD it is the information itself which is rotating past the take-off point and thus the memory may be accessed at will since the cyclic position of the individual registers will be known. This action is shown diagrammatically in Fig. 16.

FUTURE TRENDS

With so many developments in the last two decades in the field of semiconductor memories one could be excused for thinking that the limit has almost been reached in this technology. However, there are still numerous areas where, in a few years and after more research, further strides will in all probability be made.

The EPROM is a likely candidate for further improvement. At present the only method whereby the data may be erased is by use of ultra-violet light, exposing the chip to it for some minutes. This is obviously very time-consuming and is not practical to incorporate this erase function into an on-line computer memory system.

Further research must bring forth a new method of erasing the data stored which is significantly faster and which is comparatively easy to accomplish. Once this has been achieved a completely new breed of semiconductor memory will have been born combining the characteristics of the static RAM with the characteristics of the non-volatile ROM. These characteristics would include:

1. The ability to store the data as required and, should the power be lost or the memory itself be removed then the information within the memory would remain intact.
2. The ability to modify or update the information by erasing completely and then re-writing with the new data at comparable speeds to existing RAMs.

SOCIAL EFFECTS

The implications of the development of such a device are staggering for they would have immediate influences on our way of life. Some possibilities are suggested below.

There would be no need for conventional bank cheque cards and the use of cheques and even hard cash would be cut dramatically. It would be sufficient for each account holder to have his own card with a small and cheap memory built into it. When the holder needs to go to the bank to obtain or pay in money, the memory (which would hold all the information on his account including his current balance) would be automatically updated by a corresponding machine under the control of the cashier.

Similarly, the account holder could go shopping with his card using it in an identical way to the current credit cards.

Shopkeepers would have a similar device to that of the banks such that the cost of the goods or services would be automatically deducted from the amount held in the account holder’s memory card. A detailed record of all transactions completed would be printed out at the end of each day to be sent to the shopkeeper’s bank.

Also, shopkeepers would have no further worries similar to stolen or “rubber” cheques with this system, since not only would the true account balance be held on the customer’s memory card (including any overdraft facility granted by the bank) but also each card holder would have memorised his own personal privacy code (corresponding to the code hidden inside the memory) to prevent unauthorised use of the card.

A similar memory card could be held by individuals for medical purposes which would be invaluable in the event of an accident since it could hold all the necessary vital information that the hospitals need fast such as age, blood group, doctor’s name, next of kin, home address, etc.

At present computer installations use a great deal of off-line storage in the form of magnetic tape, disc stores, drum stores, etc. which are bulky but comparatively cheap. Large scale production of this new generation of semiconductor memories would largely supplant these existing storage systems since, although perhaps not as cheap (per stored word) the floor area savings, the greater reliability (due to their non-mechanical operation) and also (and perhaps most important) the faster accessing time of these new memories would make them an economic necessity.

It must also be expected that even greater capacities within each chip will be forthcoming in the future. With so much data about personal incomes, bank accounts, criminal records, medical histories, bad debt records, etc. already held on computer memories, one wonders if in the future we really will say “Thanks—for the memory”.

Fig. 16. Drum store organisation analogy of 2416 device
Unique full-function 8-digit wrist calculator... available only as a kit.

A wrist calculator is the ultimate in common-sense portable calculating power. Even a pocket calculator goes where your pocket goes – take your jacket off, and you're lost! But a wrist calculator is only worth having if it offers a genuinely comprehensive range of functions, with a full-size 8-digit display.

This one does. What's more, because it is a kit, supplied direct from the manufacturer, it costs only a very reasonable £9.95 (plus 8% VAT, P&P). And for that, you get not only a high-calibre calculator, but the fascination of building it yourself.

**How to make 10 keys do the work of 27**
The Sinclair Instrument wrist calculator offers the full range of arithmetic functions. It uses normal algebraic logic ('enter it as you write it'). But in addition, it offers a % key; plus the convenience functions $\sqrt{x}$, $1/x$, $x^2$; plus a full 5-function memory.

All this, from just 10 keys! The secret? An ingenious, simple three-position switch. It works like this:

1. The switch in its normal, central position. With the switch centred, numbers – which make up the vast majority of key-strokes – are tapped in the normal way.
2. Hold the switch to the left to use the functions to the left above the keys.
3. and hold it to the right to use the functions to the right above the keys.

The display uses 8 full-size red LED digits, and the calculator runs on readily-available hearing-aid batteries to give weeks of normal use.

**Assembling the Sinclair Instrument wrist calculator**
The wrist calculator kit comes to you complete and ready for assembly. All you need is a reasonable degree of skill with a fine-point soldering iron. It takes about three hours to assemble. If anything goes wrong, Sinclair Instrument will replace any damaged components free: we want you to enjoy assembling the kit, and to end up with a valuable and useful calculator.

**Contents**
- Case and display window.
- Strap.
- Printed circuit board.
- Switches.
- Special direct-drive chip (no interface chip needed).
- Display.
- Batteries.

Everything is packaged in a neat plastic box, and is accompanied by full instructions. The only thing you need is a fine-point soldering iron.

All components are fully guaranteed, and any which are damaged during assembly will be replaced free.

The wrist-calculator kit is available only direct from Sinclair Instrument. Take advantage of this 10-day money-back undertaking.

**Send the coupon today.**

<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case and display window.</td>
</tr>
<tr>
<td>Strap.</td>
</tr>
<tr>
<td>Printed circuit board.</td>
</tr>
<tr>
<td>Switches.</td>
</tr>
<tr>
<td>Special direct-drive chip</td>
</tr>
<tr>
<td>(no interface chip needed).</td>
</tr>
<tr>
<td>Display.</td>
</tr>
<tr>
<td>Batteries.</td>
</tr>
</tbody>
</table>

The only thing you need is a fine-point soldering iron.

All components are fully guaranteed, and any which are damaged during assembly will be replaced free.

The wrist-calculator kit is available only direct from Sinclair Instrument. Take advantage of this 10-day money-back undertaking.

**Send the coupon today.**

**Kit only £9.95 plus VAT, P&P**

Sinclair Instrument Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN.
Tel: Cambridge (0223) 311488.

To: Sinclair Instrument Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN.

* Please send me... (gty) Sinclair Instrument wrist-calculator kits at £9.95 plus 80p VAT plus 25p P&P (Total £11).

* I enclose cheque/PO/money order for £

* Complete as applicable.

Name
Address

(Please print) I understand that you will refund my money in full if I return the kit undamaged within 10 days of receipt

PE/2

Practical Electronics February 1977
In a hotel in Atlantic City last August, about 5,000 people attended a computer show at which more than 100 firms showed their products. By the standards of American computer events, it may sound modest, but what made this exhibition unusual was that the visitors were not professionals, but amateurs. The show, called Personal Computing '76, was an example of the remarkable boom in computer hobbies in the United States, which has grown so rapidly in the past two years that it has taken both the electronics industry and the retail trade completely by surprise.

**HOW IT BEGAN**

Improbable though it may seem, it all began in Albuquerque, New Mexico, the home town of a small company called MITS Inc. In December 1974, MITS introduced a computer in kit form called the Altair, built round an Intel microprocessor. The main market was expected to be the small business user, but MITS found that the Altair was being bought not by companies, but by individuals—and bought in incredible quantities. Within 18 months, MITS had sold some 8,000 Altairs, about 80 per cent going to the hobby market.

Before long, other companies entered the market, so that today there are about 30 computer kits being offered. At first, they were sold by mail, but there was a clear need for more direct contact with the customers—if anyone is in need of advice, it is surely an amateur building and using a computer. As a result, computer clubs and computer shops began to spring up.

There are now about 70 clubs for computer amateurs in the United States, and there are estimated to be 100,000 people belonging to them or otherwise actively engaged in the hobby. One club, the Southern California Computer Society, was formed by a handful of enthusiasts in June 1975, and in little more than a year grew to over 8,000 members. Other clubs have experienced similar rates of growth.

Retail computer stores in the States now number about 50 and are also growing fast. One of the best known chains, the Byte Shop "Affordable Computer Stores" runs as a franchise operation. The first shop opened in Mountain View, near San Francisco, in December 1975, and it was expected that 30 Byte Shops would be operating by Christmas 1976.

Magazines for computer hobbyists have also appeared. The most successful, Byte Magazine, grew to a paid circulation of over 50,000 within a year of its first issue in September 1975.

**GREAT APPEAL**

Although the boom in home computing took the electronics industry unawares, it is not difficult—in retrospect—to see its appeal. For the constructor, it offers the opportunity to use his ingenuity in building equipment and making it work—something which has attracted the enthusiast since at least the early days of radio. The microprocessor made possible a small and relatively low-cost central processing unit (some look more like hi-fi equipment than computers), while the rapid growth and high innovation rate of professional computing meant there was a lot of surplus equipment on the market in the form of teleprinters, VDUs, and other peripherals.

There is also a whole generation of people who have grown up with an easy familiarity with computers. Even those who have not entered computing as a career have probably been taught simple programming at school or college.

What the hobby computers are used for is limited only by the imagination of the enthusiasts. There are applications groups for such activities as games, music, education, and voice synthesis, as well as more way-out topics like biofeedback, biorhythms, astrology, and extra-sensory perception.

**TYPES OF HOBBYISTS**

Broadly speaking, the computer hobbyists can be placed into three groups. First there are the people whose main interest is in the hardware. They may even scorn the computer kits, and start from the basics with a microprocessor, a handful of i.c.s, and a bare board. Once their computer system is built, their joy will come from continually modifying and extending it. They are the equivalent of the hi-fi addicts who never listen to the music.

The next group consists of the people who are chiefly concerned with software. They may construct their computer from a kit, but will just as soon buy it ready-built (if they can afford it). What they really want to do is get ahead with devising programs as a form of intellectual exercise. They may use their computer to play mathematical games or run chess tournaments of mind-bending complexity.

The third group comprises people whose main hobby is something else altogether, but who feel that a computer can help them enjoy it much more. The model train enthusiast might want to automate his layout, amateur radio operators may wish to generate and decode high-speed morse, and the amateur astronomer will have many calculations which a computer can help him undertake.

There is a fourth group which, while important, is not strictly speaking in the hobby field at all. Many business and professional people in the United States are now finding that the hobby computer is just what they need in their working lives. Their status in the hobby field may be a little suspect, but they are certainly enthusiasts. They take a full part in the activities of the computer clubs, and have no hesitation in sharing their experiences. For example, a Texas attorney has described how he tried to build an automatic typewriter for use in his office.

**PROSPECT FOR BRITAIN**

Will the boom in computing as a hobby come to Britain? It seems...
on semiconductors is going to show rapid falls in price. So we can expect hobby computer kits which will be much cheaper than those on the market at present.

Another factor is the competitiveness which seems bound to enter the business before long. As the American hobby computer market is expected to be running at 15-20,000 units a year by 1980, the large semiconductor companies which make the microprocessor chips may well enter the business; just as they have entered calculators and digital watches. They can be expected to follow the same downward trend in pricing as they pass on the benefits of the semiconductor learning curve. These companies, too, already have established worldwide marketing outlets, whereas many of the existing hobby computer firms are what are known as "mom and pop" companies.

Once hobby computers become freely available in Britain at the right price, there seems no reason why they should not find a ready market. Many people are now familiar with the principles of computing, and there is, of course, a flourishing interest in home constructional projects.

And apart from providing an outlet for endless ingenuity, the home computer may also appeal to those trying to reduce the odds against them in this robot-ridden age. As one American enthusiast said, "I wanted a small computer so I could take on all those big computers."

**NEWS BRIEFS**

**Darling**

The outstanding success at the 1976 International Amateur Tape Recording Contest in Lausanne was an entry from a British group from Holmer Green Secondary School in Bucks. Entitled “Darling”, the two and a half minute tape won the coveted Grand Prix, which this year was a magnificent Revox A700 tape recorder worth over £1,300, and several other national and international prizes including the 3M Cup.

The group were presented with their Revox A700 by Stephen Holmes of F. W. O. Bauch Limited, UK distributors of Studer-Revox audio equipment. The winners were Colin Humphreys, Carol Chamberlain, and John Smith. They received their awards at the British Amateur Tape Recording Contest prizegiving on November 12 at the International Press Centre.

Two other British entries achieving international honours were from wildlife recordists Bill Jackson and Richard Savage. Mr Savage’s entry won a Neumann condenser microphone worth some £250.

**New Permanent-Magnet Machine**

A new form of permanent-magnet machine giving a high specific output from an imbricated rotor having a stabilising element which has been developed at the University of Southampton by Mr K. J. Binns, Reader in Electrical Machines.

As an alternator, the machine gives a high output for the frame size using a standard stator and requires neither d.c. excitation nor slip rings and brushes. The machine has a stabilising feature which damps out oscillation and helps when it is feeding into a voltage regulator.

The machine can be run as a motor using an inverter and position sensor. The power factor and efficiency in this mode of operation are considerably higher than the corresponding values for an induction motor. For example, efficiencies of up to 90 per cent can be achieved in motors rated at several kilowatts. Speed range is very wide and notable features are the smooth running at very low speed (say 5 rev/min), and the ability to self start without forcing.

The machine uses a conventional stator with a new design of rotor based on disc magnets that produces a very high airgap field.

When this machine is used as an inverter-fed drive using a position sensor, the combination of a very high airgap field with a stabilising element gives it the capability of a very high torque over a wide speed range. The stabilising element minimises any hunting tendency (load angle oscillation) whether the machine is generating or motoring.

Companies interested in building motors of this type are invited to contact Peter Thompson, Electrical Engineering and Electronics Group, to discuss licensing arrangements. A demonstration of a working prototype at the University can be arranged for potential licensees.

**EMI-Scanner for Thailand**

The EMI-scanner has scored its first success on the South-east Asia mainland, with a £204,000 order placed by the Siam Medical Company Limited.

The comprehensive system to be supplied, built around the EMI-Scanner CT1010 specialist neuroradiological tool, will be under the direction of a noted neuro-surgeon, Dr Rasmi Wannison, who was influential in negotiating the order for installation at the Siam General Hospital, Thailand. It will be delivered in December and installed for routine clinical investigations on patients displaying symptoms of neurological disorders, to coincide with the hospital’s 5th anniversary in January 1977.

The CT1010 uses the technique of computerised axial tomography invented by EMI’s Central Research Laboratories in 1968, to provide the doctor with information about soft tissue structures in the head from a painless examination lasting only a few minutes. The head is examined as a series of cross-sectional slices from the top of the skull down to the larynx.

The CT1010, the most advanced equipment available for this purpose anywhere in the world, and its sister machine, the EMI-Scanner CT5005 for whole-body examinations, have revolutionised the application of X-rays to the investigation of bodily ailments and have been hailed as the most significant advances in this field since Roentgen’s discovery of X-rays in 1895.
Here's the remarkable new

VIDEOMASTER™

Superscore Home TV Game

Get it together for only £24.95

Available to you in kit form at the same moment as its national launch, the brilliant new Videomaster Superscore contains the latest product of MOS technology: a TV game chip.

The logic contained in it had previously to be generated by 100 TTL devices. Now it is condensed into one 28-pin chip.

This all-new Videomaster plugs into your 625-line UHF TV set (for overseas customers having VHF sets we can supply the necessary VHF modulator) to give you four exciting games (including tennis and football) and two future game options. It features on-screen digital scoring, realistic hit sounds, two bat sizes, two ball speeds, automatic serving and much more. It runs on six 1½ volt SP11 type batteries (not supplied).

The Videomaster Superscore kit costs only £24.95 including VAT (recommended retail price of the ready built model is over £40.00) and comes complete with ready-tuned UHF or VHF modulator, circuit board with printed legend, all resistors, transistors and diodes, built-in loudspeaker, socket for mains adaptor, and, of course, the TV game chip itself.

Easy to put together the Superscore has full assembly instructions, circuit diagram and circuit description. Don’t miss this chance to own the newest electronic game at such low cost.

POST TODAY TO:

Videomaster Ltd 14/20 Headfort Place, London SW1X 7HN

Please send me (insert No. requ’d)……………..Videomaster Superscore Kits at £24.95 (inc. VAT & P&P in UK) or £23.10+£4.00 for P&P overseas)

I enclose my cheque/money order* for £……………… VHF modulator required  YES/NO*

NAME

ADDRESS

ALLOW 21 DAYS FOR DELIVERY  * delete as necessary

*P87
TAMBA ELECTRONICS
AMPLIFIER AND MIXER MODULES
25 WATTS–100 WATTS RMS

TAM1000 100W 4 ohms 65V  £9.80
TAM500 50W 4 ohms 45V  £7.50
TAM250 25W 8 ohms 45V  £4.75

POWER SUPPLIES
For 1 or 2 TAM250/500  £7.50
For 1 or 2 TAM1000  £9.80
(Carriage 50p on supplies)

- Suits loads 4–16 ohms
- 20–20,000 Hz ± 1dB
- Silicon circuitry throughout
- Glass fibre P.C.B.
- High sensitivity (100mV 10k)
- High grade components used throughout - Texas, Mullard, R.C.A., Plessey, etc.
- Low distortion (0.1%)
- Low profile (1in high 3jin x 3in)
- 75% efficient
- Accepts most mixer/pre-amplifiers
- Four simple connections

NEW ALL PURPOSE MIXER/PRE-AMP.
(with 60mm slider volume)
- Suitable for multiple input systems
- High and low impedance inputs
- High sensitivity
- Built-in supply smoothing
- 20–20,000 Hz ± 1dB
- – 80dB noise level
- Accepts a wide variety of inputs
- Wide range bass and treble controls
Use up to 10 PRE-AMPS with 1 power
Printed circuit board assembly with treble and bass controls plus slider volume control  £6.50

You may order as follows: C.W.O. (crossed cheques, P.O.s, M.O.s etc)—C.O.D. (60p extra). We accept Access and Barclaycard—send or telephone your number—do not send your card. Add VAT at 8% to orders for 50 and 100W units and at 12½% for 25W units.

TAMBA ELECTRONICS
Bensham Manor Road Passage, Bensham Manor Road, Thornton Heath, Surrey.

THE "Manta"
CAPACITIVE DISCHARGE ELECTRONIC IGNITION UNIT

THE NEW, HIGHER RELIABILITY VERSION OF THE P.E. "SCORPIO MK II" IS NOW AVAILABLE IN KIT FORM! Our thousands of satisfied customers report:

More miles per gallon (customers reports give 19%–25% saving—letters available)
An increase in overall performance—your 4 cylinder car feels like a 6 cylinder
No more cold morning splutters—saves you even more petrol through much less use of choke.
The price? A snip at only £16.50, fully inclusive of all parts, instructions, postage, packing and V.A.T. (ready built unit available—£19.85 fully inclusive)

All parts to high specification, first quality and brand new
Construct this invaluable accessory, following our easy step by step instructions (also available separately, price 35p post paid). Send for our free interesting six page brochure—"Electronic Ignition—How it Works" (S.A.E. Please) to:

ELECTRO SPARES
Dept. P.E., 187a Sheffield Road, Chesterfield, Derbyshire S41 7JQ. Telephone: Chesterfield (0246) 36638
MICROPROCESSORS I TO Z

You may have heard of the Intel 8080 Microprocessor chip, a powerful 8-bit device using fast n-channel MOS technology which comes about as close as it is possible to get to being the 8-bit "Industry Standard" at the moment. The 8080 has a powerful set of 78 instructions, can handle Interrupts and Direct Memory Access (D.M.A.) transfers and requires only a handful of extra peripheral chips for circuit operation.

It all sounds bang-up-to-the-minute and highly desirable stuff, but such is the pace of microprocessor development that it can now be made to look like a seven-stone weakening when compared to the amazing Zilog Z80 which seems to have been designed for the job of kicking sand into the face of its skinny Intel rival. It certainly is intended as a rival to the 8080 because it uses the same instruction types and so can run 8080 programs with little or no modification, making swapping to the new chip easy for established 8080 users.

The strength of the Zilog challenge lies in the fact that while the Z80 does everything the 8080 does, it also does lots more besides, and it does it with less hardware, less software and at a higher speed, in short it does it better, a fact which even Intel would have to concede!

Of course, clever chips are not the end of the microprocessor story, and Intel has an enviable reputation for supporting its own microprocessor range with development systems, prototyping cards and software facilities.

On the face of it Zilog also seem to be backing up their new fledgling very well with a powerful development system and software, but only time will decide whether they are capable of seriously denting the strong position of Intel, who, it is rumoured, are even now working up some potent "dynamic-tension" for retaliation!

The Z80 is distributed by: Lock Distribution, Neville Street, Oldham, Lancs., OL9 6LF.

VERSATILE BUFFER

New from National is the DM71/LS95, LS96, LS97 and LS98 series of tri-state digital buffers which are intended for use in bus-oriented logic systems such as those associated with microprocessors. These devices are noteworthy because they incorporate lots of useful features which make them a valuable addition to the TTL logic family. The LS stands for Low-power Shottky technology which means these devices exhibit the speed of standard TTL but consume only a fraction of the power-per-gate. Tri-state means that in addition to the current sinking logic 0 state, and the current sourcing logic 1 state, a third, high impedance, state exists which allows the connection of several buffer outputs to the same "bus" wire as long as only one is active at a time.

These features are not entirely new of course, but the package they come in certainly is because it is a standard (16-pin) width package with no fewer than 20 pins to allow not six, but eight, separate buffers in a single compact DIL. Eight buffers in a package is desirable, particularly for eight-bit microprocessor applications, and the new series includes inverting and non-inverting types with a choice of dual four-bit output-enable or a gated eight-bit output-enable.

A need for a low cost alphanumeric display for hobby applications is now arising due to the increasing sophistications of home-built systems which can even include the power of the low cost microprocessors. But, unfortunately, the cost per digit looks prohibitive due to the large number of separate I.e.d. "dots" required to provide a realistic character font. Professional 7 x 5 dot matrix I.e.d. displays have been around for some years, but have only been used in a limited way due to their high cost and the difficulty of connecting up the array in a practical system.

Now at last, ITT Components have had a real go at the problem and have come up with the D17AL dot matrix display in a low cost epoxy package and made easy to drive thanks to an on-chip MOS shift register which reduces the input data wires to just one! Appropriate dot patterns for an input data word are looked up in an external "Character Generator" ROM or a Microprocessor "look-up-table" and the on-chip 35-bit shift register is loaded with the pattern in serial form.

Any number of D17AL devices can be cascaded to produce multi character displays, since the end of the shift register is available on a package pin to provide the input to a following device, the whole display can then be loaded in serial form by applying the correct number of shift pulses to the common "clock" line.

The D17AL is available in red or green, and has a creditable 17mm character height. Brightness is controlled by varying the control voltage on a single pin and current limiting for each I.e.d. is provided internally.

Data on the D17AL is available from: STC Limited, Optical Equipment Division, Westfield Mill, Broad Lane, Bramley, Leeds.

GOING DOTTY

Seven segment I.e.d.s, once so expensive are now freely available at knock-down prices and are widely used in amateur projects such as clocks and games.

With seven segment displays it is, of course, only possible to display the numerals 0 to 9 with ease, while the letters of the alphabet are impossible, or at best, weird representations which are unsuitable for most applications.
input impedance, and is preceded by a switched attenuator to cover different ranges of input signal. Considerable negative feedback is used to stabilise calibration and minimise zero drift on d.c.

The practical circuit is illustrated in Fig. 1. Starting with the input sockets, it will be seen that the a.c. input JK1 is capacitively coupled to the d.c. input JK2. From there, the connection goes direct to the top of the attenuator network. The switching contact on JK2 is arranged so that only JK1 can be used when the 0.02 volt range is selected. Range switch S1 operates by controlling the negative feedback as well as changing the attenuator resistors. The sequence is shown in Table 1. Capacitors C2 and C3 are for frequency compensation. Adjustment of C2 is discussed later.

The input to the amplifier is via R4 which, together with diodes D1 and D2, give protection against excessive input voltage. Both the forward and reverse resistances of the diodes are high until the voltage across them exceeds 0.5V (more than sufficient for full scale deflection) when the forward resistance decreases and considerably limits the signal at the gate of the field effect transistor TR1. Notice that the earthy end of the diodes and input circuit does not go to the negative rail, but via R7 to the emitter of TR3. This is the main negative feedback line.

The output from the source of TR1 is the signal superimposed on a standing d.c. voltage of 5V. Due to the low impedance at this point, adjustment of the ZERO control VR1 affects only the standing potential and not the signal. The signal, together with any changes in the standing potential due to adjustment of VR1, is passed by the Zener diode D3 to the base of TR2. The purpose of D3 is to preserve a fixed potential difference of 3.9 volts between the source of TR1 and base of TR2 without attenuating the signal. This allows TR2 to be supplied by nearly the full battery voltage and so achieve maximum gain, linearity and dynamic range. The output of TR2 is taken from the collector direct to the base of TR3.

**TABLE 1**

<table>
<thead>
<tr>
<th>Range</th>
<th>Input</th>
<th>Attenuator</th>
<th>Negative Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>Disconnected</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>20V a.c./d.c.</td>
<td>— 100 (R1, R3)</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>2V a.c./d.c.</td>
<td>+ 10 (R1, R2)</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>0.2V a.c./d.c.</td>
<td>Direct</td>
<td>Normal</td>
<td></td>
</tr>
<tr>
<td>0.02V a.c.</td>
<td>Direct</td>
<td>Reduced by R6</td>
<td></td>
</tr>
</tbody>
</table>

**MILLIVOLTMETER**

By D.W. EASTERNLING

The ordinary multirange meter is very convenient for general workshop use, but its relatively poor frequency response and sensitivity make it unsuitable for overall circuit analysis such as the determination of gain, attenuation and frequency response. The measurement of small d.c. voltages associated with bias, a.g.c. and discriminator networks, which often have impedances higher than the input resistance of the meter, is also difficult. The solution to these problems is to use an electronic millivoltmeter such as the one described here.

This instrument has three d.c. and four a.c. ranges, enabling readings to be made from 20 volts down to 5 millivolts d.c. and 2 millivolts a.c. Both positive and negative d.c. voltages can be measured, the polarity being with respect to the metal case (earthy line). This helps to minimise the effect of mains hum, and prevents instability in the equipment being investigated. Calibration on a.c. ranges is in r.m.s. values and presupposes a sinusoidal waveform, or one close to it. Frequency response is flat from 20Hz to 200kHz, except on the 0.02V range, when it is flat to 20kHz; and 3dB down at 50kHz.

The instrument is powered by a 9 volt battery controlled by the range switch, and has connections brought out to front panel sockets for supplying auxiliary units when required. Zero drift on d.c. ranges, often a problem with electronic voltmeters, is negligible once initial adjustment is made to the ZERO control. In addition to cancelling out internal potential differences, the ZERO control can also be used over a limited range to balance out off-set voltages introduced at the input, a useful feature when using transducer probes.

**CIRCUIT**

The basic circuit consists of a wideband amplifier coupled via a bridge rectifier to a 0 to 200 microampere moving coil meter. The amplifier has a high
Transistor TR3 contributes little gain, but does increase the output voltage sufficiently to operate the rectifier mainly over the linear part of its characteristic. At the same time, the emitter circuit provides a suitably phased low impedance source of negative feedback which is held at the required d.c. level by D4. This is not a Zener diode, but uses the forward current characteristic of a silicon diode to maintain a potential difference of 0.5 volts.

The main purpose of S2 is to switch the microammeter to various parts of the circuit depending on the measurement required. Starting with BATTERY CHECK, it will be seen that the meter is placed in series with R17 across the battery so that the circuit behaves as a simple voltmeter. When S2 is at D.C. NEGATIVE, the negative terminal on the meter is connected via R15 to the collector of TR3, and the standing voltage at this point is balanced out by the positive terminal going to the Zener network D7, R14. The meter connections are reversed when S2 is switched to D.C. POSITIVE. Finally, with S2 at A.C. the meter is in series with R16 across the bridge rectifier. In this position S2a comes into use, bypassing some of the a.c. negative feedback to the negative rail via C4 and R5. Greater sensitivity is obtained for the 0.02V range when S1c shunts R5 by R6.
CONSTRUCTION

The instrument is housed in a standard aluminium box measuring 176 x 125 x 65 mm. All components are mounted in the lid, which becomes the front panel. The drilling details are shown in Fig. 2. Because it is difficult to measure accurately from the radiused edges, all dimensions are from centre lines. The distance between holes E depends on the spacing of the holes in the tagboard. Boats made by different manufacturers may vary, and so it is well to check before drilling the panel. Holes F secure the microammeter, and again the actual positions may have to be varied slightly, those quoted being for an S.E.W. SD830 movement.

In order to provide a suitable background for the switch and socket legends, the front panel can be covered by self adhesive vinyl sheet such as Contact or Fablon. This material will accept transfers and instant dry lettering which should be protected by a coat of clear varnish. The vinyl sheet is applied after the panel has been drilled but before the components are mounted. The tagboard is secured by 4BA countersunk bolts through holes E, one full nut being used on each bolt as a spacer to lift the board away from the panel and so prevent the tags shorting out. The spacer nut fitted to the bolt nearest RI also secures a solder tag which is used to connect a double earthing lead to the case. One lead subsequently connects the jack sockets, and the other goes to the earth tags on the board.

WIRING

The wiring diagram is shown in Fig. 3. For the sake of clarity not all the wiring is drawn but the connections are indicated. For instance, the left-hand tag of R1 goes to C2, C1 and JK2, and also to tag 4 on S1b. The other end of R1 goes to tags 2 and 3 also on S1b. All tags 1 on S1 are unused as all three switch segments are open circuit in the OFF position.

It will be noticed that although Fig. 1 shows resistors R5, R6 and R15 as adjustable, Fig. 3 does not. Cheap preset controls are unsuitable for this job and it would be better to use helical trimpots, but these are expensive. The writer used fixed resistors, trimming down to the required value by shunting them with higher values.

The usual base connections to TR1 are shown going to the tagboard. Some field effect transistors marked 2N3819 have a different base configuration, but apart from the difference in connections the performance of the two types appears similar.

TEST AND CALIBRATION

Normal voltages are shown on the circuit diagram Fig. 1. Exact values will vary slightly from one instrument to the other and will also depend on the battery state. Voltages are with respect to the negative rail and were measured with a 20,000 ohms per volt multimeter. Total current consumption is about 5mA.

Initial tests should be made with the instrument switched to 20V r.m.s. The pointer after an initial kick should return to zero. If all appears well and the battery current is normal, switch the instrument to D.C. POSITIVE and adjust the ZERO control to bring the pointer to zero reading. Now switch to D.C. NEGATIVE; the zero should remain constant. Finally try the BATTERY CHECK; the meter should read between 75 and 95 microamperes (7.5 to 9.5 volts).

Get into the habit of starting each test from the OFF position, and in the case of d.c. measurements, zero the meter on the 20V range.

The calibration procedure starts with the 0-2V d.c. range. Apply a d.c. input of exactly 0.2 volts. This can be derived from a potentiometer network across a battery, and should be monitored by the best quality d.c. voltmeter available to the constructor. Now trim R15 until the instrument being calibrated reads exactly 20 microamperes. The 2V and 20V ranges can be checked, preferably at or near the maximum end of the ranges, by applying the appropriate monitored input. Although for reasonable accuracy it should not normally be necessary to adjust the input attenuator, adjustment can be made to the 2V range by changing the value of R2, and to the 20V range by changing the value of R3.

Calibration on a.c. also commences with the 0-2V range. This time R5 is trimmed for a meter reading of 200 microamperes when 0.2V r.m.s is applied to the a.c. input socket JK1. The frequency of the test signal must not exceed 1.000Hz during this stage of calibration. Once R5 is set, the calibration on the 2V and 20V ranges should follow automatically. Finally, with the test signal reduced to 0-02V r.m.s., the lowest a.c. range can be set by trimming R6.
Note that very low meter deflections on all a.c. ranges are suspect because of the rectifier characteristic, but with ranges overlapping, this limitation is only significant on the lowest range below 2 millivolts.

Frequency response checks may now be made using an audio frequency signal generator, if available. Starting at about 100Hz the generator is set to produce a reading on the instrument being calibrated of about 150 microamperes. Keeping the output level of the generator constant, tune it down to its lower frequency limit, and then in the reverse direction to its maximum frequency. Throughout this process the meter reading should be noted.

When switched to the 0.2V range the reading should be sensibly constant from just below 20Hz to 200kHz. The process should now be repeated for the 2V range, although this time it will probably be necessary to adjust C2 for optimum results, the aim being to get a constant reading over the widest possible range of input frequencies. The 20V range should be the next to be checked. Ideally, if the 2V range was set correctly, the 20V range should follow automatically. In practice it will be necessary to find the best C2 setting for both ranges, and this will undoubtedly involve some compromises. The final result should be, however, a bandwidth very similar to that obtained for the 0.2V range. Finally, the 0.02V range may be checked. No attempt has been made to provide frequency compensation on the lowest range, and it will be seen that the bandwidth is limited to 20kHz, falling by 3dB at 50kHz.

**OTHER APPLICATIONS**

In addition to the measurement of a.c. and d.c. voltages, the meter just described can be the basis of a number of instruments useful to the experimenter. Some basic ideas are illustrated in Fig. 4. The simple diode probe enables comparative readings to be made well into the v.h.f. range. Fitted with a microphone the instrument becomes a sound or noise meter. Other probes enable light and temperature readings to be made. Various other transducers can be devised to cover almost every kind of phenomenon.
**MARKETPLACE**

Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned as quoted prices are those at the time of going to press.

**CALCULATORS**

Two new portable Oxford calculators, replacing all previous models, have just been announced by Sinclair Radionics. These new models have been designed after analysing the views of a cross section of our society, including retailers and wholesalers.

In addition to the four normal arithmetic and six trigonometric functions (in degrees and radians), the Oxford "Scientific" offers logs base 10, logs base e, antilogs, square root, cube root, memory, two levels of parentheses, sign change, plus the four slide-rule functions: $x^2$, $\sqrt{x}$, $1/x$, and $\pi$.

Accuracy is claimed to be $\pm$ one unit in the 8th significant digit on arithmetic and slide-rule functions, and $\pm 2$ units on all other functions. The large green 8-digit display shows results in normal or scientific notation (mantissa plus exponent) notation.

The Oxford "Universal" follows the proven formula of the discontinued Oxford 200, with $+, -, x, +, \%$, a constant, a large green display, and a six-function memory. However, as a result of consumer demand, three convenience functions have been added: $\sqrt{x}$, $1/x$, and $x^2$.

Both of these two new calculators offer mains or battery operation. A mains adaptor is available, or each calculator gives several weeks of normal use on a PP3 battery.

Available from most big stores and stationers, the Oxford "Universal" has a recommended retail price of £11.95 plus 8% VAT. This is £1 cheaper than the previous Oxford 200 version. The Oxford "Scientific" has a recommended retail price of £14.95 plus 8% VAT.

**MULTIMETER**

Utilising established valve-voltmeter techniques to achieve a stable and reliable instrument, the Chingaglia VTVM 2002 electronic multimeter is the latest product being marketed by Alcon Instruments suitable for the servicing technician.

With a wide 100 degree mirror-scale movement for analogue display and some 21 ranges showing an input impedance of 22MΩ on d.c.

and 1MΩ shunted by 30pF on a.c., the 2002 is capable of wide ranging measurements. For example, it can display d.c. volts, peak or r.m.s.: a.c. volts; power in dB and resistance in ohms.

Accuracy is claimed to be $\pm 2.5$ per cent on d.c. and resistance and $3.5$ per cent on a.c. When on a.c. the frequency range is 25Hz to 100kHz $\pm 1$dB and this can be extended by using an optional i.r. probe to cover up to 250MHz.

The resistance ranges are particularly interesting, providing the ability to differentiate between resistance as low as 0.2Ω or as high as 100MΩ. To cater for the TV world there is an optional high voltage probe extending the upper voltage to 30kV.

Complete with leads and instructions, the Chingaglia 2002 costs £98.60, including VAT, postage and packing. Further information is available from Alcon Instruments Ltd. (Dept. P.E.), 19 Mulberry Walk, London SW3 6DZ.

**DISPLAY SWITCHES**

A new range of compact 7-segment i.e.d. display modules with integral pushbutton-actuated decade switch is now available from Contraves Industrial Products.

Known as Multicount modules, these combined display and switch units can be assembled into multi-decade display and switching banks, with any desired number of digits, for instrument control panel mounting. Front panel mounting of the modules is achieved with push-in end brackets and locating dowels ensure positive and accurate alignment of module stacks. A full-length red filter spans all i.e.d. display in each bank.

A variety of optional functions is available, including built-in memory, up/down counter, comparator and sign display. Even TTL or CMOS logic may be specified and dummy modules can be supplied for incorporation of additional electronics, pushbuttons, etc.

The bi-directional decade switches, with BCD output, can function independently from the digital display, or may be connected internally or externally to the display logic. This combination of switch and display within one single housing reduces panel space required and greatly simplifies mounting and interconnection. Applications include event counting and limiting, timing, clock displays and position control.

Addresses of nearest stockists and catalogues for the Multicount modules can be obtained from Contraves Industrial Products Ltd., Time House, (Dept. P.E.), Station Approach, Ruislip, Middlesex HA4 8LH.

**NEW CATALOGUES**

We have received a fair selection of catalogues and kit catalogues this month which we can recommend to readers for their reference library. Of course, all prices should first be checked with firms direct or with current advertisements before ordering any goods. The catalogues received are as follows:

- Home Radio Components Catalogue Charge: £1.40. 192 pages
- Home Radio (Components) Ltd., 234-240 London Road, Mitcham, Surrey CR4 3HD.
- Arrow Electronics Components Catalogue No. 9 Charge: 40p. 44 pages (overseas orders welcome)
- Arrow Electronics Ltd., Leader House, Copthall Road, Brentwood, Essex CM14 4BN.
- Tandy 1977 Catalogue Charge: Free. 100 pages Available from any Tandy Store.
- Heathkit Winter '76-'77 Catalogue Charge: Free. 40 pages
- Heath (Gloucester) Ltd., Bristol Road, Gloucester GL2 6EE.
Star line-up for March

FREE INSIDE!

DIODE IDENTICHAIR

Lists the most commonly available small signal, Zener and power diodes with important parameters and comparable types for easy replacement.

CONSTANT VOLUME INTERCOM

An inter-communicator is one of the most useful of all electronic equipments.

Here is an improved design incorporating automatic volume control. This overcomes those commonly experienced nuisances of inaudible speech and over-loud speech with attendant noise and distortion.

HEAR IN THE CLEAR!

NEW SERIES MICROPROCESSORS EXPLAINED

An important and vital series for everyone interested in following the latest developments in electronics. These articles provide a straightforward explanation of microprocessors and what they can do; and offer guidance as to their likely practical use by constructors in the immediate future.

Essential reading for all enthusiasts!

pH METER

Gardeners, aquarium owners, home brewers and chemists; build your own pH meter. Learn the meaning of pH and how it can be measured accurately. This instrument may be used as a voltmeter too!

AUTOWAH

Look no feet! Most wah and swell pedals by definition have to be operated by a footswitch. This unit can give either effect, automatically triggering from each new note played on the guitar.

Don't be disappointed — place a firm order with your newsagent NOW

PRACTICAL ELECTRONICS

OUR MARCH ISSUE WILL BE PUBLISHED ON FRIDAY, FEBRUARY 11, 1977
During the testing of a digital clock system which did not require a display in its final application, a need was found for a circuit that would permit display of the output, and of the intermediate stages, without wiring many LEDs and their driving circuits. Such a circuit could also be used to display the output of instruments such as timers and DVMs, etc. and notes on possible applications are included later. It was decided to use an oscilloscope as the display medium, due to its flexibility and availability.

The circuit to be described is essentially a Read Only Memory (ROM) containing the numerals 0 to 9, in seven-segment format. Additional circuitry will permit numbers to be displayed on an oscilloscope, without intensity modulation being necessary. This is a considerable advantage, since most cheap oscilloscopes do not have a Z input; even when they do, it is often difficult to drive.

The system uses TTL i.c.s throughout, and is cheaper and easier to use than an MOS ROM containing ASCII characters. The total cost is about £7, which is almost independent of the number of digits displayed.

**Character Generation**

The method of generation of characters on the oscilloscope will decide some of the features of the ROM, so this is treated first. Standard ASCII characters are formed on a $7 \times 5$ matrix of dots (e.g. see Practical Electronics, March 1972). For convenience, an $8 \times 8$ matrix is used here, in order to leave a space of three columns between adjacent digits, and of one row beneath each digit. This leaves room for other symbols (e.g. a minus sign) to be added if desired.

The row and column numbering and segment identification are shown in Fig. 1. Notice that Row 1 is at the bottom of the character, for reasons to be explained shortly. Since seven-segment characters are used, the dots on each “bar” can be activated at the same time, thus minimising the logic necessary.

The dots are formed on the oscilloscope by a series of staircase waveforms, each with eight steps. By decreasing the timebase speed, the steps of the staircase will be contracted, and appear as dots. The transitions between levels are, by contrast, so fast that they are not seen.

**Fig. 1. Digit element numbering and seven-segment identification**
The staircase is generated by a digital-to-analogue converter (DAC) using IC5, IC9 and an "R-2R" ladder network. See the circuit diagram Fig. 2. This circuit gives a voltage at the output that is proportional to the binary number set up at the input. The DAC is driven by a 3-bit binary counter, to give a step on the waveform for each row of the character. Thus the DAC input is connected to the Row Address input. If the DAC output is examined with an oscilloscope, a series of staircase waveforms will be seen. With a slow timebase speed, the steps of the staircase will appear as dots.

Fig. 2. Complete circuit diagram
The method of character generation from these dots is shown in Fig. 3, which uses the digit "4" as an example. It can be seen that the parts of the waveform that are not required are "gated out" by the signals from the ROM. In order that the digits will stand clear of the baseline formed by these transitions to zero, a fourth section is added to the DAC, driven directly by the ROM output. This raises the characters up by a distance equal to their own height.

For ease of viewing, the line of numbers is separated into blocks of 1, 2, 4, etc. digits by gating the output of the ROM with a signal from the addressing circuitry, described later. This makes alternate sections of the display appear blank.

**READ-ONLY MEMORY**

When the BCD code for the required character is set up on the input to the ROM, the elements of the digit are selected in sequence by the Row and Column Address inputs. The ROM generates a signal such that when an element is addressed, the output goes to a logic 1, otherwise it is at logic 0.

The Row and Column Address inputs are decoded by BCD to 1-of-10 circuits IC11 and IC12. These have "active low" outputs (i.e. the addressed output goes to a logic 0, while all others are at logic 1). The character input is decoded by IC10, a seven-segment decoder with active high TTL outputs. The three decoders produce a unique set of outputs for any row, column and digit selected. These outputs are processed by a series of NAND gates (here acting as OR gates) in order that the

**COMPONENTS . . .**

<table>
<thead>
<tr>
<th><strong>Resistors</strong></th>
<th><strong>Capacitors</strong></th>
<th><strong>Integrated Circuits</strong></th>
<th><strong>Miscellaneous</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 330Ω</td>
<td>C1 0.047µF disc ceramic</td>
<td>IC1, IC8 7430 (2 off)</td>
<td>Vero DIP Breadboard 13401</td>
</tr>
<tr>
<td>R2-R7 1kΩ (6 off)</td>
<td>C2-C4 0.1µF disc ceramic (3 off)</td>
<td>IC2-IC4 7410 (3 off)</td>
<td>Wiring pins</td>
</tr>
<tr>
<td></td>
<td>C5 7400</td>
<td>IC5 7400</td>
<td>128</td>
</tr>
<tr>
<td></td>
<td>C6, IC9 7404 (2 off)</td>
<td>IC6, IC9 7404 (2 off)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C7 7420</td>
<td>IC7 7420</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C8 7448</td>
<td>IC10 7448</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C11, IC12 7442 (2 off)</td>
<td>IC11, IC12 7442 (2 off)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C13 7413</td>
<td>IC13 7413</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C14-IC16 7493 (3 off)</td>
<td>IC14-IC16 7493 (3 off)</td>
<td></td>
</tr>
</tbody>
</table>

The structure of the display is apparent when c.r.t. brightness is increased.

---

**Fig. 3.** An example of character generation, the figure "4"

(a) DAC output—8 step staircase. (b) Dots on 'scope, unmodulated. (c) Modulation from ROM. (d) Resultant display. (e) Slower timebase
appropriate Row or Column is activated continuously for each horizontal or vertical segment respectively.

Since the DAC output will go from zero upwards when the Row Address counts from “000” to “111”, the staircase formed will lean to the right, giving a pleasing appearance to the characters. Thus it is necessary that Row input “000” selects the bottom row of elements of the digit, hence the wiring of the NAND gates.

Each of the three logic signals necessary to activate an element (i.e. Row, Column and Character) is applied to a series of 3-input NAND gates IC2, IC3 and IC4, one for each segment of the display. When a segment is selected, the output of the appropriate NAND gate will go low. The signals from each gate are combined in an 8-input NAND gate IC1, again giving the OR function. Thus when an element is selected at the Row, Column and Character input, the output goes high as required. This completes the ROM itself.

**ADDRESSING CIRCUITRY**

A Schmitt trigger oscillator followed by a buffer (IC13) is used to drive three 4-bit counters IC14, IC15 and IC16 (7493), the first two of which drive the Row and Column address inputs. Since the digits are to be displayed on a horizontal line, the row inputs are scanned at eight times the rate of the column inputs. The last counter is used as a “memory address” output. It could be used to operate a multiplexer, or to select the location in a memory where the digit to be displayed is stored. By moving a wire link 1, 2, 4... 32 digits may be displayed. This is used to gate the output of the ROM, as explained earlier.

**CONSTRUCTION AND SETTING UP**

The prototype was constructed on a Veroboard DIL Layout Sheet as shown in Fig. 4. It is recommended that sockets be used for the i.c.s as a precaution against damage. The layout is in no way critical. The supply rail should be decoupled by a 0.1µF capacitor every four i.c.s C2, C3 and C4. The current consumption is about 300mA, and it will be found that IC10 gets quite warm when many “blank” characters are displayed (i.e. all the 7448 outputs are on).

**APPLICATION NOTES**

As mentioned earlier, the circuit was designed to display the output of a digital clock. For this and most applications, a multiplexer is needed. It should be remembered that blank spaces between digits may be selected with the input “111”. A digital voltmeter or calculator can also be used if provided with the correct interface. A simpler application would be to display an oscilloscope’s calibration settings beside the waveform being examined, possibly for photographic purposes. This is done by using the range switching to control the character input. Indeed, any digital system that uses BCD data can be examined when the circuit becomes a useful test instrument.

**Fig. 4. Component layout. All wiring is carried out on top of the board**

**Fig. 5. Circuit for the addition of a decimal point**

In practice, the circuit fulfilled the required function of a display for a clock. It has also proved useful in checking the operation of i.c. counters and flip-flops.

A decimal point may be added by means of the circuit in Fig. 5. Other symbols made of straight lines could be implemented. It should be noticed that there will be an additional input for each symbol, making multiplexing more complex. An advanced system with a large memory might display several lines of data.

---

Practical Electronics  February 1977
the planners believe that with a bit of juggling and by re-using some of the old electromechanical equipment that can get by with far less new equipment than was originally thought. Bad news, as I have said, for the industry but good news for the 14 million telephone subscribers. Even with only £100 million saved they can all, theoretically, have a £7 rebate on their bills. And I can theoretically, as it were, forecast they won't get a penny.

Of course, the Post Office is to be congratulated on its efforts to cut costs. But I suspect that the high-powered team and all the data processing is only half the story. The other half is that a lot of the proposed new equipment is now unnecessary because ordinary folk can no longer afford to use the telephone so frequently since the last round of penal charge increases. This view seems to be supported by the reduction in charges on calls through the operator which came into effect on January 4. This was announced by the Post Office as a New Year "gift" to customers worth about £5 million.

And there I was more than pleased to note the go-ahead for a full-scale trial of the millimetric wave-guide system which is said to have good export potential. The 50mm diameter glass fibre pipe can carry half a million simultaneous telephone conversations, TV channels or a mixture of both. The enormous traffic capacity through a single pipe makes it truly cost-effective although the pipe itself is expensive, according to one report costing about £20 per metre.

The operational link is to be between Reading and Bristol, a distance of some 123,000 metres so it will be a costly experiment but necessary to prove the system. Nice business for companies who make the pipe and Marconi who make the electronics. Useful, too, if the present Reading–Bristol trunk suddenly needs up to another half million lines or the TV authorities go channel-mad.

**ACCELERATED DELAY!**

Odd item of news-speak is that members of the IEE in far away places like the USA can now get their journals by a system called Accelerated Surface Post (ASP) which suggests to me fast trains and ships. The extra fee is either £1.50 or £2.00 a year respectively for "IEEE News" and "Electronics and Power" which is fair enough. But reading the small print (at which I am becoming quite expert) I find that ASP is not fast surface post but slow bulk airmail. So slow that delivery time is quoted as of the order of 14 days. How's that for progress? Maybe there was a misprint and ASP really means Accelerated Service Post. Either way it is a vivid example of the lowered standard in public services we have come to tolerate through the years.

**MORE PROFITS**

Last month I was taking to task those merchants of doom forecasting the demise of the British electronics industry. I can now report more good news. Plessey's third quarter results for the year have turned up in sales over the corresponding period of the previous year and profits up nearly 20 per cent, confirming the underlying trend of improvement. Decca's turnover for the year was up £15 million to £170 million with record exports of £49 million. Cable & Wireless, the consistently profitable earner of overseas currency, improved profits by 49 per cent while earning £41 million in foreign currency as against £27 million in the previous year.

Looking to the future we find GEC claiming to be the first European company with an all-solid-state TV camera using charge coupled devices, with production promised for this year. Big expansion in thick films is being forecast by ITT's David Boswell at the Paignton, Devon, plant. He forecasts a three-fold increase in the UK market by 1980. A Mackintosh survey forecasts a 12.9 per cent growth for the European electronics industry this year.

Meantime, solid orders are flowing in. MEL has just picked up some new Clansman business bringing the order book for Clansman military radios to over £1 million. On the investment side Marconi has just opened a new £1 million PCB facility at Hillend. Fife. Helping to pay for this are bumper contracts such as the £3 million deal with the Post Office for PCM equipment and another £1 million from Algeria for radio communications.

Marconi is now doing so well that they hardly bother to announce anything involving less than £1 million! But an interesting statistic is that in nearly 10 years of making PCM equipment, Marconi has averaged a PCM order intake of £1,200 every hour of every working day over the past 10 years. Another is that the Hillend plant had 89 vacancies in 1974 and now has 2,000 with plenty of vacancies still available.

But if anyone believes that managing a big concern is easy they would like to dwell on the fact that with present interest rates it costs £2,500 a week to maintain £1 million of stock for work in progress. Just one of the headaches faced by managers who take all the kicks for an income not much more in take-home terms than shop-floor workers.
MICROPROCESSOR FORUM for CONSTRUCTORS

Your way into Tomorrow's Technology

UNDER THE JOINT SPONSORSHIP OF NATIONAL SEMICONDUCTOR, A. MARSHALL LTD. AND PRACTICAL ELECTRONICS.
(Co-ordinator for Joint Sponsors: Dennis Dolling Ltd.)

* Come and hear the experts
* Ask your questions
* Join in the informal discussion
* Participate in the practical demonstrations

THE SPEAKERS WILL BE: Dave Brown and Stuart May of National Semiconductor

BERNERS HOTEL, BERNERS STREET, LONDON W.1.
SATURDAY FEBRUARY 26 1977 2-5p.m.

Admission £2.50 (inclusive of VAT), this includes a comprehensive Data Pack. Applications for tickets must be made on the coupon provided below. A maximum number of 3 tickets may be ordered on one coupon. Tickets will be issued strictly in order of receipt of completed coupons with correct remittances. Accommodation is limited. So book without delay.

Remittances must be by postal order or cheque (name and address on back of cheque please), and made payable to Dennis Dolling Ltd.

Please use BLOCK CAPITALS

TO: MICROPROCESSOR FORUM (PE)
Dennis Dolling Ltd., 13-17 Southgate Road, Potters Bar, Herts. EN6 5DS

Please reserve □ * seats for the Microprocessor Forum for Constructors.

I enclose P.O./Cheque No. Value

Name
Address

* 1, 2 or 3 (maximum)

PE 2/77

Practical Electronics February 1977
The circuit described is an electronic equivalent of the well-known card game "snap", in which two players pit their reflexes against each other over the chance turning of a card.

The design shown in Fig. 1 overcomes two main problems associated with the card game: (a) the need for a fair card dealer, and (b) the problem of a draw. The first difficulty is overcome by means of a delayed action "pair" light which comes on after a time, which with the circuit values given will be from 10 to 15 seconds after the game is set.

The second problem just does not arise with this version of the game, as the electronics can register the first of two close responses to within a fraction of a microsecond using TTL, rendering the chances of a draw totally negligible. If a player gives a false response, or accidentally pushes his or her response button before the "pair" light comes on, the game is automatically nulled, and a "cheat" light comes on.

**PLAY**

Play commences when the reset button is pressed. After a fixed time delay, the "pair" light will illuminate, and the first player to press his or her response button wins. A "game accepted" light will come on together with the winning player's own light.

**CIRCUIT OPERATION**

A glance at Fig. 1 shows that the circuit is quite straightforward; G1 and G2 forming bistable A (for player A), and G3 and G4 forming bistable B. These bistables are interconnected via D4 and D5 so that the first one to be triggered will inhibit the other from latching. If, for example, S1 is pressed first, then bistable A becomes "set", and D6 illu-
minutes. In this condition G4 input is held at logical 0, therefore bistable B can be toggled by S2 but cannot latch. In the event of a near simultaneous response by both players, both D6 and D7 would light up; but the final decision as to the winner would come when the players released their buttons. The one whose i.e.d. remained alight would be the winner! The reverse is true of course if S2 is pressed first.

The bistable outputs are gated together at G8 and taken to the “game accepted” and “cheat” logic, while the time delay is generated by R1, R2, C1 and TR1. The “pair” light (D9) is driven by the output of G5, which is the inverted signal from the collector of TR1. The time delay components may be altered if desired. However, 10 to 15 seconds as set, is too long for the player to anticipate, and not long enough to allow boredom to set in. As can be seen, if the “cheat” logic is activated, G7 output goes to 0 and stops C1 charging, hence stopping the game. D1, D2 and D3, together with S3 will reset the two bistables and the timer. Pressing this switch starts off the game.

CONSTRUCTION AND LAYOUT
Layout is not in any way critical and therefore construction is left to the individual. However, one or two points are made for guidance. Although the 7400 family of i.c.s are quite robust, care should be taken when soldering to avoid overheating. The prototype was made simply by placing the components on a piece of stiff board, and applying a drop of quick-set adhesive to hold them in place. Then they were wired together with fine plastic insulated single core wire, the whole assembly being covered with resin after testing.

Fig. 1. Circuit diagram of the IC Snap game. Pin details of TR1 and the i.c.s. shown viewed from underneath.

TESTING
Check the wiring carefully and then connect to the batteries. Press S3, and upon release all lights should be out. Immediately press S1 or S2, and its associated i.e.d. (D6 or D7) should light up, along with the “cheat” light. Reset S3 and wait until the “pair” light comes on. Press S1 or S2, and again D6 or D7 will illuminate but this time with the “game accepted” light.

When all lights are checked the assembly can be encased, and encapsulated with resin if desired, except the batteries, lights and switches of course! Finally connect the on/off switch in the positive battery lead and the job is finished.

COMPONENTS...

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors</td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>680kΩ</td>
</tr>
<tr>
<td>R2</td>
<td>470kΩ</td>
</tr>
<tr>
<td>R3-R7</td>
<td>220Ω</td>
</tr>
<tr>
<td>R8-R9</td>
<td>2.7kΩ</td>
</tr>
<tr>
<td>All</td>
<td>±1%</td>
</tr>
<tr>
<td>Transistors</td>
<td></td>
</tr>
<tr>
<td>TR1</td>
<td>BC108</td>
</tr>
<tr>
<td>Diodes</td>
<td></td>
</tr>
<tr>
<td>D1-D5</td>
<td>1N914</td>
</tr>
<tr>
<td>D6-D10</td>
<td>L.E.D.s (5 off)</td>
</tr>
<tr>
<td>Capacitors</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>470μF 10V elect.</td>
</tr>
<tr>
<td>Integrated Circuits</td>
<td></td>
</tr>
<tr>
<td>IC1-IC3</td>
<td>7400 (3 off)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>S1, S2, S3</td>
<td>S.P. push to make (momentary action) switch.</td>
</tr>
<tr>
<td>S4</td>
<td>S.P.S.T. on/off switch. Four 1.5V pen-torch cells.</td>
</tr>
<tr>
<td>Case</td>
<td>(a cig:r box was used for the prototype).</td>
</tr>
</tbody>
</table>
All electronic systems suffer from noise to a greater or lesser extent. Sometimes, a large amount of noise can be tolerated; at other times noise becomes so significant that it causes circuits to malfunction. Audio equipment is an example where the noise does not necessarily affect the electronics but has a disturbing effect on the listener. Let's have a look at various sources of noise, and then see how noise can be kept to a minimum.

**NOISE SOURCES**

**Thermal Noise**

Thermal noise occurs in all systems and is usually associated with resistors. The amount of noise from a resistor depends on its absolute temperature (T), the value of the resistor (R), and the bandwidth (B) of the circuit which contains the resistor. Because noise is a random fluctuating signal and not sinusoidal, it is useless to quote the mean square noise voltage. It is then possible to calculate the noise power present in a circuit due to a resistor.

**Fig. 1. Noise equivalent circuit of a resistor**

Mean square noise voltage = \(4KTBR\)

where \(K = \) Boltzmann's constant,

\(T = \) Absolute Temperature in degrees Kelvin,

\(B = \) Bandwidth in Hertz,

\(R = \) Resistor value in Ohms.

The equivalent r.m.s. voltage source has a value of \(2\sqrt{KTBR}\). The voltage \(V_i\) across the input resistor is half of this if \(R_i\) is equal to \(R\).

The power dissipated in \(R_i\) due to this voltage is \(\frac{KTBR}{R}\) = \(KTB\) watts. This result is very useful if we want to determine the noise power at the input to a radio receiver for example.

**Shot Noise**

In thermionic devices, a heated surface produces shot noise. Heating agitates the electrons and this is what is required for amplification. However, there is a random fluctuation in the quantity of electrons leaving the heated surface. The random fluctuation appears as noise. The actual value of this noise depends on the current, the circuit bandwidth and also the type of device.

**Partition Noise**

In multi-electrode devices certain electrons hit the electrodes. The result is another random variation in signal level—noise to you and me. The partition noise so produced depends on the electrode currents and the bandwidth again.

**Transistor Noise**

Noise from a transistor is due to three sources which can be equated to the three types of noise already mentioned. The base region has a resistance, producing noise equivalent to thermal noise. Minority carriers diffuse across the base-collector junction forming a leakage current. Fluctuations in this current produce noise. We can think of this as shot noise. Finally the recombination of carriers in the base region, which fluctuates, can be likened to partition noise as electrons disappear into holes. All transistors produce noise but some are designed so that the noise is minimised.

**NOISE FACTOR**

If the noise from a device or system is important, its noise factor is usually quoted. It may be in the form of a number, or alternatively it can be expressed in decibels. For any system, it is the ratio of the useful signal to the noise that we need to know rather than the absolute level of the noise.

**Fig. 2. Network noise factor**

\[ F = \frac{S_i}{N_i} \]

In decibels this is:

\[ F = 10 \log_{10} \frac{S_i}{N_i} \]

Or, if the input signal to noise ratio is \(D_i\) dB and the output signal to noise ratio is \(D_o\) dB, then

\[ F = (D_i - D_o) \]

The network introduces noise and therefore the ratio of signal to noise at the input is always greater than the ratio at the output because of the contribution due to the network itself. Taking an example, we can
demonstrate this. The input signal to noise ratio is, let us say, 70dB. If the network has a gain of 30dB, then the signal at the output will be 30dB higher. Assuming for the moment that the network contributes no noise, the noise power will be 30dB higher as well. The signal to noise ratio has not changed. However, when a measurement is made, the output signal to noise ratio is found to be 57 dB, let us say. Then:

\[
F = 70 - 57 = 13\text{dB.}
\]

In numerical terms the input signal to noise ratio is 20 times the output ratio. Fig. 3 shows the different signal to noise ratios at the input and the output of a network.

LOW NOISE CIRCUITS

Low noise devices are, in general, more expensive than standard types. Also, because minimum noise is optimised, other parameters may suffer. We therefore like to limit the use of low noise devices to essential places in the circuitry.

Consider the amplifier of Fig. 4. It consists of a number of stages, all having gain. Noise due to the first stage \( N_1 \) is amplified by the following two stages, noise in the second stage \( N_2 \) is amplified by the final stage, and then we have noise due to the final stage itself \( N_3 \). If there is noise at the input to the amplifier \( N_i \) then that is amplified by all three stages. We can say that at the amplifier output:

\[
\text{Total noise} = N_0 G_1 G_2 G_3 + N_0 G_2 G_3 + N_0 G_3 + N_3
\]

If each of the stages has a gain of 10, then we have:

\[
\text{Total Noise} = 1,000N_i - 100N_i - 10N_i = N_i
\]

It is obvious from this that noise at the input and also that due to the first stage affect the total noise the most.

The noise at the input can only be changed by altering the temperature or the circuit bandwidth. Neither of these propositions are usually possible and so we are left with using low noise devices in the first few stages. If you are having problems with excessive noise, try substituting active devices in the input stages, immersing the amplifier in liquid helium might cure the high noise but the solution would prove rather expensive.

---

**A SPECIAL SELECTION OF MUSICAL PROJECTS FROM PE**

**THE MINISONIC MK2**

**SOUND SYNTHESISER**

An updated version of the published Mk 1, the Mk 2 has an integral keyboard, two 250 mW monitoring channels and loudspeakers, and facilities for amplitude, frequency and harmonic modulation.

**THE JOANNA**

**ELECTRONIC PIANO**

has realistic piano effect with touch-sensitive keyboard and additional choice of harpsichord or honky-tonk voicing.

**THE ORION STEREO AMPLIFIER**

A hi-fi amplifier with output of over 20 + 20 watts. Compact and complete in one unit, it measures only 14 x 6 x 2.

PLUS

Some great sound effects units for guitars, keyboard instruments and general recording.

Available Now

£1.20

POST PAID

(Price allow at least 2 weeks for delivery)

If you do not wish to mutilate your copy of the magazine, please send your order on a separate sheet.

To: Practical Electronics
IPC Magazines Ltd., Receiving Cashiers Dept.,
King's Reach Tower, Stamford Street, London SE1 9LS

Please send me 

---

copy(ies) of

---

I enclose a Postal Order/Cheque for £1.20 (post paid) or (state amount for more than one copy) £2.35 post paid (post for 2 copies).

Please WRITE IN BLOCK LETTERS

---

Name

Address

---

Post code

Remittances with overseas orders must be sufficient to cover despatch by sea or air mail as required. Payable by International Money Order only.

Company registered in England Regd No. 53626
A subsidiary of Reed International Limited.
A selection of readers' original circuit ideas. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought. Why not submit your idea? Any idea published will be awarded payment according to its merits.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

Each idea submitted must be accompanied by a declaration to the effect that it is the original work of the undersigned, and that it has not been accepted for publication elsewhere.

### Polyphonic Keyboard System

The odd sounds, which on the average synthesiser, result from forgetful (or otherwise) depression of two keys at the same time, are due to the use in most keyboards of single pole switch contacts with all the keys wired in parallel. This can be overcome by using change-over switches in series. If the "Minisonic" has been built using GJ type switches in conjunction with the h.f. oscillator and detector system, a simple rewiring job is all that is required.

Where a keyboard has not yet been built, the system described here allows for simultaneous programming of two or more voltage controlled oscillators from separate keys.

Using change-over switches, one pole is required for each VCO to be programmed. This system is shown in Fig. 1. When key 1 is pressed VCO1 is connected to control voltage point 1, VCO2 is connected to the upper row of switches, and VCO3 to the middle row. If key 2 is now pressed, VCO2 is connected to CV point 2, and VCO3 to the upper row of switches. If key 3 is pressed VCO3 is connected to CV point 3. Thus all three VCOs can be programmed by separate points on the control voltage chain.

Since the hold module for each VCO has an input impedance in excess of 2,000Ω, there is minimal loading on the chain of resistors, and none is shorted out.

The switches may be either GJ types activated in pairs, or threes by one key, or else special assemblies can be made using printed circuit board and gold plated wire.

E. F. Flint,
Glasgow.
AUTOMATIC CAR AERIAL

A circuit which will raise an electric aerial to its limit on operating the ignition switch, and lower it again when switching off the ignition is shown in Fig. 1. The problem lay in supplying power to the "up" lead for two or three seconds only when the aerial was required, and to the "down" lead for a similar time. An extra requirement for the down operation was that no power be consumed by the circuit when the ignition switch was off.

When the ignition key is operated, power is supplied to relay RLA. Capacitor C2 is charged, and relay RLB is operated through contact RLA1. The down lead of the aerial motor is isolated via the now open contact RLA1. RLC operates, and power is supplied to the "up" lead via the closed contacts RLA2, and RLC1. Once C1 charges up, RLC drops out and power is no longer supplied to the aerial motor. Zener diode D2 is required to stabilise the voltage on the timer circuit. Diode D3 ensures that power is still supplied to the aerial when the starter motor is operated.

When the ignition switch is put back to the "off" position, RLA drops out and power is supplied to the "down" lead via the closed contacts of RLA1 and RLB1. Power is disconnected from C2 and RLB. Capacitor C2 discharges through RLB, and after a few seconds RLB1 opens, breaking the power to the down lead. Contact RLB2 discharges C1 in readiness for the next operational cycle.

The values of C1 and C2 are chosen to ensure that the aerial goes fully up and down respectively.

R. J. Darling,
Uddingston,
Glasgow.

OVERHEAT INDICATOR

This device (Fig. 1) gives an audible or visual indication if the sensor temperature exceeds a preset value. The latter can be situated either at the engine, gearbox, or brake drums, depending on requirements.

The sensor, R1, is a carbon rod thermistor which reduces its resistance value as the temperature increases. The temperature at which the relay operates is adjustable by VR1. When the thermistor temperature increases, the base voltage of TR1 is sufficient to energise the relay.

The transistor used for TR1 depends on the car earthing. With a negative earth TR1 should be a 2N3053, or with a positive earth a BC461. With a positive earth DI polarity and the unit supply rails should be reversed. With either earthing system, DI prevents back e.m.f. damaging TR1. The 12V supply line is taken via the vehicle ignition switch.

J. W. Cheshire,
Sutton Coldfield.
As a very simple logic test clip and probe, it is possible to use an old integrated circuit package. The old i.c. will need to have its internal circuitry removed so that it doesn’t affect the operation of the probe. This can be done by breaking open the i.c. and scraping away the silicon chip and fine gold connecting wires. Metal-plastic-metal sandwich type i.c.s are better for this purpose than plastic or ceramic packages, as it is generally easy to break off the top metal layer exposing the chip itself.

Connections can be made by soldering fine wires to the top of the pins, as close to the package as possible to avoid the pins becoming loaded with too much solder and wire, which would cause them to lose much of their natural resilience. The unit can then be glued to the base of the probe, which can be applied “piggy-back” to the i.c. under test (Fig. 1).

The method of wiring the indicator l.e.d.s is shown in Fig. 2, the circuit being repeated seven or eight times over for 14 or 16-pin i.c.s. It was found that 0.125in MAN3 l.e.d.s by Monsanto gave the brightest display consistent with a reasonable current consumption, allowing 1kΩ series resistors to be used.

A. Damper, Carshalton, Surrey.

P. D. Maddison, Blackburn, Lancs.
### TOP 500 SEMICONDUCTORS FROM THE LARGEST RANGE IN THE U.K.

<table>
<thead>
<tr>
<th>Device</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N4403A</td>
<td>2</td>
<td>NPN power transistor, 20 VA, 25/50 W, 6 A</td>
</tr>
<tr>
<td>2N4404A</td>
<td>2</td>
<td>Mosfet transistor, 500 mA, 50 V</td>
</tr>
<tr>
<td>2N4405A</td>
<td>2</td>
<td>NPN power transistor, 20 VA, 25/50 W, 6 A</td>
</tr>
<tr>
<td>2N4406A</td>
<td>2</td>
<td>Mosfet transistor, 500 mA, 50 V</td>
</tr>
<tr>
<td>2N4555</td>
<td>1</td>
<td>Op-amp, 10 MHz, 10 V, 200 mA</td>
</tr>
<tr>
<td>2N4556</td>
<td>1</td>
<td>Op-amp, 10 MHz, 10 V, 200 mA</td>
</tr>
<tr>
<td>2N4557</td>
<td>1</td>
<td>Op-amp, 10 MHz, 10 V, 200 mA</td>
</tr>
<tr>
<td>2N4558</td>
<td>1</td>
<td>Op-amp, 10 MHz, 10 V, 200 mA</td>
</tr>
<tr>
<td>2N4559</td>
<td>1</td>
<td>Op-amp, 10 MHz, 10 V, 200 mA</td>
</tr>
<tr>
<td>2N4560</td>
<td>1</td>
<td>Op-amp, 10 MHz, 10 V, 200 mA</td>
</tr>
</tbody>
</table>

*Please note: The table above is a sample of the top 500 semiconductors available from the largest range in the UK.*

---

### PHONO PLUGS (screw top)

- **3 pin:**
  - 5 pin: 0.45
  - 180°: 0.69

- **4 pin:**
  - 3 pin: 0.40
  - 5 pin: 0.55

---

### встретиться с нами 9-5, 30 Mon-Fri и 9-5.00 Sat.

---

### WE ARE NOW IN NEWCASTLE-ON-TYNE!

Marshall Aitken Ltd.
35 High Bridge
Newcastle-on-Tyne
Tel.: 0632 26729

---

### SEE MARSHALL'S FOR CMOS

- **CD4000:** 0.25
- **CD4011:** 1.91
- **CD4040:** 0.33
- **CD4047:** 1.10
- **CD4066:** 1.90
- **CD4074:** 2.20
- **CD4032:** 1.60
- **CD4013:** 1.30

---

### MICROPROCESSORS FROM MARSHALL'S

- **8085:**
  - **8080:**
  - **8089:**
  - **8090:**

---

### POTENTIOMETERS 1kΩ to 2MΩ (E3)

- **Linear or Log**
  - Single Double
- **Rotary Pots (no 1kΩ log)**
  - Sliders

---

### FULL RANGE OF VERO products stocked. See catalogue for details.

---

### PRESETS—Horizontal or Vertical

- 0.1W
- 0.3W

---

### SEND FOR OUR NEW 168 PAGE CATALOGUE WITH 500 NEW LINES—GRAHAM WITH NEW PRODUCTS, TECHNICAL INFORMATION AND ALL BACKED BY THE USUAL SUPERLATIVE MARSHALL'S SERVICE—FOR ONLY 55p POST PAID OR 40p TO PERSONAL CALLERS.

---

### NATIONAL CLOCK MODULE WITH A LARM, BEEP & VIBRATOR £5.50

---

### Transformer £1.20

---

### Switches £1.50

---

### Practical Electronics

---

### February 1977

---

### 139
In event of power failure 

**1702A UV ERASABLE PROM**

- 2048 bit static PROM 256x8
- elect programmable & erasable TTL/DTL comp.

**SPECIALS**

- 110V - $99
- 220V - $198
- 24V - $297

**AUTO CLOCK KIT**

- Digits: 37mm, LED
- Operates from 12V DC or AC
- Crystal control for high accuracy
- supplied with case

**SHIPMENT MADE VIA AIR - POSTAGE PAID**

- Ears: £47.30 incl. VAT & p. & p.
- Design based

**INTERNATIONAL ELECTRONICS UNLIMITED**

- P.O. BOX 3036 MONTEREY, CA. 93940 USA
- Phone (408) 659-3717

**INVERTERS**

- 24V-50Hz from your 12v car battery
- 25 watt...75...300 watt...245 - 245
- 40 watt...60...400 watt...237 - 237
- 75 watt...123...500 watt...246 - 246
- 150 watt...227...150 watt...237 - 237
- 300 watt...272...150 watt...237 - 237

**P.E. ORION STEREO AMPLIFIER**

- Input: 20 - 20 Watts r.m.s. into 8 ohm load
- Distortion less than 0.01% - 100Hz - 10kHz
- Frequency response +1dB 20 Hz to 20 kHz
- Hum level virtually nil with volume full on

**ASTRO IGNITION SYSTEM**

- Complete kit of parts for this proven and tested system $10 45 incl. VAT. Ready built with only two connections to alter £13.75 incl. VAT. Thousands have used this system both home and abroad. Consider these advantages more power, faster acceleration fuel economy, excellent cold starting, smoother running, no contact breaker burning. Also because of the high energy spark, the fuel mixture can be made weaker giving further economy and fewer plug problems. 

**P.W. AUTOMATIC EMERGENCY SUPPLY**

- 24V-50Hz-150 mile travel with built in battery charger in event of power failure switches over automatically from battery charger to engine alternator (Cet. 89) appeared in Dec.72 P.W. Complete kit of parts (excluding meter) £65 - £70 p. & p.

**DIGITAL WATCH**

- L.E.D. display giving hours, minutes, seconds and date Design based on American technology, and fantastic value at £16 - 30p. & p.

**TRADE & EXPORT ENQUIRIES WELCOMED**

- 10% OFF WITH £5 ORDER
- 15% OFF WITH £50 ORDER

**SPECIAL DISCOUNTS APPLY TO ORDER OF SPECIALS INCLUDED**

| CALCULATOR CHIPS | C15682 4 digit, fixed decimal - battery operation
| SM5725 | 6 digit, function plan memory, 4 functions
| SM5760 | 8 digit, function plan memory, 2 functions, 9 memories
| SM5728 | 12 digit, function plan memory, and constant, floating decimal, 8 memories
| SM5729 | 24 pin
| SM5730 | 4 digit, function, 8 memories

**P.E. ORION STEREO AMPLIFIER**

- Full kit of parts for this superb tuner unit to compliment the now well established amplifier. Parts may be purchased separately. Send S.A.E. for further information

**ASTRO ELECTRONICS**

- Spring Bank Road, West Park
- Chesterfield
PERCUSSION EFFECTS

SIMPLE envelope shapers used in synthesizers like the Minisonic are unable to produce a percussive envelope shape, since there is only control for the attack and decay, the sustain being controlled by the time the key is held. On ADSR envelope shapers the attack, decay, sustain and release can be pre-set and more variety in the envelope shapes obtained.

Using two AD envelope shapers, the control signals can be mixed with each other and a combination envelope formed which is used to control the VCA in the usual way, as in Fig. 1.

The mixer can be formed from a 741; the output level being equal to the sum of the input levels. As an example a piano envelope can be more realistically imitated by setting the attack on both ES to min, and the decay to a few milliseconds on one and to about three seconds on the other.

Other strange envelope shapes can be formed from the system, as in Fig. 2.

Miss L. Robinson, Wilmslow, Cheshire.

SIMPLE COMPRESSOR

This circuit (Fig. 1) was designed to provide sustain on a guitar with a relatively insensitive pickup, though it could be used for other instruments or signals.

Transistors TR1 and TR2 form a high gain self-stabilising pair. The output is rectified by D1, D2, smoothed by C4 and applied to TR3 which controls the brightness of the l.e.d. D3. The light from the l.e.d. falls on the light dependent resistor, varying its resistance and so controlling the level of the input signal by voltage divider action via VR1.

The l.e.d. used was a 0.2in high-intensity red type mounted over the l.d.r., the whole assembly being enclosed in a lightproof screened box.

Q. A. Rice, Mitcham, Surrey.

Fig. 1

Fig. 2
IN Fig. 1, a circuit is shown which makes it possible for common cathode displays to be used in the electronic clock of P.E. August 1975, which made use of common anode displays. Using this method, only seven resistors are used (instead of twenty-one) for the interfacing of the displays. Thus, the clock can be made more economically, and a printed circuit board can be designed with ease. For the current limiting resistor, 120Ω should be suitable for a 16V supply.

N. Coxhead, Pyrford, Surrey.

**SIMPLIFIED CLOCK DISPLAY**

![Circuit Diagram]

**HEADS OR TAILS**

Most published designs for heads or tails circuits rely on a bistable whose state is changed by a squarewave, the bistable being in one state during the mark, and the other during the space. This means that if the bistable is not to be biased towards any one state, the mark space ratio of the squarewave must be exactly 1:1. This is hard to achieve, due to component tolerances in the oscillator.

The circuit in Fig. 1 overcomes this difficulty by using an edge triggered bistable, which changes state whenever a positive-going edge appears at the clock input. Since the time between two consecutive edges is independent of the mark space ratio, i.e., D1 and D2 are on for equal periods.

The squarewave is provided by TR1 and TR2, and the bistable is one half of a 7474. The i.e.d. currents are limited by R5 and R6, preventing the outputs of IC1 from being overloaded. S1 is a push-to-make release-to-break switch, which could be replaced by a relay with a delay to simulate the spinning of a coin. A suitable delay circuit of a few seconds is given in Fig. 2. It should be noted that the frequency of the oscillator is twice the switching frequency of the bistable.

P. Chambers, Winchmore Hill, London.

![Circuit Diagram]
Careers and Hobbies in Electronics.

Enrol in the BNR & E School and you’ll have an entertaining and fascinating hobby. Stick with it and the opportunities and the big money await you, if qualified, in every field of Electronics today. We offer the finest home study training for all subjects in radio, television, etc., especially for the CITY AND GUILDS EXAMS (Technicians’ Certificates); the Grad. Brit. I.E.R. Exam; the RADIO AMATEUR’S LICENCE; P.M.G. Certificates; the R.T.E.B. Servicing Certificates; etc. Also courses in Television; Transistors; Radar; Computers; Servo-mechanisms; Mathematics and Practical Transistor Radio course with equipment. We have OVER 20 YEARS’ experience in teaching radio subjects and an unbroken record of exam successes. We are the only privately run British home study College specialising in electronics subjects only. Fullest details will be gladly sent without any obligation.

Become a Radio Amateur.

Learn how to become a radio-amateur in contact with the whole world. We give skilled preparation for the G.P.O. licence.
SOLDERLESS BREADBOARDING — DECs

The famous DEC System of Solderless Breadboarding is ideal for both the young and more mature students of Electronic Engineering as it enables circuits to be tried out without the use of soldering and because of the specially designed contacts allows components to be used over and over again. It is also extremely useful for the Circuit Designer who wishes to experiment with and perfect his circuit quickly yet economically.

S-DEC (Model PB11)
This, the most popular Board, is designed solely for use with discrete components and is particularly useful for basic educational purposes.

No. of Contacts: 70
Cost: £1.98

T-DEC (Model PB21)
This Board allows 2 T0S or 1 OIL IC Station to be used and so is primarily intended for discrete work or for linear IC application where considerable numbers of discrete components may be used.

No. of Contacts: 250
Cost: £2.21

H-DEC ‘A’ (Model PB31)
The u-DEC ‘A’ is specially designed for use with ICs and allows 2 T0S or 4 OIL IC stations to be used but will accommodate discrete components with equal facility.

No. of Contacts: 250
Cost: £1.97

H-DEC ‘B’ (Model PB41)
The u-DEC ‘B’ is similar to the u-DEC ‘A’, but has two 16 lead components as part of the circuit.

No. of Contacts: 250
Cost: £1.98

DEC ACCESSORIES

16 T0S adapter (with socket) PB060
10 OIL adapter (with socket) PB072
Single ended leads (set of 10) PB100
Double ended leads (set of 10) PB101
All prices include 8% VAT.

Our retail counter is now open, stocking a large variety of audio and electronic parts and accessories, branded and surplus.

THE COMPONENTS CENTRE
7 Langley Road, Watford, Herts., WD1 3PS.
Tel: Watford 45355

SOLDERLESS BREADBOARDING — DECS

1. Master Combinaion of components always wanted.
2. For audio fault finding, this battery operated unit may be simply attached at any point in the circuit to provide a 1 kHz square wave for pre-settable amplitude, up to 5V. Using only one 1IC the unit, complete with battery, is incorporated in a case only 50x50mm x 100mm long with probes to provide connection to circuit. Easy to construct for only:
£2.20 + S VAT (Order code 991-877)
Subject to availability

O’seas orders—add 15% for P + P. All items offered for sale subject to the Terms of Business as set out in Doram Edition 3 catalogue, price 60p. The Doram Kit brochure is also available, price 25p. Combined postage only 70p. Plasterboard office to you to 2 x 25p vouchers, each one on order placed to the value of £3.00 or more (ex. VAT).
SOLAR ENERGY BP 1 445 369

In BP 1 445 369, the German company of Rowenta-Werke GmbH provides a useful technical recap on work to date on photo-electrically converting sunlight to electrical energy, for instance using silicon cells to power domestic equipment such as clocks.

It is confirmed that the main problem to date lies in selecting a cell which will operate efficiently over the wide range of ambient lighting which will operate efficiently over the earth's atmosphere. This is likely to be some 60,000 lux in bright sunlight and as little as 200 lux on a very cloudy day.

Curves are plotted for the energy conversion characteristics of presently available cells. It is claimed that the secret for efficient operation over a wide range of different illumination intensities is keeping the operating voltages of a mosaic of photoelectric cells always at the optimum working points on their characteristic curve locus.

This is achieved in the patent by connecting a storage capacitor across the photoelectric cells and applying the output to a d.c. converter circuit. This then supplies the working load, for instance a high value capacitor and accumulator serving as energy stores, with the necessary power.

According to the invention, the converter circuit has an adjustable frequency of operation automatically controlled by a photoconductive resistor which receives light from the same source of illumination as the generating cells. If necessary a neutral density filter is used to balance the light received by the two cell types.

Two circuits are given for light controlled transformer circuits, in which the frequency of operation rises with decreasing illumination and falls with increasing illumination. Another circuit is given where the frequency rises with rising illumination and falls with falling illumination. But in either case, the circuit operates to ensure that only that amount of energy is taken from the capacitor which can subsequently be delivered by the photoelectric cells under the sensed prevailing illumination.

SIMPLIFIED TELECINE BP 1 444 591

If a recent patent (BP 1 444 591) were not from the giant Matsushita Electrical Industrial Co. Ltd., of Osaka, Japan, and named five separate inventors, it could easily be dismissed as yet another armchair invention inadequately thought through. The patent pedigree, however, suggests that the idea, although simple, may open up interesting avenues of experiment for anyone with an old cine projector available for modification.

The patent claims a generally conventional cine projector, but with the projection lamp replaceable (by the movement of a slide or the turn of a rotor) with a photoelectric converter. The lamp is used when it is required to project films on a matt reflective screen in the usual manner.

To display a film on the screen of a domestic TV set, the lamp is replaced with the converter and the projector optics focused on the screen of a television receiver. In this way the converter receives light from the flying spot on the screen via the film running through the projector. The converter converts the varying light signals into correspondingly varying electric signals which are used to modulate the brightness of a video display.

It is suggested that one TV tube can perform the function of both image display tube and flying spot tube, to provide a TV display of the film image.

Although such a technique sounds workable (for instance, there are the problems of video feedback and the effect of using intermittent film transport as commonly found in domestic projectors) electronics experimenters may well find the basic idea behind the patent a trigger for further thought.

JACKETED WIRES BP 1 433 528

A clever new method of producing a precision jacketed wire, for instance for use in temperature measuring and control techniques, is patented by G. Rau of Germany, in BP 1 433 528.

The object is to provide mechanical support for an extremely thin metallic resistor wire by means of a tough insulating jacket, but without interfering with its electrical resistance and the consistent transmission of heat to and from the wire. These requirements are normally mutually contradictory and the patented answer is to produce the insulating jacket by a gas-metal reaction.

A wire metal core is inserted into a silver tube. The core and tube are a mechanically manageable size, but are subsequently drawn to reduce their diameter to the desired size. The drawn composite is then heated to 800 °C for three hours, permeation of oxygen from the air into the interface between the core and tube creating an oxide layer which serves as an insulating jacket of precision dimensions. As an alternative, a nitrogen reaction can be promoted to produce a nitrogen-based insulating layer.

IN BRIEF

BP 1 446 747 — Nissan Motor Co Ltd: Vehicle Safety Harness. Complicated circuitry to prevent an engine being started and run from cold if the driver and passenger seat belts have not been fastened, but with over-ride circuitry which enables the engine to be re-started after a stall even without belt fastening. Intended to cope safely with emergencies such as engine stall on a level crossing, where rapid re-start is more important than belt fastening.

BP 1 445 883 — Sepro Soc D'Etudes: Automatic Collision Alarm. An inertia switch system for incorporation in a motor vehicle, the switch being slugged sufficiently to prevent its closure under all normal driving conditions. But it closes on substantial impact to trigger and hold an alarm circuit closed. In this way a car damaged by impact on a motorway can automatically transmit radio alarm signals and/or flash warning lights to following traffic to prevent another collision.

Copies of Patents can be obtained from the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price 95p each.
Transistor Socket

Sir—I recently made a transistor tester and had to find a simple, reliable method of connecting the transistors under test.

A 5-pin 240 degree panel mounting DIN socket provided the answer. The tester leads were connected as shown in Fig. 1.

The DIN socket allows easy and firm connection for most transistor configurations, without having to bend or twist the often short leads.

H. Jacobs
Twickenham.

Seeking the truth?

Sir—I feel duty bound to write in reply to the article on the Electropsychometer under the Patents Review section of Practical Electronics (August).

I have a document in front of me dated September 14, 1976, from one Lee Torbush, an employee of the Bureau of Medical Devices of the US Food & Drug Administration. In his view "The E-Meter (electropsychometer) is not capable of, nor is it possible to use it as a lie detector, or any such similar instrument. It is a religious artifact used by a Minister of the Church of Scientology to help in the Pastoral Counselling process."

I hope this information will be of some value to any budding Koijaks who believed that the circuit diagram outlined in the article would produce a lie detector. To make any effective use of the instrument outlined in the article they would have to undergo training as a Scientology Minister.

P. Thomson,
East Grinstead.

Perhaps we can help you turn that old wish into reality

As all electronics constructors know, one of the secrets of happiness is to spend leisure time on work that is both interesting and constructive. Unfortunately, one's enjoyment of the hobby is soon spoilt if you can't obtain the right components. That's where Home Radio Components come in and if you're a regular reader of these advertisements you'll know exactly what we three "typical customers" recommend. Here it is—the first step is to invest in a Home Radio Components catalogue. This will enable you to locate quickly and easily the parts you need for the project you have in mind. Then, to buy the components you have a choice of three methods. 1. You can visit Home Radio's shop in Mitcham, above Tesco's almost opposite Mitcham Baths. 2. You can send a cheque or P.O. for the items you need, in the normal Mail Order way. 3. You can join Home Radio's Credit Scheme and settle your account monthly. Full details of this popular scheme are given in the catalogue.

Whichever method you use, you will enjoy the prompt personal service Home Radio always strive to give. So, back to the first step, send off the coupon with £1.40 for your copy of the catalogue—it's a superb production!
HI-FI LOUDSPEAKER SYSTEM MKI

Beautifully made record amplifiers. Non-scratching, noise-free, non-stroking output.

Overall Size 14 x 9 x 6. Bass, Treble and Volume Controls. Suitable for use with ceramic or crystal cartridges. Can be used for automatic or manual play. Limited number of the latest 1191/1201/1211B. Treble and Volume Controls.

FOCAL FLAT" WAFER-TYPE WIDE RANGE ELECTRO-DYNAMIC SPEAKER

Ready to fit to your own cabinet to suit your own needs. Supplied complete with chrome finished Bach & Treble Controls. Suitable for use with 1191/1201/1211B. Treble and Volume Controls.

OVATION BARGAINS

All new, 1211/1201/1211B. Treble and Volume Controls. Suitable for use with ceramic or crystal cartridges. Can be used for automatic or manual play. Limited number of the latest 1191/1201/1211B.

PHILIPS

All new, 1211/1201/1211B. Treble and Volume Controls. Suitable for use with ceramic or crystal cartridges. Can be used for automatic or manual play. Limited number of the latest 1191/1201/1211B.

ALL PURPOSE POWER SUPPLY 200/240V


STEREO-DECORDER SIZE 2.5 x 3.4


SUPER SOUNDS 12 HI-FI MONO AMPLIFIER

A superb solid state audio amplifier. Brand new and tested. With knobs, valve, etc. Complete with knobs, valve, etc. Price £10.00 plus P & P.

HARVERSONIC MAINS OPERATED SOLID STATE FM TUNER

Designed and styled to match our 10 + 10 amplifier. Will suit any other standard stereo amplifier. The design, ruggedness, and component quality, circuitry, noise characteristics, and noise reference point and frequency ratio, all balanced at the rear of the chassis. All components are selected and matched to provide output of 4 watts per channel (8 watts mono) into a 3 ohm load. 200/240V. PRICE £12.75. P. & P. £0.60.

HARVERSONIC SUPER SOUN D 10 + 10 STEREO AMPLIFIER KIT

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the five stage circuit resulting in very low noise level with improved sensitivity. Integrated pre-amp with Bass, Treble and Volume Controls. Includes all parts, including valve, etc. Suitable for use with Ceramic or Crystal cartridges. Very simple to install. Complete with 1211/1201/1211B. Treble and Volume Controls. Instruction booklet supplied. Output stage for any speakers up to 8ante. \n
DE LUXE STEREO AMPLIFIER

A dual stage state of the art transistors. All components are selected and matched to provide an output of 4 watts per channel (4 watts mono) into a 3 ohm load. 200/240V. Price £22.50 plus P. & P.

Hi-Fi LOUDSPEAKER SYSTEM MKII

Handmade record amplifiers. Non-scratching, noise-free, non-stroking output. Bass, Treble and Volume Controls. Suitable for use with ceramic or crystal cartridges. Can be used for automatic or manual play. Limited number of the latest 1191/1201/1211B.

STEREO RECORD PLAYER AMPLIFIER MODEL T1


SUPER SOUNDS 12 HI-FI MONO AMPLIFIER

A superb solid state audio amplifier. Brand new and tested. Complete with knobs, valve, etc. Price £10.00 plus P & P.

QUALITY RECORD PLAYER AMPLIFIER ME.


SPECIAL OFFER

Maitland L/1129/10 + 10 Double Tuner Amplifier Model for nominal 700V. Price approx. 12 x 17 x 4. 8 Ohm loudspeakers. Price £5.00 plus P. & P.

PYE VHF/FM TUNER Quality FM Tuner, covering 88-108 MHz. Price £5.00 plus P. & P. Complete. Price £12.50 plus P. & P.

SPECIAL OFFER

Practically all consumer electronics and electrical goods are offered at the following prices. Please note: P. & P. CHARGES (Please write clearly).

HARVERSONIC MAINS OPERATED SOLID STATE FM TUNER

Designed and styled to match our 10 + 10 amplifier. Will suit any other standard stereo amplifier. The design, ruggedness, and component quality, circuitry, noise characteristics, and noise reference point and frequency ratio, all balanced at the rear of the chassis. All components are selected and matched to provide output of 4 watts per channel (4 watts mono) into a 3 ohm load. 200/240V. PRICE £12.75. P. & P. £0.60.

HARVERSONIC SUPER SOUN D 10 + 10 STEREO AMPLIFIER KIT

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors including Silicon Transistors in the five stage circuit resulting in very low noise level with improved sensitivity. Integrated pre-amp with Bass, Treble and Volume Controls. Includes all parts, including valve, etc. Suitable for use with Ceramic or Crystal cartridges. Very simple to install. Complete with 1211/1201/1211B. Treble and Volume Controls. Instruction booklet supplied. Output stage for any speakers up to 8ante. \n
DE LUXE STEREO AMPLIFIER

A dual stage state of the art transistors. All components are selected and matched to provide an output of 4 watts per channel (4 watts mono) into a 3 ohm load. 200/240V. Price £22.50 plus P. & P.

Hi-Fi LOUDSPEAKER SYSTEM MKII

Handmade record amplifiers. Non-scratching, noise-free, non-stroking output. Bass, Treble and Volume Controls. Suitable for use with ceramic or crystal cartridges. Can be used for automatic or manual play. Limited number of the latest 1191/1201/1211B.

STEREO RECORD PLAYER AMPLIFIER MODEL T1


SUPER SOUNDS 12 HI-FI MONO AMPLIFIER

A superb solid state audio amplifier. Brand new and tested. Complete with knobs, valve, etc. Price £10.00 plus P & P.

QUALITY RECORD PLAYER AMPLIFIER ME.


SPECIAL OFFER

Maitland L/1129/10 + 10 Double Tuner Amplifier Model for nominal 700V. Price approx. 12 x 17 x 4. 8 Ohm loudspeakers. Price £5.00 plus P. & P.

PYE VHF/FM TUNER Quality FM Tuner, covering 88-108 MHz. Price £5.00 plus P. & P. Complete. Price £12.50 plus P. & P.

SPECIAL OFFER

Practically all consumer electronics and electrical goods are offered at the following prices. Please note: P. & P. CHARGES (Please write clearly).
**POWER AMPLIFIER MODULES 30—240 WATTS**

- Fully tested and guaranteed.
- Full RMS Sine Wave output.
- Distortion typically 0.5%.
- 10 Transistors, 4 Diodes.
- Response 30HZ-30KHZ.
- Fully short & open circuit proof.
- Sensitivity suits most mixers.
- Built-in surge suppression & compensation
- Twin D.C. & output fuses.
- Top-grade components throughout.

### Specifications

<table>
<thead>
<tr>
<th>Watts rms</th>
<th>Output rms</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>240</td>
<td>200</td>
</tr>
</tbody>
</table>

**Price:**
- SA308: £9.50 30W rms
- SA608: £12.50 60W rms
- SA1208: £14.50 120W rms
- SA2408: £21.00 240W rms

**Power Supplies for the Above Modules—Ready Wired & Fused on Glass Fibre PCB**
- PM301: £9.90
- PM601: £12.50 60W rms
- PM1201: £19.50 120W rms
- PM2401: £31.50 240W rms

**DISCO MIXER MODULES** Mono or Stereo (with Auto Fade)

Printed circuit module assembled and tested with all components ready mounted.

Mone £19.50 Stereo £29.50

*Front panel to suit £3.50*

**ALL PURPOSE CUSTOM—MIXER MODULES** (Mono or Stereo)

- Using these modules, mixers may be built to your specification up to 20 Channels, mono or stereo, or a combination of both. System 7000 custom-mixer modules have monitoring facilities too!

**INPUT MODULES**
- Accept low/high 2 mica, ceramic & magnetic cartridges, all musical instruments & line signals.
- Low-noise circuitry—high grade components.
- Wide-range bass & treble controls (23dB).
- 20HZ-20KHZ, Noise—80dB.
- Tattoo sound return etc. really fitted.

Mono—IM7000 £5.50
Stereo—IM7001S £5.50

**Power supply for up to 20 modules—PM18 £8.50**

**MIXING MODULES**
- Only one required per mixer track whether mono or stereo.
- Feeds up to ten power modules.
- Complete with JW monitor amplifier.
- Accepts up to 20 input modules.
- Will match any other make of amplifier.

Mono—IM7002M £9.00
Stereo—IM7002S £9.00

**QUADRALECT** FOUR CHANNEL 4KW SEQUENCER WITH DIMMERS

**A COMPLETE LIGHT SHOW**

£29.50

*Panel £6.50*

**THE ONLY MODULAR SOUND TO LIGHT UNIT WITH:**
- Four integral dimmers.
- Two + Two sequencer.
- Automatic audio level.

**SYSTEM 7000 MINOTaurus—All Purpose Wide Range Amplifier**

- 100W rms — 1dB
- Input, high
- Twin mixed inputs accept power amplifier
- A wide range of signals which will deliver up to 20HZ-30KHZ ±2dB
- 110Watts out.
- 236dB bass/treble absolute must where multiple mixing & power are required.
- Four individually mixed inputs.
- Wide band range bass/treble + master

£4950

*Vinyl covered case
*Fully short proof
*Superb value for money

**SYSTEM 7000 COMPLETE DISCO MIXERS** (with Auto Fade)

The choice of the professional D.J.

Controls: Mic, volume, bass, treble, A/fade, depth, tape, Lidack r/dock vol., treble, bass, master, headphones vol., selector, left/right fader.

MONO 18V £37.50 MONO MAINS £43.50
Stereo 18V £53.50 Stereo Main £65.50

**SYSTEM 7000 COMPLETE CUSTOM MIXERS** (Mono or Stereo)

- Ideal for the economical & quick assembly of a purpose built mixer with individual channel monitoring, and optional extra facilities—consult our technical dept. to discuss your needs.
- Stainless steel panels.
- Built-in monitoring.
- Will feed all amplifiers.
- Professional grade.
- Accepts all types of signals.
- Infinity adaptable.

Mono input module £6.50
Stereo input module £12.00
Mono monitoring module £25.00
Stereo monitoring module £50.00
Power supply £3.50

**SYSTEM 7000 LIGHTING CONTROL MK II**

**H.A.S.**

- Has your sound to light converter got:
  - 4000Watt Got.
  - Integral individual dimmers.
  - Automatic audio level control.
  - Two + Two sequence facility.

**Ours Hasi—Plus:**

- Stainless steel panel.
- Heavy duty terminations.

£42.50

**SAXON SOUND-LITE**—An old design with improved appearance

- Scintillating performance.
- Similar to MK II lighting control in appearance.
- Complete with heavy duty terminations.

£24.75

**SYSTEM 7000 LIGHTING CONTROL UNIT.**

£42.50

**NEW!**

- Stainless steel case.
- Bondene case.
- Matches System 7000 mixers.

£24.75

**THE THREE CHANNEL 3KW SOUND/LITE—Low Cost—Superb Value**

- Long-established Saxon design.
- Individual level controls + master.
- RCA 8A Tracs.
- 1W-240V input.
- Individual channel fuses.
- Needs only front panel.

£16.50

*Panel £2.50*
BRANCHES AT CROYDON & WALLINGFORD
CUSTOMERS INCLUDE BBC, LONDON WEEKEND TV, SCOTTISH TELEVISION, NATIONAL TYRES, POST OFFICE, GOVT. DEPTS.

A READY-TO-USE 100W STEREO DISCO WITH BUILT-IN SOUND/LITE SEQUENCER AND LIGHTS FOR ONLY £199

THE CENTAUR
(Carr free in U.K.)
■ 100W rms stereo output
■ Twin heavy duty loudspeakers
■ Four channel fully automatic sound/lite with variable speed sequence
■ C/w premix with tape input & X fade
■ Separate mic. & music treble and bass controls
■ Tunable Vynide cabinets
■ Twin BSR decks with autostop & lift arm

A READY-TO-USE 50W MONO DISCO COMPLETE WITH TWIN HEAVY DUTY LOUDSPEAKERS FOR ONLY £89.90

■ 50W rms output
■ Twin heavy duty loudspeakers
■ Separate mic. input
■ Wide range bass & treble controls
■ Smart Vynide cases—clipped together to form one neat package
■ Twin BSR decks with lift & autostop

CUSTOM BUILT DISCOS
A full range of custom consoles are available using System 7000, from 50W mono to 500W stereo. Ask for our price list.

LOUDSPEAKER CABINETS
■ Kick proof grills.
■ Heavy duty units
■ Jointed construction
■ Black Vynide finish
■ Protective corners

FULL RANGE BASS & TREBLE CONTROLS
■ Separate mic. & music treble and bass controls
■ Tunable Vynide cabinets
■ Twin BSR decks with autostop & lift arm

INSEparable mic. Input
■ 50W rms output
■ Twin heavy duty loudspeakers
■ Separate mic. input
■ Wide range bass & treble controls
■ Smart Vynide cases—clipped together to form one neat package
■ Twin BSR decks with lift & autostop

TREMENDOUS VALUE—PRICE INCLUDES 100% of parts! leads just plug in & go!

ACCESSORIES FOR COMPLETE DISCOS & OTHER SYSTEMS
■ Electret Condenser Mic ECM31 C/W shielded & clip £12.00
■ ECM78—ass above but dual impedance with removable lead £13.00
■ Crown Stereo Headphones £6.75
■ Heavy duty boom mic. stand £12.50

CUSTOM BUILT DISCOS
A full range of custom consoles are available using System 7000, from 50W mono to 500W stereo. Ask for our price list.

LOUDSPEAKER CABINETS
■ Kick proof grills.
■ Heavy duty units
■ Jointed construction
■ Black Vynide finish
■ Protective corners

FULL RANGE BASS & TREBLE CONTROLS
■ Separate mic. & music treble and bass controls
■ Tunable Vynide cabinets
■ Twin BSR decks with autostop & lift arm

INSEparable mic. Input
■ 50W rms output
■ Twin heavy duty loudspeakers
■ Separate mic. input
■ Wide range bass & treble controls
■ Smart Vynide cases—clipped together to form one neat package
■ Twin BSR decks with lift & autostop

TREMENDOUS VALUE—PRICE INCLUDES 100% of parts! leads just plug in & go!

CUSTOM BUILT DISCOS
A full range of custom consoles are available using System 7000, from 50W mono to 500W stereo. Ask for our price list.

GOOD VALUE DISCO CONSOLES
£19 with plain motorboard—£21 with cutouts.
■ Black Vynide finish
■ Protective corners
■ With your choice of cutouts

STEREO PROJECTORS (We stock the full Pluto range) Send for details

SUPERSTROBE £19.75
■ 2-3 Joules
■ 80W Tube for long life
■ Compact 4" x 4" x 4"

PRO-STROBE £32.50
■ 4-6 Joules
■ External trigger
■ Long life tube timer circuit

150 WATT LIQUID WHEEL PROJECTOR
Accepts all accessories
■ C/w with wheel & motor plate
■ Sturdy metal construction
Remarkable value—Sold elsewhere at £85.00. Our price is only: £31.50

Please add 5% VAT to all orders (12% for SA308/PM301)
We accept Access & Barclaycard—simply telephone or send your card number. Do not send your card.
You may pay by cheque, crossed postal orders, cash (registered) or bank draft to order—For advice phone (01) 684 0085 or (01) 684 0098.
Mail orders to: 327-333 Whitehorse Rd., Croydon, Surrey CRO 2HS. Open 9am-5pm Mon.-Sat. Mail order desk 10am-3pm Mon.-Fri.
Wallingford Branch: Flint House, High St., Wallingford, Oxon. (Call(1) only) 9am-5pm Mon.-Sat. Telephone (0949) 35529

ROSE ELECTRICAL TO BONA FIDE TRADE CUSTOMERS

Sparkkrite mk 2 Capacitive discharge electronic ignition Kit

- Smoother running
- Instant all-weather starting
- Continental peak performance
- Longer coil/battery/plug life
- Improved acceleration/top speeds
- Up to 20% better fuel consumption

Sparkkrite mk 2 is a high performance, high quality capacitive discharge, electronic ignition system in kit form. Tried, tested, proven, reliable and complete. It can be assembled in two or three hours and fitted in 15/30 mins. Because of the superb design of the Sparkkrite circuit it completely eliminates problems of the contact breaker. There is no misfire due to contact breaker bounce which is eliminated electronically by a pulse suppression circuit which prevents the unit firing if the points bounce open at high R.P.M. Contact breaker burn is eliminated by reducing the current to about 1500 of the norm. It will perform equally well with new, old, or even badly pitted points and is not dependent upon the dwell time of the contact breakers for recharging the system. Sparkkrite incorporates a short circuit protected inverter which eliminates the problems of SCR lock on and, therefore, eliminates the possibility of blowing the transistors or the SCR. Most capacitive discharge ignitions are not completely foolproof in this respect. All kits fit vehicles with coil/distributor ignition up to 8 cylinders.

THE KIT COMPRISER EVERYTHING NEEDED
Ready fitted pressed steel case coated in matt black epoxy resin, ready drilled template and leads just plug in & go! The kit comprises everything needed—Ready fitted pressed steel case coated in matt black epoxy resin, ready drilled template and leads just plug in & go! The kit comprises everything needed.

OPTIONAL EXTRAS
Electronic/conventional ignition switch.
Gives instant changeover from “Sparkkrite” ignition to conventional ignition for performance comparisons, static timing etc. and will also switch the ignition off completely as a security device, includes switch connectors, mounting bracket and instructions. Cables excluded. Also available R.P.M. limiting control for dashboard mounting (fitted in case on ready built unit).

CALLERS WELCOME. For Crompton tuning and fitting service—phone (0922) 33008

PRICES INCLUDE VAT, POST AND PACKING.

ELECTRONICS DESIGN ASSOCIATES, Dept. PE2
82 Bath Street, Walsall, VVS1 3DE. Phone: (0922) 33652

NAME ________________________________

ADDRESS _______________________________________

Send S.A.E. if brochure only required.

£11.80
£14.97
£14.97
£4.30
£2.42

Fill in Cheque/PO's

£11.80
£14.97
£14.97
£4.30
£2.42

For £

Cheque No. ________________________________

Send S.A.E. if brochure only required.
**GOOD NEWS FROM**

**Connoisseur**

**THE NEW BD2/A**

Based on the popular BD2, the new BD2/A offers the hi-fi enthusiast all the features usually associated with Connoisseur turntables, such as low rumble, wow and flutter, plus the addition of an automatic pick-up arm lift-off at the end of the record. This is achieved by an ingenious, though simple, electromagnetic system, which avoids having any physical contact with the pick-up arm. It is possible, therefore, to use top quality cartridges, tracking at less than one gram, without putting any extra side pressure on the stylus.

The BD2/A comes either as a chassis model, or mounted on a slimline plinth, standing on rubber anti-vibration feet, finished in genuine American walnut, and fitted with a bronze, hinged dust cover. For those with restricted space, a compact plinth measuring only 13\(\frac{3}{4}\) x 15\(\frac{3}{4}\) is still available.

**Specification**

- Rumble: 65dB when measured in accordance with DIN 45539 using weighting network, referred to 7cm/sec, at 330Hz.
- Wow and Flutter: Less than 0.1% HUM level: 80dB.
- The BD2/A sells for a recommended price of only £55.00 + VAT. Ask your local hi-fi dealer, or write to the factory, for further details.

**Manufactured by**: A. R. Sugden & Co (Engineers) Ltd., Atlas Mill Road, Brighouse, West Yorkshire, HD6 1ES. Telephone: Brighouse (04847) 2142. Telegrams & Cables: Connoisseur, Brighouse.

---

**CMOS WITH DISCOUNTS!**

<table>
<thead>
<tr>
<th>CMOS</th>
<th>Discount for 25%</th>
<th>Discount for 50%</th>
<th>Discount for 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>4002</td>
<td>0.20</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td>4003</td>
<td>0.20</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td>4004</td>
<td>0.20</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td>4005</td>
<td>0.20</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td>4006</td>
<td>0.20</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td>4007</td>
<td>0.20</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td>4008</td>
<td>0.20</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td>4009</td>
<td>0.20</td>
<td>0.40</td>
<td>0.80</td>
</tr>
</tbody>
</table>

**GREENBANK ELECTRONICS (Dept: E2P)**

94 New Chester Road, New Ferry, Wirral, Merseyside, L62 5AG, England
Tel: 051-665 3391

---

**PHILIPS**

**YOU & PHILIPS HI-FI KITS**

The top sellers for home assembly in Europe—now available in the U.K.

Now—read all about the Philips range of quality kits for home assembly—mixers, amplifiers, speakers, etc, etc. Send today to S.S.T. Distributors (Electronic Components) Ltd., West Road, Tottenham, London N17 ORN

**PHILIPS ELECTRONIC KITS**

---

**SEND TODAY!**
MUFFIN INSTRUMENT FUNDS
Dimensions: 6 x 5 x 1.5 in. Very quiet running, precision fan specially designed for cooling electronic equipment, amplifiers, etc. For 110V, A.C. operation (practice is to run from split primary of mains transformer or use suitable mains drop. CC only 11 watts. List price over £10 each. Our price, in first class condition is £4.86.

500 V TRANSISTORISED
INSTALLATION TESTERS
Size: 13 x 7 x 4 cm. Reads from 12 to 100k. Price new, only £17. Brand new. £22.

HELLIPO TURNS COUNTER
Beckman Duodual counting dials Miniature type (22mm dia.) Counting up to 15 turns. Brand new, complete with mounting instructions £2 78.

BRIDGE RECTIFIERS
Encapsulated silicon type. Ex. equipment. Texas. 1 x TIP 20 PIV, 2 x Tip 12, 2 PIV, 4 x 1N45, 4 x 1N5460.

ADVANCE R.F. SIGNAL
GENERATORS
G1 7.5-250MHz £37.80
Q1 50kHz-220MHz £37.80
PG3 60kHz-220MHz £37.80
SG63 7.5-250, AM/FM £61

SWISS HOUR AND MINUTE
National Watch Co. 110V 50Hz 5 digits, Size approx. 3 x 3 x 3" 2 x 2 x 0.5" (various sizes available) New £6 2. P. & P. 10p.

PRICES QUOTED INCLUDE VAT. USUAL DESPATCH TIME FOR MAIL ORDERS IS 1-3 DAYS. WE URGE YOu TO ORDER 10% PERCENT FOR RETURNABLES, SO YOU CAN ORDER FOR STOCK. QUOTATIONS FOR TEST EQUIPMENT PLEASE CALL US AT THE ABOVE NUMBER.

DORR SALE
DORR KITS
POWER SUPPLY
Subject to availability

**£19.99**

An invaluable piece of equipment for the enthusiast's workshop. This 3.5-30 Volt a.c. power supply fulfils virtually all experimentation requirements. Avoid frustration and circuit damage with the variable current shown.

Regulation typically better than 0.5% (max 3%).

Ripple voltage typically better than 20mV (max 120mV)

Only £19.95 +S (order code 997-227)

O'seas orders—add 15% for P + P. All items offered for sale subject to the Terms of Business as set out in Doran Edition 3 catalogue, price 60p. The Doran Kits brochure is also available free. Last price only 70p which also entitles you to 2 x 25p vouchers, each one usable on any order placed to the value of £5.00 or more (ex. VAT).

P.O. Box TR8. Wellington Industrial Estate, Leeds LS12 2UF

An Electrocomponents Group Company
INTERLOCKING PLASTIC STORAGE DRAWERS

Newest, neatest system ever devised for storing small parts and components. Resistors, capacitors, diodes, transistors, etc. Rigid plastic construction in vertical and horizontal combinations. Transistor plastic drawers have label slots. 10 and 20 have space dividers. Build up any size cabinet for wall, bench or table top.

As supplied to Post Office, Industry and Government Departments.

SINGLE UNITS (1D) (5in x 2in x 2in). £2.50 DOZEN.

DOUBLE UNITS (2D) (5in x 4in x 2in). £4.40 DOZEN.

TREBLE (3D) £4.20 for 8.

DOUBLE TREBLE 2 drawers, in one outer case (50) £9.60 for 8.

EXTRA LARGE SIZE (4D1) £5.50 for 8.

PLUS QUANTITY DISCOUNTS
Orders over £20, less 5%.
Orders over £50, less 10%.
Packing/postage/carriage. Add 75p to all orders under £10. Orders £10 and over please add 10% carriage.

QUOTATION FOR QUANTITIES
Please add VAT, at total remittance.

All prices correct at time of going to press.
**RELAYS**

SIEMENS, PLESSY, Etc. MINIATURE RELAYS

**RELAYS, WIDE RANGE OF A.C. and D.C. RELAYS**

Available from stock, phone or write in your enquiries.

**GENTS’ 4in ALARM BELL**

3-4V d.c.
Price £6.50. P. & P. £0.50.

**HONEYWELL PUSH BUTTON PANEL MOUNTING MICRO SWITCH ASSEMBLY**


**2 WAY SELECTOR SWITCH WITH RESET COIL**

The ingenious electronic mechanical device can be switched up to 21 positions and can be reset from any position, energising the reset coil. 230/340V A.C. operation. Unit is mounted on strong chassis, complete with cover. Price £5.50. P. & P. 75p.

**NEW HEAVY DUTY SOLENOID, mfg. by Mag-Prep Devices**


**UNISELECTOR SWITCHES**


**MINIATURE C/O ROLLER MICRO SWITCH**

OMRON Type V15 FL22/1C. 10 for 115/230V a.c. Min. order 10.
Sub miniature Burgess Button Type V-4T-1. 10 for £2.50. 50 for £12.50.
Post £1.25.

**MINIATURE UNISELECTOR**


**24 VOLT DC SOLENOIDS**

UNIT containing a heavy duty solenoid approx. 25lb pull I inch travel. Two approx. I lb pull I inch travel. One 24 volt d.c., heavy duty single make relay. Price £5.50. Post £1. ABSOLUTE BARGAIN.

**600 WATT DIMMER SWITCH**


**HY-LIGHT STROBE MK IV**


**NEW HEAVY DUTY RELAYSMINIANT**

**NEW TRADING CO.**

**600/500W DIMMER SWITCH**


**NEW HEAVY DUTY RELAYSMINIANT**

**GEAREM MOTORS**


**DRAYTON MOTOR**

Type RQR

230-250V 50c. Continuously rated. 1 r.p.m. 90lb. in. Reversible Motor. Twin spindle size 100mm by 140mm. Thrust: 50mm by 80mm. Weight 2.4kg.


**BODINE TYPE N.C.I.**

(Type 3) 1 r.p.m. torque 10 lb. in. Reversible 1/80th h.p. 50Hz.


**HY-LIGHT STROBE MK IV**


**ULTRA VIOLET BLACK LIGHT TUBES**


**QUIET PROMINENCE**

A new conception in light control. Four channels each capable of handling 750 watts of spot lights, flood lights or dozens of small mains lamps. Seven programs all speed controlled, plus modulator, effectively giving 14 different displays. Makes sounds-to-light programs entirely acoustically and mechanically noise free. Price only £60. 230/340V A.C. Complete with transformer, instructions. £105. S.A.E. for order VAT 16%.

**WIDE RANGE OF DISCO LIGHTING EQUIPMENT**

S.E. (Foolscap) for details.

**MULTI RANGE METER. A.C. volts 2000(1/V D.C. and A.C.) D.C. current 0-300 volt. M/I 0.75 and 300 volt A.G. R/M/C. Also available for NV operation. Prices as above.**

**NEW POWER RHEOSTATS**

(i) 0-5 KVA (2f amp) inc. gearbox £1:1.50
(ii) 3 KVA (15 amp) inc. gearbox £3:11.00
(iii) 2 KVA (10 amp) inc. gearbox £2:50.
(iv) 1 KVA (5 amp) inc. gearbox £1:50.
(v) 0.5 KVA (3 amp) inc. gearbox £1:10.

**PROGRAMME TIMERS**

2000voltage to 1.5 or 20 r.p.m. 6 cam model £5. Post 60p.
12 cam model £15. Post 60p.
Also available for 50V operation. Prices as above.

**METERS NEW — 90 mm Diameter**

Type 830/1200V 2, 4 and 6 in. £3.10. £6.75. Post 20p.
100 amp £12. £3.15. Post 20p.
300 amp £25. £5.25. Post 20p.

**WHY PAY MORE?!**

MULTI RANGE METER. A.C. voltages 52K, 230-400V, 5000V (D.C. and A.C.) D.C. current 0-5 amp, £7.15. 0-10 amp £9.75. 0-25 amp £12.75. 54 cam £16.75. Please note above price includes a glass observation window. Built to highest specification for ultimate performance. £85.00. £2.95. SERVICE TRADING CO. Price £5.90. Inc. taxes and battery.

**TIME SWITCH**


**BLOWERS**

200-240V 0.5-1.0 A. 3.5k/5k ohm £3.70.
100 Watt 1/5/10/25/50/100/250/500/1k/1.5k/2.5k/3.5k ohm £3.70. Post 35p.

**Superior Quality Precision Made NEW POWER RHEOSTATS**

New ceramic construction, vitreous enamelled windings, heavy duty brush assembly, continuously rated.

**VAT**

At current rate must be added to all orders for the total value of goods including postage unless otherwise stated.

**SERVICE TRADING CO.**

London WC2H 7JJ

Phone 01-437 0576

---

**NEW RELAY RANGE**

**BLOWERS**

200-240V 0.5-1.0 A. 3.5k/5k ohm £3.70.
100 Watt 1/5/10/25/50/100/250/500/1k/1.5k/2.5k/3.5k ohm £3.70. Post 35p.

**Superior Quality Precision Made NEW POWER RHEOSTATS**

New ceramic construction, vitreous enamelled windings, heavy duty brush assembly, continuously rated.

**VAT**

At current rate must be added to all orders for the total value of goods including postage unless otherwise stated.

**SERVICE TRADING CO.**

London WC2H 7JJ

Phone 01-437 0576
B. BAMBER ELECTRONICS

PLEASE ADD 8% VAT UNLESS OTHERWISE STATED

GARRARD 5V DC MINIATURE MOTORS, Type 318M, 3200 RPM governed, size approx. 1 1/4 dia. x 1 1/4 long. Each £6. Brand New. 60p each or 2 for £1.

SEMI-CONDUCTOR TRANSFORMER STICKS, BY188 (resist. 2 1/2) 5p each, BY140 (equal) 4F 1/2p each. BY146 (equal) 3F 1/2p each.

VARIABLE STABILIZED POWER SUPPLY, mains input, 0-24 volt, stabilised and current limited at 1.5A. Brand New. Each £6. British made.

PROGRAMMERS (magnetic devices). Contain 9 microswitches (suitable for many applications) including some individually adjustable. Suitable for indicator machine programming. These low cost, small motor driven bars, assimilated not supplied. Approx. 5 switch £1.50 each.

HEAVY DUTY HEAT SINK BLOCKS, undrilled 2 x 2 x 3 in. with 6 fins, full height 2 1/2 x 2 in. each.

SPERRY 7-SEGMENT P.D.O. DISPLAYS, digit height 0.3in. red, with decimal point. 150V to 200V (nominal) 1800 operation. These are high quality, industrial type and therefore brighter than many domestic type. Priced per digit of £3.50 each. Suitable for use as a POTENTIOMETER in 5 volt (or 2 volt) systems. LED 3.50 each.

WE SELL A LARGE RANGE OF CAPACITORS AVAILABLE AT BARGAIN PRICES, S.A.E. FOR LIST.

PLUGS AND SOCKETS

A MINIATURE POWER TOOL
to speed your building


Mk. II Drill only £8.79 plus P. & P. 35p.

Flexible Drive Shaft £5.46 plus P. & P. 25p.

Transformer 240V a.c./12V d.c. £6 plus P. & P. 70p.

Replacement drills, stones, burrs, etc. 40p each. Circular saw blades 50p each. £2 per set of 4 sizes. P. & P. any quantity 20p.

All VAT inclusive

PRECISION PETITE LTD

119a High Street, Teddington, Middlesex TW11 8HG

Tel. 01-977 0878 (24-hour answering service)

9" x 4" S.A.E. please for leaflet and order form
ORION stereo tuner

Complete set of semiconductors £4.99
Mullard LP1186 tuner head £7.75
High quality glass fibre P.C.B. £2.45

ORION AMPLIFIER

Complete set of semiconductors £9.40
High quality glass fibre P.C.B. £2.99

FERRANTI semiconductors

Complete set of semiconductors £9.99
Mullard LP1186 tuner head £7.75
High quality glass fibre P.C.B. £2.99

PRICES DO NOT INCLUDE VAT-ADDS TO ITEMS AND 12½% TO ALL OTHERS

PE TV SOUND SEPARATOR

Complete set of semiconductors £3.60
High quality glass fibre p.c.b. £1.

PHASE LOCKED STERO DECODER

To Motorola specification. COMPLETE KIT ONLY £3.96, including MC1310P, glass fibre p.c.b., all resistors and capacitors. LED indicator, and full instructions.

Postage and Packing: 15p per order. Orders over £2 post free. All devices are top grade, brand new and to full manufacturers' spec. We do not sell seconds or rejects. Send S.A.E. for data sheet and price list.

DAVIAN ELECTRONICS

13 Deepdale Avenue, Royton, Oldham, Lancs. (Mail order only)

Dimmit range of light dimmers and lighting control systems

Illustrated is the popular PMSD1000 module. A 1kW slider control dimmer, interference suppressed, 60mm slider range size 4½ x 2 x 1½in. Ideal for low cost stage and disco lighting. Used by schools, theatres, studios, etc. Complete with scale plate, fixing screws and full instructions. £9.06 inc. VAT and post and packing.

Complete compact light dimmer systems for stage, club and disco lighting, etc.

DD61M (illustrated). Six 1kW channels, six outlet sockets, master control, mains on/off switch, size 21 x 8½ x 5in. Price £311 inc. VAT and P. & P.

DD61-B. Six 1kW channels, using module PMSD1000, lowest cost system. Price £66.50 inc. VAT and P. & P.

ALL PRICES REDUCED FOR A LIMITED PERIOD

The Dimmit range includes rotary and slider control dimmers and sound to light converters for home, entertainment and professional applications. Ratings 1kW, 2kW, 3kW.

All products are guaranteed and are supplied with full instructions and applications. Full after-sales service. Technical advice given.

For full information on all modules and lighting control systems send for our FREE illustrated catalogue and price list. Callers welcome, visit our showroom for a demonstration of any of the modules or systems. Mon.-Fri. 9.30 to 6.00 p.m. Sat. by arrangement.

YOUNG ELECTRONICS LTD.

184 Royal College Street, London NW1 9NN Tel. 01-267 0201
SMALL ADS

The prepaid rate for classified advertisements is 15 pence per word (minimum 12 words), box number 40p extra. Semi-display setting £12.00 per single column inch (2.5cm). All cheques, postal orders etc., to be made payable to Practical Electronics and crossed "Lloyds Bank Ltd." Treasury notes should always be sent registered post. Advertisements, together with remittance, should be sent to the Classified Advertising Manager, Practical Electronics, Room 2337, IPC Magazines Limited, King's Reach Tower, Stamford St. London, SE1 9LS. (Telephone 01-261 5918).

CONDITIONS OF ACCEPTANCE OF CLASSIFIED ADS

1. Advertisements are accepted subject to the conditions appearing on our current advertisement rate card and on the express understanding that the advertisement does not contravene any Act of Parliament or is in an infringement of the British Code of Advertising Practice.

2. The publishers reserve the right to refuse or withdraw any advertisement.

3. Although every care is taken, the Publishers shall not be liable for clerical or printers' errors or their consequences.

RECEIVERS AND COMPONENTS

P.C.B. Bezel P55 in Slim, 6 by 5 for 85p, 12m x 9m 60p. Bezel 17m x 9in, 50p. Glass Bezel, 13n, 89p, 12m x 11m, 51p. D.S. Jinn x 8m, 20p. Neons, 20 for £1, 5 figure Resettable Counter 18/22V works on 12V, £3. Assorted 74 Series ICs £0.60 10p, for 50p. Assorted 12V C74 Series % on panels, £4.40 9p. Reduced purchase. 51 Assistance Transistors, 7W B.E. RADIO.

12 Barford Centre, Barford Road, Northampton, NN1 9LX. All items paid post. Mail order only.

LADDER

LADDERS, varnished, 2-3ft. ext., £27 -64. Cart £1-00. (Lord Bishop, 13, Telford Street, Prestwich, Manchester, M25 3BF).
EDUCATIONAL

TECHNICAL TRAINING

Get the training you need to move up into a higher paid job. Take the first step now—write or phone ICS for details of ICS specialist homestudy courses on Radio, TV, Audio Eng. and Servicing, Electronics, Computers; also self-build radio kits from:

ICS SCHOOL OF ELECTRONICS
Dept. 772B, Intertext House, London SW8 4UJ
Tel. 01-622 9911 (all hours)

COURSES—RADIO AMATEURS EXAMINATION—City and Guilds. Pass this important examination, and obtain your G8 licence, with an R.R.C. Home Study Course. For details of this, and other courses (G.C.E., Professional Examinations, etc.) write or phone: THE RAPID RESULTS COLLEGE, Dept. J81, Tufton House, London, SW19 4DS. Tel. 01-947 7252 (Careers Advisory Service) or for particulars only ring 01-946 1102 (24 hr. recording service).

COLOUR TV SERVICING

Learn the techniques of servicing Colour TV sets through our new homestudy course approved by leading manufacturers. Covers principles, practice and alignment with numerous illustrations and diagrams. Other courses for radio and audio servicing. Full details from:

ICS SCHOOL OF ELECTRONICS
Dept. 772B, Intertext House, London SW8 4UJ
Tel. 01-622 9911 (all hours)

FOR SALE

AMATEUR DISPOSING of "as new" equipment. Many unused items. (Laskys) meters £10, PPA £5. Little used. N. TURNBULL, 6 Kingsley Road, Brighton.

A New Issue: DEWTRON. Derbyshire. Harrogate, N. Yorkshire. Tel. (0423) 55885. Many unused items. (Laskys) meters £10, PPA £5. Little used. N. TURNBULL, 6 Kingsley Road, Brighton.

NEW ISSUES of "Practical Electronics" available from April 1974 up to date. Over 120 issues. Send S.A.E. for List. 19 Albert Road, Southend, Essex.

KENT COUNTY COUNCIL

Tenders are invited for the sale of surplus Constabulary Operations Room equipment consisting of a Mark IV Thermionic Tape Recorder, a Selectro panel for indicating vehicle position and Panels containing numerous relays and uniselectors. Write for tender forms to the County Supplies Officer, County Supplies Department, Sandling Road, Maidstone, Kent ME14 2LP, to whom sealed tenders must be returned by Friday, 4th February, 1977.

PRACTICAL ELECTRONICS, November 1964 (first issue) to December 1974. Up to 1971 in binders. All good condition. Offers. 28 Kennet Road, St. George, Ilkleton, S.R.

DEWTRON. Pair matched VCO2s £40, SHE I £60, PPA £25. Little used. N. TURNBULL, 6 Kingsley Road, Brighton.

SITUATIONS VACANT

RADIO TECHNICIANS

Government Communications Headquarters has vacancies for Radio Technicians. Applicants should be 19 or over.

Standards required call for a sound knowledge of the principles of electricity and radio, together with 2 years experience of using and maintaining radio and electronic test gear.

Duties cover highly skilled telecommunications/electronic work, including the construction, installation, maintenance and testing of radio and radar telecommunications equipment and advanced computer and analytic machines.

Qualifications: Candidates must hold either the City and Guilds Telecommunications Part I (Intermediate) Certificate or equivalent HM Forces qualifications.

Salary scale from £2,230 at 19 to £2,905 at 25 (highest pay on entry) rising to £3,385 with opportunity for advancement to higher grades up to £3,780 with a few posts carrying still higher salaries. Pay supplement of £313 20p per annum.

Annual leave allowance is 4 weeks rising to 6 weeks after 27 years service. Opportunities for service overseas.

Candidates must be UK residents.

Further particulars and application forms available from: Recruitment Officer, Government Communications Headquarters Oakley, Priors Road, Cheltenham, Glos. GL5 2SAJ
Tel.: Cheltenham (0242) 21491 (Ext. 2270)

BOOKS AND PUBLICATIONS

NEW BOOKS READY NOW

BP34 Practical Repair and Renovation of Colour TVs 95p
BP35 Handbook of IC Audio Pre- and Power Amplifier Construction 95p
221 28 Tested Transistor Projects 95p
222 Solid State Shortwave Receivers for Beginners 95p

Obtainable through most large branches of W. H. Smith, good bookshops, component dealers, mail-order houses, etc.

S.A.E. BRINGS FULL LIST OF TITLES

BANABI PRESS & BERNARDS (Publishers) LTD.
THAME, OXFORDSHIRE

PRACTICAL ELECTRONICS, November 1964 to May 1975. Good condition, 3 copies missing. Offers. 28 Kennet Road, St. George, Ilkleton, S.R.

STYLI, CARTRIDGES AND AUDIO LEADS

For the best at lowest prices send S.A.E. for free illustrated list to: FELSTEAD ELECTRONICS (PE), Longley Lane, Oakley, Cheshide, Cheshire, SK6 4EE.

H.M. ELECTRONICS

275 Fulwood Road, Broomhill, Sheffield S10 3BD

Give your project that professional looking finish. Build it in a B.C. Dry transfer lettering now available

SUPERB INSTRUMENT CASES by Bazelli, manufactured from heavy-duty p.v.c faced steel. Hundreds of people and industrial users are choosing the cases they require from our vast range. Competitive prices start at a low 80p. Examples: width, depth, height, 8in. x 8in. x 12in. £1; 10in. x 10in. x 15in. £1.70; 12in. x 12in. x 20in. £3.90; 14in. x 14in. x 24in. £5.95; 15in. x 15in. x 30in. £7.95. Prompt despatch. Free literature (stamp would be appreciated): BAZELLI, No. 32, St. Wilfrid's, Foundry Lane, Halton, Lancaster LA2 8LT.

LOW COST I.C. MOUNTING for any size DIL packages. 100 Solderless sockets 65p. 2 and 4 hole plastic supports 50p/pair. Quantity rates. S.A.E. details and samples. Trial pack 65p (P. & P. 10p). Details from ADAM HALL (ELECTRONICS) 82p. Offers. 28 Kennet Road, St. George, Ilkleton, S.R.

CABINET FITTINGS

FOR Stage Loudspeakers and Amplifier Cabs Frescofichs, Coverings, Recess Handles, Strip Handles, Feet, Castors, Locks and Hinges, Corners, Trim, Speaker Bolts, etc., etc. Send 2 x 8p Stamps for samples and list.

ADAM HALL (P.E. SUPPLIES)
Unit 6, Starline Works, Grainger Road Southend-on-Sea, Essex.

EDUCATIONAL

ELECTRICAL
DIGITAL CLOCK KITS

Of only 5 components with full instructions for assembly of 12 hour clock, excluding case £1.50;
Clock Kit for I.C. dual tone. Dat: op. for TTL and CMOS £26.50.
All prices inclusive (mail order only).

FUSLHAW ELECTRONIC CONTROLS LTD.
38 Thornsett, Birch Vale, Nr. Stockport, Cheshire, SK12 8BP.

MUSICAL MIRACLES

by Dewtron®

Build your own synthesizer or musical effects using one of the largest range of dewtron modules. Or, build your own from-wa-wa-at budget prices using special kits.
Send 25p for Catalogue from:
D.E.W. Ltd, 254 Ringwood Road, Ferndown, Dorset BH20 2AR.

RECHARGEABLE NICAD BATTERIES "AA"

(HP7), £1.05; Sub. "C" £1.25; "D" (HP11) £2.02; "DD" (H2) £2.92; PP3 £4.88. Matching chargers, respectively, £4.48, £4.48, £5.24, £5.24, £8-88. All prices include VAT. Add 10% P. & P. S.A.E. for full list, plus, if wanted, 35p for "Nickel Cadmium Power" booklet. SANDWELL PLANT LTD., 1 Denholm Road, West Midlands, B73 6PP.

BUILD THE TREASURE TRACER MK III

Metal Locator
- Varicap tuning
- Stripper/strip-cutter metal locator kit
- Hand erected case
- Supplied with trolley
- Easy and use
- 100% accuracy
- Precision setting
- Five hour repair circuit
- Thoroughly professional finish
- You only need add detector
- Easy and use
- Supplied in BNC USSR & BNC USSR T

Send stamped addressed envelope for
Compliance £1.75
Post £1 + £1.20 VAT
WINCKES ELECTRONICS, 56 CLEVELAND ROAD LONDON E18 2AN (Mail Order Only)

GLASS FIBRE P.C.B.'s

From your own tape, film or ink master. Send S.A.E. for quotation.
PRactical ELECTRONICS P.C.B.'s in glass fibre, tinned and drilled, June 76 Transmitter £95, Coder £65, July 76 Receiver £65, Decoder £70, Interface £50, August 76 Servodrive £65, Servo £75, Day Driver £65, Complete set of above boards £33.00, Sept. 76 Tone Generator £65, Tone Decoder £75, Sept. 76 Cross Hatch Generator £25.00, Nov. 76 Hazard Warning Flasher £65.00, Dec. 76 FM Stereo Tuner £2.50. Send S.A.E. for information on current boards. C.W.O. please.

PROTO DESIGN

4 Highcliffe Way, Wickford, Essex SS11 8LA

ENAMELLED COPPER WIRE

S.W.G. 1lb reel 1lb reel
10 to 19 £3.95 £6.50
20 to 29 £3.15 £6.00
30 to 40 £3.45 £5.45
35 to 40 £3.45 £5.45
All the above prices include the cost of postage and packing in the U.K.

COPPER SUPPLIES

102 Parrawood Road, Withington, Manchester 20
Telephone 061-445 8753

PRINTED CIRCUIT BOARDS supplied in glass fibre and drilled tinned 8g per sq in or tinned (10g per sq in). P. & P. 30p. R. F.
DARLISON, 1 Valentine Drive, Oadby, Leicester. Tel. (0533) 710673.
SEND OR CALL FOR FREE CATALOGUE giving details of our complete range of Clock kits, LED displays, Cases, and other components

IT'S EASY WHEN YOU KNOW!
To avoid missing your copy of PRACTICAL ELECTRONICS—simply complete your order form and hand it to your newsagent.

ORDER FORM

To: __________________________ (name of newsagent)

Address ______________________

Please reserve/deliver every month one copy of PRACTICAL ELECTRONICS unless further notice.

My Name ______________________

Address ______________________
Save up to £17.30 when you join the

Science Fiction Book Club

Take any 3 books for only 15p (plus carriage)

Billion Year Spree

The History of Science Fiction
Brian W. Aldiss

Ship Wreck

Counts as One Book

The Tenth Planet

EMIC

Alfred Bester

Extra

The Jonah Kit

Counts as One Book

The Dynostar Menace

Kit Podder and Gerry Davis

TWO FREE BOOKS INCLUDED WITH YOUR ORDER

Camera Kits and Ready Built Modules

Whether professional, student, teacher or amateur, a CROFTON module is the answer

Apart from our popular C.C.T.V. Camera Kits we are launching a range of ready built, tested and guaranteed electronic modules both for trade and end user.

The ultimate range will be extensive. Some of the existing modules available are:

- E.T.I. Master Mixer
- E.T.I. Electronic Ignition
- Wide range R.F. Wobbulator
- E.T.I. Digital Voltmeter
- E.T.I. Frequency Meter
- Video Amplifier
- Video Mixer
- Sound/Video Modulator
- Guitar Amplifier
- As well as all E.T.I. P.C.B.s
- V.L.F. Transmitters and Receivers
- Send S.A.E. for information

Secondhand cameras and monitors always available

CROFTON ELECTRONICS LTD
Dept. E, 35 Grosvenor Road, Twickenham, Middx. Tel. 01-891 1923

Camera Kits and Ready Built Modules

Whether professional, student, teacher or amateur, a CROFTON module is the answer

Make light work of wiring with the NEW SELF ADHESIVE WIRE STAPLES

Countless uses in industry and offices

*QUICK AND EASY TO APPLY—EVEN IN AWKWARD PLACES
*SAVES DAMAGE TO WOOD AND PAINTWORK
*STICKS ON INSTANTLY: HOLDS WIRE FIRMLY

You'll save enormous time and trouble with the new Brandauer adhesive staple. Just peel off the backing strip and press staple into place. Then bend clips over to hold wire firmly in position. No messing with pins, tacks, soldering or drilling. No damage to wood or paint. Use the Brandauer Staple for any wall, frame or cabinet wiring jobs—it's wonderfully easy for fitting in those awkward corners.

Send now for details to:

SPECIAL PRODUCTS DISTRIBUTORS LTD
81 Piccadilly, London W1V OHL. Tel: 01-629 9556.
The new Maplin Catalogue is no ordinary catalogue...

Semiconductor section includes full details of a range of fascinating TV games, rhythm generators, preset on and off timer/clock, plus radio/IC op amps, voltage regulators, mono and stereo power amp, ICs, etc.

SEND THIS COUPON FOR YOUR COPY OF OUR CATALOGUE ON APPROVAL! Price 50p - SEND NO MONEY NOW.

Our bi-monthly newsletter keeps you up to date with latest guaranteed prices, our latest special offers (they save you pounds), details of new projects and new lines. Send 30p for the next six issues (5p discount voucher with each copy).

Catalogue includes a very wide range of components: hundreds of different capacitors, resistors, transistors, ICs, diodes, wires and cables, discotheque equipment, organ components, musical effects units, microphones, turntables, cartridges, styli, test equipment, boxes and instrument cases, knobs, plugs and sockets, audio leads, switches, loudspeakers, books, tools - AND MANY MANY MORE.