wireless world
MARCH 1980 50p

Metal detector
Electronic lock
Not just a Data Analyser, Signature Analyser, or Logic Analyser, but...

...all three in one very portable box: The 308 Analyser

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Tektronix UK Limited, PO Box 69, Coldharbour Lane, Harpenden, Herts. AL5 4UP.
Tel: Harpenden 63141
Regional Telephone Numbers; Livingston: 32766, Maidenhead: 73211, Manchester: 428 0799, Dublin: 508132

Tektronix COMMITTED TO EXCELLENCE
Metal detector

Electronica

Front cover is a photograph, by Paul Brierley, of the printed-circuit pattern on a Motorola microcomputer board.

IN OUR NEXT ISSUE

Digital capacitance meter is a 3½-digit instrument, with full-scale readings of 200pF to 20pF.

How serious is multipath distortion? An investigation into this effect in v.h.f./f.m. sound broadcasting and results of recent research.

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wireless world
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Fault us on specification and we’ll eat it.

From the raw material to the finished component, Erie has been deeply involved in producing crystals for the past twenty years – to exacting specifications. The factory and test facility complies with the latest MIL standards. Each crystal is tested at least nine times during manufacture. Only after a final check against the customer’s specification is it allowed through the door.

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### TRANSISTOR RANGES (PNP OR NPN)

<table>
<thead>
<tr>
<th>ICBO</th>
<th>BE</th>
<th>hFE</th>
<th>VCE(sat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10nA, 100nA, 1µA, 10µA and 100µA f.s.d. acc. ±2% f.s.d. ±1% at voltages of 2V, 5V, 10V, 20V, 30V, 40V, 50V, 60V, 80V, 100V, 120V, and 150V acc. ±3% ±100mV up to 10µA with fall at 100µA &lt; 5% + 250mV.</td>
<td>10V or 100V f.s.d. acc. ±2% f.s.d. ±1% at currents of 10µA, 100µA and 1mA ± 20%.</td>
<td>3 inverse scales of 2000 to 10, 400 to 30 and 100 to 10 convert IB into hFE readings.</td>
<td>1V f.s.d. acc. ±20mV measured at conditions on hFE test.</td>
</tr>
</tbody>
</table>

- **BDV**
  - 10nA, 100nA, 1µA ... 10mA f.s.d. acc. ±2%
  - f.s.d. ±1% at fixed IF of 1µA, 10µA, 100µA, 1mA, 10mA, 30mA, and 100mA acc. ±1%.

- **hFE**
  - 3 inverse scales of 2000 to 100, 400 to 30 and 100 to 10 convert IB into hFE readings.

- **VBE**
  - 1V f.s.d. acc. ±20mV at collector currents of 1mA, 10mA, 30mA and 100mA with IC/IB selected at 10, 20 or 30 acc. ±20%.

### DIODE & ZENER DIODE RANGES

<table>
<thead>
<tr>
<th>IDR</th>
<th>Vz</th>
<th>VDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>As IEBO transistor ranges.</td>
<td>Breakdown ranges as BDV for transistors.</td>
<td>1V f.s.d. acc. ±20mV at IF of 1µA, 10µA, 100µA, 1mA, 10mA, 30mA and 100mA.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>£145</th>
<th>Type</th>
<th>£155</th>
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<tbody>
<tr>
<td>TM12</td>
<td></td>
<td>TM14</td>
<td></td>
</tr>
</tbody>
</table>

Optional extras are leather cases and mains power units. Prices are ex works, V.A.T. extra in U.K.
Top value test equipment from TANDY

**LCD DIGITAL MULTIMETER.**
Low-cost hand held digital multimeter with a full 3½ digit LCD display. 0.5% basic accuracy, auto polarity operation. 10 Mohm DC input impedance.

**Scales:**
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- AC volts: 1mV to 500V (1½ ± 2 digits accurate)
- DC current: 1µA to 200mA (1½ ± 1 digit accurate)
- Resistance: 9 to 20 Mohm
- Power source: 9V battery or AC

**Reading to ± 1999.**

**AC/DC 8 MHz OSCILLOSCOPE**
A new approved 8MHz version of last years' winner! The advance design features of this oscilloscope make it an absolute essential for industrial uses on production lines, in laboratories and schools. Ideal for radio and TV servicing, audio testing, etc.

**Specifications:**
- Horizontal axis: Deflection sensitivity better than 255mV/DIV. Vertical axis: Deflection sensitivity better than 100mV/DIV. 6mm Bandwidth 0.8MHz. Input impedance: 1MOhm parallel capacitor x 10pF. Time base: Sweep range 10µs to 10ms complete with sweep generator 220 VAC 50/60Hz. Supply 220/240VAC 50/60Hz.

**PRICE**

**53.19**

**A new low-cost LCD multimeter**
A portable, compact sized multimeter with a full 3½ digit LCD display. Auto polarity operation, low battery indicator. 10 Mohm Input impedance.

**Scales:**
- DC volts: 2, 20, 200 1000V
- AC volts: 200, 500V
- DC current: 2, 20 200mA
- Resistance: 2, 20 200 2000 Kohm
- Power source: 9V battery or AC

**Reading to ± 1999.**

**AC/DC 8 MHz OSCILLOSCOPE**
A new approved 8MHz version of last years' winner! The advance design features of this oscilloscope make it an absolute essential for industrial uses on production lines, in laboratories and schools. Ideal for radio and TV servicing, audio testing, etc.

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**PRICE**

**39.93**

**COMPONENTS AND PARTS**

<table>
<thead>
<tr>
<th>CAT No.</th>
<th>DESCRIPTION</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>276 - 032</td>
<td>LED</td>
<td>£4 for £69p</td>
</tr>
<tr>
<td>276 - 033</td>
<td>LED</td>
<td>£2 for £48p</td>
</tr>
<tr>
<td>276 - 034</td>
<td>LED</td>
<td>£2 for £59p</td>
</tr>
<tr>
<td>276 - 142</td>
<td>Infra-Red Emitter Detector Pair</td>
<td>£1.37</td>
</tr>
<tr>
<td>277 - 1003</td>
<td>DC Automotive Digital Clock Module</td>
<td>£17.52</td>
</tr>
<tr>
<td>276 - 9110</td>
<td>DC/AC Converter for 277 1003</td>
<td>£40p</td>
</tr>
<tr>
<td>276 - 1373</td>
<td>Power Transistor Mounting Hardware</td>
<td>£50p</td>
</tr>
<tr>
<td>276 - 1363</td>
<td>TO 220 Heat Sink</td>
<td>£60p</td>
</tr>
<tr>
<td>276 - 1364</td>
<td>TO 3 Heat Sink</td>
<td>£81p</td>
</tr>
</tbody>
</table>

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NE556 14 Dual Timer 50p
UA733CN Voltage Regulator 39p
7812 Voltage Reg 55p

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Now you can operate 115/120 Volts American equipment from 240 Volts. This converter has outlets for American type 2 or 3 pin plugs. Rated 700VA. Only £8.95.

From 1 T1. TL490 BAR/DOT DRIVER IC. Drives 10 LEDs with adjustable analog inputs. Units are encapsulated up to 12 (1000 each). Drives LEDs directly. Great for voltages, currents or audio displays. Similar in features to LM331 with specs and pinout noted. Only £1.75 NEW!

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**F5VS07** Medium Blue Clear Case RED EMITTING. These are not iridescent off-axial units as sold by some of our competitors. These are factory prite, first quality, new units.

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5p each 1000 off
5p each 2000 off

Intersil Universal Timer/Counter Evaluation Kit
ICM7226A EV/KIT
8 digits 5 Function 4 range A 10MHz with 0.1Hz res. time interval and period to 10 seconds with 0.1 microsecond res. units up to 10 million and micro. A breadboarding unit is provided for use to add your input conditioning circuitry or preamplifiers and digital outputs are available as multi-pled as well as being displayed.

Complete kit only £39.95 + VAT

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Appledore, Nr. Sidmouth
North Devon EX9 1RY
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Telex 8833084

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- 3½ digits 0.56" high LED for easy reading
- 100μV, 1μA, 0.01Ω resolution
- High input impedance 10 Megohm
- High accuracy achieved with precision resistors, not unstable trimpots
- Input overload protected to 1000V (except 200mV scale to 600V)
- Auto zeroing, autopolarity
- Mains (with adaptors not supplied) or battery operation built-in charging circuitry for NiCads
- Overrange indication
- Hi Low power ohms, Lo for resistors in circuit, Hi for diodes

Specifications:

<table>
<thead>
<tr>
<th>DC Volts</th>
<th>Range 200mV, 2V, 20V, 200V, 1000V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>1% ± 1 digit, Resolution 1mV</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Overload protection</th>
<th>1000VA max</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Current</td>
<td>Range 2mA, 20mA, 200mA, 2A, 2amp</td>
</tr>
<tr>
<td>Accuracy</td>
<td>1% ± 1 digit, Resolution 1 Microamp</td>
</tr>
<tr>
<td>Overload protection</td>
<td>- 2 amp fuse and diodes</td>
</tr>
<tr>
<td>DC Current</td>
<td>Range 2mA, 20mA, 200mA, 2 amp</td>
</tr>
<tr>
<td>Accuracy</td>
<td>15% ± 2 digits, Resolution 1 Microamp</td>
</tr>
<tr>
<td>Resistance</td>
<td>Range 20, 200, 2K, 200K, 2 Meg. 20 Meg.</td>
</tr>
<tr>
<td>Accuracy</td>
<td>1% ± 1 digit, Resolution 0.1 ohms</td>
</tr>
<tr>
<td>Environmental</td>
<td>Temo coeffient 0 to 30 C ± 0.25C</td>
</tr>
<tr>
<td>Operating Temp</td>
<td>0 to 60C Storage - 20 to 60C</td>
</tr>
</tbody>
</table>

General
- Maint adaptor, 6.9 Volt @ 200mA (not supplied)
- 4C size batteries (not supplied)
- Size 8% x 5½ x 2½
- Weight 2.5 lbs.

To: Maclin-Zand Electronics Ltd.
1st Floor, Unit 10, East Block
38 Mount Pleasant, London WC1X 1AP

Please send me:
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To let the system grow with your needs.

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This powerful system is now available today.

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This software package provides the most powerful set of tools yet available for the microcomputer programmer.

Apple Pascal

Net V.A.T. Total

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Give your system immediate access to large quantities of data.

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Parallel Printer Interface Card

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Allows your Apple to 'talk through a modem' with other computers and terminals over ordinary telephone lines. Enables sophisticated communications, data exchange, and automatic sending and receiving of telemessages to remote terminals or access terminals over ordinary telephone and television cables.

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Communications Interface Card

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Superboard II

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Superboard comes complete with documentation and sample software on cassette.

Net V.A.T. Total

Superboard II

188.00 28.20 216.20

1 U.R.F Modulator 200 038 288

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A third generation personal computer system, the video genie is a powerful microcomputer that is completely compatible with the Tandy TRS-80 TM.

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The system uses the powerful and popular Z-80 processor. A system reset button is mounted at the rear of the console. Power down is not required should the system crash.

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16 lines of 3212 pixels or 64 characters, switch selectable. Full software cursor control.

Composite video output to domestic television.

Net V.A.T. Total

Video Genie

369.57 55.43 425.00

Sharp

SHARP MX-82

- 2.80 boosted CPU

- 4K Byte monitor RAM

- Internal memory capacity from 4 to 48K RAM.

- 16K Extended BASIC.

- 12K Extended Level II Basic interpreter, system monitor.

- Complete compatibility with TRS-80B LEVEL II BASIC.

- Integral 500 Kbps cassette deck eliminates external control system.


- An extended Level II Basic compatible with the TRS-80 LEVEL II BASIC.

- Features (line editing, formatted printing, multi dimensional arrays, AUTO Line numbering, Program linking)

- A huge range of software on cassette is already available.

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Full ASCII keyboard with 10 key rollover. Automatic keyboard bounce. Expansion connector provides a parallel 1/0 Port for printer.

Net V.A.T. Total

Sharp

Net V.A.T. Total

439.50 65.85 505.35

Acorn

Acorn is a third generation personal computer.

- Full 79 Key Keyboard.

- Built in monochrome video monitor with 24 x 124 resolution.

- Fast reliable cassette unit with tape counter.

- Wide variety of software available on 50 pin bus connector for system expansion.

Acorn Memory

A high quality three glass, hole plated, phosphor screen and component identification, this computer has provision for 8K of RAM (2114) and 8K of EPROM (2732).

Net V.A.T. Total

Acorn Memory

595.00 88.00 683.00

Net V.A.T. Total

55.43 425.00

V D U Card (Kit)

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Microdigital are one of the largest and longest established Microcomputer firms in Europe. We sell a wide range of systems, backed up by support services that are second to none.

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Nevertheless with good amplifiers and loudspeakers (and on those occasions when the people at the recording and transmitting end get it right) a musical experience can be achieved which is extremely satisfying and one of the greatest pleasures of our time.

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Tel: (0480) 52561.

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HH Acoustics Limited, Viking Way, Bar Hill, Cambridge CB3 8EL. Telephone: (0954) 81140. Telex: 817515 HH Elec G.

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**TEKTRONIX 465**
- DC-100MHz Dual Trace 5mV-5V/Div
- 0.05µs-0.5s/Div Delayed T/B XY DC 4MHz

**TEKTRONIX 475A**
- DC-250MHz Dual Trace 5mV-5V/Div
- 0.01µs-0.5s/Div Delayed T/B XY DC 3MHz

**Prices**

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC-100MHz Dual Trace 5mV-5V/Div</td>
<td>£1250</td>
<td></td>
</tr>
<tr>
<td>DC-250MHz Dual Trace 5mV-5V/Div</td>
<td>£1950</td>
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</tr>
</tbody>
</table>

**WIRELESS WORLD, MARCH 1980**

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**Acoustic**

- **BRUEL & KJAER**
  - 2233 Precision sound level meter
  - 1613 Octave filter set couples directly to 2203 & 2204

- **MARCONI**
  - 2170 1-300 MHz, Multi-Mode, 10V/100Ω sine, triangular

- **RUSSELL**
  - 288+ CT Cap on AC recording ammeter

**Deliveries**

This catalog is available for delivery until March 31, 1980. The prices listed are valid until that date. Prices are subject to change without notice. For further details, please contact Carston Electronics at the provided contact information. Prices are in £ and exclusive of VAT.

---

**Multimeters**

- **MARCONI**
  - 3220 Drive for Clary Printer
  - 3221 Drive for Facit 4000

- **TEKTRONIX**
  - 5303A DC-50 MHz, 100µV sens. 
  - 5308A DC-520 MHz, 100µV sens.
  - 5309A DC-50 MHz, 100µV sens.

**Prices**

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<td>£1950</td>
<td></td>
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</tbody>
</table>

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**Modulation Meters**

- **MARCONI**
  - 3240/3301 Data Transfer Unit and Totalise
  - 3238 Power Supply

- **TEKTRONIX**
  - 5303A DC-50 MHz, 100µV sens.
  - 5308A DC-520 MHz, 100µV sens.
  - 5309A DC-50 MHz, 100µV sens.

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</tbody>
</table>
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<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>HM 307</td>
<td>Single Trace DC-10 MHz, 5 mV/cm Plus built in Component Tester</td>
<td>£149</td>
</tr>
<tr>
<td>HM 312</td>
<td>Dual Trace DC-20 MHz, 5 mV/cm Sweep Speeds 40 ns - 0.2s/cm 8 x 10 cm Display</td>
<td>£250</td>
</tr>
<tr>
<td>HM 412</td>
<td>Dual Trace DC-20 MHz, 2mV/cm Sweep Speeds 40 ns - 2 s/cm and Sweep Delay</td>
<td>£350</td>
</tr>
<tr>
<td>HM 512</td>
<td>Dual Trace DC-50 MHz, 5 mV/cm Sweep Speeds 20 ns - 5 s/cm plus Sweep Delay</td>
<td>£580</td>
</tr>
<tr>
<td>HM 812</td>
<td>Dual Trace DC - 50 MHz, 5 mV/cm 20 ns - 5 s/cm, Sweep Delay and Storage</td>
<td>£1325</td>
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</tbody>
</table>

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The PM 2517 has set the standard and the pace in Europe for hand-held digital multimeters - and still it remains in a class of its own. Remember, its many important features include full four digits, so on mains voltage readings, for example, you might get 240.3 instead of the 240, which a 3½ digit meter would read.

Some other PM 2517 plus points:
- LED or LCD display
- True RMS readings of AC voltage and current
- Autoranging with manual override
- Optional accessories include temperature and data hold probes

Reader inquiry number 220

NO WAITING FOR THESE TOP PRODUCTS

GREAT COUNTERS MYSTERY

Philips engineers have encountered the same reaction from customers and competitors alike when showing off the new microcomputer controlled PM 6667 (120 MHz) and PM 6668 (1GHz) frequency counters: "How do they do it for the price?" Here's a brief summary of what the counters offer.
- Reciprocal frequency counting (for higher resolution without ±1 cycle error)
- Auto-triggering on all waveforms

Reader inquiry number 222

The PM 3207 - Super Scope - is a tough, general purpose oscilloscope which offers at a low price the quality and technology you expect from Philips Test and Measuring Instruments.
- 15 MHz dual trace
- Auto triggering from either channel with adjustable level between peaks and TV triggering
- 5 mV sensitivity, Y and X (via A input)
- B invert facility

Reader inquiry number 221

Both these instruments are available off the shelf from the Philips Electronic Instruments Department (see address below) or from the following distributors. British Tungsram, West Road, Tottenham, London N17 ORN. Tel: 01-886-4884. Philips Service Centres (25 throughout the country). Tel: 01-886-0905 for the address of your nearest branch. Wessex Electronics Ltd, 144-146 North Street, Downend, Bristol BS 16 5SE. Tel: (0272) 570516. These products are also available from Pye Unicam Ltd, Essex Electronics, 144-146 North Street, Downend, Bristol BS 16 5SE. Tel: (0272) 570516.

Reader inquiry number 222
Our 19" Card frame will house your projects in a 'professional' manner. It is designed to take Eurocards or Modules and offers facilities for interconnection through 2-part DIN 41612 or direct edge connectors. A full range of compatible items are available — all selected from the established range of industrial products — boards, accessories, cases etc. Just send 40p. and we'll send you our catalogue by return — it's got the lot!

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In future, recording the present will be a thing of the past.

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But it's fundamental to the very existence of communications recording to be able to replay a selected portion of tape to find out what was said by who, to whom ... and when. And 'when' can be vital.
Equally vital, particularly in emergencies when every second counts, is the ability to obtain such replay access rapidly, precisely, automatically. With absolute certainty — and without time-consuming multiple knob-twiddling aided by guesswork.
Racal Recorders has recognized this need and produced TIMESEARCH — designed specifically for its ICR range of multi-channel communications recorders — and providing just these facilities.
TIMESEARCH can generate a coded time reference signal of crystal accuracy and index it onto the tape. It can read and display that signal. It can search a tape at high speed for a pre-selected time signal and automatically initiate replay at that time.
In communications recording, the future becomes the present; the present becomes the past. And when you need to recall the past with precision, you need TIMESEARCH.

And for providing precise time signals every 10 seconds for recording onto magnetic tape: the International Timing Unit.

Racal Recorders always on the right track
The MSI System 12 computer system combines the popular MSI 6800 processor...the MSI FD-8 QUAD floppy disk system, and the new MSI HD-8/R 10 megabyte fixed/removable hard disk system in one compact desk unit.

Ideal for business applications, the MSI System 12 gives you a large capacity hard disk for mass storage, and a floppy disk system for program loading, backup, software updates and exchanges. System 12 will use MSIDOS, SDOS or FLEX operating systems. A variety of programs is available including Multi-User BASIC and a complete Management/Accounting package.

Complete with industry standard CRT and high speed printer, the MSI System 12 is one of the most powerful microcomputer systems available.

---

**Quantum Electronics**

NEW PRODUCTS — NEW PRODUCTS

Our product range for the 80s is outlined but it is impossible to cover everything in such a small space. For detailed information and a price list send a large SAE or a dollar bill.

PRE-AMP & POWER AMP KITS

The pre-amp is now available in kit form in versions to suit any cartridge and consists of the module C1 (below) and the hardware kit HK1. No soldering is involved and assembly takes about 20 mins. There are four power amp kits, four mono and two stereo, from 45 to 260W to satisfy virtually every requirement. They use ready-built and tested p.c. boards to achieve an ease of construction similar to module-based kits at lower cost. There are also mains supply kits to enable independent use of the pre-amp, which is normally powered via our power amp. Similar equipment is also available ready-built from us or via our dealers.

- C1 + HK1: £68.70
- C1mc + HK1: £70.95
- P2 (stereo 45W per channel) kit: £87.28
- P4 (stereo 110W per channel) kit: £109.42

MOVING-COIL & PRE-AMP MODULES

Previously restricted to trade and export, the C1 pre-amp module is now available separately in 3 versions to match any cartridge. It has unbeatable specifications, caters for disc, auxiliary and 2 or 3 head tape machines and requires only a rough supply of 18 to 36V d.c. The new moving coil pre-pre-amp achieves low total harmonic distortion, high overload, good noise performance without resorting to the expensive multiple transistor design. Only tantalum capacitors and metal oxide resistors are used in the signal path and it can be powered either via the C1 or by a battery. Hardware kits are available to build both types and they are also available ready-built.

- MC1 Module: £49.50
- C1mc Module: £51.75
- C1 Module: £49.50
- C1mc £51.75

POWER AMP MODULES AND SUPPLIES

The power amp modules are now also available to retail customers in a variety of powers and formats up to 260W r.m.s. They use the same high performance circuitry as the kits above, giving t.h.d. below 0.1% at 1kHz, but are capable of sustained high level use with excellent reliability. There are power supplies for use with any one or two of these modules, all of which use toroidal transformers, also available separately. The module illustrated is a medium duty 150W, r.m.s. type, the M150S, which requires the MS3 supply.

- M1508: £35.79
- MS3: £26.28

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And yet the ZX80 really is a complete, powerful, full-facility computer, matching or surpassing other personal computers on the market at several times the price. The ZX80 is programmed in BASIC, and you could use it to do quite literally anything from playing chess to running a power station.

The ZX80 is pleasantly straightforward to assemble, using a fine-tipped soldering iron. Once assembled, it immediately proves what a good job you've done... Connect it to your TV set... link it to an appropriate power source and you're ready to go.

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* FREE course in BASIC programming and user manual.

Optional extras

* Mains adaptor of 600 mA at 9 V DC nominal unregulated (available separately - see coupon).
* Additional memory expansion board plugs in to take up to 3K bytes extra RAM chips (Chips also available - see coupon).

* Use a 600 mA at 9 V DC nominal unregulated mains adaptor. Available from Sinclair if desired - see coupon.

Two unique and valuable components of the Sinclair ZX80.

The Sinclair ZX80 is not just another personal computer. Quite apart from its exceptionally low price, the ZX80 has two uniquely advanced components: the Sinclair BASIC interpreter, and the Sinclair teach-yourself BASIC manual.

The unique Sinclair BASIC interpreter offers remarkable programming advantages:

* Unique 'one-touch' key word entry: the ZX80 eliminates a great deal of tiresome typing. Key words (RUN, PRINT, LIST, etc.) have their own single-key entry.
* Unique syntax check. Only lines with correct syntax are accepted into programs. A cursor identifies errors immediately. This prevents entry of long and complicated programs with faults only discovered when you run them.
* Excellent string-handling capability - takes up to 26 string variables of any length. All strings can undergo all relational tests (e.g. comparison). The ZX80 also has string input-to request a line of text when necessary. Strings do not need to be dimensioned.
* Up to 26 single dimension arrays.
* PDB/NEST loops nested up to 26.
* Integer names of any length.
* BASIC language also handles full Boolean arithmetic, conditional expressions, etc.
* Exceptionally powerful edit facilities, allows modification of existing program lines.
* Randomise function, useful for games and secret codes, as well as more serious applications.
* Timer under program control.
* PEEK and POKE enable entry of machine code instructions, USR causes jump to a user's machine language sub-routine.

* High-resolution graphics with 22 standard graphic symbols.
* All characters printable in reverse under program control.
* and the Sinclair teach-yourself BASIC manual.

If the features of the Sinclair interpreter listed alongside mean little to you - don't worry. They're all explained in the specially-written 96-page book free with every kit! The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming - from first principles to complex programs. (Available separately - purchase price refunded if you buy a ZX80 later.)
Fewer chips, compact design, volume production - more power per pound!

The ZX80 owes its remarkable low price to its remarkable design: the whole system is packed onto fewer, newer, more powerful and advanced LSI chips. A single SUPER ROM, for instance, contains the BASIC interpreter, the character set, operating system, and monitor. And the ZX80's 1K byte RAM is roughly equivalent to 4K bytes in a conventional computer, because the ZX80's brilliant design packs the RAM so much more tightly. (Key words, for instance, occupy just a single byte.)

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The ZX80 kit costs a mere £79.95. Can't wait to have a ZX80 up and running? No problem! It's also available, ready assembled, for only £99.95.

Whether you choose the kit or the ready-made, you can be sure of world-famous Sinclair technology - and years of satisfying use. (Science of Cambridge Ltd is one of the Sinclair companies owned and run by Clive Sinclair.)

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<thead>
<tr>
<th>Quantity</th>
<th>Item</th>
<th>Item price</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>Sinclair ZX80 Personal Computer kit(s): Price includes ZX80 BASIC manual, excludes mains adaptor</td>
<td>79.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ready-assembled Sinclair ZX80 Personal Computer(s): Price includes ZX80 BASIC manual, excludes mains adaptor</td>
<td>99.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mains Adaptors (600 mA at 9 V DC nominal unregulated)</td>
<td>8.95</td>
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<tr>
<td></td>
<td>Memory Expansion Board(s) (takes up to 3K bytes)</td>
<td>12.00</td>
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<tr>
<td></td>
<td>RAM Memory chips - standard 1K bytes capacity</td>
<td>16.00</td>
<td></td>
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<tr>
<td></td>
<td>Sinclair / ZX80 Manuals (manual free with every ZX80 kit or ready-made computer)</td>
<td>5.00</td>
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</tbody>
</table>

Total: £

NB: Your Sinclair ZX80 may qualify as a business expense.

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THE CS1830 30 MHz + Sweep Delay

The CS1830 is a completely new 30 MHz dual trace oscilloscope employing a square format, internal graticle, PDA tube for accurate bright display. A new feature is the inclusion of calibrated sweep delay with a range of 1μS-100mS and trace bright up to show the delay position. As you can see from close study of the photograph, the CS1830 has all the facilities you could require in a high performance instrument but for more detail, simply ask us for a comprehensive leaflet.

Brief Specification
- Rectangular PDA tube 120 x 96 mm. P31 phosphor.
- Bandwidth DC - 30 MHz
- Sensitivity: 5mV/cm (30 MHz) 2mV/cm (20 MHz)
- Input R.C. 1 MΩ/23 pF
- Rise time 11.7 nS
- Sweep delay 1μS-100mS

CS1830 only £455 + VAT includes 2 probes

THE CS1572 30 MHz for the VTR Lab.

If you are in Video, you need the CS1572

The CS1572 is a dual trace 30 MHz oscilloscope designed for the video tape recorder engineer. Video delayed sweep facilities are provided to allow magnification and analysis of any point in a single video frame together with separation of video odd and even fields. A truly unique tool for anyone concerned with video measurements as well as a top specification dual trace wide band oscilloscope for general lab use. The complete range of video facilities is too great to explain in a small advertisement so why not call us and ask for the full story on the CS1572.

Brief Specification
As for CS1830 except that the sweep delay feature is replaced by comprehensive video sweep delay facilities which allow complete analysis of video wave forms and VTR alignment.

CS1572 only £425 + VAT, includes 2 probes

THE CS1577 30 MHz at 2mV + Signal Delay

The most popular scope in the range.

The CS1577 is, without doubt, our most popular oscilloscope and hundreds of satisfied users in all sections of the electronics industry will confirm this. The CS1577 combines a wide bandwidth DC-30 MHz performance with extremely wide trigger bandwidth (DC-40 MHz) and 2 mV sensitivity over the full bandwidth. Fixed signal delay is provided by a helix delay line which allows viewing of the leading edges of fast pulses for accurate rise time measurement, and the 130 mm PDA tube gives a bright, stable trace even at the highest sweep speeds (20 nS/cm using X 5 expansion). Good triggering, even at low levels has always been an outstanding feature of Trio oscilloscopes and the CS1577 demonstrates this to perfection. Triggering, as in the other 30 MHz instruments can be from CH1 or CH2 or can be alternated with the beam switching so that input signals of differing frequency will provide stable displays. Truly an oscilloscope masterpiece. CS1577.

CS1577 only £410 + VAT, includes 2 probes.

THE CS1575, unique dual trace 4 function Audio Scope

The CS1575 is a unique tool for the audio engineer. It features the normal facility of dual trace display with sensitivity to 1 mV/cm but not only can it display the input signal on two channels, it can simultaneously display the phase angle between them and measure the phase angle referenced to a zero phase calibration display. In addition to these unique features, you also have independent triggering from each channel to give stable displays even with widely differing input frequencies.

Absolutely indispensable to the professional audio engineer, the CS1575 is now in use all over the world. See it in action or send for complete details.

CS1575 only £235 + VAT.

AND TWO NEW ADDITIONS TO THE RANGE

DL705 MULTIMETER

DC to 1000V
AC to 1000V
0 to 20MA
1 to .2A
Semi Auto Ranging

£70 + VAT

For further details and ex stock delivery contact

LCW ELECTRONICS

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<thead>
<tr>
<th>Product Description</th>
<th>Price</th>
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<tr>
<td>AIRMEC 248A 5-300MHz WAVE ANALYSER</td>
<td>£15600</td>
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<tr>
<td>DYMAR 771 A.F. Wave Analyser 20Hz-50KHz</td>
<td>£150.00</td>
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<tr>
<td>HEWLETT-PACKARD 331A Distortion Analyser 5Hz-600KHz</td>
<td>£350.00</td>
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<tr>
<td>MUIRHEAD D-988-A High Frequency Analyser 0.2KHz-64MHz</td>
<td>£120.00</td>
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<tr>
<td>TEKTRONIX 1L20 Spectrum Analyser 10MHz-4.2GHz</td>
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<tr>
<td>General Radio 1607A Transfer Function &amp; Immittance Bridge</td>
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<tr>
<td>MARCONI TF.868B 1% Universal Bridge 1KHz &amp; 10KHz</td>
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<td>MARCONI TF.2701 Insitu Universal Bridge</td>
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<td>WAYNE KERR 221A .1% Universal Bridge</td>
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<td>WAYNE KERR B.601 .1% R.F. Bridge 15KHz-5MHz</td>
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**BRIDGES**

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<td>AIRMEC 364A 5-300MHz WAVE ANALYSER</td>
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<td>HEWLETT-PACKARD 350A Dual Beam DC-1MHz 100V/cm</td>
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<td>TEKTRONIX 954 Storage Dual Trace 2mV/Div.</td>
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<td>TELEQUIPMENT D.32 Dual Beam DC-10MHz Malloy/Batt.</td>
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<td>TEKTRONIX Plug Ins. E.U.R.3.1A-1A/CA/821S1 from</td>
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<td>MARCONI TF.791D Carrier Deviation Meter</td>
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<td>MARCONI TF.2600 Sensitive Valve Voltmeter 10KHz-5MHz</td>
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<td>BOONTON 91DA R.F. Voltmeter 20KHz-1200MHz</td>
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<td>DYMAR 761 Noise Factor Meter 100Hz-100KHz</td>
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<td>HEWLETT-PACKARD 431C Power Meter &amp; Thermistor</td>
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**OSCILLOSCOPES**

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<td>HEWLETT-PACKARD 130C X-Y-Y DC-150KHz 200mV/cm</td>
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<td>SCOPEX 4D-10B Dual Beam 10MHz 10mV/cm, NEW</td>
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<td>SCOPEX 4D-30 Dual Beam 35mHz 10mV/cm, NEW</td>
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**RECORDERS**

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<td>B &amp; K 2305 Sound Level Recorder</td>
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<td>GOLDS 200 Circuits 6-channel Recorder</td>
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<td>HONEYWELL 5.124 17-channel U/V Recorder &amp; 7 Galvos</td>
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<td>MARCONI TF.3200 2-channel Thermal Recorder</td>
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**MISCELLANEOUS**

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<td>B &amp; K 1118 Automatic Vibration Exciter</td>
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<td>R &amp; E 312 Filter Set Band Pass-4 and 1 Octave</td>
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<tr>
<td>BARNETT Dead Weight Tester + Weights &amp; 2 Gauges</td>
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<td>POCHMORE Vibration Bowl 18&quot; &amp; 24&quot;</td>
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<td>PYE LINQ Vibration Systems 1000b. Thrust</td>
<td>£700.00</td>
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<td>REDIN Climatic Oven -10°C to +150°C</td>
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<td>MONTFORD Climatic Oven -20°C to +60°C</td>
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**WIRELESS WORLD, MARCH 1980**

Go for Wow/Flutter standard from Bang & Olufsen when precision, versatility and good value for money are high on your list of priorities.

The Bang & Olufsen microprocessor quartz controlled Wow and Fluttermeter calibrator is a compact low cost device, especially designed to calibrate Wow/Fluttermeters with great accuracy according DIN, IEC, CCIR and IEEE standards. The application in this microprocessor controlled instrument has rendered calibration obsolete. Therefore the first and the last produced WFC 1 will be exactly alike!

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*Another accolade for SME: the Series III precision pick-up arm was one of the Design and Engineering Awards at the 1979 U.S Summer Consumer Electronics Show, the only pick-up arm to be acknowledged in this way.

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WIRELESS WORLD, MARCH 1980
MORE SPEC. FOR YOUR MONEY

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COVERS THE RANGE 0.1Hz to 100KHz

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ACCEPT 0 from less than 1 to over 300
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Hi and LO PASS 12 dB per octave
OSCILLATE Sinewave and squarewave

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FROM OMB ELECTRONICS
WIRELESS WORLD, MARCH 1980

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—NOW USING WAVEFORM SYNTHESIS—

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Listen and choose in comfort at Britain's most up-to-date air conditioned sound demonstration studios. Full ranges of Hi-Fi, Video equipment, in-car and portables, etc., from all leading manufacturers; B & O, Sony, Sony, Hitachi, Pioneer, J.V.C.

Get the latest update from Sonic Sound: the premier home entertainment store. In -car and portables, etc., are on request. ONLY £45 COMPLETE + 15% VAT. Anyone even contemplating short wave equipment, be they looking for the best possible available for their Embassy, press department or home use, should visit or contact Sonic where they will be able to view and listen to the most comprehensive range of the latest short wave equipment on the market today. Sonic Sound Audio is a Marconi Group Company.

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the M97 Era IV Series pickup cartridges

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<thead>
<tr>
<th>Model</th>
<th>Stylus Configuration</th>
<th>Force</th>
<th>Tracking Force</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>M97HE</td>
<td>Nude Hyperelliptical</td>
<td>¾</td>
<td>¾ to 1½ grams</td>
<td>Highest fidelity</td>
</tr>
<tr>
<td>M97ED</td>
<td>Nude Biradial (Elliptical)</td>
<td>¾</td>
<td>¾ to 1½ grams</td>
<td>Where light tracking forces are essential.</td>
</tr>
<tr>
<td>M97GD</td>
<td>Nude Spherical</td>
<td>¾</td>
<td>½ to 1½ grams</td>
<td></td>
</tr>
<tr>
<td>M97EJ</td>
<td>Biradial (Elliptical)</td>
<td>⅜</td>
<td>1½ to 3 grams</td>
<td>Where slightly heavier tracking forces are required.</td>
</tr>
<tr>
<td>M97B</td>
<td>Spherical</td>
<td>⅜</td>
<td>1½ to 3 grams</td>
<td></td>
</tr>
<tr>
<td>78 rpm Stylus for all M97's</td>
<td>Biradial (Elliptical)</td>
<td>⅜</td>
<td>1½ to 3 grams</td>
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Since a television programme put the cat among the pigeons and made the world at large believe that Karel Capek’s view of the future was to materialise in about a fortnight at the very latest, engineering persons have become accustomed to hearing references to ‘chips’ from the unlikeliest of sources. Cabinet ministers, trade union leaders, industrial writers, popular magazine and newspaper columnists, television commentators — all kinds of non-engineering person never seem to tire of discussing integrated-circuit technology and its impact on society in terms that imply total familiarity with semiconductors in all their manifestations.

It is quite difficult to discover the received picture of modern electronics possessed by people whose interests do not include engineering. The crescendo of strident and frequently doom-laden prophecy, initiated by the adoption of ‘the chip’ as a sort of 1970s Spinning Jenny substitute, coupled with the more sanely informed comment from engineers, must have generated considerable confusion among those whose only present involvement is the direct or indirect provision of finance.

The attitude of mind which impels otherwise reasonable people to walk out on strike when ‘new technology’ is discovered in the offing is unlikely to be of much assistance to anyone. If an organisation is compelled by a lack of understanding to stick to outmoded methods of working, its customers will simply go to another source of supply which has taken advantage of modern developments. Many people will no doubt need to change their skills, but there is no reason to think that a smaller total workforce will be needed in the society of the next decade.

The microprocessor is not an invention of the Devil, but in the face of sensational reporting it will tax the skill of educators to prove it.

A Ludditic reaction to ‘new technology’, fuelled by badly disseminated information and mass news posing as information, is one possibility; the newspaper industry has already seen an illustration. The alternative is to demonstrate the respectability of the microprocessor as a down-to-earth, extremely useful, but entirely non-occult electronic component in a programme of education carried out by people who really do know what they are talking about. We have seen far too many newspaper and television pieces whose aim has been to describe the applications of integrated circuits in the ‘wonder of modern science’ manner, heightening in a most irresponsible way modern man’s ingrained and well-founded suspicion of single-minded, but accident-prone technocrats.

The microprocessor has an aura of sanctity about it which its lineage and capabilities do not warrant, and which may well be not only technically but politically perilous.
Pulse induction metal detector
Experimental system for overcoming magnetic viscosity effects
by J. A. Corbyn

Because the author considers buried "treasures" to be the most lasting and potentially most informative repositories of human history, he feels that their detection and excavation should be restricted to approved organisations. This article describes an experimental metal detector, originally developed for detecting gold in Western Australia (so far unsuccessfully), that can be adapted for archaeological or military applications. Particular emphasis is placed on magnetic viscosity and how to eliminate this undesirable effect.

Metal detectors used in searching for buried metallic objects are similar in concept to those used for geophysical exploration. All such instruments depend on the measurement of a magnetic field associated with eddy currents induced in the target by a primary magnetic field. The two main groups of metal detector are the continuous wave type where normally a sinusoidal primary magnetic field produces eddy currents in the target, and the pulse induction system where the primary field is a series of pulses. In a continuous wave detector, coupling between the transmitter and receiver is effected by the geometry of the system which must be rigid for detecting small metallic targets such as archaeological artifacts. Rigid geometry is not so important in a pulse induction system because there is no direct coupling between the transmitter and receiver.

Early metal detectors were mainly continuous wave types because simple circuits could be used. However, pulse induction systems have been described in the geophysical context by Grant and West, and in the archaeological context by Colani.

In a conventional pulse induction system a primary magnetic field is switched off and induces eddy currents in a conductive target. Voltages induced by the decay of these eddy currents are detected and then displayed. Fig. 1 shows a system comprising circular primary and receive coils which are coaxial with a target illustrated as a conducting loop. Fig. 2 shows the case where a magnetic flux of Bp Weber is normal to a loop of radius a and effectively falls to zero in time δt. If L is
the self inductance of the loop, $R$ the resistance and $i$ is the current then

$$iR = -\frac{d}{dt}[B_o \pi a^2 + Li] \quad (1)$$

If $B_o = B_0$ at $t = 0$, $B_p = 0$ at $t = \Delta t$ and $i_{at}$ is the current at $t = \Delta t$,

$$i_{at} = \frac{\pi a^2}{L} B_o - \frac{R}{L} \int_0^{\Delta t} idt \quad (2)$$

If $\Delta t < L/R$, equation (2) can be approximated by

$$i_{at} = \frac{\pi a^2 B_o}{L} \quad (3)$$

If the target is given a standard form of a cylinder with radius $a$, height $a$ and wall thickness $a/2$, $L$ can be calculated from an adaptation of Wheeler's formulae

$$L = a \times 2.07 \times 10^{-6} \text{H} \quad (4)$$

Although equation (4) is an approximation it is sufficient for practical purposes because targets are rarely standard shapes. The resistance can be calculated from

$$R = \frac{0.289 \times 10^{-5} \times k}{a} \Omega \quad (5)$$

where it is assumed that the specific resistance of the metal is for gold ($0.023 \times 10^{-6} \Omega \text{m}$) and $k$ is the specific resistance in relation to gold. When the primary magnetic field is removed the current in the target decays exponentially with a time constant.

$$T = \frac{L}{R} = 7.16a^2 \quad (6)$$

The eddy current induced in the model target is then

$$i = \frac{\pi a^2 B_o H_0}{a \times 2.07 \times 10^{-6}} e^{-\frac{r_a}{7.16a^2}} \text{A} \quad (7)$$

and setting $H_0$ at $4 \pi \times 10^{-7} \text{H/m}$

In the pulse induction system of Fig. 1 the primary magnetic field at $P$ is

$$H_0 = \frac{\pi r_a^2 N_1 I_2}{4 \pi h^3} = \frac{r_a^2 N_1 I_2}{2h^3} \text{A/m} \quad (8)$$

The voltage at the receiver coil is determined by the rate of change of flux linkage originating from the target and is given by

$$V_r = 0.262 \times 10^{-6} r_a^2 N_1 N_2 \frac{ak}{h^5} e^{-\frac{r_a}{7.16a^2}} \quad (9)$$

If the received signal is integrated the mean output signal level $V_m$ will be

$$V_m = \frac{1}{T_{rep}} \int_0^{\infty} V_r \, dt = \frac{1.875 \times 10^{-8} r_a^2 N_1 a H_p}{T_{rep} h^5} \quad (10)$$

where $T_{rep}$ is the repetition interval defined in Fig. 1 and $T_{rep} \gg T$. As an example, consider the case where $T$ is 0.6m, $T$ is 0.545m, $N_1$ is 54 turns, $N_2$ is 68 turns, $a$ is 0.04m, $h$ is 1m, $I_p$ is 1A and $T_{rep}$ is 0.016s. Equation (10) gives a $V_m$ of 1.1pV and for $k = 1$, $T = 5.7$ms. This is very approximate because $h$ is not much greater than $r_a$.

The time constant of a non metallic material in the vicinity of a metal detector can be calculated by appropriate modifications to equation (6) as

$$T = \frac{1.64 \times 10^{-6} a^2}{S} \quad (11)$$

where $S$, is the specific resistance of the material. Substituting $a = 1\text{m}$ and $S = 0.20\Omega\text{m}$, the approximate specific resistance of sea water, the time constant is 0.85s.

Most rocks and soils have a specific resistance much higher than this so an effective separation can be made between signals due to metallic targets and conductivity effects in the ground by
introducing a delay $\Delta t$ between switch off of the transmitter current and observation of the returned signal. In practice delays from 40$\mu$s to 300$\mu$s are suitable.

**Magnetic viscosity effects**

The magnetic properties of soils and rocks are mainly attributable to magnetite and maghaemite. These minerals exhibit a magnetic viscosity effect because their magnetization does not instantaneously follow an applied magnetic field. Magnetic viscosity is qualitatively similar to the effects of a conductor on a metal detector. The direction of temporary magnetization is the same as the primary magnetic field and the magnetic flux in the conductor being detected. Although there is no comprehensive theory of magnetic viscosity, Tropin has critically reviewed Neel's theory which is described by Stacey and Banerjee. Useful data for metal detector design has been provided by Colani and Aitken.

When designing a pulse induction metal detector it is necessary to know the response of soil or rock to a decreasing step in magnetic field. A general equation is

$$M(t) = K \Delta H g(t)$$

(12)

Fig. 7 Gated amplifier. Note that only one section of the 4053 is used, all unused inputs should be connected to ground. All voltages are d.c., measured with a high impedance meter. All capacitors are ceramic or aluminium electrolytic types.
where \( K \) is the magnetic susceptibility and \( M \) is the magnetic moment per unit volume of material resulting from a change \( \Delta H \) in the magnetic field at time \( t \) after this change. Equation (12) is linear in that \( g(t) \), which describes the decay of the magnetization, is independent of the primary magnetic field. At \( t = 0 \), \( g(t) \) should be finite and as \( t \to \infty \), \( g(t) \) should go to zero. Furthermore, \( g(t) \) from practical experiences should be a decreasing function of \( t \). Fig. 3 shows the response of a soil or rock to a decreasing step in magnetic field. A review of available literature and some experimental work shows that \( g(t) \) can be expressed as a sum of two exponentials. An electronic system was constructed to simulate the sum of exponentials and compare the result with the response of soil or rock. A satisfactory model for the derivative of \( g(t) \) is

\[
g'(t) = (1 - P)e^{-t/T_1} + Pe^{-t/T_2} \tag{13}
\]

where \( T_1 \) is 75\( \mu \)s, \( T_2 \) is 550 to 800\( \mu \)s and \( P \) is in the range 0.08 to 0.30. These observations apply to lateritic soils in the goldfield region of Western Australia. The function \( g'(t) \) does not depend on the physical dimensions of the material being magnetized and the form of the decay due to a conductive target is generally a simple exponential decay as in equation (7). I therefore decided to construct a ground effect elimination system for a pulse induction metal detector by determining the difference

**Fig. 8** Synchronous detector. The regulated power supply is shared with the gated amplifier. The 47pF compensation capacitor is soldered directly to the 3130 leads.

**Fig. 9** Sum of exponentials eliminator. Resistor \( R_1 \) controls the mixture of exponentials, \( R_2 \) controls the decay constant \( T_1 \), and \( R_3 \) controls the decay constant \( T_2 \). Production of the initiation pulse from logic level \( A \) is shown in Fig. 10.

<table>
<thead>
<tr>
<th>Switch</th>
<th>Type</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S_1 )</td>
<td>4016</td>
<td>Both closed only when initiation pulse is present</td>
</tr>
<tr>
<td>( S_2 )</td>
<td>4016</td>
<td>Closed during end of receive period pulse</td>
</tr>
<tr>
<td>( S_3 )</td>
<td>4016</td>
<td>Output earthed except when logic level is high</td>
</tr>
</tbody>
</table>

**Logic level A**

- Receive period
- Initiation pulse
- End of receive period pulse

**Output**

\[ \text{+6k} \]
between the response of the ground and the observed response, assumed to be due to magnetic viscosity.

Coil design

Design objectives for the coil system are to maximise the primary magnetic field at the target and the voltage induced in the receiver coil by eddy currents in the target. The noise level due to variations in the earth's magnetic field and movement of the gradiometer over the ground is about 1 µV with a coil of 25 turns, an area of 1 m² and with a similar coaxial coil 1 m away. This limitation was determined for a receive system with a centre frequency of 200 Hz and a bandwidth of 10 Hz. The major noise contribution is from normal variations in the earth's magnetic field and does not account for man-made electrical interference.

The time constant of a critically damped gradiometer constructed with the above limitation is generally under 10 ms for a coil diameter above 1 m.

Transmitter coil design is controlled by the decay resistance required to prevent an excessive voltage being applied to the transistor switch, being Fig. 4. Neglecting coil capacitance, the decay of current I through a coil of self inductance L, and decay resistance R is

\[ I = I_0 e^{-t/T} \]  

(14)

where T is the decay constant \( R/L \) and \( I_0 \) is the initial current through the transmit coil. If \( M_r \) is the mutual inductance between transmit and receive coils and \( V_0 \) is the peak voltage permitted at the switch, the voltage decay at the receive coil due to the current decay through the transmit coil is, for \( I < I_0 \),

\[ V_r = V_0 \frac{M_r e^{-vT}}{L_1} \]  

(15)

If \( V_r \) is the maximum permitted voltage at the receive coil at time \( \Delta t \)

\[ \Delta t = T \log_e \left( \frac{V_{0r} M_r}{V_r L_1} \right) \]  

(16)

With \( V_{0r} = 750 \text{V}, V_r = 1 \mu\text{V} \) and \( M_r/L_1 = 0.1 \), equation (16) gives \( \Delta t = 18.1 \text{ ms} \).

Equation (16) shows that the minimum value of \( \Delta t \) is determined principally by \( T \). In practice \( T \) cannot be much greater than 5% of \( \Delta t \), depending on the ability of the circuit to reject a background decaying voltage during the receive period.

A circular metal detector array with coaxial receive and transmit coils is shown in Fig. 5. The receive coils are arranged in a gradiometer configuration and the bottom winding is coplanar with the larger transmit coils. Increasing the size of the transmit coils reduces the magnetic viscosity effects due to a relatively intense primary field close to them.

In addition to this array, various circular types have been constructed with diameters from 0.05 to 2 m, and rectangular versions up to 2 m long for searching large areas. For the larger arrays it is desirable to keep coil capacitance as low as possible by careful winding design. As previously noted, rigid system geometry is not essential for a pulse induction system, and the simple wooden structure described is sufficient.

Circuit design

A block diagram of the metal detector circuit is shown in Fig. 6. An alternating primary magnetic field is used to avoid magnetic polarization of the ground and to improve the overall signal-to-noise ratio. The gated wideband amplifier in Fig. 7 consists of a high voltage protection network, a c.m.o.s. analogue switch and a transistor amplifier designed for fast recovery from saturation. The 4053 grounds the amplifier input except during the receive period when the receive coils are connected. The passband of the amplifier is 20 Hz to 100 kHz and the gain is approximately 4000. It is not practical to use a higher gain due to instability and amplifier saturation caused by the decay of current in the transmit coils.

The synchronous detector in Fig. 8 recognises a pulsed alternating signal with a unity-gain sign switched amplifier. The op-amp provides an output of +1 or -1 and the 4053 grounds the input when a useful signal cannot be received. The rise-time of the detector for a square wave is about 25 µs.

A sum of exponentials eliminator is shown in Fig. 9. This circuit takes samples of 60 µs duration at the beginning and end of the receive period and simulates the magnetic viscosity effect of the ground by inserting a function as shown in equation (13). The simulated ground effect is subtracted from the input signal to give an output when the response does not match that caused by the ground. The parameters \( T_1, T_2 \) and \( P \) can be changed to suit the ground conditions. RC combinations are used for the simulation and a 0.32 µF capacitor stores the background level to which the sum of exponentials decays. With the components shown the range for \( T_1 \) is 20 to 240 µs (typically 80 µs), for \( T_2 \) 50 to 900 µs (typically 800 µs) and \( P \) is from 0 to 1.

References


February cover — correction

The thyristor stack pictured on our February issue front cover was made by Powerstax Division of The House of Power, of Orpington, Kent, not by Pinnacle Electronics Ltd as stated in the caption. We apologise to both companies and to readers for any inconvenience that may have resulted from this error.
Non-echoic acoustic measurement with the H-P 3582A

New Hewlett-Packard spectrum analyser uses digital signal processing

by R. N. Grubb, Auris of Boulder, Colorado

The HP3582A is a recently announced audio spectrum analyser using fast Fourier transform analysis. A number of its features can be exploited in the measurement of loudspeakers and microphones in non-echoic conditions. These are described and some practical examples of its application given.

THE RECENTLY announced model 3582A spectrum analyser by Hewlett-Packard is an example of the new generation of instruments which depend on microprocessor technology to provide powerful capabilities at a lower price than has previously been possible. In this case, digital signal processing technology is used to implement a flexible 0.02 Hz-25.5kHz spectrum analyser, using the fast Fourier transform (FFT) of the digitized input signal to calculate the signal spectrum in the frequency domain from a sample of the input signal in the time domain. Although the instrument is a computer system, the mechanics usually associated with the use of a computer are completely transparent to the user, who is presented with a fairly conventional-looking front-panel control layout. The program is, of course, contained in read-only memory.

The 3582A is not a real time third octave analyser. In fact, one thing which may put off the average audio engineer is the lack of anything but linear frequency-scale presentations. However, it is inherent in the fast Fourier transform approach that a linear, equally-spaced set of spectral estimates is produced. The resolution and bandwidth of each estimate depends on the length and shape of the time window used to select the signal sample for analysis. Thus a logarithmic presentation of the data would necessarily be only cosmetic, information at the higher frequencies being lost, if a constant proportional resolution were displayed. As the available frequency ranges of the instrument are very extensive, all the information is available, although it is perhaps more time consuming to obtain.

By audio spectrum-analysis standards, the capabilities are unconventional, including measurement of phase, measurement of transfer functions and time-domain signal averaging before analysis.

Measurement of the phase response of audio systems, particularly of loudspeakers, has recently become of interest in the quest for the more realistic reproduction of transients. The 3582A provides in one box the means to make response measurements, including phase, on loudspeakers and other audio transducers, without requiring an anechoic chamber, or the roomful of minicomputer used by loudspeaker manufacturers to make such measurements.

Before proceeding to explain how to use the analyser for this purpose, it may be useful to some readers to review what is meant by phase response and in particular how it can be measured by a spectrum analyser. The phase response of a device refers to a measurement of relative phase, usually the difference between the input and the output of the device. Unlike amplitude, or spectral amplitude, which is measured with a single connexion to the system under test, two separate connexions are needed to measure phase response as in Fig 1. Thus, although a spectrum analyser is normally a single-input device, with analysers like the 3582A, one must think in terms of two inputs to measure phase. Simply feeding in a composite signal to one channel of the instrument will give a perfectly good amplitude spectrum, but the phase answer computed will be different for each time sequence analysed because of the lack of a reference. This may not matter in some applications. For instance, if we want to know whether sidebands observed on a carrier are due to amplitude or phase modulation, their phase relationships to the carrier itself as seen in Fig 2 and a single sample

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**Fig. 1. Arrangement required for phase measurement.**

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**Fig. 2. Identifying amplitude or phase modulation.**
capability can be applied very neatly to the measurement of microphones. By connecting two microphones, one of which is to be regarded as the standard, to the two inputs of the analyser and placing them close together and in the sound field of a loudspeaker fed from the analyser noise source, their responses can be compared directly and very quickly. Figure 3 shows the result of comparing two nominally-identical C451 microphones with CK1 capsules. This disclosed the interesting information that although the microphones are well matched up to 15kHz, the two differed by nearly 6 dB at 17.5kHz. In this case, since neither microphone could be regarded as a standard, it was not possible to say which microphone or whether one or both was at fault. Exchanging the capsules on the microphone bodies showed the problem to be in the capsules and not in the microphone electronics or the amplifier chains.

The upper trace shows the phase difference. The constant phase slope at low frequencies shows that the “test” microphone was slightly in front of the reference microphone and it was possible by careful adjustment of the relative microphone position to make the phase slope zero. It is interesting that the difference between the capsules shows up in the phase at a lower frequency than in the amplitude. One thing to note in this and in most of the other examples shown is that the lowest-frequency point plotted by the analyser in the zero frequency start mode is in fact actually 0Hz, i.e., d.c. and the position of this point depends on the analyser amplifier d.c. offsets or externally applied d.c. In this case, of course, the microphone amplifiers are a.c. coupled, so the zero frequency point is quite meaningless.

Figure 4 shows another comparison of two microphones, in this case two 1in diameter capacitor microphone capsules mounted one above the other in the same case and designed to be used as a coincident stereo pair. The lower trace is the magnitude again. This showed a good match at all frequencies, except in the region 3-9kHz, where there are 2-3dB differences. Some experiment and the use of another microphone as a comparison standard showed that the irregularities were only present in the lower of the two capsules and were very sensitive to the angle of the microphone in the vertical plane to the direction of the incident sound field. This seemed to show that the problem was due to diffraction effects at the microphone case, the lower capsule being much closer to the vertical plane to the direction of the microphone in the vertical plane to the direction of the incident sound field.

Transfer function

The most straightforward mode of operation to give repeatable phase measurements is that of the transfer function measurement. The two channels of the analyser are connected across the input and the output of the device to be tested and one of the two built-in noise sources connected to the input. The analyser now plots the ratio of the amplitudes and the difference in the phase of its two inputs versus frequency.

This transfer function measurement analysis will give us the answer we want.

Impulse testing

All the preceding three examples were measured in a normal room with some acoustic treatment, but nevertheless far from anechoic. Thus, the sound field at the microphones being compared is composed of direct and reflected components. The comparison results have to be based on the assumption that the microphone polar responses are similar. It is only possible by this method to compare a cardioid microphone with another cardioid or an omnidirectional one with another omnidirectional microphone, etc. Providing the pair of microphones is not too far from the source compared with the dimensions of the room, and that the room is reasonably non reverberant, then small errors in polar response should have little effect on the comparison. However, we can do this kind of measurement in a non-anechoic room without these restrictions by using the capability of the instrument to analyse the impulse response of loudspeakers and microphones and present the results in the more familiar terms of amplitude and phase and it is to this, probably least familiar, mode that I now turn.

Fourier transform theory tells us that a zero width pulse contains equal energy per unit bandwidth (power spectral density — p.s.d.) at all frequencies, i.e., it possesses an infinite bandwidth. Of course, this is a mathematical abstraction because, unless the impulse is infinitely large in amplitude its energy in any particular bandwidth will be infinitely small. Fortunately for any given audio bandwidth, it is easy to produce an impulse sufficiently narrow for the p.s.d. to be flat. The theory tells us that the power spectrum of a pulse of width t is

\[ P(f) = \frac{Asin(\pi ft)}{\pi ft} \]

This function, the familiar \( \sin x/x \), is plotted in Fig. 6. By choosing t to be small enough, we can make the p.s.d. as flat as we wish over the working bandwidth. For instance, it is easy to calculate that a 1μs wide pulse is only 0.01dB down at 25 KHz, the maximum band-

![Fig. 6. The function \( \sin x/x \).](image-url)
width of the analyser. A 10μs pulse is only ≈1dB down. At the rear of the 3582A is a t.t.l.-level impulse output. This gives a positive-going pulse which is ≈ 1μs long at the widest analysis bandwidth (25kHz) which increases in width as the analysis bandwidth is reduced. If this output is connected to the input of the analyser, the displayed amplitude spectrum will show the first of the problems of impulse analysis which has to be carefully considered in order to obtain valid results. Indeed, the analyser shows a flat spectrum but, as the sensitivity is increased to bring the observed spectrum above the baseline the input channel overload light rapidly comes on. In fact, it is impossible to get more than a 20dB measurement range above the noise floor. This, of course, is because the test signal has a very high ratio of peak to mean value, and the analyser input dynamic range, which is set by its analogue to digital converter, only permits this limited range in the spectral domain. This situation can be improved considerably, however, if an external impulse source is used. As calculated above, a pulse of ten times the width (100μs) is about 1dB down at 25kHz. This gives another 20dB of analysis dynamic range, which is adequate for nearly all acoustic testing; it is easy to correct for the small loss at high frequencies of the test signal, if 1dB is important.

Phase

Having developed the test signal, the next question to consider is what is meant by the phase of the test signal and how the analyser measures it. The reference, in this case, is set in the time domain by the position of the time window, in which the analyser samples the input signal. At a time $t_0$, one can think of all the reference frequencies starting simultaneously at zero phase (zero amplitude for a cosine wave). If the impulse is positioned at $t_0$, then its spectrum consists of all frequencies starting at zero phase and the analyser will read $0°$ at all frequencies. If the impulse is displaced from $t_0$, then there will be a progressive displacement, increasing with frequency, in the analysed phase expressed by the formula for the group delay introduced by the displacement

$$\Delta \phi = \Delta t \times 360° / \Delta f$$

where $\Delta \phi / \Delta f$ is the phase slope with frequency. For a positive delay (signal later than $t_0$) the phase of the higher frequencies lags the lower and vice versa. Note that a linear rate of change of phase implies only a delay and no waveform distortion.

In the 3582A, $t_0$ is set at the middle of the time window when the ‘flat top’ or Hanning passband shape is selected, or at the start of the time window when the ‘uniform’ passband shape is selected. The latter is the passband intended for transient analysis. In the former cases, the passband shape is set by amplitude weighting in the time domain so that a transient at the beginning or end of the time window would not be analysed correctly. To be able to interpret the phase readout from the analyser, it is necessary to place the impulse close to $t_0$ because a large phase slope due to a time difference will obscure the properties of the system under test and, if too large, renders it discontinuous, because the discrete samples computed by the analyser are not close enough together to resolve the rapid phase change. To adjust the timing, the analyser can be operated in two ways and can be thought of more like an oscilloscope. In fact, the time-domain sampled waveform can be selected for display on the c.r.t.; this is an almost indispensable mode for setting up the analyser for transient analysis. In the free-run mode, the instrument repeatedly starts new time windows as soon as it is ready to analyse new data. The rear-panel impulse output occurs at the start of each time window. Alternatively, the analyser can be triggered like an oscilloscope by an input signal on channel A or by a t.t.l. level pulse at a rear-panel input.

Echo gating

The advantage of using a transient signal to analyse the response of acoustic devices is that it is possible to suppress the effect of room reflections entirely without having to work in an anechoic room. To a close approximation, sound travels 1 foot per millisecond: the typical response of a loudspeaker to a 10μs wide impulse is over in 2-3ms, depending on the physical size of the cabinet. Even in a quite small room with a loudspeaker 3 to 4 feet from the floor and the measuring microphone 8 feet away, the first room reflection will arrive at the microphone 3-4ms later than the direct sound. Figure 7 shows the situation. A typical time domain response of a loudspeaker to a 10μs wide impulse is shown in Fig 8, which was taken from the analyser screen, with the instrument set on the 0-25kHz range. On this range the time window is ≈5ms long and, by controlling the trigger time, the transient picked up by the measuring microphone can be positioned near the centre of the time window with the first reflection just outside the window. This enables the amplitude response to be obtained, but as explained above, the transient should really be positioned near the start of the time window if the phase response is desired. Since the time window gets longer as the analysis bandwidth is reduced (necessary if the
low frequency response is to be examined in detail), an electronic signal gate is needed so that the first direct-path signal can be isolated. To do this, and to be able to adjust all the delays correctly and generate the test impulse required some auxiliary equipment in addition to the analyser itself. This is unfortunate because it seems that it would have been quite simple to build all the required functions into the analyser in the first instance.*

Figure 9 shows the overall timing and gating required. Because the analyser time window must be started later than the impulse sent to the loudspeaker, it is best to generate the measurement repetition rate externally. This should be set to the highest rate which allows all room responses to die out before the next pulse.

Two delayed trigger pulses are then needed — one to start the analyser time gate at the correct time with respect to the transient picked up by the measurement microphone, and one to start the signal gate. A convenient way to get the first delay is to use a second microphone slightly closer to the loudspeaker under test and feed its amplified output to channel A of the analyser as the trigger signal. The measurement microphone output is fed to channel B. The delay is adjusted by setting the relative distances of the two microphones to bring the received transient just at the start of the time window on channel B. Channel A should also be examined to make sure that the trigger point on the transient is a stable one.

It is very important to make sure that all the significant energy from the transient radiated by the loudspeaker is included in the time gate. This can be checked both by inspection in the time domain and by changing the signal gate window over a small range and seeing if it affects the transformed frequency and phase response. With high quality loudspeakers of small dimensions, it seemed the response died essentially to zero after about 3ms, and it seemed to be possible to get a clean separation between the direct arrival and the first reflected arrival in a room with a smallest dimension of 8 feet. With larger loudspeakers or units with pronounced resonances, this may not be possible and it would be necessary to use a larger room.

The delay mechanism for the signal gate and the signal gate itself need to be electronic. Commercial pulse generators can be used to generate these and the basic impulse and its repetition rate or, with the aid of a few digital i.c.s, a special generator and controller could be assembled. Some commercial signal gating devices may be satisfactory in this application — a simple shunt f.e.t. switch such as is shown in Fig. 10 works well. It is most important that the switch does not introduce appreciable transients itself in the signal path. When the analyser bandwidth is reduced, the time window becomes longer and it may be necessary to readjust the system repetition rate. Also, as discussed previously, the impulse length must be increased proportionately to preserve approximately constant spectral power density.

Practice

Unfortunately, no measuring technique is completely free of disadvantages and the gating-out of room reflections is no exception. The problem is that of determining whether the initial response of the loudspeaker really has died away or not. It turns out that the use of a time sample of length t produces an uncertainty in the value of the spectral amplitude points for all frequencies roughly less than 1/t in frequency. Why the effect is an uncertainty and not just a calculable loss can be seen by considering a couple of simple examples. If the device being analysed is perfect (i.e. a piece of wire) then locating the time window would clearly have no effect, because the input impulse signal has a zero value at all times except for a small interval near zero time. However, if the device had a low-frequency cut off caused by the equivalent of a single pole RC network, then its response to the impulse would have an overshoot following the impulse which returns to the baseline exponentially with a time constant of RC seconds. In this case, a significant error will be made in the low-frequency response measurement unless the time window is maintained for 5 or 6 time constants, so that the response has reached zero for all practical purposes. Locating the impulse response at a point where the net remaining area under the response is negative will result in an apparent enhancement of low frequencies well below 1/t and vice versa. Thus the effect of the truncation depends entirely on the exact form of the impulse response.
Figures 11 and 12 show typical results obtained in the author's studio with a Sennheiser BCC and a Chartwell LS3/5A. The phase response clearly show the effects of the crossover in the case of the Chartwell as a change in time delay (phase slope) starting at \( \approx 3 \text{kHz} \). With a little more flexible arrangement, the average phase slope could have been brought closer to zero with resultant easier integration. In all cases, the measurement microphone was about on axis and 6 feet from the loudspeaker. Figure 13 shows the effect of disabling the signal gate and allowing some of the room reflection to be analysed! I found that these loudspeaker measurements were relatively unaffected by the microphone used, providing it was a capacitor type and of professional quality, since these microphones invariably have a much flatter response than monitor loudspeakers. If a standard measuring microphone is not available, then a \( \frac{1}{2} \text{in diameter, omnidirectional capacitor microphone such as the AKG C451 with a CK2 capsule would be the best second choice.} \) The examples shown were made with this same microphone but with a CKI capsule, which probably does affect the results somewhat. In all cases the low frequency response below about 2-300 Hz appears to be attenuated compared with the published responses of these particular speakers, so it must be assumed that some truncation of the impulse response was taking place.

Care should be taken not to overdrive the loudspeaker with the impulse: A few watts peak power should be all that is required. The sound should be that of a quite quiet tick similar in volume to that of a typical alarm clock. If the measurement conditions are quiet, then the response can be obtained with only one impulse. However, if you don't live in the country or have a well isolated studio handy, there is no need to despair; use the last unique feature of the analyser, time domain averaging. This adds together, algebraically, each successive sample at the same time with respect to the trigger. The wanted signal is preserved but non coherent background noise cancels itself on the average. Thus, not only do you not need an anechoic room to make loudspeaker measurements, you do not even need a quiet one. The examples in Figs. 11 and 12 used a signal average of 16 impulses. All the comparison tests of microphones described earlier can be better done using a loudspeaker excited by an impulse with the appropriate delays and gating. In this case, since both signal channels will be needed for the measurement, the rear-panel t.t.l.

**Measurement modes**

1. Frequency spectrum, amplitude and phase.
2. Transfer function, ratio of input channel amplitudes and difference in phase.
3. Coherence function, the degree of coherence (0-1) between the input channels.

**Signal sources**

1. Random noise. This is generated digitally and adjusts automatically with the frequency range selected to maintain a constant power output in the analysis band.
2. Periodic noise. This is also generated digitally and is arranged to have a 'comb' spectrum which exactly matches the calculated spectral points. This gives the same effect as a tracking generator in a convensional swept analyser with the advantage over random noise that no frequency domain averaging is needed to get an accurate answer.
3. Impulse. This varies in width depending on the frequency range selected. It is timed to occur at the start of each analysis time window.

**Averaging modes**

1. Frequency Domain
   a) r.m.s. average of calculated spectral points with 4-256 points averaged or an exponential 'running average' mode.
   b) Peak. 4-256 points or peak hold in a continuous mode.
2. Time domain.
   4-256 input signal time sequences averaged. The zero time is set by a trigger circuit on input channel A or by an external trigger input at t.t.l. level.

**References**


With this same microphone but with a wire.

Wide-angle source.

Transistorized inverter (12V)

Metal outer case

Cross-sectional view of the EEV character display tube. The flying lead grid connections are for multiplexing; the "expected life" of the tube is 40,000 hours or about five years.

**EEV provides bright lights for ATV games**

A large scale, computer-controlled electronic display board supplied by English Electric Valve Co. can be seen by television viewers of the Bob Monkhouse "Family Fortunes" panel game on Sunday evenings. The main body of the display consists of 300 "character display tubes" (a form of r.c.t. costing about £100 each), which EEV say offer very high variable brightness, low power consumption and electronic switching with low level logic. The control logic, including a keyboard and v.d.s. control console, includes an Intel single board computer and the complete installation is said to have cost ATV about £80,000.
Numerical data from the keyboard is encoded to b.c.d. and fed to the memory data inputs. Four of the memory address pins are used to address an alarm time and are driven by a 4-bit binary counter. Two of the pins address the four digits of the alarm time and are connected directly to the A and B multiplex control lines from the clock. In the Set mode the alarm key clocks the counter and accesses the memory locations which store the next alarm time. In the Run mode, control line C clocks the counter so that the alarm times are scanned at one every 6ms. The read/write control circuit ensures that only the correct memory locations are used.

The memory input circuits are shown in Fig. 5 and Fig. 8. To set an alarm time, S2 is switched to Set and S3 to Alarm which takes Y low. This transition is differentiated by C16 and R26, see Fig. 8, and takes pin 12 of IC17b momentarily low. The output of IC17b goes low which sets both Q outputs of IC6 high and also resets IC7 via IC16b. In Fig. 5, if no key is pressed, the outputs of IC1 are all high and data valid is low. If a numerical key is pressed, an inverted binary code of the number appears at IC1 output, data valid goes high and the first monostable in IC23 is triggered which in turn triggers the second. This produces a 15ms write pulse at pin 5 of IC23 and, because the first monostable has a period of about 150ms, the second monostable cannot be retriggered by contact bounce, see Fig. 9. The write pulse clocks IC6a in Fig. 8 and the Q output goes high which clocks IC6b whose Q output goes low. The Q outputs of IC6 are compared with the multiplex control lines A and B by exclusive NOR gates IC15a and IC15b, and the output is high only when the control lines are both low. The write pulse from IC23 is delayed by R27 and C11, to allow IC6 to be clocked, and is gated to the memory r/w pin if data valid is high and all three multiplex lines are low. Data present at the memory inputs is then written into the tens-of-hours locations for the first alarm time. Pressing a second key clocks IC6a again so that its Q output goes high. Therefore, writing

Fig. 8. Memory control circuit.
Components marked with an asterisk refer to the Rugby clock designed by A. F. Cross.
can only occur when control line A is high and B, C are low which means that the data is written into the hours location of the memory. This procedure is repeated for the tens-of-minutes data. If a mistake is made, pressing four more keys overwrites the incorrect data.

When the first alarm time has been set, the alarm key is pressed which triggers the second monostable in IC22 and produces a low advance-alarm pulse at the Q output. This pulse is gated through IC11 to the set inputs of IC6 so that the Q outputs are high. The advance-alarm pulse also clocks IC7 via S2b and S1b so that the memory locations corresponding to the second alarm time are addressed, see Table 2. If a numerical key is released in less than 15ms the data-valid line goes low to force the memory read pin high and prevent the writing of false data.

Memory output circuit
A display selector switches the actual time or the alarm time and is controlled by the Run-Set and Alarm-Day switches. A comparator compares the actual time with the output from the memory and the comparison detector recognises an agreement if the alarm is enabled. The output circuit then drives a relay or other suitable device. Because

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The output drive capability of the memory is only one t.t.l. load, each output is buffered and inverted to produce non-inverted b.c.d. as shown in Fig. 10. Data is selected from the memory or the b.c.d. time output from the clock by IC4. When Y is low in the Set-Alarm mode the alarm times are displayed as they are set. As only the hours and minutes are set, seconds are blanked by IC21d. When Y is high in the Run mode the output of IC21d is low and the time is displayed normally. The memory output data is compared with the multiplexed time from the clock by

Key pressed

Pin 12 IC23

150 ms.

Write pulse

Pin 5 IC23

15ms.

Fig. 9. Single write pulse.
IC2. Normally, IC2 is clocked by control line C via S2a, so that the alarm times are fed out from the memory in sequence at one every 6ms. This sequence repeats after 16 x 6 i.e. 96ms. The comparator output in Fig. 10 is high when all four bits of a digit in the time agree with the memory data. The two inputs to IC13e are high only when the alarm is enabled by IC34, output going low, and during the first four seconds of a minute, i.e. tens-of-seconds A, B and C, and seconds C and D are all low. The output of IC13c is high only when the above conditions are met, control line C is low, i.e. tens-of-seconds or seconds data is not being processed, and the clock is not being updated at 100kHz i.e. the set-time pulse line is low. Therefore, if a true comparison between the stored alarm time and the displayed time exists, a 4ms high pulse appears at the output of IC13e. The 4ms pulse is repeated at 96ms intervals until four seconds past the start of the minute. However, during this time shorter pulses may appear at IC13e output such as a 3ms pulse produced by agreement of three consecutive digits in one alarm time. Pulses which are not 4ms long are rejected by the comparator detector in Fig. 11. The comparator output goes low for 2ms every 6ms when control line C goes high. Capacitor C16 therefore discharges through D20 to around 0.7V in the 2ms period, and then charges via R49 when the comparator output goes high. Resistor R49 is adjusted so that pulses shorter than 4ms are rejected.

Construction alignment and testing

Construction of the timer depends largely on how the clock has been built. In the prototype a Rugby clock was assembled on two 8x8in boards and the timer was built on third board. The keyboard and day indicator were mounted on the board inside a case to prevent unauthorised setting. The remaining components were positioned carefully to minimise wiring. The memory must be handled carefully to avoid damage by static charges and the 5V supply to the ICs should be decoupled at regular intervals with 10nF capacitors.

Alignment and testing is best carried out on individual sections. After constructing the power supplies check that no switching spikes are present on the battery charger and control circuit when the mains is switched on and off. Adjust R1 until the charging current is about 45mA and then disconnect the battery. Next, construct the keyboard encoding and debouncing circuit and insert all of the ICs except for the memory. Check that pins 4 and 12 of IC32 give single 150ms pulses when the respective keys are pressed and only when S2 is switched to Set. Check that 5 of IC32 gives a 15ms pulse when any numerical key is pressed.

Assemble the day-of-the-week indicator and check that the day advances each time the day key is pressed. To test the midnight-pulse circuit, set the clock to 23.59 by injecting pulses into the divider chain with the clock switched off, and check that the day indicator advances by one when the display changes to 00.00.00. Construct the alarm-enable/inhibit section and set the switches to Set Day. Test that the alarm-enable I.E.D. switches on by pressing key 1, and off by pressing key 0. Check that the data is recycled correctly by pressing the Day key seven times.

Construct the read/write control circuit and comparator, then modify the clock for display blanking and switch-on-reset as shown in Fig. 8 and Fig. 4 respectively. Insert the memory, check that the time is displayed with S2 at Run and that only hours and minutes are displayed with S2 at Set and S1 at Alarm. These digits will be random due to the unprogrammed memory. Pressing a numerical key should write into the continued on page 67
Microwave radar alarm
Improvements to the 1977 design

Accumulated experience since publication of Mike Hoskings design (July & August 1977) has led to a number of useful comments being received on the operational performance which, when combined with some circuit re-design, has resulted in a generally improved alarm system. This article presents the new system, which still has Home Office type approval for indoor use.

The alarm operates on the Doppler effect whereby a frequency shift occurs when a signal source and a receiver are moved relative to each other. For a given source frequency, the Doppler shift depends only on the relative radial velocity and is expressed by $f_d = 2V/\lambda$, where $V$ is the radial velocity, and $\lambda$ is the source wavelength. In this intruder alarm, the source and receiver are combined together into a single module, which then operates like a single radar.

The transmitter is a Gunn device mounted in a resonant cavity and produces a c.w. signal. This signal spreads out over a wide beam and when positioned in a room portions of the signal are reflected back into the receiver. The receiver front-end consists of a single Schottky-barrier mixer diode, operating as a superhet by mixing a directly-coupled portion of the transmitter power with the reflected signal. A difference or beat frequency is then extracted from the mixer output terminals.

When no movement is present, the received radar signal is at exactly the same frequency as that transmitted and so there is no output frequency (only a rectified d.c. level) from the mixer. As soon as any movement occurs, such as from an intruder, a Doppler frequency shift is imposed upon the reflected signal and appears at the mixer output. The appearance of such a signal can then be used to operate a remote alarm system.

Such is the basic simplicity of the alarm, but when account is taken of false alarms, transient movements, r.f. interference and special triggering requirements, then careful circuit design is necessary. It is in the amplifying, filtering, triggering and control sections that the up-dates and improvements to this intruder alarm have taken place.

In this country, the emission characteristics of the radar module are specified by the Home Office and for this application, the transmitter frequency is 10.687GHz. From the equation, the linear relationship between Doppler frequency and radial velocity is 71.25Hz for each metre per second (or 31.85Hz per mile/h).

In the complete circuit of the alarm shown the power supply is essentially the same as the previous supply to the radar module and provides an adjust-
able, highly stable output voltage with low ripple. This aspect is important as it minimizes the a.m. and f.m. content of the transmission. The main differences from the original version are

- fewer components
- conversion to a single-sided supply rail, making battery operation more convenient
- active filtering
- modification to the diode pump circuit to give increased immunity to interference and transient responses
- automatic switch-off and alarm reset after sounding for a period.

At the heart of the electronics is the RC4136 quad op-amp. Each individual op-amp is similar to the popular 741, but has a lower input noise figure. The first stage is used as a filter with a fixed gain of about 60dB, leading into a variable-gain second stage. Following the second stage is the diode pump, with the addition of a transistor to act as a fast discharge path and so prevent the circuit charging up on short-lived inputs such as might be generated by interference, insects or twitching curtains. This, together with the mains and i.f. input filter gives an excellent immunity to false alarms and ensures reliable triggering on more sustained movement.

A feature of the original circuit which is retained, but implemented differently is a built-in delay of about 45 seconds from the time of initial switch-on to when the alarm will start to respond. This allows one to leave the room after switching on the alarm. The delay is provided by the charging time constant of R1 and C1 to switch the output level of IC2c, and hence the correct non-inverting input of IC2d. Conversely, a new feature is now provided by the R2, C2 feedback combination which will automatically switch off the subsequent transistors after they have been on for about half a minute. This is a relatively long time for a loud alarm to sound and is considered sufficient to scare off an intruder. It also removes the embarrassment of returning home after a weekend away only to face one's neighbours, sleepless after an incessantly ringing alarm. After the re-set action, the alarm is, of course, returned to the "on-guard" state. Finally, the alarm circuit suggests a relay, with the coil connected in parallel with the sounder, so that a set of contacts may be provided for activating additional external circuitry.

Printed circuit board for this improved version of the 1977 intruder alarm is available from Intignex Ltd, Portwood Industrial Estate, Church Gresley, Burton-on-Trent, Staffs DE11 9PT, for £3.75 plus v.a.t.
Performance specification

Transmitter frequency 10.6775 GHz ± 12 MHz
Transmitter output power 10 mW max
Antenna gain 5 dB above isotropic
Out-of-band radiation 40 dB below carrier
Operating temperature range -5 to +40 °C

Range approx. 10 m against a man-sized object
Switch-on delay approx. 45 s
Automatic re-set after approx. 30 s

Range of professional electron tubes, cathode ray tubes, vacuum capacitors and special products such as reed capsules and gas detectors are described in the EEV/M-09 abridged data book for 1980/81. An equivalents index is included. Available free of charge in response to requests on company letter heads.

A film entitled "The challenge of choice," written by David Weir and directed by James Hill for STC, examines the effect of developments in telecommunications on people's lives. A brochure containing the script is available from STC at STC House, 190 Strand, London WC2R 1DU. WW 408

A bulletin on the various sound systems which can be assembled from equipment made by Millbank, describing several specifications, is obtainable from Millbank Electronics Group Ltd, Uckfield, Sussex TN22 1PS. WW 409

Connectors of various types, including those for printed boards, modular connectors and other multi-way and single-pole kinds, are illustrated and briefly described in a leaflet from Hypertac Connectors, Chronos Works, North Circular Road, London NW2 7JT. WW 410

A vapour deposition system for production work on semiconductor materials is the subject of a leaflet, available from Metals Research Ltd, Melbourne, Royston, Herts SG8 6EJ. WW 411

Multiplexed monitoring and control systems made by Vindicator is described in a leaflet from the UK representatives, Fieldtech Ltd, London (Heathrow) Airport, Hounslow, Middx. WW 412

Performance optimization, fault-finding and evaluation of minicomputer using logic analysers is the subject of an application note from Hewlett Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks. WW 413

Analogue and digital test-meters made by Sanwa are described in a catalogue from Quality Electronics Ltd, 24 High Street, Lydd, Kent TN29 9AJ. WW 414

An introduction to laser velocimetry and details of systems and components available are offered in a publication from Biral, Bristol Industrial Research Associates Ltd, PO Box 2, Portishead, Bristol BS20 9JB. WW 415

Weighing cells type Z7, which are shear-beam transducers for tensile and comprehensive loading, are the subject of a leaflet from the manufacturers, HBM, Stonefield Way, Ruilsip, Middx HA4 6TJ. WW 416

The 1980 catalogue from Livingston Hire is now available from Shirley House, 27 Camden Road, London NW1 9NR. WW 417

‘Radio navigation and radar’
The article on 'Radio Navigation and radar' in the January issue, p 47, contained an error, pointed out to us by LCDR R. E. Burke, Jr. The description of the Loron-C hyperbolic system on p 48 was in reality that for Loron-A. Loron-C is also a pulsed system, working on a 100 kHz carrier, but the time differences are measured on the carrier itself, giving errors of 30 to 300 feet from the starting point on a return trip. Ground wave, LCDR Burke tells us, extends up to 1000 miles, with a position accuracy of 0.25 nautical mile. We apologize for the mistake.
Alternative astable circuits

by Peter Williams Ph.D. Paisley College of Technology

These have generally been designed for special rather than general purpose use. Both transistors go off and on simultaneously. In circuits such as the one shown a long space is obtained by making \( R_2 > R_1 \). Hence the current is only on for a small part of the time and the mean current is low. Similarly astables based on the complementary pair shown earlier in the unijunction model have been used as pacemakers for heart stimulus. In these applications a space to mark ratio of up to 10,000:1 is needed to prolong battery life. Such circuits have an additional advantage in that the mean dissipation is also reduced for a given peak output current. The basic principle of the circuit shown is seen by assuming both devices are conducting though not saturated and then switch off. Point A rises sharply because of the positive step at Tr, collector while B corresponding falls. The capacitors then recover with \( R_1 + R_2 \) determining the rate of recovery and A and B approach and then pass each other. When the difference is about 1V the transistors just begin to conduct and regenerative switching forces A down and B up. The base currents are dependent on the current gains and the pulse duration is relatively short but ill-defined.

The two-transistor astable is often advocated because it can provide anti-phase and square-wave outputs. That facility is easily attainable with logic gates and flip-flops from almost any astable or pulse generator and more attention is due to such alternators. The long-tailed pair is the basis of a current-switching astable which operates at much higher speeds because neither transistor need be saturated. In this it is closely linked to the e.c.i. gate with which it can be implemented. The emitter resistor is sometimes replaced by a true constant-current circuit but this is not critical. Provided \( R_1 < R_2 \) the circuit will not saturate; keeping \( R_1 \) low reduces output pulse size, but generally improves the speed of response. Assume Tr, goes into conduction. The fall in collector voltage drives the base of Tr, negative and Tr, cuts-off transferring all of \( R_1 \) 's current to Tr,. As the base of Tr, recovers toward zero the amplifier enters its linear region. Tr, begins to conduct and current is diverted from Tr,. Its collector voltage rises and regenerative switching carries it up to +V. All the current in \( R_1 \) now flows in Tr, until the base of Tr, again returns to its linear region and the cycle recommenced. The long-tailed pair is a non-inverting amplifier of finite gain and the circuit is equivalent to a known form of op-amp astable.

A similar conclusion can be drawn about the emitter-coupled astable if it is considered as cascaded common-collector and common-base stages. The non-inverting combination having both \( A_1 > 1 \) and \( A_2 > 1 \) consists of a pair of cascaded common-emitter stages and this example is treated later. The analysis of this astable is easiest if \( R_{12} \) is replaced by constant-current sources \( I_1 \) and \( I_2 \). The capacitor must change its p.d. by equal and opposite amounts during succeeding portions of the cycle as the p.d. must always return to its original value at the start of each cycle in any stable oscillator. When the emitter of Tr, goes high, Tr, is cut off and the current in \( C \) is \( I_1 \). When Tr, conducts it pulls the base of Tr, below its emitter cutting it off and the current in \( C \) is \( I_2 \). Hence \( I_1 t_1 = I_2 t_1 \) and the mark-space ratio is unity for \( I_1 = I_2 \). If \( R_2 \ll R_1 \) the voltage steps on the resistors are small compared to the mean values and the waveforms and frequency differ little from the constant-current case. The circuit is again non-saturating and is capable of high speed.

Current-operated circuits extend the range of possibilities as compared to the restriction of voltage operation. A halfway house is provided where active devices are operated in series from a voltage supply. These are again a specialized sub-group of astables, but can be simple and effective. The version shown is a serial form of the emitter-coupled astable though implemented with junction f.e.t.s as this eliminates a number of bias components.

This circuit has been referred to above and can be approached in more than one way: as a conventional astable in which one of the capacitive couplings is replaced by a direct connection, as one of the two-amplifier single capacitor astables similar to a c.m.o.s. astable, or as equivalent to a single positive-gain amplifier with CR feedback. In this last interpretation the two inverting stages perform the same function as the two non-inverting stages of the long-tailed pair and emitter-coupled astables. This emphasizes the danger of "is" statements in electronic circuits. To say that a given circuit "is" a particular type refers only to the way in which the designer or user has decided to partition it. Each redrawing or repartitioning may reveal a new pattern, a new way of classifying it, or even a new class of which it is the first member. This particular astable has still greater significance when related to the classic two-transistor monostable.
**THEORY**

From symmetry then, when the transistors are conducting, the emitters are both at $V_s/2$ with the bases ±0.6V about that level. The timing is imprecise depending inter alia on $h_{FE}$. It is only one of a number of such complementary astables and no analysis is offered though the period is primarily defined by $R_1 C$.

In this circuit the output voltage step is of magnitude $V_s R_e / R_1$, for a supply of ±$V_s$ as the current in $R_1$ is switched between $T_R_1$ and $T_R_2$. If the circuit were to have a linear voltage gain $A$, then the switching thresholds would be at ±$V_s R_e / R_1 A$ and the appropriate values of $V_1$, $V_2$ are

$$V_1 = V_s \left(1 - \frac{R_c}{R_t A_t}\right)$$

$$V_2 = V_s \frac{R_c}{A_t R_t} \left(1 - \frac{R_t}{A_t R_t}\right)$$

$$t_2 - t_1 = R_t \log_a \left[ \frac{A_t R_t}{R_t - 1} \right]$$

For $R_t$, $R_c$ comparable $A_t \gg 1$

$$T \approx 2 R_t \log_a \left[ \frac{A_t R_t}{R_t - 1} \right]$$

A more accurate analysis uses the transistor exponential characteristics to derive the non-linear transfer function $V_s = k\tanh(V_1 / 2kT / q)$. From this the condition $dV_a / dV_t = 1$ can be obtained, fixing the switching threshold accurately.

Assume $R_e < R_{11}$, $R_{12}$ so that voltage swing is small. Then charging and discharging currents are approximately constant at $V_s / R_e$ for supply ±$V_s$ and $R_{11} = R_{12} = R_e$.

Hence the transitions are separated by a time interval governed by $\Delta V \approx R_e V_s / 2 R_1$ (since for $T_R_1$ conducting, $R_c$ carries currents in both tails while for $T_R_2$ conducting the current in $R_c$ is negligible) while the current in the capacitor in each case is $V_s / R_c$. Thus $T \approx 2 \cdot C \Delta V / I = 4 C R_1$.

The above involves a number of approximations that make the result useful as a guide to the behaviour but not an accurate one. It suggests that neither $R_e$ nor the negative supply rail have any significant effect on the frequency of oscillation though they directly control the amplitude.

Circuit behaviour is strongly dependent on the variable fet characteristics.

The voltage step at $T_R_1$ collector is $V_{R_1} (\text{sat}) - V_{C_1} (\text{sat}) \approx 0.5V$. The voltage available to control the current in the capacitor is too small for a stable well-defined frequency to be achieved. An additional resistor in the base of $T_R_2$ helps.

---

**EXAMPLE**

A long-tailed pair astable has $R_e = R_1$ and supply voltage of ±5V. Assume that the differential output current $(I_d)$ of a long-tailed pair is given by $I_d / I = \tanh(V / 2kT / q)$ where $V$ is the large-signal differential input voltage and $I$ is the tail current. Determine the value of $V$ at which the open-loop voltage gain from input base to output collector falls to unity. Hence determine the amplitude of the waveform at the base and the frequency of oscillation in terms of $\tau = R_e C$.

The gain will be half that for the differential output condition i.e. the latter is derived and equated to 2.

$$V_o = I \cdot R_e = I R_e \tanh \left( \frac{V}{2kT / q} \right)$$

But $I = \frac{V_s}{R_e}$ for a supply of ±$V_s$

$$\frac{dV_o}{dV} = \frac{V_s R_c}{2kT / q} \cdot \text{sech}^2 \left( \frac{V}{2kT / q} \right)$$

$\text{sech}^2 \left( \frac{V}{2kT / q} \right) \approx 1.2$ for $V/2kT \approx 1.2$

$\text{sech}^2 \left( \frac{V}{2kT / q} \right) = 0.5$ for $V \approx 1.95$

$V \approx 100mV$

The circuit should thus switch when the input base reaches about +100mV and again at −100mV giving a peak-peak amplitude of 200mV.

The collector step voltage is $V_s$. This might lead to saturation and a slowing of the response; reducing $R_e$ to $R_e / 2$ avoids this but reduces the threshold to 80mV and the peak-peak amplitude to 160mV.

For a step of $V_s$, the resistor voltage is raised from −$V$ to −$V + V_s$ i.e. from −0.1 up to 4.9V, decaying to +0.1V before initiating the switching action again.

From symmetry $t_2 - t_1 = 2 \cdot \log_a \left[ \frac{V}{2kT / q} \right] \approx 3.9\tau$

$\text{From symmetry } t = \frac{1}{2} \cdot \frac{1}{2 \cdot 3.9 \tau} = \frac{1}{7.8\tau}$ assuming $R_e \gg R_c$.

For $R_e = R_1 / 2$ the step size is reduced making $V \approx 2.4V$ but the gain is also reduced

$\text{sech}^2 \left( \frac{V}{2kT / q} \right) = 0.5$

$V \approx 1.54$

$V \approx 80mV$

$\text{For } R_e = R_1 / 2 \text{ the step size is reduced making } V \approx 2.4V \text{ but the gain is also reduced}$

$\text{sech}^2 \left( \frac{V}{2kT / q} \right) = 0.5$

$V \approx 1.54$

$V \approx 80mV$

$\text{This is a reduction of about 13% for a 50% fall in resistance. This is reasonable stability for a fast and simple circuit.}$
WORLD OF AMATEUR RADIO

What's cooking?
The reluctance (for whatever reasons) of the Home Office to introduce a low-power citizens' band radio facility in the UK is in marked contrast with the open-ended permission given to the public to install crude, high-power transmitters in their homes in the form of microwave ovens. Radio-astronomers at Jodrell Bank have investigated (Nature, Vol 282, 6 December 1979) the amount of broadband spurious "out-of-band" emission from typical ovens and have confirmed that this is sufficient to cause interference to extra-terrestrial signals when picked up on the sidelobes of large radio-telescopes at distances up to 20km or more on some frequencies.

Ovens generally use the "rectified a.c." form of pulsed, self-excited microwave generators on the i.s.m. (industrial, scientific, medical) frequency of 2.45GHz with a power output of the order of 1-2kW.

The primary source of leakage of unpolarized radiation is, the report states, from the seals around the oven door. "The seals are non-contacting and seem to consist of a resonant, quarter-wavelength choke nominally tuned to 2450MHz, followed by microwave absorbing material." It is emphasised that while this form of sealing is sufficiently effective at 2.45GHz to satisfy the UK safety regulations (i.e. exposure to microwave radiation), it fails to give adequate out-of-band suppression to prevent possible interference with other radio services authorized to operate within the 1-6GHz spectrum. Elsewhere it has been suggested that harmonic emission from ovens could prove to be "the major source of interference to I.O.2G microwave television from direct-broadcast satellites."

The use of large numbers of microwave ovens in residential areas could also prove a major problem for radio amateurs interested in the development of microwave communication at low signal levels.

The Jodrell Bank team complain that for the past ten years they have been urging the Home Office to specify permitted levels of out-of-band spurious radiation from ovens.

A boom in the hobby
Amateur radio in the UK experienced a sharp boom during 1979 and a record 26,981 licences were current in December. The number of new licences issued by the Home Office during the year amounted to 3155, of which 1054 were Class C, 12,745 Class A and 201 Class B (v.h.f./u.h.f., no more). Some 2400 people passed the first "multichoice" Radio Amateurs' Examination held in May 1979 and a considerable number sat the December examination.

The RSGB reports a 10.5 per cent increase in membership with some 4145 new members enrolled during 1979.

It remains to be seen whether these exceptional increases in the hobby were part of a long term trend or were partly the result of the unusual amount of media coverage during 1979 which included the "Open Door" and "Nation-wide" programmes. The British electronics manufacturing industry, however, has benefited only marginally from this boom, with the overwhelming majority of factory-built equipment coming from overseas. While there appear to be no figures on the total UK amateur market, Electronics estimates the US market as worth $23-million in 1979, rising to an estimated $26-million in 1980.

Topics in the air
The New Year brought forth a flurry of "new prefix" activity. East German amateurs appeared under the guise of "2Z" instead of the long familiar "DM" in what seems likely to be a permanent change. A selected 200 Russian amateurs in Moscow, Leningrad, Tallinn, Kiev and Minsk introduced a series of prefixes to mark the country's hosting of the Olympic Games, using RX, RZ, RR and RU prefixes for what are termed, "special Olympic ham operations." Club stations in Moscow and Tallinn will similarly change prefixes on July 1st and those in Leningrad, Kiev and Minsk on July 15th. These special prefixes end on August 3rd.

The first complete break in 50MHz long-distance propagation in more than two months came on December 15th, 1979 when the expected decline in solar flux took effect. A feature of the period of high solar activity was its remarkable freedom from geomagnetic disturbances, normally expected at sunset maximis. An aspect of v.h.f. propagation in the USA that does not appear to occur in the UK is a regular winter Sporadic E season affecting signals on 28 and 50MHz.

A 432MHz amateur television repeater in operation in the Wellington area of New Zealand, providing opportunities for tv transmission over distances of 60 to 100 miles, with several more in the planning/construction stage. An estimated 50 such repeaters are now operational in various parts of the world. A special "intruder watch" call-sign, G3DFY, has been issued by the New Zealand Post Office but will not be used for normal contacts.

A new reciprocal operation agreement between Canada and the USA came into force on January 21st with exceptionally liberal terms. It allows amateurs of either country while visiting the other to operate without needing to obtain prior written permission. However, since US-type novice and technician licences are not issued in Canada, US amateurs with such licences are still not permitted to operate in Canada.

The Vojvodina Amateur Radio Federation of Yugoslavia has more than 10,000 members and its basic aims are: "to maintain radio links, teach and train young people in electronics and telecommunications and train all members for all-people's defence and social self-protection". The national amateur society in Yugoslavia is SRJ (Savez Radioamatera Jugoslovija).

A special event call-sign GB9 in the UK in the series GB4 plus two or three letters are being issued through the RSGB; the GB3 plus two letter calls will in future be used for repeater stations, and GB3 plus three letters for beacons. Special event call-signs in the series GB2 and GB8 continue to be issued.

A number of FCC employees who received call-signs in a manner stated to have been "inconsistent" with official procedures are to be allotted new calls. This follows an investigation into fraudulent licensing and issuance of stations in recent years.

A special Certificate of Membership has been presented by the Royal Naval Amateur Radio Society to 87-year-old Mrs F. V. McKenzie, OBE, former VK2FV who was Australia's first YL operator, first qualified woman electrical engineer and founder of the Women's Emergency Signalling Corps (later Women's Royal Australian Naval Service) which trained about 11,000 Australian, American and Indian radio operators during World War 2.

In brief
A new RSGB award for microwave operation will require confirmation of contacts with five "large QTH locator squares" on any of the bands between 1.3 and 24GHz. The FCC is expected soon to permit American rtty enthusiasts to use ASCII... A regular moonbounce newsletter is being organized by the Oxford University EME Group (G3WLG, The Crescent, Pottishall, Towcester, Northamptonshire).

Rev G. C. Dobbs, G3RJV, Hon. Secretary of the "G-QRP-Club", has changed address to 17 Aspen Drive, Chelmsley Wood, Birmingham B37. A linear translator (repeater) on the 1296MHz band is operating in San Jose, California.

PAT HAWKER, G3VA
Impedance mismatching

A pitfall to be avoided when using Thevenin and Norton equivalent sources

by F. J. Lidgey, Ph.D., B.Sc. Oxford Polytechnic

Power transfer from a source into a load is frequently discussed in circuit theory. Also a parameter of interest is the transfer efficiency (\( \eta \)) defined as the ratio of load power \( P_L \) to total power delivered by the source \( P_s \). The proposal of this article is to outline a common error made in calculating \( \eta \) which stems from an incorrect assumption regarding the power delivered by a Thevenin or Norton equivalent source.

With transfer efficiency in mind it is easy to show that a 'mismatching' of load to source impedance reduces power dissipation in the source impedance. For example, in Fig. 1:

\[
P_L = i_L^2 R_L = \frac{v_s^2}{(R_s + R_L)^2}
\]

\[
P_s = v_s i_s = \frac{v_s^2}{(R_s + R_L)}
\]

Thus \( \eta = \frac{R_L}{R_s + R_L} \).

\( \eta \) tends to zero for \( R_L = 0 \) and \( \eta \) tends to its maximum value of one for \( R_L = R_s \). If for example \( R_s = 500 \) then 80% efficiency of transfer of power into \( R_L \) occurs for \( R_L = 200 \) and \( P_s = 64\% \) of \( P_s \) max. However, there is obviously no optimum choice, as can be seen from the plot of Fig. 2, which shows that for \( \eta \) of 100%, i.e. no power dissipated in the source, then no power flows in the circuit, since \( R_L = R_s \to 0 \) and \( i_L \to 0 \).

All this seems quite reasonable and as one would expect, if \( R_s \) and \( v_s \) are really known in any circuit. At first sight, it appears that they are: all that seems necessary is to generate the Thevenin equivalent source, which gives \( R_s \) and \( v_s \); hence, \( \eta \) may be obtained from the expression given previously. This, however, is a fallacy, which can be exposed by the example of Fig. 3.

Taking the special case of \( v_s = 2v_s \) and \( R_s = 2R_s \), then applying Thevenin's Theorem, the source can be replaced by a voltage source of \( v_s \) and a source resistance of \( R_s \), exactly as in the circuit of Fig. 1. Clearly, \( P_s \) is the same but is \( P_s \).

For Fig. 3:

\[
P_s = \frac{(2v_s)^2}{(2R_s + 2R_L)} = \frac{v_s^2}{(R_s + R_L)} = P_s\]

For Fig. 1:

\[
P_s = \frac{v_s^2}{(R_s + R_L)} = P_s\]

As already stated, in obtaining the Thevenin equivalent source \( P_s \) remains the same, so \( P_s = P_s \) must remain the same; since the source powers are different, \( P_s \) is different in the two circuits; the power dissipated in the source resistance of the Thevenin equivalent source is not equal to the power dissipated in the original source.

The same argument applies if a current source is substituted for the voltage source, as in the circuit of Fig. 4, which is a Norton equivalent of Fig. 1.

\[
P_L = i_L^2 R_L = \frac{(v_L + R_s)^2}{R_s + R_L}
\]

\[
P_s = v_s i_s = \frac{v_s^2}{(R_s + R_L) R_s}
\]

Continued on page 78
LETTERS TO THE EDITOR

STATUS OF ENGINEERS

Regarding the status of engineers, as discussed in your editorials and correspondence. One factor seems to be overlooked, viz. that the status and respect given to doctors and lawyers increases exponentially with age, right up to their 70s, whereas that of an engineer, however experienced, reaches a plateau at 25 and then drops off rapidly beyond 35. How many jobs offered in WW advertisements are open to anyone over 30? Precious few!

Nor is this exclusive to Britain, but has already spread to the USA and is now beginning to be felt in Japan.

In countries devoted to production in support of the almighty deutschmark, engineers are still accorded some degree of respect in their middle years, but one wonders how long it will stay so when production there also falters, as indeed it must eventually in a world of resource shortages.

The sad fact is that engineers don't stay engineers long enough to get status! It would be interesting to know what old engineers do, for a living. Is there a suitable subject for a survey there? (They can't all retire at 40!)

A final word: no matter how much headway young engineers make, the days when they might have made it socially have gone. Yet, somehow, I don't ever expect to see aged engineers make, the days when productive engineers are still accorded some degree of respect, right up to their 70s, whereas that of doctors and lawyers increases exponentially with age, but that of an engineer, however experienced, reaches a plateau at 25 and then drops off rapidly beyond 35. How many jobs offered in WW advertisements are open to anyone over 30? Precious few!

Ronald G. Young
Peacehaven, Sussex

DIGITAL FILTERS

Perhaps, following Mr Gray's letter in your January 1980 issue, I could raise a point which is not always well-made in text books and which space did not permit me to touch upon in my article on simple digital filters in the July 1979 issue.

A digital filter algorithm performs calculations and outputs certain values at fixed intervals of time. Strictly speaking, the output values are only meaningful at those exact instants, and what happens in between is not defined; hence the plots of the points only in Figures 2 and 5 of my article.

This, however, is not particularly helpful in practice since we generally wish to produce some analogue waveform for further use or inspection on an oscilloscope. As soon as we do this we enter the field of waveform recovery and make implicit assumptions about the technique involved. Most frequently, as Mr Gray's Fig. 1 implies, a zero-order-hold is assumed, the properties of which have been well discussed by Zuch, and include an average delay of half the iteration interval and a linear phase response equal to 90° lag at the Nyquist frequency. If Mr Gray finds a phase advance of half the iteration interval, I would suggest he has made an error in interpreting or plotting his results.

Other methods for waveform recovery are, however available. A first-order hold retains the value of the previous iteration as well as the present one, and uses this data to generate a slope which will, one hopes, lead towards the point where the next sample will arrive as shown here. This method effects a significant reduction in the delay terms. A second order hold is also possible and this will generate second order or polynomial. I do not know of any applications in real time where this technique is used, but it is not uncommon for curve generation in the computer numerical control of milling machines, for example.

These factors are of importance to the practical engineer, since they imply that the exact response obtained from a digital filter as we approach the Nyquist frequency may owe as much to the waveform recovery technique as to the filter itself.

Incidentally, the reference to Nyquist derives from the communications field; it may be of interest to note that in the process industries virtually the same law is known as Shannon's Theorem but the formulation places greater emphasis on the exclusion of frequencies higher than 1/2T.

P. A. L. Ham
NEI Parsons Ltd
Newcastle-upon-Tyne

References
1. E. L. Zuch: "Designing with a sample-hold won't be a problem if you use the right circuit." Electronic Design 23, November 8, 1978, pp. 84-89.

AUDITORY CUES IN STEREOPHONY

We were most interested in Philip Vanderlyn's article on auditory cues in stereophony in the September 1979 issue. The whole piece begs one particular question — what does the current craze of multimiking do for our stereo perception? Perhaps Mr Vanderlyn could be persuaded to relate his research experiences in this aspect. I, for one, would be interested in a researcher's views of this particular debasement of Alan Blumlein's original ideas.

But more immediately I would question Mr Vanderlyn's attribution of "in the head" sounds to dummy head derived stereo, listened to on headphones. We are currently marketing a number of binaural records and would claim that "in the head" sounds are the last things being achieved. Real distance "out of the head" effects are clearly discernible on many parts of our discs. True, it is easier to get distance, side and rear effects as opposed to "out front" images, but to describe the effect as "in the head" clearly defeats the reason for the marketing of our discs.

M. G. Skeet
Whetstone Records
Milton Keynes

The author replies: First of all multimiking is not a current craze; it has been going on almost from the introduction of stereo records. Secondly, it owes nothing to research, so I have no experience of it in that context. Thirdly, my personal opinion of it is not for publication, but I would agree with him that it represents a debasement of Blumlein's conception. There is a fourth aspect, the economic one. Very early in the practice of stereo recording using "pure Blumlein" techniques it was found difficult and time consuming to get a good musical and spatial balance. It also called for much patience and understanding on the part of musicians and conductors. It was thus very expensive and the multimiking technique came into being, which permitted subsequent editing and which produced a colourable imitation of "real" stereo. I did wonder at one time whether it fell foul of the Trade Descriptions Act, but because the definition of stereophony in BS 691 is so widely drawn it appears it can unblushingly be called stereo.

Nonetheless it is a fact that, in this way, many very satisfying stereo records have been made that would not or could not have been necessary to keep to theoretically rigorous methods. We have to bear in mind, as I
am sure Mr Skeet does, that record companies exist to sell home entertainment rather than to demonstrate scientific truths.

My comments on headphone stereo were based on early experiences when it was found impossible to create a convincing image using dummy head techniques. The expression "in the head" was a form of words used to describe the vivid but unnatural effects produced. At that time the only headphones readily available were those affectionately known as "cans" — excellent for reading Morse code signals but not really suited for serious listening. Now that there are many excellent high quality headphones the situation is different and it is possible to listen with pleasure to all types of programme material. I must admit that on more than one occasion I have heard realistic external sounds, but these have been from special recordings which preserved possible cues due to the pinna. I am inclined to think that the role of the pinna, which has only recently been studied in detail, has hitherto been underrated. However, I still feel that the head rotation cue is an essential part of any convincingly external image, at any rate over an appreciable period of time, and there seems to be no possible way to provide this using transducers held in a fixed relationship to the ears.

Philip Vanderlyn

**RUMBLE CANCELLATION FILTER**

Congratulations to J. P. Macaulay for his elegant method of removing rumble from stereo disc reproduction without degrading the deep bass response (Circuit Ideas, September 1979 issue). The concept of turning the lowest bass into a mono signal is so beautifully simple that one wonders why this technique is not widely used.

After having studied the discrete circuit design, I decided to build a simplified and improved version, making use of today's superior integrated op-amps. The diagram shows how a TL074 quad op-amp is used together with a simpler matrixing system to form a rumble cancellation filter (as I prefer to call it) with near ideal characteristics. The TL074 exhibits a performance, in terms of extremely low distortion coupled with high slew-rate and bandwidth, that is hard to beat using even complex discrete designs. Expected figures will be around 100V noise, d<0.002%(to 20kHz) and f<1 several MHz.

In his filter Mr Macaulay uses equal C-values (33nF); this will not give a Butterworth characteristic. For this a ratio of 2.1 is required, hence my corrected values of 47 and 22nF.

It should be kept in mind that the rumble filter inverts the polarity of the input signal. If it is ever to be installed in a system where it may be switched in or out of service, inverting gain-of-one buffers must be used for the polarity convention to be preserved.

**Jens Langvad**

**Vanlose**

**Denmark**

**TRICKLE DOWN OR TRICKLE UP?**

Referring to the November editorial, I thought that in general the "trickle down" theory of reducing poverty by development was discredited, though there are exceptions. Where a country has a resource which can be turned into cash, as for example Britain's North Sea oil, there is a case for using the cash for capital investment in industry. This was also the Shah's policy in Iran, and no-one who has seen the traffic jams (of private cars) in Teheran would suppose that the benenficiaries of this policy were very few in number, though they might well be a minority of the whole population. On the issue of intermediate technology versus capital-intensive technology, there is also the prestige consideration which may be rationalised in the form: "If we are going to buy machinery from abroad, we should obviously buy the most up-to-date."

Those who are seriously interested in under-developed countries should see a book such as "Income Distribution Policy in Developing Countries" by Irma Adelman and Sherman Robinson.* Much of this book is concerned with the technicalities of constructing a computer model (for South Korea); but the authors do discuss various economic policies and conclude that the most effective single weapon to reduce poverty in such countries is to assist agriculture.

A pocket calculator is of no use to an under-nourished family; and such things as radio communication to call a doctor improve the amenities but do not reduce the poverty. The positive contribution of electronics is through computer simulation of the economy, which makes it possible to answer the question "What will happen if we do such-and-such?" without actually implementing an experiment which might prove to be disastrous. "Chips with everything" may be all right for developed countries, but we should be modest enough to admit that high technology alone cannot solve all the world's problems.

D. A. Bell

**Walshington**

**Beverley**

**Yorks**

*Published for the World Bank by Oxford University Press, 1978. There are many books on income distribution, but this one (a) is concerned with developing countries and (b) has a computer model, based on continuing processes rather than interpolation of past data, which appears to match reality successfully.

**3D TELEVISION**

K. P. Wood (October 1979 letters) suggests that it is impossible to provide stereoscopic viewing of a moving object on a flat screen without viewer discomfort. This he claims is because of conflict between focusing and convergence clues received by the viewer. However, his claims are pure hypothesis without any attempt to provide qualitative or quantitative evidence.

A major factor he omits to mention is perspective, a subject all painters and photographers have to fully comprehend to master their arts and crafts. A very strong illusion of depth is conveyed in mono pictures whether paintings or projected kinematograph films by the correct use of perspective in images on a flat surface. If Mr Wood is correct there would be a strong case for supposing that viewing of painted pictures with strong perspective would cause viewer discomfort. Surely he would not sustain this argument?

It is true that viewing of red/green anaglyph 3D images is tiring, but this is because it is quite an abnormal situation for one eye to see only deep red images whilst the other sees only green.

It is also true that viewing of a large number of early 3D polaroid colour films produced headaches and eye strain. However, it has now been established, as a result of research and a better understanding of the subject, that this was not due to the factors postulated by Mr Wood. It was because the camera men and directors who made the early 3D films did not properly understand
the rules that apply to stereo-cinematography and both in camera work and subsequent editing produced visual cue conflict situations much worse than Mr Wood postulates.

There is now no reason to believe that a correctly photographed and edited 3D stereo film of the colour/polaroid type will produce any viewer discomfort even over long periods. If there is any scientific evidence to the contrary I shall be most interested if Mr Wood will quote the basis of it.

Meanwhile, recommended reading for those interested in factual accounts of work done in this field is: "Introduction to 3D" by H. Dewhurst, Chapman & Hall, 1954; and American Cinematographer, (special 3D issue), April 1974, 1782, North Orange Drive, Hollywood, Calif. 90028.

A. E. Lott
Reading Berks

THE ‘WHY?’ OF ELECTRONICS

I was just reflecting on our good fortune in having in Wireless World a high quality technical journal which (unlike the numerous trade journals) is not afraid to discuss the why? and what for? of electronics as well as the how? when I came across Mr Greenwood’s letter (January issue) calling for an end to “political rhetoric” in your editorial.

Unlike Mr Greenwood I think it needs more than a few “delightful moments of humour” to “demonstrate that technical people can be human.” Technology is changing society now faster than at any other time: some changes are for the better, some for the worse. The people who find their livelihood changed as a result of the engineers’ combined efforts will not think us “human” if we blindly and mechanically create what we’re told to without sparing so much as a comment in a technical journal on the desirability or otherwise of what we are creating. Technology has great potential for improving the quality of life — if applied sensibly. As technologists we must make our contribu-

tion to the discussion of how to apply it sensibly, rather than allow its control to pass unquestioned to those primarily concerned with financial gain in the short term.

So, long may Wireless World continue its perceptible and searching editorial comment, followed I hope by vigorous discussion in the letters pages.

P. A. D. Bird
South Brent
Devon

'’TRIVIAL’ AMPLIFIER DESIGNS

In reply to Mr Duncan’s letter ‘‘Trivial amplifier designs’’, in the January issue, whilst I am in general agreement with his views on psycho-austhetics, I feel he may have missed the object of my article (“Low distortion amplification,” October 1979).

The nature and control of distortion and other important parameters in a.f. amplification are generally misunderstood, resulting in the growth of illusion and mysticism (as witnessed by Mr Duncan). The aim of my article was to combat this by defining the problems in engineering terms and using the solutions as design criteria for a gain cell block. Although the article described its use in a domestic sound reproduction system it could have equally been applied to a laboratory amplifier, low distortion oscillator, distortion factor meter etc.

To take Mr Duncan’s objections to their logical conclusion, should design in any one field of engineering be terminated due to imperfections in another?

B. J. Codd
Medical Physics Department
Leicester Royal Infirmary

FAILURE OF DISTRESS SIGNALS AT SEA

I was surprised on reading the letter by R. Philpot (November) and a previous letter by John Wiseman (June) about the problems encountered at sea operating at 500 kHz. In theory a solution of salt and water effectively earths the r.f. power present in the aerial’s insulator, which makes electrical contact with the wire.

The practical solution is the use of e.h.t. cable, so that there is no electrical contact with the conductor. A 150-watt input has been used, but much higher levels are believed possible. In the experiment, RS Components 18kV e.h.t. cable was used.

I feel sure that this is a late, but effective answer, and with lives at stake the cost is very small.

Peter C. Gregory, G4 HKV
Ashton-under-Lyne
Lancs

Mr Wiseman replies:

The use of e.h.t. cable would be similar in principle to the naval practice of using p.v.c. coated whip aerials. However, the statement that “...a solution of salt water effectively earths the r.f. power...” is an over-simplification. I have letters from people at sea reporting severe problems with ‘wet insulators’ at 500kHz but less effect at 2182kHz and similar, and very little at all at h.f. in the 4 to 21 MHz marine bands, and my own experience confirms that. Since Mr Gregory gives an amateur call sign, the experiments he refers to will have been carried out in the amateur bands 1.8 to 30 MHz. A ship’s main aerial is invariably greater than ¼ wave-length at h.f., and why h.f. is almost unaffected I leave to others to explain, but at 500kHz the antenna is always less than ¼ wavelength and its capacitance forms part of the pi-coupler resonant tank circuit. It is, in my opinion, change in antenna capacitance due to Kohlraush Effect that is the cause of the problem at 500 kHz.

For reasons of economics, the pi-coupler range of adjustment will be much less at 500 kHz than at h.f., due to the size of components required. The pi-coupler may be able to accommodate changes in aerial parameters at h.f. which it cannot accommodate at 500 kHz.

E.h.t. cable of the automotive kind would present some problems. Coated with water it might become a concentric capacitor, aggravating pi-coupler problems. It would lack mechanical strength and would not stand up to rough treatment; once the insulation was cut or bruised it would be rendered ineffective, and it does not lend itself to easy repair if broken by a wharf crane, for example.

John Wiseman

PROGRAMMABLE NOTES FOR MUSICAL INSTRUMENTS

Mr Waters is incorrect on several points in his letter in your January issue.

The system of temperament that was discarded when equal temperament was adopted about 140 years ago (not 250 as Mr Waters states) was mean tone temperament, not natural or just temperament. Mean tone temperament is based on natural temperament with a few judicious changes which produce harmonious music in 6 major keys and 3 minor keys. The remaining keys suffer from the effects of the changes and have rough harmonies. Handel and Bach had instruments tuned to this system. Equal temperament is an artificial system not based on the natural system at all. The result is that all keys have equally rough harmonies but music can be played in all keys.

The system I am proposing uses natural temperament, which sounds best, and allows modulation to any key. Surely, had such a system been available to Bach he would have adopted it in favour of equal temperament. I would be interested to find out in which ways Mr Waters’s musician friends consider my proposal is retrograde since it has not been possible hitherto!

M. Robins
Bilton
Rugby

I was very interested in M. Robins’s letter “Programmable Notes for Musical Instruments” in the November 1979, issue since I did some research on the possibilities a couple of years ago for my own amusement. I would like to mention, for anyone interested in pursuing this subject, the excellent treatise “On the Sensations of Tone” by Helmholtz, which is published by Dover with many extra appendices and tables; the theoretical work on harmony and tuning has never been bettered.

The information required by an instrument to perform a perfect job of just tuning is more complex than merely the key of the music. It
requires some skill in analysing harmonies to derive the data, and more than a few keys to enter it into the instrument. I do not believe that performers would welcome additional manual input to the instrument of this complexity.

My research concerned a computer model of an instrument which would analyse the music in real time and tune from the knowledge gained. Actually, it is theoretically impossible to make the perfect job of this in real time, as M. Robin probably knows, because the context of the harmony must be known, including what follows. My work showed that only about half of the job could be done this way, and it would not be cheap, given the amount of computer power it consumes.

Just temperament is interesting, but it is not obvious that it is musically desirable all the time. Unaccompanied singing, such as the close harmony which I have done, tends to go flat, for good reasons related to the tuning changes that occur when modulating in just temperament. This would be unacceptable in some situations. Further, the sound of chords in just temperament is very smooth and restful, lacking the high frequency beats which are normal in any other temperament. These are important, since they add "life" to the instrument, which would be dull and monotonous without them.

The service area is large; it is claimed to cover most of Europe but in some areas interfering signals may cause trouble. There is a powerful transmitter 1,000 hertz away from MSF and in the Manchester area it is 10 dB larger than MSF. In Preston it is 20 dB larger. A relatively wide band receiver is needed to make use of the coded time signals and this project has defeated several of our students.

May we suggest that anyone considering the problem do a few measurements in his area before building the complete clock? It would be interesting to know if your readers have ever had trouble with commercial equipment in this area.

Another source of interference is the fourth harmonic of the TV line timebase which this can be solved by moving the receiver.

T. G. Izatt
Preston Polytechnic
M. D. Samain
University of Salford

Reference
I. Mullard Technical Communications, Volume 14, Number 40, October 1979.

We understand that the interfering transmitter (on 61.8 kHz) is in fact a M.S. Inskip, between Preston and Blackpool.

MAGAZINE PROJECTS AND KITS

It occurs to me that many of your readers may be puzzled as to why different companies quote such widely differing prices for kits of parts for projects in the magazines, and possibly a few words explaining this might be of interest.

The fact is that when engineers design a product, they do not anticipate what happens to be at hand, and then when the project is finalised, a list of parts is sent out by the magazine to the leading companies for pricing.

If completely standard parts, normally carried in stock by the firms concerned, are specified, then there is no problem, and all companies should be able to offer competitive prices. Unfortunately, this is seldom the situation, and very often special non-stock items have to be obtained. Even this in itself would be unimportant if one knew how many kits were going to be sold, but it is usually pure crystal-ball gazing, and because of this the special parts have to be costed on a one-off basis.

Another problem is that for convenience a designer often uses a purely trade source to obtain his parts. This would not be particularly important if retailers were able to buy competitively from these sources, but one of the best and most reliable trade sources offers no discount for the retailer, and will not sell direct to retail customers, which means the retailer has to add his margin, and the end product becomes very expensive.

This letter is not meant as a criticism of designers or magazines, but might assist designers to provide economical kits. There is no doubt that if there was more liaison at the design stage with the retailers concerned many of these problems could be overcome.

J. N. Shipton
A. Marshall (London) Ltd
London NW6

Hijacking Carfax?

D. P. Leggatt of the BBC (October letters) in replying to Peter Manson's letter expresses optimism that the designers of the Carfax service have adequate means to control the security and authenticity of the information broadcast. Surely such a system is fundamentally vulnerable to hijacking for the following reasons.

Firstly, inexpensive Carfax decoders are going to be manufactured in large quantities; therefore their principles of operation cannot be inordinately complex. Secondly, some 80 genuine transmitters throughout the country will be quite openly broadcasting the "secret" initiation code every few minutes. Thirdly, test generators producing the appropriate signals will, no doubt, be extensively used in service workshops.

But, perhaps, traffic wardens will have their duties extended to ensure that no obscene, humorous or alien messages are being transmitted.

Mandy Peterson
Swindon
Wills

The BBC replies:
Mandy Peterson will not let me get away with my rather generalised statement on Carfax security, and she makes some very relevant comments.

Certainly 'secret' initiating codes would have their limitations, but there are other techniques available including comparisons between the original and transmitted signals.

As ever, it will be difficult to ensure absolute security and I must confess that our obscenity detector is not yet perfected.

D. P. Leggatt
Head of Engineering Information Dept
BBC, London W1
DIGITALLY CONTROLLED ATTENUATOR

I read the Circuit Idea on the digitally controlled attenuator by Mr S.R. Taylor, in the December issue. The AD75XX series of c.m.o.s. d-to-a converters are all inherently 4-quadrant multiplying devices. They can all therefore be used for audio applications, one of which Mr Taylor describes. It is not a large step of course to implement a stereo balance and volume control system using two such circuits running from updown counters fed serially.

Perhaps I could emphasize one or two general points with regard to such audio applications. Compared with analogue-controlled electronic attenuators, digitally-controlled attenuators offer some distinct advantages. Total harmonic distortion figures are significantly better, bandwidth is significantly wider and noise immunity greatly improved. In addition, such systems have the facility for remote operation under touch-switch or microprocessor control.

Could I also make a recommendation with regard to Mr Taylor’s circuit? The selection of the operational amplifier should be done with care. The output resistance of the d.c.a.c. changes with code-setting (as does its capacitance). This means that an amplifier with a large input-offset should be avoided as a code-dependent variable output-offset will result. This may produce significant noise during code change. As the d.c.a. has a few pF output capacitance typically 37-120pF (depending on code), capacitive feedback compensation is recommended when using wide-bandwidth amplifiers. This is usually about 10-20pF depending on the amplifier.

Instability may occur at some code settings if no compensation is used. Mr Taylor shows a gain-adjust potentiometer in the feedback loop of his system. I would suggest a fixed, low noise, resistor of value 1kΩ in the feedback loop and include a 2kΩ adjustable resistor in the input line to the AD75XX. (However, I suspect that there is only a limited need for a full scale absolute accuracy of better than 0.1% in anything other than test equipment).

In conclusion, perhaps to back up the above comments, Mr Taylor and other audio engineers may be interested to know that Analog Devices intend introducing a device specifically for the audio field, the AD7110, in mid March 1980. The AD7110 is a monolithic c.m.o.s. digitally controlled attenuator in a 16-pin d.i.l. package. The analogue output voltage decreases logarithmically as the 6-bit digital-input code increases. The attenuation range is 0 to 88,5dB (plus full muting facility) in 1.5dB steps. The total harmonic distortion is better than –96dB (0.002%) and the signal-to-noise ratio is 124dB. When tested with a commonly available audio op-amp, a bandwidth of 0 to 250kHz was observed.

M. I. Stephenson
Analog Devices B.V.
Limerick
Republic of Ireland

AND NOW THE PICOBEL

Contrary to Anne King’s letter (November 1979), the millibel has immediate and important application in musical recording/ reproduction systems. In fact, a lengthy article in International Audio Review 3 was devoted entirely to the 2-5 millibel sensitivity of the ear to 2-5 millibel deviations in frequency response, and the consequent need for very precise RIAA de-emphasis in phono preamplifiers.

This article discussed how those traditional experiments, which established the entrenched belief about our hearing insensitivity to loudness changes on single tones of less than 1 dB, are irrelevant to our hearing sensitivity to frequency response deviations on broadband signals, such as music.

Our experiments have established that we can hear frequency response differences in the 2-5 millibel area, as has empirical work by our friends Stanley Lipshitz and others. Not only can we reliably detect that there is a difference (which is a sufficient criterion to establish an auditory threshold), the difference is so clearly perceivable that we can quite readily describe it, quantitatively, and, yet more remarkably, qualitatively.

For example, we aurally compared one pre-amplifier against a straight wire on music. In spite of the masking presence of the pre-amplifier’s distortion byproducts, which seemed to add distorted bright energy to music above 5kHz, we also heard what seemed to be a purely tonal balance anomaly. We aurally judged this anomaly to be a plateau hinged at the 2120Hz RIAA breakpoint, and estimated its magnitude at 20 mB. Once we had established the pre-amp’s actual RIAA frequency response was flat—save for a plateau hinged at 2120Hz that measured 20 mB in magnitude (±1 mB). The pre-amplifier’s designer and manufacturer, who witnessed this experiment, asked why we even bothered with measurements, if the human ear could be that perceptive and calibrated.

Incidentally, our measuring technique presented in IAR 3 can reliably measure down to about 0.2 millibels, unlike the 0.5 dB limitation of Ms King’s meters. And since IAR 3 we have extended our measuring sensitivity (using differential techniques) into the picobal region. Therefore, and in sympathy with Mr Marks’ desire to end decimal point confusion, I herewith enter a plea for the picobal as the standard unit of commerce! Also, if we are to capitalize on engineering unit names in deference to the scientists they honour, let us do the job right and revert from bel to Bell, not Bel. That bell which tolls is hardly ever capitalized, so the confusion should be minimal.

J. Peter Moncrieff
International Audio Review
Berkeley
California, USA

In the UK it is standard practice to use capital letters for the abbreviations of unit names but not for the full names. — Ed.

LIQUID-STATE AMPLIFIER

The late Professor Fleming’s account of the thomonic diode (November 1979 issue) reminded me of a little search for the ‘missing counterpart of the vacuum-tube and solid-state devices – the liquid-state amplifier.

Although it might be argued that this is the biological amplifier of choice, as, for example, in the form of the ‘cochlear microphonic’ signal generator available in the mammalian ear (a signal capable of driving an ordinary audio amplifier), I was interested to find that a liquid ‘ionic diode’, at least is easy to arrange. A diode made with a platinum wire and a silver/silver-chloride wire dipped in dilute sulphuric acid gave a forward to reverse conductance ratio better than 25:1 for signals of less than ±100mV amplitude d.c. Moreover, Professor Fleischmann (Southampton) was able to describe a two-membrane ‘ionic triode’ which he constructed in an Physics student in 1947.

Considering the speeds of the various charge carriers estimated below:

\[
\begin{align*}
&> 10^4 \text{ m.s}^{-1} \text{ for a hard valve}, \\
&< 10^4 \text{ m.s}^{-1} \text{ in a copper wire}, \\
&< 10^3 \text{ m.s}^{-1} \text{ in an aluminium wire}, \\
&0.1 \text{ m.s}^{-1} \text{ for an electric field of } 1 \text{V.m}^{-1},
\end{align*}
\]

1 expect the frequency response of the wet triode is, well, wet.

B. Whatcott
Addlestone
Surrey
Electronic combination lock

Non-volatile logic devices give easy programming and long-term storage

by Alan Oakley, B.Sc. Plessey Semiconductors

This article describes how an ordinary key operated mechanical door lock can easily be converted to a 4-digit, multi-code electronic security lock, using non-volatile logic devices. The data in these devices can be altered easily but once entered can be retained for a considerable time even in the absence of applied power. The 4-digit combination codes are easily programmed and the versatility of the design means that the system does not need clearing down. It is a simple matter to extend the system from a 4-digit code (some 65,000 odd combinations) to any greater number of codes by adding more quad latches. Apart from the normal door latch such a system could find application anywhere where access is to be restricted, and could also be converted to be remote controlled.

The MN9102 quad latch is one of the NOVOL range of integrated circuits produced using the Plessey ‘metal-nitride-oxide-silicon’ (m.n.o.s.) process. This is essentially a p-channel, metal-gate process, but with the additional feature that variable-threshold memory transistors may be fabricated alongside conventional fixed threshold m.o.s. transistors. These memory transistors can be used to retain data even in the absence of applied power and therefore provide the facility of non-volatile data storage in standard m.o.s. circuits.

Data may be stored in the MN9102 for at least one year, in the absence of applied power, over a 0°C to 70°C temperature range. The device runs off standard m.o.s. supplies of +5V and -12V which are used internally to generate the high-voltage supply normally associated with m.n.o.s. memory devices, and requires only a single external capacitor to act as a charge reservoir for supplying current when writing into the memory. The data that is applied to the four inputs is written into the memory when the SAVE control is taken to a logic 0 level, presents a high-impedance state on each data output line, thus permitting multiplexed operation.

The digital security code system uses the MN9102 quad latch to store hexadecimal digit data in the absence of applied power. When this data is interrogated with the correct incoming data from a keyboard there is a 2½ second delay before an electro-mechanically operated mortice catch is opened for 2½ seconds. The delay and opening times may be varied easily and are included to improve security and conserve power. The number of digits in the security code is totally dependent on the number of quad latches.

Data is entered into the system via a hexadecimal keyboard with a diode/resistor decoder, if a 16, single-pole output keyboard is used. Alternatively, the data may be entered using a 16 key encoder (74C922) if a 4 x 4 matrix output keyboard is in use. Either system generates the four data signals and 'anykey,' which is normally low but goes high when a key is pressed; this signal is used to generate the timing pulses. The four data signals are fed into a c.m.o.s. quad D-type flip-flop (74C175) which is clocked by SRCLK, generated from two monostables gated with 'anykey' to prevent any keyboard bounce effects. Once clocked, this data is then compared with the stored data in the MN9102 using a c.m.o.s. four-bit magnetic comparator (14585). If the keyboard data is the same as the stored data, then the A = B output of the comparator will go high. For more digits the quad latches, comparators and flip-flops are cascaded as follows. The outputs of the nth flip-flop are connected to the inputs of the (n+1)th flip-flop, with all the 74C175 connections the same: i.e., SRCLK to CLK, clear held high, and all the Q outputs unused. The outputs of the nth flip-flop are also connected to the inputs of the nth quad latch. The outputs of the nth quad latch are connected to the second set of inputs of the nth comparator, of which the nth A = B output is connected to the (nth + 1)th A = B comparator input. Other common connexions are A > B and A < B held low with their respective outputs unused for the 14585, and output enabled high and Save inputs common for programming on the quad latch.

When a 4-digit code is stored the following sequence of events will occur when the code is interrogated. If, for example, the code stored was 9102, the data stored would be with 2 in latch A, 0 in latch B, 1 in latch C and 9 in latch D. The 9 when entered would be clocked into the output of flip-flop A and compared

![Fig. 1. Internal block diagram of MN9102 quad latch.](image-url)
with 2 in latch A, giving A = B on comparator A as a low level. When the 1 is entered, the 9 is clocked to the output of flip-flop B and compared with the 0 in latch B, hence A = B out of comparator B will also be low level. The 1 will be at the output of flip-flop A and will be compared with the 2 in latch A, so the A = B output on comparator A will remain low. The third digit 0 will cause the 9 to be clocked to the output of flip-flop C, the 1 to the output of flip-flop B and the 0 to the output of flip-flop A. The A = B output of comparator C will be low, as will the outputs of the other two comparators. The final digit 2, when entered, will cause the correct digits to fall in place with the stored data, hence the 2s will match in position A, the 0s in position B, the 1s in position C and finally the 9s will match in position D: the A = B outputs of all comparators will go high, indicating that the code was correct.

To program a new code, it is entered and the Save inputs to all latches are held low for at least 10ms, by pushing a switch for that time. The switch poles are connected to the inputs of a bistable, which have pull up resistors to +5V, and the centre pole is at 0V. When the switch is operated, the outputs change state, giving a high-to-low transition on one of the bistable outputs, going high again when the switch is released: this is the signal which is used as the common Save.

To make the system more secure...
Clock timer 2 continued from page 52

there is a 2½ second delay after the correct code has been found. This is achieved by means of a 14528 retriggerable c.m.o.s. monostable, which is positive-edge triggered from SRLCK, and initially preset with a delayed power-up pulse. When Q goes high again it is ANDed with 'Correct code' to give 'Door open', which is normally low but which goes high 2½ seconds after 'Correct code' goes high. The positive edge of 'Door-open' triggers another 14528 retriggerable monostable whose Q output, when it goes low again after 2½ seconds, is ANDed with 'Correct code', thus producing a 'Door enable' pulse. Although this signal is normally a low level, going high 2½ seconds before going low again, the values of the resisters and capacitors on the monostables may be varied to give different 'Door enable' delays and widths. The 'Door enable' signal is used to drive two bipolar transistors, which in turn activate the electromechanically operated motor. The second inverter consists of a high-power p-n-p transistor, which is designed to switch between the regulated supply and zero volts to provide the solenoid. A l.e.d. and resistor are used to indicate when the door is open.

Further modifications may be made to the outlined system with provision to activate an alarm when more than three incorrect codes are entered or possibly control the logic remotely, depending on the user’s requirements. The system described would need only the minimum modifications.

Clock timer 2

with the real time. Leave the switches at Set Alarm and check that the waveforms agree with Fig. 13(b). Insert the remaining i.cs and adjust R48 for a suitable output pulse length. Note that if the value of R48 is too low, IC1 is retriggered and produces a double output pulse. If the timer does not operate correctly when the tested circuits are connected together it is probable that 100Hz ripple on the 10V supply is turning Tr4 off every 10ms which produces spikes on the power fail line. This is easily cured by increasing the value of C3.

Modifications

The output of the 555 timer is t.t.l. compatible and can directly drive a variety of interface units. A simple flip-flop enables an external circuit to be switched on at one alarm time and off at the next. A counter and decoder allows the system to be expanded for the control of several different devices. The alarm-enable/inhibit circuit can be modified to select one of two different alarm-time programmes by selecting the alarm-enable line to a spare address input on the memory, pin 3 or 21, and grounding pin 13 of IC2c.

Up to 64 alarm times can be obtained by adding two flip-flops to the chain in IC7 and connecting the two new outputs to the spare memory address pins. If the alarm-enable/inhibit section is not required, the circuit can be omitted except for IC1ic. Alternatively, if the alarm-enable/inhibit section is duplicated and the two alarm-inhibit lines are connected to the spare memory address pins, four alarm-time programmes are obtained. If this modification is made, the control logic IC1ic and IC19c must be altered so that keys 0, 1, 2 and 3 select the appropriate programmes.

The timer can be used with a conventional digital clock which has a suitable multiplexed display and multiplex control lines coded in binary. A midnight pulse and the inputs to IC1c, and IC19c, have to be decoded from the display. The five inputs to IC1c can be replaced by the tens-of-seconds C bit driving a monostable to give a pulse of at least 100ms duration at the start of each minute. If switch-on-reset is not needed the set-time-pulse input is grounded and the circuit around Tr1, Tr5 omitted.

Acknowledgements

The authors thank the management of EMI Electronics for permission to publish this article and the technical staff in the Operations Training and Education department for their encouragement and assistance.
The long-awaited Finniston Report (see p36 Jan., p88 March and p46 June, 1978 issues) has now been officially published, some weeks after much of it had been leaked. Having had time to consider the proposals in the report, the professional institutions are welcoming it, but they also have reservations.

The Council of the IERE was disappointed to find that the Finniston Committee had little to say about what the IERE considered to be the root cause of the inadequate performance of the nation's manufacturing industry, namely the general lack of enthusiasm for work at non-professional levels and the consequent low standard of industrial relations within many areas of British industry. They also regretted that the summary report failed to give credit to the industry. They also regretted that the summery relations within many areas of British thusiasm for work at non-professional levels to be the root cause of the inadequate per-

little to say about what the IERE considered to find that the Finniston Committee had made a statement in which they endorsed the Finniston Report's analysis of the ill of the British manufacturing industry and its broad objectives for recognising and improving the contributions to be made by professional engineers. The council particularly supported the view that employers must be encouraged to look on their engineers as valuable investments to be developed, rather than assets to be exploited; and the need for thorough practical training for engineers in industry. The CEI, however, had reservations about the proposed methods of attaining these objectives, and the relevance of these proposals to the practical and urgent needs of manufacturing industry, they thought, would require critical examination.

According to the CEI, the benefits to industry claimed by the Finniston Report could be achieved much more cheaply and quickly by an evolutionary process — that of developing the already existing machinery of the engineering institutions to meet the broad objectives set in the report — rather than by the revolutionary process of replacing this machinery, which operates in the public interest under the authority of the CEI's Royal Charter, by the British Engineering Authority. The CEI was strongly opposed to the recommendation that all members of the proposed BEA should be appointed by the Secretary of State, as they saw this as having their affairs taken out of their hands — it is characteristic of all professions in the UK that they are mainly self-regulating and consist of members who have been elected or nominated by the profession itself.

Being aware that new engineers — products of the proposed education arrangements — could not become fully qualified engineers before the late 1980s, and that for the next half-century the majority of practising engineers will be those who now exist or who are under training by the present methods, the CEI warn that unless the morale of these engineers and international confidence in their ability are fully maintained, very great damage would be caused to the national interest.

The CEI considered that the report's failure to make any proposals for improving the education, training and progression of engineering technicians was a serious weakness. A union view.

Ken Gill, General Secretary of the Technical, Administrative and Supervisory Section of the AUEW was disappointed with the Finniston Report because the Committee of Enquiry had failed to deal with the pay and status of engineers. "It is surprising that in a report of 253 pages only about six pages are devoted to engineers' pay and the role of the trade unions in the engineering industry", he said. TASS, he said in a recent report, blamed the engineering professions' lack of status on inadequate salaries and the lack of rational salary structures. "If urgent consideration is not given to raising the salary and status of engineers, the British manufacturing industry will fail to attract and recruit a large enough number of new engineers", he added.

"In the beginning…….

Analysis of the cosmic microwave background radiation left over from the "big bang," the primordial explosion which it is believed began our universe, suggests the existence of clusters of galaxies containing hundreds of millions of stars. Data collected by NASA's U-2 aircraft in the upper atmosphere from remnants of radiation points to the conclusion that the Milky Way galaxy, of which we are a part, is hurtling toward the constellation Virgo at more than a million miles an hour, under the gravitational influence of a "supercluster" around it.

University of California scientists believe the supercluster contains 30 to 40% more galaxies than are normally found in the same volume of space and that it may be 2 billion light years across.

The supercluster would account for about 1% of the volume of the observable universe, which extends through 10 billion light years of space. Dr. George Smoot has pointed out that not enough time has elapsed since the "big bang" for such a supercluster to have formed, which implies that such a gigantic concentration of mass dates back to the beginning of the universe: "If one such huge concentration of matter exists," says Dr. Smoot, "there are probably others."

The new findings introduce an element of doubt into the previously accepted idea that the event which started the universe about 15 billion years ago was a powerful but tightly controlled expansion of matter in all directions at a uniform speed. The supercluster's existence implies that the primordial fireball was "lumpy" and that the vast forces released were by no means uniform in their effects.
BBC responds to WARC '79
frequency proposals

In a recent engineering press statement the BBC outlines its reactions to the WARC '79 frequency allocations, those for Region 1 having been given in our February 1980 issue.

The Corporation's response is generally favourable where domestic broadcasting is concerned, but it is "less happy with the implications of those services on the h.f. bands." For domestic radio broadcasting, extension of the v.h.f. band II to 108 MHz is welcomed. Although formal international agreement does not provide for complete clearance for both v.h.f. and u.h.f. channels the provision of up to four additional channels will considerably ease the planning of further extensions of u.h.f. coverage throughout the country.

Allocations for s.h.f. satellite links are also welcomed, but the rearrangement of the h.f. bands for overseas broadcasting falls considerably short of the BBC's wishes, especially at frequencies below 8MHz where no extensions have been agreed.

The statement ends with the BBC asserting its support for the reservations entered by the UK and the USA delegations to the conference, retaining the right to "take whatever steps may be necessary to maintain the effectiveness of our external services."

Microwave unit detects cancer

An instrument containing a sensitive radiometer capable of measuring temperature variations of less than 0.1° Celsius, part of a microwave applicator made by Microwave Associates, an American company, is being used to locate and possibly destroy cancerous tissue. The equipment has located tumours in 14 known cancer patients and has detected a cancerous site in one patient which was not revealed by the use of conventional techniques.

The principal advantages offered by the new instrument are that it does not emit harmful radiation, can be used outside the body and could become relatively inexpensive if mass-produced.

Cancerous tissue is hotter than healthy surrounding tissue and conventional methods such as infra-red thermography can detect tumours near the surface of the skin, but the new method permits checking at a much deeper body level.

If the instrument proves itself effective, after an extensive series of hospital and laboratory tests, it could become standard equipment in doctor's surgeries. Patients could be quickly and easily tested for many forms of cancer, just as they are now tested in a routine manner for heart malfunction by means of an electrocardiograph.

The treatment side of the new instrument's use would involve microwave heating of a tumour to destroy cancer cells. Tumours have a relatively poor vascular system (compared with healthy tissue) and researchers believe that a tumour will heat faster and remain hot longer than surrounding tissue because there are fewer blood vessels to carry the heat away.

The next stage in the instrument's test programme will be its use on cancers in large animals in the Norfolk, (Virginia) Medical School laboratories.

Scripts by wire at Bush House

Two mini-computers and an array of disc store units form the heart of a "scripts by wire" system now in operation at the BBC's Capital Projects Department.

Some 30 million scripts covering news stories and radio and television talks can now be distributed around the country, all by electronic means. The central newsroom contains 39 v.d.u.s and journalists dictate their stories to operators who type them into the system. Once written, the story is entered on magnetic tape and later transferred onto a megabyte disc pack drive. New material is entered into the system which can accommodate items of up to 5000 words; news stories are kept on file for seven days, current affairs stories for 14 days and general features for 100 days.

A selective "list" can be drawn up on the v.d.u. according to subject matter, or the full list of talks may be checked. On the other hand, stories which only apply to a particular part of the world may be called up for display.

The electronic distribution system is controlled by two General Automation 16/440 mini-processors. Both are in continuous operation and receive the same input, but only one provides output. If a fault occurs, the standby processor can take over immediately. Each processor is associated with a 2 megabyte fixed-head disc and a 24 megabyte disc pack drive. New material is entered onto magnetic tape and later transferred to microfiche for archive storage.

Each of the 137 v.d.u.s distributed around the building can undertake full text editing, but only those in the news, talks and features areas are free to amend stories in the central store. Hard copies are available from 85 printers strategically placed amongst the offices.

Ken Clayson, engineering manager in charge of the new system says, "The system is saving an enormous amount of time and paper and it lets us make far wider use of the material we prepare. Every one of the broadcasting sections at Bush House now has access to every script prepared here. In the days when we relied entirely on paper that was just not possible."

The hardware was provided by the data system division of ITT Business Systems to a specification set up by the BBC's Capital Projects Department.
Mullard to "axe" 900 jobs

Mullard's decision to "streamline" its tube production business will, according to a report in The Times, 16th Jan 1980, result in the loss of 900 jobs at its Durham and Simonstone Lancashire works.

The main changes, to take place over the next two years, will involve further automation and alterations to quality control departments; these moves are seen as necessary to compete with the high output of quality tubes and tv receivers from Japanese manufacturers and in the face of the development of domestic products using tv-like tubes.

The National Economic and Development Office has recently identified certain trends in the tv and components industries and a study of production costs of colour television sets in the UK, Japan, South Korea and West Germany has shown that Japan in particular gains a high cost advantage from its overall higher level of investment in advanced automated plant, superior efficiency in manufacturing and design and more rigid quality control of components.

The Mullard decision reflects an awareness of these findings and also links up with NEDO's main recommendations which include the "rationalization" of UK tv production into larger units producing five times the current number of receivers, more involvement directly with Japanese technology, to improve and introduce more new designs and to carry out more research and development.

Only about 100 of the threatened jobs will go in 1980 and Mullard says that it "intends to continue to invest substantially in the picture tube business."

Multi-I.led. aircraft instruments under test

A 4in by 3in screen incorporating more than 49,000 i.e.ds, providing a resolution of 64 lines per inch is currently being evaluated by the USAF Flight Dynamics Laboratory as part of a joint project between the USAF and the Canadian Department of Industry, Trade and Commerce.

The device is intended as a replacement for the mixture of dials and c.r.t. displays at present found in aircraft cockpits; it is computer-controlled and is designed to provide the pilot with information on various subsystems, such as navigation or weapon delivery. This information can then be called up at the flick of a switch, the data being depicted on the i.e.d. screen.

Walter Melnick, of the Flight Dynamics Laboratory says that the new display system is an advance on the c.r.t. form due to its less cumbersome nature and higher reliability - he estimates a c.r.t. display life of 500 hours and an i.e.d. display life of 10,000 hours. Furthermore, while all information can be lost in the event of tube failure, even if several thousands of i.e.ds fail, the display can still be read.

Several technical solutions to the problem were examined before deciding on the i.e.d. method, and this was eventually selected because it is adaptable to the "building block" mode of construction, where one inch squares of the diodes can be assembled into a variety of display sizes.

Bowmar Instruments, of Weybridge, are the UK representatives of the makers of the display, Optotek Ltd. of Canada.

Disobedient spacecraft

Radio contact with Voyager 1 was lost on 3rd January just after the spacecraft had been commanded to turn in space and fire thrusters for a trajectory correction. The manoeuvre apparently took place but the antenna alignment was not entirely successful. However, later in the day NASA controllers received confirmation that command signals intended to switch on the low-gain antenna and place it in a two-way reception mode, had been received and executed.

Efforts are being made to correct the antenna/Earth alignment, the problem requiring some analysis to ensure that attitude control fuel is not wasted.

Voyager 1 was launched in September 1977 and flew past Jupiter in March 1979. The spacecraft is now 660 million miles from Earth and is scheduled to encounter Saturn in November 1980. Voyager 2, a sister craft, is due to encounter Saturn in August 1981.

News in brief

The FCC is proposing to award additional frequencies for c.b. use on s.s.b. operation and may also liberalize rules on the distances c.b. stations are permitted to work over. The use of variable frequency oscillators may also be permitted.
Car to telephone service launched in Norwich

A new car telephone service, claimed by Air Call Ltd. as the first of its kind in England, was started in Norwich on the 21st January 1980.

This service, known as "interconnect", enables direct two-way communication between a car telephone user and subscribers to the public telephone network and is now available to Air Call's East Anglian customers. The company's branch manager, Derek Cunningham, says that Interconnect will be available to subscribers in addition to the existing range of services, which includes message handling, "talking bleeper" and telephone answering services.

In order to house the additional equipment required, the Norwich control complex has been moved to larger premises in the city centre, and plans have been drawn up to extend the Interconnect service to most of the company's 34 control centres during the coming year.

Car telephone users can take advantage of the new service without necessarily changing the equipment in use; the cost of all messages and inland telephone calls is included in the rental charge.

ITT researcher wins award

Paul Barton, a research engineer with Standard Telecommunication Laboratories, has received the William E. Jackson award from the Radio Technical Commission for Aeronautics (USA).

Mr Barton won the award, consisting of an honorarium and commemorative plaque, for his thesis, "Airborne Signal Processing for the Microwave Doppler Landing System," submitted for a Ph.D degree from University College, London. He graduated from Churchill College, Cambridge with an honours degree in mechanical sciences and joined STL in 1965, working with the late Alec Reeves on pulse-code modulation and electro-optic systems.

In 1971, he began work on the microwave landing system (MLS) programme, being particularly concerned with the design of the Doppler scanning system and in 1978 began the work which led to the winning thesis. He holds some 20 patents in the MLS and radar fields and is currently leading a team working on radar and adaptive systems at STL.

The award is a memorial to William E. Jackson, a pioneer in the development and implementation of the present airways, air traffic control and aviation communication systems.

News in brief

The British Amateur Electronics Club, which claims that it is the only national amateur electronics club, is seeking help from established local electronics groups, its main problem being difficulty in finding premises for meetings. The mainly scattered nature of the membership adds to the problem and if local groups are willing to welcome BAEC members to their meetings, they would be prepared to pay an affiliation fee. The chairman of the BAEC will send out a copy of a simple questionnaire to any reader who is interested enough to contact him: Cyril Bogoli, "Dickens", 26 Forrest Rd, Penarth, S. Wales.

The EIEE have the following lecture events held on the subjects "Tapes and high fidelity" from 2nd to 4th March inclusive. On Monday 28th March two conference debates will be held on the subjects "Tapes and high fidelity" and "standardization and high fidelity".

Frequency change for BBC's Ventnor Radio 3 Transmitter

In order to escape interference from the French transmitter at Caen in Normandy, the BBC's Ventnor v.f. transmitter has changed frequency (on 1st February). The previous frequency of 91.6MHz has been changed to 91.7MHz, but no change will be made to the shared Radio 1/2/4 frequencies also relayed by this transmitter.

The station is located at St. Boniface Down, on a height above the town, serving about 6,000 people in the Ventnor area and also relays the tv services of BBC1, BBC2, and ITV on 625 lines (u.h.f) and the 405-line BBC1 service. Listeners will only have to change the tuning of their receivers by a very small amount.
More frequency allocations

WARC 79 decisions for 10GHz to 275GHz in Region 1

Last month we published a list of frequency allocations, as decided at the 1979 World Administrative Radio Conference, Geneva, for radio services up to 10GHz. We now present the remainder of the frequency allocations made at WARC 79, from 10GHz up to 275GHz. This, of course, is the microwave region of the frequency allocations made at the 1959 Geneva conference for radio services up to 10GHz, as decided at the 1979 World Administrative Radio Conference in Geneva, for radio services up to 10GHz.

An outstanding feature of the present list is the large amount of spectrum space now allocated to satellites — communication, broadcasting, Earth exploration and so on. It will be seen from the key to the code letters that, of the traditional categories of terrestrial radio services (fixed, mobile broadcasting, amateur etc.), there are now seven which also have a corresponding service provided through satellites. The coming of the satellite was first recognized officially by the ITU at an Extraordinary Administrative Radio Conference in 1963 and there have been others devoted to satellites since then.

The results of a 1971 space conference were already embodied in the Radio Regulations before WARC 79 took place, and now, following WARC 79, three further ITU conferences devoted to space services have been planned or requested.

As we reported earlier, the UK Home Office had recommended that allocations for communication satellites should be increased in the 10-11GHz band. This proposal has in fact been generously implemented by a doubling of the spectrum space available. The original allocation was 500MHz, split into two separated bands at 10.95-11.2GHz and 11.45-11.7GHz, but now, as will be seen from the list, there is a new, uninterrupted 1GHz band from 10.7 to 11.7GHz in which, in fact, communication satellites are a primary service (although this band is shared with fixed and mobile primary services). In the space-to-Earth direction of communication this is a world-wide allocation. In the Earth-to-space direction, however, for Region 1 countries this band is also reserved for use by feeder links ("uplinks") to broadcasting satellites.

The needs of the maritime mobile-satellite as well as the aeronautical mobile-satellite services have been provided for and as a result these systems will be able to develop without hindrance. Also, in principle, it was agreed to provide for the feeder links to these services in the bands allocated below 10GHz. A mobile-satellite service has been introduced and frequencies have been provided for this.

Passive sensing in the Earth exploration-satellite and space research services have been identified as important activities in the future, so provision has been made for these services. Furthermore, in some parts of the spectrum where the fixed and mobile (except aeronautical mobile) services operate under a footnote provision, agreements have been reached to either limit or phase out the fixed and mobile services over a period of time with the intention of providing exclusive bands for the passive services. Increases have been made to the spectrum space allocated to Earth exploration satellites and space research. In addition, provision has been made for the operation of radars on board spacecraft in these services (e.g. in the band 35.5-35.6GHz).

Key to code letters in list

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>A</td>
<td>Amateur</td>
</tr>
<tr>
<td>AR</td>
<td>Aeronautical radionavigation</td>
</tr>
<tr>
<td>AS</td>
<td>Amateur — satellite</td>
</tr>
<tr>
<td>B</td>
<td>Broadcasting</td>
</tr>
<tr>
<td>BS</td>
<td>Broadcasting — satellite</td>
</tr>
<tr>
<td>BSL</td>
<td>Broadcasting satellite feeder link</td>
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<tr>
<td>F</td>
<td>Fixed</td>
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<tr>
<td>FS</td>
<td>Fixed — satellite</td>
</tr>
<tr>
<td>IS</td>
<td>Inter satellite</td>
</tr>
<tr>
<td>ISM</td>
<td>Industrial, scientific, medical</td>
</tr>
<tr>
<td>LMS</td>
<td>Land mobile — satellite</td>
</tr>
<tr>
<td>M</td>
<td>Mobile</td>
</tr>
<tr>
<td>MA</td>
<td>Meteorological aids</td>
</tr>
<tr>
<td>MS</td>
<td>Mobile — satellite</td>
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<tr>
<td>RA</td>
<td>Radio astronomy</td>
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<tr>
<td>RL</td>
<td>Radiolocation</td>
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<tr>
<td>RN</td>
<td>Radionavigation</td>
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<tr>
<td>RNS</td>
<td>Radionavigation — satellite</td>
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<tr>
<td>S</td>
<td>Space research</td>
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<tr>
<td>SAT</td>
<td>Earth exploration satellite</td>
</tr>
<tr>
<td>SFTS</td>
<td>Standard frequency and time signal — satellite</td>
</tr>
</tbody>
</table>
Additional spectrum has been allocated to the fixed-satellite service in the Earth-to-space direction near 100GHz, keeping in mind the allocation to the broadcasting-satellite service in the band 85-86GHz (see later).

The pattern of allocations to the inter-satellite and the fixed-satellite services follow, in general, that laid down by the 1971 space conference, i.e., with the former concentrated in the absorption bands so as to take advantage of the atmospheric attenuation to provide shielding between the space and the surface (or low-altitude) systems, and the latter located in parts of the spectrum between the absorption bands.

In certain combinations of space and terrestrial services the conference concluded that there was inadequate information on sharing. Footnotes were therefore added to reflect this uncertainty and the subjects were referred to the CCIR for further study.

The three bands for direct broadcasting from satellites remain substantially unchanged. 11.7-12.5GHz is completely unchanged (and it will be recalled that 40 channels within this band were assigned at the 1977 satellite broadcasting conference – see January 1979 issue, p.41). However, the original 41-43GHz satellite broadcasting band has now been shifted slightly downwards to 40.5-42.5GHz. This has been done to give better clearance for various radio astronomy frequencies around 43GHz which are used for spectral observations of silicon monoxide. Furthermore the band is now shared with three other services – terrestrial broadcasting (on a “permitted basis”) and fixed and mobile communications (secondary basis).

The third band for satellite broadcasting, 84-86GHz, is unchanged in its band limits, but, whereas in the 1977 frequency plan written into the Radio Regulations it was exclusively for this use, it is now shared with primary fixed, mobile and terrestrial broadcasting services. (Although there is a footnote saying that these three must not cause harmful interference to broadcasting satellites to which frequencies are assigned.)

What is completely new in relation to broadcasting satellites is the set of frequencies chosen for the uplinks to them – the communication channels which convey the programme signals to the satellites’ transmitters. These were not planned at the 1977 space conference. At WARC 79 a wide range of proposals came from different countries. For example, the official British proposal was 21.2-22GHz (which the Scandinavians objected to because of rain attenuation at their northern latitudes), while the Indian proposal was 14.5-15.25GHz (which the USA and UK objected to because it conflicted with fixed communication services including military systems). In the end a world-wide compromise was found which did not conflict too seriously with the other services sharing allocations with it (see list), and this was 17.2-18.1GHz. At the same time the door was left open for two other bands to be used in particular areas. Outside of Europe and for Malta, 14-14.5GHz may be used for the uplinks, with the lower end, 14-14.4GHz, “subject to co-ordination with other networks broadcasting in the fixed satellite service”. And in Region 1, the uplinks may, as mentioned above, use the new 10.7-11.7GHz allocation which is otherwise intended for communication satellites, fixed and mobile services.

An unusual type of satellite uplink, pioneered by the IBA in Britain, is a road transportable earth station on a trailer designed for sending television outside broadcasts from any location straight up to a communications satellite (see picture in January issue, p. 42). It has already been used, in fact, with the OTS satellite. Largely through the IBA’s initiative, supported by the BBC, a decision was made at WARC 79 to allocate...
Radio and Electronic Laboratory Handbook, by M. G. Scroggie, is probably far too well known and respected to need much introduction. It has changed considerably, however, in the forty years since it was first published, having been continually revised to keep pace with accelerating change in the industry. It is now in its ninth edition, this one updated largely by G. G. Johnstone.

The plan of the book remains the same, information on measuring equipment being concentrated in the first half. Measuring techniques take up most of the second half of the book, and the already large reference section is extended for this edition: the piece on filter design is particularly useful. Throughout the text, references to the literature are lavishly scattered. The book is published in hard back at £17.99 by Newnes-Butterworths, and contains 592 pages.

Frequency Engineering in Mobile Radio Bands, by W. M. Pannell. Continuous expansion of land mobile radio communication makes it essential to plan allocations inside a frequency band in such a manner that interference is kept to a low level and that the spectrum is used to its fullest possible extent. The book is intended to help in the early stages of frequency planning, and is in two sections, the first dealing with general procedures and the second a more specific nature. Mr Pannell has many years of experience in the mobile radio field, and was responsible for the Pannell Report on future spectrum requirements for mobiles in the UK. Published in hard back, at £25.00 by Granta Technical Editions, Hargrave Lodge, 7 Brooklands Avenue, Cambridge.

Audio Equipment Tests, by Gordon J. King, is intended to demonstrate the performance of high-fidelity sound equipment to technicians, dealers and those who take an interest in the technicalities of their equipment. Each component of an audio chain from f.m. tuner (no a.m.) to loudspeaker model, complete with battery, loudspeaker as though expecting a materialization, and of malevolent infants being tranquillized by a bedtime story.

The sets described range from the Model ER-753 crystal receiver at 18 dollars to the Aeriola Grand valve detector, amplifier and loudspeaker model, complete with battery, aerial and instructions covering 150-550 at a cost of 409 dollars. In 1922, the catalogue cost 35 cents: now, it is published by The Vestal Press, 320 N. Jensen Road, PO Box 97, Vestal, NY 13850, USA at 12 dollars 50 cents, plus postage.

Entertainment Year Book

What used to be simply the Hi Fi Year Book has now been extended in scope to include reference material on colour television sets, electronic organs, video cassette recorders and television games. This is in addition to the familiar illustrated information on current audio products, including descriptions, technical data, prices (where available) and suppliers' names, addresses and telephone numbers. There are four survey articles on various audio topics. The 1980 'Hi Fi Year Book & Home Entertainment' contains over 580 pages and can be obtained from book-sellers at £3.75. Alternatively it can be obtained directly from the publishers, IPC Business Press Ltd, by sending £4.25 which includes packing and postage.
### Micro-soldering!

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You'll never meet a better meter
Maxwell's equations revisited

A critique of orthodox electromagnetic theory

by Ivor Catt, CAM Consultants

"It was once told as a good joke upon a mathematician that the poor man went mad and mistook his symbols for realities; as M for the moon and S for the sun." Oliver Heaviside, Electromagnetic Theory, 1893, volume 1, page 133.

... the universe appears to have been designed by a pure mathematician.


Faraday's Law of Induction, \( \nu = -\frac{d\Phi}{dt} \), seems to imply:
1. A causality relationship; the rate of change of magnetic flux through a surface causes a voltage around the circumference of the surface.
2. A reluctance, or resistance to the change of magnetic flux indicated by the minus sign.

A careful analysis of this one equation will give an insight into the vacuous nature of contemporary mathematical operations in electromagnetic theory. First let us discuss the minus sign, which leads us to the idea of a Lenz's Law reluctance, or resistance to the change \( \Phi = \frac{d\Phi}{dt} \).

We shall see that a minus sign is a solution to these equations. It is reasonable to do so, because Newton's Laws are close to common sense and the obvious. Common sense will prevent absurd conclusions from creeping into a Newtonian theoretical framework, even though the mathematical formulation of Newton's Laws has always been slovenly in this respect.* (Another perhaps permissible slovenly aspect is the use of the \( = \) sign, for numerous different, mutually contradictory meanings.)

Maxwell's Equations are not in the same class. Common sense will not save us from absurdity and nonsense if our initial formulations are ambiguous or wrong.

Let us consider an electromagnetic wave front advancing at the speed of light. When the step (or more accurately ramp) passes, as shown here

\[
\frac{\partial H}{\partial x} \text{ is negative. However, } \frac{\partial H}{\partial t} \text{ for the step is positive. To get the algebra right, we are forced to conclude that }
\]

* Even the brilliant philosopher Ernst Mach failed to notice this anomaly.

The text books say the "solution" to this pair of equations is a sine wave! See references 3 to 7. (In fact, almost anything is a solution to these equations.)

At this stage, the whole subject starts to look sophisticated and profound. Really it is neither.

Let us regard the velocity of the train \( \frac{dx}{dt} \) as positive. This creates an anomaly when we want to write the equation

\[
\frac{\partial H}{\partial x} \frac{\partial H}{\partial t} (1)
\]

It would be absurd to suggest that there was a causality relationship between \( \frac{\partial H}{\partial x} \) and \( \frac{\partial H}{\partial t} \). They are both descriptions associated with the passage of the train. Since Newton, it is accepted that a body continues in its state of uniform motion without a continuing cause, or push. (However, this principle is taking a long time to be applied to electromagnetic waves.)

Now we regard the velocity of the train \( \frac{dx}{dt} \) as positive. This creates an anomaly when we want to write the equation

\[
\frac{\partial H}{\partial x} \frac{\partial H}{\partial t} (1)
\]

because the left hand side product is negative when the right hand side is positive, as in the case of the leading face of the train.

This kind of absurdity, or anomaly, is ignored when Newton's Laws are considered. It is reasonable to do so, because Newton's Laws are close to common sense and the obvious. Common sense will prevent absurd conclusions from creeping into a Newtonian theoretical framework, even though the mathematical formulation of Newton's Laws has always been slovenly in this respect.* (Another perhaps permissible slovenly aspect is the use of the \( = \) sign, for numerous different, mutually contradictory meanings.)

Maxwell's Equations are not in the same class. Common sense will not save us from absurdity and nonsense if our initial formulations are ambiguous or wrong.

Let us consider an electromagnetic wave front advancing at the speed of light. When the step (or more accurately ramp) passes, as shown here

\[
\frac{\partial H}{\partial x} \frac{\partial H}{\partial t} (1)
\]

In fact, the last two equations (3), (4) are meaningless. If the front end of the high speed train were pointed, sloping out sideways as we step upwards, and \( w \) were the term given to width (as \( H \) stands for height), exactly the same pair of equations could be constructed.

\[
\frac{\partial w}{\partial x} = -\frac{e}{c} \frac{\partial \Phi}{\partial t} (3)
\]

\[
\frac{\partial H}{\partial x} = -\frac{\mu}{c} \frac{\partial \Phi}{\partial t} (4)
\]

As with e-m theory, we could conclude with equal validity that a train's height (and width) must vary sinusoidally along its length, making our trains look like the Loch Ness monster, or more accurately, like a row of short sausages, as shown here.

It is shocking that this nonsense has survived for a century at the core of a subject as crucial as electromagnetic theory. We see now that mathematical formulation of e-m theory, far from making the subject more rigorous, has
made it ludicrous and false. We see that the mathematicians are incompetent where physical reality is concerned and hide their incompetence and confuse others by conjuring up nonsensical, interrelated formulae.

When Hertz established that electromagnetic waves existed, Maxwell's equations should have been re-examined, and the large rubbish element removed. Instead physically ignorant mathematicians took over, piling garbage on garbage, frightening away those with real insight into the subject—the latter-day Faradays.

Those who try to build extensions, or additions to, the House of Newton should not assume that since the foundations were good enough for Newton's simpler theory, they are strong enough to support their own more complex constructions. Minkowski's failure to re-examine the foundations of Newton, in particular his assumption that velocity is positive and the passage of time is positive, makes his constructions useless in the same way as Maxwell's equations are useless.

In the Minkowski sense time really flows from $+\infty$ to $-\infty$, not, as he thought (and our clock faces, with their ascending sequence of numbers, think), from $-\infty$ to $+\infty$. Velocity, being the gaining of distance in return for the loss of time, is negative. This points to a fundamental difference between space and time, and means that the "space-time continuum" as Minkowski formulated it is bogus. At best, we see his pronouncements as oracular, similar to the answer that Delphos gave when being asked about the sex of an unborn child, "Girlnboy". This remark could well be interpreted as true, but really it has no content.

Einstein failed to consider the problem of the sign of time and of velocity. Also, he never succeeded in fighting his way through the mass of mathematical garbage surrounding electromagnetic theory.

**References**


**Impedance mismatching**

Thus, for maximum power transfer efficiency from the Norton source, the load must be such that $R_L/R_s \to 0$ (the opposite of the voltage source case). A similar set of arguments to those used above can be used to show that the expression for $\eta$ is meaningless unless the actual circuit is a simple current source with source impedance.

Despite the fact that the Thevenin/Norton equivalent sources do not allow calculation directly of the transfer efficiency, it is perfectly true that to attain maximum power transfer into a load, the load impedance should be chosen to match the Thevenin or Norton source impedance (they are the same) but to say that this means 50% of the power from the source is lost in the source resistance is in general not true; often the power loss in the source resistance is higher!

Despite the cautions outlined in this paper the notion of transfer efficiency is not without its uses, since a number of frequently encountered circuits behave as true Thevenin or Norton circuits; for example, the common emitter amplifier shown in Fig. 5. Neglecting the bias-resistance loading effects and assuming that all capacitors are short circuits, the mid-band voltage gain is given approximately by

$$A_v = \frac{\beta_2}{\beta_1} \left( \frac{R_{e2}}{R_{e1}} \right)$$

which occurs when the input impedance of $T_{r2}$ is much less than the collector resistance of $T_{r1}$, i.e. $\beta_2 R_{e2} < R_{e1}$. The output of $T_{r1}$ is a current source of impedance $R_{e1}$ and the Norton transfer efficiency result obtained above tells us that $R_L/R \to 0$ for good transfer efficiency, i.e. $\beta_2 R_{e2}/R_{e1} < 1$.

In conclusion, I would stress that extreme care should be taken to interpret the components of a Thevenin or Norton equivalent circuit correctly especially in deriving expressions for losses in power transfer.
Microwave intruder detector — 2

Design with good interference rejection and noise monitoring

by K. Holford, C.Eng., Philips Research Laboratories

This design provides a simple but effective circuit which uses a cycle counting scheme to prevent the alarm being triggered by short movements or pulses. The circuit has excellent interference rejecting properties. A noise monitoring circuit is described that allows the alarm to be set up easily and reliably in terms of a low false-alarm probability.

The complete intruder alarm circuit designed for use with the Mullard CL8960 module is shown in Fig. 9. It requires a nominal 12 volt power supply able to produce at least 300mA during switch-on but in general less than 200mA unless a high current relay is used (about 160mA plus the relay). This supply can be a car battery with the usual voltage variation during charging such as up to 16 volts. The minimum voltage is safely 11 volts with a 7.5 volt supply (or 10.5 volts with a 7.0 volt setting). With a selected 748 as in the text, this voltage is reduced by up to another 0.5 volts. However, with supply ripple, these represent an alarm risk level and should be avoided.

Supply ripple within these restrictions can be up to 1V pk-pk without affecting performance and some prototypes have tolerated 5V pk-pk with a 13 volt supply and a Vg of 7.5 volts.

The radar sensitivity is limited entirely by that of the microwave module, afterwards just called a module, rather than the circuit design. However, to realise this, due regard must be paid to the use of short screened leads at the amplifier input, because of the gain the circuit has to 100Hz and 1000Hz signals.

Two 741 op-amps are used as the main Doppler amplifier. These can be a single (twin) 747, if required. Thus the complete circuit uses one 1.5 watt power transistor, four small transistors and three cheap I.C.s. Much of the circuit is directly connected which saves on components.

The microwave module requires some cautionary remarks because the mixer contains a diode of extremely small electrical proportions so as to respond to the 10.687GHz frequency. If the mixer, or its lead to the amplifier, is touched with a measuring lead or an object which has not been grounded to the module metalwork it could be destroyed by static discharge. If a shorting clip across the mixer is supplied leave it in situ until connections have been made.

The microwave module requires a nominal 12 volt power supply and a Vg of 7.5 volts. However, with supply ripple, these represent an alarm risk level and should be avoided.

Connect the module to the amplifier circuit as follows. Use a screened input lead and make the amplifier connection first. The braid is connected to 0V at only the amplifier end. Keep exposed unscreened ends down to about 12mm. Next make the amplifier 0V connection to the module 0V metalwork. Then clip a lead with crocodile clips between the soldering iron bit and the module metalwork to equalize potentials. If the iron is not earthed, make a second lead between the module and earth. The lead from the amplifier which is to be connected to the mixer should now be touched on the module metalwork just prior to connection. Maintain one finger on the metalwork while the joint is being made to discharge and prevent the build-up of static also on the solder. Remove any shorting clip while the metalwork is being contacted and after making the connections.

Fig. 9. Components: Tr1, BC557, Tr2, BC547 or BC107, Tr3, BC135 or BFY51, with 50°C/W fin. Capacitors: Bead tantalum maximum leakage C2, 2μA, C1, 1μA at tmax. Resistors: all 0.1W, R1 and R3 are 2%, the rest 5% or could be 10%.

Connect the module to the amplifier circuit as follows. Use a screened input lead and make the amplifier connection first. The braid is connected to 0V at only the amplifier end. Keep exposed unscreened ends down to about 12mm. Next make the amplifier 0V connection to the module 0V metalwork. Then clip a lead with crocodile clips between the soldering iron bit and the module metalwork to equalize potentials. If the iron is not earthed, make a second lead between the module and earth. The lead from the amplifier which is to be connected to the mixer should now be touched on the module metalwork just prior to connection. Maintain one finger on the metalwork while the joint is being made to discharge and prevent the build-up of static also on the solder. Remove any shorting clip while the metalwork is being contacted and after making the connections.

Should it be necessary to measure the mixer direct voltage while it is working contact the metalwork beforehand and while the leads are being handled; but make the 0V connection first. To ensure no static, fit a 10kΩ resistor to the end of the measuring lead and touch on the metalwork just prior to the measurement. Mixer failure is evident by loss of sensitivity and by little or no direct voltage when passing a direct current, such as the 40μA bias current.
Circuit description

The circuit supplies about 40µA of current via Rf for mixer d.c. bias. Mixer bias will be about 300mV with no microwave energy and ideally about half this with the optimum mixer power. However, voltages from about 90 to 270mV with a 300mV diode will only cause a 1.5dB loss in signal-to-noise ratio at the extremes but require 5dB more gain for the same signal at the upper bias point. Observe the precautions mentioned when measuring mixer voltage to avoid static discharge during measurement it is best to point it upward and have no obstruction in front for at least 300mm. Covering the module requires special material (see data sheet) which is near-transparent to microwaves.

A hand moved slowly at about 150mm in front of the module should move the bias by a few tens of mV and confirm in front of the module should move the microwaves. A 2mm screw can be used to reflect the diode will mean a useless relay unless it is set by 2% tolerance resistors R2 and R3. The design centre voltage from IC1, and IC2, the design centre voltage from IC1, and IC2, is 3.9 to 4.4V with a 7.5V line and roughly in proportion for other voltages. Voltages about 4.8V can in frequently occur due to end-of-spread leakage current in C7 and C8 and if this happens a selected component should be used. An inaccurate d.c. level will limit the output voltage swing from IC4. Leakage has limited the value of these capacitors and they would otherwise have been increased by a factor two.

The supply voltage to the amplifiers is also used for the Gunn microwave oscillator in the module and so should lie between 7.25 and 7.75V. Lower voltages than 7.0V may not allow the oscillator to work properly, although will cause no damage. Voltages above 8.0V risk damage; the life at 10V can be just a few seconds. Thus the 7.5V line should be checked before connection.

Using a 7.5V zener diode with IC3 will usually produce a voltage within the above spread. Lower voltages can be corrected using the link AF, with a second resistor of higher value across FB. For instance a 10kΩ resistor will raise the voltage by about 10%. No adjustment exists for too high a voltage other than changing the diode. Alternatively a 6.8V zener may be fitted, in which case the resistor FB will lie between about 3.9 and 18kΩ.

The module produces audio frequencies in response to radial movement, the relationship being 32Hz per 1 mile/h. Movement across the 140° beam will produce a much lower frequency, or even zero at perfect constant radius with no change in target reflection properties during the movement. Range depends on the target size and is about 10 metres or could be more if C7 were increased and R7 decreased. But a high

module, Fig. 10, at a position in line with the centre web, such as between 4 and 8mm out from the shroud-to-module interface joint (without the plastics.

The intended optimum mixer power will occur naturally if the module is bolted to a 160 x 43mm aperture in a 1/16in plate, such the side of a box, provided the plate is sandwiched between the front shroud, Fig. 10 and the rest of the module. The shroud and module are supplied together.

*The intended optimum mixer power will occur naturally if the module is bolted to a 160 x 43mm aperture in a 1/16in plate, such the side of a box, provided the plate is sandwiched between the front shroud, Fig. 10 and the rest of the module. The shroud and module are supplied together.

![Fig. 10. Mixer power can be adjusted by-fitting a 2mm screw in shroud](image-url)
Setting the sensitivity

Setting the sensitivity can be done using an oscilloscope, but the noise monitor circuit of Fig. 11 is strongly recommended. The alarm starts to operate when the signal output from IC2 reaches 1.5V pk-pk and 2.0V pk-pk will usually lead to an alarm. The sensitivity should be set for no more than 0.5V pk-pk from IC2 to leave a margin for unforeseen events. This noise level will be entirely due to extraneous disturbance as the noise level of the alarm itself in a perfectly "quiet" room with the circuit values shown will be several times less than this.

Setting the sensitivity without either an oscilloscope or the circuit of Fig. 11 is more difficult if it is important that a false alarm should not occur. By shunting R12 with 100kΩ the memory can be shortened and an indicator l.e.d. can be fitted to the relay contacts and a walkabout test carried out. Fitting the 100kΩ will shorten the memory time to five seconds to 37% of previous movement stored in C7. However, to be sure that there will not be a build up to an alarm with the 100kΩ removed the gain of the amplifiers really needs to be increased by 3 or 4 times or more as a test. This could be done by reducing R4 to, say, 1kΩ and increasing C2 to 22µF to maintain the low speed response, but precautions must be taken to see that an alarm is not false due to the introduction of hum with long unscreened wires and that the leakage of the 22µF does not cause the voltage out of IC2 to go above 5V.

It is much better, and there will be more reliability, to build the noise monitoring circuit given. This will also monitor the MID environment and give warning that the safety factor is insufficient.

False alarms

The MID circuit should be well screened from 50Hz pick-up and preferably in a metal box with a good fitting lid. There should be no mains transformer nearby to induce 50Hz voltages. The alarm should not be used in the same room as fluorescent lamps while they are on as the gas in these ionizes at 100Hz to become a fluctuating reflector. Fans inside equipment, having apertures through which microwave energy can pass, will cause signals. These apertures can be screened with gauze of, say, not more than 6mm mesh size, and tested by placing the radar fairly close. The alarm sensitivity should not be greater than necessary bearing in mind that radar signals grow very quickly as range is shortened. The rate is four times in voltage per range halving and so if a target is detected occasionally at one range it will be detected most positively at half that range.
Flat metal surfaces should be treated as mirrors via which the radar may be able to see a movement or fluorescent lamps. Radar signals pass through glass, although weakened, and through dry plasterboard. Any testing must include walking outside windows.

Short flapping movements can lead to an alarm. A flap of less than about 14mm can give rise to one pulse into C7, and an extra pulse for each 14mm approach and recede travel.

Movement across the beam has less effect than when radial and may be used to advantage in the siting of the radar.

Circuit construction

In constructing the circuit treat it as you would a high gain audio amplifier. Screen the input lead and mount the circuit preferably inside a metal box with just the business end of the module protruding. Avoid earth loops and don't spread out the circuit. Insulate the box from the circuit and connect to the 0V line by only a single connection. Ideally the module metalwork would be insulated from the box, but if this is not so the module metalwork is already 0V and no other 0V connection should be made to the box.

If the box is bonded to earth, as preferred, leave the power supply floating so as to be earthed via the 0V and the box. Preferably use the same bolt to earth the box as used for the 0V connection inside the box. If both must have separate earth wires do not use the box as a conductor for 0V, nor take the earths for the box and that of the power supply to two different ground points.

Avoid long leads in circuit wiring associated with transistor connections because these high frequency devices can produce h.f. oscillation. In the case of Tr4 a capacitor of lNf is fitted across it and close to it to prevent this being caused by the relay inductance. The 0V lead from the regulator and IC3 is three separate leads to each part of the circuit to avoid possible earth loop problems.

Apart from the 2% tolerance resistors R7 and R3, which set the d.c. working point of the i.c.s resistor tolerance is not critical and 5% or even 10% can be used if they must.

Transistor Tr3 dissipates about 1.5 watts and requires a small heatsink of 50degC/watt or better. This could be a fin of say 15 x 25mm or an area of printed board copper of say 12mm square, and could have the transistor bolted to it. In each case use heatsink compound or silicon grease in the joint.

The microwave module can be obtained from RS Components who will also send out a licence form with it. Unfortunately they do not deal more directly with stockists - ming themselves into groups may be a better approach and obtain them for about £25 plus v.a.t.

The open ends of the microwave module should preferably be covered to keep out dust which may eventually degrade performance. However, such a cover must not reflect appreciable microwave power or this will upset the mixer working. A simple and effective covering is to sandwich a very thin polythene membrane between the module shroud, Fig. 10, and the rest of the module. Ordinary plastic bag material is suitable; the thinner the better. A capacitor of about 10Nf should be soldered across the Gunn connection to the module metalwork to prevent high frequency oscillation on the Gunn supply lead due to the negative resistance of the Gunn diode.

Microwave intruder alarms are required to be licensed so that the Home Office is aware of their location should there be an interference problem with other equipment. A licence costs £1.40 and last for 5 years and is called a Telapproach Licence. Normally only finished equipment is approved as a production equipment. However, as the microwave module is set at the factory to meet Home Office requirements, the Home Office will issue a licence on the understanding that the frequency-setting screws on the module are not disturbed from their factory settings and the equipment is operated only indoors. When applying for a licence the Home Office will issue a licence on the understanding that the frequency-setting screws on the module are not disturbed from their factory settings and the equipment is operated only indoors.

Internal photograph of demonstration model shows circuit board using Fig. 9 circuit only.

---

![Microwave Intruder Alarm Circuit Diagram](image-url)
Provided that the frequency setting is not disturbed the possibility of interfering with other services is extremely remote. Some mutual interference with another alarm in the vicinity is a possibility where the two microwave frequencies drift through each other to produce a spurious signal. Where two must be operated in these circumstances it is normal practice to install as pairs having their frequencies staggered by about 5 MHz.

False alarm confidence indicator

The intruder alarm circuit of Fig. 9 seems to be about the simplest that can be produced and still achieve the standard considered necessary in a microwave intruder alarm. But unless it can be readily set up to work as intended with a low false alarm risk, it is likely to remain a novelty. Thus some attempt should be made at obtaining a setting up and monitoring circuit for completeness.

Basically what is needed is an amplifier with about five times voltage gain to follow the last amplifier of the previous circuit and which will show by means of an i.e.d. whether the noise level of the MID, with its chosen setting of sensitivity, is too high to be reliable as in the main part of the MID circuit. This would not only monitor the noise due to the alarm circuits themselves but also the environment in which the alarm worked.

There are really two requirements. One for a quick response for setting-up the installation, and a second which allows the equipment to be monitored to see that the noise level stays within safe limits. The monitor should have an amplifier but ideally should also be followed by indentical bucket counting as in the main part of the MID circuit. Furthermore, the long-term monitor should have an i.e.d. indicator which stays on once it is lit until reset manually with a push button.

A circuit with a two-way switch, S\text{p}, is shown in Fig. 11 for these purposes. It has been built and tested on a one-off basis and worked extremely well. The connections M1 to M4 go to the similarly marked points on the MID Fig. 9. As shown the switch is in the setting-up mode and the values of R\text{p} and C\text{p} are 220 kQ and 4.7 \mu F for quick response and extinguish. When the switch is thrown these are increased to approximately 1 M\Omega and 4.7 \mu F, as in the main MID circuit. Also the capacitor discharge resistor is taken to the collector of Tr\text{p}. The i.e.d. then locks-on and the reset button has to be pressed to extinguish it. The lock-on mode may also be preferred for setting up, as this can then be done by one person; in which case S\text{p} should just short out the 820 kQ from Tr\text{p} collector.

Setting up the MID is now easy. Check that the monitor is working by walking in the protected area. Turn the

<p>| COMPONENTS |</p>
<table>
<thead>
<tr>
<th>Description</th>
<th>Type</th>
<th>Value</th>
<th>Rating</th>
<th>Tol. %</th>
<th>Make</th>
</tr>
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<tbody>
<tr>
<td>R1</td>
<td>All carbon</td>
<td>CR16</td>
<td>100 Ω</td>
<td>±20</td>
<td>Mullard</td>
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<tr>
<td>2</td>
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<td>47 kΩ</td>
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<td>17(R\text{p})</td>
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</tr>
<tr>
<td>C1</td>
<td>Electr. LV</td>
<td>015 90001</td>
<td>1 μF</td>
<td>63 V</td>
<td>+80</td>
</tr>
<tr>
<td>2</td>
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<td>4.7 μF</td>
<td>35 V</td>
<td>±20</td>
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<tr>
<td>3</td>
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<td>630 02472</td>
<td>4.7 μF</td>
<td>100 V</td>
<td>±10</td>
</tr>
<tr>
<td>4</td>
<td>Tantalum</td>
<td>101-838</td>
<td>22 μF</td>
<td>16 V</td>
<td>±20</td>
</tr>
<tr>
<td>5</td>
<td>Ceramic</td>
<td>630 02472</td>
<td>4.7 μF</td>
<td>100 V</td>
<td>±10</td>
</tr>
<tr>
<td>6A, 6B</td>
<td>Ceramic</td>
<td>789 02223</td>
<td>330 kΩ</td>
<td>820 V</td>
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</tr>
<tr>
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<td>Ceramic</td>
<td>630 02102</td>
<td>16 V</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>23</td>
<td>Ceramic</td>
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</table>

Voltage rating of capacitors is that of components used by author. They need be no more than 16 V in practice.
sensitivity to maximum, set the monitor switch as shown and carry out tests by walking outside windows etc., thumping walls to simulate vibration (and therefore possible MID movement) and see if the l.e.d. can be made to indicate. If the l.e.d. indicates or the sensitivity is higher than needed, reduce the sensitivity.

In the setting-up mode the circuit responds much faster than the main MID circuit and also has less memory time, which speeds the setting-up process. Having established a safe sensitivity setting, it remains to check that the MID is sensitive to an intruder. In doing this there is no need to be too critical as signals increase in voltage by a factor of four each time range is halved. Thus occasional detection at one range becomes most positive at 70% of that range.

It is a good idea to mount the l.e.d. outside the protected area, so that with the monitor switched to the long time constant, the safety factor can be monitored without intruding the protected area. Any tendency to approach a risk situation will be latched in by the l.e.d. staying on until reset. In the case where the MID is set to sound an alarm for five minutes and stop if there is no further movement, it is worth fitting a second latched l.e.d. by the side of the first to show that the main MID circuit has alarmed. This will help sort out the situation where the monitor l.e.d. is latched. For instance, was this due to an intruder or a noise problem? If the main MID indicator is out then it is most likely, though not certain, that it is an interference problem to be aware of.

The above setting-up does not cover the case where the MID appears to have a safe setting but in fact is close to making the l.e.d. indicate and so a second attempt has to be made to get it correct; after perhaps one day seeing the l.e.d. indicating. This would need some two-stage gain control so that the alarm is first set up and then the gain is reduced even more to ensure a once-only setting up. An alternative, well worth considering, is to give the monitor circuit a higher gain in the setting-up mode than in the monitor mode. Perhaps seven times for setting up and four as a monitor. The gain is \(1 + \frac{R}{r}\) and the reader can choose the value of \(R\) to suit.

One can carry on increasing the complexity of MID's almost indefinitely. For instance, a clock could be included to show the time of the intrusion. But the above system in my opinion is the least that should be provided in any professional equipment. A great advantage of such monitors is that it allows the MID to go on test for a few days without being connected to an alarm bell.

For a long time there has been a need for this type of monitor circuit. True an oscilloscope can be used to look at the noise level in a particular installation, but this is no substitute for proper monitoring. Poor design in the past has been one reason for the growth of companies which now intercept alarm calls before passing these on to the appropriate security people. Of course, the problem of protecting a warehouse, where the roof may rise and fall in the wind, is much more difficult than a house or shop, and such problems may be helped by a security house who know about the difficulty. So would a wind meter which turned down the sensitivity in a storm.
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Microelectronics and the Third World

An argument against labour intensive technology for less developed countries

by S. Jacobsson Research Policy Institute, University of Lund, Sweden

Microelectronics based technologies are now spreading into economies with already high unemployment levels. After discussing the possible implications of this technical change for employment in these countries, the author argues against the widespread view that the solution to the problems of the less developed countries lies in labour intensive manufacturing. Human labour has natural limitations and cannot match the abilities of the new electronic machines and the superior technologies that result from them.

Concern about the effect of microelectronics on future employment is now strengthened by the fact that microelectronic based technologies are being diffused into economies with already high unemployment levels. In the OECD (Organization for Economic Co-operation and Development) area the level of unemployment in the second half of the 1970s was the highest ever since the second world war and, more importantly, it stayed at a high level also in the post-recessionary period of 1975-8. While this situation in the OECD area is serious enough to warrant more attention than is given to it today, it is nevertheless rather insignificant in comparison with that of the less developed countries (LDCs). In the rest of this article I shall outline some possible effects of technical change induced by the diffusion of microelectronics on the employment situation in these economies.

The prevalent view on the evolution of the employment structure in the development process has suggested that the manufacturing sector would gradually absorb the rural labour force and transform the employment pattern in LDCs into something similar to that which prevails in the industrialized world of today. Table 1 gives a rather interesting perspective on this hypothesis. (A similar table is found in Stewart (1978).) It shows that, on the basis of past trends, not even the yearly addition to the labour force has been absorbed by the expanding manufacturing sector in any of the countries. Indeed, apart from the Republic of Korea, the jobs provided by the manufacturing sector were extremely inadequate in relation to the number of jobs required as a result of only the growth of the labour force, not to mention the already vast number of unemployed. (The figure of 1 billion has been mentioned by the ILO.)

Now it seems reasonable to ask whether this inadequate employment generation potential will prevail also in the future and, if so, what implications will it have. While there are several factors which may determine the answer to this question, e.g. rate of population growth and capital accumulation, we shall deal with only one factor, namely technical change, as this is the one most strongly associated with the diffusion of microelectronics.

The overwhelming majority of the world's technology is produced in the OECD area and there is nothing that points to any significant reduction in the LDCs' technological dependence on the developed countries in the future. What happens here is therefore of greatest relevance for the LDCs.

In Table 2 we have reproduced data on trends in manufacturing output and employment in the 'EEC-five' countries. (The same trends exist also in Britain; see Clarke (1979).)

The table reveals that in the postwar period and in particular since the early 1960s, there has been a strong downward trend in employment generation for a given rate of change in output. While the data covers only the period up to the 1973 'oil crisis', the trends have continued also in the post-recession period. Thus, the manufacturing output did not only recover but increased after 1975, while manufacturing employment has fallen in absolute numbers in most OECD countries.

While part of the change in labour input versus output can be explained by a structural shift of relatively labour intensive processes to the LDCs, for example in garment manufacturing, the magnitude of the change strongly suggests that the figures reflect an increased absorptive potential of the manufacturing sector will decline even further in the future.

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large scale is the neoclassical economis's conceptualization of alternative technologies in terms of different quantities of capital and labour. I would instead suggest that there are extremely important qualitative differences between the two factors of production. To my knowledge the first economist or social scientist who pointed out the qualitative differences between capital and labour was Marx. The distinctive feature of what he called large scale modern industry was that the characteristics of the worker and his physical limitations did not constitute a limiting factor in the design of the production processes. The distinction is, with his analysis, it is simple to argue that the physical properties of labour are quite different from those of a machine. In relation to a machine a person is first of all variable, which implies uneven quality; secondly he is weak, which has obvious implications; thirdly, he cannot achieve the same precision, which is absolutely basic in any machine-making activity; fourthly, he cannot stand extreme heat, and heat is essential in key processes such as steel and chemical production; fifthly he is slow, which implies that any industry which produces above a certain minimum level of output will use machines instead of people. From studying the history of technical change one may, as Marx did, draw the conclusion that technical change is to a very large extent a process of overcoming the restrictions set by these properties of human labour, through increasing the capital intensity of the production process.

Today developments in electronics mean that it is not so much human muscle as human intelligence which is replicated and extended. Thus any system which involves the processing of data, decision making, control of systems and equipment, in short, any task involving logic — is a candidate for the application of electronics. A list (not exhaustive) of these tasks includes:

1. controlled movement of materials, components and products
2. control of process variables
3. shaping, cutting, mixing, moulding, etc. of materials
4. assembly of components into sub-assemblies and finished products
5. control of quality at all stages of manufacture by inspection, testing or analysis
6. organisation of the manufacturing process, including design, stockkeeping, dispatch, machine maintenance, invoicing and the allocation of tasks.

This all-embracing character of electronics will probably have important implications for the application of more labour intensive technologies in LDCs and thus for the possibility of absorbing a greater proportion of the labour force in the manufacturing sector through reversing the trend towards more capital intensive technologies.

The reason behind this assertion is that the cause of increased competitiveness through using electronically based innovations lies not only in their labour saving nature (which is less important in cheap labour economies), but also in probability savings in investment, maintenance and producing a better quality product, thus leading to superior technologies. 2,3 The labour saving nature has been amply dealt with in the public debate, but the last-mentioned characteristics need some elaboration. I shall give examples from two situations which traditionally have been very labour intensive, the mechanical industries and the garment industry.

Mechanical Industries. In metalworking industries batch production dominates over flow-line techniques, with an associated low efficiency through poor machine utilization. Numerically controlled machine tools (n.c. machines) constituted a first attempt to increase the efficiency in this sector. With these machines, the control signals containing the information needed to produce the part are fed into the machine as the operation is performed. The control signals imitate the instructions given by a skilled machine operator, but with much greater speed and precision. By changing the control tape, an n.c. machine can be quickly switched to the next job which may involve a totally different sequence of operations. In this way the downtime — the setting time — of the machine tool is reduced, which is very important for machine utilization in small batch production work. By replacing the still relatively inflexible hard-wired circuitry in the n.c. machines by software in mini- or micro-computers — i.e. producing computerized numerically controlled machine tools (n.c.c. machines) — the versatility and flexibility of the machine tools are considerably enhanced.

The capital saving nature of technical change in this sector stems not only from increased machine utilization. C.n.c. and direct numerical control (which involves one computer controlling several machines) increase quality, for example in precision things. They also increase the throughput and reduce inventories, which saves capital embodied in materials. Furthermore they allow for in-process quality control, which makes possible early discovery of mistakes, and correction of process variables through electronic feedback. The latter source of capital saving is of considerable importance for process flow techniques also, for example in paper pulp and glass production, where work in progress often constitutes a very substantial part of total capital cost. Finally, the fixed investment costs are reduced by price cuts in the cost of control systems. According to one Japanese source, "today's n.c. systems are priced at a quarter of those of ten years ago".

Garments. The clothing sector has been characterized by having capital costs among the lowest in manufacture.4 The complexity of the production process and ever changing fashions have justified purpose built equipment except in some cases. However, with microelectronics both a high flexibility and a high degree of automation are made possible. As Dr Juan Rada explains:

"The use of self-programming robotic arms for cutting, and computerised systems for design, producing patterns, monitoring quality of fabric and leading laser beam cutters, is changing the face of the industry. Microprocessors are being used to control knitting heads (instead of the centuries old Jacquard's card), to control injection machines with high flexibility to change design and colours; they are used to control sewing patterns and fast stitching. These are part of a growing number of applications the trend being towards a "total system concept" which means the use of computerised techniques to detect flaws, keep track of patterns and orders, monitor the progress of work throughout the plant, automatic stitching of patterns and the cutting and sewing. These applications save labour, skills and materials (in the case of cutting, the saving ranges from 8 to 15 per cent)."

The investment saving nature of micro-electronic based innovations in this sector has been particularly emphasized by Raphael Kaplinsky who gives the example of a UK firm who produced an electronic pattern machine for a single knitting loom. This machine cut down time in the change-over of knitting patterns by more than 50% "as well as lowering the hardware costs of the control system (itself at 20% of the total loom cost) by 50 percent.”

Thus, because of the breakthrough made possible by microelectronics, in the near future the competitive edge in garments manufacturing will probably no longer be labour costs but technology.

All in all, it seems therefore very unlikely that more labour intensive technologies may be chosen in LDCs to the extent that the trends towards more capital intensive techniques may be altered or reversed.

The transformation of the technology

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1From the figures in Table 1, we can see that if only the yearly addition to the labour force were to be absorbed by the expanding manufacturing sector, the labour intensity of new investment projects would on average have to increase by a factor of 12.25 in the Philippines, 8.6 in India, 5.3 in Peru and 3.3 in Brazil and Kenya.
in some traditional industries, i.e. not only garments but also textiles, leather and shoes, may have particularly severe implications for LDCs. The contribution to the total increase of manufacturing employment in the period 1968-1975 from these industries amounted to 30% for all LDCs and nearly 38% for the Asian LDCs. Furthermore in some Asian countries such as the Republic of Korea and Hong Kong, manufacture for exports accounts for a sizeable part of total employment. For example, it has been estimated that more than one half of the total employment growth in manufacturing during 1963-1970 in the Republic of Korea was due to an expansion of exports. (This may partly explain Korea's exceptional performance as shown in Table 1.)

The important point is that it is particularly in these economies where textiles, garments, leather and footwear products account for a considerable part of manufacturing exports.

Two implications can be drawn. Firstly, these traditional industries which account for a considerable part of yesterday's and today's employment generation in LDCs will probably fail to be duplicated by other LDCs. Secondly, as R. Kaplinsky has pointed out, the export-oriented growth and employment strategy - much cherished today among both LDCs and Western economists - which so successfully has guided the industrialization strategy of the Republic of Korea, will probably not be able to be duplicated by other LDCs in the future. This is essentially so since cheap labour will probably lose its importance as a factor in determining international trade. Of course, some more advanced LDCs with the necessary skills and 'industrial environment' might be able to pursue a growth strategy based on the new technologies, but the employment impact will then be marginal. (It could be argued, as has convincingly been done by R. Kaplinsky, that the high and possibly increasing unemployment figures in the OECD area will restrict the market for these countries.)

The implication of the previous analysis is that the manufacturing sector in most LDCs will not be able to absorb the growing labour force, not to speak of transforming the structure of employment in a way similar to what has happened in the OECD area. While the urban-based service sector may improve the employment situation slightly, the only possible way out seems to be that the agricultural sector will have to absorb the main part of the labour force permanently. This sector has greater potential to fulfill this task as it is much more flexible in the degree of mechanisation than the manufacturing sector - mainly due to the fact that the human limitations of precision/speed/quality etc. are not so critical in agriculture as in industry.

Well, what is the problem then? one may ask. Why not let a very 'modern' industrial sector coexist with a very labour intensive agriculture?

There are at least two very considerable ones. Firstly, institutional changes - mainly concerning distribution of land - need to be implemented if agriculture is to absorb a growing proportion of the labour force. This is widely recognized - even by the World Bank - so I will not elaborate on it. Secondly, even if the employment problem were to be solved in this way, the LDCs would experience a gigantic distributional problem since they would be faced with vastly different labour productivities in the industrial and agricultural sectors. (I was first made aware of this problem by C. Edquist at the Research Policy Institute, Lund, Sweden.) To take China as an example, as she has undertaken the most far reaching institutional changes in recent decades, the pressure on the agricultural sector to absorb the growing labour force has been associated with a decreasing marginal productivity of labour between 1959 and 1975. Indeed, this occurred in spite of massive capital formation projects such as irrigation schemes. For example, since the agricultural sector may absorb the labour force, the price to be paid for it, as noted already by the classical economists, is a very low and possibly decreasing labour productivity.

The very important point here is that as the industrialization process continues agriculture and the agricultural sector is charged with the job of absorbing the labour force, the political problem of transferring income from the high productive, and geographically concentrated, industrial sector to the low productive agricultural sector will take on increasingly stronger dimensions. This distributional problem will probably be one of the key ones for developing countries to deal with.

This article is a revised version of an article 'Technical Change, Employment and Distribution' which was attached to the Lund Letter of Science and Technology for Basic Human Needs, 15 June, 1979, published by the Research Policy Institute, University of Lund, Sweden. We are indebted to both the Salen Foundation and to SAREC for financial support for that essay. The Salen Foundation also generously sponsored the Lund workshop on technological change in industrialized countries and its consequences for developing countries, held in Lund in May 1979. Part of the content of this article has greatly benefited from discussions in the workshop. In addition, many people have contributed with very helpful comments on earlier drafts. In particular, we would like to thank C. Edquist, H. Hoffman, Howard Rush, Jon Sigurdson and John Wilson, but also Enrique Bautista, Richard Conroy, Charles Edquist, Christopher Freeman and Hans Gustafsson.

21. UNIDO. World Industry since 1960. Pro-}
Optically-isolated triac control

A common problem with optical isolators is that a separate power supply is required. A tapping from a mains transformer primary can be used, but this is not always available, particularly on small transformers. A simple solution is to use the transformer primary as a current limiter for a suitable low voltage supply. However, triacs often require a gate current of around 50mA, which is more than this type of supply can provide. To overcome this problem, gate current is pulsed with a duty cycle of about 10%. The current required by the I.E.D. to turn the triac off is about 250μA, so it can be directly driven by c.m.o.s. logic. Resistor R1 is included for protection in case the Zener diode goes open circuit.

G. R. Rulter
Woking
Surrey

Voltage-to-period converter

In some circuits it is more convenient to have an oscillator whose period, rather than frequency, has a linear relationship to the control voltage. This circuit was developed to drive an analogue delay line for audio signal processing. Resistors R1, R2, R3, diode D1 and Tr, form a reasonably temperature-stable current source, which charges C1 until the ramp voltage exceeds the control voltage. The comparator is biased by R4 for high current and fast slew rate, and R4, C2 decouple the control input and prevent spurious triggering. The output is taken via D2, R5, which prevent negative bias, to a c.m.o.s. buffer and discharge circuit. With the values shown, antiphase outputs equal to the reset pulse width are available from pins 12 and 1 of IC2. The reset pulse width of around 100ns is determined by propagation delays in the I.C.s. If a longer pulse width is required, C2 may be used to form a monostable with a period of approximately C2 R5. If low-frequency operation is required, C1 must be completely discharged and C1 should be equal to C1/6. The value of C1 is limited by the ability of IC2 to discharge it without damage and, in the prototype, a 100nF has been successfully used. With the values shown the period varies from about 0.5 μs to 30 μs for control voltages from 0.15 to 8V.

E. J. Leonie-Smith
Royston
Herts
Enlarger analyser

This analyser uses a recently introduced silicon-blue photoamplifier i.c. to achieve high linearity at low light values. A bridge circuit measures the current drawn by an open-collector output of the TFA 1001W and a set-time control converts this current into a voltage which is compared with a reference level. The reference is set by a speed control for various brands of printing paper. Bridge balance is indicated by a TCA965 window discriminator and three l.e.ds. The bridge is fed with a few millivolts of a.c. from the transformer to overcome hysteresis. At balance the set-time control is used with the 555 timer to expose the paper. S, turns the enlarger on for focussing and measurement, or allows S2 to start the exposure. Times from 2 to 140 s with paper speeds from 80 to 400 ANSI can be selected after speed calibration using test strips.

In the prototype, the photoamplifier was housed in a potting box together with the linearity control, associated components and twin-screened lead to the main circuit. Linearity is adjusted, with a d.v.m. across the time control set to 1MS2, by using the halving values obtained from progressively stopping the lens. Judicious setting of linearity can compensate for reciprocity failure. Note that linearity setting only applies at low light values and the components may be omitted if higher levels only are used.

R. I. Harcourt
Thornton Heath
Surrey

Economic three rail supply

In t.t.l. circuits which use 710 type comparators, power supplies of +5V, +12V and -6V are needed. The common arrangement is inefficient and costly compared with this circuit, which provides the voltages required from a single standard transformer. Although the 5V rail may have to provide a substantial current, the other supply rails only need to deliver small currents which can be provided by half wave rectification. During positive half-cycles the lower winding feeds the +6V rail via D1, and the two windings in series feed the +12V rail via D3 and D4. Diodes D3 and D4 are biased off. During negative half-cycles D1 and D2 are biased off and the windings are isolated. The top winding now feeds the +6V rail with a return via D3 and the lower winding feeds the -6V rail via D4. Therefore, the +6V rail is fed during both half cycles by the two secondary windings alternately and both low current rails are fed on alternate half cycles. The voltages shown increase when capacitors are connected to provide an adequate margin for the regulators.

R. M. Adelson
Hornby
Lancaster

Simple oscillator

A silicon bilateral switch, s.b.s., is a useful component for producing a simple, economic and versatile audio oscillator. With a 12V d.c. supply the circuit oscillates at 100Hz and draws only 400 µA. Direct or alternating supplies can be used and with suitable component values, mains operation is possible. Frequency modulation or on/off control is achieved by feeding a voltage or pulse to the gate. Minimum direct supply voltage is about 10V but an 18kΩ resistor between the gate and
Triggered timebase

High-quality oscilloscopes with sweep rates up to 0.1 μs/cm use special components, such as fast f.e.ts and tunnel diodes, together with logic i.cs. This timebase provides a wide sweep range with trigger hold-off and bright-line functions and does not require any expensive or uncommon devices. Three NAND gates generate a ramp waveform, and a Schmitt trigger shapes and inverts the square wave from gate C. When the flip-flop is set the output goes low and C1 discharges via D1 to provide the flyback at pin 3 and a pulse at pin 4. Ramp rate is varied by R1, and C1 is switch-selectable for a wide range of sweeps. The trigger input is shaped by a 710 and gated by a Schmitt trigger, so the flip-flop is only clocked when the output of gate C is high. This sets the output high and charges C1 linearly. The 710 output also goes to D2 and an integrator, which negatively charges C2 and disables the oscillator around gate K. When disabled, the oscillator output is high and therefore enables gate G to clock the flip-flop. When no input signal is present, the oscillator feeds the clock input of the flip-flop and provides automode operation for the timebase.

K. Padmanabhan
Madras
India

Two terminal constant current source

Most constant-current sources require output, ground and supply connexions to a circuit. However, a two-terminal arrangement can be obtained by combining two standard sources, of opposite polarity, back-to-back. In the circuit diagram the current is 2Vbe/R.

J. J. Ellis
Cambridge
**Prestel / Viewdata printer**
The Olympia International NMP 40 mechanism, incorporated in a printer terminal, forms one of the first screen image printers to appear in the UK. A hard copy of displayed Prestel / Viewdata images can be made with the printer which Dataplus, the equipment’s distributor, claims as “very quiet” in operation. The unit will print alphanumeric characters and graphics at high speed and paper loading is simple. The printhead consists of 240 discrete electrodes equally spaced across the 127mm wide paper and each is spring-loaded, obviating the need for adjustment. The rubber platen is driven by a small d.c. motor, this being the only moving part. Overall dimensions of the terminal are 250mm wide X 360mm deep x 150mm high. Production quantities of the unit will be available in late 1980 as will the full drive electronics to suit UK television receivers. Dataplus Ltd, 39-49 Roman Road, Cheltenham.

**D.i.y. keyboards**
Individual keys, rows of keys or groups of keys, elements of the series 87 family of switches, can be used to create keyboard forms for prototypes, short runs or volume production, according to the makers, Highland Electronics. Legending of switches is achieved by hot stamping of the buttons to customers’ requirements before delivery, although for prototype work, versions of the switches are available with snap-on caps. In this event a legend sheet is supplied and each legend is placed under the cap. The series 87 employs snap-dome contacts previously used on Highland series 83, 84 and 86, all 16 button keypads. A typical circuit for these switches is single-pole/common-bus and the $3 \times 4$ and $4 \times 4$ keypads are also available with matrix switching. Highland Electronics Ltd, Highland House, 8 Old Steine, Brighton, East Sussex.

**V.s.w.r. / power meter**
Direct reading of v.s.w.r. and output power without the need for interpolation is one of the capabilities of the v.s.w.r. /power meter offered by Zycomm Electronics. The unit is autoranging for power output measurement, covering 20W to 2kW in three ranges for 1.8 to 30MHz and 50 to 1500MHz, and 2W to 200W for the 430 to 470MHz range. V.s.w.r. from 1:1 to 1:10 can be measured. Separate sensing heads are supplied to cover each frequency range and these can be connected at any point in the feed line, including the masthead, for precise radiated power indication. Push switches on the front panel permit the selection of the appropriate head and the display of forward or reverse power as either peak or r.m.s. readings. The electronic comparator included in the unit permits constant readout of v.s.w.r. irrespective of power variation, thereby giving true indication during speech on s.s.b. The unit is for operation on 240v 50Hz mains. Zycomm Electronics Ltd, 47, 49 and 51 Pentrich Rd, Ripley, Derby DE5 3DS.

**Digital slow scan transceiver**
The Colorado Video model 285 is intended to provide “quality” tv picture transmission over data channels and is available as a receiver, a transmitter or transceiver. Features incorporated are “frame freeze”, a repeating “freeze and scan” mode for surveillance applications and continuous display at the receiver as each new image wipes off the previous image. The unit accepts tv signals from camera, v.t.r. or video disc recorder and also produces a signal for viewing on c.c.t.v. monitors. Transmission is in the synchronous serial digital form at rates up to 500 k/bits/s and the equipment requires no adjustment when changing rates, the unit itself tracking the modem clock rate. The operator may select left-to-right or top-to-bottom scanning to suit the item scanned and may transmit either a single field (shorter transmission time at reduced resolution) or a full frame, i.e. normal transmission time at full resolution. Transmission times vary according to the grey-scale levels chosen, either 64 levels (6 bit) or 256 levels (8 bit) depending upon the bit rate. Data may be encrypted for security purposes. Prices start at $9,000; this being the price for the receiver only. Colorado Video, Box 928, Boulder, Co, 80306, USA.
Music processor/mixer

The Cambridge Electronic Workshop music processor is a full broadcast specification mixer intended as an off-the-shelf item for club and mobile use, built in standard 19in rack units in modular form. The technical complement includes transformer-coupled inputs with phantom powering, microphone limiters, plastic track faders with remote start for external tape or disc transport mechanisms, and separate equalization for two disc units, two line inputs and both microphone inputs. Outputs are complete with a stereo limiter, "voice over," adjustable voice switch from the d.j.'s microphone and a nine-band graphic equalizer. Also featured is a built-in comprehensive lighting control which is compatible with Pulsar equipment and contains a six-channel sound-to-light chaser, strobe drive and four independently controlled mains terminals. Cambridge Electronic Workshop, 4 Water Lane, Oakington, Cambridge CB4 5AL.

WW305

High temperature contact adhesive

Excellent acid resistance, high moisture resistance and good dielectric strength are properties which Aremco Products International attributes to its Aremco-Bond 570, an elastomer-phenolic adhesive intended for the bonding of ceramic, glass and metallic materials at temperatures up to 315°C. A further characteristic is its good shock resistance due to a small degree of flexibility being present after curing, thus allowing bonding of materials with a dissimilar coefficient of expansion. The adhesive is applied in the usual manner to both surfaces, which are allowed to dry before pressing together and final heat cure under pressure will produce a high temperature high strength bond. Aremco-Bond 570 costs £21.50 per pint, plus carriage costs. Photograph shows the adhesive being used to bond together two ceramic bushes. The Meclec Company, 5-6 Towerfield Close, Shoeburness, Essex SS3 9GP.

WW306

Radio l.c.s

Two new l.c.s which the makers, Motorola, describe as "the first in the industry to be specifically characterised and specified for "crowbar" applications, is accompanied by data sheets giving a graph detailing peak capacitor discharge current. This plot indicates peak discharge current as a function of power supply discharge time, permitting power supply designers to select a specific s.c.r. whose peak current characteristics are suited to a particular supply circuit. Each item in the MCR67-71 range of s.c.r.s is capable of dumping peak currents of 300 to 1700A, thus discharging the power supply output capacitors and clamping the voltage to the on-state voltage of the s.c.r. until a fuse or circuit breaker opens. Gate trigger current for the series is 2mA minimum and 30mA maximum. The s.c.r.s are available in both metal and plastic packages with operating voltages between 25 and 100V. Motorola Ltd, Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex HA9 0FR.

WW309

Infra-red detectors

A range of lead sulphide and lead selenide infra-red detectors manufactured by the American Optoelectronics Inc, is now being marketed by Wentworth Laboratories. These detectors are available in single element or multi-array packages incorporating standard units made up from elements in sizes from 1 to 5mm square. Detectors for use at room temperatures are included and these can be provided as standard units or units with an optional built-in thermostatic cooler. Thermistors may be used in conjunction with the detectors for the monitoring of detector temperature and to allow closer control of performance. Wentworth Laboratories Ltd. Sun St, Potten, Essex HA9 0LR.

WW310

Spark gap c.r.t. protectors

The focusing electrode of a c.r.t. can be protected from the damaging effects of excessive e.h.t., by the spark gap series 5389, manufactured by Welwyn Electric. These units can also be used to protect v.d.u. tubes, oscilloscopes and photomultipliers from high voltage discharges and transients. The three items in the series cover the "popular" (perhaps not so for the t.v. service technician!) breakdown bands of 7 to 9kV, 8.5 to 10.5kV and 10 to 12kV all with current handling up to 1500 amps. These spark gap protectors meet BS2011 ("Components for printed circuit applications.") and are flame retardant in accordance with BS415-14/4. Welwyn Electric, Bedlington, Northumberland NE22 7AA.

WW307

"Crowbar" s.c.r.s

A range of s.c.r.s which the makers, Motorola, describe as "the first in the industry to be specifically characterised and specified for "crowbar" applications, is accompanied by data sheets giving a graph detailing peak capacitor discharge current. This plot indicates peak discharge current as a function of power supply discharge time, permitting power supply designers to select a specific s.c.r. whose peak current characteristics are suited to a particular supply circuit. Each item in the MCR67-71 range of s.c.r.s is capable of dumping peak currents of 300 to 1700A, thus discharging the power supply output capacitors and clamping the voltage to the on-state voltage of the s.c.r. until a fuse or circuit breaker opens. Gate trigger current for the series is 2mA minimum and 30mA maximum. The s.c.r.s are available in both metal and plastic packages with operating voltages between 25 and 100V. Motorola Ltd, Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex HA9 0FR.

WW310

Bar graph l.c.d. unit

Numerical annunciation and over-range/under-range indication are features included in the 20 element bar-graph liquid-crystal display unit from Hamlin Electronics. Each bar has a separate backplane enabling each of the two bars to be driven independently. The display is available with pins for d.i.l. mounting or with snap-on terminal strips. An applications note, including a drive circuit for the display, is also available. Hamlin Electronics, Diss, Norfolk.
THE VALVE AND TUBE SPECIALIST

RECEIVING, S.Q., TRANSMITTING , GAS FILLED, DISPLAY, TV ETC. AT NEW SPECIAL LOW PRICES

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A NEW WIDEBAND
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THE POWER AMPLIFIERS

Model | Output Power R.M.S. | Distortion Typical at 1KHz | Minimum Signal/Noise Ratio | Power Supply Voltage | Size in mm | Weight in gms | Price + VAT
---|---|---|---|---|---|---|---
HY30 | 15 W into 8 Ω | 0.02% | 80dB | -20 -0 +20 | 105x50x25 | 155 | £6.34 + 95c
HY50 | 30 W into 8 Ω | 0.02% | 90dB | -25 -0 +25 | 105x50x25 | 155 | £7.24 + £1.09
HY120 | 60 W into 8 Ω | 0.01% | 100dB | -35 -0 +35 | 114x50x85 | 575 | £15.22 + £2.28
HY200 | 120 W into 8 Ω | 0.01% | 100dB | -45 -0 +45 | 114x50x85 | 575 | £18.44 + £2.77
HY400 | 240 W into 4 Ω | 0.01% | 100dB | -45 -0 +45 | 114x100x85 | 1.15 Kg | £27.68 + £4.15

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Input sensitivity - all models 500 mV.
Input impedance - all models 100K. linear.
Frequency response - all models 10Hz - 45Hz - 3dB

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Model

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<td>AL20</td>
<td>3-way auto amplifier module</td>
<td>$2.50</td>
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<td>AL30</td>
<td>6-way auto amplifier module</td>
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<td>AL40</td>
<td>9-way auto amplifier module</td>
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<td>AL50</td>
<td>12-way auto amplifier module</td>
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<td>AL25</td>
<td>15-way auto amplifier module</td>
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<td>AL23</td>
<td>20-way auto amplifier module</td>
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<tr>
<td>AL22</td>
<td>25-way auto amplifier module</td>
<td>$5.00</td>
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**STEREO PRE-AMPLIFIER**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>PA100</td>
<td>100-watt power amplifier</td>
<td>$7.90</td>
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<tr>
<td>PA101</td>
<td>10-watt power amplifier</td>
<td>$5.90</td>
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<tr>
<td>PA110</td>
<td>110-watt power amplifier</td>
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<tr>
<td>PA120</td>
<td>120-watt power amplifier</td>
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**MONO PRE-AMPLIFIERS**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
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<tr>
<td>MM100G</td>
<td>Mono power amplifier</td>
<td>$20.00</td>
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<tr>
<td>MM101G</td>
<td>Mono power amplifier</td>
<td>$22.00</td>
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**TRANSFORMERS**

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<th>Model</th>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>2024</td>
<td>7.5mm 500 ohm</td>
<td>$2.50 each</td>
</tr>
<tr>
<td>3036</td>
<td>7.5mm 1050 ohm</td>
<td>$3.00 each</td>
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**DIODES**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>1N4001</td>
<td>50V 1A rectifier diode</td>
<td>$0.01 per piece</td>
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<tr>
<td>1N4002</td>
<td>25V 1A rectifier diode</td>
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</tr>
<tr>
<td>1N4003</td>
<td>15V 1A rectifier diode</td>
<td>$0.01 per piece</td>
</tr>
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**LINEAR**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>7805</td>
<td>5V regulator</td>
<td>$0.01 each</td>
</tr>
<tr>
<td>7812</td>
<td>12V regulator</td>
<td>$0.01 each</td>
</tr>
<tr>
<td>7909</td>
<td>9V regulator</td>
<td>$0.01 each</td>
</tr>
</tbody>
</table>

**SPECIAL OFFER**

**COMPONENT PARCELS**

- **D/D** includes free delivery for all of your PCB designs.
- **SPECIAL OFFER** includes free delivery for all of your PCB designs.

---

**WIRED-world, March 1980**

**SUPER SOUND SAVING! DINE IN LOW NOISE CASSETTES**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCA11</td>
<td>2 channel</td>
<td>$5.00 each</td>
</tr>
<tr>
<td>SCA12</td>
<td>3 channel</td>
<td>$6.00 each</td>
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**ALL REDUCED CAPACITOR PARCELS**

<table>
<thead>
<tr>
<th>Capacitor</th>
<th>Description</th>
<th>Price</th>
</tr>
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<tbody>
<tr>
<td>0.1uf</td>
<td>1000VDC 10%</td>
<td>$0.01 each</td>
</tr>
<tr>
<td>0.1uf</td>
<td>500VDC 10%</td>
<td>$0.01 each</td>
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</tbody>
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**RESISTOR PARCELS**

<table>
<thead>
<tr>
<th>Resistor</th>
<th>Description</th>
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<tbody>
<tr>
<td>270ohm</td>
<td>1% Tolerance</td>
<td>$0.01 each</td>
</tr>
<tr>
<td>470ohm</td>
<td>1% Tolerance</td>
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**IC SOCKET PARCELS**

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<th>IC Socket</th>
<th>Description</th>
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<tbody>
<tr>
<td>74HC14</td>
<td>Quad 2-input NOR gate</td>
<td>$0.01 each</td>
</tr>
<tr>
<td>74HC15</td>
<td>Quad 2-input NAND gate</td>
<td>$0.01 each</td>
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**VOLTAGE REGULATORS**

<table>
<thead>
<tr>
<th>Regulator</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>7806</td>
<td>5V regulator</td>
<td>$0.01 each</td>
</tr>
<tr>
<td>7815</td>
<td>15V regulator</td>
<td>$0.01 each</td>
</tr>
<tr>
<td>7818</td>
<td>18V regulator</td>
<td>$0.01 each</td>
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**OPTOELECTRONICS**

<table>
<thead>
<tr>
<th>Diode</th>
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<th>Price</th>
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<td>IN4001</td>
<td>50V 1A rectifier diode</td>
<td>$0.01 each</td>
</tr>
<tr>
<td>IN4002</td>
<td>25V 1A rectifier diode</td>
<td>$0.01 each</td>
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**2ND QUALITY LED PARCELS**

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<tr>
<th>LED</th>
<th>Description</th>
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<tbody>
<tr>
<td>5007</td>
<td>3mm red LED</td>
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**L.E.D. PARCELS**

<table>
<thead>
<tr>
<th>LED</th>
<th>Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>7806</td>
<td>5V regulator</td>
<td>$0.01 each</td>
</tr>
<tr>
<td>7815</td>
<td>15V regulator</td>
<td>$0.01 each</td>
</tr>
</tbody>
</table>

**L.E.D. CLIPS**

<table>
<thead>
<tr>
<th>Clip</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1023</td>
<td>10mm chrome knobs</td>
<td>$0.01 each</td>
</tr>
</tbody>
</table>

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- **SUPER DUPER COMPONENT BOX**
  - 30% off in weight each of a fantastic assortment of Electronic Components - Pads, Resistors, Condensers, Transistors, Wireless Semiconductors, etc. Hardware etc. etc. etc.
  - **This is a large box and is set to improve your order.**

**CAPACITOR CHIPS**

<table>
<thead>
<tr>
<th>Capacitor</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>22uf</td>
<td>16V 5% electrolytic</td>
<td>$0.01 each</td>
</tr>
</tbody>
</table>

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Suitable Bookshelf Cabinet

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With spindles

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400 Ohm

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Suitable for erasing all types of记录, including reel to reel, reel to reel, and reel to reel.

WIRELESS WORLD, MARCH 1980

Baker Loudspeakers

"SPECIAL PRICES"

<table>
<thead>
<tr>
<th>MODEL</th>
<th>OHMS</th>
<th>POWER TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAJ0Z</td>
<td>3</td>
<td>D1</td>
</tr>
<tr>
<td>MIK1X 12</td>
<td>3</td>
<td>ALUM</td>
</tr>
<tr>
<td>SUPERI</td>
<td>3</td>
<td>ALUM</td>
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<tr>
<td>AUDITORIUM</td>
<td>3</td>
<td>ALUM</td>
</tr>
<tr>
<td>GROUP 45</td>
<td>3</td>
<td>ALUM</td>
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<td>GROUP 50</td>
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<td>ALUM</td>
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<td>DISCO 100</td>
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</tr>
<tr>
<td>DISCO 125</td>
<td>3</td>
<td>ALUM</td>
</tr>
</tbody>
</table>

WIRELESS WORLD, MARCH 1980

Baker Amplifier

£63 Post £1.60

Ideal for Halls/PA systems, Discos and Groups. Two inputs: Volume Controls, Mains Amp, Treble, Bow Gain Controls. 50 watts max. m.s. Three loudspeaker outlets 4, 8, 16 ohms.

Famous Loudspeakers

"SPECIAL PRICES"

<table>
<thead>
<tr>
<th>MODEL</th>
<th>OHMS</th>
<th>POWER TYPE</th>
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<tbody>
<tr>
<td>SEALS</td>
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<td>D1</td>
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<tr>
<td>GOODMAN 90W</td>
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<td>D1</td>
</tr>
<tr>
<td>NUDAX  60W</td>
<td>4</td>
<td>D1</td>
</tr>
<tr>
<td>MID-RISE 50W</td>
<td>4</td>
<td>D1</td>
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<tr>
<td>MID-RISE 30W</td>
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<td>D1</td>
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<tr>
<td>MID-RISE 15W</td>
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<td>D1</td>
</tr>
<tr>
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<td>D1</td>
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<tr>
<td>MODERN  15W</td>
<td>4</td>
<td>D1</td>
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<tr>
<td>McKINNEY 15W</td>
<td>4</td>
<td>D1</td>
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<tr>
<td>CELESTIAL 15W</td>
<td>4</td>
<td>D1</td>
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<tr>
<td>CELESTIAL 15W</td>
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<td>D1</td>
</tr>
<tr>
<td>CELESTIAL 15W</td>
<td>4</td>
<td>D1</td>
</tr>
</tbody>
</table>

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SUB FREQUENCY SYNTHESIZER
When connected to your HiFi system or PA this unit will generate frequencies one octave below the lowest frequency recorded on your discs or cassettes. SUB FREQUENCY SYNTHESIS adds a fourth dimension to sounds. It enables you not only to hear, but to feel the vibrations created by bass instruments. Connected to a high powered HiFi system the S F S assays your body with blasts of infra-sound. A disc (or cassette) recording lacks most of the frequencies below 50 Hz that were present in the original music. The S F S recreates these lost parts of the sound image, widening the dynamic range of the recording.

HOW IT WORKS
The frequency and amplitude of recorded signals in the range 60 to 120 Hz are used to synthesize frequencies one octave lower. These high tonal purity sub-harmonic signals are then added to the existing bass to produce a smooth spectral extension of the recorded sound. Higher frequencies are not affected by the S F S.

Two controls on the front match the input signal to the synthesizer level and control the level of sub-harmonic sound. The S F S was tested by the Swedish Audio magazine R&T Ino.5/1979) which praised the unit for its sensational effect when connected to a system of adequate power capacity. The sensation of feeling sound was described as tremendous.

The S F S is available as a kit comprising a mounted and tested PC board, aluminium case, mounting hardware and assembly instructions. The kit, when completed, is easily connected to any HiFi system, following the instructions provided. Cost is £76 + p&p (£3.3) + V.A.T. Enclose cheque for £79 when ordering.

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INGENJÖRSMARNA LEIF MARENJUS & CO HB
P.O. Box 5086, S-421 05 VÄSTRA FROLUNDA, Sweden

FEEL DEEP DOWN BASS
We are the Designer Approved suppliers of kits for this excellent design. The Author’s reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High quality 6082 VU meters with excellent ballistics. Complete, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, neatly built and tested layout. All these features added to the high quality metalwork make this a most satisfying kit to build. Also included at no extra cost in our new HS15 Sendust Alloy record/relay head, available separately at £7.80 plus VAT, but included FREE as part of the complete kit at £91.99 + VAT.

All prices plus VAT

CASSETTE HEADS

<table>
<thead>
<tr>
<th>Head</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS15 Sendust Alloy Super Head</td>
<td>7.60</td>
</tr>
<tr>
<td>HS20 Sendust Alloy R/P head for replacement use in car players, etc.</td>
<td>6.25</td>
</tr>
<tr>
<td>HM90 Stereo R/P head for METAL tape</td>
<td>7.20</td>
</tr>
<tr>
<td>HS61 Special Erase Head for METAL tape</td>
<td>4.90</td>
</tr>
<tr>
<td>HS24 Standard Ferrite Erase Head</td>
<td>1.50</td>
</tr>
<tr>
<td>4 Track R/P Head Standard Molding</td>
<td>7.40</td>
</tr>
<tr>
<td>R484 2/2 (Double Mono) R/P Head Std. Mtg.</td>
<td>4.80</td>
</tr>
<tr>
<td>ME151 2/2 Ferrite Erase, Large Mtg.</td>
<td>4.25</td>
</tr>
<tr>
<td>COE/BRN 3/2 Esrex Std. Mtg.</td>
<td>7.90</td>
</tr>
</tbody>
</table>

We are the actual importers of these heads and invite Trade/quantity enquiries.

All prices plus VAT

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High Quality Cassette Recorders

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LINSLEY HOOD 30-WATT AMPLIFIER

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- **Accuracy** 1.5% D.C., 2.5% A.C.

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- **D.C. Voltage** 300V-1000V
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- **Accuracy** 5% F.S.D.
- **Oscillator output** 1kHz 50/50 squarewave

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**SPECIAL OFFER OF BRAND NEW USSR MADE MULTIMETERS**

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<tr>
<th>Type</th>
<th>U4323</th>
<th>U4315</th>
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<tr>
<td>Sensitivity D.C.</td>
<td>20,000 o.p.v.</td>
<td>20,000 o.p.v.</td>
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<tr>
<td>Sensitivity A.C.</td>
<td>20,000 o.p.v.</td>
<td>20,000 o.p.v.</td>
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<tr>
<td>D.C. Current</td>
<td>0.6mA-1.5mA</td>
<td>0.6mA-2.5mA</td>
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<tr>
<td>A.C. Current</td>
<td>0.5mA-2.5mA</td>
<td>0.5mA-2.5mA</td>
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<tr>
<td>D.C. Voltage</td>
<td>75mV-1000V</td>
<td>300V-1000V</td>
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<tr>
<td>A.C. Voltage</td>
<td>15V-600V</td>
<td>1V-1000V</td>
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<tr>
<td>Resistance</td>
<td>50-1K</td>
<td>50-1K</td>
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<tr>
<td>Accuracy</td>
<td>5% F.S.D.</td>
<td>5% F.S.D.</td>
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<th>Power Amps</th>
<th>Details</th>
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<tr>
<td>21L02 450W</td>
<td>83p</td>
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<td>21L16 5W</td>
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- 8K 16K
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WIRELESS WORLD, MARCH 1980

ELECTRO-TECH COMPONENTS LTD.
364 EDGWARE ROAD, LONDON, W.2. TEL: 01-723 5667

JVC-VICTOR HIGH FIDELITY STEREO CASSETTE TRANSPORT MECHANISM

ELECTRO-TECH COMPONENTS have secured a very large quantity of cassette transport mechanisms, equipped with all the latest improvements, as well as "SEN-ALLOY" type 1.5 micron record/replay heads, and solenoid-controlled auto-stop action. These were manufactured by JVC/VICTOR of Japan to specification of TANBORG OF NORWAY, for inclusion in a cassette deck costing over £250. This mechanism alone would normally cost over £50.

FEATURES:
- Close-tolerance, high-quality, tape loading transport
- "SEN-Alloy" (SA type) R/F head
- Solenoid driven auto-stop circuit
- Automatic head cleaning device
- Air damped "soft" cassette eject
- Miniature microswitches for switching
- Pre-aligned heads and calibrated motor speed regulator built in
- Three-digit tape position counter
- PCB connectors and cables attached
- High-mass balanced flywheel with permanent lubrication spindle
- Full specifications for motor, heads, and switches, available on request (S.A.E. please).

Price of above unit £14.95 VAT inc.

Plus £1 P&P.

Regular readers of WIRELESS WORLD will know of the original LINSLEY-HOOD CASSETTE DECK design, published in May 1976. Subsequent articles by Mr. Linsley-Hood have confirmed that the design far exceeded his original expectations, so much so that he published a number of improvements, modifications, and additional features to the original design, which are now incorporated in our: *CASSETTE DECK KIT BASED ON DESIGN OF MR. LINSLEY-HOOD*

We have developed an outstanding stereo cassette kit with the aid of Mr. Linsley-Hood, to complement the improved specification and latest important advances in casette electronics since the original design was published. The kit is ideal for use in conjunction with the JVC transport mechanism (above).

Included in the kit are two fibre-glass PCB's, drilled and plated for immediate assembly, two VU meters, Dual LED Peak Meters, Variable Bias system. Price of Kit (without transport mech.) £35.95 VAT inc. plus £1.00 P&P.

SOFT CARRYING CASE

Trade and Export Enquiries Invited

Also available: A custom-designed case for the kit, this is a fully screened enclosure, sloping panel, satin anodised, wood end panels, professional finish. Price of Case £9.75 VAT inc. plus £1.00 P&P.

HERE IT IS! THE BRAND NEW 8022A HAND-HELD DMM

Consider the following features:
- 6 resistance ranges from 200 ohm-20k ohm.
- 8 current ranges from 2mA-2A.
- 10 voltage ranges from 200mV: 2000V.
- 200mV - 750V.
- 10 voltage ranges from 200mV - 1000V.
- 1000V.
- 0 to 6k ohms.
- 6 meg. ohms.
- 60 meg. ohms.
- 600 ohms.
- 500 ohms.
- 100 ohms.
- 50 ohms.
- 20 ohms.
- 5 ohms.
- 2.5 ohms.

Price £112

Carriage and insurance £3.00

A handsome soft carrying case is included (this model only).

SOFIT CARRYING CASE £7 extra

Even more sophisticated is the Fluke 8020A, identical in most respects to the 8022A but in addition incorporates a conductance range from 0.01-200k ohms.

Price £159

Carriage and insurance £3.00

A handsome soft carrying case is included (this model only).

DIGITAL MULTIMETERS

8010A AND 8012A BENCH MODEL D.M.M.s

The 8010A is a general purpose, bench-top digital multimeter with more functions for testing than most of the others for such a low price. Its companion, the 8012A, has similar characteristics except that it has two additional low resistance ranges, 20 and 200 to replace the 8010A's 0.1 micro-ohm current range. The 8010A and 8012A feature:
- Full voltage ranges from 0.0 to 1000 v.
- 1000V.
- 0 to 250V.
- 0 to 100V.
- 0 to 50V.
- 0 to 10V.
- 200 micro-volts.
- 20 micro-volts.
- 10 micro-volts.
- 5 micro-volts.
- 2.5 micro-volts.
- 1 micro-volt.
- 0.5 micro-volt.
- 0.25 micro-volt.
- 0.125 micro-volt.
- 0.0625 micro-volt.
- 0.03125 micro-volt.

Price of Kit (without transport mech.) £159.

Carriage and insurance £3.00

Some quotations on:
- Ferric Oxide Cassette.
- Chorme Dioxide Cassette.

FOR FURTHER INFORMATION SEE ADVERTS ON NEXT PAGE.

CHROME DIOXIDE CASSETTES

Limited quantity only. Excellent quality low noise brand (Italian). Satisfaction guaranteed. C90s only. Price per six (minimum quantity) £6 inc. VAT. P&P 75p any quantity.

FERRIC OXIDE CASSETTES

Excellent quality (Italian) C120s only. Price per 6 (min. quantity) £5 inc. VAT. P&P 75p any quantity.

This offer only applies while stocks last.

LOW COST, AUTORANGING MULTI-FUNCTION COUNTER MODEL 1900A

- Acquiring in both frequency and period measurement modes.
- Triple-frequency display, 250, 2000, 2MHz.
- High sensitivity 2µVs max. ±5%.
- ±5 digit LED display with 5 segments; automatic illumination; auto-identity.
- Dual internal batteries; battery positioning in 4 hours continuous operation.
- Automatic on when in time, full function switches.
- Four manual views with time bases; providing resolution to 0.1 Hz.
- Built-in precision and 10% errors with superlow output.
- Signal input conditioning with selectable 1.5k low pass filter and attenuator.
- Rugged mounted case with convenient lifting carrying handle.
- Front panel panel layout with electrical print and illumination.
- Traditional Fluke quality.

Price £175

Carriage and Insurance £3

PLEASE ADD 15% VAT TO ALL ORDERS

EXCEPT WHERE ITEMS MARKED "VAT INCLUDED."

CALLERS WELCOME

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Monday-Saturday

We carry a very large selection of electronic components and electrical materials. Special quotations on request.

For further details write: JVC-VICTOR, HIGH FIDELITY STEREO CASSETTE TRANSPORT MECHANISM, ELECTRO-TECH COMPONENTS LTD., 364 EDGWARE ROAD, LONDON, W.2.

T.E.L.: 01-723 5667

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ELECTRONIC KITS OF DISTINCTION FROM

DE LUXE EASY TO BUILD LINSLEY-HOOD
75W STEREO AMPLIFIER £99.30 + VAT
This easy to build version of our world-wide acclaimed 75W amplifier kit based upon circuit boards interconnected with gold plated contacts resulting in minimal wiring and construction delightfully straightforward. The design was published in Hi-Fi News and Record Review and features include rumble filter, variable scratch filter, versatile tone controls and tape monitoring whilst distortion is less than 0.01%.

WIRELESS WORLD FM TUNER £70.20 + VAT
A pre-aligned front-end module makes this Wireless World published design very simple to construct and adjust without special instruments. Features include an excellent a.m. rejection push-button station selection as well as infinitely variable tuning and a phase locked loop stereo decoder. incorporating active filters for "birdy" suppression.

LINSLEY-HOOD CASSETTE DECK £79.60 + VAT
This design, published in Wireless World, although straightforward and relatively low cost provides a very high standard of performance. There are separate record and replay amplifiers and switchable equalisation together with a choice of bias levels are also provided. The mechanism is the Goldring-Lenco CRV with electronic speed control.

TRANSCENDENT 2000
SINGLE BOARD SYNTHESIZER
As featured in Electronics Today International
The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or 1/2% metal film) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibre glass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £79!

COMPLETE KIT ONLY
£168.50 + VAT!
Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more than a multi-meter and a pair of ears!

CHROMATHEQUE 5000 5-CHANNEL LIGHTING EFFECTS SYSTEM
This versatile system featured as a constructional article in ELECTRONICS TODAY INTERNATIONAL has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound-to-light or have it strobe all the lights at a speed dependent upon music level or front panel control setting or use the internal digital circuitry which produces some superb random and sequencing effects. Each channel handles up to 500W and as the kit is a single board design wiring is minimal and construction very straightforward.

COMPLETE KIT ONLY
£49.50 + VAT
Most kits also available as separate packs (e.g. P.C.B. component sets, hardware sets, etc.). Prices in FREE CATALOGUE.

MPA200 100W MIXER/AMPLIFIER
Panelsize 19.0"x3.5". Depth 7.3"

COMPLETE KIT ONLY
£49.90 + VAT
**T20+20 AND T30+30 20W 30W AMPLIFIERS**

SPECIAL PRICE FOR COMPLETE KIT £47.70 + VAT

PRICES IN OUR FREE CATALOGUE

Following the success of our Wireless World FM Tuner Kit this time reduced model was designed to complement the T20+20 and T30+30 amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with other.

**WE’VE MOVED! NEW FACTORY UP! PRICES DOWN!**

DIGITALLY CONTROLLED, TOUCH SENSITIVE, POLYPHONIC, MULTI-VOICE SYNTHESIZER

The Transcendent DPX is a really versatile new 5 octave keyboard instrument. There are two audio outputs which can be used simultaneously. On the first line there is a beautiful harpsichord or reed sound — fully polyphonic I.e. you can play chords with as many notes as you like. On the second output there is a wide range of different voices, still fully polyphonic. It can be a straightforward piano or a harpsichord or a piano that has been tuned to the standard Western scale. Alternatively you can play strings over the whole range of the keyboard or bass over the whole range of the keyboard or should you prefer — strings on the top of the keyboard and brass at the lower end (the keyboard is electronically split after the first two octaves) or vice versa or even a combination of strings and bass sounds simultaneously. And on all voices you can switch in circuitry to make the keyboard touch sensitive! The harder you press down a key the louder it sounds — just like an acoustic piano. The digitally controlled multiple-system makes practical sensitivity with the complex dynamics law necessary for a high degree of realism. There is a major volume and tone control, a separate control for the brass sounds and also a vibrato circuit with variable depth control together with a variable delay control so that the vibrato comes in only after waiting a short time after the note is struck for even more realistic string sounds.

**PACKETS - PRICES IN FREE CATALOGUE**

To add interest to the sounds and make them more natural there is a chorus/ensemble unit which is a complex phasing system using CCD (charge coupled device) analogue delay lines. The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble quality can be controlled in with either strong or mild effects.

As the system is based on digital circuits it can be easily taken to and from a computer (or storing and playing back accompaniments with or without pitch or key change, computer control, etc.) and a 12-bit interface is provided for this purpose.

Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophisticated, the kit is mechanically extremely simple with excellent access to all the circuit boards which can be kept in any room.

The kit includes fully finished metalwork, solid teak cabinet, professional quality components (all resistors 2% metal oxide). nuts, bolts, etc. even a 1 3A plug and draught proofing and seals are used throughout. Also available as separate packs — prices in free catalogue

**COMPLETE KIT ONLY £299.00 + VAT!**

**EXPORT A SPECIALITY!**

Our Export Department can readily dispatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits.

Value Added Tax not included in prices

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**PRICE SATISFACTION Policy with confidence** Inrespective of any price changes we will honour all prices in this advertisement until April 30th, 1980. If this month’s advertisement is mentioned with your order.

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**SECURITY DELIVERY:** For this optional service (U.K. mainland only) add £1.50 per kit.

**SALES COUNTER:** If you prefer to collect your kit from the factory, call at Sales Counter. 9 a.m. to 12.30 p.m. and 1.30 to 4.30 p.m. Monday to Thursday.

**QUALITY:** All components are brand new first grade full specification guaranteed devices. All resistors (except where stated as metal oxide) are low noise carbon film types. All printed circuit boards are fibreglass, drilled copper

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<td>RANK WAVEVELOUTER MF802 £25</td>
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<td>R &amp; S RF SIGNAL GENERATOR 20HZ-100KHZ</td>
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<td>117-119</td>
<td>MARCONI WAVE ANALYSER type TF2330 20HZ-50KHZ</td>
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<td>120-122</td>
<td>R &amp; S SIGNAL GENERATOR SCR BN8.3-16</td>
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<td>123-125</td>
<td>MARCONI TF1066B AM/FM Signal Generator</td>
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<td>126-128</td>
<td>R &amp; S SPECTROSCOPE SWB BN4110 £50</td>
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<td>R &amp; S UFH TEST RECEIVER USVU BN151 0.9-2.7GHZ £120</td>
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<td>MARCONI TF1066B AM/FM Signal Generator</td>
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<td>R &amp; S UFH STANDARD SIGNAL GENERATOR 50AF £120</td>
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<td>SIEMENS THERMAL MILLIVOLTOMETER ohm 1.500V/ 0-12GHZ £120</td>
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<td>SOLARTRON SCOPES CD523S 3 Single Bech DC-10MHZ £50</td>
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<td>144-146</td>
<td>WAYNE KERR CAPACITANCE BRIDGE 541C</td>
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<td>147-149</td>
<td>TEKTRONIX SAMPLING scope type 66 complete with plug-ins</td>
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<tr>
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<td>WAYNE KERR CAPACITANCE BRIDGE 541C</td>
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<td>177-179</td>
<td>WAYNE KERR CAPACITANCE BRIDGE 541C</td>
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**Plugs-in available for above Oscilloscopes**

- **CA DC-24MHZ** Dual Trace 50mV/cm | £65 ea
- **D HIGH GAIN DIFFERENTIAL 1mV/cm** | £300 ea
- **E LOW LEVEL DC Differential 50mV/cm** | £49 ea
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- **G LOW BAND DC Differential 50mV/cm DC-20MHZ** | £20 ea
- **H DC-30MHZ 50V/cm** | £60 ea
- **I L HIGH GAIN SINGLE BEAM 5mV/cm** | £20 ea
- **J 1A4; 1S1. 1A4 4 TRACE 10mV/cm DC-50MHZ** | £75 ea
- **K SAMPLING UNIT** | £115 ea
- **L FOR MEASUREMENT of Transistor Parameters** | £100 ea
- **M Z FOR ACCURATE Voltage Measurements** | £150 ea
- **N SAMPLING UNIT** | £250 ea
- **O 151 SAMPLING UNIT** | £500 ea
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- **T HIGH SLED 1A4; 1S1. 1A4 4 TRACE 10mV/cm DC-50MHZ** | £75 ea
- **U HIGH SLED 1A4; 1S1. 1A4 4 TRACE 10mV/cm DC-50MHZ** | £75 ea
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**WIRELESS WORLD, MARCH 1980**

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Electronics Field-Technicians

Company Car

Linotype-Paul field technicians install, commission and service real time high technology systems for the printing/publishing industry. Our technicians can think logically, work alone and provide a timely, accurate service. Because they meet customers, often at high level, they also have to be diplomatic, tactful and friendly.

We want to build our team with men and women who are qualified to ONC level and have several years experience on electronics equipments which we will complement with progressive product training.

We provide a competitive salary and generous expenses and benefits. As there is considerable travel, sometimes involving overnight stays, a company car is provided which is available for private use. In time there may be the opportunity to work abroad for short periods.

We are continually expanding our markets and products and career prospects could not be better.

If you are interested contact: Personnel Department, Linotype-Paul Limited, Kingsbury Road, Kingsbury, London NW9. (01-205-0123)

Linotype-Paul

Electronics Engineers

Do not miss this opportunity!

Apply your inventor's ingenuity in designing, developing complex communication systems for commercial and military use over the next decade and beyond.

Our work demands a dedication not normally experienced in an electronics manufacturing environment. Highly skilled qualified men and women are needed to make a useful contribution in any of the hardware/software areas below:

- Digital Design
- A/D Signal Processing
- Micro-Processors
- ECM and ECCM
- Circuit Design
- Systems Analysis
- UHF/VHF Development

Send a brief C.V., give me a ring to arrange an informal chat with one of our Senior Engineers, or just complete the coupon and send it to me for further information.

Jack Burnie, Marconi Space & Defence Systems Limited, Browns Lane, The Airport, Portsmouth PO3 5PH, Tel: Portsmouth 699414.

Name
Address

Area of Interest
Tel:

Marconi Space & Defence Systems (Portsmouth)
A.G.E. Marconi Electronics Company

IMPERIAL COLLEGE
(UNIVERSITY OF LONDON)
DEPARTMENT OF COMPUTING AND CONTROL

Applications are invited for a

RESEARCH ASSISTANT

to work on an SRC funded project which involved the design of communication techniques for distribution process control, based on a network of 4LSI II microcomputers.

Candidates should have a degree in computer science or digital electronics and post graduate experience in computer communications, distributed processing, or real-time mini or micro computer systems.

The appointment will be for 2 years, with a salary on the 1A scale, £3335-£7521 (under review) plus £740 London Allowance and USS.

Applications, including curriculum vitae and the names and addresses of two referees, should be sent to Dr. M. Sloman, Computing and Control Department, Imperial College, 1983 Queen's Gate, London SW7 2BZ, from whom additional information can be obtained.

UNIVERSITY OF SURREY

ELECTRONIC/ ELECTRICAL ENGINEERING OPPORTUNITIES

Owing to the expansion of the highly successful Industrial Electronics Group in the Department of Electronics and Electrical Engineering at the University of Surrey, vacancies exist, immediately, for technicians (engineers) who are keen to further their training.

Candidates should have a degree in computer science or digital electronics and post graduate experience in non-destructive testing and signal processing fields with interest in/experience in microprocessor based Instrumentation and control systems. Some experience in control engineering or computer communications would be advantageous.

The Group at present consists of a small team of Professional Engineers and Technicians who liaise closely with academic staff in problem solving for industry. Projects usually entail the development of novel instrumentation covering communication, non-destructive testing and signal processing fields.

Applications, including curriculum vitae and the names and addresses of two referees, should be sent to Dr. M. Sloman, Computing and Control Department, Imperial College, 1983 Queen's Gate, London SW7 2BZ.

Normal hours are 371/2 per week and flexible working arrangements can be arranged. Day release is possible for study leading to higher qualifications.

The University facilities provide a wide range of social and sports opportunities. Assistance with the cost of moving house will be given where appropriate.

Candidates are advised to contact Doctor Sloman prior to application.

Contact: Mrs. J. Histon

A.V. AND VIDEO SERVICE ENGINEERS

We require service engineers with specific experience of Tape/Slide systems and/or Video. Salary according to age and experience.

Contact: Mrs. J. Histon

KADEK VISION LIMITED
Shepperton Studio Centre
Shepperton, Middlesex
(0933) 281567

138 WIRELESS WORLD, MARCH 1980
Graduate Electrical/ Electronic Engineers

Research and Development in telecommunications

The Directorate of Telecommunications, London, is responsible for the extensive and sophisticated facilities used by the police, fire, prison and associated services. The role of the Research and Development Section is to ensure that maximum benefit is derived from the use of modern techniques.

The training and experience given to Graduate Engineers — ranging from the initial interpretation of non-technical statement of requirement through to the management of design, development and contract — is carefully planned by a senior engineer and covers the training requirements of the IEE.

You should preferably be aged under 26 and must have a good honours degree in electronics or electrical engineering or an allied subject.

Salary (under review) starts at a minimum of £5035. Completion of training (usually one or two years) leads to a salary rising to £7680. Promotion prospects. Non-contributory pension scheme.

For further details and an application form (to be returned by 13 March 1980) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG 21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). Please quote Ref: T/5308.

Home Office

LIVERPOOL AREA HEALTH AUTHORITY

ELECTRONICS TECHNICIAN

— (MEDICAL PHYSICS TECHNICIAN III)

Salary Scale: £4,605 to £5,952 per annum

Applications are invited from Technicians / Engineers with good general electronics experience for the above post which will involve the maintenance/development of equipment used in the Department of Nuclear Medicine at the new Royal Liverpool Hospital.

Application form available from the Personnel Department, Royal Liverpool Hospital, Prescot Street, Liverpool 7.

Closing date: March 7th, 1980.

SOUNDOUT Laboratories, Surbiton, Surrey, who manufacture a range of professional sound equipment, are looking for an experienced TEST ENGINEER

who has had extensive experience of testing amplifiers, mixers and other audio apparatus. The post entails total responsibility for final product approval. Remuneration up to £5,000 plus profit-sharing and a total package including BUPA, 18 days annual holiday and sickness benefit.

Call John Stadius, Technical Director, on 01-399 3392.

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Saudi Arabia c £7,500 tax free

The Whittaker Corporation of the U.S.A. is responsible for the staffing and management of three general hospitals in Saudi Arabia, where the task is to provide a high standard of Health Care in this rapidly developing country.

We now wish to appoint a man with 2/3 years' experience of biomedical electronics who has successfully completed a formal course in biomedical electronic equipment repair.

The benefits package includes free accommodation, life and medical insurance and return air fare. In addition, there are bonuses of around £500 after 6 and 15 months' service and an extra months salary on completion of the 2 year contract.

Please write with full career details, or telephone 01-584 7639.


Dedicated to a world of health

Whittaker Life Sciences Ltd
Test Development Engineer

Our Test Projects Section has an opening for a Test Development Engineer. In this job he/she will be developing practical production test methods for our broad range of integrated circuits.

The work covers evaluating test methods with the designers and producing test hardware and software, through to the production of efficient test facilities for use on sophisticated computer-controlled test equipment. This requires interfacing with the production, QA and circuit design functions of our business and thus offers a unique opportunity for those who wish to broaden their knowledge of electronics.

Applicants must have a minimum qualification of HNC plus a practical engineering background.

Write or phone for an application form to Shirley Cave, Resourcing Officer, Plessey Semiconductors Limited, Cheney Manor, Swindon, Wilts. SN2 2QW. Tel. Swindon 36251.
Electronics Engineers

Linotype-Paul is in the process of expanding its Test Engineering facility throughout the production function. Recently considerable expenditure has taken place in the provision of additional sophisticated ATE facilities. We seek a number of Engineers/Technicians with experience of digital electronics who may wish to become involved in ATE Programming. Ideally some previous experience of ATE would be an advantage, although Electronics Engineers having good hardware experience in logic techniques will be provided full appropriate programming training. Consideration will also be given to recently qualified Electronics Engineers who seek their first industrial appointment. Vacancies also exist for Engineers and Technicians to provide a wide range of duties on sophisticated digital equipment. The above posts are open to both men and women. Assistance with relocation will be provided where appropriate. Please write to the Personnel Department, Linotype-Paul Ltd, Runnings Road, Cheltenham. Telephone Cheltenham 45001.

Linotype-Paul

Electronics R&D

Take your pick
HF - VHF - UHF -
Microwave Optics & Acoustics
A challenging and full career in Government Service.
Minimum qualification — HNC.
Starting salary up to £6,737.
Please apply for an application form to the Recruitment Officer (Dept. WW1), H.M. Government Communications Centre, Hanslope Park, Milton Keynes MK19 7BH.
**Wireless Technicians**

We require staff, male or female, to prepare and maintain the latest in communications equipment used by the Police and Fire Brigades in England and Wales.

You will need to be qualified to at least City and Guilds Intermediate Telecommunications standard and be able to demonstrate practical skills in locating and diagnosing faults in a wide range of equipment from computer based data transmission to FM and AM radio systems. You would live near to and work from one of our service centres located at Andover, Hants; Bishops Cleeve, Gloucecs; Hannington, Basingstoke, Hants; Shapwick, Somerset; Harrow, Middlesex.

Specialised courses or training are run to assist staff to keep up to date with developments and new equipment and there are opportunities for day release to gain higher qualifications. Applications from registered disabled persons will be considered.

Promotion prospects are good and the work represents a secure future with generous leave allowance and non-contributory pension scheme.

Possession of a driving licence is essential since some travelling will normally be involved.

The salary scale is as follows: £3,900; £4,160; £4,420; £4,680; £4,940; £5,200; £5,530.

If you are interested in working with us, then write for further details and application form to:

Mr. C. B. Constable, Directorate of Telecommunications, Horseferry House, Dean Ryle Street, London SW1P 2AW. Telephone 01 211-5293.

---

**INSTRUMENTS & ELECTRONICS SUPERVISOR**

DRG Flexible Packaging is one of Europe's largest converters of protective packaging materials using a wide variety of sophisticated plant and machinery.

There is a vacancy for a Supervisor in the instruments and electronics section of the engineering department. The section consists of six electronics and three industrial technicians and is responsible for the maintenance and development of industrial electronic equipment including photo-electric, process control and measuring equipment and machine drives. The section works mainly double shift (although it serves a treble shift factory) but the Supervisor's job is a day position. The successful applicant will have had several years' experience in electronics and hold a relevant qualification such as City and Guilds Full Technical Certificate.

The Company offers a competitive salary, 4 weeks' holiday a year, a contributory pension scheme and other benefits associated with working for a large company.

Applications should be made in writing, giving brief career details and current salary to:

Mr. P. Hawkins

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Fishponds, Bristol BS16 3RY

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---

**SCOTTISH HOME AND HEALTH DEPARTMENT**

**Wireless Technician**

Applications are invited for one post of Wireless Technician in the Scottish Home and Health Department.

**Location:**

The post is in Inverness.

**Qualifications:**

Candidates must hold an Ordinary National Certificate in Electronic or Electrical Engineering or a City and Guilds of London Institute Certificate in an appropriate subject or a qualification of a higher or equivalent standard.

**Experience:**

3 years' appropriate experience.

**Starting Salary:**

£3,900, scale maximum £5,530.

Applicants should have sound theoretical and practical knowledge of Radio Engineering and Radio Communications equipment in HF, VHF and UHF bands. The work involves installation and maintenance of equipment located at considerable distance from headquarters. A current driving licence and ability to drive private and commercial vehicles are essential.

The appointment is unestablished initially but there is prospect of an established (i.e. permanent) appointment after 1 year's satisfactory service.

Application forms and further information are obtainable from Scottish Office Personnel Division, Room 110, 16 Waterloo Place, Edinburgh EH1 3DN (quote ref: PM(PTS) 3 /2 /80) (031-556 8400, Ext. 4317 or 5028).

Closing date for receipt of completed application forms is 18 April, 1980.
R & D Engineers

required to work on digital circuits for
micro-processor based industrial and commercial
systems.

The candidate should have a working knowledge of
TTL and CMOS logic and have experience of
programming at assembler language level for
micro-processor systems.

Engineers should hold a degree/HNC or equivalent
qualifications. Salary will be commensurate with
qualifications, age and experience.

If you are seeking an enjoyable position involving
both hardware and software development, write
giving your career to date or telephone

Dr. G. O. Towler
(New Product Development Manager)
British Relay Electronics Ltd.
32 Biggin Way
Upper Norwood
London, SE19
Tel. 01-764 0931

RADIO OFFICERS

If your trade or training involves radio operating, you
qualify to be considered for a Radio Officer post with the
Composite Signals Organisation.

A number of vacancies will be available in 1980/81 for
suitably qualified candidates to be appointed as Trainee
Radio Officers. Candidates must have had at least 2 years' radio
operating experience or hold a PMG, MPT or MRGC
certificate, or expect to obtain this shortly. Registered
disabled people may be considered.

On successful completion of 40 weeks' specialist training, appointees move to the Radio Office Grade.

Salary Scales:

<table>
<thead>
<tr>
<th>Age</th>
<th>Trainee Radio Officer</th>
<th>Radio Officer</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>£3271</td>
<td>£4493</td>
</tr>
<tr>
<td>20</td>
<td>£3382</td>
<td>£4655</td>
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<tr>
<td>21</td>
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<td>£4844</td>
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<tr>
<td>24</td>
<td>£3767</td>
<td>£5559</td>
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<tr>
<td>25+</td>
<td>£3856</td>
<td>£5899</td>
</tr>
</tbody>
</table>

then by 5 annual increments to £7892 inclusive of
shift working and Saturday, Sunday elements.

For further details telephone Cheltenham
21491 Ext. 2269, or write to the address
below.

SIP, Recruitment Office
Government Communications Headquarters
Oakley, Priors Road, Cheltenham GL52 5AJ

SENIOR ELECTRONICS ENGINEER
Gloucestershire

The Company, pleasantly situated on the
outskirts of Cheltenham, is a leading
manufacturer of aircraft gas turbine fuel systems
and associated equipment. Our Electronics
Laboratory has a vacancy for an experienced
Electronics Engineer to join a small team
engaged in the design and development of
special purpose prototype instrumentation and
control equipment.

Applicants, male or female, educated to at least
HNC/HND standard or equivalent should have
practical experience in current digital and
analogue design techniques.

In addition to a competitive salary, we offer
excellent fringe benefits including a self-
financing productivity scheme and excellent
pension scheme. Generous assistance with
relocation expenses to this desirable Cotswolds
area will be given where appropriate.

Please write giving details of career to date and
salary expectations to: The Senior Personnel
Officer, Dowty Fuel Systems Ltd. Arle Court,
Cheltenham or telephone. Cheltenham 21411
Ext. 163 for further details and an application
form.

DOWTY

Rogers BRITISH HIGH-FIDELITY

We require two additional qualified
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to work in our acoustics and electronics divisions on the testing and development
of our prestige range of loudspeakers, amplifiers and tuners.

The electronics post is based at our factory in London S.E. 6, within 20 minutes
of Central London, as is the acoustics post which is based at our Wadhurst
Loudspeaker Division.

Both positions offer a competitive salary with fringe benefits. Applicants should
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MR. M. S. SCED
Technical Director
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4/14 Barmeston Road, London SE6 3BN

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Limited

Electronic Engineers
Worldwide Airborne Surveys

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A wide spectrum of electronics is covered with a growing emphasis on microprocessor based devices. Qualifications or experience to HNC standard together with a flair for fault diagnosis, solving interfacing problems and mechanical packaging ability is desired.

Persons interested in joining our teams or who require further information should apply to:

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Hunting Surveys
& Consultants Limited,
Elstree Way, Borehamwood,
Herts, WD6 1SB.
Appointments

Calling All
Engineers

Up to £19,000
Per contract year after tax

The Communications Department of Aramco, the world’s largest oil producer, based in Saudi Arabia, urgently requires

MICROWAVE ENGINEERS experienced in microwave system project management and design, with practical knowledge in one or more of the following: Telephone, mobile radio, analog-digital communications and control systems.

UHF/VHF ENGINEERS experienced in mobile UHF/VHF systems project management and design and practical experience in one or more of the following: Microwave, telephone, analog-digital communications and control systems.

SENIOR FIELD CONSTRUCTION SPECIALISTS/FIELD CONSTRUCTION SPECIALISTS to install and commission electronic instrumentation and data acquisition systems. Experienced in trouble shooting complex digital electronics at the system, card and component levels. Familiarity with electronic test equipment, digital diagnostic test procedures and equipment as applied to mini-computers and/or other digital systems.

PLANNING & SCHEDULING ENGINEERS to evaluate schedules, implementation and control analysis and, if necessary, initiate corrective action. There are also requirements for Engineers & Technicians in INSTRUMENTATION, ELECTRICAL & ELECTRONICS disciplines, £14,500 - £19,000

All positions require at least HNC and 10 years experience.

Renewable contracts, single status.

12 days Public Holidays per year.

Leave for married men - 14, 14, 25 days after each 4 month period per contract year.

Leave for single men - 30 days after 12 months.

Free Medicare.

Valid U.K. Driving Licence essential.

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Write with career details quoting ref: ww/2

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All the others are measured by us...

At Marconi Instruments we ensure that the very best of innovative design is used on our range of communications test instruments and A.T.E. We have a number of interesting opportunities in our Design, Production and Service Departments and we can offer attractive salaries, productivity bonus, pension and sick pay schemes together with help over relocation.

If you are interested to hear more, please fill in the following details:-

Name Age

Address

Telephone Work/Home (if convenient)

Years of experience 0-1 1-3 3-6 Over 6

Present salary £2,500-£3,500-£4,500-over

Qualifications None C & G HNC Degree

Present job

Return this coupon to John Prodger, Marconi Instruments Limited, FREEPOST, St. Albans, Herts, AL4 0BR. Tel: St Albans 59292

Marconi Instruments
DEVELOPMENT ENGINEER
To work on the design of new broadcast TV studio products. Applicants should have some knowledge of television studio techniques and be qualified to HND or Degree level.

TEST ENGINEERS
At senior and intermediate level to work on our range of advanced broadcast television studio products, including colour and monochrome television studio cameras.
Applicants should have an up-to-date knowledge of digital and linear circuit techniques gained from experience working on television studio equipment, radar equipment or similar sophisticated products and qualified to HND, HNC or equivalent level.

SYSTEMS ENGINEER
You would be involved in all stages of product management on the design and building of studio and mobile TV systems and should be prepared for occasional world-wide travel. The appointment requires someone with a background in this type of work, or in the operational side of television with the ability to take charge of people and deal with problems in the field on your own initiative.
Employment benefits include excellent salary, generous holidays, free life and health insurance, pension scheme, subsidised meals and relocation expenses.

Please apply for further details and application forms to Jean Smith at the address given below.

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GLYN HOUSE, CHURCH STREET, EWELL
The Centre is within easy reach of main line railway stations and on bus routes, convenient for shops. There is ample free parking available on site.

Field Service Engineer
(Electronic A/V Equipment) (M/F)
£4317–£4770
To carry out on-site service, including fault finding, on schools' audio visual equipment, e.g., language laboratories, TV/Video installations, radio systems, Hi-Fi, etc.
Some of the time, you will be engaged in bench service at the Centre workshop. Experience in the maintenance/repair/fault diagnosis of some, or all, of the above is essential, and practical experience is vital. You should possess City & Guilds or ONC and experience in digital equipment is highly desirable.

Installation/Field Service Engineer
(M/F)
£4317–£4770
To carry out installation/repair work of school fixed A/V systems, wiring of radio lines, aerials (not roof work), language laboratory trunking, etc. This will involve installing screens in school classrooms (drilling walls, etc.), installing study carrels, etc., relocating language laboratories, moving all services, furniture, etc., and re-installing in new positions. Also some bench work at the Centre, dealing with repair of some A/V items. You should possess ONC or City & Guilds and practical experience of installation work together with a working knowledge of A/V systems.

Applicants will be expected to use their own transport for travelling to establishments — an appropriate car allowance is payable.
Application forms from Mrs S. Goode, Administrative Officer at the Centre, Tel: 01-393 0208.

MIDDLE EAST
Precision Measuring Equipment Technicians
The Northrop Corporation, a major US aerospace company, is seeking experienced personnel for their support operations at a number of locations in Saudi Arabia.
Qualified to C & G/ONC or equivalent, you should have at least 5 years' laboratory experience on the calibration and testing of avionics systems and related ground based equipment.
This is an opportunity to secure a sound financial future for yourself and to become involved with the latest developments in electronics technology. The employment package includes:
   * 1 year renewable contract
   * Good bachelor accommodation
   * Regular home leave
   * Excellent recreational facilities
Please contact us quoting ref. 84 PMT.

INTERNATIONAL RECRUITMENT CONSULTANTS,
45 KENSINGTON HIGH STREET, LONDON W8 5ED.
TEL: 01-937 6586 TELEX: 21879 ATT WEBB WHITLEY.
Opportunities for Radio Hazards and Microwave Engineers

At EMI Electronics Ltd. Feltham, we are involved in the design and development of high technology equipments. Thanks largely to the high calibre of its staff, the Company is already a recognised authority in this sphere and is rapidly gaining an international reputation for its specialized equipment and expertise.

Radio Frequency Engineers
To join the existing team engaged in work associated with the assessment of the radio frequency characteristics of a variety of weapon systems. The work currently in hand includes the definition of user requirements, the generation of new analytical and measurement techniques, the development of new forms of miniature radio frequency and analogue instrumentation, and the performance of field trials.

We are looking for engineers with a relevant degree or equivalent qualifications together with up to five years' post-degree experience. Vacancies also exist for less experienced graduates with an interest in this exciting field.

Microwave Development Engineers
To join our radiation laboratory for work on the design and development of microwave components, aerials and systems for ground and airborne applications.

The people we are looking for include graduates with one or two years' post-degree experience in an appropriate field. New graduates with a good degree in physics or electronic engineering and who are looking for an exciting career in the microwave field are also invited to apply.

EMI offers competitive salaries of circa £7,500 for the senior posts, excellent experience and career prospects as well as good employment conditions and substantial fringe benefits. Relocation expenses will be paid where appropriate.

To apply, telephone or write to Lisa Kleinhorn, Personnel Officer, EMI Electronics Ltd., FREEPOST, Victoria Road, Feltham, Middlesex. (NO STAMP REQUIRED). Tel: 01-890 3600 ext 117 or 01-751 0702.

EMI Electronics Limited, Feltham.

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LONDON — BRISTOL — MANCHESTER — GLASGOW

Our Company specialises in both sales and servicing of Discotheque Sound and Lighting equipment. We currently have vacancies for engineers who have had previous experience of either HiFi, Studio PA or similar equipment. Excellent salary plus quarterly bonus and P.P.P. Please telephone or write to Andree Mead, Personnel Director for further details.

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Barnet Trading Estate, Park Road, Barnet, Herts EN5 5SA
Telephone: 01-441 1919

TELECOMMS ENGINEERS/TECHNICIANS
for Saudi Libya Nigeria
Salaries to £22,000 p.a.
for degreed Switching Engineers, External Plant Engineers, Microwave and Mux Engineers. Minimum qualifications must be BSc or equivalent.

Salaries to £12,000 p.a.
for Telephone Technicians with digital PABX experience, Radio Technicians, Telex/Telex Installation and Repair Technicians.

All salaries are paid tax-free plus accommodation and transportation.

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The White House, 12A Lodge Road, Hendon, London NW4
Tel. 01-203 4272
RF pollution control wasn’t so critical in the first crystal age

Electronics Engineers/Physicists to specialise in interference technology

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Pleasantly situated in purpose-built laboratory units at Titchfield, Hampshire, we’re a well-established and rapidly expanding test house offering in-depth specialist services to a wide variety of Government and industrial organisations.

Strengthening an existing team of experts in one of the most advanced computer-aided testing facilities in Europe, you’ll be responsible for evaluating the effects of across-the-spectrum electro-magnetic interference on a wide range of electronic equipment.

Ideally, you should have analogue or digital experience, together with a relevant qualification, and knowledge of radio frequency measurement techniques.

Lack of experience in interference technology should not be a bar to applicants since training can be arranged.

There are opportunities at all levels from Assistant Engineer upwards with salaries to suit up to £7,500, plus benefits including generous relocation expenses where appropriate.

Contact Richard Wyatt, Recruitment Manager, on Titchfield 0329 43031 or write to him at Plessey Assessment Services Limited, Titchfield, Fareham, Hampshire, PO14 4QA.

Plessey assessment services
Calibration and Maintenance Engineer

We'd like to start by asking you a few pertinent questions:

- Do you enjoy working with digital and analogue measuring and test equipment?
- Can you maintain, calibrate and program microcomputer-based ATE?
- Do you have ONC, HNC or something similar in Electrical/Electronic Engineering or can you match it with relevant experience?
- Are you looking for more technical and professional challenge and an environment where an ambitious product development programme is investing no less than £2 million in new test facilities for the 80s?

If the answer is 'Yes', you could be the man or woman we need to join the small metrology team based at the Brighton manufacturing plant of ITT Creed, Part of ITT Business Systems Group Ltd., already one of the leading names in data comms - and fast becoming a world leader. There will be occasional travel to other ITT locations: a current driving licence would be essential.

Salary is attractive, there's an excellent range of benefits - and our location offers the pleasant choice of living by the sea or in the country.

For an application form and more information, please contact Hazel Johnson, ITT Creed Limited, Hollingbury, Brighton BN1 1AL.

Tel. Brighton 50 1111 Ext. 3521. Outside office hours please leave a message on our answering machine.

ITT Creed Limited

GWM RADIO LTD., of radio telephones

PNEUMATIC MASTS

£43.

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Details. AVO movements.

Type

Road, Worthing, Sussex, Tel: 01903 637437.

We can design for RECORDING QUALITY, STUDIO QUALITY, HI-FI QUALITY, OR P.A. QUALITY. PRICES ARE HIGHLY COMPETITIVE AND WE SUPPLY LARGE OR SMALL QUANTITIES AND EVEN SINGLE TRANSFORMERS. Many standard types are in stock and normal dispatch times are short and sensible.

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For details and inspection please contact:

Mr. G. Peabody
Walker Engineering Ltd.
Staveley, Derbyshire S43 3JN

Telephone: 0246.87-2147

Telex: 547323

SOWTER TRANSFORMERS

Manufacturers and Designers

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Suffolk, P.O. Box 36 Ipswich IP1 2EL, England

Phone: 01472 527246 & 01472 219390

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OUR CLIENTS COVER A LARGE NUMBER OF BROADCASTING AUTHORITIES, MIXING DESKS, MANUFACTURERS, RECORDING STUDIOS, HI-FI ENTHUSIASTS, BAND GROUPS, AND PUBLIC ADDRESS FIRMS. Export is a specialty and we have overseas clients in the COMMONWEALTH.

Send for our questionnaire which, when completed, enables us to post quotation by return.

SOWTER TRANSFORMERS

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Suffolk, P.O. Box 36 Ipswich IP1 2EL, England

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