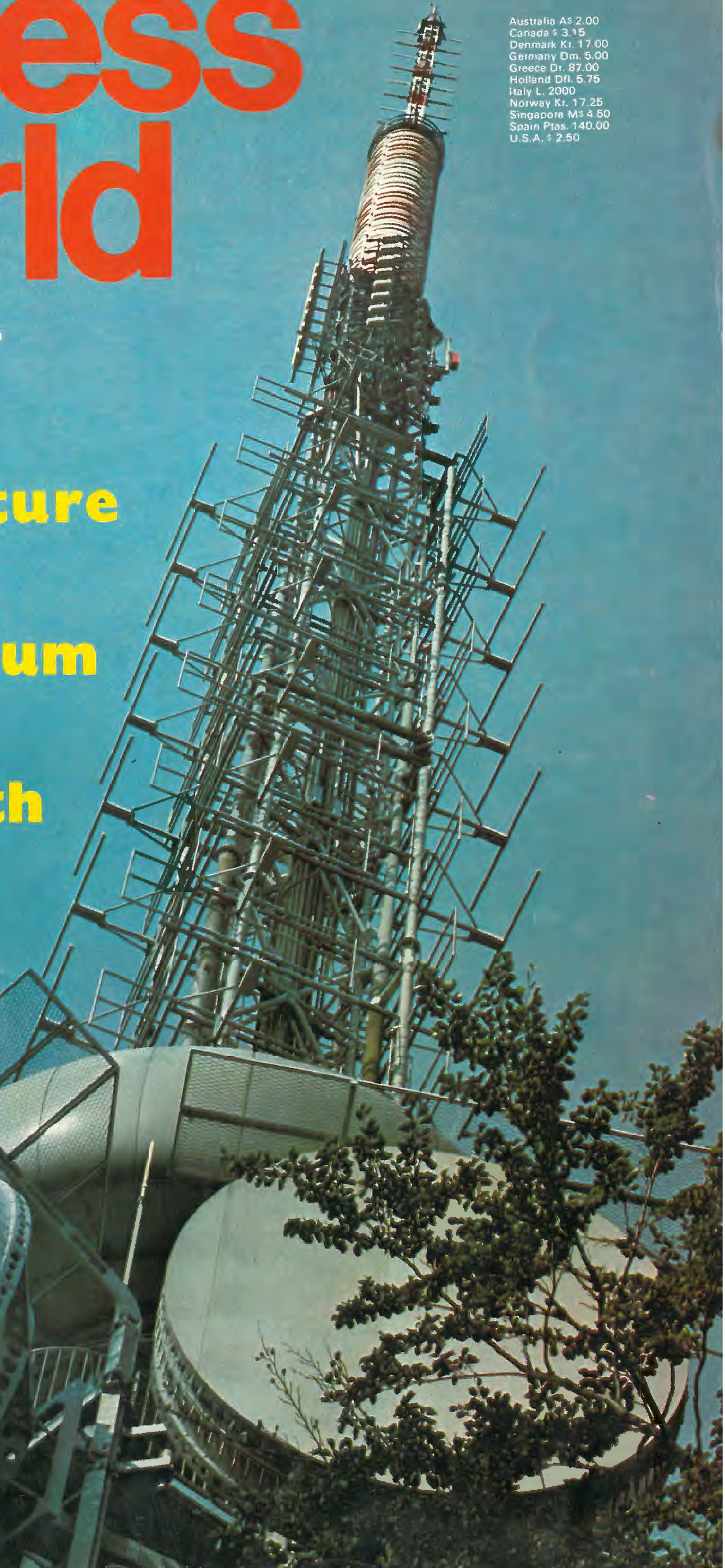
wireless world

Australia A$ 2.00
Canada $ 3.15
Denmark Kr. 17.00
Germany Dm. 5.00
Greece Dr. 87.00
Holland Dfl. 5.75
Italy L. 2000
Norway Kr. 17.25
Singapore M$ 4.50
Spain Ptas. 140.00
U.S.A. $ 2.50

MAY 1980 50p



Weather Picture Processor

Audio Spectrum Analyser

Designing with Micros

Careers in Electronics

WIRELESS WORLD MAY 1980 VOL 86 NO 1532

wireless world

Australia A$ 2.00
Canada $ 3.15
Denmark Kr. 17.00
Germany Dm. 5.00
Greece Dr. 87.00
Holland Dfl. 5.75
Italy L. 2000
Norway Kr. 17.25
Singapore M$ 4.50
Spain Ptas. 140.00
U.S.A. $ 2.50

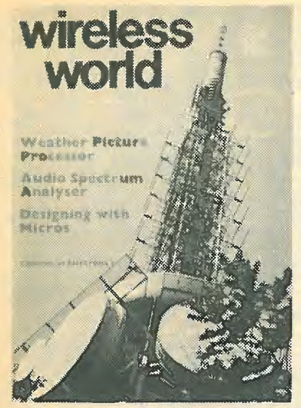
MAY 1980 50p

Weather Picture Processor

Audio Spectrum Analyser

Designing with Micros

Careers in Electronics



Front cover shows aerials of Bantiger television station operated by Swiss PTT. Photo: the Hamer-Smith Swiss collection.

IN OUR NEXT ISSUE

Wideband audio amplifier **design by Yuri Miloslavskij aims at good transient response using class A circuitry and no overall feedback.**

Constructional design for *multisection tone equalizer* is made inexpensive by use of quad op-amps and preset controls.

Also **articles on community broadcasting, an unusual technique for metal detecting and analogue computing methods. For details of these see panel on page 85.**

Current issue price 50p, back issue (if available) £1.00, at Retail and Trade Counter, Paris Garden, London SE1. Available on microfilm: please contact editor.
By post, current issue 86p, back issues (if available) £1.00, order and payments to Room CP34, Dorset House, London SE1 9LU.
Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.
Telephones: Editorial 01-261 8620. Advertising 01-261 8339.
Telegrams/Telex: Wiworld Bisnespres 25137 BISPRS G. Cables Ethaworld, London SE1.
Subscription rates: 1 year £9.00 UK and $31 outside UK.
Student rates: 1 year, £4.00 UK and $15.50 outside UK.
Distribution: 40 Bowling Green Lane, London EC1R ONE. Telephone 01-837 3636.
Subscriptions: Oakfield House, Perrymount Road, Haywards Heath, Sussex RH16 3DH. Telephone 0444 59188. Please notify a change of address.
USA mailing agents: Expediters of the Printed Word Ltd, 527 Madison Avenue, Suite 1217, New York, NY 10022. 2nd-class postage paid at New York.

ISSN 0043 6062

ibpa ABC

wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

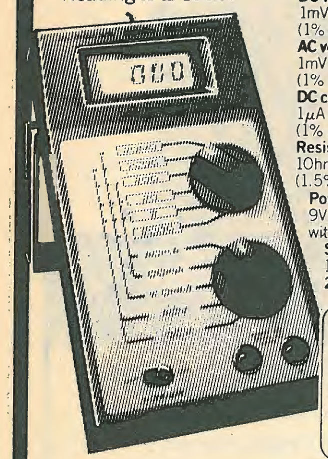
MAY 1980 Vol 86 No 1533

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.
Reading to ± 1999.

Scales:
DC volts: 1mV to 1000V (1% ± 1 digit accuracte).
AC volts: 1mV to 500V (1% ± 2 digits accurate).
DC current: 1μA to 200mA (1% ± 1 digit accurate).
Resistance: 10hm to 20 MOhms (1.5% ± 1 digit accurate).
Power source: 9V battery or AC with optional adaptor.
Size: 155 x 75 x 30 mm.
22–198

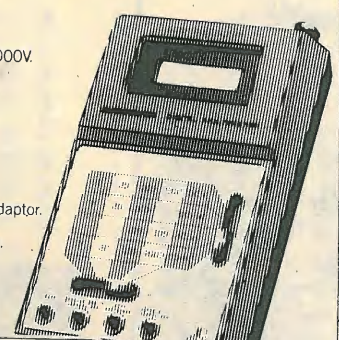


PRICE **53·19**

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 adaptor.
Size: 37 x 85 x 130 mm.
22–197



PRICE **39·93**

COMPONENTS AND PARTS

CAT. No.	DESCRIPTION	PRICE
276–032	LED	4 for 69p
276–033	LED	2 for 48p
276–034	LED	2 for 59p
276–142	Infra-Red Emitter Detector Pair	£1.37
277–1003	12V DC Automotive Digital Clock Module	£17.52
276–9110	6 pin edge connector for 277 1003	40p
276–1373	Power Transistor Mounting Hardware	50p
276–1363	TO 220 Heat Sink	60p
276–1364	TO 3 Heat Sink	81p

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 250mV/DIV. **Vertical axis:** Deflection sensitivity better than 10mV/DIV (1DIV 6mm). Bandwidth: 0.8MHz. **Input impedance:** 1MOhm parallel capacitance 35pF. **Time base: Sweep range:** 10Hz 100kHz (4 ranges). Synhronization: Internal ( ) **Size:** 200 x 155 x 300 mm. Supply: 220/240 /50Hz. **22–9501.**

PRICE **137·36**

You save because we design, manufacture, sell and service.
Tandy have over 7,000 stores and dealerships worldwide. Over 2,500 products are made specifically for or by Tandy at 16 factories around the world. The quality of our products has been achieved by over 60 years of continuous technological advancement.

KNOWN AS RADIO SHACK IN THE U.S.A. MAKERS OF THE WORLD'S BIGGEST SELLING MICROCOMPUTER TRS80

TANDY

The largest electronics retailer in the world.
Offers subject to availability. Instant credit available in most cases.
OVER 170 STORES AND DEALERSHIPS NATIONWIDE.

TANDY DEALER

Most items also available at Tandy Dealers. Look for this sign in your area.

Access, Barclaycard and Trustcard welcome.

WW—026 FOR FURTHER DETAILS

INPUT FROM PHILIPS TEST & MEASURING INSTRUMENTS

NO WAITING FOR THESE TOP PRODUCTS

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

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 0RN. Tel: 01-808-4884. **Philips Service Centres** (25 throughout the country). Tel: 01-686-0505 for the address of your nearest branch. **Wessex Electronics Ltd,** 114-116 North Street, Downend, Bristol BS16 5SE. Tel: (0272) 571404.

PATTERN FOR THE FUTURE

The **PM 5519** colour TV pattern generator is already a widely used instrument. As a major manufacturer of Video cassette recorders, and colour television receivers - and the company which has developed the world's most advanced video disc system - Philips have carefully selected the best patterns for aligning and testing these products. With over 20 colour and b/w test patterns to choose from it is the most versatile pattern generator on the market.
- **PM 5519 I** for British system - versions available for other TV systems
- RF signals available in bands I, III, IV and V
- Variable Video Output (with 1 volt fixed position)
- External video and sound modulation facility
- Composite sync output for triggering - includes the line frame and blanking pulses to the local TV standard

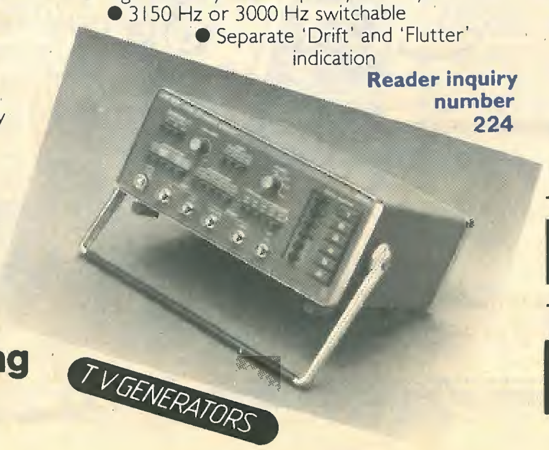
Reader inquiry number 222

Some other Philips audio and video service instruments:
PM 5326 RF SIGNAL GENERATOR
- 100 kHz-125 MHz in 9 overlapping ranges
- Built-in 5 digit counter
- 50mV RF output at 75Ω can be attenuated to over 100dB
- Electronically stabilised output level
- Wobbulator facility

Reader inquiry number 223

PM 6307 WOW AND FLUTTER METER
- X-tal controlled oscillator
- High accuracy and frequency stability
- 3150 Hz or 3000 Hz switchable
- Separate 'Drift' and 'Flutter' indication

Reader inquiry number 224



All Philips audio and video service instruments are also available from Philips Service Centres (for details see end of PM 3207 section).

Input advertisements are designed to meet the needs of our professional customers. They are a shop window for Philips Test and Measuring Instruments - and we will be changing the display frequently because we have a lot of products to show you.
Where you require full information about a product, tick the coupon and attach it to your name and address, or letterhead - or, of course, use the journal's reader inquiry service. You will receive in return a detailed information pack reflecting your specific requirements.

	Inquiry no.	
PM 2517 multimeter	220	☐
PM 3207 oscilloscope	221	☐
PM 5519 colour TV pattern generator	222	☐
PM 5326 RF signal generator	223	☐
PM 6307 wow and flutter meter	224	☐

Pye Unicam Ltd
Philips Electronic Instruments Dept.
York Street, Cambridge, England CB1 2PX
Tel Cambridge (0223) 358866 Telex 817331

PHILIPS

PHILIPS **Test & Measuring Instruments**

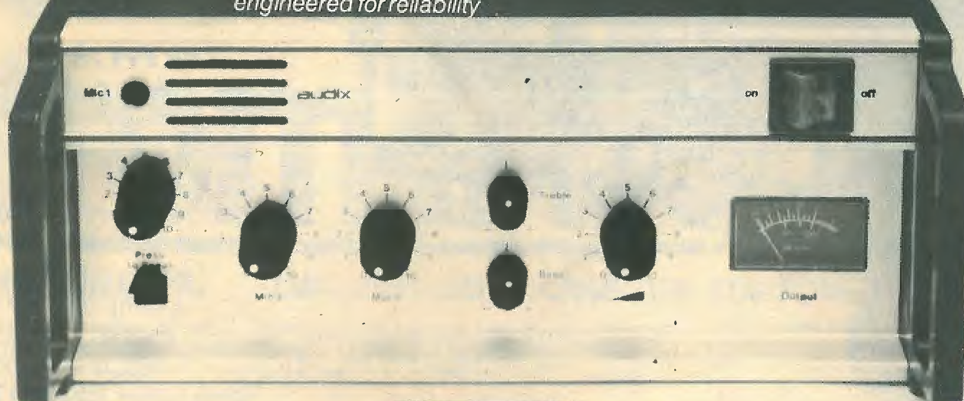
WW — 039 FOR FURTHER DETAILS

BUILT FOR RELIABILITY

Newport Range –

Sound reinforcement and public address amplifiers; 30, 60, 120 or 200 watts – with a range of 10 models for free standing and rack mounting use –

engineered for reliability



Newport with inbuilt microphone and call key

audix

Audix Limited, Station Road, Wenden, Saffron Walden, Essex CB11 4LG

Tel: Saffron Walden (0799) 40888; Telex: 817444

CROPICO - A CERTAIN MEASURE OF PERFECTION

Cropico, established as one of Britains leading manufacturers of precision electrical measuring equipment, offer a wide range of instruments which have been proved for accuracy and performance throughout the world.

Resistance Boxes	D.C. Null Detectors
Resistance Bridges	Digital Temperature Indicators
Resistance Standards	Electronic Standard Cell
D.C. Potentiometers	Multimeters, Digital or Analogue
Thermocouple Reference Junctions	Wattmeters, Digital or Analogue
	Insulation Test Sets
Thermocouple Switches	Earth Resistance Meters
Pt 100 Switches	Fluxmeters
Pt 100 Simulators	And many more

Cropico – Britains leading manufacturer, exporter and importer of precision electrical measuring equipment.

Request full details — Visitors Welcome

CROPICO LTD., Hampton Road,
Croydon CR9 2RU
Telephone: 01-684 4025 and 4094
Cables: CROPICO-CROYDON
Telex: 945632 CROPCO G

CROPICO

WW—016 FOR FURTHER DETAILS

The sound of science.

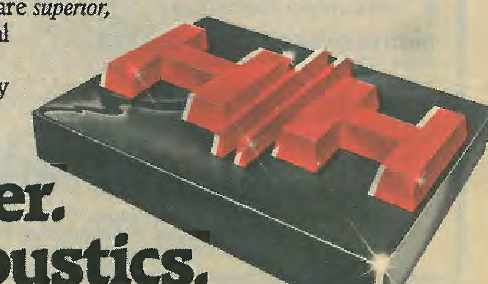
We wouldn't knock our rivals.

After all, it was they who inspired us to design and manufacture our own power loudspeakers . . . because of the frustration we experienced when trying to obtain power loudspeaker components for our enclosures. Nobody could consistently supply components to the exacting HH standards of quality, power and performance – at any price.

So, our designers started from a clean drawing board and were prepared to defy convention in the construction of a *superior* power loudspeaker. Our powerful computer calculated optimum cone profiles, whilst our scientists pushed back the frontiers of adhesives technology to develop new construction methods. Then we tested them relentlessly and did our best to destroy these new products (that was the hardest part.)

Now this range of *superior* power loudspeakers, crossover networks, "bullet" radiators, compression drivers and horns can be purchased at sensible prices from HH dealers. In their new and convenient packs you will also find an applications book, full of useful hints.

Send for our brochure, so you can convince yourself why our components are *superior*, by following our logical scientific arguments. Then you'll realise why we never need to knock our "rivals".



Power to the Performer.
HH Acoustics.

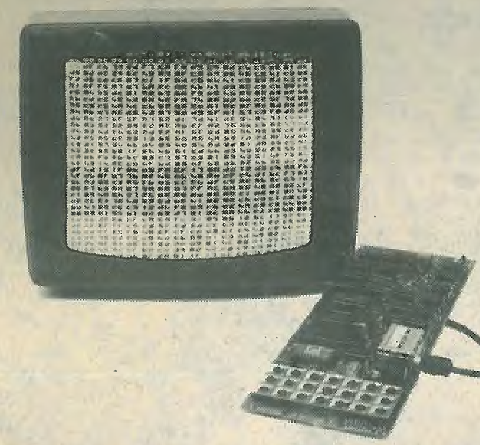
HH Acoustics Limited, Viking Way, Bar Hill, Cambridge CB3 8EL. Telephone: (0954) 81140. Telex: 817515 HH Elec G.

DAL 9095

WW — 018 FOR FURTHER DETAILS

SOFTY Software Development System

EX-STOCK



MICROSYSTEM DEVELOPMENT USING SOFTY

SOFTY is intended for the development of programs which will eventually become software residing in ROM and forming part of a microsystem. During the development stage of a microsystem, SOFTY will be connected in place of the firmware ROM via a ribbon cable, terminated in a 24 pin DIL plug.

Data may be entered into the SOFTY RAM via the **serial port, parallel port, direct memory access, or the keypad,** and manipulated using the **assembler key-functions.** When the program has been entered, the internal microprocessor can be 'turned off', and the external microsystem and its resident microprocessor allowed to access and run the program in SOFTY's RAM and/or programming socket. In this way modification can be made until the required program is complete — **the contents of the RAM being clearly visible as a 'page' on TV or monitor.** 4 pages are available, 2 of the Data RAM an 2 of the programming socket.

In the end, when the program is complete and working, the DIL plug is removed and replaced by an EPROM device programmed by SOFTY. **SOFTY is able to program the 2704/2708/2716 family** which have 3 voltage rails — we supply with each SOFTY details of a simple modification which allows SOFTY to program the single rail 2716/2732, etc.

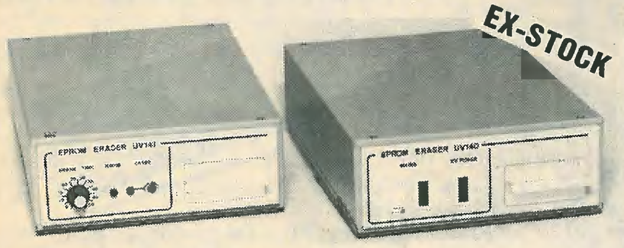
(If you want to program EPROMs/PROMs other than the 2704/2708/2716 family, we may be able to help you — our range of add-on Programming Modules is currently under development.)

To help in the process of program development SOFTY has various assembler key-functions, which include — **block shift without overwriting, block store, cursor control, match byte and displacement calculations (for jumps, etc.) A high speed cassette interface** is also provided for storing working programs and useful subroutines. Software is supplied for serial data transfers — which means that you can write an assembler for your favourite MPU in BASIC on your Superboard, UK101, NASCOM, etc. and transfer the hex code directly to EPROM via SOFTY. The serial transfer program runs in the scratchpad and can be easily loaded from cassette, or the programming socket. Besides software development and EPROM programming, SOFTY has other uses — as a **training aid,** or as a **control computer** in its own right, with up to **2K bytes firmware, 1K of RAM, 22 I/O ports and Direct Memory Access.**

SOFTY Kit-of-parts (including zero insertion force socket for EPROM programmer, ribbon cable and 24 pin D.I.L. header plug for connection to the system under development).
Price £115 (inc. VAT, p&p).
SOFTY power supply kit £23 (inc. VAT, p&p)
SOFTY built and tested £138 (inc. VAT, p&p)
Write or telephone for full details

MODEL 14 EPROM ERASERS

EX-STOCK



MODEL UV141 EPROM ERASER

- Fast erase times (typically 20 minutes for 2708 EPROM)
- 14 EPROM capacity
- Built-in 5 to 50 minute timer to cater for all EPROMs
- Safety interlocked to prevent eye and skin damage
- Convenient slide-tray loading of devices
- MAINS and ERASE indicators
- Rugged construction
- Priced at only £89.70 (inc VAT, p&p)

MODEL UV140 EPROM ERASER

Similar to Model UV141 but without timer
Low price at only £70.73 (inc. VAT, p&p).

WRITE OR TELEPHONE FOR FULL DETAILS OR SEND CHEQUES/OFFICIAL COMPANY ORDERS TO:

GP Industrial Electronics Limited

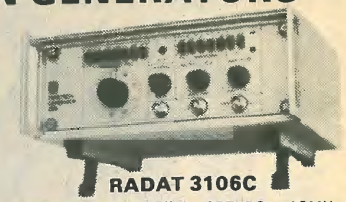
(Retail Sales), Skardon Place, North Hill, Plymouth PL4 8HA. Telephone: Plymouth (0752) 28627
TRADE AND EXPORT ENQUIRIES WELCOME

WW—006 FOR FURTHER DETAILS

LOW COST SCOPES AND FUNCTION GENERATORS

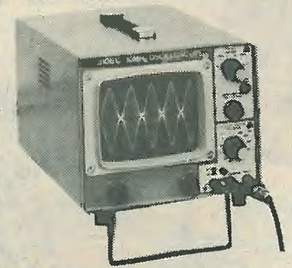
RADAT 2301

10V sine, rectangular, triangle outputs, with or without offset, up to 3MHz into 50Ω. Stability ≥ 1% over 24h. TTL output. Rise and fall times 50ns into 500. **As recommended by Practical Wireless £148 + VAT.**

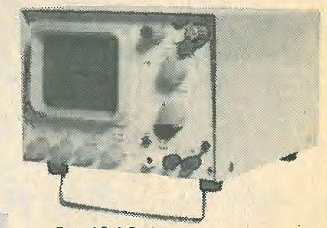


RADAT 3106C

FEATURES: Large 5" flat CRT. DC to 10MHz bandwidth -3db 10mV to 50V/cm in 12 calibrated steps 0.5HS to 0.01 sec/cm sweep range 182x200x400mm. 4.5 kilo weight. Magnifier x5. Fully automatic trigger. DC to 2MHz horizontal bandwidth. **As recommended by Practical Wireless £148** + VAT.



ELMAC 4810 CRT 5MHz scope £120 + VAT. **As recommended by ETI.** The best selling 5MHz 4" CRT scope in the UK. Timebase include sweep range — 100 msec/div to 1µ sec/div in 5 steps. **3" also available. £96** + VAT.



Free 10:1 Probe
Elex 5810 5" CRT (12.5MHz) £181.71 + VAT. Vertical axis. 1 deflection sensitivity - 10mV/div Bandwidth — DC:DC 12.5MHz (between 3dB points). AC: 2Hz 12.5MHz (between 3dB points). Rise time-20n sec. Input Attenuator - 12 step - 10mV/div to 50V/div in 1-2-5 sequence calibrated. Time Base — Sweep range - 0.5µ sec/div to 0.1 sec/div in 12 steps, calibrated with X5 expansion. Fine control - Variable between steps - includes T.B. calibration position.

SINCLAIR SC110 (mini scope) £145.20. PFM 200 £52.50. DM 450 £102.45. DM350 £76.99. PDM 35 £34.50. DM235 £55.80.

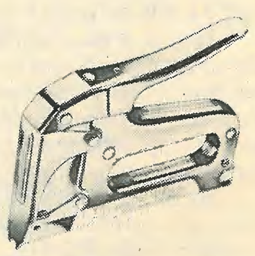
KRAMER & CO., 9 October Place, London NW4
Tel: 203 2473 Telex: 888941 Attn. K7
Open: Mon.-Fri. S.A.E. for further details

TRUE AS AN *Arrow*

Professional Wire and Cable Fasteners for all installation requirements.

TELEPHONE — ELECTRONICS
COMMUNICATIONS
ALARM SYSTEMS, ETC.

4 Precision made models.
12 different staple sizes.
Rugged all steel construction in chrome finish.
Grooved guide.
Grooved driving blade.
Tapered striking edge.
Jam-proof mechanism (patented).
Short span easy compression handle.



Some of the features that make an Arrow cable fastener the outstanding tool for all installation engineers..

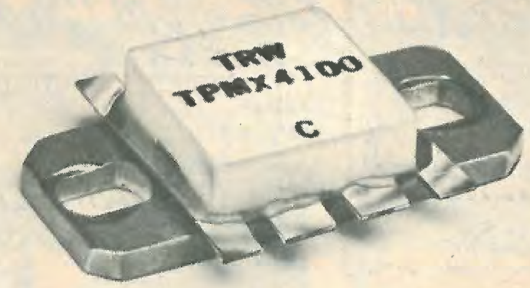
Illustrated literature and details of staple sizes available from:

SPECIAL PRODUCTS DISTRIBUTORS LTD.
81 PICCADILLY, LONDON W1V OHL
TEL. 01-629 9554. Telex 265200 (A/B RACEN)
Cables: Speciprod London W1

WW—041 FOR FURTHER DETAILS

Cover the whole band with one device.

This device.



The TPM 4100. From 100MHz to 400MHz.

Designed specifically for military applications the new TRW TPM push-pull RF power transistor offers some very worthwhile advantages.

It has been specially designed for multi-octave bandwidth high power applications and its internal matching and package configuration provide high input and output impedances. Power gain 7.5dB min @ 400MHz.

Maximum heat dissipation and operating efficiency are achieved by the use of multicell die design and ultra thin beryllium oxide header.

Diffused silicon ballast resistors and TRW gold metallisation process give long term reliability and ruggedness.

The versatility of the TPM 4100 enables it to be used in a wide variety of applications, saving setting up and engineering time as well as reducing inventory.

TRW® RF SEMICONDUCTORS
MCP Electronics Ltd., Alperton, Wembley, Middx.
Tel: 01-902 5941.

WW — 036 FOR FURTHER DETAILS

COMPUTER KITS FROM NEWTRONICS

ELF II

Hobbiests! Engineers! Technicians! Students!

Computer Kit
STARTS AT
£59.95
plus V.A.T.

ELF II
BOARD WITH VIDEO OUTPUT

FEATURINGTHE
RCA COSMAC 1802 cpu

STOP reading about computers and get your "hands on" an ELF II and Tom Pitman's short course. ELF II demonstrates all the 91 commands which an RCA 1802 can execute, and the short course speedily instructs you how to use them.

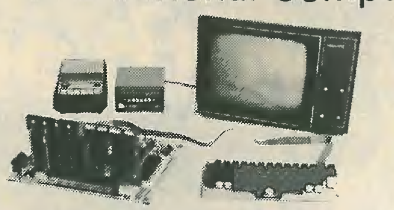
ELF II was designed to be both a trainer and the heart of a powerful computer system. The £59.95 ELF II gives you all components and everything you need to write and run your own programs immediately, even if you've never used a computer before. Then, once you've mastered computer fundamentals, ELF II can be expanded to give you tremendous computing power.

Plus the greatest range of Expansion Kits and Software:

GIANT I/O Bd : 4K RAMS : ASCI KEYBOARD : LIGHT PEN : VIDEO DISPLAY BD : PROTOTYPE BD : PSU : CABINETS : FULL BASIC WITH RPN : TINY BASIC : ELF-BUG : TEXT EDITOR : ASSEMBLER : DISASSEMBLER : MANUALS AND LOTS MORE.

Explorer/85

Professional Computer Kit



AT
£299 + VAT
with
Microsoft BASIC
in ROM

WITH
ONBOARD S-100
EXPANSION

FEATURES INTEL 8085 cpu

FLEXIBILITY: Real flexibility at LAST. The EXPLORER/85 features the Intel 8085 cpu. 100% compatible with all 8080A and 8085 software. Runs at 3MHz, Mother Board (Level A) with 2 S-100 pads expandable to 6 (Level C).

2K Monitor ROM — 1K Video RAM — 4K WORKSPACE/USER RAM — Expandable to 64K — 8K Microsoft BASIC in ROM — STANDALONE FULL ASC11 Keyboard Terra — RS 232/20Ma Loop — Direct interface for any S-100 Board — p.s.u. requirements 8v, 6.3v AC — Runs with North Star controller and Floppies — EXPLORER/85 can be purchased in individual levels, kit form or wired and tested OR as a package deal as above.

16k Dynamic RAM Kit — S100 CARD

Expandable to 64k on one S-100 board in 16k increments, designed for NO wait state operation utilizing the most advanced RAM controller.

16k RAM Kit	£139 + VAT
16k RAM Expansion Kit	£89.95 + VAT

SEND SAE FOR COMPREHENSIVE BROCHURE

Please add V.A.T. to all prices (except manuals). P&P £2. Please make cheques and postal orders payable to NEWTRONICS or phone your order quoting BARCLAYCARD, ACCESS number. We are now open for demonstrations and Sales. Monday-Saturday, 9.30 a.m.-6.30 p.m. Near Highgate Underground on main A1 into London.

Newtronics
255 ARCHWAY ROAD, LONDON N. 6
TEL: 01-348 3325

WW — 033 FOR FURTHER DETAILS

The finest amplification kits from Crimson Elektrik

CPR 1 — THE ADVANCED PRE-AMPLIFIER. The best pre-amplifier in the U.K. The superiority of the CPR 1 is probably in the disc range. The overload margin is a superb 40bB, this together with the high slewing rate ensures clean top, even with high output cartridges tracking heavily modulated records. Common-mode distortion is eliminated by an unusual design. R.I.A.A. is accurate to 1dB; signal to noise ratio is 70dB relative to 3.5mV; distortion <005% at 30dB overload 20kHz.
Following the stage is the flat gain/balance stage to bring tape, tuner, etc. up to power amp. Signal to noise ratio 86dB; slew-rate 3V/uS; T.H.D. 20Hz — 20kHz<008% at any level. F.E.T. muting. No controls are fitted. There is no provision for tone controls. CPR 1 size is 138 × 80 × 20mm. Supply to be ± 15 volts.

MC 1 — PRE-AMP-AMPLIFIER. Suitable for nearly all moving-coil cartridges. Send for details.

X02: X03 — ACTIVE CROSSOVERS. X02 — two way, X03 — three way. Slope 24dB/octave. Crossover points set to order within 10%.

REG 1 — POWER SUPPLY. The regulator module, REG 1 provides 15-0-15v to power the CPR 1 and MC 1. It can be used with any of our power amp supplies or our small transformer TR 6. The power amp kit will accommodate it.

★★ NEW ISSUE 5 ★★

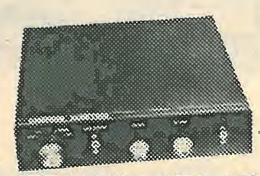
POWER AMPLIFIERS. Our new issue 5 power amplifier modules have automatic shut-down that will not allow serious overloads for more than 0.1 sec — thus vastly increasing reliability at elevated temperatures. Other improvements to the circuitry have improved the subjective qualities which keeps CRIMSON even further ahead of the field.

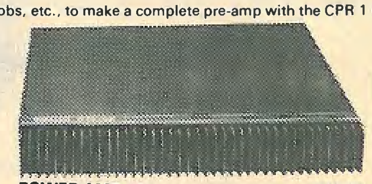
POWER SUPPLIES. We produce suitable power supplies which use our superb TOROIDAL transformers only 50mm high with a 120-240 primary and single bolt fixing (includes capacitors/bridge rectifier).

POWER AMPLIFIER KIT. The kit includes all metalwork, heatsinks and hardware to house any two of our amp modules plus a power supply. It is contemporarily styled and its quality is consistent with that of our other products. Comprehensive instructions and full back-up services enable a novice to build it with confidence in a few hours.

PRE-AMP KIT

This includes all metalwork, pots, knobs, etc., to make a complete pre-amp with the CPR 1 (S) module if required.





POWER AMPLIFIER MODULES

CE 608	£21.00
CE 1004	£24.50
CE 1008	£27.50
CE 1704	£35.00
CE 1708	£35.00

HEATSINKS

Light duty, 50mm. 2 C/W	£1.70
Medium power, 100mm. 1.4 C/W	£2.70
Disco/group. 150mm. 1.1 C/W	£3.50
Fan mounted on two drilled 100mm heatsinks 2×4 C/W 65 max. when used with two 170W modules	£36.00
THERMAL CUT-OFF, 70C	£1.90

POWER AMP KIT	£38.80
PRE-AMP KIT	£39.80

PRE-AMPS

These are available in two versions — one uses standard components, and the other (the S). uses MO resistors where necessary and tantalum capacitors

CPR 1	£34.00
MC1	£26.00
CPR 1S	£44.50
MC 1S	£37.50

ACTIVE CROSSOVER

XO2	£19.00
XO3	£28.35

POWER SUPPLY

REGI **£9.30** TR6 **£2.50**

BRIDGE DRIVER, BD1

Obtain up to 350W using, 2x170W amps and this module

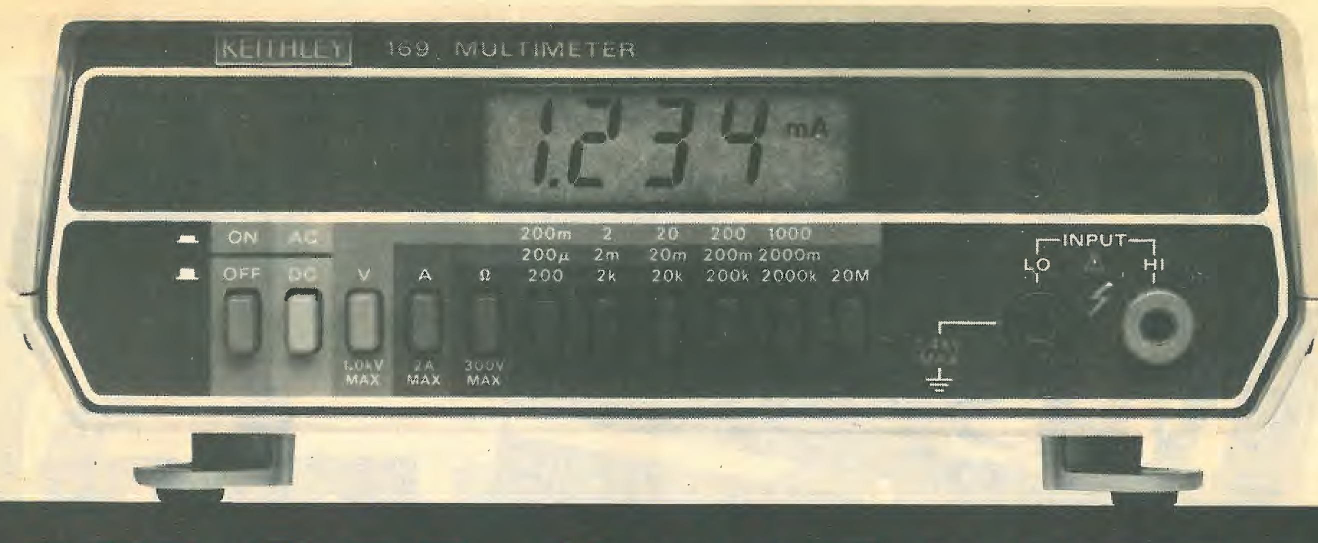
BD1	£7.25

All prices shown are U.K. only and include V.A.T. and post. C.O.D. 90p extra £100 limit. Export is no problem, please write for specific quote. Send large S.A.E. or 3 International Reply Coupons for detailed information.

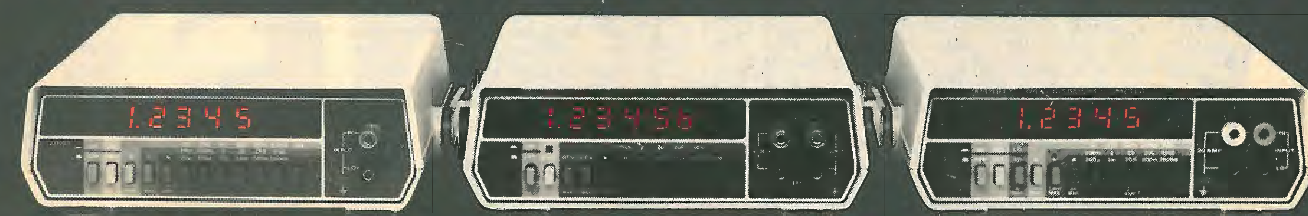
Crimson Elektrik

1a STAMFORD STREET, LEICESTER LE1 6NL. Tel. (0533) 553508
U.K. — Please allow up to 21 days for delivery
Write for free literature or send 50p for application/users' manual.

WW — 015 FOR FURTHER DETAILS



HIGH QUALITY



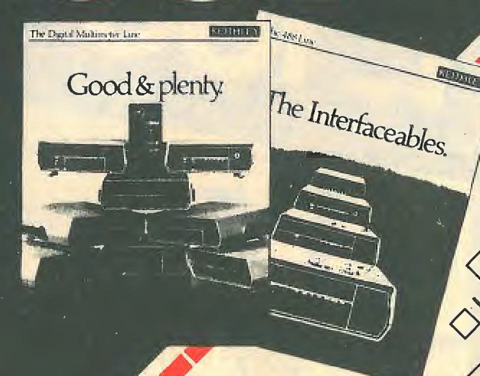
WIDE CHOICE

Keithley D.M.M. Test Equipment:
Quality. With machines like the 169 shown above. 3½ digits; .25% accuracy. A no-nonsense five function D.M.M. at a no-nonsense price. Only £99 + V.A.T.

Choice. The Keithley range spans Pocket, 3½, 4½, 5½ digit D.M.M.'s; many with I.E.E.E. options. So we can be sure of having exactly the right product for your own requirements. Built to a standard that very few people can equal.

LOW COST

Cost. And at a price even fewer can match. From £79 + V.A.T., Keithley D.M.M. test equipment is backed by the resources of a specialist company with a formidable reputation. To find out more, just fill in the coupon, and get your free literature today.



KEITHLEY

Keithley Instruments Ltd
1 Boulton Road Reading Berkshire RG2 ONL
Telephone (0734) 861287

I would like to know more about Keithley D.M.M.'s. I am particularly interested in: ☐ 3½ Digit Models ☐ 4½ Digit Models ☐ 5½ Digit Models ☐ I.E.E.E.

Name ____ Position ____
Company ____
Address ____
____
Tel ____

WW5

WW — 069 FOR FURTHER DETAILS


VHS
VIDEO CASSETTE
E180

Hands off.

We mean it.

The new 30AX colour tube system from Mullard doesn't need innumerable twists and turns of a screwdriver to set it up.

It needs no adjustments at all. Because every one has been 'designed out'.

Every tube that leaves our factory is completely pre-adjusted by us. Leaving only the turn of one screw to affix or remove the coil.

No dynamic convergence adjustments.

No colour purity adjustments.

And no raster orientation adjustment.

As for what it has to offer, the 30AX's focus is sharper and its definition greatly improved.

Its in-line guns and specially built coil provide the best picture shape yet.

And rest assured it'll stay that way. In a slim 110° package that trims about 3″ off conventional 22″ 90° TV cabinet depths.

Some features of the 30AX however, are a little more established.

Like its excellent colour registration. High brightness. Soft flash protection. Fast warm-up. And of course, greater overall reliability. This is the new 30AX colour tube system.

For more information just write your name and address on this page and send it to Dept. MCG, Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.

30AX is a trademark of Mullard Ltd

Mullard
30AX. The perfect slimline.

WW — 081 FOR FURTHER DETAILS

Britain's first complete computer kit.

£79.95

Including VAT.
Including post and packing.
Including all leads and components.

A complete personal computer for a third of the price of a bare board.

Also available ready assembled for £99.95

The Sinclair ZX80.

Until now, building your own computer could easily cost around £300 – and still leave you with only a bare board for your trouble.

The Sinclair ZX80 changes all that. For just £79.95 you get *everything* you need to build a personal computer at home... PCB, with IC sockets for all ICs; case; leads for direct connection to your own cassette recorder and black and white or colour television; everything!

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.

Your ZX80 kit contains...

- Printed circuit board, with IC sockets for all ICs.
- Complete components set, including all ICs – all manufactured by selected world-leading suppliers.
- New rugged Sinclair keyboard, touch-sensitive, wipe-clean.
- Ready-moulded case.
- Leads and plugs for connection to domestic TV and cassette recorder. Programs can be SAVEd and LOADed on to any portable cassette recorder.
- 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 boards allowing up to 16K bytes RAM. Extra RAM 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.

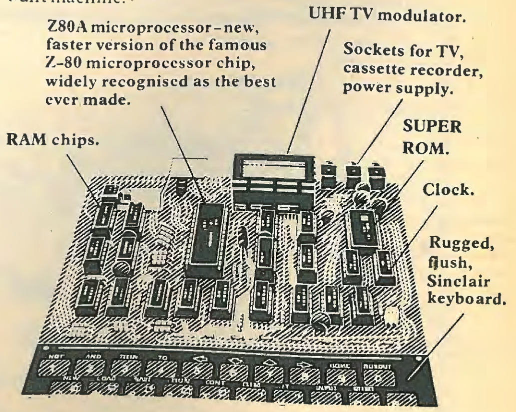
The unique Sinclair BASIC interpreter... offers remarkable programming advantages:

- **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 try to 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.
- FOR/NEXT loops nested up 26.
- Variable 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.
- Lines of unlimited length.

...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 128-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.)

A hardware manual is also included with every kit or built machine.



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 on to 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 – typically storing 100 lines of BASIC. Key words occupy only a single byte.

The display shows 32 characters by 24 lines.

And Benchmark tests show that the ZX80 is faster than all other personal computers.

No other personal computer offers this unique combination of high capability and low price.

The Sinclair ZX80. Kit: £79.95. Assembled: £99.95. Complete!

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.

Demand for the ZX80 is very high: use the coupon to order today for the earliest possible delivery. All orders will be despatched in strict rotation. We'll acknowledge each order by return, and tell you exactly when your ZX80 will be delivered. If you choose not to wait, you can cancel your order immediately, and your money will be refunded at once. Again, of course, you have a refund option for 14 days after your computer is despatched. We want you to be satisfied beyond all doubt – and we have no doubt that you will be.

sinclair ZX80

Science of Cambridge Ltd

6 Kings Parade, Cambridge, Cambs., CB2 1SN.
Tel: 0223 311488.

Order Form

WW5/80

To: Science of Cambridge Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN.
Remember: all prices shown *include* VAT, postage and packing. No hidden extras.

Please send me:

Quantity	Item	Item price £	Total £
	Sinclair ZX80 Personal Computer kit(s). Price includes ZX80 BASIC manual, excludes mains adaptor.	79.95	
	Ready-assembled Sinclair ZX80 Personal Computer(s). Price includes ZX80 BASIC manual, excludes mains adaptor.	99.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	8.95	
	Memory Expansion Board(s) (each one takes up to 3K bytes).	12.00	
	RAM Memory chips – standard 1K bytes capacity.	16.00	
	Sinclair ZX80 Manual(s) (manual free with every ZX80 kit or ready-made computer).	5.00	
NB. Your Sinclair ZX80 may qualify as a business expense.		TOTAL	£

I enclose a cheque/postal order payable to Science of Cambridge Ltd for £
Please print
Name: Mr/Mrs/Miss
Address

Complete Audio/Tuner Kits

Mk III FM Tuner series

Carriage for Mk III tuner £3 inc

The Mark III series FM tuner has been updated, and now includes a centre zero tuning meter as standard. The instruction manual has been meticulously revised, enabling easy assembly by constructors of various levels of experience - a preview copy may be purchased for £1.00.

Mark III A series	'Reference series' tuner modules	........£171.35 inc.
Mark III B series	'Hyperfi' modules, with switched IF BW, pilot cancel decoder	........£198.95 inc.

A matching synthesiser unit will be made available later this year, and can be retrofitted to either version. All versions include digital frequency readout/clock, VU deviation meters, 6 preset stations, 10 turn pot manual tuning, toroidal PSU, output level adjustment, 110/240v AC input. Full alignment service available.

Power Amplifier

Style and performance - with a real 'belt and braces' PSU design.

After a couple of preview comments, it seems that many of you are waiting to hear about the matching HMOSFET power amplifier for the Mk III tuner. Well, it's out at last - complete with twin toroidal PSUs for comfortable 80W RMS per channel, over 100W peak, but limited by thermal shutdown of the HMOS. 10W-100W log LED output peak indicator, DC offset protection and switch-on pause relay. AC or DC input coupling, direct or relay protected output terminals. The works.
Only one version of this item: Complete kit ....£178.25 inc. Carr. £5.

Preamplifier

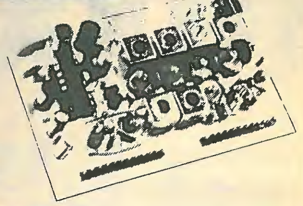
More features and facilities, thanks to DC switching and control design

Previewing the most comprehensive audio preamplifier yet...... DC switching of 7 inputs, plus two tape in/outs. 2 low pass, 2 high pass active filters, genuine volume related loudness, 1dB channel matching, with DC volume, balance, bass and treble controls. Suitable for bus/remote control, tape dubbing, switched monitor etc. 80dB S/N+, THD -75dB or better. Pluggable PU equalization boards, tone control override. Price for complete unit about £149 ex VAT.

Radio/Audio/Communications Modules

LW-MW-SW-SW DC tuned and switched

91072- All switching of bands by a single pin to gnd. Varicap tuned, with LO output for synth. MW/LW version or MW/LW plus 1 or 2 SW bands
MW/LW: £15.58 +1SW £16.73



VHF Tunerheads

Europes largest stock range for broadcast and communications. Probably also the world's — details in the catalogues and PL. Specials are also supplied in the region 30-220MHz.

Pilot Cancel PLL Stereo decoders

Again, Europe's widest range of stereo decoders including pilot cancel PLL types. The pic shows the 944378 - pilot cancel including post decoder 26/38kHz filtering and muting preamp output

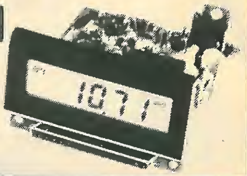
944378-2 £26.45

Switched bandwidth FM IF strips

Broadcast FM IF strips for all occasions, including the new 911225 - with diode switched narrow filter option, ultra linear phase ceramic filters, 84dB S/N, and 0.04% THD (40kHz deviation). Plus usual things like AGC, AFC, dev. mute, level meter drive. £23.95 (supplied in screen can with 0.1 edge connection system) Also the 7230 hyperfi series - as the 911225, but with slope controlled AFC that operates in conjunction with signal level - and an extra IF amp stage for DXing.

Various digital frequency displays

The World's largest range of receiver DFMs is now joined by the DFM7 (shown) - and L shaped version of the DFM3 with remote display mount connector possibility . 1kHz SW resolution with 455kHz or 10.7MHz offsets, 100Hz res up to 3.9999MHz, and VHF to 299.99 MHz in 10kHz steps : £41.75

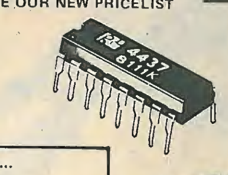


Semiconductors

Radio/Communications ICs

FOR COMPLETE LISTINGS — SEE OUR NEW PRICELIST

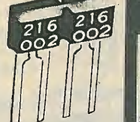
CA3089E	2.11	HA1197	1.61	SD6000	4.31
CA3189E	2.53	CA3123E	1.61	TDA4420	2.59
HA1137W	1.95	TDA1072	3.09	MC1330P	1.38
HA11225	2.47	TBA651	2.53	MC1350P	1.38
HA12412	2.81	TDA1090	3.51	KB4412	2.24
KB4420	1.95	TDA1220	1.61	KB4413	2.24
TBA120S	1.15	TDA1083	2.24	KB4417	2.53
KB4406	0.80	TDA1062	2.24	MC3357P	3.16



SL1610	1.84	SL1626	2.80
SL1611	1.84	SL1630	1.86
SL1612	1.84	SL1640	2.17
SL1613	2.17	SL1641	2.17
SL1620	2.50	SL6600	4.31
SL1623	2.80	SL6640	3.16
SL1624	3.77	SL6690	3.68
SL1625	2.50	MC1496	1.44

VARICAP DIODES........
A section from our PL:

BA102	0.35	16:1 ratio AM tuning	
BB204	0.41	KV1215 9v triple	2.93
BB105	0.41	KV1211 9v dual	2.01
BB109	0.31	KV1225 25v triple	3.16
MVAM2	1.93	BB212 9v dual	2.25



POWER MOSFETS

100W PA's made simple

Since pioneering the 100W complementary MOSFET technique - Hitachi have developed a range of output devices and drivers that ought to revolutionise opinions and attitudes towards the design of all LF amplification systems. We have a new 48 page application note (£1.50 inc) and complete sets of parts, modules and now the new complete PA system (see above).

2SK133	120v N-ch 100W MOSFET	£6.33	2SJ48 Pch complement	£6.33
2SK135	160v N-ch 100W MOSFET	£7.29	2SJ50 Pch complement	£7.39
PA101B	Kit for 100W MOSFET PA less Heatsink £16.10. (£23 inc heatsink/bkt)			

ULTRA LOW NOISE PU PREAMPLIFIER

The HA12017 is the last word in PU preamps, and general low noise audio design. It is an SIL IC, with 86dB S/N in RIAA configuration, 10v RMS output capability, 0.002% typ THD at 10v RMS output (imagine the overload margin !!). It comfortably supercedes discrete circuit designs in terms of price/performance, and takes the art beyond the TDA1042's capabilities. (Replaces HA1457) £1.80 each - or an RIAA applications PCB with two ICs for £5.75. Complete with Rs&Cs £9.95.

Radio Control ICs

We have various RC ICs, including NE544 NE5044, and two new ones from OKI

KB4445 - 4 channel dig.prop. FM TX IC. 30mW out (amplifyable) -£2.30 inc
KB4446 - 4/5 ch. dig. prop FM RX IC. Suits KB4445 or RCME syst. £2.65.
KB4445/6 pair: £4.75. New 8 page data sheet 35p + SAE. More RC ICs in list

CMOS, LPSNTTL, TTL, MPU: Listings in the new pricelist.

Most CMOS is available in low volume - also LPSN. Standard linears and TTL OK.

Things like ICM7216B, ICL8038, 8080A, 6800P, 2708, NE555,NE556, etc

Coming Soon...........

Contain yourselves, RF fans ! Not yet ready for a full launch until autumn, but previewed here:-

SSB transceiver system : 10kHz to 1000MHz !!

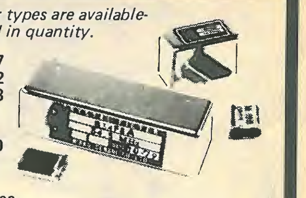
A modular VLF to UHF SSB TX/RX system at last. With the correct first mixer, the basic PCB covers 10kHz to 1000MHz - using LO fed from ext. source (Our 2 IC Mullard synth for instance) and RF PA for TX OP. 0.2uV basic sensitivity in HF, Typ cost for HF synth SSB RX will be less than £200. Add an RF PA for full TRX for another £50. See one in our foyer, and marvel.

Components

Crystal Filters

Most popular types are available-ex-stock, and in quantity.

10.7MHz	25kHz Channel spacing 8pole	£16.67
	12½kHz ..	£17.82
	2.4kHz SSB	£19.78
	Monolithic dual roofing filter	£2.30
34.5MHz	1.3dB loss, 80dB stopband HF first filter in synth. RX	£36.80
RC XTALS	FM pairs (no spilts)	£3.74
	AM pairs ..	£3.57
USB/LSB	Xtals for 10.7SSB filter	£2.88 ea



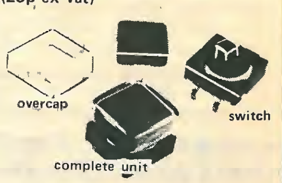
Piezo Sounders

The most efficient warning sounders yet

The latest thing in electro-acoustic efficiency. 1mA of drive from CMOS will give an SPL of 83dB - 10v RMS drive from CMOS uses 3mA for 100dB SPL at 4.8kHz (88dB at 1.65kHz)
The data sheets shows various drive circuits, and give full specifications with regard to broadband responses and power consumption etc. 1 off .44p inc. 100 off 28.75p (25p ex vat)

Keyboard switches and caps

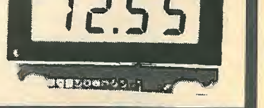
From the world's most widely used switch manufacturers - ALPS - come the biggest and best range of keyswitches, and data entry keyboard switches. The SCM81101 is shown here, with the KT5 2-part cap (with clear top, to enable easy fitting of your chosen legend. Other types are available with built in LED, 90° mounting etc.
SCM81101 : 17p, KT5 : 16p - or 29p/pair



LCD CLOCKS
LCD DVM

Clocks use 1.5v at 15uA only. DVM 9v/1mA

CM161: 7mm LCD 12/24hr, alarms etc £11.44 each
CM172: 13mm, 12hr, alarms,timer etc £14.32 each
CM174: 13mm, 12hr, min/sec stopwatch £14.32 ea
DVM 176: ICM7106 based LCD 3½digit £22.36 each



WHAT's NEW at AMBIT

NEW PRICELIST/SHORTFORM:- 28 pages, FOC with A5 SAE pse

Bigger print than our recent one page list - and vastly extended

If you still need convincing to invest £1.60 in the cats, be mean and get this first.

POWER MOSFET APPLICATIONS HANDBOOK by HITACHI :

£1.50 each - or free with pairs of HMOS and the PA101B.

Everything you should know about HMOSFET devices theory and applications.

Please send an SAE with all enquiries. Phone orders by ACCESS - but minimum £5 Callers welcome

CATALOGUES 60p ea, all three for £1.60
PRICES SHOWN HERE INCLUDE VAT
POST/PACKAGE CHARGE NOW 35p

ambit INTERNATIONAL

CWO PLEASE : Commercial MA terms on application. Goods are offered subject to availability, prices subject to change - so please phone and check if in doubt.

Parts 1-3 AMBIT catalogues 60p ea, or £1.60 the lot.

200 North Service Road, Brentwood, Essex

TELEPHONE (STD 0277) 230909 TELEX 995194 AMBIT G POSTCODE CM14 4SG

WW — 104 FOR FURTHER DETAILS

MORE SPEC. FOR YOUR MONEY

TYPE 643 FUNCTION GENERATOR

0.01Hz to 999KHz

SINE, SQUARE and TRIANGLE
DIGITAL SETTING
DC OFFSET
PROGRAMMABLE
SIMULTANEOUS OUTPUTS
50 Ω MAIN OUTPUT
(10V. attenuable)

£105
& 2.50 carriage, ins. etc.

TYPE 643A FUNCTION GENERATOR

0.01Hz to 1.1MHz

SINE, SQUARE and TRIANGLE
DIAL SETTING
DC OFFSET
PROGRAMMABLE
SIMULTANEOUS OUTPUTS
600 Ω MAIN OUTPUT
(10V. attenuable)

£89.03
& 2.50 carriage, ins. etc.

OMB ELECTRONICS, RIVERSIDE, EYNSFORD, KENT DA4 OAE
Tel. Farningham (0322) 863567

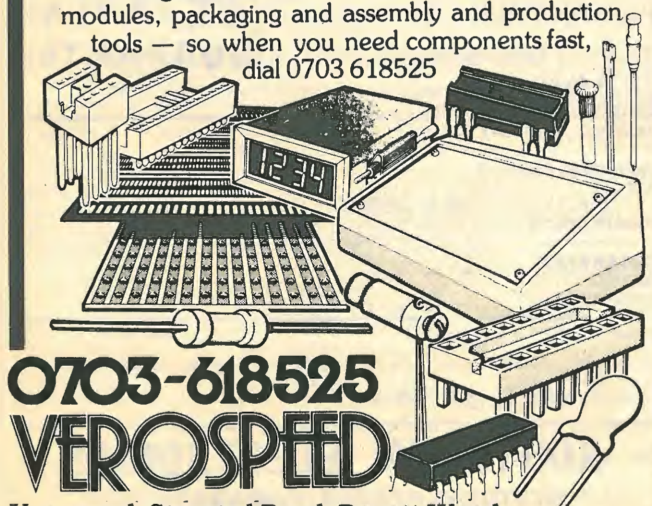
Prices, which are CWO and ex-VAT, are correct at the time of going to press and are subject to change without notice.

FROM OMB ELECTRONICS

WW — 005 FOR FURTHER DETAILS

Electronic Components FAST...

When you need electronic components in a hurry, call Verospeed. Our service is designed to get them to you without delay.
We hold over 1300 product lines in stock for immediate same day despatch to solve your R & D problem or production hold-up.
The range covers active components, meters and modules, packaging and assembly and production tools — so when you need components fast, dial 0703 618525



0703-618525
VEROSPEED

Verospeed, Stansted Road, Boyatt Wood
EASTLEIGH, Hampshire SO5 4ZY

WW—080 FOR FURTHER DETAILS

Plan the 80's with the best

K1000 & K2000 SOLDERING IRONS

- 16w Producing 420°c (Helping the Save-it campaign)
- PUSH-IN TIPS
- 6 MONTHS GUARANTEE

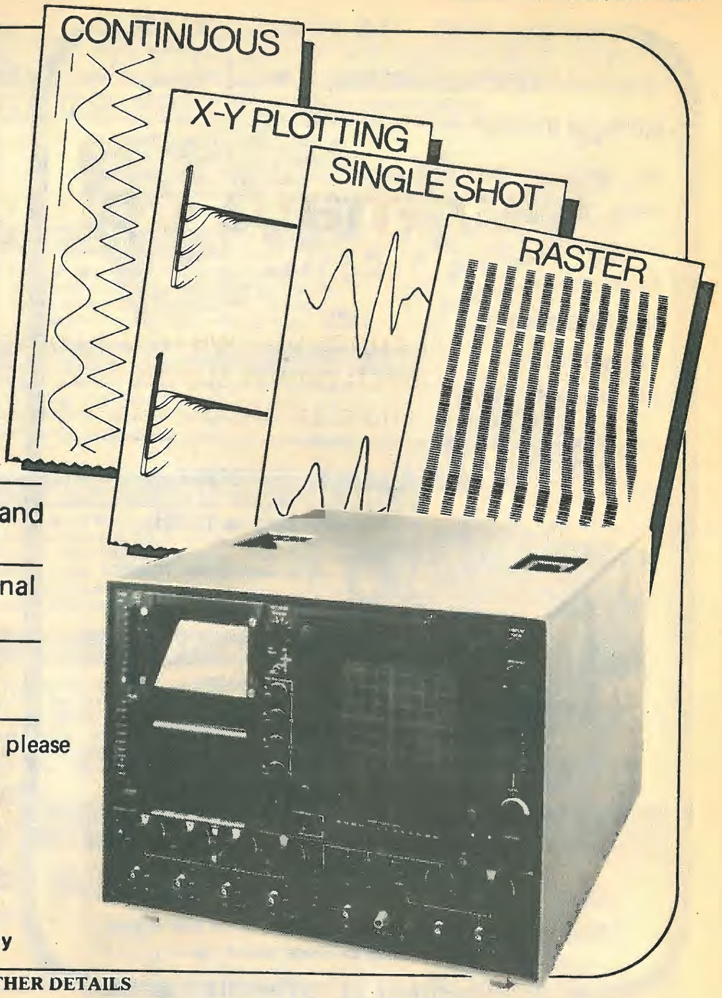
ADCOLA

United Kingdoms Leading Soldering Instrument Manufacturers
Tel. 01-622-0291/4

ADCOLA PRODUCTS LIMITED
GAUDEN ROAD, LONDON SW4 6LH

WW—009 FOR FURTHER DETAILS

THE FOR-1004 A NEW WIDEBAND GRAPHICAL RECORDER



9 Recording Modes

The FOR-1004 is the first of a new generation from Medelec. A highly versatile graphical recorder, it has been specially developed for wide ranging applications in research and industry. In both performance and economy it has many advantages over conventional instrumentation.

There are nine recording modes – all push button controlled, which permit the optimum presentation of most graphical data. Triggering is fully automatic and displayed signals can be monitored via an internal loudspeaker. The fast response time and wide range timebase allows the detailed examination of transients and trends.

Attractive new styling and ease of operation combine to make the FOR-1004 an important new instrument.

Simultaneous View and Record

Four High Input Signal Channels

High Resolution, Inexpensive Records

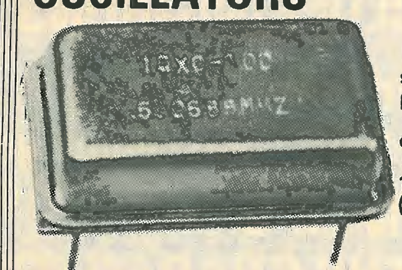
For further information please contact:

Medelec Limited
Manor Way Old Woking
Surrey GU22 9JU England
Tel: Woking (04862) 70331
Telex: 859141 Medlec G
A Vickers Limited Company

medelec
Industrial Products

WW — 024 FOR FURTHER DETAILS

IQXO-100 SERIES LOW PROFILE CRYSTAL CLOCK OSCILLATORS



- Hermetically sealed metal package
- DIL compatible
- 20.70L × 13.08W × 5.08H (mm)

The frequency range 600 Hz to 30 MHz is covered by both CMOS (600 Hz – 8 MHz) and TTL (150 KHz – 30 MHz) types having an overall tolerance of ±0·01% from 0 to +70°C. For more stringent requirements, ±0·01% from −55 to +125°C is available.

Many frequencies can be supplied from stock.

IQD

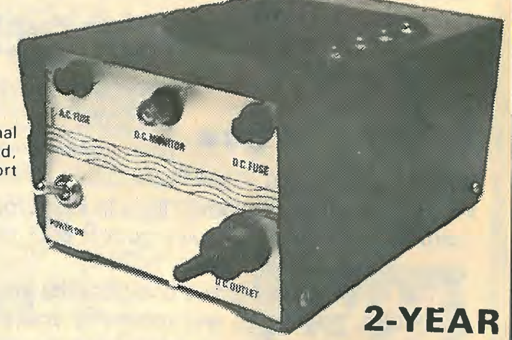
INTERFACE QUARTZ DEVICES LTD
29 Market Street, Crewkerne, Somerset TA18 7JU
Crewkerne (0460) 74433 Telex 46283 inface g

WW—052 FOR FURTHER DETAILS

REGULATED POWER SUPPLIES

Protection:

All models internal foldback, overload, thermal and short circuit protected. Fully fused.



2-YEAR GUARANTEE

Type AD12 - AD24 (Illustrated)

TYPES AVAILABLE

MODEL NO.	AD12	AD24	AD2412	ADV030
OUTPUT CURRENT	8 amp	8 amp	16 amp	5 amp
NOMINAL OUTPUT VOLTS	12	24	12	0 to 30 Fully variable and metered
INPUT VOLTS	15-230-250 50 cycles a/c	115-230-250 50 cycles a/c	24 DC	115-230-250 50 cycles a/c
TOLERATED MAINS VARIATION	15%	15%		15%

PRICES

1 off — AD 12-AD24 .... £68.50
1 off — AD 2412 .... £54.00
All subject to VAT @ 15%

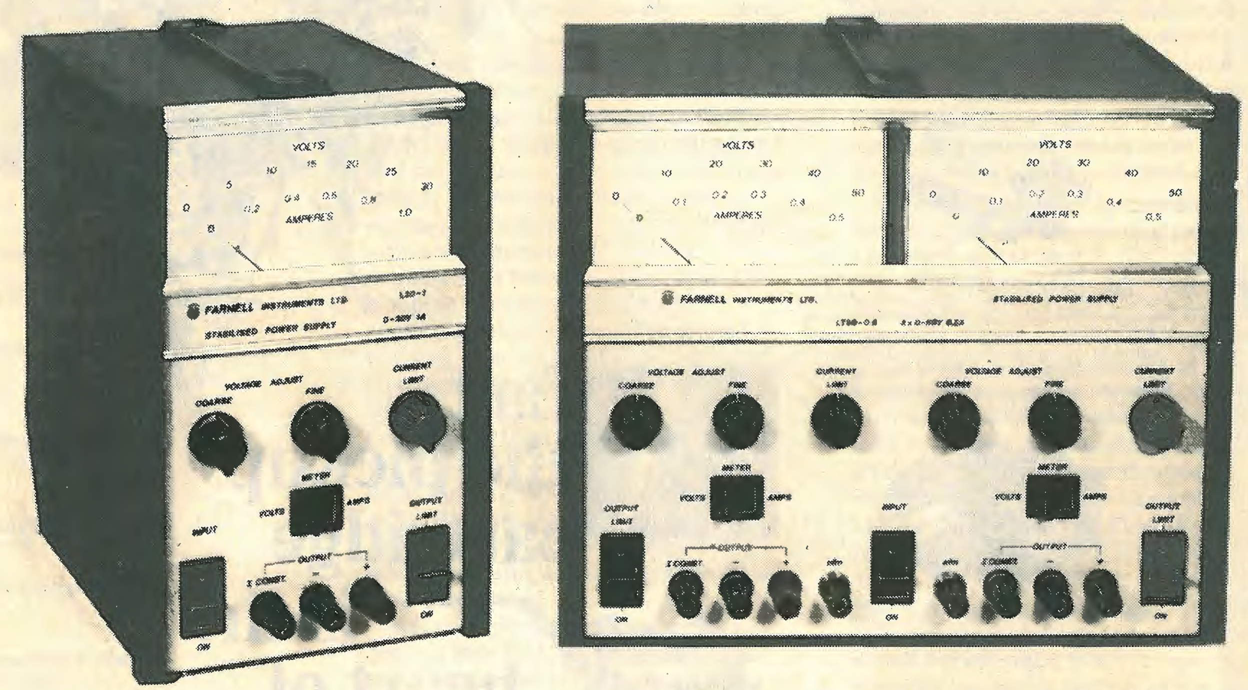
1 off — ADV030 £118.00

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

WW — 047 FOR FURTHER DETAILS

Our main competitor!

The stiffest opposition we find against making a sale for a bench power supply is your old friend alongside. There are thousands of them still working perfectly after more than 10 years in service.



Around 40,000 L series bench power supplies have been sold and the latest units are still uncompromising in performance and reliability. They provide constant voltage or constant current, feature large recessed meters, overload and short-circuit protection, coarse and fine adjustment controls, a separate output switch and LED indicators for mains on and current limit.

Models available

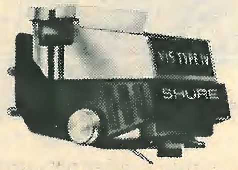
L50-05	**0-50V, 0.5A**	**L12-10C***	**0 – 12V, 10A**
L30-1	**0-30V, 1A**	**LT50-05** twin output unit **2 x 0 – 50V, 0.5A**	
L10-3C*	**0-10V, 3A**	**LT30-1** twin output unit **2 x 0 – 30V, 1A**	
L30-2	**0-30V, 2A**	**LT30-2** twin output unit **2 x 0 – 30V, 2A**	
L30-5	**0-30V, 5A**	*with adjustable overvoltage protection	

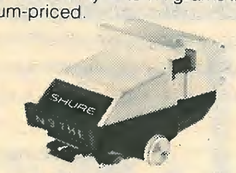
For full specification and prices contact:

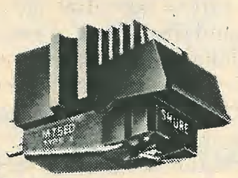
Farnell

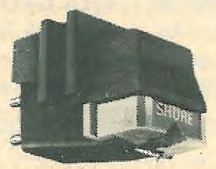
FARNELL INSTRUMENTS LIMITED · WETHERBY · WEST YORKSHIRE LS22 4DH · TEL. 0937 63541 or 01-864 7433

WW—071 FOR FURTHER DETAILS









wireless world

Current affairs

If the recent correspondence on displacement current has done nothing else it has drawn our attention to the pitfall that awaits us if we take a mental model as the whole truth about a phenomenon. Under examination is a model in the form of a set of equations and the extent to which it represents a reality. We see immediately that equations are like architects' drawings —precise, quantitative, stating relationships between quantitites but stopping somewhere short of a convincing description of an actual building. Like all mental models they lack body. The pitfall that awaits us is what A. N. Whitehead called "the fallacy of misplaced concreteness" — the mistake of attributing reality to what is no more than a construct of the mind. Because there is a word (or symbols) for it, and a corresponding mental picture, we assume it exists as a concrete entity.

As for displacement current, our readers may be forgiven if they feel confused by the various statements made about it by contributors. One author says the fact that the solution of Maxwell's equations is a propagating wave is a result that "is only obtained through the existence of displacement current" and issues the rallying cry "no radio waves without displacement current." A correspondent then asks (presumably thinking of propagation in outer space) "what is displaced in a vacuum?" to which there is no direct answer. And later another correspondent remarks "presumably no one is insisting that everyone must believe that there is any physical reality in a current which is said to flow in empty space when there is nothing to carry it . . . "

The puzzling question is: how are we justified in describing as an electric current something which has no physical reality as a motion of charge? Perhaps the answer is because displacement current exists in one respect anyway as a rational construct of the mind. We can consider this in the light of Kant's "mind contribution" to science — the notion that the mind supplies *a priori* concepts, independent of all experience (e.g. the truths of formal logic), to which we make our empirical observations conform. (See Kant's *Critique of Pure Reason*.)

When we consider any current intuitively, as a movement of charge in a conductor, its concreteness seems beyond question, especially when we are able to feel the heat or see the light or sparks it produces. But as soon as we try to define it quantitatively, in the way we do as a rate of flow of charge, Q/t, we move into an abstract world; for a rate is not an empirical fact but an *a priori* concept, independent of all experience, belonging to the realm of logic and mathematics. Current may flow but current strength doesn't: it *exists*, as a correspondent has pointed out. It is a pure concept, isolated from those realities of practical circuits in which, for example, you also need electrical potential and energy to push round the needle of your ammeter. Similar considerations apply to the rate of change of electric displacement, dD/dt. When a current is shown in the mathematical form of a term in an equation we are not seeing a full representation of a real current but merely a symbol or symbols for one of the properties of a current, its strength, defined as a rate.

Writers often refer to the "necessity" for displacement current in Maxwell's equations, as if this necessity were in itself a compelling proof of concrete existence. But, of course, necessity is not an empirical fact. As Hume showed in his famous analysis of cause and effect, "necessity is something that exists in the mind, not in objects . . . " (e.g. logical necessity).

To confuse *a priori* concepts such as necessity and rate with physical realities is to be caught in the fallacy of misplaced concreteness.

Designing with microprocessors

1 — Basic components of the microprocessor chip

by D. Zissos and Laurelle Valen Department of Computer Science, University of Calgary, Canada

This series of articles responds to the need "to demonstrate the respectability of the microprocessor as a down-to-earth, extremely useful, but entirely non-occult electronic component" (our March editorial) and is intended for electronics engineers who want to learn how this component can be used in the design of systems. The authors therefore use formal, step-by-step procedures in their explanations of how the device operates. This first article deals with the basic components of eight- and sixteen-bit microprocessor chips and the second will continue with their internal operation from the designer's point of view.

The starting point in the design of microprocessor-based systems, and indeed of all programmable systems, is a working knowledge of hardware, software and of their interaction. This view, although not generally accepted, is becoming more widespread. The roots of this attitude can be traced back to the early 1960s, when computers were becoming widely used. Because of the lack, at that time, of formalized hardware design procedures, much of the research effort was directed towards the development of machine-independent languages. This resulted in thick layers of software administered by bureaucrats being erected around the machines. In the 1970s formal methods for the design and implementation of hardware were developed[1], but largely were, and still are, being ignored by main-frame users. The evolution of m.s.i. and l.s.i. (medium and large scale integration) chips in general, and of microprocessors specifically, has made such an attitude progressively more difficult to sustain and justify, as the software/hardware barriers erected in the 1960s are not easily tolerated today. We shall therefore start the series by finding out how microprocessor chips work.

The newcomer to this area will be relieved to learn that basically there is no difference between various microprocessor chips, in spite of attempts to classify them into various categories, or, for example, into three generations. Their difference (as with cars) is one of refinement rather than substance. The reader should be aware that, in general, superior performance calls for expertise, and that one may experience fewer problems with a less sophisticated microprocessor chip than with the 'latest' and 'fastest.' As we shall see later, fast system response (if desired) with present-day knowledge, becomes a management rather than a technical problem.

The microprocessor chip

From the user's point of view, the microprocessor chip is a device which accepts **control data** and **problem data** and produces processed data, as shown in Fig. 1. The control data is commonly referred to as **op codes,** and the problem data as **operands***.

From the designer's point of view, the

*Operand is defined as the entity on which operations are performed.

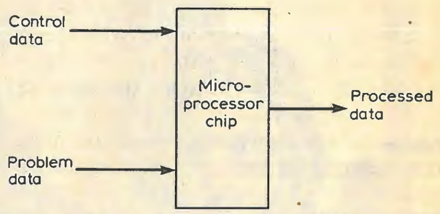


Fig. 1. The microprocessor from the user's point of view.

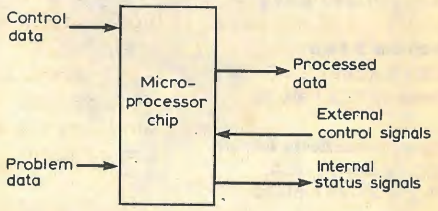
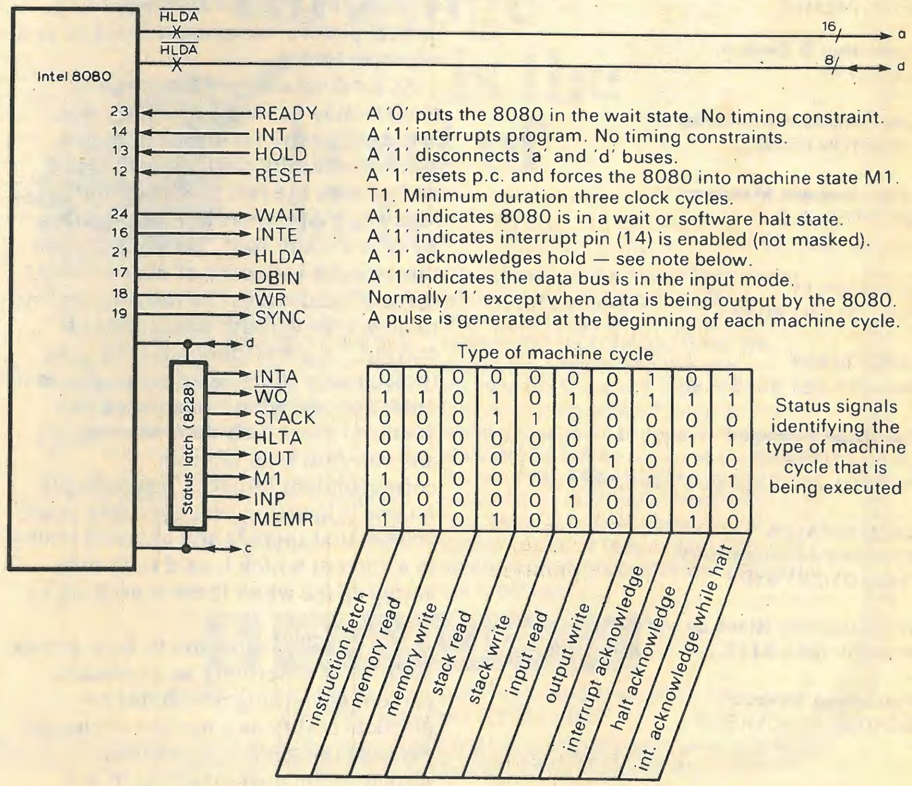


Fig. 2. The microprocessor from the designer's point of view.



Note: Signal HLDA goes high within specified delay of the leading edge of $\phi 1$. The address and data buses are floated high within a brief delay after the rising edge of the next $\phi 2$ clock pulse.

Fig. 3. Status and control signals of the Intel 8080 microprocessor chip.

microprocessor, in addition to performing arithmetic and logic operations on given data, can respond to external signals, the **control signals** in Fig. 2. Such signals are used to interrupt the execution of a program, to initiate a direct memory access cycle, and so on. In common with all digital circuits, microprocessor chips generate **status signals,** indicating their internal state. The wires carrying the control and status signals of a microprocessor chip are collectively referred to as **the control bus,** denoted by letter *c*. Similarly, the set of wires carrying the data in and out of a microprocessor chip is referred to as **the data bus** and is denoted by *d*. The **address bus** is the set of wires that carries address signals and is commonly denoted by *a*. Note that in the case of 16-bit machines, as we shall see later, the same set of wires carries the data and address signals on a time-sharing basis.

The status and control signals of the Intel 8080, Motorola 6800 and the Intel 8085 [2,3,4] are shown in Figures 3, 4 and 5, respectively.

In Fig. 6 we show the basic configuration for single-processor systems. The functions of the interface blocks are to monitor the status of signals of the microprocessor chip and of the corresponding peripheral, and to generate the correct sequence of command (control) signals that will allow them to communicate with each other.

The basic components of a typical microprocessor chip from the designer's point of view are

- The accumulator(s) (acc.)
- Addressing registers (r)
- The arithmetic and logic unit (a.l.u.)
- Condition flags
- The instruction register (i.r.)
- The program counter (p.c.)
- The timing and control unit [5,6].

Their basic functions are as follows.

Accumulator (acc.). This is a register which is used to hold incoming and outgoing data, as well as the outcome of specified arithmetic and logic operations. Some microprocessor chips have more than one accumulator; for example, the Motorola 6800 has two accumulators, A and B.

Addressing registers (r). Any internal register that can be connected to the address bus will be referred to as an addressing register. Examples of addressing registers are: register *r* in Fig. 7, program counters (p.cs), stack pointers (s.ps), index registers (ixs) and so on.

Arithmetic and logic unit (a.l.u.). This is a logic circuit which performs various arithmetic and logic operations.

Condition flags. These are one-bit flip-flops whose set/reset states are determined by the result of the execution of certain instructions. They typically indicate if the outcome of an a.l.u. operation is negative, zero, or

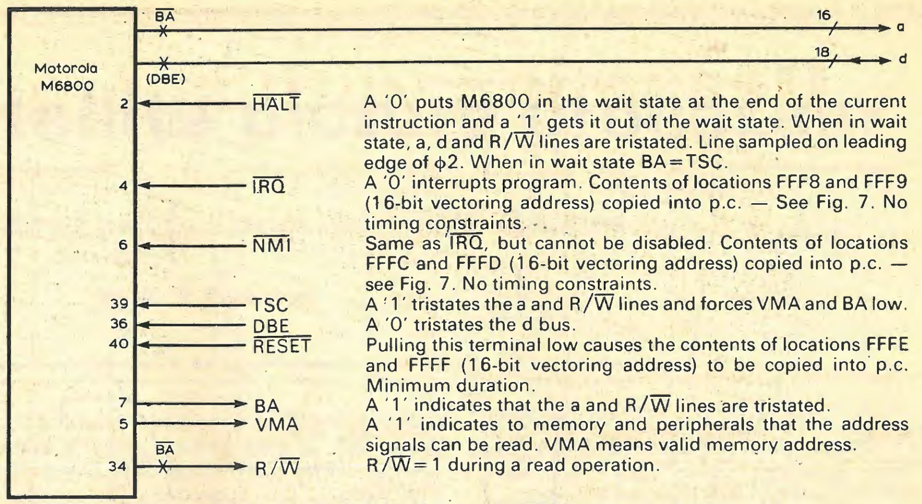
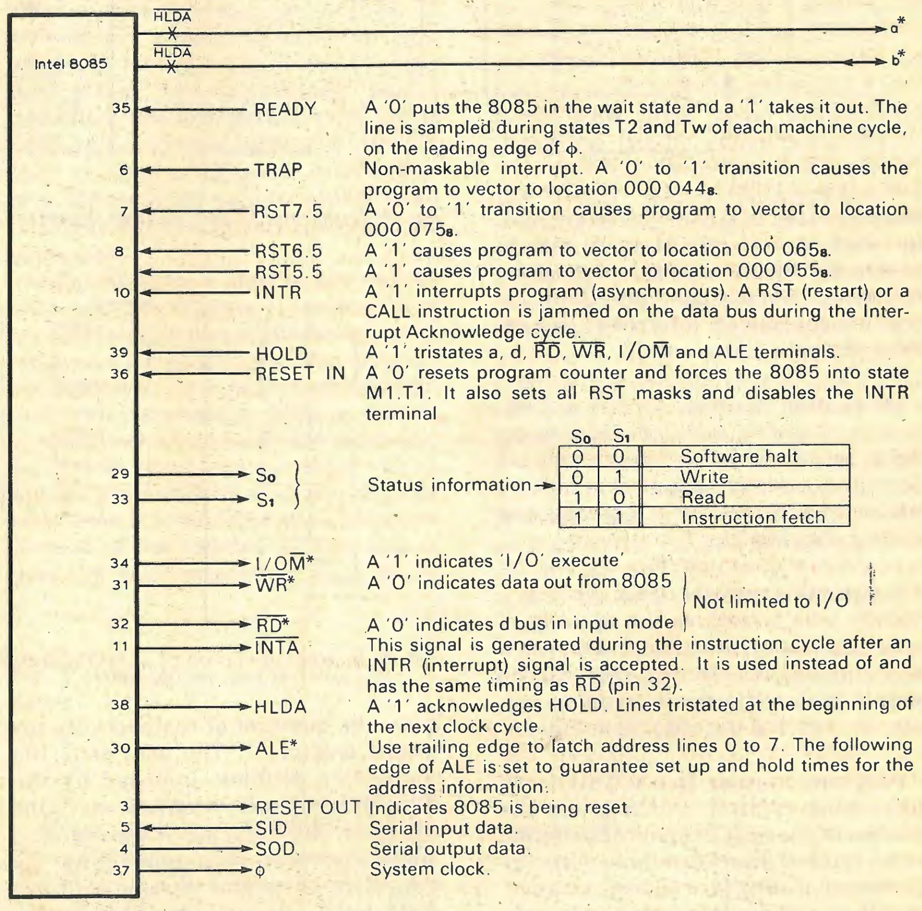


Fig. 4. Status and control signals of the Motorola 6800 microprocessor chip.



*Tristated during 'software halt'

Fig. 5. Status and control signals of the Intel 8085 microprocessor chip.

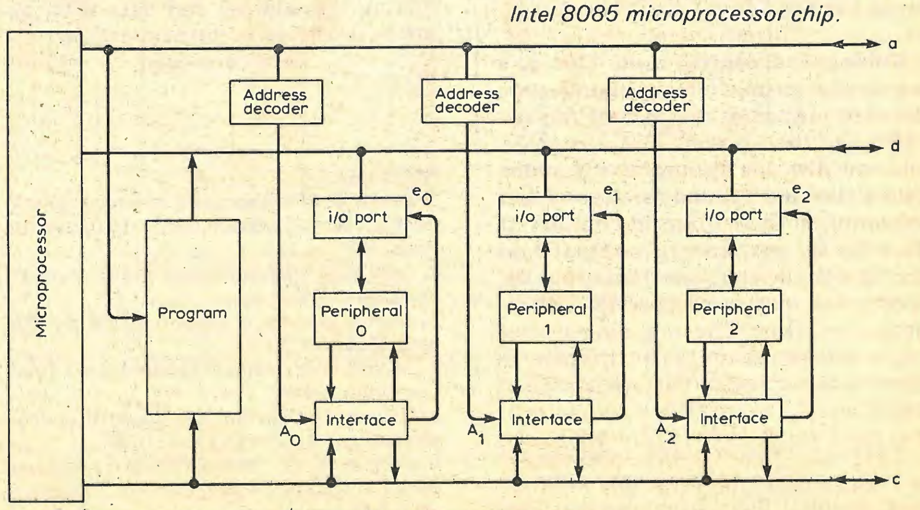


Fig. 6. Basic configuration for single-processor systems.

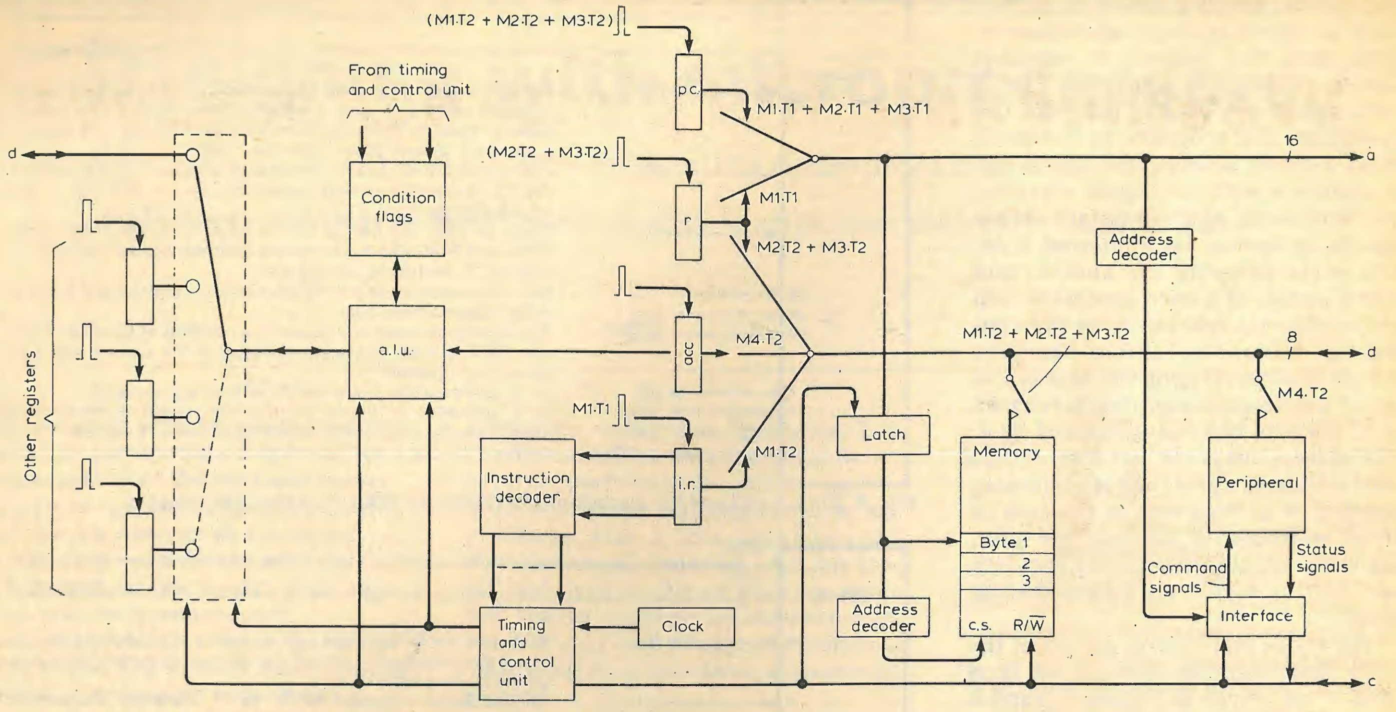


Fig. 7. Components and internal organization of an eight-bit microprocessor chip.

whether there is a carry after an 'add' operation and so on. They are mainly used to modify the sequence of program execution. Sometimes the condition flags are collectively referred to as **condition codes** or **status word.**

Instruction decoder. This is a combinational circuit used to decode the op code, held in the instruction register (i.r.), into a set of signals that can be interpreted directly by the timing and control unit. See Fig. 7.

Instruction register (i.r.). This is a register which receives the op code of each instruction in turn and holds it during execution. In our case the op code is loaded into the instruction register (i.r.) during state M1.T2 in Fig. 8.

Program counter (p.c.). This is an addressing register which holds the address of the next byte in the program to be fetched from memory, with the exception of such instructions as jump, branch and so on. It is connected to the address bus, *a*, during state T1 in a fetch cycle. See Fig. 7.

Timing and control unit. This is a sequential circuit which samples the decoded output of the instruction decoder and the external control signals, and specifies the appropriate machine cycles that are needed for the correct execution of the current instruction. It does so by generating control and timing signals which are routed to the appropriate components of the microprocessor chip. The machine cycles required to execute a three-byte (input/output) instruction are shown in Fig. 8.

Microprocessor chips contain no special circuits that do not exist in conventional digital computers. This

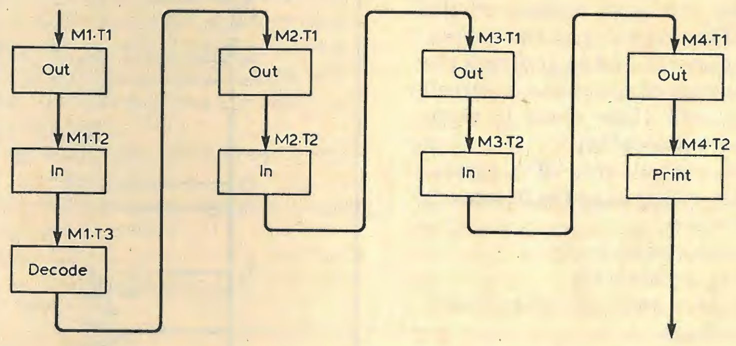


Fig. 8. Internal operation of a microprocessor chip.

raises the question of the necessity for special treatment. The answer is the connection problem imposed by the relatively small number of pins (typically 40) that are attached to a microprocessor chip containing the equivalent of several thousands of discrete logic components. This access problem is solved in practice by time-sharing the address and data pins, as will be described in the next article.

To be continued

References
1. Zissos, D. "Problems and solutions in logic design," second edition, Oxford University Press, 1979.
2. Intel 8080 microprocessor user's manual, September 1975.
3. M6800 microprocessor system design data, Motorola, 1976.
4. MCS85 user's manual (preliminary), Intel Corporation, 1977.
5. Zissos, D. "System design with microprocessors," Academic Press, 1978.
6. Duncan, F. G. "Microprocessor programming and software development," Prentice Hall, 1979.

Scientific computer club

Following the publication of a two-microprocessor scientific computer design (April to September 1979 and January to February 1980) we have received a large number of requests for more information and details of clubs linked to this design. We are therefore pleased to note the formation of a computer users' club for the Adams machine, which we hope will stimulate interest in this design and encourage correspondence between readers.

To start the ball rolling a monthly newsletter, starting in May, will be circulated by Phillip Probetts to members for an annual subscription of £5.00 including postage. John Adams, the designer, will contribute a series of articles describing the computer in greater depth, and he will also help to answer members' queries. The early issues will contain short editorials and include programming information and examples, while later issues will reflect members' interests by publishing their programmes, letters and comments.

Feedback is important, so send subscriptions, suggestions, contributions and queries to Phillip Probetts, 50 Cromwell Road, Wimbledon, London, SW19, 8LZ, England.

Weather satellite picture processor

Visible and infra-red pictures from the TIROS-N series

by G. R. Kennedy

This signal processor produces real-time visible and infra-red weather pictures side-by-side and correctly exposed. Up to four satellites may be preset on the unit, which has been designed for high quality pictures from the 137MHz transmissions. For a description of a facsimile machine suitable for use with this processor, and for background information on weather satellite reception, readers should refer to previous articles by the author, listed in the references.

A prototype of the latest American polar orbiting weather satellites, TIROS-N (TIROS X1, 1978-96A), was launched on October 13, 1978. One of the main differences between the TIROS-N series and the ITOS (NOAA) predecessors is the improved picture definition. This is due to improved scanning radiometers and a faster scanning rate, 120 r.p.m. compared with 48 r.p.m. for the NOAA-1 to 5 series. Two channels of picture information are sent on the v.h.f. transmission and in normal use one channel is infra-red while the other is in the visible spectrum. The choice is made at ground control and later satellites will be capable of sending, on v.h.f., two of five available spectral range pictures from the S-band repertoire. Images received on one of the two frequencies used for the TIROS-N series, 137.50 and 137.62MHz, have a ground definition of 4km and have image-distortion correction so that the received pictures are flat, and do not suffer from "bottle distortion" as with earlier satellites. The receive antenna needs to be right-hand circularly polarized and the receiver must cope with a peak 2.4kHz deviation of ±17kHz. The TIROS-N series v.h.f. video format is shown in Fig. 1 and a block diagram of the signal processor is shown in Fig. 2.

The clock channel produces various timing signals, locked to the satellite subcarrier signal, for use within the processor and externally for fax machine or oscilloscope synchronization. A phase-lock-loop is used, preceded by two limiter stages to render the clock circuits immune to signal amplitude variations. The p.l.l. output is buffered by a Schmitt trigger and divided to produce the timing and synchronizing signals.

A linear channel handles the video signal without stretching or cramping. It normally amplifies the visible-spectrum satellite channel which has a high dynamic range and is fairly constant in mean level throughout the year all within a reasonable range of geographical latitude. The linear channel comprises four parallel linear amplifiers, one selected at a time, and is used as a reference against which the third channel is adjusted. After inversion, the amplified signal is applied to an analogue switch common to both video channels.

A log.-channel is used to process the infra-red video signals. However, there are several problems in producing good pictures, such as the small f.m. subcarrier deviation for a large dynamic picture-content change. This is due to temperature variations, for example, the coldest cloud tops can be at −60°C and the warmest land at about 40°C[3]. If a coastline is to be depicted, which aids location of the weather system and is generally more interesting, only small differences of a few degrees can be expected. Because these changes are in the warm part of the infra-red range, advantage can be taken of the logarithmic amplifying process where the gain is maximum at low (i.e. warm) signal levels and reduces with an increase in amplitude. Therefore, the coastline can be enhanced and the cold cloud systems, with their large temperature variations, can be shown quite clearly. Two problems with this technique are the level at which log. amplification starts, and the changes in mean temperature with season and latitude. In this design a variable control with a dial is used which allows resetting for different orbits. The approximate mean picture level for the i.r. channel is roughly matched to that of the sunny portion of the visible channel. The sunny part of the visible channel is used because it is normal to see the daylight terminator on a polar orbiter, especially in winter. Also, interest is heightened by producing the i.r. and visible pictures side-by-side and observing, from the i.r. scene, the weather in the darkened visible section.

After the input level potentiometer, a switch allows either direct log. amplification of the signal, or expansion

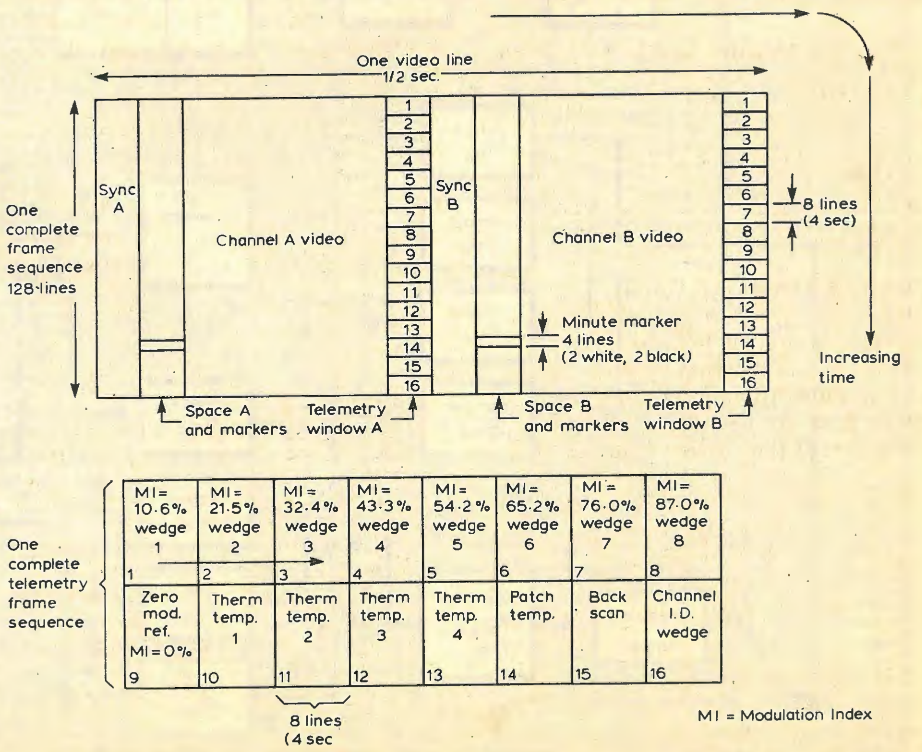


Fig. 1. Video format for the TIROS-N series.

before amplification. For TIROS X1, expansion is not essential, but the facility is available for other or later satellites. The logging stage is followed by four separately switched amplifiers in parallel as in the visible channel. The output of the selected amplifier is fed to the common analogue-switch and, because the log. amplifier inverts the signal, both scenes have the same sense.

The analogue-switch multiplexes a number of analogue signals together in a serial mode. With timing from the clock channel, the switch adds the linear and log. signals in time sequence and produces a picture scan-line of each, correctly processed and in sync. with the transmitted satellite signal. This is followed by a linear output amplifier which produces a signal suitable for a fax machine or an oscilloscope.

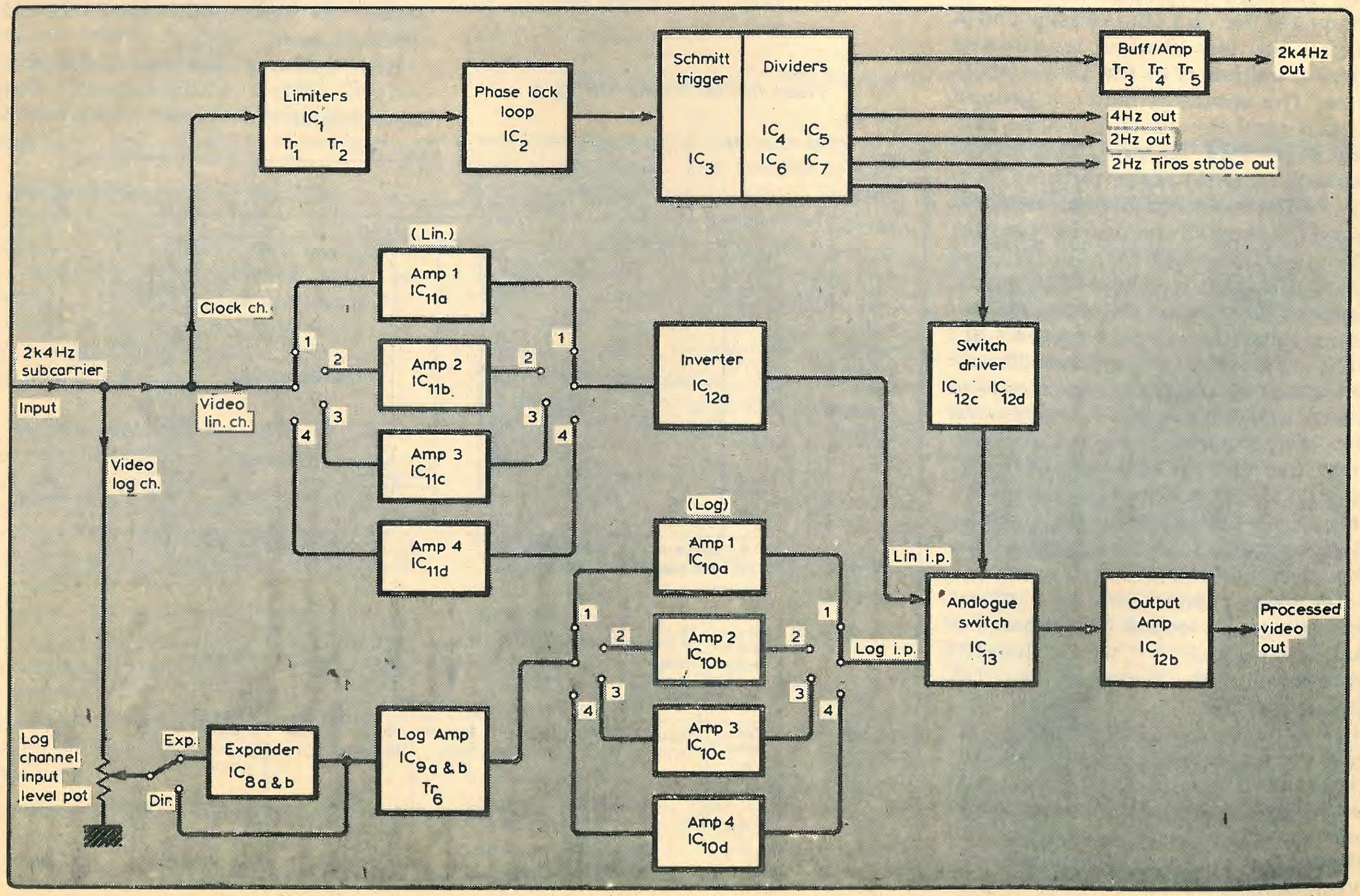
Circuit description

The clock channel is shown in Fig. 3. The 2.4kHz demodulated subcarrier signal from the receiver output, which is amplitude modulated with the picture information, is amplified by IC_1. Signals are a.c. coupled in and out of the amplifier so that the mean 2.4kHz signal is amplified. This stage is not necessary for printing TIROS-X1 transmissions, but it is required with some Russian Meteor signals which may be required to produce weather pictures. Some of these signals, which also use the 2.4kHz subcarrier, have almost 100% amplitude modulation. The amplifier stage at the beginning of the clock chain ensures that the final pictures stay in lock by providing, under all usable signal levels, sufficient 2.4kHz to lock the following p.l.l. The input amplifier is followed by two limiter stages around Tr_1 and Tr_2, which comprise ladder-feedback tuned amplifiers with a.c. coupled back-to-back diodes at their inputs. Only the forward voltage drop of the diodes is amplified and the working point is around the zero-crossing of the subcarrier signal. In this way, amplitude modulation is ignored and the 2.4kHz is selectively amplified. The output of the second limiter feeds the p.l.l. whose v.c.o. frequency is set to 2.4kHz by R_{18}, R_{131} and C_{18}. The loop bandwidth can be selected by S_2, and the values of C_{21} and C_{22} give a good compromise for weak and strong signals. For a strong signal, a wide bandwidth gives solid lock and sharp pictures. A narrow bandwidth may be necessary in the presence of noise, but if noise impulses exceed the tracking range of the loop, a cumulative phase error can occur along the picture line to give locked and noisy pictures with vertical ripples at the right-hand side, for a left to right picture. The loop can be unlocked by S_1, which is best effected using a toggle switch biassed to the locked-loop condition. The rate of locking is set by R_{132} and by this means, the edge of the picture and the order of the i.r. and visible channels across the final image can be set. Automatic phasing can be added by replacing S_1 with a pair of transistors fed by two frequency-selective amplifiers tuned to 1040Hz and 832Hz. Seven cycles of either frequency preceed each of the channels. Normally for TIROS-X1, the i.r. channel is preceded by the higher frequency with a 50% duty cycle, and the visible by the lower frequency with a 60% duty cycle.

The 2.4kHz output of the p.l.l. is a.c. coupled to Schmitt trigger IC_{13} which squares the signal at t.t.l. level. This is buffered by Tr_3, Tr_4 and Tr_5 to an external socket for fax and oscilloscope use, and also fed to a series of dividers. IC_4 divides by 12 to give 200Hz, part of IC_5 divides by 5 to give 40Hz and IC_6 divides by 10 to give 4Hz with an equal mark-to-space ratio.

The 4Hz is distributed to Schmitt trigger IC_3 which buffers the signal to an external socket, to part of IC_5 which divides by 2 and provides a t.t.l. 2Hz sync. signal at an output socket, and also to flip-flop IC_7 where it is again divided by two with an equal mark-to-space ratio to provide a TIROS strobe signal. The division state can be inverted by reset-switch S_8 which sets the flip-flop preset to low. The strobe signal is used for printing just the i.r. or visible satellite channel. When using a facsimile recorder, printing only one image gives a print twice the size. The drum speed is 240 instead of 120 r.p.m. for the pair, and the strobe pulse, which is high for exactly half of the satellite video

Fig. 2. Block diagram of the facsimile-machine driver.



line, keys the fax light-souce off for the unwanted half line. By switching S_8, the channel being printed can be changed. This is a useful feature in winter when the southerly portion of a northern hemisphere pass can be printed in visible, and the northern portion, which may be in darkness, printed in i.r. without losing picture lock. The strobe pulse is taken from the flip-flop Q output, and the $\overline{Q}$ output passes via S_3 to a pair of op-amps in IC_{12}. These amplifiers control the analogue switch, and drive l.e.d. indicators which show log. or lin. status. With S_3 in the TIROS position, IC_{12} is driven at 2Hz and, because no feedback resistor is used, the output latches from —12 to +12V at 2Hz. Op-amp IC_{12c} operates in the same way but at 180° out of phase, and this pair of outputs switch the lin. and log. channels on and off once per video line. With S_3 in the normal position, S_7 (log./lin.) sets the Q and $\overline{Q}$ lines of the analogue switch by selecting +12 or —12V.

The linear channel and analogue switch are shown in Fig. 4. The 2.4kHz video signal is taken via S_6 to one op-amp in IC_{11}. Each amplifier has a gain control and a level setting potentiometer which can be adjusted for a given satellite without affecting the other amplifiers. If four satellites are not required, optimisation for a particular satellite can be tried without losing the previous settings. The output of the selected amplifier goes to IC_{12a}, a unity gain inverter, which feeds part of analogue switch IC_{13}. The circuit has been designed so that only positive going signals are accepted. Both video channels pass through an inverted L arrangement of two analogue switches where the series arm has a 47kΩ resistor in series and a further 56kΩ resistor to the next stage. At the junction of these resistors the shunt switch connects directly to ground. By keeping the output impedance high, turning on the shunt switch effectively stops any signal leakage. The on resistance varies with load conditions and supply rails, in this circuit it is around 600Ω. Again, raising the path impedance makes the switch resistance insignificant compared with the two resistors. also, when the shunt switch is on, its resistance is minute compared with the series-switch off resistance and board leakage, so the overall signal leakage is very low. The output of IC_{12d} controls the series switch, and IC_{12c} controls the shunt switch. The output of each part of the dual switch circuit is summed by IC_{12b} whose gain is selected by R_{73}. A typical value for this resistor is 680kΩ which gives a gain of 12 and is suitable for the facsimile machine published from Dec. 1976 to July 1977.

The logarithmic channel is shown in Fig. 5. The input video signal is passed through a potentiometer to set the amplitude and the scaled signal then passes to an expander[4] with resistors altered to suit standard values. With S_4 in position 1, the expander is bypassed and a resistor is placed in the op-amp feedback paths to prevent spurious oscillation. The video signal is then a.c. coupled to a rectifier. The logarithmic amplifier[5], which comprises IC_{9ab} and Tr_6, generates a logarithmic output voltage from a linear input current. Transistor Tr_{6a} is the non-linear feedback element for IC_{19a} whose output current is fed around R_{111} and Tr_6 to the summing input. Therefore, the loop current is directly proportional to the input voltage at R_{110}. IC_{9b} and Tr_{6b} form a constant current circuit where the current through R_{114} is equalled by the feedback current through the collector of Tr_{6b}. Therefore, the emitter-base voltage of Tr_{6b} is constant and, with the base of Tr_{6a} grounded, the base of Tr_{6b} must rise or fall by a voltage logarithmically related to the input voltage at R_{110}. Due to the temperature dependence of the circuit[5], R_{112} should be 1kΩ and have a positive temperature coefficient of +0.3%/degC. For normal room conditions a standard high stability resistor is adequate. Resistor R_{136} sets the offset voltage for IC_{9a} and provides some control over the lower threshold at which logging starts. Diode D_{12} prevents damage to the dual transistor if the +12V rail momentarily goes negative at switch-on. Capacitors C_{37} and C_{38} prevent the op-amps from oscillating, and C_{36} decouples the supply.

The logarithmically amplified and inverted signal is switched by S_5 to one of the linear amplifiers in IC_{10}, and the selected signal is fed directly to IC_{13} which switches in the same way as the linear channel.

Construction

The linear and log. channels should be separated to avoid crosstalk and to enable adjustments to be made without confusion. The gain controls, which are seldom altered after their initial adjustment, can be ordinary carbon presets mounted on the circuit board. The level controls, which are often adjusted, should be 10 or 15 turn

Components list

Resistors ¼W

31	47
30, 33	100
19, 20	180 ½W
34, 88, 89	220
15, 16	330
23, 24, 32	470
12, 18, 22, 27, 45, 112	1k
7, 26, 107	1k5
21, 35, 113	2k2
36, 93, 94	2k7
67, 69, 108	3k3
25, 28, 37, 38, 39, 40, 55, 57, 59, 61, 95, 124, 126, 128, 130	4k7
96	6k8
41, 44, 97	8k2
1, 2, 4, 5, 8, 9, 13, 14, 62, 63, 65, 74, 92, 98, 104, 106, 110	10k
99	12k
10, 29, 46, 47, 48, 49 50, 51, 52, 53, 54, 56, 58, 60, 100, 111, 115, 116, 117, 118, 119, 120, 121, 122, 123, 125, 127, 129	15k
42, 43, 86, 87, 90, 91, 101, 109	22k
84, 85, 102	27k
82, 83, 103	33k
17, 66, 68, 81	47k
70, 71, 80	56k
79	68k
77, 78	82k
3, 72, 114	100k
6	390k
11	470k
73	680k

Capacitors 20%

1, 3, 8, 9, 14	47n
2	50n
4, 10	470p
5, 6, 7, 11, 12, 13	1n8
16	1n
17, 18, 27, 30, 33	22n
19, 20	25μ, 10V
21, 35	100n
22, 34	2.2μ, Mylar
23	47p
24	220μ, 6.3V
25	15n
26, 32	100μ, 16V
28	47μ, 6.3V
29	33n
31	2200μ, 6.3V
36	10n
37	680p
38	330p

Semiconductors

IC_1	741
IC_2	565
IC_3	7413
IC_4	7492
$IC_{5,6}$	7490
IC_7	7474
$IC_{8,9}$	747
$IC_{10,11,12}$	348
IC_{13}	4016
IC_{14}	LM309K
$Tr_{1,2,3,4,5}$	2N3704
Tr_6	2N2223A
$D_{1,2,3,4}$	OA47
$D_{5,6}$	5.6V 400mW Zener
$D_{8,9}$	red l.e.d.
$D_{7,10,11,12,13}$	1N914

Variable resistors (see text)

R_{131}	5k
R_{133}	10k, 10 turn
$R_{134,135}$	1k
R_{136}	500, 10 turn
$R_{137,139,141,143,145,147,149,151}$	10k
$R_{138,140,142,144,146,148,150,152}$	100k
R_{132}	1M

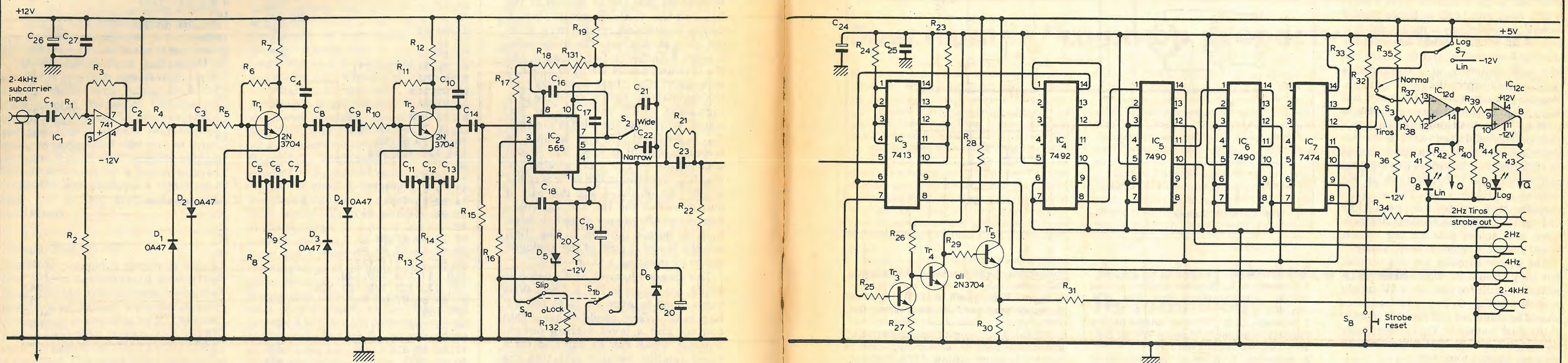


Fig. 3. (top) Clock channel.

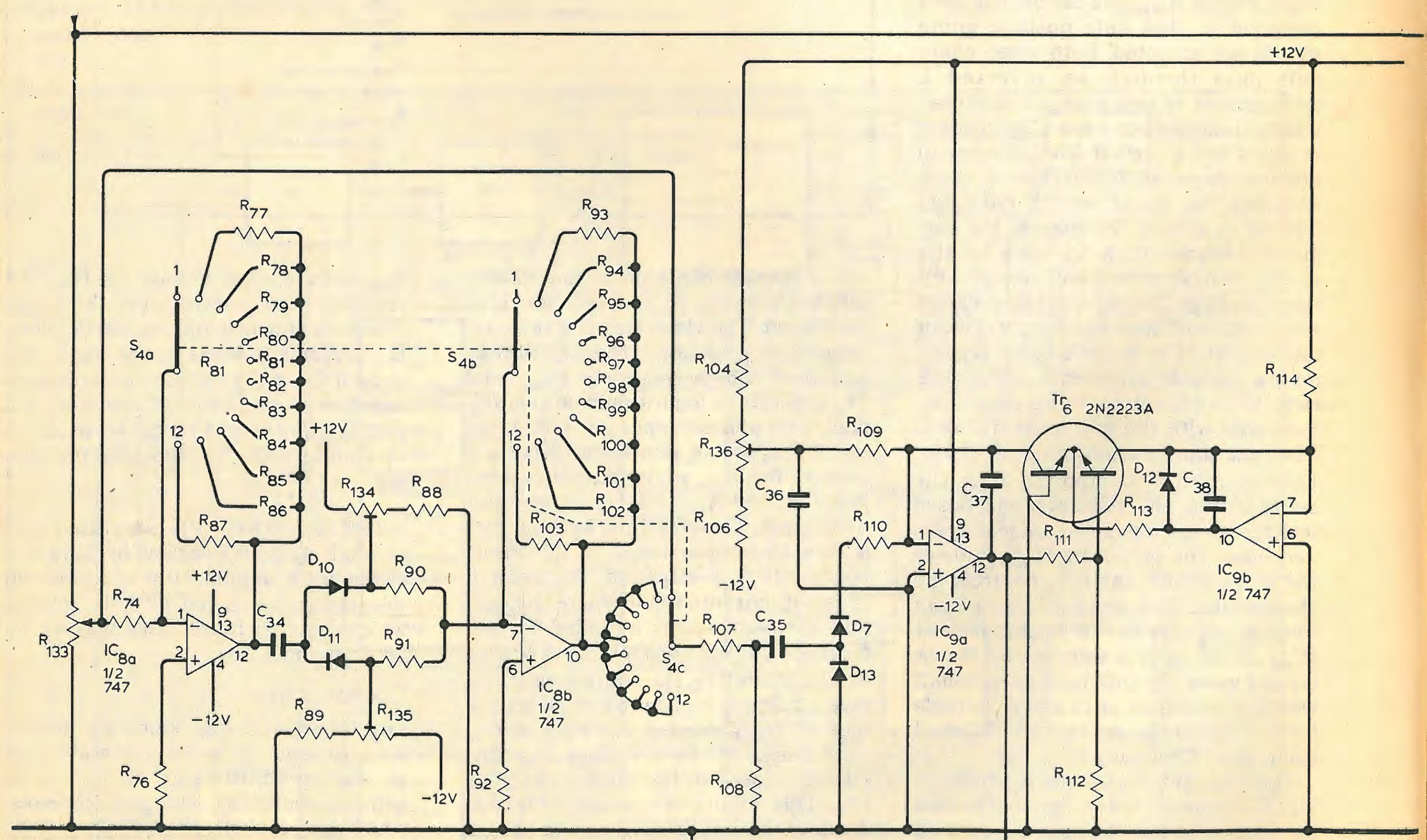


Fig. 5. (bottom left) Logarithmic channel.

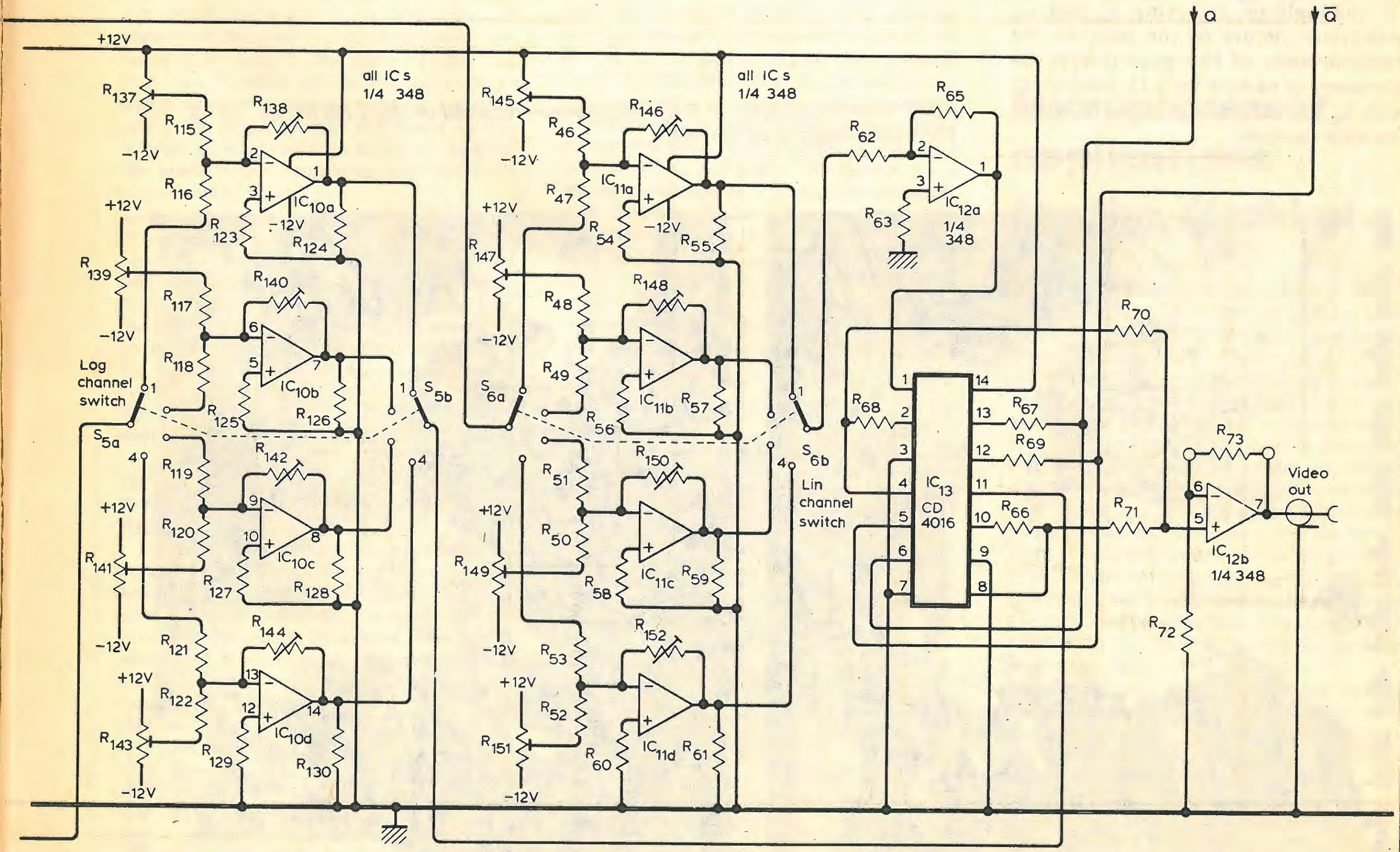


Fig. 4. (bottom right) Linear channel.

cermet types and have screwdriver access through the instrument case. If the processor is to be used with a drum fax in a darkroom, it is worth building the instrument either inside the fax machine, or in a shallow case underneath. Also, any l.e.ds or lamps should be red if bromide type paper is used. It is helpful to use large white lettering for dim-light operation, and to mount the slip/lock switch S_1 at a comfortable position away from the other controls. R_{132} can be a screwdriver slot preset, but R_{133} must be noise-free, smooth to operate, well positioned for easy adjustment and fitted with a turns-counting dial if high quality prints are to be obtained. For darkroom use, a digital mechanical dial is better than an engraved analogue type. The output-amplifier gain resistor may need to be changed if a different readout device is used, and solder pins on the circuit board make the removal of R_{73} easier.

The power supplies are not critical, but they should be well smoothed. A suitable circuit for the ½A +5V supply is shown in Fig. 6. The ±12V supplies should be stabilized and rated at 100mA. If the dual transistor Tr_6 cannot easily be obtained, two 2N3704 devices can be epoxy cemented together.

To ensure that the circuits, particularly the log. amplifier, are temperature stable, the unit can be permanently on.

After satellite acquisition, slip S_1 to establish the picture edge position on the fax or oscilloscope, and select either the side-by-side order of the visible and i.r. channels or, by using S_3 and S_7, select one picture or the pair. At the extreme ends of the pass it may be necessary to narrow the p.l.l. bandwidth with S_2, but normally this can be left in the wide position.

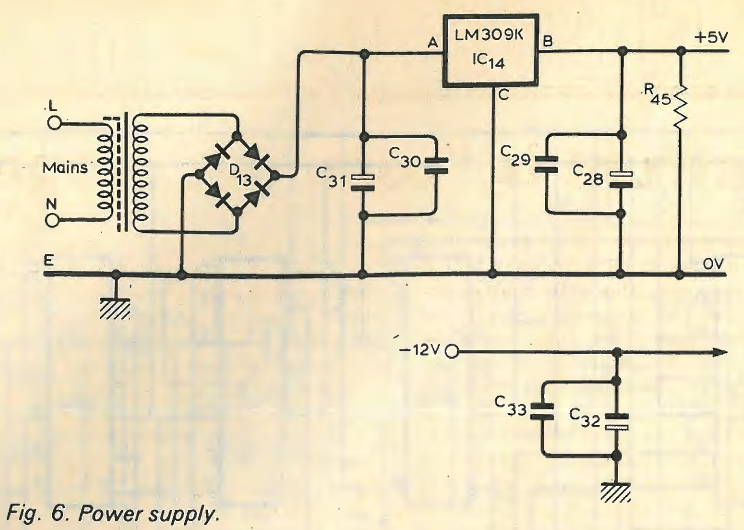
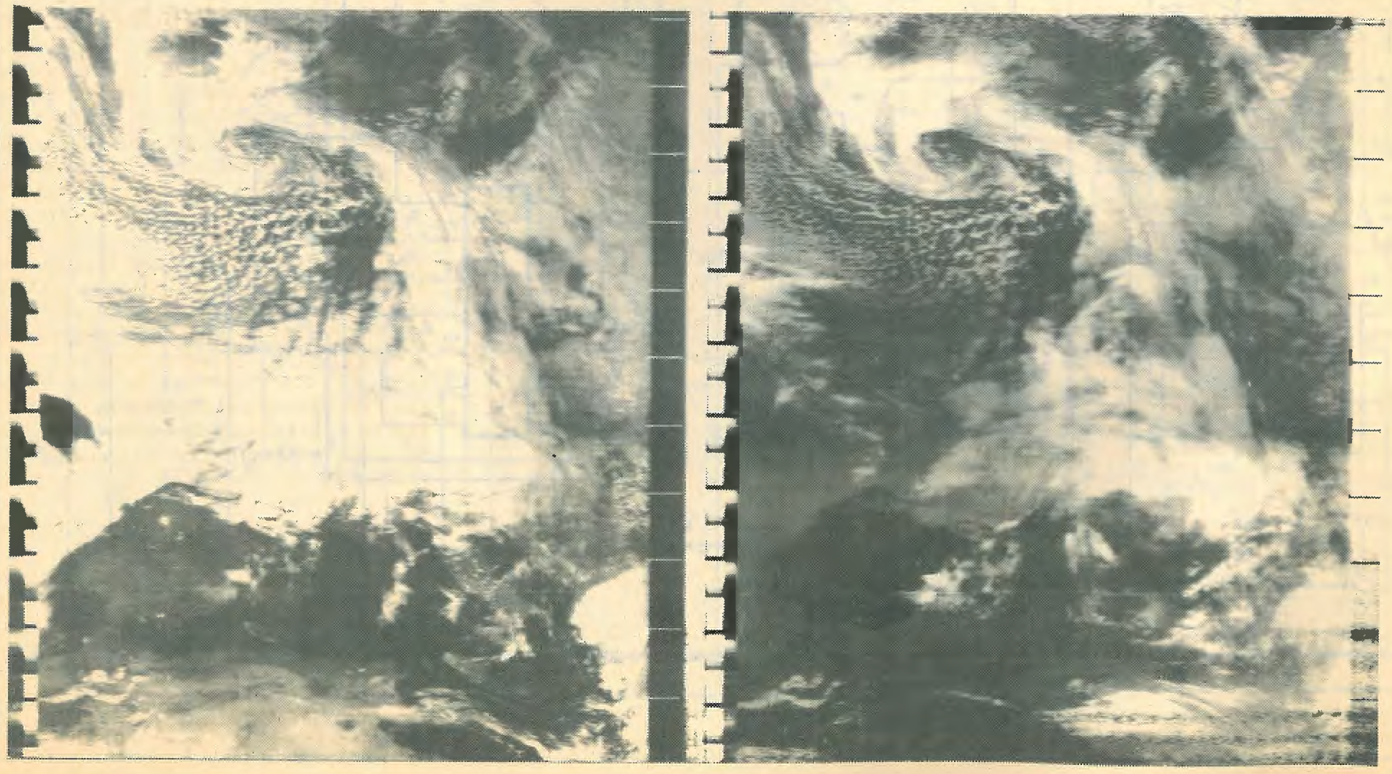


Fig. 6. Power supply.

References

1. Kennedy, G. R. "Weather satellites ground station," *Wireless World*, Nov., Dec. 1974, Jan. 1975.
2. Kennedy, G. R. "Weather satelite picture facsimile machine," *Wireless World*, Dec. 1976, Jan., Feb., March and July 1977.
3. Anderson, R. K. et al "Application of meteorological satellite data in analysis and forecasting," ESSA Technical Report NESC 51, March 1974, National Oceanic and Atmospheric Administration, Washington, D.C. 20233, USA.
4. Baylis, P. E., Brush, R. J. H. "Contrast expansion processor," *Wireless World*, Dec. 1973.
5. Dobkin, R. C. "Logarithmic Converters," application note 30, Linear Applications volume 1, third edition, 1973, National Semiconductor Corporation, Santa Clara, California 95051, USA.

Fig. 7. Satellite pictures of the Mediterranean received on the 11th March, 1979. The visible image is on the left.



NEWS OF THE MONTH

Spectrum is "common property of mankind"

The electromagnetic spectrum and the geostationary orbit for satellites, both of which are natural resources, should be more equitably shared as the common property of mankind. This is one of the conclusions of the final report of the International Commission for the Study of Communication Problems which was recently presented to the director-general of UNESCO. The 16-member commission has welcomed the decisions taken at WARC 79 to convene a series of conferences over the next few years on specific aspects of the utilization of these resources (February issue p. 46, March issue p. 72).

The report deals comprehensively with the right to receive, seek and impart information as a fundamental human right, and its main message is the need for a greater democratization of communications (as discussed in our December 1979 leader). It takes the view that fundamental communication problems transcend mere media questions and recommends that communication "be no longer regarded merely as an incidental service and its development left to chance". In setting up new systems "preference should be given to non-commercial forms of mass communication" and, while obviously the media need their revenues, "ways and means should be considered to reduce the negative effects that the influence of market and commercial considerations have in the organization and content of national and international communication flows". The report points out that "the freedom of the citizen to have access to communication, both as recipient and contributor, is not the same as the freedom of an investor to derive profit from the media while remaining indifferent to quality and content."

On broadcasting, the "development of comprehensive national radio networks, capable of reaching remote areas, should take priority over the development of television . . ." and "national capacity for producing broadcast material is necessary to obviate dependence on external sources . . ." For communities in developing countries "local radio, low-cost, small-format television and radio systems and other appropriate technologies would facilitate production of programmes relevant to community development efforts, stimulate participation and provide opportunity for diversified expression".

Tariffs for telecommunications, the report says, "are one of the main obstacles to a free and balanced flow of information. This situation must be corrected, especially in the case of developing countries, through a variety of national and international initiatives. Governments should in particular examine the policies and practices of their post and telegraph authorities. Profits or revenues should not be the primary aim of such agencies. They are instruments for policy-making and planned development in the field of information and culture . . . International action is also necessary to alter telecommunication tariffs that militate heavily against small and peripheral users . . . UNESCO might, in co-operation with ITU, also sponsor an overall study of international telecommunication services by means of satellite transmission in collaboration with Intelsat, Intersputnik and user country representatives to make proposals for international and regional co-ordination of geostationary satellite development."

The new technologies coming into communication have both great potential and great danger, says the report. Countries should evaluate their social implications and should promote "participation and discussion of social priorities in the acquisition or extension" of these new technologies. Decisions on "the orientation given to research and development should come under closer public scrutiny". Concentration of communications technology in a few developed countries and multi-national corporations "has led to virtual monoply situations in this field. To counteract these tendencies national and international measures are required, among them reform of existing patent laws and conventions, appropriate legislation and international agreements."

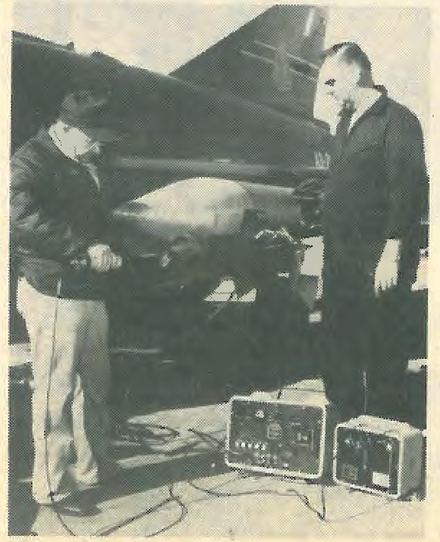
Australian Air Force up-dates its technology

William Scholes, a contact in Sydney, reports that the first trials of laser-guided bombs (LGBs) in Australia, using a Mirage fighter of the RAAF, were held recently at the Woomera Rocket range in South Australia.

The trials, conducted by Texas Instruments (USA) in collaboration with the Defence Science Research Centre and the Aircraft Research and Development Unit, are a direct result of Prime Minister Fraser's response to the American call for "increased surveillance of the Indian Ocean area by America's allies," although why better killing devices are needed to improve surveillance has not been explained. LGBs use semi-active homing devices in that they contain passive detectors which collect and process laser energy which has been reflected or scattered from a target, previously illuminated by a separate laser source. The angular displacement between the bomb's central axis and the direction of the laser radiation is measured by the LGB's guidance system and correction signals are sent by means of a servo system during flight, causing deflection of the bomb's strap-on wings. The flight path is corrected accordingly and the bomb steered towards its target.

During the Vietnam conflict, both the USAF and US Navy employed LGBs as well as electro-optical guided bombs. These bombs used a similar form of visual target identification but were equipped with a different guidance system which offered greater flexibility than the LGB method.

Engineers checking operation of the LGB guidance head using a flight line test kit.



Microprocessor applications for the disabled

The Bias '80 exhibition, to be held in conjunction with Microelettronica in Milan from June 4th to 8th 1980, includes a competition for projects aimed at helping handicapped persons. Total prize money is $7000 in addition to prizes in the form of systems, instruments and other items of electronic equipment. Engineers and designers interested in competing should bear in mind that the projects should be useful as aids to disabled persons such as those who are blind, deaf mutes and persons with difficulties in communication, expression and/or movement. Consideration will also be given to other unconventional applications of microprocessors not strictly tied to the subject of the competition provided they are of real interest in the bioengineering or medical electronics field.

Special prizes will be presented in this section. Projects should be presented with block diagrams and circuits, hardware complement, software, cost, weight and dimensions. Presentation of a prototype is desirable but not essential. Entries should reach the competition secretariat no later than May 20th 1980. Phone or write to Studio Barbieri, Viale Premuda 2, 20129 Milano, Italy, tel. 796 096 421 635

"Challenge of the Chip" exhibition

There can't be many western industrialized persons to whom the "chip" is a total mystery, but the few to whom it is would do themselves a favour if they were to go along to the Science Museum's "Challenge of the Chip" exhibition, which opened in late February and continues until sometime in December 1980.

In spite of a variety of adjectives used to describe the exhibition, and a spate of journal reports which did little more than précis the official booklet, it is one of the most effective displays the museum has staged; as a history of the development of modern microelectronics it is highly successful, dodging about from basic materials and fabrication methods to applications in a surprisingly unstructured fashion. Some of the conceptual illustrations are particularly sharp, such as, in an early exhibit, where the seemingly paradoxical nature of semiconducting materials is outlined, i.e. that heating causes an improvement in conduction in semiconductors, the diametrically opposite effect to that observed in a conventional conductor.

The major area of concentration is of course that of computing in its many forms, from sophisticated medical equipment and military radar applications to the multitude of toys and games based on the chip.

All the exhibits do not flash lights or count or converse with human beings, although those that do have been the best occupied. The Dept. of Industry's exhibit, a small hall set aside for posters of MAP — initials not explained — was totally empty for over 20 minutes while hordes of children gleefully punched buttons and re-programmed things alongside.

Kiddies, it seems, are one of the major hazards of the exhibition business if the opinions of one or two of the "keepers" are anything to go by. "Too many of the little demons all at once, that's the worst of the school holidays," said one of them. Visiting the exhibition during term time might be the quieter answer therefore, although this presumes that coach-loads will not occasionally arrive, press-ganged into the trip by avid science teachers.

It's all great fun though, and very informative, leading right through from the development of the first point-contact transistor to the "latest" on the information retrieval systems.

Some elements were a little silly (but forgivable) such as that showing applications of the chip for "sensing" processes in rather trivial areas on the family car—oil and petrol level sensing, o.k., but sidelight checking by photoelectric means? More sensors needed to check the checking l.e.d. which in turn checks on the state of another checking device, always assuming that your l.e.ds are reliable and you don't come to the conclusion that a length of optical fibre, carried from sidelights etc. to the dashboard is all that's needed for instant feedback to the human optical system.

The relatively "perfect" actions of microcomputers were thrown into sharp relief by the apparent incapacity of the technicians who must surely have set the exhibits up to ensure good results from the video monitors dotted around the showcases. In one batch of six, two were suffering from ballooning (presumably low e.h.t.) and two from line pulling at the top of the screen.

At £1.65, the official booklet is good value, being crammed with excellent illustrations and only really falling short in the rather wooden style in which it is written and the single hole in its claim, common to the handbook and the exhibition, to show how "microelectronics will affect your future." There is no direct information or comment on either the more intense social changes or possible shifts in employment in the future as a result of "chip activity".

However, if one of its more staggering "facts" is any sort of indicator, that the pocket calculator gives us as much computing power as would have cost £50,000 only twenty years ago, then maybe the author's sharp intake of breath at this self-revelation prevented further literary effort on the subject.

Microprocessor competition

To be fair, he couldn't really have known about, for example, the results of the recent British Microprocessor Competition, which was organized by the National Research Development Council (NRDC) in collaboration with the National Computing Centre (NCC). The first prize in category 1 (working models) of £10,000 was won by Sinar Agritec Ltd, of Egham, Surrey, for their design for a portable grain moisture meter (see photo). This is adaptable for other commodities such as rice or seeds and features calibration data for several varieties of crop, located in a single e.p.r.o.m., using a computer language called FORTH.

Operation is by means of only two push-buttons and an l.c.d. unit, and the complete program routine can be stepped through by an untrained operator. The judges considered this design to be of value for agricultural purposes for both developing and advanced economies.

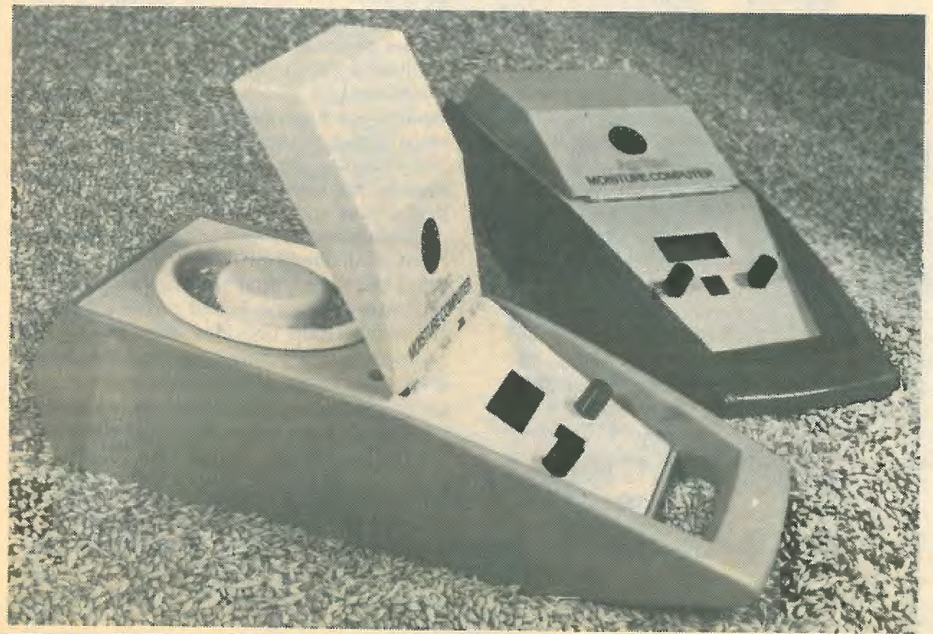
The second prize of £5,000 was won by a team from the University of Manchester Institute of Science and Technology (UMIST) Department of Mechanical Engineering. The interactive programming system for lathes permits the operator to "converse" with the machine and the judges felt that the market potential for small machine shops is substantial, if the right company can be found to complete development of the design.

The Truestock stock control system won for Grundy Terminals of Teddington, Middlesex, the third prize of £2,000. Once again, this offers sophisticated techniques for use by untrained operators enabling, for example, a component or sub-assembly to be instantly identified by pointing to it on an overlay drawing with a light pen.

In the second category (ideas on paper), MDB Electronics of Deptford, London, won the first prize of £2,000 for their design for a portable electrocardiograph machine. This offers battery operation and facilities for on-the-spot print-out and analysis of heart activity. Once developed, there could be a significant market for this type of instrument in surgeries, ambulances and first aid posts.

Second prize of £1,000 in this category was won by a private individual, Mr. C. Goss of St. Margaret's, Twickenham, for his electronic aid for the speech-impaired. This is based on comparatively cheap speech synthesis chips with limited, but nevertheless useful, vocabularies. A hand-held device is used to enter abbreviated words into a microprocessor, which employs "ingenious" algorithms to produce complete sentences. The judges foresaw the development of a device which is unobtrusive and portable, at a price which people with speech handicaps will be able to afford.

A special prize of £500 was awarded to the Royal Grammar School, Newcastle-upon-Tyne, for its microprocessor-controlled theatre lighting system.



The moisture meter designed by Sinar Agritec which won first prize in the British Microprocessor Competition. Using an RCA 1802 m.p.u., it provides calibration programs for 30 types of cereal or 64 commodities in all, and has built-in electronic weight balance and automatic temperature correction. The commodity being tested acts as a dielectric in a capacitance method of moisture measurement. The makers founded their company in 1978 on the principle that microprocessors should be applied not only to fast-profit consumer products but also to ultra-practical devices to help increase the quality and consistency of food produce. (Sinar is an Indonesian word meaning radiant light.)

Richard Kirby at conference on spectrum conservation

The keynote address at a conference organized by the IEE on the subject of "Radio Spectrum Conservation Techniques", to be held at the IEE headquarters from 7 to 9 July 1980, will be given by Richard Kirby, Director of the International Radio Consultative Committee (CCIR), to which body the ITU looks for technical guidance on radio.

His main subject will be the role of technology in coping with the more intensive frequency sharing arrangements resulting from WARC 79. General IEE interest in the subject dates from 1976, when the Electronics Divisional Board set up a special committee to investigate the many aspects of radio spectrum conservation. The idea for this year's conference arose from the committee's discussions.

Response to the call for papers has been good and topics for discussion include alternatives to the use of radio, modulation techniques for reducing the bandwidth of transmitted signals, methods of processing of information, aerial designs to limit wasteful radiation, techniques for reducing interference, computer-aided techniques for spectrum planning and management and methods of confirming the radio energy level required for a particular region or application.

For further information contact the IEE, Savoy Place, London WC2R 0BL.

Andrew Corbyn, designer of the pulse induction metal detector described in our March and April issues, explains a point about the prototype to Marie Tracey, chairman of Pulse Induction Ltd of Yateley, Surrey, which has an interest in the patent application. Andrew, 35, is a chartered engineer with degrees in mining engineering and geophysics from Imperial College. Apart from his research in rock mechanics, potential field theory and statistical evaluation of mineral deposits, he has worked as a teacher, mining engineer, computer programmer and plumber. He has designed large metal detectors for searching for gold in Western Australia. Marie, together with her husband, electronics engineer Lee Tracy, formed Pulse Induction Ltd in 1972. She has done business in metal detecting with military forces in various parts of the world and her visits to remote spots have included travel on a camel across deserts in Libya and Egypt. She is an expert shot with "cowboy" type hand guns, with which she has given demonstrations, and has also worked as an artist's model. Her company is now part of the Kay Organisation, which includes Lansing Bagnall fork lift trucks.

GLC document, largely favourable to c.b., seeks public response

A consultative document, recently issued by the GLC, outlines the main details of the citizens' band debate and urges a strong public response to support the council's "belief in the freedom of individuals to take advantage of modern technology in their work and recreation, subject only to this freedom not interfering in an unacceptable way with the freedom and rights of others."

The document points out the potential social and commercial benefits of c.b. by reference to the USA, where it is possible to use the facility to book hotel rooms, order meals in advance, give warning of traffic jams or accidents or to provide back-up facilities for the emergency services. It emphasises the advantages for those who are disabled and refers to cases such as the elderly, who may be vulnerable to sudden illness or physical assaults while in their homes, or the invaluable nature of c.b. to a disabled driver whose car may have broken down and who may be incapable of walking to a telephone.

Possible disadvantages of c.b. are also considered in the document, such as its use by the criminal fraternity in co-ordinating criminal enterprise (which could well be outweighed by virtue of the fact that anyone tuned to the transmission frequency would be warned of the plan) or obscene language broadcasts. Furthermore, the point is made that illegal c.b. activity is fairly widespread and criminal acts may be planned whether or not the service is legalized. The "pro-c.b." lobby argues that criminal activities would be rendered more difficult by official policing of the system, especially if legislation on c.b. sets included a compulsory identification code signal. Balancing this would be the problem that manpower would be required to regulate the service, which does not fit with current "trimming down" of public service departments through cuts in government funds. A decision on the issue was postponed by the government after an official statement on 6 December 1979 that the really strong argument was one based upon personal freedom, although the major problem was that of the selection of a suitable frequency band. Another important feature of the frequencies which could be used for c.b. is their relationship with sets already manufactured in the USA and Japan and, according to this document, stockpiled in this country ready for sale if c.b. is legalized. Most of these sets (about 100,000) are for operation in the 27 MHz band, and there is common ground between the advocates of c.b. and the government that this frequency band is unsuitable and undesirable for the purpose.

"This band . . . directly threatens the users of hospital and other paging systems and the activities of model control enthusiasts. In addition, it is understood that harmonics of transmissions on this band can interfere with broadcasting, the emergency services, old people's alarm systems and aircraft communications. Signals at this frequency also have a longer range than required . . .

"Estimates have been made that there could be a requirement of between 6 and 8 million sets if c.b. were to be legalized in this country. A potentially large new market could thus be created for British firms, particularly if the controls imposed on band, modulation and set specification were such that all manufacturers, overseas as well as at home, were starting from a new base in the design of the product. This would include type-approved equipment having to perform accurately to the frequency chosen and the system capable of extension to accommodate (possibly) data transmission and station coding to identify the transmitter.

"The government's clear intention to allocate a frequency other than the 27MHz band would remove an advantage currently held by the USA and Japan since they permit c.b. activity in that band and their sets are produced accordingly."

Comments and views on the issue in general should be sent before June 4th 1980 to The Director-General (DG/PR), Greater London Council, The County Hall, London SE1 7PB.

Periphonic sound

First public demonstration of periphony at AES convention

Back in 1970 Michael Gerzon, a mathematical researcher at the University of Oxford, was experimenting with tetrahedral* recording. Four almost-coincident microphones were angled for spherical sound pickup, with playback over four loudspeakers in a tetrahedral array. Microphone angles were determined, matrix co-efficients calculated and the discovery made that there was redundancy in the four channels and the minimum number of non-redundant channels was three. And it worked. Not perfectly, but well enough for him to remark two years later: "Those who have had the opportunity of hearing periphony at its best can have no doubt that the height effect is important in the reproduction of sound and in the enjoyment of music . . ."

Now, a decade later, the first public demonstrations have taken place using a recently-developed periphonic decoder. Until now only ambisonic equipment for horizontal surround sound has been available but the general theory is just as applicable to the third dimension of height.

There were not many who had heard periphony then; there can't be that many more now, though the NRDC-sponsored Ambisonic partnership did a sterling job at the recent London Audio Engineering Society Convention with frequent six-at-a-time demonstrations for three and a half days. But even if one couldn't prove the pudding one wonders why it wasn't intuitively obvious to many whom one thought it should have been that as sounds in nature arrive from all directions, a system which sets out to create a good illusion of reality should take account of this fact.

Whilst the market place may not yet be ready for six or eight loudspeaker sound systems interest in periphony is steadily increasing. The development of the periphonic or soundfield microphone (see "British lead in surround sound microphone' *WW*, August 1978, page 75) was a necessary condition for this, and many recording engineers are now aware that together with its signal processing circuitry it offers mono, stereo and two and three-channel horizontal surround, as well as periphonic options, at the touch of a few control knobs, to say nothing of the extraordinary post-recording flexibility for effective alteration of microphone position and polar response. And this at a time when digital systems are promising the audio world access to a greater number of high quality audio channels.

Progress in periphony and in periphonic decoder design in particular became possible due to the development of a fairly comprehensive theory of the psychoacoustics of directional reproduction which helped to unravel just why periphony didn't work perfectly the first time. Equipment design is greatly simplified and subjective results readily optimized using the results of this work, some aspects of which were summarized in a lecture by Michael Gerzon at the convention.

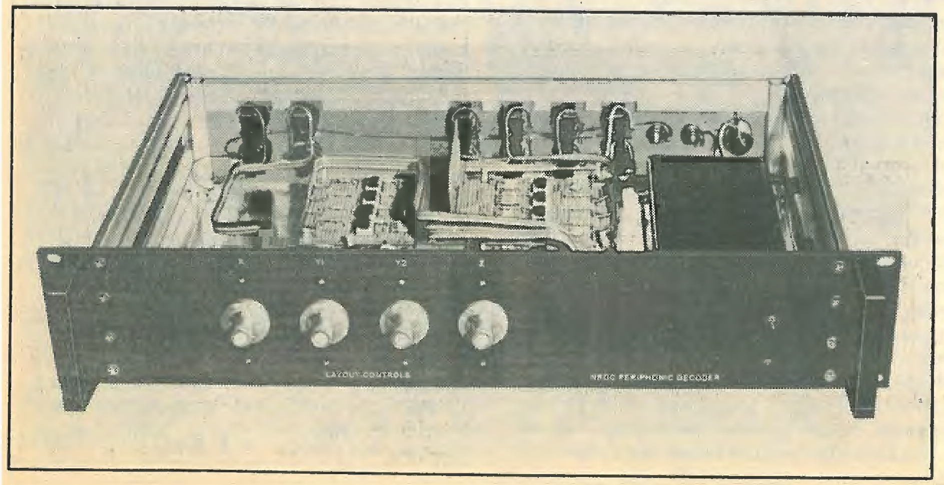
To oversimplify this, imagine vectors drawn from the centre of a four-speaker array with directions pointing toward each speaker and whose length is proportional to the amount of sound emitted from each speaker. At low frequencies, below 700Hz, where localization depends on inter-aural phase differences, make the length of each vector proportional to the *amplitude* of sound emitted and add their magnitudes to give a total amplitude. Also add vectorially, which gives a localization according to the Makita theory (which is that direction to which the head turns to give zero phase difference). Now when the head points in another direction the perceived direction generally differs, and to stabilize the image position requires that the magnitude of the resultant vector is the same as the total amplitude of sound from the loudspeakers. This ratio is called the vector magnitude r_v (r comes from real, v from velocity) and should ideally be unity in reproduced sound, as it is with a live sound source.

At high frequencies, where localization is by inter-aural intensity differences, make the length of each vector proportional to the *energy* of sound emitted, and again add the magnitudes to give a total energy. Adding vectorially gives a localization according to the energy-vector theory (which is that direction to which the head turns to give zero intensity difference). Then, it is argued, to give good image stability the vector magnitude r_E, i.e. the ratio of resultant vector length to total energy, should be as close to unity as possible. (This ratio would be unity for a real sound source, but it has been shown that this value cannot be attained when reproducing multiple sounds.)

As well as meeting these two criteria good decoder design must get both localizations correct for all frequencies and in all directions. Though it wasn't obvious at the time the trouble with the

continued on page 75

*A theory of spin spherical harmonics, a three-dimensional equivalent of circular harmonics with analogy to quantum theory, showed that the early tetrahedral array was only one member of an hierarchial family, which Michael Gerzon termed periphonic.



First periphonic decoder built by the NRDC-sponsored Ambisonic partnership has controls that allow a variety of loudspeaker arrays to be used.

LETTERS TO THE EDITOR

THE INTELLIGENT PLUG

Having been involved in power line carrier design for some time I particularly enjoyed the article "The Intelligent Plug" in the December 1979 issue. The techniques described for the remote control of domestic appliances are straightforward and practical.

Some time ago I entered into a development programme for a full duplex power line carrier intercom in conjunction with Semiconductor Circuits Inc. of Haverhill, Massachusetts. This work culminated recently with the production of a number of prototype systems, working in pairs so that a person in one room could simultaneously talk and listen to another in a separate room without having to operate any controls. We even went exotic with the addition of telephone adapters to convert the intercoms into loudspeaking telephones and demonstrated operation with both impulse and touch tone dials.

From extensive tests on these units by engineers and enthusiastic marketing personnel, we have been forced to acknowledge that power lines provide less than ideal transmission and have a decidedly unpredictable nature. On this side of the Atlantic our lines are 115 volt but have similar impedance characteristics to the one shown in Fig. 2 of your article. However, these characteristics vary from circuit to circuit, house to house, office to office. The average impedance falls from approximately 20 ohms at 30 kHz to 10 ohms at 200 kHz and then rises, depending on the circuit, to 20 or 50 ohms at 400 kHz. We have stayed clear of higher frequencies (even though they are permitted by the FCC) because of the large number of powerful medium-wave radio stations around each city. Superimposed on these impedance trends are troughs down to two or three ohms and peaks of 70 to 120 ohms. Such resonances are accompanied by zeros in transmission spectra that wreaked havoc with our frequency selection plans. These transmission 'holes' are produced by reactances in appliances connected to the circuit and to resonances in local voltage dropping transformers. We found that an 'instant on' tv set completely wiped out a channel centred on 300 kHz. Incidentally, the line loss here is greater than you show, while a good circuit will have 20dB loss; a more common figure is between 30 and 40dB and in offices this rises to over 50dB. Noise is just as unpredictable, being either non-existent or spikes of a few volts. It is worse at lower frequencies and appears to fall off exponentially as frequency rises.

Commercial manufacturers of power line carrier intercoms such as Fanon avoid transmission band irregularity problems by providing alternative working frequencies; if one doesn't work well, the other one should. This is easy in a simplex system but difficult when working full duplex since shifting frequencies necessitates switching transmit-receive filters and can be very expensive. I would imagine that working simplex or half duplex with 'The Intelligent Plut' is no less hazardous since the absence of signal due to a transmission hole is not obvious to an unskilled operator.

One major problem not mentioned in the article is that once satisfactory transmission has been established throughout the required house there is also a fair size signal heading other nearby houses, an effect that is commercially exploited by intercom manufacturers; you can put one in your baby's room while you go out on the town and the other in your neighbour's house. Transmission is generally good enough for this 'baby alarm' mode of operation. When voice transmissions are carried over the power line the effect is to automatically 'bug' your house! Even worse, the installation of a number of similar systems within a neighbourhood ensures that each will interfere with the others and nobody can reliably transmit or receive anything.

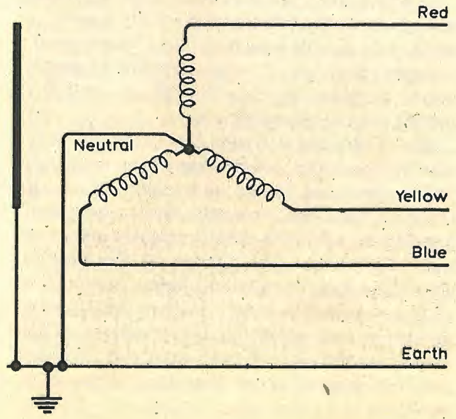
Experience with our own full duplex systems forced us to conclude that unless the power line circuits themselves are modified in some way they do not provide a sufficiently predictable link. All of the problems can be simply overcome by installing blocking filters, either in the form of adapter plugs and sockets in series with troublesome appliances or to block out-of-house transmission and reception by clipping filters around the cables entering the house.

The challenge now is to evolve acceptable line conditioning adapters and educate the general public so that this most economical signal transmission medium can come into its own for all kinds of application.

Lewis Illingworth
Beaconsfield
Quebec, Canada

As an electrical engineer employed by the supply industry, I read, with interest, the article by Messrs McArthur, Wingfield and Witten on the use of household wiring for data transmission (December 1979). However, the details of electricity distribution given in the article are not entirely correct and this may have an effect on the operation of such a data transmitting system.

In urban situations, it is true that all three phases are used for distribution, but not that every third house is connected on the same phase. It has been common for many years to loop two houses together on the same phase which could lead to severe house to house interference. More importantly, the diagram of a distribution substation is incorrect. It should show the neutral and earth solidly connected as in the accompanying diagram.



The importance of the neutral to earth connection to the Intelligent Plug cannot be under-estimated. This situation is further confused by the use of p.m.e. (protective multiple earthing — not phase multiple earthing mentioned by yourself). The introduction of p.m.e. has led to the neutral and earth being joined together at many places on the distribution system to give a number of parallel current paths, ensuring low neutral-earth impedance. The use of p.m.e. had led to the use of combined neautral-earth cables where the neutral and earth currents share the same conductor. In this case, I do not see how the Intelligent Plug, as described, could function.

Signalling, using the live/neutral pair, would be feasible, but because of the dangers involved and possible damage to faulty equipment, I do not recommend it. I would be interested to know what the 20 metre section of mains wire, that the authors investigated, was connected to and what effect the many junctions and branches common to household wiring have on the impedance of it at frequencies in excess of 30kHz. Before the system could be used commercially, some more detailed experiments on the characteristics of household wiring, and the effects on the distribution network that such a communication system may have, would be essential.

A. J. Skinner
Edmonton
London N9

MICROELECTRONICS AND THE THIRD WORLD

With reference to "Trickle, trickle little chip", your leader in the November 1979 issue, I would have liked to commend you for pointing out the deficiencies of the now widely discredited 'trickle-down' theory of world economic development had you not, when talking about "accelerating capital accumulation" using high technology, been advocating the very same thing, albeit in a watered down version. Unfortunately the arithmetic simply does not work. The cost of the high technology workplace, and the market for the goods produced in a world saturated by them, mean that world poverty would take hundreds of years to diminish, if ever, by these means.

In the battle against poverty, i.e. in meeting the basic needs of the poor, we must swallow some ideological pride and realize that the real 'capital' in the development equation lies in the vast waste of human potential that poverty implies. Generations of poverty bring about fatalism and stagnation, but let a poor people realise the things that can be done if they work together towards a common goal, and are free of those who are doing very nicely out of the status quo, and this vast human potential will be unlocked. Basic needs will be met in tens, not hundreds of years. The 'money' capital needed, e.g. irrigation pipes, cement, to fuel this process is surprisingly small but obviously the political problems are correspondingly large.

Once this process is under way, to consolidate the gains made microprocessor based production is highly relevant and should be used. Alternative technology, of course, is by its nature primarily for meeting local basic needs and was never really intended for developing export markets.

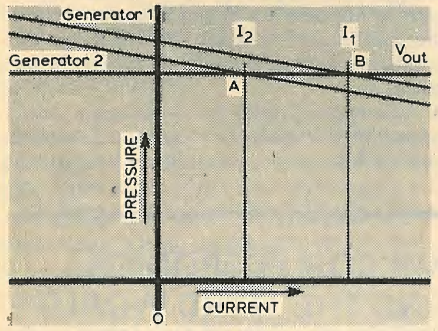
I see a two-way education process as being necessary. The Third World may not know much of the possibilities of microelectronics and people in the West may not know much of the Third World. As its role in the first part I would encourage *Wireless World*, with its world-wide readership, to give special attention to the use of microelectronics in the Third World, and for the second part I can only refer readers to magazines such as the *New Internationalist*.

N. W. P. Payne
Danbury
Connecticut
USA

PUSH-PULL AMPLIFIERS

On page 74 of your January 1980 issue is a circuit diagram for a push-pull class-A amplifier.

When two generators feed a single load the question of load sharing is liable to arise. As is well known, when the generators are in parallel it is necessary for them to have a not too low internal resistance (or regulation) to cope with inevitable differences in e.m.f., the effect of which is easily shown by a diagram,



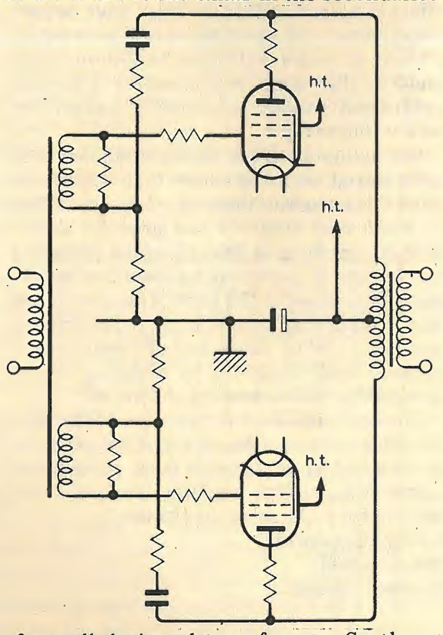
here. If the internal resistance is too low the output characteristics of the two generators are almost horizontal and the distance between points A and B can become large. Indeed it is quite possible for one of the points to be to the left of the vertical axis, which means that one generator is supplying current not only to the load but also into the other generator. Clearly there is magnification of inequalities.

In an electronic amplifier we can give to the two generators (the two halves of the output stage) any internal resistance, and the ideal arrangement for good load sharing is two generators with infinite internal resistance (i.e. current generators). There is then no magnification of inequalities in the transconductances or inputs of the two sides of the amplifier; and the combination can be given the required low output resistance in the usual way by feedback.

A good basis for such an arrangement, it seems to me, is the Peter Blomley amplifier (February, March 1971 issues). This is a class-B design; but the current-splitting stage can easily be changed to class A by putting resistance between the emitters and introducing extra bias between the bases. And, of course, other changes will be needed — to resistances and to sizes of heat sinks — to cope with the changed working conditions.

The two sides of Mr Pollock's amplifier have low output resistance, partly because of the emitter-follower connection and partly because of the overall feedback on each side (the parallel feedback chains); and that there is a serious load-sharing problem is shown by the call for resistors matched to 0.1%. An experienced engineer would, I think, have seen this unusually tight requirement as a sign that he was not on the right path.

I find it interesting to recall that one of the first published feedback-amplifier designs (the *Wireless World* p-a amplifier, if my memory serves me correctly) had similar parallel feedback paths. But in those days the moderate amount of feedback used reduced the output resistance to about only a half or a third of the load resistance. Moreover there is nothing in electrical engineering as accurate as the ratios of the e.m.fs in the secondaries



of a well-designed transformer. So there would not in this amplifier be a serious load-sharing problem. The arrangement of the output stage was, as far as I can remember, as shown above: unfortunately my pre-war *Wireless Worlds* are not to hand.

E. F. Good
Darlington
Co. Durham

TOWNSMAN AERIAL

Since the publication of my article the "Townsman 2m/70cm aerial" in the February issue, a few queries have arisen, mainly as a result of conversations over the air on the 2-metre and 70 centimetre amateur bands. Further experience with the aerial since the article was written enables me to answer most of these, although the obvious one, "Where can I obtain flat metal strip 1 cm wide?" must remain open at present.

The first question concerns a certain confusion about the tabular data. Column No. 1 is the data for the two-band 2m/70cm aerial. Columns 2, 3, 4, 5 and 6 give details of single band "simple" models for 70cm, and for indoor television reception.

In the two-band model, I can now be very precise about the positioning of the cooking-foil suppression sleeve as a result of on-air tests carried out recently since the commissioning of more 70cm repeater stations near my home. The centre of the sleeve should be 3 inches (7½cm) *below* the centre of the dipole element, and not exactly as shown in the drawing, level with it. This makes its manner of operation rather obscure, but results show that this is the best position.

Tests using a variety of different hook-up wire for the hair-pin matching loop disclose the fact (originally overlooked!) that thin wire with thin insulation bends into a tighter hair-pin than thick wire with thick insulation, and that the influence of the metal of the transformer strip is far greater with the thin wire than with the thick wire. The length shown is for thin wire with thin insulation; a possible minimum length for wire extracted from ten-amp mains flex would be in the region of 3 inches (7½cm), rather than the five inches (12.7cm) shown.

The conductor wire is taped lightly along the metal of the transformer until it flares away for 7½ inches (19cm). The shape of the flare adjusts the matching rather critically, particularly on 2m. It is helpful, to permit accurate adjustment and to maintain long-term stability, to brace this free section of the conductor wire with a strip of thin Formica and fit a grub-screw through the metal about 2cm above the last strapping, for the purpose of fine-adjusting the rate of flare. With such a screw adjustment, v.s.w.r. can be brought to unity with almost 'factory-test' rapidity.

The aerial is necessarily a compromise. It is recommended that adjustment be made to be correct on 2m, and some v.s.w.r. accepted on 70cm. This need not be worse than 1.5:1.

I used plastic tubing coloured white. I suspect that black coloured tubing may include a carbon content which would make it unsuitable for these purposes.

B. J. P. Howlett, G3JAM
Woodford Green
Essex

IS 500kHz A GOOD DISTRESS FREQUENCY?

It is quite common when using marine m.f. transmitters under certain circumstances to experience considerable loss of radiated r.f. power on medium frequency 405-525 kHz. The effect is most pronounced with very rough sea conditions in gales or storms, the radiated power dropping off on the main transmitter from its normal 7 amps r.f. down to approximately 2 amps, or under certain conditions less. In extreme cases it has been known for the radio operator to be unable to power the transmitter on m.f. due to the transmitter tripping off. H.F. is not affected to the same extent.

Similar loss of r.f. radiated power was also recently experienced when using the emergency transmitter during calm conditions but with a high temperature and high humidity present. Radiated power on m.f. dropped from its normal 4.1 amps down to 1.8 amps r.f.

In gales or storms or when humidity is high, all the aerial insulators become saturated with wet salt spray; this alone causes considerable loss of radiated power on m.f. Probably, though, a greater loss of radiated power is also caused by the fact that in such conditions the atmosphere surrounding the vessel and its antenna is saturated with salt water droplets and spray which can extend to a considerable height above sea level (well above the antenna height). This presents an extremely poor dielectric constant and means that one is attempting to operate an m.f. transmitter into a load (antenna) which is almost immersed in a saline solution existing between the aerial and sea level. It is difficult or impossible to load the transmitter into the aerial under such conditions.

This is at a time when there is always the possibility that a vessel could get into difficulties in heavy weather and it may be

necessary to transmit a distress call on 500 kHz. Under these conditions it may not be possible to do so, or, if possible, it would be at much reduced power output. Should a vessel in these circumstances be any distance from another station it could result in the call going unheard on m.f. Perhaps this explains why vessels have disappeared in heavy weather without a distress call being heard.

Does not this raise the question: is 500 kHz a suitable frequency for distress traffic working under these conditions?

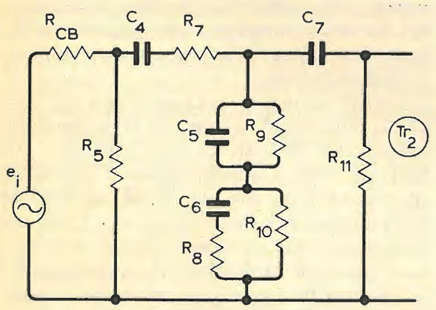
A. K. Tunnah
Ardrossan
South Australia

PRE-AMPLIFIER WITH NO T.I.D.

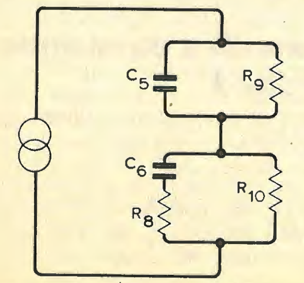
We all read very attentively the June 1979 *Journal of the Audio Engineering Society* in which Mr Lipshitz has given so many examples of the errors in commercial pre-amplifiers (even in "very expensive models") and his letter in your January 1980 issue is one more reminder. In 1978 we could not have known, unfortunately, about his article of 1979. Further, the specification of the equalization network will be considered according to the circumstances. Unfortunately, the question of the equalization network is not the main point of my article "Audio pre-amplifier with no t.i.d." in the August 1979 issue.

Firstly, the term "grossly in error" should be put in context. Let's take into account the fact that the pre-amplifier is always followed by volume and tone controls, filters, loudspeakers and a listening room. As far as is known, these units distort the signals to a greater extent (in amplitude and phase). By the way, in my August 1979 article I pointed out a discrepancy of the frequency response at the edges of the audio band, and I mentioned the possibility of modifying or completely replacing the equalization network. And for sure there is nothing in the article, using Stravinsky's words, that has "finally arrived". Taking all this into account it doesn't seem reasonable to complain of the RIAA network being "grossly in error".

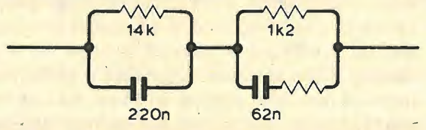
Postscript: Employing the classical equivalent network of the output circuit Tr_1 we have:



After the usual simplifications we have the equivalent network with a current generator:



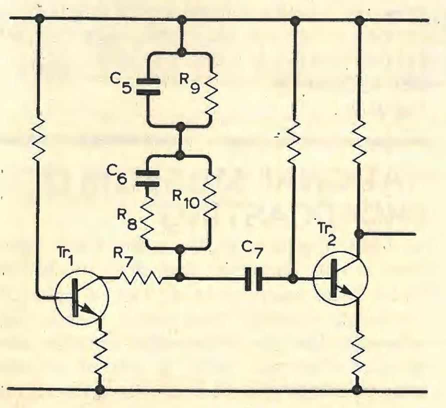
For a long time we have had the original and accurate method of calculation for such an equalization network; here, for example, is one of many possible versions:



It is clear from Lipshitz's letter and article that de-emphasis is passive, and in this case R_7, R_8, R_9, R_{10}, C_5, C_6 are the components "grossly in error". (It is just R_8, R_9, R_{10}, C_5, C_6 that are replaced in measurements by the 240-ohm resistor.)

If we take into account that R_5 of the following stage has some effect on the equalization network and there is a possible reduction of high frequencies by the input filter of the pre-amplifier (moving coil), as well as attentuation of low frequencies by all other following isolating capacitors (without putting on additional stages, etc.) we inevitably have to come to some compromise. And that has been achieved.

The circuit may also be used this way:



The resistor R_7 is used only for "equalizing" the loading of Tr_1.

Y. Miloslavskij
Institute of Constructional Physics
Moscow, USSR

"TRIVIAL" AMPLIFIER DESIGNS

I was slightly perturbed by Mr B. J. Duncan's letter in the January 1980 issue. Since he has radically altered the design of my pre-amplifier by removing the discrete semiconductors and introducing i.c. circuitry, I hardly think it is fair to carry on referring to it as my design, and do not feel impelled to take any responsibility for its performance or lack thereof.

I do agree that an unacceptable aura of mysticism still seems to surround the performance of audio equipment. A great deal of nonsense is still being talked about "musical" capacitors, metal oxide resistors, and so on, although as far as I can tell the field is still wide open for the first brave man to stand up and explain how ears can register differences that not only escape the best test gear, but are also unknown to electrical science. Presumably, given time and a complete lack of supporting evidence, such silliness will once more become unfashionable.

However, I do differ with Mr Duncan in his assessment of the worth of increasing amplifier refinement based on actual engineering principles. If someone finds a way to reduce distortion in a given case from 0.005% to 0.004%, then surely the design approach involved is worth reporting, even if the current state of art in analogue magnetic recording renders such an improvement largely academic. Also, I suggest that there is much satisfaction to be gathered in constructing a piece of equipment that will degrade the signals passing through it as little as humanly possible, even if the signals available are of variable quality.

I see no reason why amplifier designers should stay shut up shop just because other parts of the audio chain have a lot of catching up to do.

Douglas Self
London E17

M.F. RECEPTION

I am pleased to note that Mr Schemel's recent article on loop aerials (July 1979), and my own letter on m.f. broadcast reception (November 1978), are giving rise to some interest in this area.

I should like to take up a point in Mr Hill's letter (February 1980) concerning the use of long-wire aerials. I agree that the image rejection of domestic receivers, typically no better than 30-40dB even after careful alignment, makes the untuned connection of a long-wire aerial of doubtful value. I also agree that in the majority of cases, loop aerials represent a much more effective way of increasing signal pickup. But I ought to have made it clear that my original method of coupling the aerial to the receiver was not as Mr Hill assumed.

Where practical considerations make the erection of a long-wire aerial an attractive prospect, I found that the most satisfactory method of coupling such an aerial to a ferrite-rod receiver was to use a surplus ferrite rod aerial with a standard m.f. winding, earth one end, and connect the other to the long-wire via a 500pF variable. Mounting this assembly in a small plastic box enables the amount of coupling, and the phase of the additional signal, to be varied by physically moving the plastic enclosure with respect to the receiver. Depending on the length of the aerial used, some adjustment to the number of turns on the coupling rod may be necessary to achieve the desired tuning range.

Not only does this offer similar discrimination against second-channel interference to that obtained with a resonant loop, but the substantially omnidirectional pickup of a long-wire aerial (or even better, a loaded vertical whip) means that careful juxtaposition of receiver and coupler can produce a cardioid-type pickup pattern, which can be particularly useful at night, where absolute field strengths are quite high, and gain is not as important as directivity. During daylight hours, the omnidirectional pickup of a long-wire aerial can have advantages during a general band-scan.

I also note that Mr Hill uses a low-pass filter in the audio circuitry of his receiver. I agree that a sharp cut-off above 5kHz is extremely advantageous for reception of similarly band-limited transmissions, but surely the notch should be at 9kHz, not eight. I would also favour a faster roll-off: both the BBC and the IBA transmit a response which is substantially flat up to 5kHz, and then rolls off to −40dB at around 7.5kHz, and at least −50dB at 9kHz. A good filter for reception should be at least as steep.

I note that recent trends in consumer design do not appear to include much, if anything, in the way of audio treatment after the detector. Instead, the latest designs rely on a narrow block filter as the major part of the i.f. selectivity, relying on accurate (and usually manual) tuning to provide the necessary h.f. attenuation. The block filters popularly used have a nose bandwidth of little more than 6kHz, presumably a sacrifice willingly yielded in order to improve adjacent-channel rejection within the necessary budget. This means, however, that the recovered audio response falls sharply, and to my mind undesirably, above 3kHz or so, and that receiver tuning has to be very precise.

Given that the brief of consumer audio equipment is generally to provide the best possible reception of *local* transmissions, where even at night the wanted signal may be presumed to be at least as strong if not stronger than anything on the adjacent channels, I would suggest that a better approach would be to employ a much wider block filter, with a −3dB bandwidth of around 10kHz, and then to eliminate adjacent-channel whistles and 'monkey chatter' by means of a steep, and preferably switchable, low-pass filter with a cut-off frequency between 4.5 and 5kHz. The use of such a filter also has the advantage of eliminating high-frequency distortion products arising from the detection process.

Finally, I should like to point out that there are at least two transmitters with a ground-wave signal of usable strength in some parts of the country, which radiate a much wider audio bandwidth than the 5kHz now standard within the UK and much of Europe. They are, are the time of writing, RTE Radio 2 on 612kHz, which can be received quite well in Wales, West and North-West England, Southern Scotland and Northern Ireland, and the pirate station Radio Caroline on 963kHz, which can be heard in South-East England. It is, strictly speaking, illegal to listen to the latter, and I mention it only out of technical curiosity.

Norman McLeod
Hove
East Sussex

MILLIBEL IS RUBBISH

I have a little sympathy for Mr Duncan's *cri de coeur* (January letters) over yet another super hi-fi amplifier project (October 1979). Too often designers are carried away by maternal enthusiasm for their brainchild and the high accuracy of a modern calculator. Consistently overlooked are the realities of the situation – that the amplifier is but one element in a very long chain of accumulating imperfections and, in a domestic system particularly, the ultimate fidelity overall will be limited by the programme source.

However, my spleen feels distended by a letter in the March issue with a suggestion of such idiocy that I had to check the cover to make sure that it wasn't an issue a month early. But no, the writer was deadly serious and dangerously literate with it. Can it really be suggested that again, for one small element in the recording/reproducing chain it is *imperative* that any amplitude/frequency deviations be maintained within an accuracy of *0.05dB*? (I assume that this is the total spread). Frankly, I just do not believe it and regard the proposition as rubbish, pure and simple – and I say it as an engineer of 30 years' experience and accustomed to working to tolerances far tighter than those currently practised in the hi-fi industry.

For a start, how in heaven's name can one guarantee a consistency *considerably* better than this outside the pre-amplifier – in the programme sources, for example, which will be used for the subjective tests? Once before, when challenging a myth being propagated by hi-fi commentators of questionable ability, I offered a sum of money to any charity if the spurious arguments being put forward could be proved. My bait was never taken and it remained for others subsequently to demolish the false gods. I will make the same offer yet again, and raise the ante this time.

Prove this ludicrous proposition with an independent listening panel under a scientifically controlled set of conditions. If the panel are able to detect with statistically significant accuracy a frequency/amplitude deviation at some agreed point in the spectrum of 0.05dB on a variety of programme material, I will donate £100 to any charity named by whoever takes up my challenge. I have my charity ready if the test fails, to receive the same amount from the proposition's supporter.

Meanwhile, may I conclude by expressing my disappointment that a magazine of *Wireless World*'s stature should continue to provide a platform for cranky views. These are more proper to the hi-fi comics.

Reg Williamson
Norwich

NATIONAL MUSEUM OF BROADCASTING

As a BBC Engineer at Washford, I was interested to read about the demise of the Brookmans Park transmitters. The Washford, Somerset, regional transmitter was in fact taken out of service at the end of October, after 46 years of service. Both on grounds of electrical efficiency and maintenance effort, it had to go, but its destruction breaks another link with the early days of broadcasting.

For the present, however, the transmitter itself remains intact. Since the prime movers and rotating machinery have gone, it can never be used again, but it would provide a unique centrepiece for any museum. The main transmitter hall and office block will shortly become surplus to the BBC's requirements — what an ideal opportunity to provide a showcase for the Corporation's achievements! The IBA already have a broadcasting gallery in London (displaying BBC history!): once a central museum can be established at Washford, it would be relatively easy to mount smaller exhibitions at major BBC centres in London and elsewhere. Public interest abounds, as various "open days" over the years will verify.

The BBC are not museum curators, so it would be necessary to set up some form of trust, financially independent, but liaising closely with all departments of the Corporation to provide an interesting and financially viable museum. Historic items abound, hidden, within the BBC. Here is the opportunity to allow everyone to see them. During last summer, the Corporation were advertising two "Doctor Who" exhibitions on non-BBC sites. Surely this was not necessary.

Housed in an historic and impressive building, in a major holiday area, the possibility of free advertising on television, such an enterprise cannot fail. This is a golden opportunity, probably the final opportunity, to create a national museum of broadcasting.

J. E. Butterworth
Blue Anchor
Somerset

A POOR JOKE

In your January issue J. Greenwood lodged an objection to a marked tendency in *Wireless World* to include controversial political matters. Though I suspect I may have a little more sympathy with some of the views expressed (though not in Feb. 1980) I equally consider that *W.W.* is the wrong place to express them. One is subjected to so much political discussion in so many places, and looks to *W.W.* as a unique source of *technical* information within certain ill defined but well understood limits.

Having stood up to be counted at this end of *W.W.* I now turn to the other to express the hope that a certain five words by Mixer are no more than a slip and not signs of a trend. A second point of my agreement with Mr Greenwood is that humour *is* a fitting ingredient of *W.W.* Even though myself of Aberdonian grandparents, I was able to pass over Mixer's inevitable linkage of Scotland with northern mists and haggis with no more than a slight wince, but I did seriously deplore his gratuitous addition 'of BL cars disintegrating' as one of the noises over which a certain Klaxon horn could be heard. For one thing, it is a cheap and in this context meaningless jibe of the same order as the perennial mother-in-law jokes – hardly up to *W.W.* standard. But the serious aspect is that it is one more example of the British disease of self-denigration, which ultimately deters people from buying cars that have been made to look a joke. Does Mixer know that BL vehicles are used *exclusively* for their fleets of cars and lorries by Rolls-Royce, who testified in *The Times* that they find them very satisfactory?

In the same way we have a national problem because our children are preconditioned by silly jokers to find maths incomprehensible.

If I look like becoming political myself, it just shows what happens when such matters are brought into *W.W.!*

M. G. Scroggie
Bexhill
Sussex

Mixer replies:

Having been at the receiving end of many shafts of 'humour' concerning my own northern origins, I am familiar with the "slight wince" that Mr Scroggie feels impelled to exhibit at the mention of haggis, cabers and northern mists. I see no reason why he should be spared.

On the subject of the precarious cohesion of BL cars and Mr Scroggie's own inevitable cliché, the "British disease", the jibe was most certainly not meaningless. I am unable to comment on the use of BL vehicles by Rolls Royce, but I can say that if I had not persistently and recklessly chosen to drive a succession of unreliable BL cars myself, I would now be a good deal richer than I am.

Maxwell's equations revisited

We have received a large number of letters commenting on "Maxwell's equations revisited" by Ivor Catt in the March issue. There are too many to be published individually, so the main points will be selected and presented collectively, accompanied by a joint reply from the author.

Audio spectrum analyser

Narrow bandwidth without expensive filters

by Peter Hiscocks, Ryerson Polytechnical Institute, Toronto

This instrument is used with an oscilloscope to form an audio analyser at a cost more in keeping with an amateur experimenter's budget than a commercial design. The synchrodyne technique is used to avoid the need for expensive, narrow-band filters. Dynamic range is about 60dB.

The conventional mode of operation of commercial spectrum analysers entails the use of an extremely narrow-band filter, a circuit which is too complex and expensive to be attractive to the home constructor or to schools. Consequently, the design described in this article uses an unusual technique of frequency changing which neatly avoids the difficulty. This type of analyser is intended to investigate unvarying signals, which means that it is not suitable for analysing music or speech waveforms.

Figures 1 and 2 show examples of displays obtained with the instrument. The trace in Fig. 1 is the spectrum of a 1kHz square wave, while that in Fig. 2 is of a 1kHz sine wave, showing 3rd and 5th harmonics. The small responses at a lower frequency than the fundamental in each photograph are spurious products resulting from the method of analysis chosen: they do not normally cause trouble, since they are lower in frequency than the area of interest. Display axes are linear.

Since the instrument is fairly complicated to make, it cannot be recommended for a first attempt: constructors will need a digital voltmeter, a dual, regulated power supply and an audio signal generator.

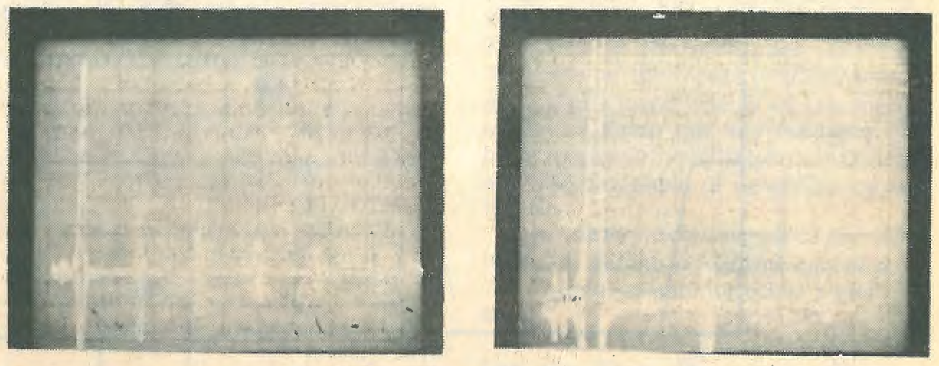


Fig. 1 and 2 show typical responses obtained with the analyser. Fig. 1 shows the spectrum of a 1kHz square wave, showing odd harmonics up to the 11th, while in Fig. 2 is the analysis of a sine wave at the same frequency, with small 3rd and 5th harmonics. Bandwidth was 200Hz.

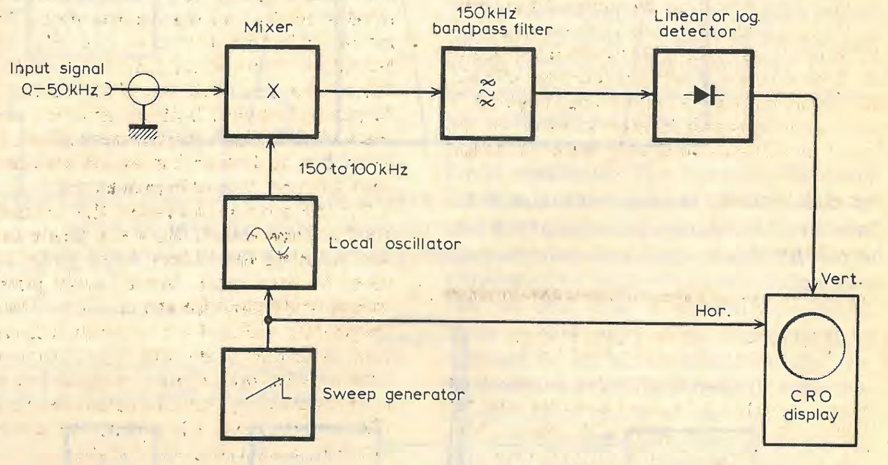


Fig. 3. Block diagram of a conventional spectrum analyser. The 150kHz bandpass filter must be very narrow: one commercial design uses five crystal resonators to achieve the required performance.

Basic principle

The block diagram of a conventional spectrum analyser is shown in Fig. 3. The local oscillator might be tunable between 100 and 150 kHz, when the sum of the l.o. and input frequencies will be translated into the passband of the analysis filter. However, the construction of a filter which will separate harmonics some 60 dB apart in amplitude, a few Hertz apart at 150 kHz, poses enormous problems for the home constructor. For example, the Hewlett-Packard 3580A spectrum analyser[1] uses five crystal resonators[1], the crystals being matched for temperature drift.

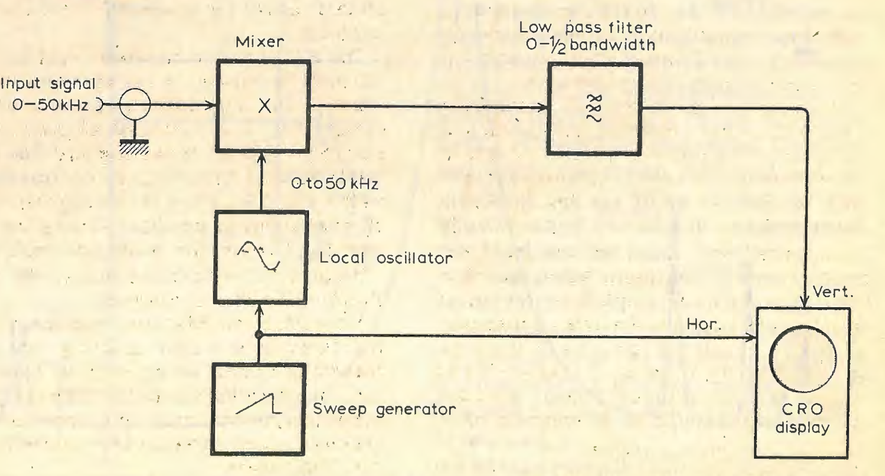


Fig. 4. Method used in this design, in which the filter takes the form of a low-pass circuit in the audio range.

Fortunately, M. G. Scroggie[2] has suggested an alternative technique based on the synchrodyne radio receiver. Figure 4 shows a block diagram of this analyser. The tunable local oscillator sweeps over the range to be analysed, and the low-pass filter passes signals that are close to a zero beat between the input signal and the analysis signal. This process may be regarded as a translation of the low-pass filter to the frequency of the local oscillator, together with a mirroring of the low-pass filter characteristics around the local oscillator frequency as shown in Fig. 5(a). The result is effectively a band-pass filter, with its centre frequency at the setting of the local oscillator and a bandwidth equal to twice the cutoff frequency of the low-pass filter. The design of the analysis filter thus becomes an exercise in low-pass filter design. In the prototype, a four pole Sallen and Key filter was used, with cutoff frequencies between 5 and 250 Hertz.

For those familiar with the techniques of correlation analysis, the analyser may be regarded as a type of cross correlator[3]. The local oscillator sine wave is cross correlated against the input signal; the low-pass filter is an averaging device which produces a signal whenever a match is found between the input sine wave and that of the local oscillator.

The local oscillator must tune over a much wider range in proportion to its centre frequency than in a conventional spectrum analyser. In this design, a sweep range between 100 Hz and 16kHz was achieved without undue difficulty. The range may be moved by switching a local oscillator capacitor.

A particular advantage of this system is its ease in identifying the frequency of any particular harmonic: the analysis frequency is equal to the local-oscillator frequency. In this design, a simple digital readout of analysis frequency is provided.

Changes in analysis bandwidth in the low-pass filter have the effect of changing the quiescent output voltage of the filter. The simplest solution to this problem is to capacitively couple the filter to the output of the mixer, even though this results in the narrow notch in the centre of the analyser's filter pass band shown in Fig. 5(b). This is a slight inconvenience in use, since the local oscillator must be slightly detuned from the harmonic frequency when reading amplitude. However, the notch does help in determining the exact frequency of a signal.

The major problem with the synchrodyne analyser is that harmonics of the local oscillator fall within the pass band of the analysis filter and show up on the display as false readings below the fundamental frequency of the input. There are two approaches to this problem. One, obviously, is to keep the distortion of the local oscillator as low as possible. The easiest approach to the design of a swept oscillator, however, is to use a function generator, and the output of a function generator must be shaped in a diode network to produce a sine wave. It is difficult to reduce the distortion of such a sine wave below one percent, particularly when this waveform is to be varied in frequency over a wide range.

The other approach is to learn to recognize and identify the spurious harmonics. An example of this is shown in Fig. 6, the analysis of a 2.98kHz sine wave from a commercial function generator. The vertical axis has been converted to a logarithmic scale by the Hewlett Packard Log Converter, thereby emphasizing low level distortion products.

The spurious distortion products due to the analyser are labelled A, B, C and D on this graph. Notice that these all fall below the fundamental of the input signal and that they are not harmonically related to the input signal.

Spurious product A is created when the fifth harmonic of the spectrum analyser local oscillator beats with the fundamental of the input signal. Products B, C and D are similarly caused by the fourth, third and second harmonics of the local oscillator.

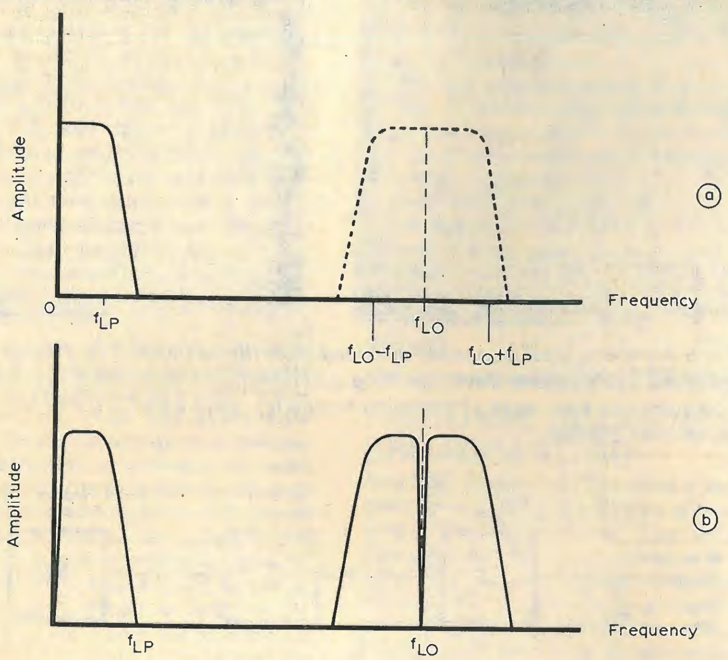


Fig. 5. Frequency response of the analyser. At (a) is shown the low-pass characteristic 'translated' in frequency to that of the local oscillator, while retaining the same bandwidth. The notches shown in the response at (b) are the result of capacitance coupling.

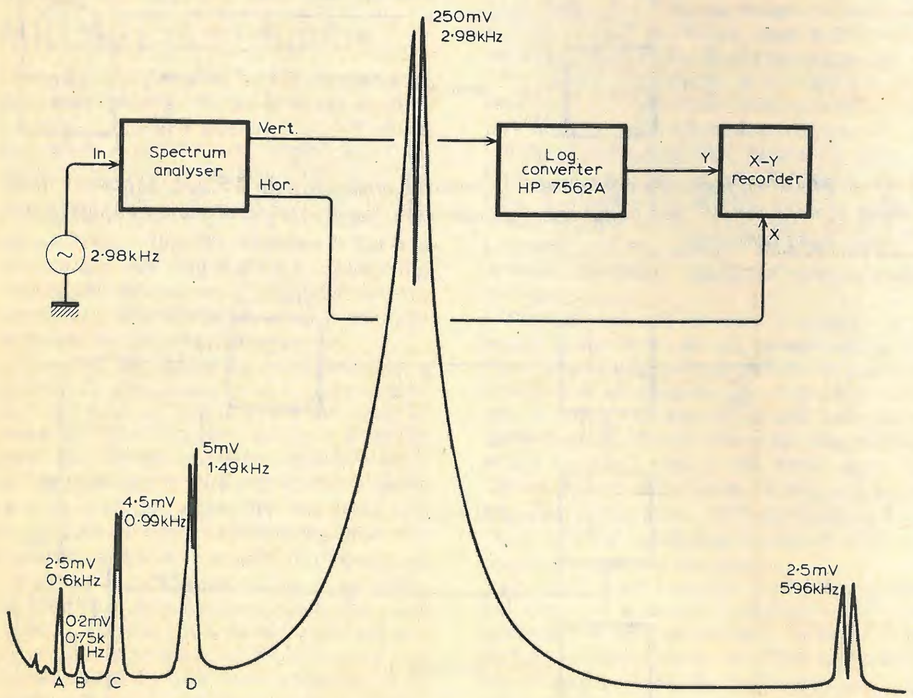


Fig. 6. A typical analysis. The fundamental is at 2.98kHz, its second harmonic being clearly shown at 5.96kHz. The spurious products are all below the frequency of the fundamental.

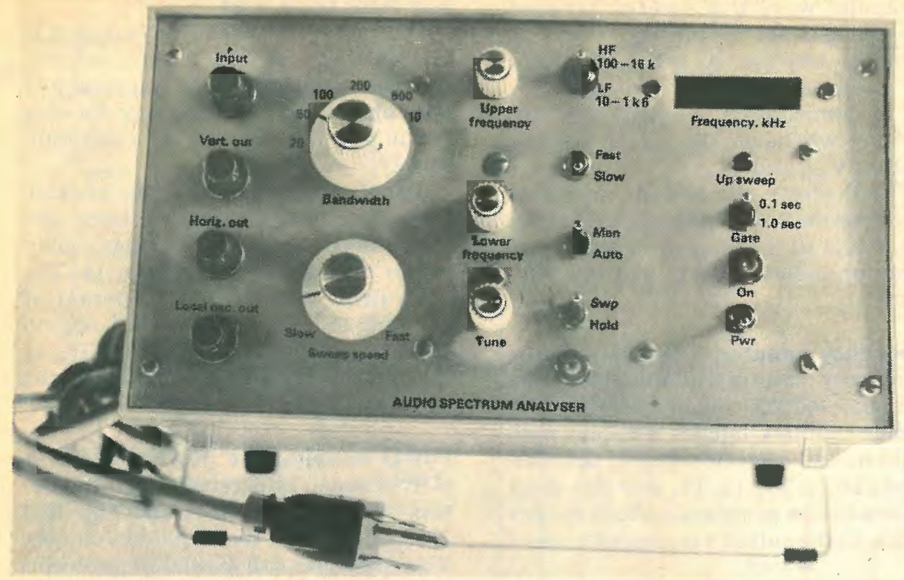


Fig. 7. Prototype analyser.

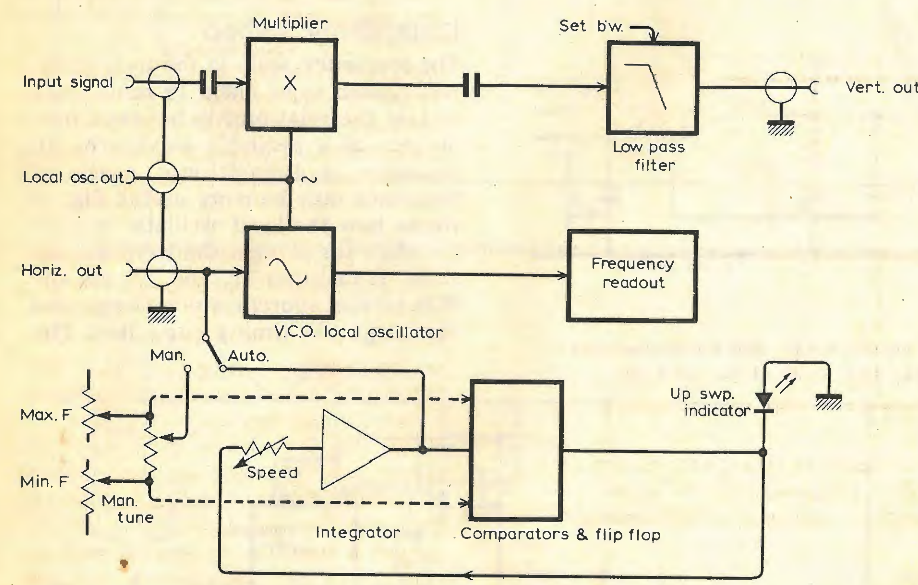


Fig. 8. Detailed block diagram of the instrument. Horizontal and vertical outputs are taken to the oscilloscope, and the local oscillator output is for use with an external counter or other test gear.

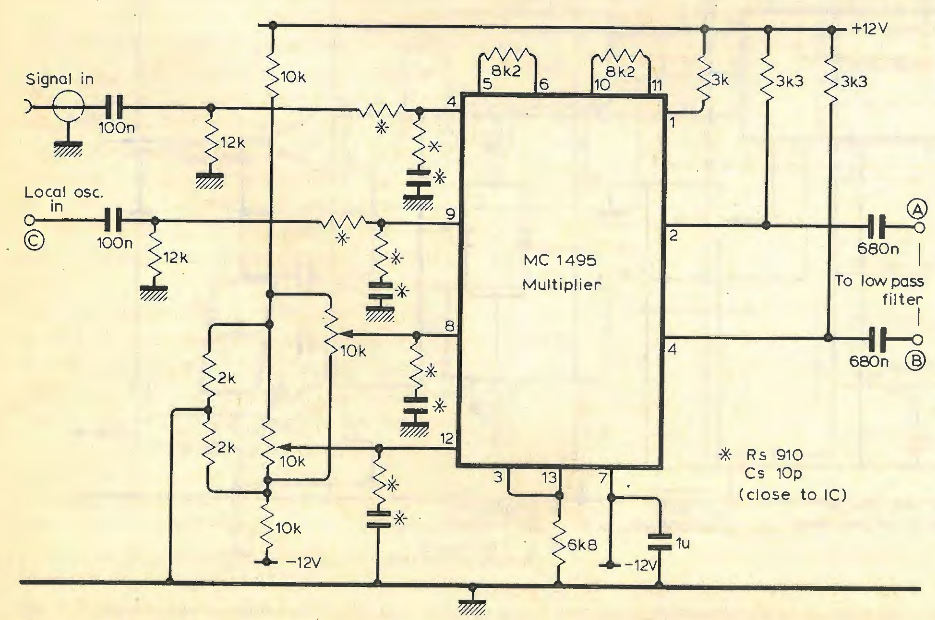


Fig. 9. Multiplier circuit.

The 5.95kHz harmonic is the second harmonic of the input signal. Spurious products do not appear below this harmonic because both it and the spurious products of the local oscillator are small in magnitude.

The spectrum analyser is shown in Fig. 7 and its detailed block diagram in Fig. 8.

Detailed circuit description

Multiplier. A Motorola MC1495 is used as the signal multiplier, shown in Fig. 9. Its maximum input signal should be limited to 8V peak to peak to limit distortion in the multiplier. The RC networks on the inputs (910Ω in series with 10pF) lower the Q of the input leads and damp out any tendency to high frequency oscillation since the MC1495 is capable of operation up to 10MHz.

The 10kΩ potentiometers are adjusted to minimize feedthrough of the v.c.o. signal when the other signal is absent.

Low-pass filters. The low-pass filter in Fig. 10 consists of a differential amplifier, followed by a four-pole, Sallen and Key, low-pass filter to achieve a slope of 24dB/octave above the cutoff frequency.

The variation of the low-pass resistors causes some d.c. shift in the voltage at the vertical output connector. This is not usually a problem, since the detector is usually a.c. coupled.

Local oscillator. The Intersil 8038 used for this purpose generates sine, square and triangle waveforms. Unfortunately, the since wave is very distorted since, although the 8038 requires a full +/−15V, in this case it is being operated from −15V only. The distortion is reduced to an acceptable level by the germanium diode/2kΩ resistor network connected at pin 2 of the i.c. The 2kΩ resistor should be adjusted while observing the spurious harmonics on a display as in Fig. 6. The square wave output from the 8038 is used by the frequency counter display circuit.

Voltage control of frequency is accomplished by the op. amp. network[4] connected to pin 8. Since this is a *linear* v.c.o. circuit, the voltage range must be equal to the frequency range. Although 1000:1 is possible, improved stability and lower distortion are obtained by selecting the v.c.o. capacitor by the h.f./l.f. range switch. An exponential v.c.o. is described later.

A transistor network[5] connected to pin 10 of the 8038 generates a compensation current of about 1μA to improve the symmetry of the waveforms at very low frequencies. If operation at very low frequency is not a requirement, it may be omitted.

The sine wave is buffered by a 741 op. amp. and passed to the local oscillator output connector. This signal may be used in frequency-response tests of equipment. A second op. amp. increases the sine-wave amplitude by a factor of 6.7 to provide sufficient signal for the multiplier circuit.

Sweep-control. Maximum and minimum frequency are set by the two ten-turn potentiometers, F_{max} and F_{min} shown in Fig. 12. Unity-gain amplifiers A_1 and A_2 buffer these voltages, and set them up at opposite ends of the ten-turn tuning control. In 'manual' mode, operating the tuning control will vary the v.c.o. control voltage between the voltages set up on the F_{max} and F_{min} pots. (Some care must be taken in operation that the F_{max} voltage is always greater than the F_{min} voltage.)

Amplifier A_6 reverses the sense of the sweep voltage so that an increase in frequency is caused by a positive-going "Horizontal Output" voltage. The rest of the sweep-control section generates a triangular wave that sweeps between the voltages set by the F_{max} and F_{min} controls. Amplifier A_3 is the integrator for the sweep oscillator, and A_4 and A_5 act as comparators to toggle the 7400 flip-flop whenever the sweep voltage reaches V_{max} and V_{min}.

The discrete-component amplifier driven by the 7400 flip-flop amplifies the t.t.l. signal to ±12V to drive the sweep direction indicator l.e.d. and the integrator.

Frequency counter. The heart of the frequency counter in Fig. 13 is the National 74C925, which contains four decade counters, latches, a display multiplexer, and a seven-segment decoder. Transistors Tr_1 to Tr_4 are the digit drivers for the common-cathode display which, in the author's instrument, was a surplus nine-digit integrated type, only four digits being used.

The gate for the frequency counter is provided by a 555 timer, which, although possessing a time accuracy of only about 1%, is satisfactory for this circuit as a replacement for a dial indicator.

Signetics 8162 monostables provide the proper timing signals to latch and clear the counter in the manner shown in the timing diagram of Fig. 14. The 'gate time' switch sets the period of counting to 1.0 or 0.1 seconds. A second contact on this switch causes Tr_5 to select the proper decimal point for the display.

Power supply. The power supply is conventional. Integrated circuit regulators — National LM326 and Fairchild 7805 — generate the required voltages. To avoid noise and oscillation problems the sections of the spectrum analyser should be wired separately, as in Fig. 16.

Logarithmic sweep

The frequency scale in the instrument was chosen to be linear to show more clearly the relationship between harmonics of a periodic waveform. In practice, a logarithmic scale of frequency may be more useful. Fig. 17 shows how the local oscillator may be modified for a logarithmic frequency scale. Transistors Tr_1 and Tr_2 are the 8038 current sources which charge and discharge the timing capacitor. The

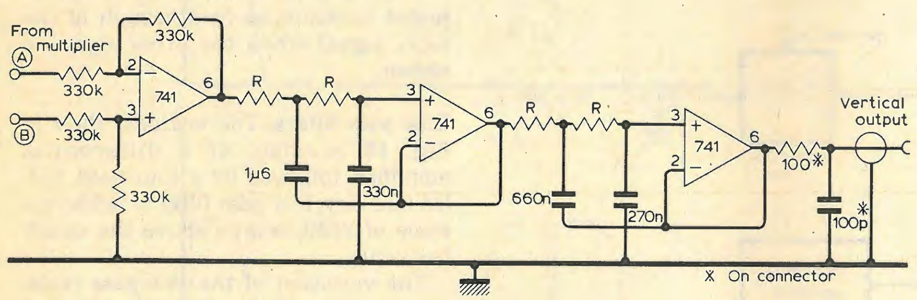


Fig. 10. Low-pass filter. The resistors shown as R are switched, and for bandwidths of 10, 20, 50, 100, 200, 500 Hz should be 72k, 36k, 15k, 7.2k, 3.6k and 1.3k.

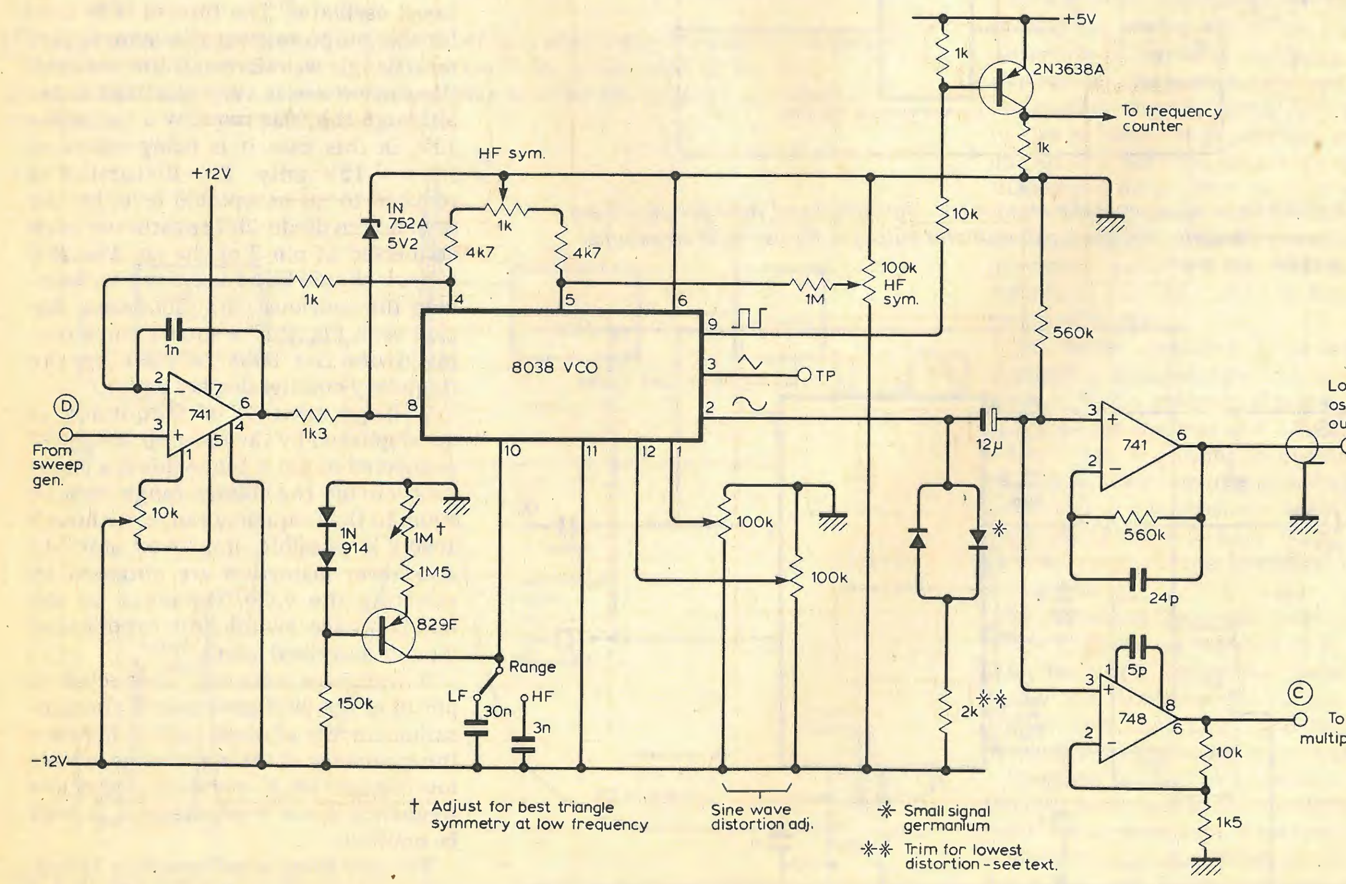


Fig. 11. Local oscillator circuit diagram.

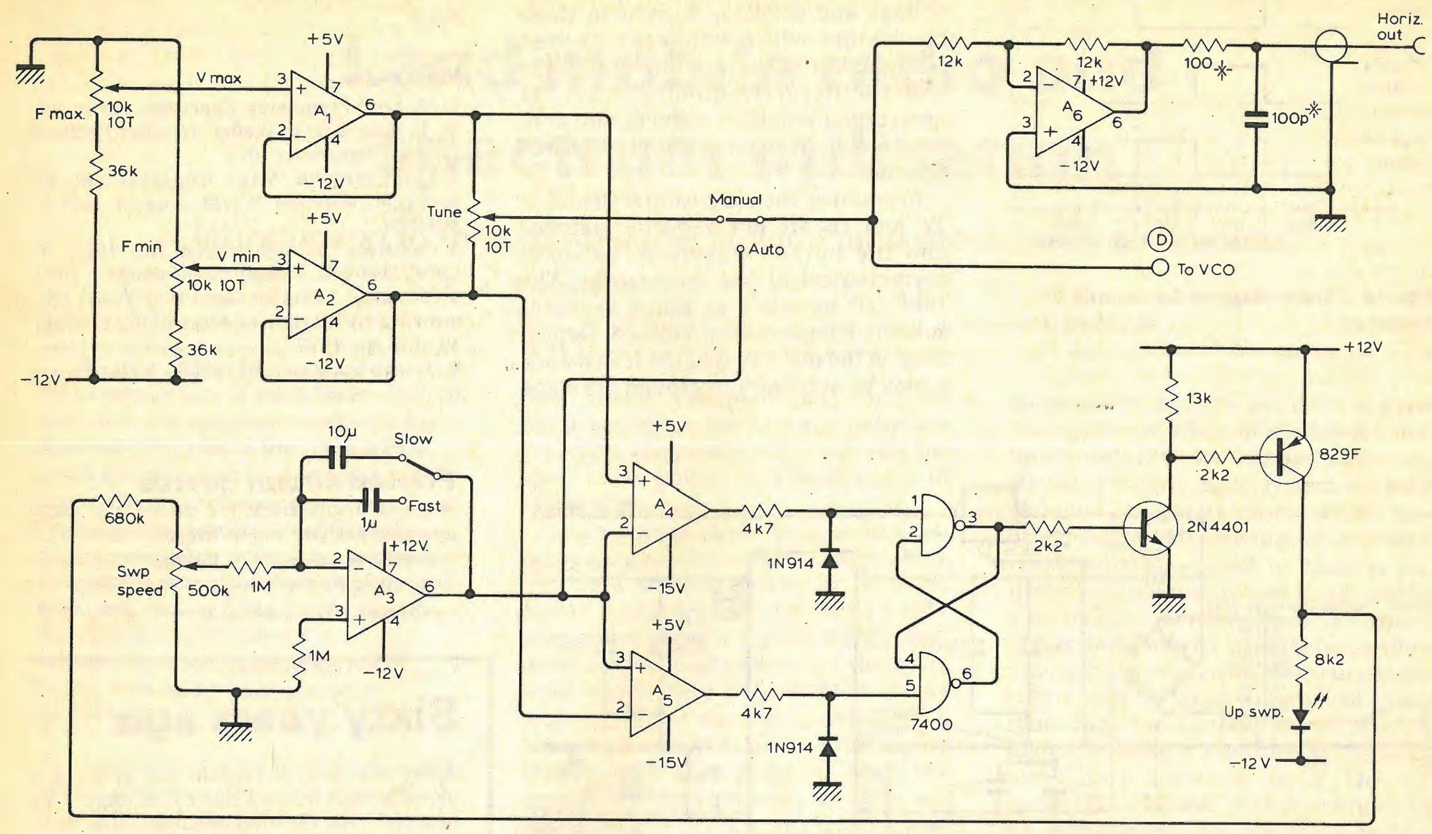


Fig. 12. Sweep control section. Components marked with asterisk are mounted on connector.

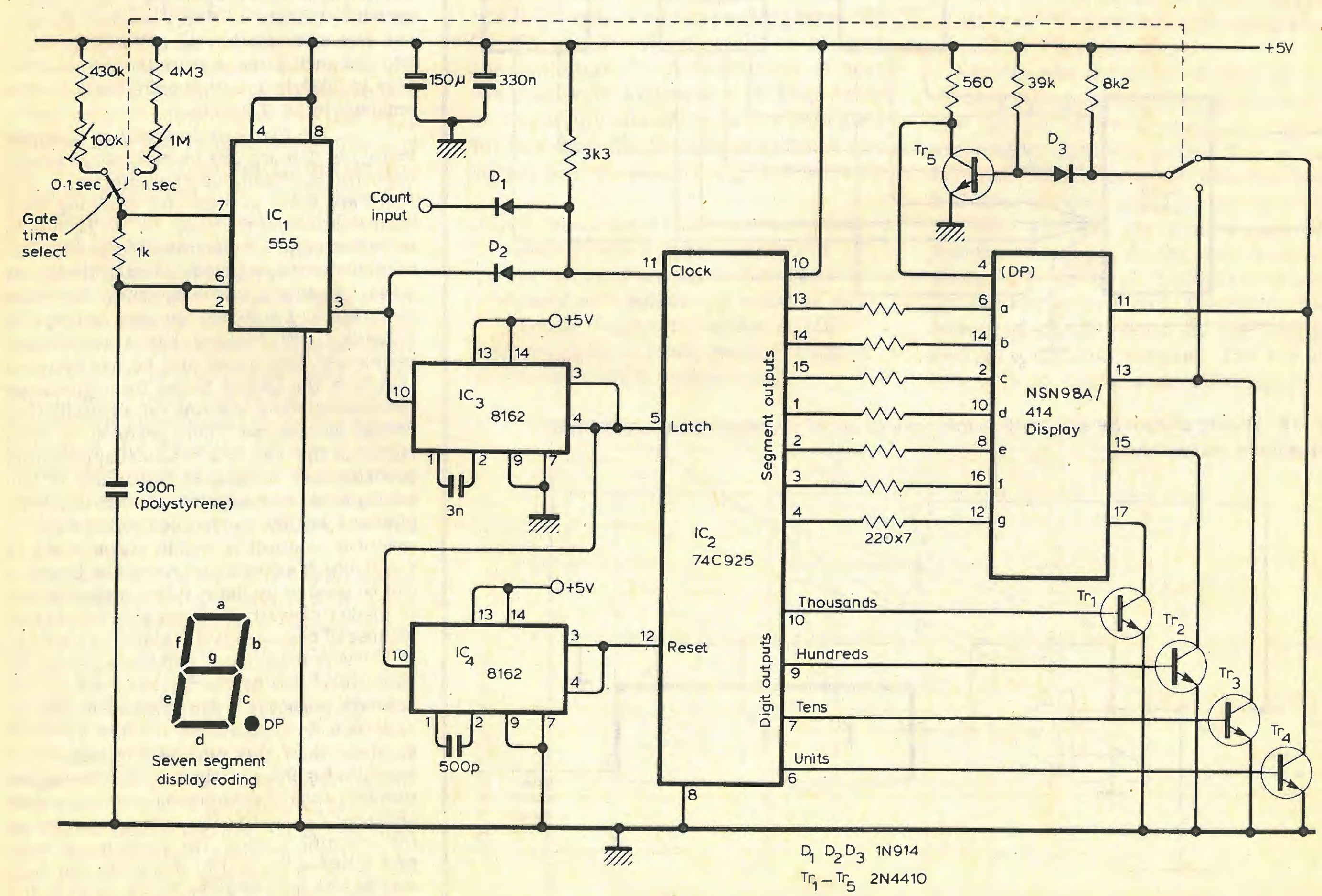


Fig. 13. Frequency counter and display. Author used a surplus National Semiconductor display module in his prototype. A multiplexed, common-cathode type is needed. An error: pins 6, 7, 9, 10 are transposed; pin 10 should be "units".

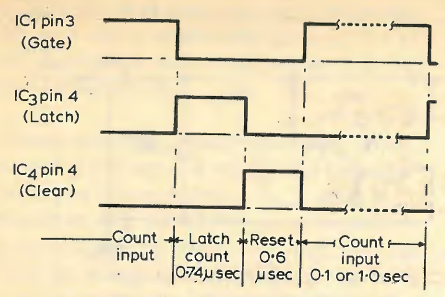


Fig. 14. Timing diagram for counter operation.

exponential relationship between base voltage and collector current in these transistors will provide the desired relationship between control voltage and oscillator frequency. The 741 operational amplifier reduces the control voltage swing at pin 8 to the desired amount.

In practice, the base-emitter diodes of Tr_1 and Tr_2 are not perfectly matched and the output waveform becomes asymmetrical at low frequencies. The 10kΩ/2Ω network at pin 4 provides suitable compensation voltage. Depending on the mismatch of the transistors, it may be necessary to ground pin 4 and

connect the compensation network to pin 5.

References

1. 'A Low Frequency Spectrum Analyser', W. L. Hale & G. E. Weibel, *Hewlett Packard Journal*, September 1973.
2. 'Inexpensive Wave Analyser', M. G. Scroggie, *Wireless World*, August 1955 p. 360-365.
3. 'Separate the Signals from the Noise', T. Cate, *Electronic Design* 25, December 6, 1970.
4. 'Modified Function Generator Yields Linear VCO', A. Tagliavini, *Electronics*, October 30, 1975 pp. 96, 97.
5. Compensation of 8038, *Polyphony*, November 1977, p. 28.

Printed circuit boards

A set of single sided p.c.b.s for the audio spectrum analyzer will be available for £10.50 including v.a.t. and UK postage from M. R. Sagin at 23 Keyes Road, London N.W.2. □

Sixty years ago

There are several reasons for printing a monthly piece entitled 'Sixty Years Ago'. One can pick out the first mention of a well-known effect or piece of equipment; sometimes the writing itself can be funny, as in some of the replies to queries ("We advise you to take up some other pastime"); occasionally a historical event is mentioned — the outbreak of war perhaps. But the most interesting are the prophecies, most of which are wildly inaccurate. Every so often, though, one sees someone having a 'blinding flash', and just such a one appeared in the issue for May 15, 1920, in an article on research for the amateur, by W. T. Ditcham.

". . . . . the query as to whether a simple rectifying contact can be made to generate oscillations of suitable characteristics, and there are good grounds for thinking that such is probably the case. Dr W. H. Eccles some years ago demonstrated the production of oscillations by a galena contact, though at what frequency and amplitude, or what constancy, I am not aware, and quite recently G. W. Pickard, the American experimenter, has stated that he has received signals in the United States from European continuous wave stations on an oscillating crystal heterodyne. There seem to be difficulties in the way of a practical application, probably due to lack of continuity of the oscillations, but such results having been obtained, we are encouraged to hope that a practical solution is within the bounds of possibility. If a crystal or crystal combination can be used to oscillate, it can probably also be made to amplify, and one gets a futuristic glimpse of cascade crystal amplifiers, which, if they ever materialise, will quickly relegate valve receivers to the background for all ordinary purposes. I can think of no line of research more suitable for the average amateur than this one, as the apparatus requisite for the experiments need be of the simplest, and the phenomena met with would probably fall within the comprehension of the scientific novice. The investigator who first achieves success in this particular field may feel assured of an enduring niche in the wireless Hall of Fame, and the acquirement of a fair quantity of less enduring, but nevertheless perfectly good, lucre."

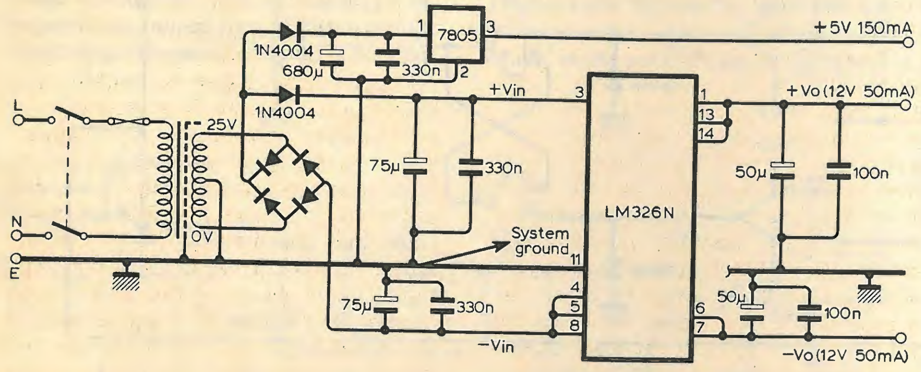


Fig. 15. Power supply circuit.

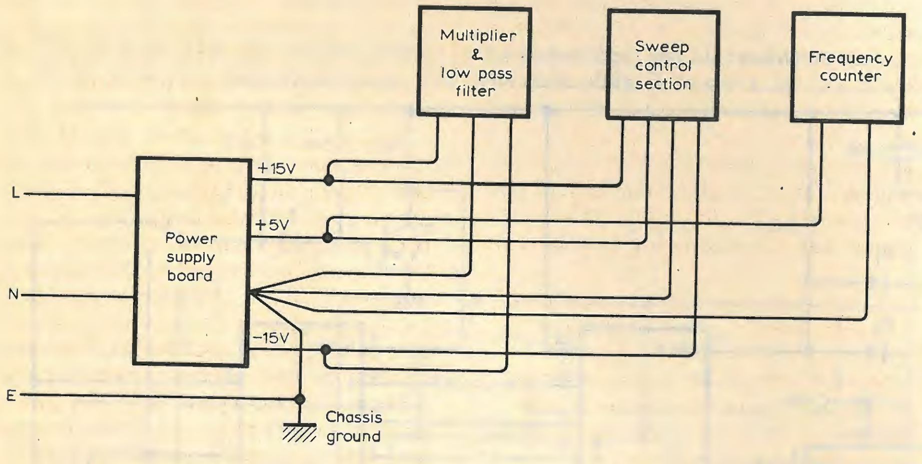


Fig. 16. Wiring should be arranged in this way to avoid common impedances and consequent instability.

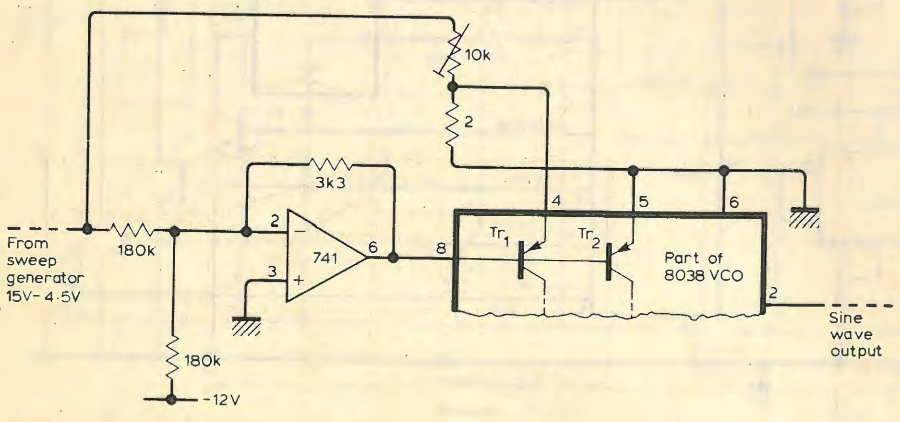


Fig. 17. Modified in this way, the local oscillator of Fig. 11 will provide a logarithmic frequency sweep.

Land mobile radio and spectrum utilisation

Introduction to the possible use of wideband modulation techniques

by P. A. Matthews B.Sc.(Eng.), Ph.D., F.I.E.E., M.I.E.E.E.
Department of Electrical and Electronic Engineering, University of Leeds

With conventional modulation methods the spectrum available for land mobile radio is insufficient to meet the demand. In this article the author first outlines the propagation problems in communicating with moving vehicles then discusses the number of users possible in a given area; and finally goes on to consider the possibility of using wideband modulation such as in the various spread spectrum techniques.

The conventional method of providing radio communication to vehicles on land is to use either a.m. or f.m. radio operating at v.h.f. or u.h.f. In general the number of channels available is insufficient to meet the demand from users or potential users of these systems.

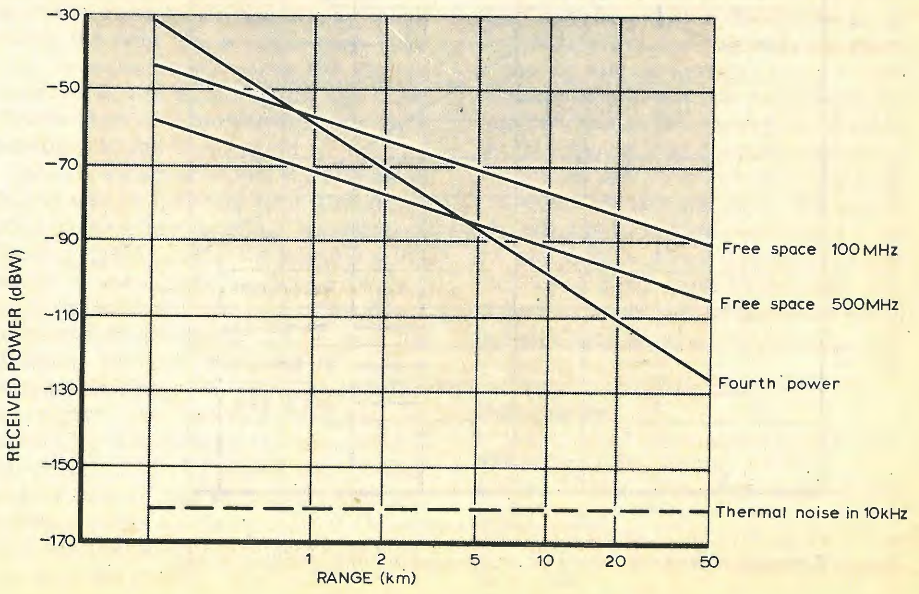
Most signals for communicating to vehicles use a base station with antennas at a high point to cover the area to be served. The antennas on the vehicles are, however, close to the ground and it is unusual for there to be a clear line of sight between the base station and the vehicle antennas. The signal suffers from reflection at the ground, reflection from buildings, diffraction over hills and diffraction around buildings. As a vehicle drives along the road, the variation in signal strength can be divided into three parts. Firstly, as the radial distance between transmitter and receiver increases there is an increase in spatial attenuation. For this type of path, the median received power falls approximately as the fourth power of the distance between transmitter and receiver. This variation in median power level can be compared with the square law variation expected in free space.

The median power level falls much more rapidly on a mobile radio path than, for example, in a line-of-sight radio relay system. The variation in power with distance is illustrated in Fig. 1. This is drawn for a transmitter power of 10W, a half wavelength dipole antenna at the transmitter, a transmitter height of 100 metres, a receiver height of 2 metres and a quarter wavelength monopole at the receiver. It is assumed that the antennas have the gains expected of ideal antennas of these lengths and that there are no circuit losses in the system. The fourth power law is independent of frequency, but the free space variation depends on frequency when the antenna gains are constant. To provide reference level the ideal noise power in a bandwidth of 10kHz is shown.

These curves show that, as the distance increases from 1km to 10km, there will be a 40dB decrease in received power. It also appears that using a 10W transmitter there is a good margin between the received power and the noise level which may be expected in the receiver. If we assume a receiver i.f. bandwidth of 10kHz and a noise figure of 6dB, then at a range of 20km the margin is 45db. However, we have not yet taken into account the fluctuations in received power due to diffraction and reflection.

Because vehicles have to follow the roads the path between transmitter and receiver will be obscured by hills and buildings. When the vehicle is in the shadow areas, a signal may be received by diffraction over the hills or around the buildings. Such diffraction effects are relatively insensitive to frequency and over any one of the bands allocated for mobile radio the attenuation of the signal due to shadowing is relatively

Fig. 1. Variation in mean received power in a mobile radio system with fourth power law dependence on distance compared with square law variation in free space. Transmitter power is 10W; antenna gains 2-15dB; antenna heights, transmitter 100m, receiver 2m.



constant for any one path. For a particular path the effect of shadowing may be calculated. However, when designing a mobile radio system we want to know the fluctuations which may occur due to shadowing as a vehicle moves from one point to another and these fluctuations are best described by a probability distribution which shows the probability of a certain shadow attenuation occurring. Measurements taken over a large number of sites[1] show that the distribution of shadow fading follows a log-normal distribution. This is shown in Fig. 2. The log-normal distribution is characterised by the standard deviation σ in dB and for different areas and frequencies the value of σ may change. However, typical values for σ seem to lie between 6 and 12 dB. Taking the curve for σ=6dB, we can see that an attenuation of more than 14dB can be expected at 1% of sites, or for a vehicle travelling along a road for 1% of the time.

Besides the attenuation due to shadowing, there is also fading caused by the phase interference of signals arriving by different paths. This occurs because signals can be reflected from buildings giving a signal at the receiving antenna which is the phasor sum of a number of signals. As the vehicle moves along the road the path lengths between transmitter and receiver for the various reflected components of the signals vary in a random manner. The vehicle has only to move a short distance in terms of the wavelength for the phasor sum to vary completely. This combination of random phasors leads to a Rayleigh distribution for the probability distribution of the amplitude of the received signal. Because the signal amplitude depends on variations in distance of a fraction of a wavelength this kind of fading is frequency sensitive and the fading pattern measured for two adjacent frequencies can be completely different. As a vehicle moves along a road this phase interference gives a rapid fading which is superimposed on the shadow fading. For the Rayleigh distribution an attenuation of 28dB can be expected for 1% of sites or 1% of the time.

Because of the combined effects of shadowing and the rapid fading due to reflection, the probability distribution for the received signal depends on the combination of the two individual distributions. The derivation of the expressions for the probability distributions has been given by French[2]. The result is shown in Fig. 2 for two different values for the standard deviation σ of the shadow fading. These curves show that at 1% of sites and with σ = 6dB, an attenuation of 24dB or more may be expected. Thus the median margin above noise of 45dB is reduced to only 21dB for 1% of sites. The actual margin required depends on the type of modulation used and the output signal/noise ratio required. For example for a s.s.b. transmission the output s.n.r. is the same as the input s.n.r. Assuming a 5kHz i.f. bandwidth, a required output s.n.r. of 10dB and a 99% probability of reception Fig. 3 shows a range of 36km. For f.m. with a 10kHz i.f. bandwidth and assuming no noise improvement the corresponding range is 25km.

Area cover and number of users

If an isolated area is served by one base station the problem of fading can in principle be overcome by increasing the transmitter powers. However, there are practical limits to the power of mobile transmitters and problems caused by intermodulation of signals. In the isolated area, the number of users is limited by the number of channels available.

In practice the radio transmissions are not confined to an isolated area and interference is likely between users of the same channel in adjacent areas. To limit the effect of interference there must be sufficient distance between transmitters using the same frequency for the probability of interference to be below some low limit. If the radius served by a given transmitter is r_1, and the distance between transmitters using the same frequency is r_2, then over a large area that frequency can only be used for a fraction of the total area. The total area can be divided into cells and the total number of channels divided into groups shared between the cells. If the ratio of the distances (r_2/r_1) is called the re-use distance D then the number of groups of frequencies, C, is given by $C = D^2/3$. To find the re-use distance the probability of interference occurring must take into account the probability of fading of the wanted transmission, whilst the interfering signal may not have faded. The result is that the re-use distances may be large, and hence the number of groups large. Because the re-use distance is a ratio of distances, the number of groups is independent of the actual area, provided all the cells are within the same radio horizon distance.

Calculations of re-use distance presented in (2) show that taking into account both shadow fading and phase interference fading, the available channels may have to be divided into large numbers of groups. For example, for a probability of interference of not more than 3%, f.m. with 25kHz spacing may require 57 groups and s.s.b. 133 groups. Considering a 10MHz bandwidth, the f.m. system with a channel spacing of 5kHz would give 15 channels per group. Thus, in any one particular area the number of channels which can be used is severely limited when the problem of mutual interference is taken into account.

Because the number of groups and cells is independent of their area, the number of users in a given physical area

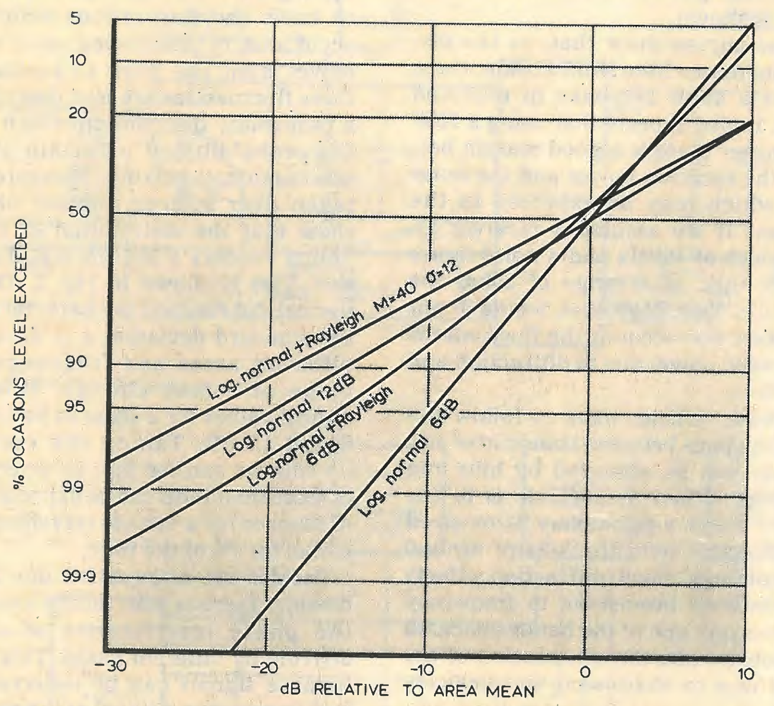


Fig. 2. Fading levels for log-normal shadow fading and long-normal plus Rayleigh fading. Area mean given by fourth power law variation.

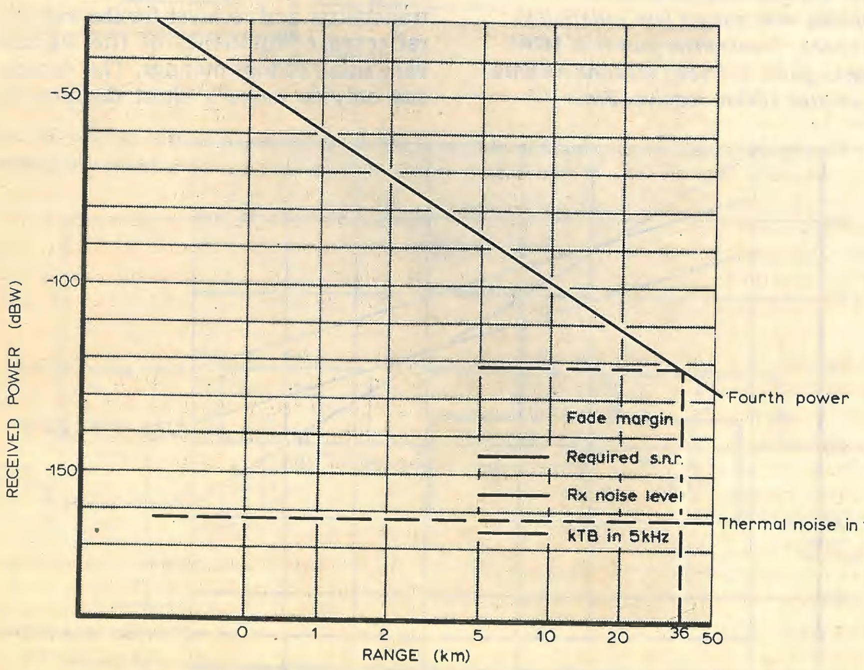


Fig. 3. Estimation of range for s.s.b. system taking into account fading.

can be increased if the area covered by each cell is limited. This implies using a large number of cells with low power transmitters in each cell. However, such a system produces problems when a call has to be made over a distance spanning several cells. Direct communication is not possible and a relay system must be set up to transfer calls from one cell to another.

Wideband modulation

So far this discussion has considered f.m. or s.s.b. transmission, and it has shown that when interference between transmissions on the same frequency is taken into account the number of users/MHz in a given area is limited to a small number. We need to consider whether other modulation techniques can accommodate more users. A class of modulation techniques which should be considered are the various spread spectrum techniques[3].

The use of wideband spread spectrum techniques has generally been ruled out for mobile radio systems because of its apparently extravagant use of the r.f. bandwidth. In a spread spectrum system the available power may be spread over a bandwidth of possibly tens of megahertz, either by modulating a conventional transmission by a noise-like wideband signal or by hopping the carrier frequency over the band. At the receiver, the original transmission is recovered by taking advantage of known properties of the wideband noise-like signal or of the hopping pattern. In both cases the s.n.r. for the wanted signal is raised relative to that of unwanted signals by the ratio: the bandwidth of the wideband signal to that of the narrow band signal. This so-called processing gain G_p improves the s.n.r. for the wanted signal, and at the same time gives the interfering signals a noise-like property. The processing gain also depends on the cross-correlation between the wanted and unwanted signals. Ideally, there should be no cross-correlation.

If a given band is to be shared by a number of users then the information from each user must be spread in a manner which is unique to that user, and in a way which produces a wideband signal which is uncorrelated with the signals from other users. The methods by which the spreading process can be carried are described by Dixon.[3] So far as a particular wanted signal is concerned, the signals from other users are noise. As the number of users increases the noise level in the band rises. If each of the transmissions produces the same power at a receiver then the s.n.r. after recovering a particular signal can be estimated. Suppose there are N transmissions, all covering the same band. Then there is 1 wanted transmission and $(N-1)$ unwanted transmissions. At the receiver antenna the s.n.r. is $1/(N-1)$, but after processing with a processing gain G_p, the s.n.r. becomes $R = G_p/(N-1)$. This gives $N = 1 + (G_p/R)$, which is plotted in Fig. 4 for various values of processing gain and output s.n.r. For example, if the required value of R = 16dB in a 5kHz bandwidth and the spread bandwidth is 10MHz, then G_p = 33dB and N = 50. It appears that 50 users could be accommodated in the 10MHz bandwidth. However, this is on the assumption that each transmission produces the same power at the receiver.

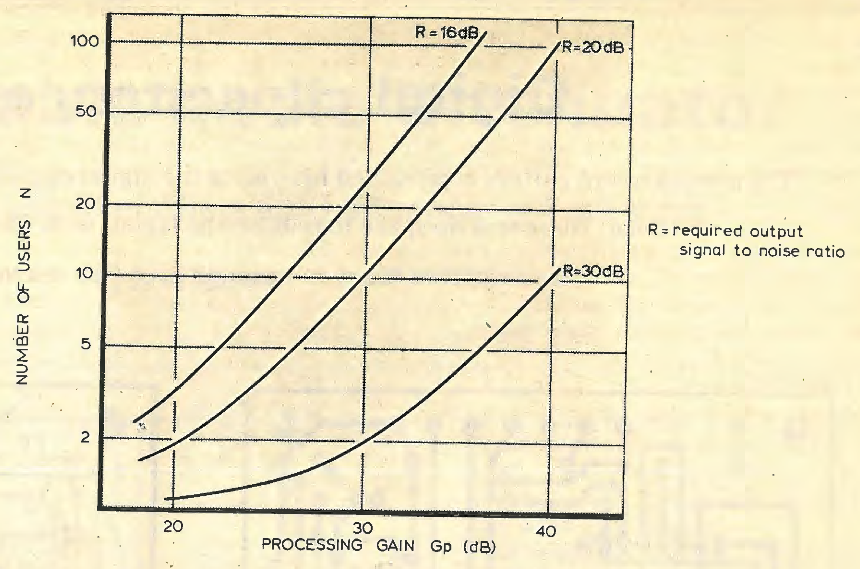


Fig. 4. Number of users in a spread spectrum system as a function of processing gain and required output signal-to-noise ratio.

Clearly this requirement for equal power levels cannot be achieved if all the transmitters on the vehicle radiate the same power because the vehicles will be at different distances from any given receiver. However, for transmission to a common base station it may be possible to control the power transmitted from the mobiles to give equal powers at the base station receiver. Because of the variability in the path loss between transmitter and receiver due to distance and shadowing, control of power must be carried out by measuring the path loss in some way. This may be possible by using the signal received at the mobile from the base station to control the level of transmission back to the base station.

With a wideband signal the effects of fading will be different from the effect on a narrow band signal. The effect of shadow fading which is relatively insensitive to frequency may be expected to be the same in both cases. The effect of phase interference fading will be different because this kind of fading depends strongly on the frequency or wavelength used. A narrow band signal suffers from deep fading because of the cancellation of the signal due to the phasor sum of the signals arriving by different paths summing to zero. On an adjacent frequency the phasor sum may reach a maximum. The effect on a wideband signal will be to distort the signal spectrum in amplitude and phase. The problem then is whether the wanted signal can be recovered from the energy in the distorted spectrum.

For transmission from mobiles to a common base station it seems that it may be possible to use wideband transmissions. Power control of the transmissions is necessary and must be based on the measured path loss. The measured path loss will compensate for the attenuation due to both distance and shadow fading provided the dynamic range of the system is great enough. The effects of phase interference fading have to be worked out in detail, but provided the signal can be recovered from the energy available it appears that wideband modulation techniques may provide at least as much system capacity as narrow band schemes.

This problem of recovery of the signal will differ depending on whether a noise-like wideband signal or a frequency hopping scheme is used. In a frequency hopping scheme the signal at any one time is a narrow band signal on a particular frequency. Even if the effect of shadow fading is removed by controlling the mean power level the particular frequency component at any one time may be reduced due to phase interference fading. This may be overcome by using several frequencies simultaneously, but this will reduce the number of users in inverse proportion to the number of frequencies used for a particular user. For noise-like signals the effect of distortion of the signal spectrum is to reduce the output s.n.r. To maintain a given output s.n.r. the number of users must be reduced. The reduction in number of users has yet to be calculated or measured.

References

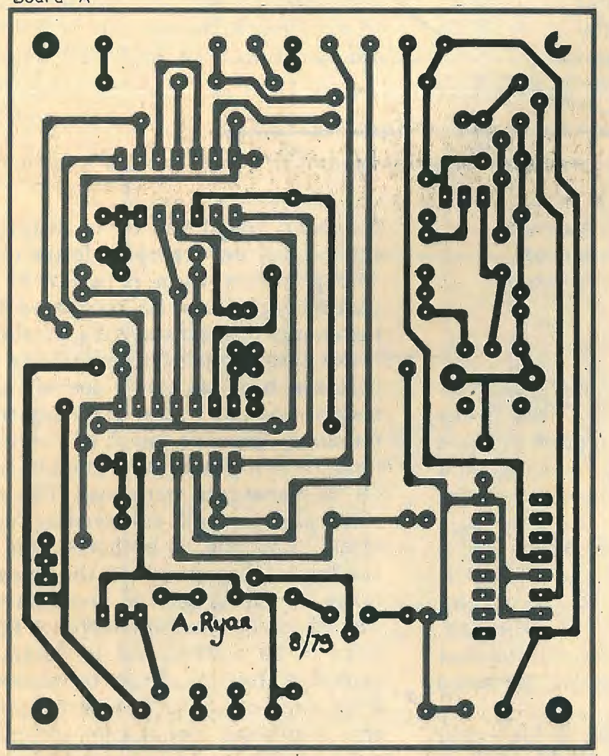
1. W. C. Jakes, Ed. Microwave Mobile Communication, Wiley, 1974, pp. 79-131.
2. R. C. French. "The effect of fading and shadowing on channel reuse in mobile radio," *IEE Trans. VT-28*, 1979, pp. 171-181.
3. R. C. Dixon. Spread Spectrum Systems, Wiley, 1976.

Digital capacitance meter

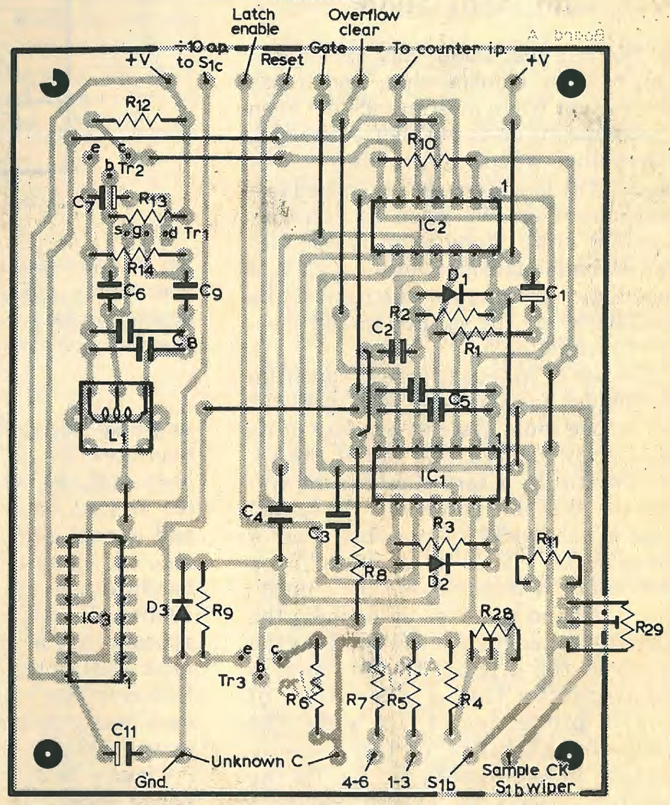
The printed-board pattern reproduced here is for the digital capacitance meter described in our April issue. There was no space to publish the layout with the article and, regrettably, we neglected to say it was held over. The drawings are full size.

Copper side

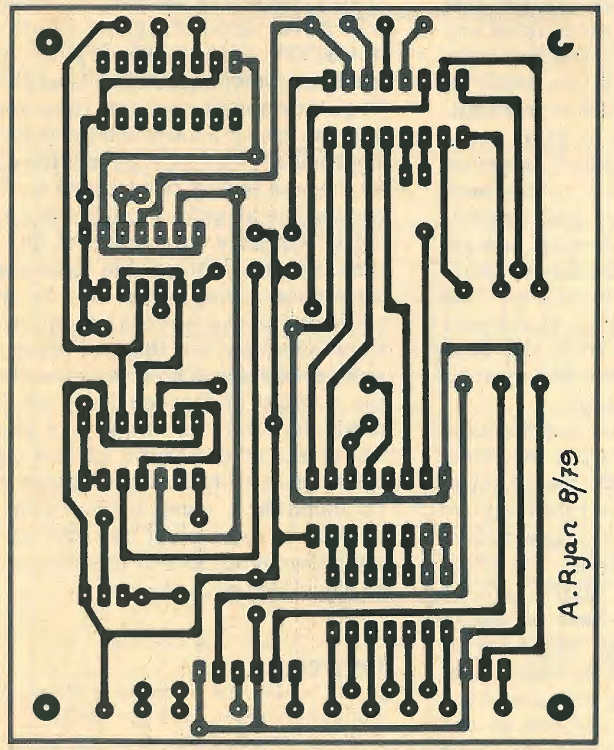
Board A



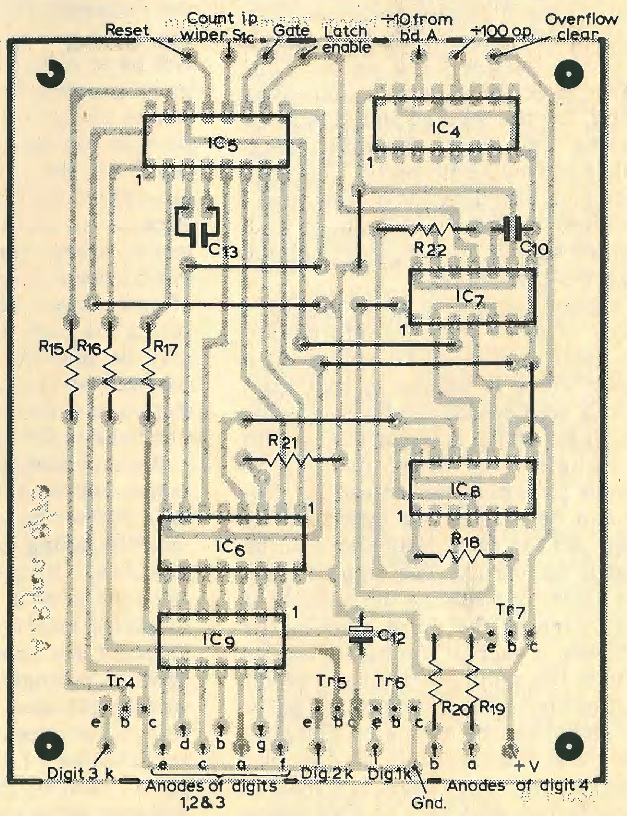
Component side



Both boards 78·5mm x 98mm



Board B



Programmable audio attenuator

Gain controlled line amplifier offers a 60 dB range in 1 dB steps

by J. M. Didden

After experimenting with various linear gain control systems, the author chose a combination of linear and logic circuits to provide a high quality audio attenuator. The final design uses a 6-bit word to program the gain, and can be used for remote control applications or, with the aid of a microprocessor, for automatic level control.

This circuit was originally designed to remotely control the volume and balance in a stereo system. Several methods were tried, such as the two-quadrant multiplier in Fig.1. However, this circuit suffered from high distortion for input levels of more than 100mV, and tracking between units was poor. Attempts to improve the performance with current-source loading did not significantly improve the performance. A f.e.t. used as a voltage controlled resistor produced similar problems, so a l.d.r. design was tried as shown in Fig.2.

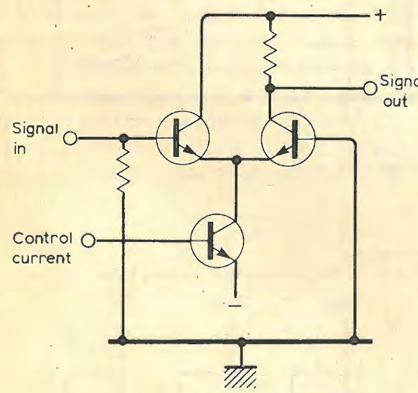


Fig. 1 Basic two-quadrant multiplier.

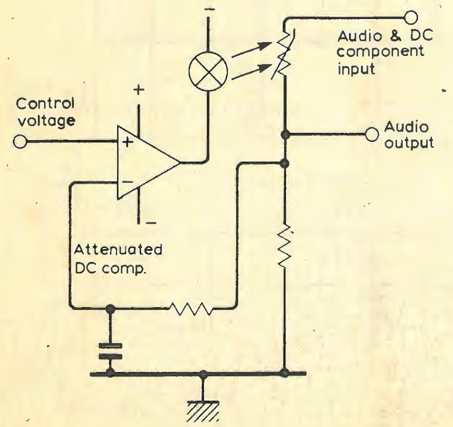


Fig. 2 Closed-loop light dependent resistor attenuator.

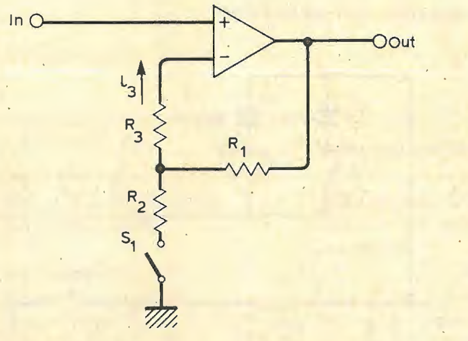


Fig. 3 Basic gain switching circuit.

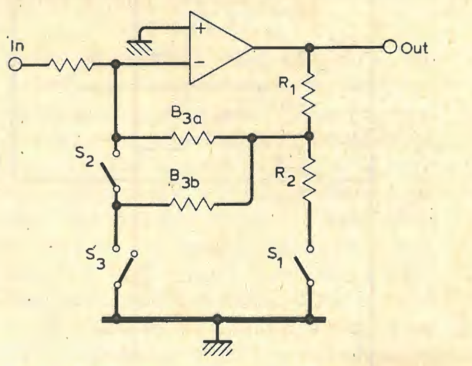


Fig. 4 Extended circuit with two independent switches.

This circuit had a good signal level capability, and tracking between units was made almost perfect by using a compound audio plus d.c. input. The attenuated d.c. was fed back to the control circuit. Unfortunately, the l.d.r. produced high noise levels at medium to high attenuation, and control-loop stability was difficult to achieve. Because these analogue approaches did not produce the performance required, I investigated gain switching with f.e.ts. Although f.e.ts are nonlinear, this is not a problem if the signal voltage across a closed switch is very small. A basic circuit is shown in Fig.3. When f.e.t. S_1 is closed, the signal across it equals the input voltage times the ratio of the f.e.t. on resistance to R_2. In practice, ratios of 1/1000 are easily obtained, so a signal level of several volts, which is not uncommon in a line amplifier, produces only a few millivolts across the switch. At these levels the f.e.t. is almost perfectly linear. Two independent gain settings can be achieved by switching R_3 and keeping I_3 constant. With S_2 closed and S_3 open in Fig.4, R_{3a} and R_{3b} are connected from R_1 to the virtual earth of the op-amp. With S_2 open and S_3 closed, R_{3b} is connected to the real earth. Therefore, by using a s.p.d.t. switch for S_2 S_3, and a s.p.s.t. for S_1, four gain settings are possible.

An extension of this circuit is shown in Fig. 5 where, with S_5 closed and S_4 open, gain is determined by the ratio of R_5 to R_1. With S_5 open and S_4 closed, the gain is determined by the ratio of R_5 to R_1 and R_3 to R_4. Combining the circuits in Fig. 4 and Fig. 5 gives eight gain settings. For all of these configurations the switches have only a small signal across their on resistance and carry very little current when opened. The values of the series resistors are high compared with the off resistance.

Selection of a suitable f.e.t. presented some problems. Switch arrays for analogue applications are available, but are generally expensive. Analogue multiplexers, such as the 4051, contain eight c.m.o.s. switches with a common input and integral one-of-eight decoder for control by a 3-bit word. However, the switching produces spikes on the audio output due to an internal capacitive coupling of the control signal to the switch terminals. This can be minimised by loading the switch, but smaller resistors must then be used which consequently produces higher distortion levels. Although "soft" switching with a RC network is one solution, see Fig. 6,

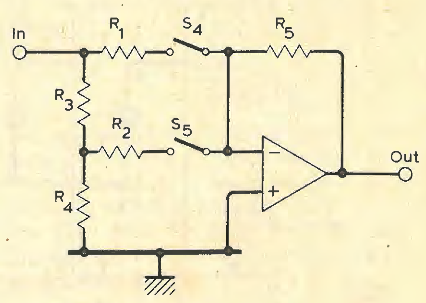


Fig. 5 Alternative two-switch circuit.

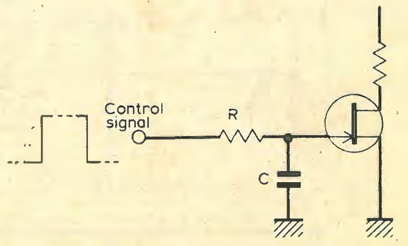


Fig. 6 Soft switching to overcome spikes.

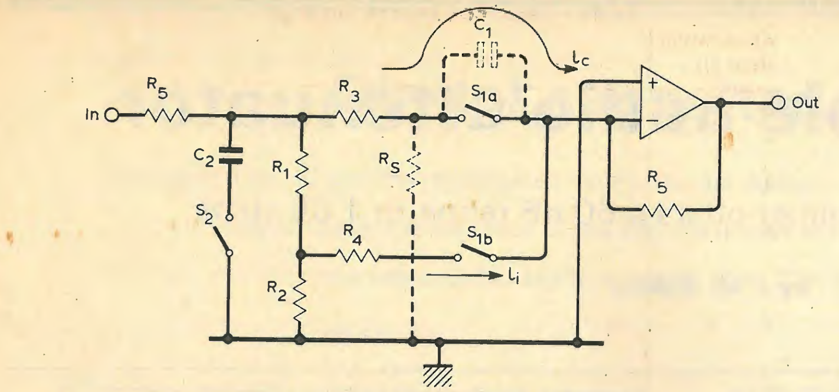


Fig. 7 Internal capacitance effect and compensation low-pass filter.

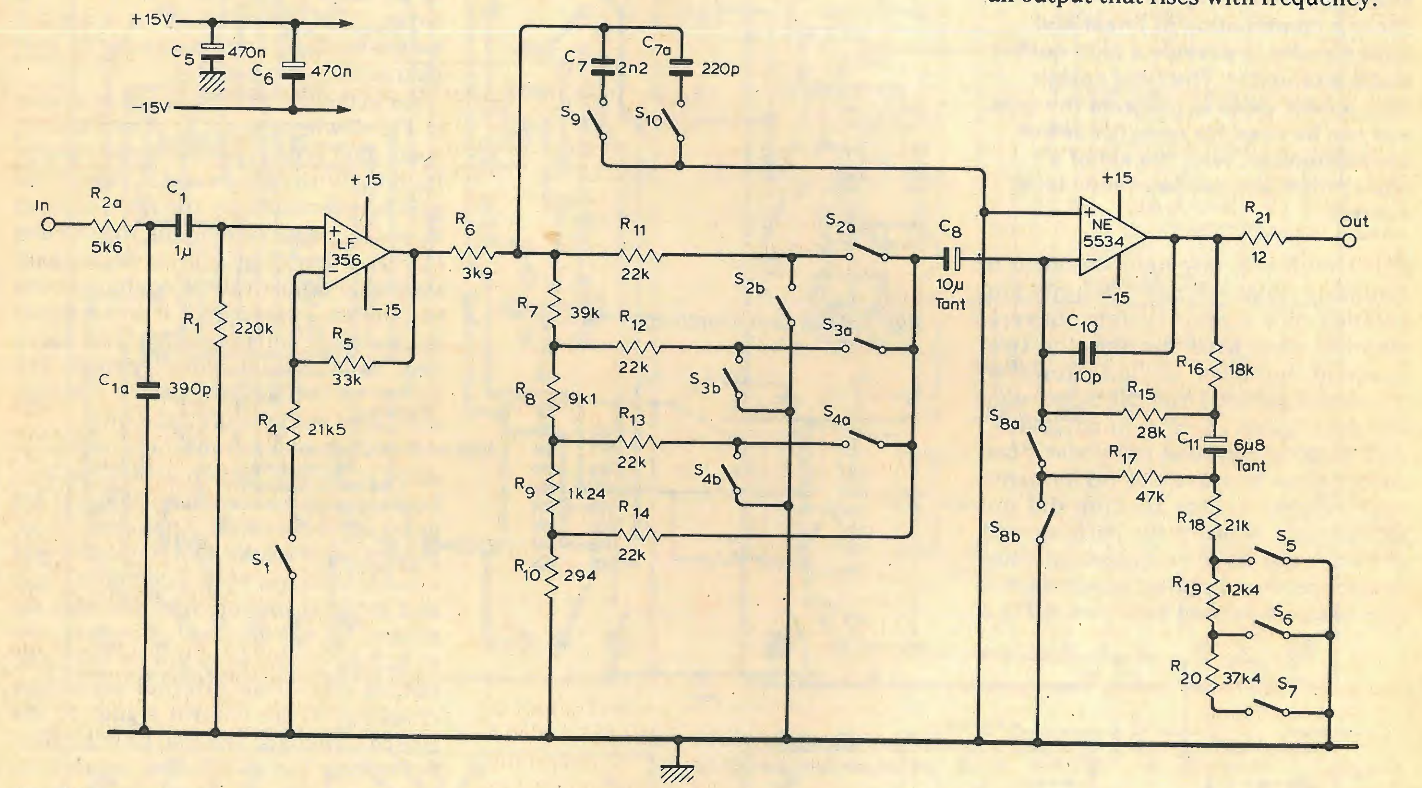


Fig. 8 Complete attenuator circuit for one channel. The switches are grouped in five i.cs as follows; S_5+S_6, S_7+S_{8ab}, $S_{2ab}+S_{3ab}$, $S_{4ab}+S_1$ and S_9+S_{10}. All resistors should be 1%.

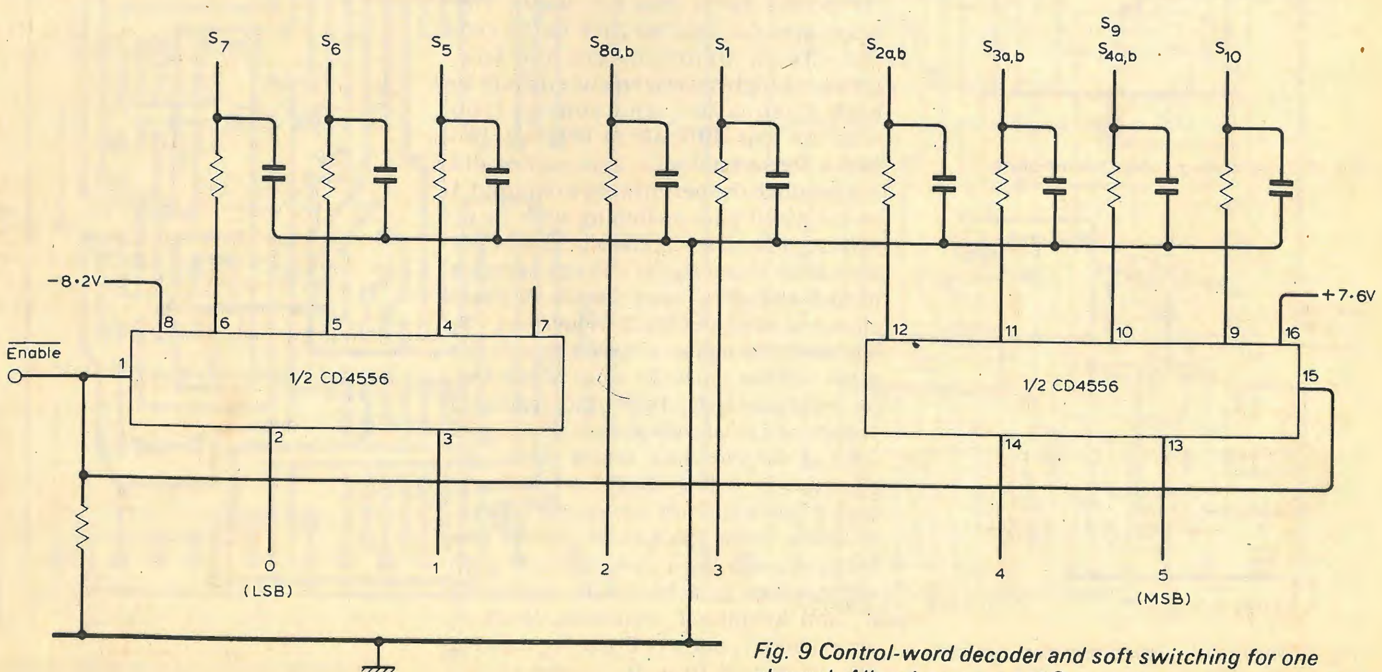


Fig. 9 Control-word decoder and soft switching for one channel. All resistors are 1MΩ and all capacitors are 1.8 nF.

the gate of the f.e.t. must be accessible. I finally decided to use the low cost 4007 which contains two s.p.d.t. switches and an inverter.

In practice, 1dB steps in gain produce a gradual change and a range of about 60dB is sufficient for most applications. Because high value series resistors are required, high attenuation can only be achieved with the circuit in Fig. 5. However, as shown in Fig. 7, if S_{1b} is closed and S_{1a} is open, a small current flows through the internal switch capacitance. At high attenuation and high signal frequencies, this current may not be insignificant and can cause an output that rises with frequency.

This problem can be overcome by grounding the left terminal of S_1 when it is open, and this is easily achieved with the 4007 s.p.d.t. switches. Because there is an on resistance, R_s, a small signal voltage remains across the open switch. The low-pass filter R_5 C_2 compensates for this with S_2 closed when S_{1b} is closed and S_{1a} is open. The frequency response is flat within 0.3 dB up to 25 kHz and at high attenuation. Fig. 8 shows the final circuit for one channel and table 1 shows the range of attenuation levels. Ten mixed s.p.s.t. and s.p.d.t. switches are required and these can be produced with five 4007 i.cs. It is important that the signal amplitudes across S_1, S_8, S_5, S_6 and S_7 do not exceed the positive or negative supply voltages because an internal protection diode will conduct and cause distortion. As audio signals are bipolar, the supply voltage should be centered around ground because one side of the open switches is always connected to either a signal ground or virtual earth. To balance the on resistances of the p and n-channel m.o.s.f.e.ts, a positive supply of 7.6V and a negative supply of 8.2V is used. In Fig. 8, S_1 and $S_{8a,b}$ can be controlled by a single bit. Switches S_{2a} to S_{4b} and S_5 to S_7 require the four decoded values of a 2-bit control word. This is carried out by a 4556, which containes two one-of-four decoders, see Fig. 9.

Selection of the switch-network resistors is a compromise as already explained. The typical on resistance of a switch is about 300Ω and the maximum variation is about 200Ω. With a series resistor of 22kΩ 1%, this is comparable with the switch tolerance. Calculations for the resistor values are given in the appendix. Fig. 8 also shows that some switches are capacitor-coupled to the circuit by C_8 and C_{11}. These remove a small output offset-voltage change with gain which can be heard as clicks at low input signal levels.

The capacitor values have been chosen to give a low-frequency response to below 10Hz. A f.e.t. input op-amp, LF 356, is used to provide a high input impedance, wide bandwidth, high slew-rate and low distortion. A NE 5534 is used at the output because it can deliver a high output level into a 600Ω load with little distortion. With R_{21} and C_{10} to stabilize the op-amp, a 10nF load will not produce ringing or overshoot of a square-wave signal. The 5534 is also a low noise device, which is important, because most of the attenuation takes place at its input and this reduces the signal-to-noise ratio of the last stage. Performance parameters of the complete amplifier are shown in table 2. If a f.e.t. input selector switch is required, the LF 350 can be used in the inverting mode as shown in Fig. 10. The compensation capacitors, which may be necessary with other op-amps, are shown in Fig. 11.

If a visual indication of the attenuation is required, the control word can be converted to a two-digit b.c.d. output for driving a seven segment display.

To be continued

Table 1. Gain and switch settings

Attenuation steps dB	S_1	S_{2a}	S_{2b}	S_{3a}	S_{3b}	S_{4a}	S_{4b}	S_5	S_6	S_7	S_{8a}	S_{8b}
0								C	O	O		
1								O	C	O		
2								O	O	C		
3								O	O	O		
0											O	C
4											C	O
0	C											
8	O											
0		C	O	O	C	O	C					
16		O	C	C	O	O	C					
32		O	C	O	C	C	O					
48		O	C	O	C	O	C					

Table 2. Performance details of the attenuator

Max. r.m.s. output level	8.5V across 600Ω.
Max. input level	3.8V or 9V depending on S_1, provided max. output level is not exceeded.
Max. capacitive load	10 nF.
Frequency response	better than 10 Hz to 25 kHz within 1 dB.
Output noise level	at least 86 dB below 1 V r.m.s. at all gain settings (unweighted).
T.h.d. and i.m.	less than 0.03% and 0.02% respectively.
Gain	variable in 1 dB steps from 16.8 dB to −46.2 dB.

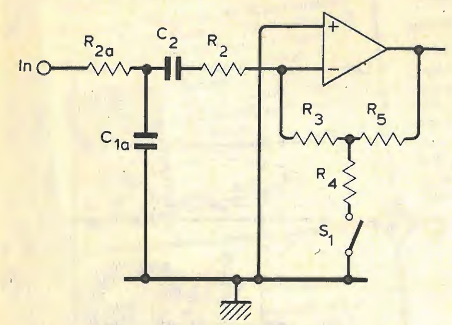


Fig. 10 Inverting input buffer.

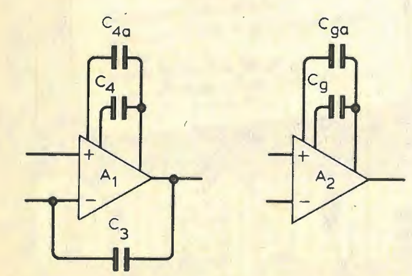


Fig. 11 Alternative compensation networks for other op-amps.

Appendix

Calculation of resistor values.
For these calculations a dB table or calculator with log. and inverse log. functions is required.
For the 1, 2 and 3 dB attenuators in Fig. 12, with S open,

$$i=\frac{U_{u1}}{R_1+R_f} \quad (1)$$

for an output of U_{u1} volts. With S closed and an output of U_{u2} volts, the equivalent voltage source U_1 is

$$U_{u2}\frac{R_x}{R_1+R_x} \quad (2)$$

and the equivalent source resistor is

$$\frac{R_1R_x}{R_1+R_x} \quad (3)$$

therefore,

$$i=U_{u2}\frac{R_x(R_1+R_f)}{R_1R_x+R_f(R_1+R_x)} \quad (4)$$

Because i always equals i_s, equations (1) and (4) are equal. Substituting G for U_{u2}/U_{u1} gives

$$R_x=\frac{R_1R_f}{(G\text{-}1)R_1+R_f} \quad (5)$$

The minimum resistor values for R_1 and R_f, for a given G and R_x, are obtained if $R_1=R_f$. The minimum R_x is found for $G=3$ dB and, taking $R_x=20k\Omega$ as a design value, R_1 and R_x are about 18kΩ. However, R_f is also part of the 4dB network, so this is calculated first using a R_f of 18kΩ.

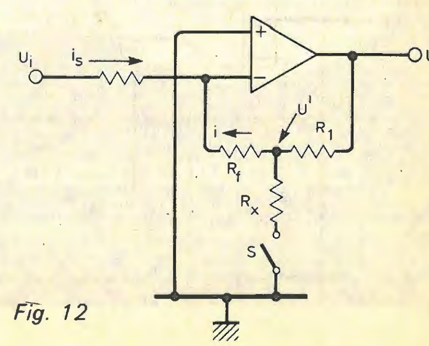


Fig. 12

The circuit is given in Fig. 13. If S_1 is closed and S_2 is open,

$$i = \frac{U_1}{R_1} + \frac{U_1}{R_2} \qquad (6)$$

With S_1 open and S_2 closed,

$$i = \frac{U_1}{R_1} \qquad (7)$$

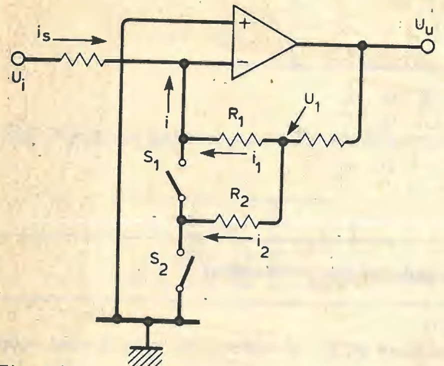


Fig. 13

As already mentioned, i_1, i_2 and U_1 are equal in both cases. In the first case, gain is the ratio of i_s to i_1+i_2, and in the second case, the ratio of i_s to i_1. The change in gain is therefore

$$G = \frac{i_1+i_2}{i_1} \qquad (8)$$

and equations (6), (7) and (8) give

$$R_1 = R_2(G-1) \qquad (9)$$

and

$$R_2 = \frac{R_1}{G-1} \qquad (10)$$

Substituting $R_1//R_2 = 18k\Omega$ in (10) gives

$$R_2 = \frac{G.18k\Omega}{G-1} \qquad (11)$$

For $G=4$dB, R_2 is about 48kΩ. Using the standard value of 47kΩ and adding the nominal on resistance of the switch gives 47.3kΩ and R_1 becomes 27.6kΩ. With the nearest preferred values, R_{15} is 47kΩ and R_{17} is 28kΩ in Fig. 8.

The value of R_f in (5) now becomes 17.46 kΩ, i.e. $R_1//R_2$. The R_x values are calculated next. For $G=1$ dB, R_x is 72.64 kΩ, which is the on resistance in Fig. 8. For $G=2$ dB, R_x is 34.23 kΩ which is $R_{18}+R_{19}+$ on resistance. For $G=3$ dB, R_x is 21.48 kΩ, i.e. $R_{18}+$ on resistance. With the nearest preferred value, R_{18} is 21 kΩ, R_{19} is 12.4 kΩ and R_{20} is 37.4 kΩ.

For the 8 dB switch refer to Fig. 14. With S open the gain is 0 dB, and with S closed the gain is R_1+R_x/R_x which gives

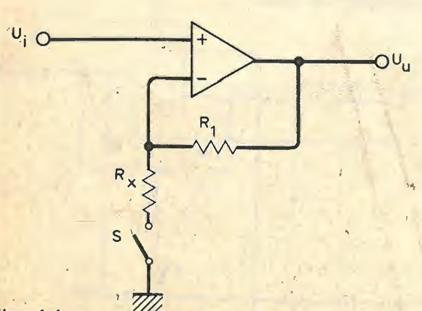


Fig. 14

$$R_x = \frac{R_1}{G-1} \qquad (12)$$

Choosing 33 kΩ for R_1 gives 21.83 kΩ for R_x. Subtracting the 300Ω on resistance gives a standard value for R_4 in Fig. 8 of 21.5 kΩ and 33 kΩ for R_5.

Calculations for the remaining switch network are more difficult because the series resistors are either connected to ground or to virtual earth, see the equivalent circuit in Fig. 15. To save a switch, R_{14} in Fig. 8 always

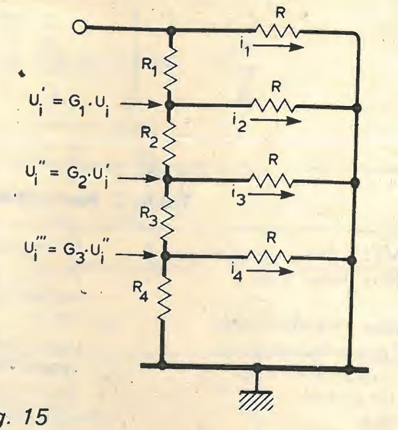


Fig. 15

delivers current to the summing node. Therefore, for the various gain settings, the following input currents flow;
No attenuation, i_1+i_4
-16 dB, i_2+i_4
-32 dB, i_3+i_4
-48 dB, i_4
For a gain step A, the current ratios are

$$A = \frac{i_2+i_y}{i_1+i_y} \qquad (13)$$

$$A = \frac{i_3+i_y}{i_2+i_y} \qquad (14)$$

$$A = \frac{i_y}{i_3+i_y} \qquad (15)$$

If all series resistors are equal, gain changes only depend on voltages G_1U_i, G_2U_i and G_3U_i. Therefore,

$$G_1 = \frac{i_2}{i_1} \qquad (16)$$

$$G_2 = \frac{i_3}{i_2} \qquad (17)$$

$$G_3 = \frac{i_4}{i_3} \qquad (18)$$

If A is -16dB,

$$G_3 = \frac{A}{1-A} (0.188\text{–}14.5\text{dB}) \qquad (19)$$

$$G_2 = \frac{A}{1+A} (0.137\text{–}17.3\text{dB}) \qquad (20)$$

$$G_1 = \frac{A}{1+\frac{A^2}{1+A}} (0.155\text{–}16.2\text{dB}) \qquad (21)$$

Note that A is the input-current gain step and G_n is the gain step of the voltage across the series resistor relative to G_n-1.

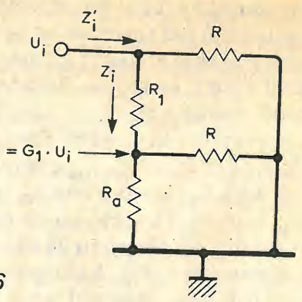


Fig. 16

In the simplified circuit of Fig. 16, because $Z_i^1 = Z_i//R$,

$$Z_i = \frac{Z_i^1 R}{R-Z_i^1} \qquad (22)$$

and

$$R_1 = Z_i - \frac{R \cdot R_a}{R+R_a} \qquad (23)$$

also, because

$$G_1 = \frac{\frac{R \cdot R_a}{R+R_a}}{Z_i}$$

$$G_1 Z_i = \frac{R \cdot R_a}{R+R_a}$$

Therefore,

$$R_1 = Z_i(1-G_1) \qquad (24)$$

and

$$R_a = \frac{R \cdot G_1 \cdot Z_i}{R-G_1 \cdot Z_i} \qquad (25)$$

Again, using a design value of 22kΩ for the series resistors, and adding 300Ω on resistance gives 22.3 kΩ for each resistor. As R_{14} in Fig. 8 has no series switch, R in formula (30) and on will be 22 kΩ. After a little trial-and-error to find a standard value for R_1, the value of Z_i^1 was set to 15.04 kΩ, which is the constant load presented to the buffer amplifier. From (22), (23) and (24), Z_i is 41.2 kΩ and R_1 is 39 kΩ. From (25), R_a is 10.55 kΩ. By repeating this procedure Fig. 17 is achieved where

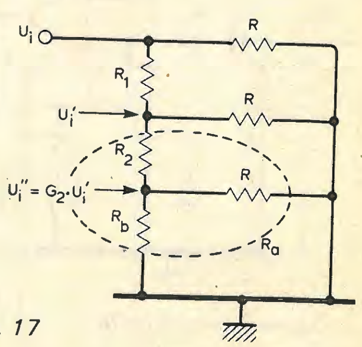


Fig. 17

$$R_2 = R_a - \frac{R \cdot R_b}{R+R_b} \qquad (26)$$

$$G_2 = \frac{\frac{R \cdot R_b}{R+R_b}}{R_a} \qquad (27)$$

continued on page 74

Binary codes for error protection

Detection and correction of errors in transmitted binary data

by **D. A. Bell,** F.Inst.P., F.I.E.E.

So far as is possible without recourse to far more mathematics than would be appropriate in *Wireless World*, Prof. Bell expounds the theory underlying the use of protection bits, which enable errors in data transmission to be detected and corrected. An example of the technique is the Hamming code used to protect the header row in teletext and viewdata transmissions

The term "error-protection" covers both "error-detection" and "error-correction". The latter is prima facie more desirable but is always more complex (much more complex for multiple errors) so that it is sometimes better in practice to use only error detection and to re-process erroneous items either by repetition or by taking them out of the system. Communication systems have to rely on repetition, but in bank clearing operations an occasional cheque on which the account number cannot be correctly read by machine can be diverted from the machine for human attention. (This is particularly relevant because error-correcting codes are less well developed in decimal than in binary notation.)

Check digits

Most of the codes in common use are binary codes, and most readers must be familiar with the use of a single (binary) check digit to detect a single error, or more exactly any odd number of errors. For example, in the ASCII code for input to a computer or for the text of teletext, each character (number, letter, punctuation mark, etc.) is represented by a particular pattern of 7 binary digits. One then adds an eighth digit which is made 1 or 0 according as the number of ones in the original 7 digits is odd or even: the total count of ones over the 8 digits is then always even, i.e. it is equal to zero modulo 2*. In order to correct an error in a binary group, one need only find *which* digit is in error and interchange 0 and 1 in that place. If we start with one information digit and add one check digit, we shall not know whether a failure of the parity check on reception is due to an error in the information digit or in the check digit, so another check digit has to be added to resolve this ambiguity. In fact a single-error-correcting code for a group n digits long requires to include enough check digits to distinguish between no error and an error in any one of n places, i.e. $n+1$ possibilities. But r binary digits can distinguish between 2^r possibilities (see "Communication Theory", *Wireless World*, April 1976) so code construction is simplified if $n=2^r-1$. The number of information digits, $n-r$, is denoted by k, the number of errors which can be corrected is t, and the complete characteristics of the error-correcting code are denoted in the form (n,k,t). The single information digit with the two check digits is then a (3,1,1) code which fits into the standard pattern of single-error-correcting codes with $r=2$, $n=2^2-1=3$, $k=n-r=1$.

Let us now try to construct the (7,4,1) code which has $r=3$. In order to show which digit places are checked by each check digit, an array is constructed with a line for each check digit containing a weight (either 0 or 1 in binary) for each of the n digits of the code. (Remember that the check digits are included in the n places.) In the following example every digit place is covered by at least one check digit, so any single error will be discovered: put another way, the no-error condition is indicated by the success of all three parity checks.

Digit no.	1	2	3	4	5	6	7
Check no. 1	0	0	0	1	1	1	1
Check no. 2	0	1	1	0	0	1	1
Check no. 3	1	0	1	0	1	0	1

Then proceeding by successive binary divisions, the first check digit indicates whether there is an error in the second half; the second check digit covers the second and fourth quarters; and the last covers the odd numbered places (odd eighths, approximately). Hamming[1] offered a special feature: if the check digits are in places 1, 2 and 4 (and successive powers of two for longer codes), the combined result of the check sums (known as the "syndrome") would represent in binary the number of the erroneous digit. For example, if check number 1 produced an even sum but numbers 2 and 3 produced odd sums, giving a syndrome 0 1 1, the error must be in digit number 3.

The addition of one overall check digit to any t-error-correcting code will allow it to *detect* $t+1$ errors. (See below for explanation in terms of "distance".) Thus the (7,4,1) code can be extended to length 8 digits, 4 information and 4 check digits, which will *correct* all single errors and *detect* all double errors. There are then 10 possibilities to consider (no error, 8 distinct single errors, or any double error) so that 4 check digits are ample: the modified code is not perfectly packed. This is the code which is used for the address elements in teletext.

It was remarked above that a single-error-*detecting* code using a simple parity check will actually detect any odd number of errors; but this is usually ignored on the ground that the occurrence of three errors is of negligible probability compared with the occurrence of one error. If errors occur at random, affecting only one digit at a time, with probability p per digit, then the probability of one error in a block of n digits is np and the probabilities of 2, 3, ... errors are $n(n-1)p^2$, $n(n-1)(n-2)p^3$ etc. One commonly takes the approximation that if the chance of one error in a block is P the probability of t errors is P^t. So if a single parity check is used for error detection when the probability of one error in a block is 10^{-3} one can ignore the detection of a triple error which occurs with probability about 10^{-9}: one is more concerned about the undetected double error which in this case would have probability about 10^{-6}.

Codes for multiple-error-correction

For codes with the capability of correcting multiple (random) errors, the method of allocating a particular task to each check digit is impracticable and one has to turn to the idea of *distance* between code members. The idea in principle is that one allocates to each *message** a cluster of *signals* surrounding the corresponding code-member

* To reduce a number modulo x, subtract from it the largest possible multiple of x leaving a difference less than x, which is defined as the original number modulo x.

* The terminology is that a *message* is a unit of information to be communicated, e.g. a number or a letter or a group of them, while a *signal* is that which is transmitted, e.g. a group of binary digits.

signal. Then as long as errors shift the signal from the code member only to another point in its cluster, the receiver can still identify the signal as originating from that code member (provided the clusters do not overlap). The distance between two binary signals (properly called Hamming distance to distinguish it from geometric distance) is defined as simply the number of digits in which they differ and the points in the cluster around the code member are known as *guard points*. A code to correct t errors must have a distance of at least $2t+1$ between any pair of code points, since each must be surrounded by a cluster of extent t, and to avoid overlapping the two clusters must be separated by a further unit of distance. If the distance is increased by one by the addition of an overall check digit, the extra set of points allocated will each be equidistant between two signal points; and this means that they can be recognized as erroneous but not corrected. The code will still be capable of *correcting* t errors and can now also *detect* $t+1$ errors. In the single-error-correcting code with $d=3$, there are n possible errors so that each cluster will contain $n+1$ points, including the code point. But the whole binary code of length n occupies a 'space' of 2^n points. Therefore the greatest number of code points which can be packed into the space (i.e. the number of members of the code) is the total number of points available, 2^n, divided by the number of points in each cluster, $n+1$. But it has been shown above that the quotient can be made equal to 2^r by choosing n equal to one less than a power of two. These Hamming single-error-correcting codes are therefore said to be perfectly packed, meaning that every point in the available space is allocated to one of the clusters of guard points.

Each code point in a code for correcting t errors will need guard points corresponding to 1, 2, ... t errors, the numbers of which are given by

$$n, \binom{n}{2}, \cdots \binom{n}{t}$$

where the binomial coefficient

$$\binom{n}{x}$$

is the number of ways of choosing x (erroneous) digits out of n and is equal to $n!/x!(n-x)!$. With the one exception of the (23,12,3) code due to Golay[2] (see Appendix), multiple-error-correcting binary codes are not perfectly packed;[3] and the packing gets worse as n increases. (One can visualise packing of shapes in three dimensions. But packing of polyhedra in n dimensions, where n may range from seven to some thousands, is to most of us just a form of expression for the mathematical constraints, or at most an allegory.) The problem then is so to distribute the code points in n-dimensional space that as many as possible may be packed in without their clusters of guard points overlapping. Unfortunately, the mathematical techniques which have been

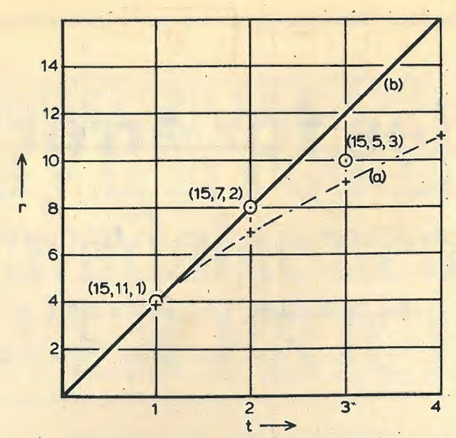


Fig. 1. Numbers of check digits for error-correcting codes of length 15. (a) Theoretical (non-integral) values. (b) The mt rule for BCH codes. Circled points indicate the values for actual BCH codes.

employed are above the level which readers of *Wireless World* can reasonably be expected to digest. Those who are not deterred by the use of combinatorial algebra can find the details in a specialist book[4]. A general-purpose set of codes, which can be constructed to any length $n=2^m-1$ and certain other lengths and with various error-correcting capacities is generally known as BCH (Bose-Chaudhuri Hoquenghem in full); and it has the special feature that a code of length 2^m to correct t errors can be constructed with *not more than mt* check digits. For $t=1$ the relation $r=mt$ always holds exactly and these codes are equivalent* to the Hamming codes. But for $n=15$ or greater and $t \geqslant 3$ for $n=15$ and roughly proportionately larger for longer codes, *fewer* check digits are required. Figure 1 for $n=15$ (a fairly small value of n makes the calculation of binomial coefficients manageable, or avoidable by the use of tabulated values) shows (a) the minimum number of check digits ideally required in order to correct 1, 2, or 3 errors (b) the straight-line relationship $r=mt$ and circled points corresponding to known BCH codes. BCH codes result from factorising suitably X^n-1, where n is the length of the code, into a product g(X).h(X); and a table of irreducible polynomials (the algebraic equivalent of prime numbers) is given in reference 4. The (composite) factors g(X) and h(X) can be used to form a generator matrix and a check matrix which are necessarily mutually orthogonal. For example, $X^{15}-1=(X^4+X+1)(X^4+X^3+X^2+X+1)(X^2+1)(X^4+X^3+1)(X+1)$ The last factor would be $(X-1)$ in ordinary algebra; but -1 does not exist separately in binary arithmetic, so $+1$ is written instead. The first three factors† multiplied together with binary arith-

* The order of the digits in a code can be changed, provided the order of columns in the check matrix is changed in the same way. Codes which result from such re-ordering are equivalent to the original code.

†The reason for these being "suitable" factors goes beyond the mathematical depth of this article.

metic of coefficients, $1+1=0$, give the polynomial $X^{10}+X^9+X^7+X^4+X^2+1$ so that the generator matrix consists of the binary series corresponding to this plus its four shifts:

$$G=\begin{vmatrix} 1&1&0&1&0&0&1&0&1&0&1&0&0&0&0 \\ 0&1&1&0&1&0&0&1&0&1&0&1&0&0&0 \\ 0&0&1&1&0&1&0&0&1&0&1&0&1&0&0 \\ 0&0&0&1&1&0&1&0&0&1&0&1&0&1&0 \\ 0&0&0&0&1&1&0&1&0&0&1&0&1&0&1 \end{vmatrix}$$

If r is the degree of the composite factor, $k=n-r$ is the number of information digits. In this case $n=15$, $r=10$ and therefore $k=5$: it is a (15,5,3) code. For a code correcting t errors we must take t irreducible polynomials; and since each irreducible factor may in principle be of degree m when $n=2^m-1$, there may be at most mt check digits. But it may be possible to use a factor of less degree, like the third factor in this example, so that the number of check digits is less than mt. It depends how X^n-1 factorises.

It can be shown that BCH codes of length $n=2^m-1$, distance $d=[n/2]$ and $t=[n/4]$, where the square bracket mean "the nearest integer less than", are exactly related to Hadamard matrices of dimension $n+1$. Some of the Hadamard matrices can be used as the basis of the much-discussed Walsh functions. It follows from the orthogonal property of the rows of Hadamard matrices that in this particular case BCH codes are optimum in the sense of having the maximum possible number of code members for the given length and distance[5].

Implementation of BCH codes

BCH codes are *cyclic*, i.e. if one has a key pattern of digits to represent 2^0, then 2^x is represented by the same pattern shifted x places. One can represent the whole code by an array (matrix) in which each row is of length n and the number of rows is equal to the number of information digits in the code word. As a simple example, the (7,4,1) code can be represented by a generator matrix G:

$$G=\begin{vmatrix} 1011000 & 2^0 \\ 0101100 & 2^1 \\ 0010110 & 2^2 \\ 0001011 & 2^3 \end{vmatrix}$$

Then if the 4-digit binary number 1101 (decimal 13) is to be encoded, take the first, third and fourth rows of G, corresponding to 2^0, 2^2 and 2^3, and add them together digit by digit modulo 2 (without carries) to give 100101 as the coded version of 1101. Note that the code can be considered to be based on the polynomial $1+x^2+x^3$ and its multiples by x, x^2, x^3 and the number to be encoded is similarly represented by $1+x+x^3$; then the encoding operation is equivalent to multiplication of the polynomial equivalent of any binary message by the

fixed polynomial of the code. Decoding is by division of the received signal by the code polynomial: an error-free signal must divide exactly and the value of any remainder indicates the nature of the error pattern. Because a division must be started at the most-significant end of a number, the signal must be sent with high-order coefficient first: e.g., when $2^3+2^2+2^0$ is sent the train of digits moving to the right into the transmitting encoder will look like 1011. If T is the duration of a digit, the system in Fig. 2(a) will respond to a single 1 digit input by giving an output of 1 immediately, 1 after a single digit delay in the second digit place, then nothing more until 1 in the fourth place, combining to give 1011 (read from the right). Following digits, being each in turn one place later, will give outputs (counting from the same starting point) commencing with the appropriate number of noughts. Since the patterns produced by successive input digits will overlap, the various feeds to the output line must go through modulo-2 adders. A practical point is that the delays are usually obtained from shift registers, of which every stage has an equal delay of one digit period. Each stage stores one digit, and on each clock beat the content of each stage is passed to the next stage in line: the original form of (binary) shift register employed a flip-flop for each stage, but a charge-coupled device is preferable for a large number of stages. With these two modifications the circuit now looks like Fig. 2(b), where each square box represents one stage of a shift register. A blank interval – a number of noughts equal to the number of check digits in the code – must be left after each message group to allow the shift register to clear before inserting further digits.

It is a commonplace in analogue working that any operation can be inverted by placing the operator in the feedback path around an operational amplifier, e.g. the inversion from differentiation to integration. In the same way a digital operation can be inverted by substituting feedback for feedforward; and Fig. 3 shows the dividing circuit corresponding to the multiplying circuit of Fig. 2(b). The output is zero for a number of shifts equal to the number of check digits, followed by the quotient which in the absence of transmission errors would be the original message. (Full details, including a stage-by-stage comparision with algebraic long division, are given in Peterson and Weldon[4].) If the division is not exact the remainder is left in the shift register, which should otherwise be zero at the end of the signal. It is therefore necessary to provide some means of inspecting the content of the shift register at the end of every signal block. One method would be to transfer the whole content in parallel to another register having the same number of stages and then check out serially the content of the latter. In the meantime

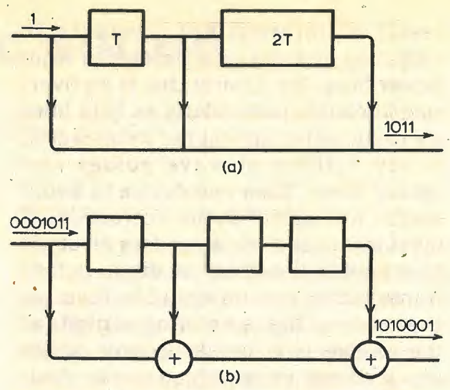


Fig. 2. (a) Encoding a single digit by means of delays T and 2T.
(b) Encoding a group of digits by means of a tapped shift register and adders.

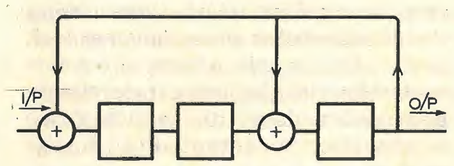


Fig. 3 Decoding by means of a shift register with feedback.

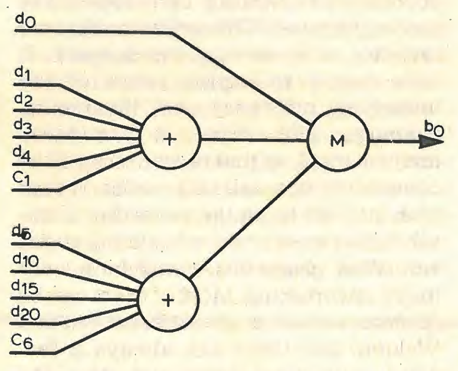


Fig. 4 Portion of majority-logic decoder, for one digit of Hsiao code.

the message would have to be held in another register, in case any corrections were required.

Decoding by majority logic

A disadvantage of the BCH codes for correcting multiple errors is that the procedure for converting from the error syndrome of the received signal to the location of the erroneous digit tends to be complicated. But there are some codes with which the step from syndrome to digit correction can be carried out by logic circuits using majority-decision gates as well as ordinary adders, but without requiring any other algebraic operation (like the solution of simultaneous equations). These methods of decoding are described by Peterson and Weldon[4] in their Chapter 10 under the title of "Majority-logic-decodable codes", including a logic diagram for decoding the Hamming (7,4,1) code. Another family of cyclic codes called Euclidean Geometry codes and Reed-Muller codes, are also suitable for this type of majority-logic decoding.

But such majority-logic decoders require the clocking of the information digits through a shift register, so that corrections can be made one by one. In communication systems the insertion of a further delay of one word time is not usually important: it does not affect the communication *rate*. But such delay is not tolerable in a computer which handles all digits in parallel, e.g. in reading information out from a random-access memory. So a different form of majority logic decoding, was proposed in the early days of semiconductor memories[6] and it relates to memories in which each digit of a word is stored in a separate l.s.i. plane. Now it is difficult to ensure perfection in every cell of a l.s.i. plane, but unlikely that faulty cells will occur in the same position in several planes of the stack. Therefore it is assumed that any given word (digit position in the planes) may have only a small number of errors. In order to avoid delay in read-out, the code is designed so that each digit in the word can be obtained immediately by majority vote of a group of digits read out from certain memory planes and the digits of these majority groups, consisting partly of information digits and partly of check digits, are interleaved and shared in such a way that the total number of memory planes need not be unduly increased. Particular examples for a 25-bit error-free output are:

(a) Single-error-correcting (best out of three voting) 35 planes;
(b) Double-error-correcting (best out of five voting) 45 planes;
(c) Triple-error-correcting (best out of seven voting) 55 planes.

Figure 4 shows how this works for the first output bit b_0 in the case of a single-error correcting code which has a total of 35 planes, 25 information digits d_0 to d_{24} plus 10 check digits C_1 to C_{10}. The elements M are the majority-logic gates, the output of which will agree with any two similar inputs (or all three if alike). It would not be true to say that the correct output is instantaneous on the computer time scale, since two successive gates are involved; but the delay in a gate is normally small compared with a digit period and certainly very small compared with the n digit periods of a serial word.

Burst errors

The codes which have been mentioned so far are concerned with random errors, and where provision must be made for several errors in a block the number of possible error patterns is large and the code correspondingly complicated: an example is the (15,5,3) BCH code, which for 0,1,2 or 3 errors in a block of 15 has 576 different error patterns and uses 10 check digits to discriminate between them. In contract, if it were known that any errors which occurred would be grouped together as a burst of 1, 2 or 3 digits the number of possible error patterns would be 15 for a single digit plus 14 for a burst of 2 and 13 for a burst of 3, making a total of 43 (including the no-error case). The first cyclic burst-error-correcting codes, due to P. Fire, needed $3b - 1$ check digits for bursts of length up to b, but later codes listed by Lucky, Salz and Weldon[7] are better. Peterson and Weldon quote on p.364 a code length 15 capable of correcting bursts up to length 3 with only 6 check digits, as against 10 or 3 random errors. In fact the rule is that a code capable of *detecting* bursts up to length b needs precisely b check digits but a code for *correcting* such bursts needs *at least 2b* check digits. Codes using exactly $2b$ check digits are known for lengths 7, 15, 27, 34 and 50 with corresponding values of b of 2, 3, 5, 6 and 8; and a few more check digits are required for longer codes. (But the longer codes cited by Peterson and Weldon have mostly fairly small values of b, between 3 and 7).

The mathematical techniques used in the construction of these cyclic burst-error-correcting codes are very similar to those of the BCH codes. For example the (15,9,3b) code for correcting bursts up to length 3 can be constructed from the pattern

111100100000000

which is taken to be 2^8, and its 8 right shifts which are taken to be the powers of two from 2^7 to $2^0 = 1$. Then the decimal number 409, which is $2^8 + 2^7 + 2^4 + 2^3 + 2^0$, encodes as

100000110100001

There may be a requirement to correct both random and burst errors. It is often said that random errors are typical of radio communication, as a result of thermal and shot noise in the receiver and atmospherics; but bursts are typical of land-line circuits, as a result of intermittent contacts in switching systems or interference from power lines. But clearly this is an over-simplification, particularly as land lines are using higher and higher frequencies, to say nothing of wave guides and optical fibres. Then one device to avoid special measures for the correction of burst errors as well as random errors is to scramble the order of digits before transmission and unscramble them at the receiver. The re-ordering of digits at the receiver will break up any bursts into scattered errors which can be dealt with by a code for random errors. However, the whole point of burst-error-correcting codes is that for a given number of check digits they can deal with more errors in a burst than scattered at random; so the scrambling should extend over more than one block so that, for example, a burst of 6 errors in one block length during transmission becomes 3 random errors in each of two blocks after "unscrambling" in the receiver.

Error-correcting and error-detecting codes constitute a vast subject, with special codes being developed for special purposes. This article makes no pretence of reviewing the subject: it aims merely to explain some of the underlying principles with illustrative examples. The subject is formidably mathematical, so that most users will be content to use existing codes rather than attempt to design codes for themselves; but even to list all existing codes with their properties would be a very major undertaking. Most of them can be found in books such as Peterson and Weldon[4] but there are always a few which have been developed since the publication of a book. Fortunately the basic codes such as BCH will serve for most purposes.

Appendix. The Golay code

Golay discovered a triple-error-correcting binary code of length 23, with 12 information digits, which is perfectly packed. A code of length $n = 23$ and capable of correcting up to 3 random errors will have to be able to distinguish between $1 + 23 + \binom{23}{2} + \binom{23}{3}$ error patterns. The binomial coefficients evaluate to 253 and 1771 so that the whole series sums to 2048, which is exactly 2^{11}; and so with 11 check digits (and therefore 12 information digits) the code is perfectly packed. This Golay (23,12,3) code is the only binary code capable of correcting more than one error which is perfectly packed. A cyclic code which is equivalent to the Golay code can be developed from the following sequence and its eleven shifts:—

10101110001100000000000

References

1. Hamming, R. W., Error detecting and error correcting codes. *Bell Syst. Tech. J.*, vol. 29, pp 147-160 (1960)
2. Golay, M. J., Notes on digital coding. *Proc. Inst. Rad. Engr.*, vol. 37 p.657 (1949)
3. Tietäväinen, A., On the nonexistence of perfect codes over finite fields. *SIAM J. Appl. Math.*, vol. 24 pp 88-96 (1973)
4. Peterson, W. W. and Weldon, E. J., Error Correcting Codes. The M.I.T. Press (Cambridge, Massachussets, 1972)
5. Bell, D.A. and Laxton, R., Some BCH codes are optimum. *Electronics Letters*, vol. 11 pp 296-297 (1975)
6. Hsiao, M.Y., Bossem, D.C. and Chiem, R. T. Orthogonal Latin square codes. *I. B. M. Journ. R&D*, vol. 14, pp 390-394 (1970)
7. Lucky, R. W., Salz. J. and Weldon, E. J. Principles of Data Communication, McGraw Hill (New York, 1968)

Programmable audio attenuator

From this

$$R_2 = R_a(1-G_2) \quad (28)$$

and

$$R_b = \frac{G_2 R_a R}{R - G_2 R_a} \quad (29)$$

Therefore, R_2 is 9.09 kΩ (9.1 kΩ standard value) and R_b is 1.54 kΩ. The last step gives Fig. 18 where

$$R_3 = R_b - \frac{R \cdot R_y}{R + R_y} \quad (30)$$

and

$$G_3 = \frac{\frac{R \cdot R_y}{R + R_y}}{R_b} \quad (31)$$

From (30) and (31),

$$R_3 = R_b(1-G_3)$$

and

$$R_y = \frac{G_3 \cdot R_b \cdot R}{R - G_3 \cdot R_b}$$

The nearest standard value for R_3 is 1.24 kΩ and for R_4 is 294Ω. These calculations give an idea of the accuracy that can be expected. The worst case error occurs with a maximum error in the input switching network of A_2. If, for example, R_{j1} and S_{2a} in Fig. 8 each have a maximum resistance error of 200Ω in the same direction, the gain error would be no more than 0.15 dB.

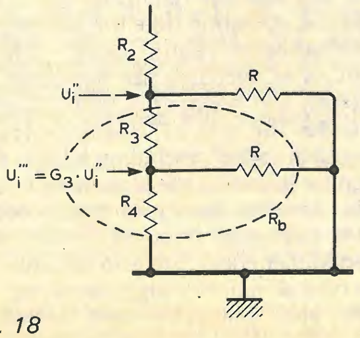


Fig. 18

Printed circuit board

A printed circuit board which accommodates one attenuator circuit and decoder will be available for £4.20 inclusive of v.a.t. and UK postage from M. R. Sagin at 23 Keyes Road, London NW2.

The author

J. M. Didden started his career in 1964 with Philips where he was involved in the design of tv receiver deflection circuits. After three years he joined the Royal Netherlands Air Force to work in air defence operations and specialise in software.

The author is currently involved with software design for NATO air defence systems. Apart from audio, his hobbies include reading science fiction.

Periphonic sound

continued from page 50

early tetrahedral array (besides its awkwardness) was that these two localizations didn't coincide; in fact energy vector localizations show that with the tetrahedral array sounds at high frequencies are pulled toward the loudspeakers.

Requirements for coincidence of localizations according to the two main theories are neatly summed up in Gerzon's diametric decoder theorem, which says that

- all loudspeakers must be the same distance from the centre
- speakers must be diametrically opposite pairs
- the sum of two signals fed to a pair must be the same for all pairs

(Incidentally, Gerzon has also shown that such layouts can be fed by $p + 1$ channels, where p is the number of speaker pairs, so four speakers need three channels, six speakers need four channels.) One of the most convenient speaker arrays that meets these requirements is a birectangular type because it also provides conventional stereo speaker placement. Speakers are at the corners of two rectangles, one horizontal, one vertical. This was the arrangement used in the recent AES demonstration which produced a very satisfying result, the loudspeakers being as acoustically unobtrusive as one would hope. The images were not so sharp as perhaps one is accustomed to with fewer loudspeakers, but nevertheless well fixed. The demonstrators remark that what is lost in image precision is gained in stability seemed borne out. Switching to the horizontal rectangle made the sound less compelling and the reversion to "full sphere" sound was distinctly more satisfying.

With the horizontal type of ambisonic decoder it is not possible to achieve a value of r_E of unity to give ideal image stability. In fact, averaged over all directions, it has been shown that the value cannot exceed 0.707. But it is possible to increase the value in some directions (e.g. 0.8 front-back) at the expense of others (0.6 left-right). Two-channel decorders are worse in this respect with a maximum average of 0.5, giving poor image stability, though it is said that judicious distribution around the circle can hide the fault to some extent. With spherical reproduction the maximum average value is 0.58; and it is argued that the decoder shelf filters must therefore be carefully optimized. But the opportunity for directional trade-offs is obviously greater, and a typical choice would be 0.69 front-back, 0.58 left-right, 0.39 up-down.

Because of this the shelf filters of an horizontal-only decoder are different from those for a spherical or periphonic decoder. (Shelf filters allow different matrix coefficients to be used at low and high frequencies and provide a controlled transition from one to the other.) For instance the ratio of l.f. to h.f. shelf-filter gains for horizontal-type decoders is 0:1.76 (in dB) for the W signal and 0:—1.25 for the X and Y directional components, whereas for a periphonic decoder the gains are 0:3 for W, and 1.76:0 for X, Y, Z signals. Production periphonic decoders would almost certainly contain switchable shelf-filtering but the day that four channels reach the home, existing ambisonic decoders will need some alteration!

For periphony to be judged in effectiveness against horizontal systems perhaps what is needed is a statistical assessment in objective terms compared with stereo and two and three-channel horizontal surround systems. It was eight years after the introduction of the first quadraphonic surround system before preference tests were carried out (by NHK) that showed the square speaker array had a rating of + 0.9, + 0.5 and + 0.3 for non-experts, audio enthusiasts and acoustic engineers respectively, where 1.0 meant "slightly better" than two-speaker stereo. Little wonder it didn't catch on?

BBC's data company will link with Europe-wide information service

In order to exploit commercially its large store of information, which includes 24 million press cuttings from British national and provincial newspapers as well as complete collections of news bulletins broadcast on radio, tv and external services, the BBC has set up a new trading company called BBC Data.

The new company is an information provider for Prestel International and is currently discussing, with a number of other organizations, ways of making BBC information available in machine-readable form. BBC Data's manager, Richard Hewlett, says that the company will also link up with Euronet-DIANE as a "host" information provider (see our news report, Feb. 1980 issue) although the precise interface method has not yet been decided.

Mr Hewlett expects BBC Data's income to be "substantial" after about three years and the next major move will be a deal with a computer services "bureau" whose equipment will be used as a host for the electronic versions of the BBC's files. Information acquisition will then merely entail the customer contacting the bureau via computer terminals accessed by telephone.

Massive report on GaAs is dubious

A report written by Gene Hnatek, quoted as a "noted US authority on integrated circuit technology" by Infotech, and which is said to consist of 650 pages, priced at £150, has been dismissed by Dr Cyril Hilsum, a leading UK expert on gallium arsenide applications, as "melodramatic."

The report maintains that GaAs devices, due to their increased switching speed, will "rapidly replace the silicon chip," but Dr Hilsum points out that production processes cannot compete with silicon on an economic basis and GaAs will be used only where its properties make it a sensible choice.

Exhibitions, courses and conferences

Breadboard '80 will be held at the Royal Horticultural Halls, Elverton St, Westminster, London SW1, from November 26 to 30, 1980. Opening times have been changed to read Wednesday 26, 10 a.m. to 6 p.m., Thursday 27, 10 a.m. to 8 p.m., Friday and Saturday, 10 a.m. to 6 p.m. and Sunday 30, 10 a.m. to 4 p.m.

Electronic Test and Measuring Instrumentation '80 will be held at Wythenshawe Forum, Manchester, April 22 to 24th 1980. Full details are available from Trident International Exhibitions, Ltd, 21, Plymouth Rd., Tavistock, Devon.

The S.E. Asia 3rd Biennial International Exhibition of Electrical and Electronic Engineering opens at the World Trade Centre, Singapore from 21 to 25 October 1980. Interested parties should contact Interfama Pte. Ltd, 834, 8th Floor, World Trade Centre, Maritime Square, Singapore 0409.

Cambridge Microcomputers are offering a series of one-day courses under the general title of "Practical Introduction To Microprocessors." Each course costs £50 (plus v.a.t.) for early courses (22 April, 21 May, 18 June, 30 July) with later courses (September to December 1980) costing £55 per day and a five-day course on m.p.u.-based systems costing £240 plus v.a.t., running from March to July 1980. Further details are available from Cambridge Microcomputers Ltd, Milton Rd, Cambridge CB4 4BN.

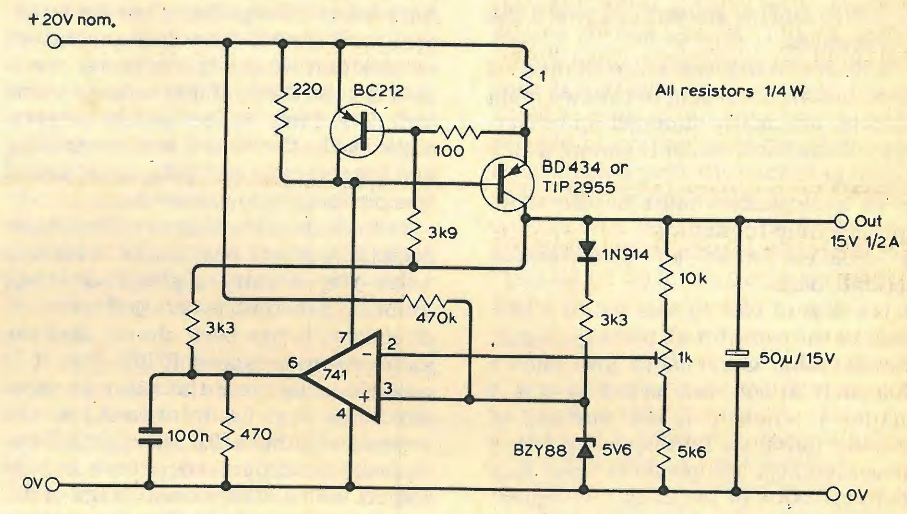
A series of lectures and seminars dealing with general microelectronics topics will be held at the South-West Herts Teachers' Centre, Tolpit's Lane, Watford. It will be run by the GEC-Marconi Group and a teachers' organization. Contact Peter Rackham, Marconi House, Chelmsford CM1 1PL.

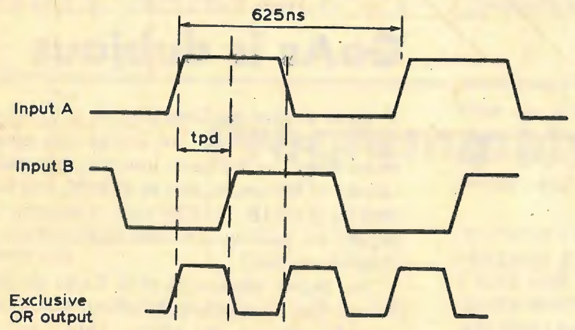
CIRCUIT IDEAS

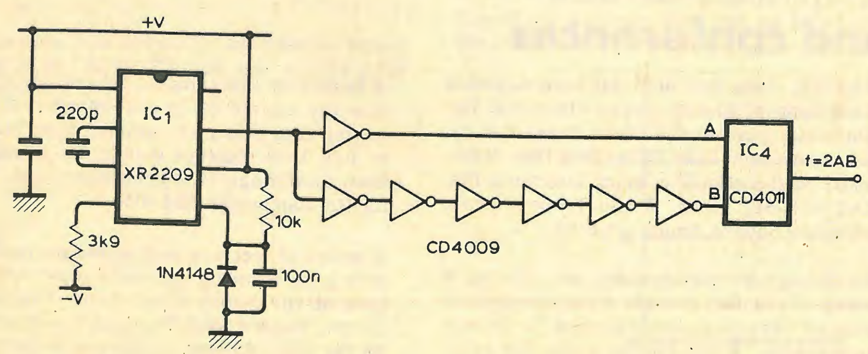
15V ½A regulator

Although cheap and general purpose components are used throughout, this circuit offers good load regulation and temperature stability. Output resistance is typically 20 μΩ at low frequencies and, unlike conventional regulators where the power transistor is connected to the op-amp output, only a few hundred milliVolts are required across the series-pass transistor to maintain regulation. The circuit can be built for negative regulation by using n-p-n transistors in the negative supply lead of the 741. Fold-back current limiting is included to limit the maximum dissipation to 4W. The 3k3 resistor allows the output stage of the 741 to turn off when no current is being drawn, and the 220 Ω resistor prevents the 741 quiescent current from turning the power transistor on. The diode and 470kΩ resistor allow start-up and the 0.1μF capacitor improves the response to sudden changes in output current.

J. W. Rowe
Brinsley
Notts.







High-frequency doubling with c.m.o.s.

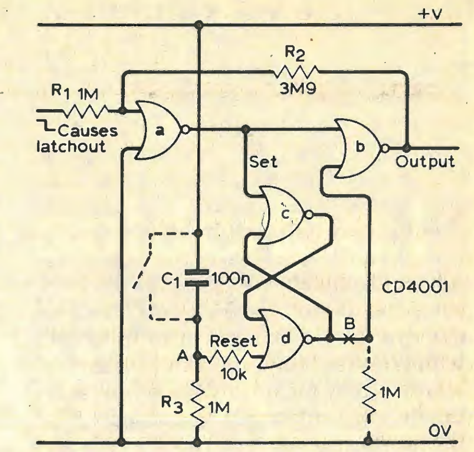
High-frequency doubling can be achieved by using the propagation delay of c.m.o.s. together with exclusive OR gating. The circuit shows an oscillator operating at 1.6 MHz, and an exclusive OR gate fed with the oscillator output and an inverted and delayed output. Propagation delay of the buffers depends on V_{DD} and the load capacitance, but for a 7.5V supply and a load capacitance of 50pF, the delay for each buffer is about 34ns. Therefore, the total delay t_{pd} for six buffers is 204ns and the difference between the two signals is 170ns, which produces a 3.2 MHz output with an almost equal mark-to-space ratio.

D. J. Greenland
Bear Hill
Cambridge

Simple manual-reset latch

One 4001 can provide a latch that will turn off but will not turn on again until manually reset. Gates a and b together with two resistors form a Schmitt trigger which provides noise immunity. A low at the input causes the output of gate a to go high and the output of gate d to go high which then inhibits the output of gate b after it has gone low. Reset is achieved by removing the power supply to discharge C_1, or replacing C_1 with a push-to-make switch for manual reset. If the capacitor is used it must be large enough to ensure that the input goes high before point A goes low. If a switch is inserted at point B and 1MΩ resistor connected to 0V, the circuit will follow the input. Resistors R_1 and R_2 can be omitted if the latch is driven by logic and noise is not a problem.

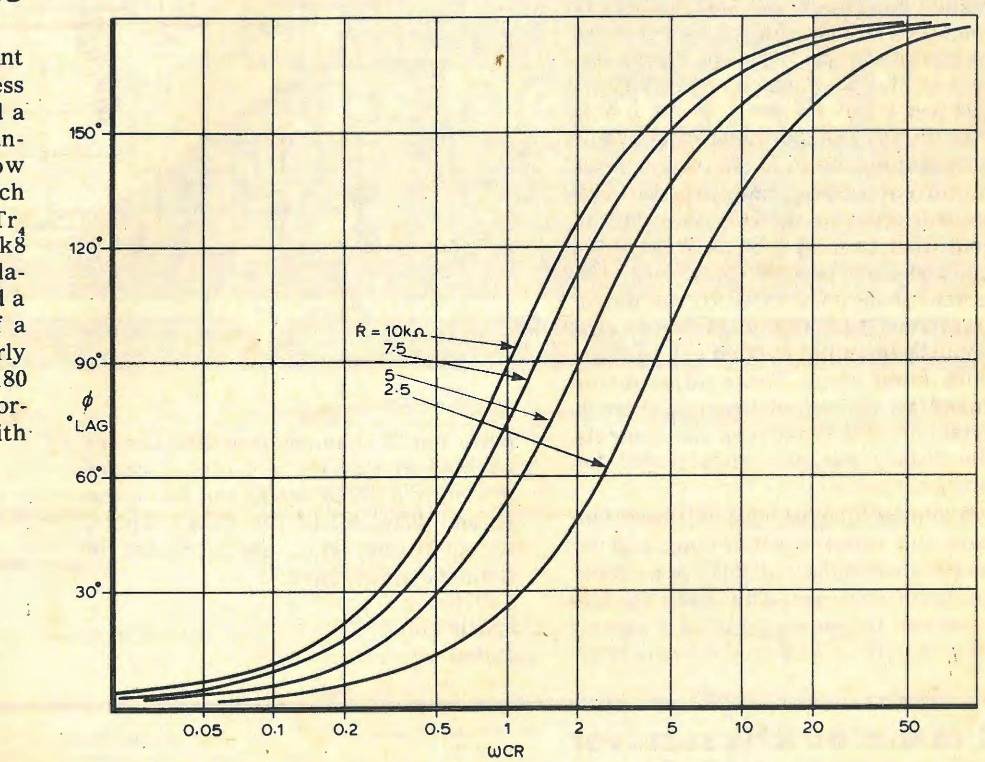
I. J. Nicolle
Guernsey
Channel Isles

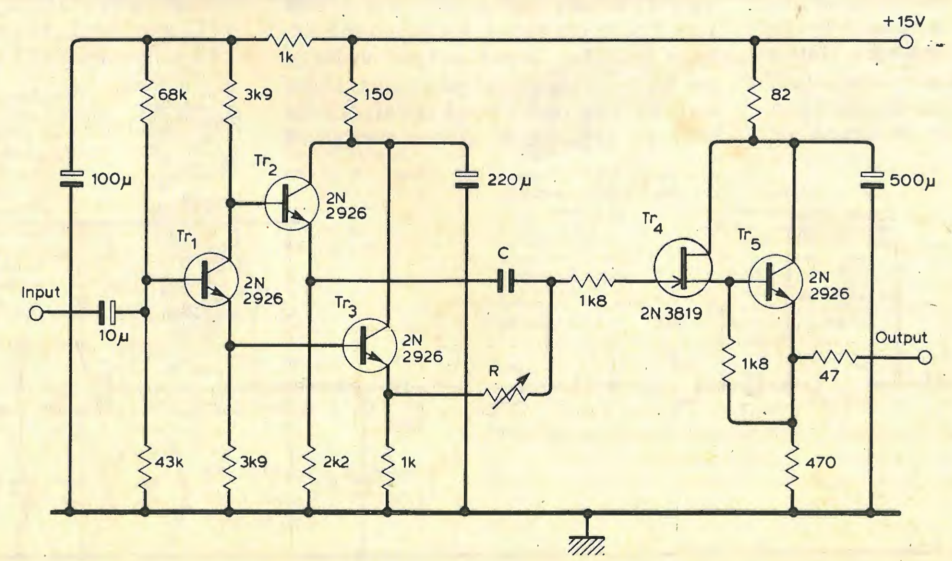


Variable phase all-pass filter

This all-pass filter offered constant amplitude, a distortion content of less than 0.1% for a 1V r.m.s. output, and a frequency range up to 100 kHz. Transistors Tr_1, Tr_2 and Tr_3 form a low output-impedance phase-splitter which drives a CR network. Transistors Tr_4 and Tr_5 form a buffer stage, and the 1k8 gate resistor prevents spurious oscillations. With a 10kΩ potentiometer and a suitable value for C, the phase of a waveform can be varied from 0 to nearly 180° or, by reversing C and R, from 180 to near 0°. The graph shows the normalized all-pass phase response with four values of R.

T. G. Izatt
Preston Polytechnic
and
E. Ball
Salford University



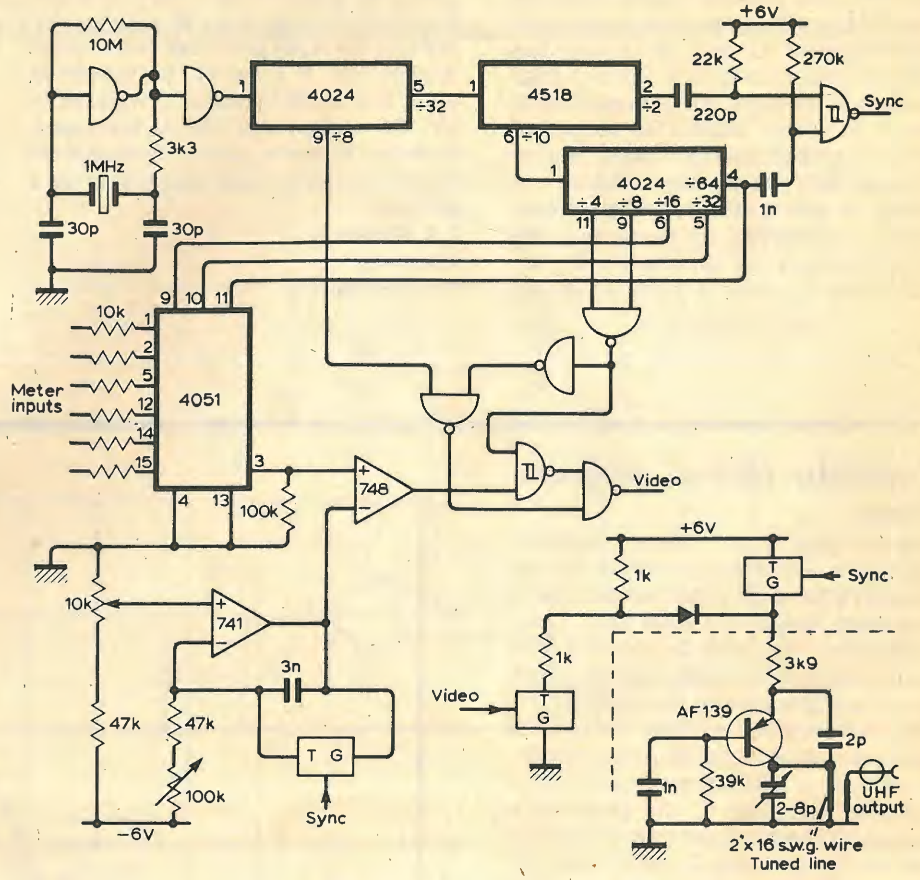


Multi-channel voltmeter with tv display

This voltmeter provides up to 25 channels and displays them as horizontal bars on a television screen. A scale is provided by an 8×line-frequency square wave, gated as a video signal between adjacent bars. The circuit comprises an integrator which ramps from 0 to 1V in 40μs and is reset to slightly below 0V at each line sync. pulse. The input signal is gated by one or more 4051 analogue multiplexers, depending on the number of channels required, and fed to a 748 comparator whose remaining input is connected to the integrator. When the integrator output equals the input signal, the video output is switched from white to black. The sync. timing chain consists of a 1MHz crystal oscillator, a 4024 and 4518 which provide a divide-by-64 for line sync. (15,625Hz) and a second 4024 provides a divide-by-320 for frame sync. (48.8 Hz).

An AF139 modulator is shown, but the circuit can be modified to drive one of the commercial modulators now available. The transistor is housed in a small tin box and the 10kΩ preset is adjusted to zero the display on a convenient scale point close to the left of the screen. The 100kΩ preset is adjusted with a 1V input to set the display on the tenth scale point. These adjustments should be rechecked because there is some interaction between the controls. The display can also be adjusted for centre zero.

A similar circuit, but without the scale and input multiplexing, can be used as a wobbulator display or a simple spectrum analyzer. The drive for the v.c.os can be generated from a second integrator, reset only on the frame sync.



pulse. For 25 channels, four 4051 i.cs are enabled in turn by a 1-of-4 decoder driven by a divide-by-32 and 64 on the second 4024. All of the 4024 outputs, except frame sync., are increased in frequency four times.

J. D. Owen
Castle Lloyd
Dyfed

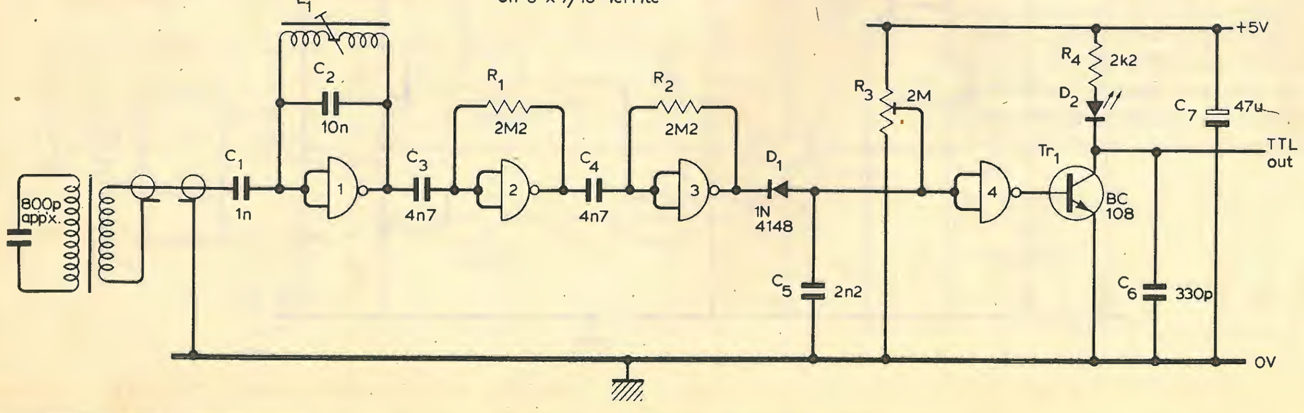
Displays from left to right show 0V, 0·35 and 1V

C.m.o.s. 60 kHz receiver

One c.m.o.s. NAND gate i.c. can be used as a low frequency receiver as shown. All of the gates are connected as inverters and the first three operate in the linear mode with 100% feed-back. Gate 4 and Tr_1 provide amplification and a t.t.l. interface. The input to gate 4 is biased so that; with no carrier, Tr_1 is turned off and the output is high. With the carrier on, negative half-cycles at the output of gate 3 partially discharge C_5 via D_1 and turn Tr_1 on via gate 4. Although the a.c. gain and d.c. input-output voltage varies with different packages, three 4011AE i.cs functioned satisfactorily with R_3 adjusted to give a carrier-off voltage of 0.3V at the base of Tr_1. With a correctly tuned aerial, the only critical components are C_1, C_2 and C_5. The value of C_2 assumes L_1 to be the input winding of a yellow-coded i.f. transformer.

G. Jackson
Greigiau
Cardiff

Aerial 300T 36s.w.g., 35T 30s.w.g. on 6"x 7/16" ferrite



Why does an electron have inertia?

Give me an electron and I can move the world

by T. B. Tang, M.Tech., Ph.D. Darwin College, Cambridge

Professor Jennison's article in June 1979, in dealing with the mass and inertia of the electron, mentioned Mach's suggestion that the inertia of a body originates from the influence of the distant masses of the Universe. Although the Mach Principle has no empirical support, the author here sketches an elementary scheme for the interaction it visualizes and claims that this "appears capable of explaining, in a manner, some of the known facts concerning inertial mass."

WHEN you switch on an oscilloscope to monitor a signal, you are in essence deflecting a scanning beam of electrons by an electric field proportional to the signal. The inertial mass of an electron has been established as a constant whose value is known to 6 parts in 10^6, so that the angle through which the beam will be deflected can, if you wish, be predicted for any given strength of the transverse electric field.

Many people, however, are not satisfied by merely knowing *how* things behave: they want to find out *why* as well. Why does an electron have inertia, and furthermore why is its inertial mass that particular value and not some other magnitude? Indeed, why matter in general exhibits inertia? Inertia is, of course, defined in Newton's Second Law. Therefore the question is reduced to why $F = ma$, where the symbols have the usual significance. Our modelling of the objective world will be more complete if this law, of which the First Law is a special case, is shown as derived and no longer remains an axiomatic postulate.

Mach principle

As mentioned in a recent *Wireless World* article[1], so far the only suggestion to explain inertia is that attributed to Ernst Mach. The idea can be traced further back, to Leibniz, but it is usually referred to as the Mach Principle, a terminology used by Einstein who strived to incorporate it in his theory of gravitation – but did not quite succeed. It is, contrary to the opinion expressed in that article, *not* entirely a qualitative hypothesis that is incapable of accounting for the precise observations of inertial mass and inertial force. In fact, it has been realised in a number of alternative theories[2-8]. True, none of them is commonly accepted. Nevertheless, many interesting deductions can be made in even a simple realisation of the Mach Principle[9]; some we are going to describe in this article. First, however, let us discuss the content and the plausibility of Mach's (or Leibniz's) proposal.

The Mach Principle embodies the conception that the inertia of an object arises wholly from its interaction with background matter. A force has to be applied to an electron to change its state of motion, because, in its own frame of reference, the applied force is needed to balance the pull by you, the Earth, the sun and planets, and the 'fixed stars': a pull which is generated whenever it accelerates relative to the surrounding matter. Were all background matter removed then for the electron, alone, no distinction could be made between uniform and accelerated motions. This seems reasonable enough unless space on its own can, metaphysically, have intrinsic inertial properties. (Strictly speaking, quantum field theory envisages that the vacuum is still filled with carriers of the fields of the lone electron. The existence here of these virtual quanta is, however, completely irrelevant because there are no other particles to absorb or emit them.)

In other words, accelerating an electron is kinematically *and dynamically* equivalent to accelerating, in the opposite direction, all other matter in the Universe. Take the particular case of rotation. In accordance with the Mach Principle, an object is dynamically non-rotating, meaning suffering from no centrifugal or Coriolis force, if and only if it is seen to be not rotating with respect to distant matter, which constitutes the bulk of the Universe and which by definition is non-rotating. The Earth is rotating, as made apparent for instance by the Foucault pendulum at the United Nations' headquarters in New York. So there must be much more matter in the sky than there is under our feet. Is then the collection of some 10^{11} suns forming the Milky Way non-rotating? Its shape is of a flattened disc, indicating the presence of centrifugal forces. There should exist, therefore, extragalactic matter. It duly turns out that the Galaxy is but a member of the 'Local Group' of about 30 galaxies, which, together with more galactic groups and chains, forms what has been recognised as the Virgo Supercluster. This local supercluster, containing 10^2 to 10^3 galaxies, is apparently again flattened. Well, from sky surveys we find at least 10^{10} other galaxies further out in the Universe!

From the measured degree of isotropy (to 3 parts in 10^4) of the 2.7K cosmic radiation, it has been calculated[10] that the distant galaxies cannot be rotating faster than once in 10^{19} years. The placing of this lower limit on the rotational period, 10^9 times the age of the Universe, is a strong, albeit indirect, observational support for the Mach Principle.

Second Law of motion

Let us now devise a simple mathematical expression for the Machian interaction which is experienced whenever matter accelerates, and explore the consequences. Following Einstein (see for example his book *The Meaning of Relativity*) we assume that the interaction is gravitational in nature, so that its strength between one gravitational mass (m) and another (M) depends on G, the universal constant of gravitation, and will have the form

$$F = (G/c^2)mMar^{-1} \qquad (1)$$

where a is the relative acceleration and r the distance between m and M. F has to fall off as the first power of r, no faster and no slower, else strange things would happen[9]. The velocity of light c is involved in the coupling constant to give the right-hand side the dimension of a force. The form of equation (1) will be justified by its predictions.

F as specified above is Newtonian in the sense that it is instantaneous interaction. However, it was shown by Milne and McCrea, in the 1930s, that Newtonian cosmologies lead to results which are formally identical to those from general relativity models, once an interaction cut-off range is introduced. That is, the Universe is considered as a closed sphere in Euclidean space, with a finite radius, the test particle under study being put at its geometrical centre. With the use of this convention in solving first-order linear problems, the mathematically difficult (and perhaps even pathological) relativistic models can be avoided, and at the same time difficulties such as the existence of infinite gravitational potential in an unbounded universe disappear. In this way, the pull on m which is being accelerated with respect to other matter in the 'island universe' can be summed, in the simplest (scalar) manner, as

$$F_m=(G/c^2)m(-a)\int_0^{cA} 4\pi r^2\rho r^{-1}dr$$
$$=-ma(2\pi G\rho A^2) \qquad (2)$$

in which ρ is the mean density of the Universe, whose 'radius' is its present age A multiplied by c. Checking with experimental and observational data we now discover the remarkable fact that, within the margin of errors, the dimensionless number

$$2\pi G\rho A^2=1 \qquad (3)$$

Hence (2) very probably reduces to $F_m=-ma$. Since the applied force $F=-F_m$, Newton's Second Law is at once derived.

Life and gravitation

There are in cosmology a number of numerical coincidences which are empirically found to hold but none of which can be fitted into the structure of known physics. Equation (3) is one of them but, as has just been shown, turns out to be explainable by the Mach Principle. They are of imposing importance to us, speculating or otherwise (see last sentence of this paragraph). Based on some of the other cosmological coincidences, Dirac has proposed several unconventional cosmological models, in a series of papers in *Proceedings of the Royal Society* the first of which was in 1938 and the latest in 1979. However, we shall have the space to say no more about the numerical 'coincidences', except to state that the validity of many of them is a prerequisite for our ability to live in the Universe[11, 9]!

To continue with the discussion on the Machian theory, we point out that it can reproduce all the dynamic effects pertaining to co-ordinate acceleration in Newtonian mechanics. The case of linear acceleration has been dealt with in the above. In circular motion, centrifugal and Coriolis forces of the right form come out when F_m, acting on m which is 'non-rotating' by 'rotating' background matter, is summed in the same manner. This should hardly be surprising, since these forces are consequences of Newton's Second Law which can be derived via F_m.

Most interestingly, it has been claimed[12] that the force described by Newton's Law of universal gravitation is in fact but a manifestation of F_m. The elementary particles in two bodies execute implusive motions ('zitterbewegung' of electrons etc.) and are therefore continuously accelerating; the resulting Machian interaction between their constituents is, it was argued, the force traditionally called 'gravitational attraction'. My comment is that, if this bold idea is valid, then inertial and gravitational forces are completely unified, and also the problem of infinite self gravitational energy for a point-like electron is removed. The theory will achieve such economy and eliminate such a long-outstanding singularity that it should not be wrong.

Relations between inertial and gravitational masses

Equation (2) proves that the inertial mass of an object is proportional to is gravitational mass m. This is why two balls of different weights but released from identical heights should really take the same time to strike the ground. The proportionality has been demonstrated with increasing accuracy by Galileo (who probably had not performed the Leaning Tower experiment he said he had, but did have done some inclined plane experiments), Eotvos, Dicke, and others. It cannot be explained, however, in either classical mechanics or Einsten's theory of gravity: in the latter, indeed, it is postulated under the name 'Principle of Equivalence'.

There is another interesting deduction. When the object is alone, it has no inertial mass but, when brought back to the centre of the island universe, it acquires a mass m. At the same time, it acquires a gravitational potential energy

$$E'=-G\int_0^{cA} m(4\pi r^2\rho/r)dr=-mc^2 \qquad (4)$$

where in the last step we have used (3). The process should conserve energy and, therefore, the inertial mass has to be associated with an energy $E=mc^2$, as implied by $E+E'=0$.

The mass of an electron

As a final illustration of the fruitfulness of hypothesis (1), an estimation will be made of the rest masses of stable elementary particles. The exercise will be instructive but, unfortunately, only a phenomenological approach can be adopted and the accuracy will only be to the rough order of magnitude. Consider an electron. Since its inertial mass is not an intrinsic property but is purely determined by surrounding matter, m will be slightly different from that of another electron. However, the difference Δm is 'insignificant', because experimentally electrons are observed indistinguishable (as shown for example by chemical spectroscopy). Now, the energy associated with Δm is, as has just been deduced, Δmc^2. The longest time interval over which the electron has existed before its mass is 'measured' (before it interacts with another particle) is the age of the Universe. Hence, the difference is unobservable, as judged by Heisenberg's uncertaintly principle, if

$$\Delta mc^2A \leqslant h \qquad (5)$$

where h is Planck's constant and any factors of the order unity are ignored. Secondly, the total number of electrons, or protons, in the Universe is $N=\rho(cA)^3/m$, factors such as $4\pi/3 \sim 1$ again being neglected. By a statistical rule of thumb,

$$\Delta m/m=1/N^{1/2} \qquad (6)$$

Substituting for N and eliminating Δm between (5) and (6) we obtain

$$m\leqslant[(h^2/c)\rho A]^{1/3} \qquad (7)$$

which, on plugging in the numerical values, gives 10^{-27} g and is a correct order of magnitude! The degree of closeness is astonishing in view of the enormous range of magnitudes for different combinations of the factors appearing in (7). Heavier particles should be unstable, which indeed is the case. A zero rest mass (and correspondingly a vanishing Δm) is, of course, also consistent with (5) and (6); this is the case of the other two types of stable particles, namely the photon and the neutrino family.

If the Mach Principle can be generalised, it may be conceived as that all local properties are related to the global condition of the Universe and as such are ultimately changeable: that a part, however small, must not be regarded in isolation from the whole. This means that any collection of particles constitutes an open system, for which dynamic equilibrium will always be accidental rather than the normal state, just as a living organism or a biosphere is. The Principle itself is speculative, enjoying as yet no direct empirical evidence, but we have sketched here an elementary scheme for the interaction it visualises. Surprisingly, the resulting simple-minded theory appears capable of explaining, in a manner, some of the known facts concerning inertial mass. Are you sufficiently impressed to believe that you now understand more about what actually happens to the electron beam in the oscilloscope, and why one should wear a seat belt?

References

1. Jennison, R.C. *Wireless World*, June 1979.
2. Sciama, D.W. *Mon. Not. Roy. Astron. Soc., 113*, 33 (1953).
3. Dicke, R.H. *Science, 129* 621 (1959).
4. Hoyle, F. and Narliker, J.V. *Proc. R. Soc. Lond., A 282*, 191 (1964).
5. Sachs, M. *Nuovo Cimento* (Ser. 10), *B 53*, 398 (1968).
6. Sciama, D.W. 'The Physical Foundations of General Relativity', Doubleday, Garden City, N.Y., 1969.
7. Barbour, J.B. *Nuovo Cimento* (Ser. 11), *B 26*, 16 (1975).
8. Eby, P.B. *Lett. Nuovo Cimento, 18*, 93 (1977).
9. Tang, T.B. *J. Br. Interpl. Soc., 32*, 84 and 88 (1979).
10. Hawking, S.W. 'Confrontation of Cosmological Theories with Observational Data', Ed. M.S. Longair, I.A.U. 1974, p.283.
11. Carr, B.J. and Rees, M.J. *Nature, 278*, 605 (1979).
12. Cook, R.J. *Nuovo Cimento* (Ser. 11), *B 35*, 25 (1979).

WORLD OF AMATEUR RADIO

Communication receiver design

Even before the end of the 1930s, the h.f. communications receiver could provide a high standard of performance: designs such as the National HRO, Hallicrafters SX28, Hammarlund Super Pro and the RCA AR88 enabled operators to select and copy extremely weak signals close up to far stronger signals, aided by good single-crystal filters and the reasonable immunity to spurious responses of single-conversion superhets having two tuned r.f. stages. Indeed many of the subsequent developments were aimed primarily at reducing the high cost of tuning mechanisms used in such models with their four ganged tuned circuits and with providing the additional stability and lower tuning rate needed to cope with single-sideband transmissions. The gradual change from valves to transistors tended to result at first in **lower** standards, particularly in the reduced ability of receivers to cope with both very weak and very strong signals without driving stages into non-linearity. Questions of "shape factor" of filters and then "dynamic range" of the early stages of solid-state designs have tended to dominate the scene, and it is only in the past few years that all-solid-state designs have reached and improved on the best valve designs of the fifties and sixties.

Now, however, the steady progress is making the measurement and evaluation of receiver specifications increasingly difficult, as Wes Hayward, W7Z01 has pointed out. Such parameters as "minimum detectable signal" are easier to describe than actually to measure; "intercept point" is being interpreted in different ways, and so on; furthermore many of the improvements become important only in highly competitive conditions, making little noticeable difference during routine communication.

The limiting factors of high-performance receivers now tend to be reciprocal mixing due to noise sidebands on the h.f. oscillators; insufficient "ultimate rejection" of filters, particularly when actually installed in receivers; non-linearity and sometimes non-reciprocal effects in "passive" components such as crystal filters and ferrite cores. For most amateurs the difference between a "good" and a "not-so-good" receiver is still likely to involve questions of "operability"; convenient controls without backlash; absence of hum; ability (missing from many current models) to be able to turn the a.g.c. off; good audio performance, etc. Perhaps what we are seeking is the good electronics of the best 1980 models combined with the excellent mechanical designs of 40 years ago. Unfortunately while electronics still get relatively cheaper, mechanical excellence grows steadily more expensive.

Winter Sporadic E

Recently it was suggested (WoAR March) that while American amateurs recognise the existence of a winter Sporadic E season, this did not appear to be the case in Europe. John Branegan, GM4IHJ of Saline, Fife, however reports that he has observed such a season each year since 1977. He uses sensitive equipment including a tunable Eddystone 770R v.h.f. receiver, various pre-amplifiers and converters feeding a Yaesu FRG7, a multi-standard tv receiver and rotatable 3-element Yagi aerials.

He finds the winter Sporadic E season usually starts about Christmas and lasts until about the first week in February (with three of four days of such events followed by several days without any). During winter, SpE signals are heard up to about 53MHz and on about one-in-three occasions to 70MHz; very rarely to about 90MHz; no event extending to 144MHz has been observed. From contacts with VE1AVX during the 50MHz F2 layer openings, he believes that winter SpE occurs on the same days at the same local time in Eastern Canada. As an example of a typical winter SpE event he provides a clear picture of Norwegian tv (48.25MHz) taken on January 21 this year. Curiously, he does not find that the range of SpE signals changes in the manner that has been suggested as likely due to the gradual descent of metallic particles in wind-shears, but remains in the range bracket of 650 to 1250 miles throughout the events.

GM4IHJ is convinced that there are still endless possibilities for amateurs to add to our meagre understanding of Sporadic E, including the differing world patterns (SpE conditions are almost a regular daily event in tropical countries such as India).

EMC regulations increasing

German amateurs are worried at some aspects of new "electromagnetic compatibility" regulations which are due to be introduced there in July 1981 and which could present major problems to the operators of medium or high-power transmitters in residential areas. While a welcome feature of these regulations is the setting of a minimum limit to the strength of broadcast transmissions that are regarded as protected against interference, ranging from 0.1 to 0.5 mV/m for v.h.f. and television to 1mV/m for m.f. and l.f. transmissions, they also specify the standard of "immunity" to very strong local signals that receivers should be expected to withstand, implying that listeners and viewers can expect to be protected against any signals which are stronger. The limits vary from 3V/m to only 0.5V/m between 47 and 108MHz and as low as 0.2V/m on intermediate frequencies of the receiver. It has been shown that field strengths of 15V/m can be encountered at distances of about 12m from amateur transmitting aerials of stations operating at legal levels in Germany.

Regulations introduced early in 1980 in Switzerland appear similarly to set a limit of 1V/m to receiver immunity, with the possibility that the amateur station may be held to blame for interference arising from higher signal levels. The subject is also being considered with a view to EEC regulations. The German e.m.c. regulations are not concerned with electronic appliances other than radio and tv receivers and do not cover audio amplifiers, tape recorders or electronic organs.

In brief

Jeremy Royle is reported to be developing new techniques for the transmission of slow-scan tv pictures in colour . . . Amateur stations in the USSR are reported to be increasing by about 8 to 12 per cent annually and by early 1979 there were 30,034 stations of which 3629 were "club" stations, 17,234 individual h.f. stations and 9111 v.h.f. licences; nevertheless it is suggested that in some areas numbers of stations remain stagnant due to insufficient attention being given to the development of amateur radio, especially stations for collective ("club") use . . . Swiss amateur licences increased from 2341 at the end of 1978 to 2681 at the end of 1979 . . . The number of amateur licences in West Germany, where for a long time the totals were roughly comparable with the UK, now seem to have forged decisively ahead, totalling 41,500 of which 17,610 are Class C (v.h.f. only) licences. There are 1305 club stations (including 208 repeaters) and 2090 "YL" and "XYL" licensees . . . The annual Radio & Electronics Exhibition of the Northern Radio Societies Association will be held at Belle Vue, Manchester, on April 27, with numerous contests, inter-club quiz. Morse code challenge, 145.550MHz and 433.200MHz talk-in stations (GB4NRS G8NRS/A) . . . The RSGB National Amateur Radio Exhibition is at Alexandra Palace on May 9 and 10.

PAT HAWKER, G3VA

Outlook for short-wave broadcasting

Meagre increase of frequency allocations gained from WARC 79

by Jim Vastenhoud Radio Nederland

Most readers will have seen reports about the 1979 World Administrative Radio Conference (WARC 79) in this journal, and will know that short-wave radio stations all over the world attach great importance to its results. The main objective of the conference was the re-allocation of the radio spectrum (February issue pp. 46-48, March issue pp. 72-74). The allocations are to be found in Article V of the Radio Regulations, a book which contains all international agreements on the use of the radio spectrum and is the standard reference for radio users all over the world. Article V was revised previously in 1959. Since then, however, there have been significant shifts in the usage of the spectrum, partly due to technical developments, such as the opening-up of satellite communications, but also resulting from other world developments like the new frequency requirements of nations which have gained their independence since 1959. These frequency requirements of the emergent nations affect all fields of communications and especially those bands which were already heavily loaded, or even congested, in 1959.

Increased demand

The most marked increase in the demand for radio spectrum space in the past twenty years has taken place in the fields of maritime mobile communications and short-wave radio broadcasting. In Band 2, the v.h.f./f.m. band, agreement was reached at WARC 79 on an expansion in Regions 1 and 3 to 108 MHz. A planning conference, to be held in a few years' time, will decide about the channel allocations in this band for each area. Before this can take place, however, non-broadcasting services which still make use of the band will have to be relocated in other frequency ranges. Medium-wave broadcasting has also grown considerably, but a frequency plan for the medium- and long-wave bands was adopted at the ITU conference on m.f./l.f. broadcasting in 1974/75 (January 1976 issue, p. 42) and its results were accepted (with some minor changes) at WARC 79.

The frequency range between 6 and 30 MHz is suitable for world-wide communications without the use of repeaters or satellites. This fact makes this h.f. part of the spectrum important to various users — mobile communications on land, at sea or in the air, fixed communications between points on earth, radio amateurs, and broadcasting, to mention a few. In the past twenty years the occupation of various bands in this range has changed. Extensive monitoring, taking place all over the world in recent years, has shown that the number of stations in the fixed bands (which occupy about 48% of the available short-wave spectrum) has considerably decreased. It has also shown that the number of stations inside the allocated short-wave broadcasting bands has grown to intolerable levels.

The decrease of band loading in the fixed bands was due partly to the development of satellite communications, which proved to be more reliable to the fixed user and is able to handle all traffic without interference. Apart from this measured effect, however, many young nations still feel the need for frequencies in the fixed bands, to establish and maintain domestic or international radio communications (telephony, commercial traffic, data transmission).

Many short-wave broadcasting organizations, after studying the results of monitoring the fixed bands and looking at the gloomy situation inside the short-wave broadcasting bands, had the feeling that it would be reasonable to re-allocate portions of the fixed bands for broadcasting purposes. This feeling was strengthened by the knowledge that some administrations (the official postal and telecommunication authorities of the various countries) have permitted their short-wave broadcasters to move into the fixed bands. This situation, not endorsed by many countries who live by the intentions and rules of the Radio Regulations, was made possible by the use of an escape clause in these regulations which renders such a move possible if no interference is caused to other services which are allotted in the fixed bands. Since the broadcasting service usually replaced a fixed service of the same country (though at an increased bandwidth), generally no complaints from other fixed users were filed and the broadcasting service in the fixed band could thus be established.

Exclusive h.f. bands

In most countries, however, short-wave broadcasting stations have not been allowed to operate "out-of-band", because the administration is wary of causing congestion in the fixed bands with transmissions of another kind. Most administrations felt bound by the 1959 agreement, which established certain frequency bands for the exclusive use of high frequency (short-wave) broadcasting only and provides a similar arrangement for the fixed bands. Mixing the two would cause precedents which would harm international interests.

At the start of WARC 79 a number of administrations had hoped to correct this situation by extending a number of short-wave broadcasting bands into adjacent fixed bands, thereby giving all s.w. broadcasters equal opportunities to establish a good service while doing away with the privileged situation of those broadcasters who are already operating in the fixed bands. It was not expected that all the administrations concerned would co-operate with such a measure, but those against were considered to be in the minority.

However, things turned out differently. The non-aligned countries, which now have a voting majority in most international bodies, could only be partly convinced of the reasonableness of the international broadcasters' requirements. Moreover, they were concerned about the loss of fixed frequencies, which are so vital to them.

Meetings held in the important working group 5BB, which dealt with the frequency range between 3.9 and 27.5 MHz, were difficult and progress was slow. The proposals, which obtained a majority in the group, did account for about 780 kHz of band extension for all broadcasting bands between 9 and 22 MHz, or less than half the extension needed to operate short-wave broadcasts with a reasonable chance of satisfactory reception quality. The results, agreed on by Committee 5 and the Plenary Assembly, are given below.

Band (m)	Old frequency range (MHz)	New frequency range (MHz)
75 m	3.950-4.000*	3.950-4.000
49 m	5.950-6.200	5.950-6.200
41 m	7.100-7.300†	7.100-7.300
31 m	9.500-9.775	9.500-9.900
25 m	11.700-11.975	11.650-12.050
22 m	—	13.600-13.800
19 m	15.100-15.450	15.100-15.600
16 m	17.700-17.900	17.550-17.900
13 m	21.450-21.750	21.450-21.850
11 m	25.600-26.100	25.670-26.100

* Not allocated in Region 2. 3900-4000 kHz allotted in Region 3.
† Not allocated for broadcasting in Region 2 (the Americas).

The outcome must be considered "meagre" by many administrations and short-wave broadcasters in the western world, who have put so much work into measuring and evaluating data and calculating what they consider to be a very reasonable proposal for all concerned, based on technical data rather than on political motives. It is a disapproving result, which might also be ascribed to the failure of some delegates from less technically developed areas to fully appreciate the real value of the proposals put forward and their unjustified reserve as to the good intentions behind them.

An observer at WARC 79 must have felt that some of the voting was indeed not free from political motivation. Some countries could occasionally be seen grouping together, and the influence of certain leaders was sometimes very evident. But this is all part of the modern set-up where each country has one vote only, regardless of the size of its population.

One of the important decisions taken at the conference was to set in motion the preparation for a new technical conference. Such a conference, called a planning conference for the h.f. broadcasting bands, will be held in two sessions, probably in 1982 or 1983. The first session will establish the technical parameters to be used during the planning conference. Some of the important parameters are: maximum number of frequencies used for the same programme to the same zone; the necessary or maximum transmitter power to be allowed; and a specification for a single-sideband system suitable for future use. Also, the CCIR, which is the ITU's technical consultative committee for broadcasting, is to prepare and distribute extensive data on directional antennae, on methods of estimating field strengths and transmission losses, on calculating necessary protection ratios between co-channel and adjacent channel broadcasts, on frequency prediction methods, on solar indices, and so on.

The second session, which will be the planning conference proper, will be held 12 to 18 months after the first session. During this period all concerned will be in possession of the same data. This means that there will be no technical arguments based on data of different origins or liable to different interpretations. It also means that everyone concerned has at least the opportunity to prepare for the responsible task of participating in a world forum on h.f. broadcasting, which will determine its weal and woe for the next twenty years or so. □

Jim Vastenhoud, author of this article, is the deputy director of engineering services of Radio Nederland, the Dutch world broadcasting organization. He joined them in 1953, transferred to Dutch television in 1962 but returned to Radio Nederland in 1969. His present work is on engineering projects and the co-ordination of frequencies for short-wave broadcasting. He occasionally takes part in BBC "World Radio Club" broadcasts from London.

News notes

The Australian government has authorized tv stations to go ahead with data broadcasting services. The announcement was made by Mr T. Staley, the minister for Post and Telecommunications, who welcomed this development as a useful addition to community services.

A multi-track digital recording of an opera, using the 3M Mincom 32-track digital mastering system, was made by Polygram during December 1979 and January 1980. The recording of Wagner's four-and-a-half-hour opera "Parsifal" was performed by the Berlin Philharmonic Orchestra and the Chorus of the Berlin Opera. Analogue tapes were also made of the sessions.

The first deep water optical-fibre telephone cable, a trial 9.5km loop, was laid by the STC division of ITT, using the Post Office cableship "Iris" in Loch Fyne, on the West coast of Scotland early in March. A regenerator housing with mechanical terminations was also laid with the cable, to be equipped later with the necessary regeneration equipment.

IN OUR NEXT ISSUE

The case for community radio

Many people are dissatisfied with the centralised nature of national broadcasting, even when it includes regional and local stations. Community feeling, discussion and culture could be encouraged by alternative radio. Norman McLeod assesses what could be done in the UK.

'Off-resonance' metal detector

This newcomer to metal detecting is basically similar to the b.f.o. type but senses the search coil's inductance change differently and uses the properties of a parallel-tuned circuit to obtain more information about the physical nature of the object.

What happened to analogue computers?

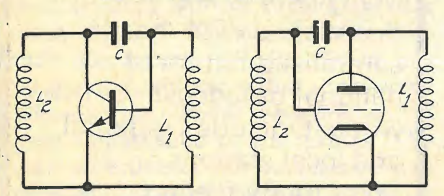
Apart from the i.c. op-amp, analogue computing techniques seem to have been swamped by the tide of digital computers and microprocessors. This article reminds us of the basic electronic analogue techniques and of how flexible they are for modelling proposed systems.

On sale 21 May

LC oscillators: general theory

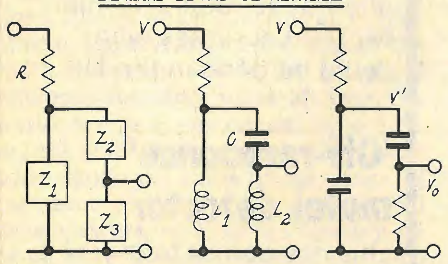
by **Peter Williams,** Ph.D. Paisley College of Technology

TRANSISTOR AND VALVE OSCILLATORS



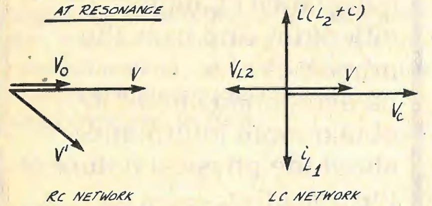
Transistor and valve oscillators can be closely related: not in the obvious way by a direct replacement, but with inputs and outputs interchanged. If a particular network requires a transistor of short-circuit current-gain h_{fe} for oscillation, and used with a valve with terminations reversed requires an open-circuit voltage gain of μ, then $\mu = h_{fe}$. Neither the input resistance of the transistor nor the output resistance of the valve appear in the frequency and gain-determining relationships. This is a surprising result and though exactly true only for a circuit composed of pure reactances it remains useful under a wide range of practical conditions. The minium number of pure reactances for oscillation with a single device is three, two of one type and the third of the opposite type. By extension, circuits may use mutual inductance and other more complex arrangements but at the frequency of oscillation the reactances are always equivalent to two inductive and one capicitive or vice versa.

GENERAL LC AND RC NETWORKS



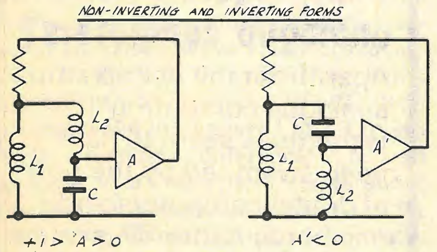
Taking the device resistance (h_{ie} for the transistor and r_a for the valve) into the external circuit the passive circuit becomes the general form shown, i.e. activated by an ideal voltage amplifier from left to right or by a current amplifier from right to left. The particular LC form corresponds to the previous valve/transistor oscillators. The configuration is identical with the RC lag-lead network, the basis with the related Wien and lead-lage networks of so many RC oscillators. In the LC form the overall phase shift is found to be 180° at the frequency for which the reactances go into series resonance and an inverting amplifier is used. The RC circuit has zero phase shift at the frequency of maximum response and needs a two-stage amplifier for the non-inverting gain. From the standpoint of frequency stability, it is the rate-of-change of phase of the passive network at the frequency of oscillation that is important. The higher this value the smaller the frequency shifts in compensating for internal amplifier phase errors or those resulting from the intermodulation via feedback distortion components.

PHASE RELATIONSHIPS AT RESONANCE



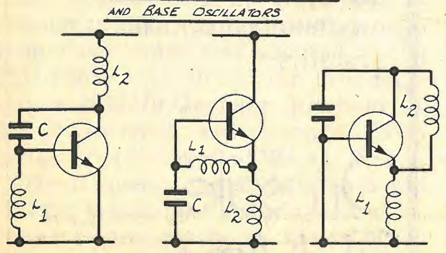
These are quide different for the two circuits; that the LC circuit has a higher $d\phi/d\omega$ at the frequency of oscillation. Considering the RC circuit first, the two sections result in successive phase lags and leads. It is simplest to visualize if the second stage impedance is much higher than the first but with equal time-constants. There is then a simple relationship for the frequency at which the first stage provides a 45° lag simultaneously with a 45° lead for the second stage, i.e. a net phase-shift of zero. Equal R and C values modify the relationship but leave the principle the same, viz a single frequency at which the phase shifts cancel. The LC circuit depends on resonance to obtain the necessary phase conditions. The currents in L_1 and L_2, C are antiphase only for those frequencies at which the reactance of C exceeds that of L_2. The net current flow can therefore become zero resulting in there being no voltage dropped across R. It is this that allows R to vanish from the frequency and gain-determining equations.

NON-INVERTING AND INVERTING FORMS



Further inspection of the phase relationships shows that the voltages across C and L_2 are anti-phase with v_c greater in magnitude than v_{L2}. Because, at resonance, v_{L2} is antiphase to the drive voltage v, it is the inductor voltage in this configuration that is normally used to close the oscillatory loop. This form is shown in the second of the two circuits with an inverting amplifier. If the locations of L_2 and C are interchanged then at the same frequency the output of the network is now in phase with the drive voltage but of greater magnitude. Hence a non-inverting voltage amplifier with voltage gain below unity is required. The new oscillator might be described as a grounded-collector (or drain or anode) oscillator but *not* a common-collector. This last terminology must be avoided as there is no external signal source and hence there cannot be a common point between input and output. The terminal that is grounded is merely a matter of convenience, perhaps of biasing of minimizing stray capacitance or of extracting the signal; the nature of the oscillator remains unchanged.

GROUNDED EMITTER, COLLECTOR, AND BASE OSCILLATORS



The three circuits shown simply represents shifts in ground points for the same basic oscillator; L_1 still appears between base and emitter, L_2 between collector and base. The supply times are assumed to have zero impedance to ground and bias networks are omitted. This latter point is of practical importance because one factor influencing the choice of configuration will be the case of biasing. Considering the common base circuit first it can be seen that a direct current path is needed for the colleltor current, but one whose impedance is very high at the frequency of oscillation. This suggests a large-value inductance (or a parallel resonant circuit!) which is not an attractive solution. This problem is not present with the other two, though each requires a bias path for base currents. If the bipolar transistors are replaced by junction fets capable of operating with $V_{GS} = 0$ then a self-biasing oscillator results in each case.

LC oscillators: general theory

THEORY

● The two forms have the passive networks similarly terminated on the assumption that only the input resistance of the transistor and the output resistance of the valve or f.e.t. need be considered, i.e. in both cases there is a conducting path across L_1 but not across L_2.

● Let $t_v = v_o/v$ for the general passive network shown. Applying Thevenin's theorem to R, Z_1

$$t_v = \frac{Z_3}{Z_3 + Z_2 + \frac{Z_1 R}{Z_1 + R}} \quad \frac{Z_1}{Z_1 + R}$$

$$= \frac{Z_1 Z_3}{Z_1 Z_3 + Z_1 Z_2 + (Z_1 + Z_2 + Z_3) R}$$

For oscillation the circuit would need to be connected to an amplifier of voltage gain A_v so that

$A_v t_v = 1$ at one frequency only

$$A_v = 1 + \frac{Z_2}{Z_3} + \frac{R}{Z_1 Z_3}(Z_1 + Z_2 + Z_3)$$

By reciprocity, if the same network is interconnected with an ideal current amplifier of current gain A_i then A_i has to meet the same constraint.

For many oscillators the impedances are almost pure reactances i.e. $Z_1 = jX_1$, $Z_2 = jX_2$, $Z_3 = jX_3$, where X_1, X_2, X_3 can have either sign subject to the constraints to be established below.

$$A_v = 1 + \frac{X_2}{X_3} - j\frac{R(X_1 + X_2 + X_3)}{X_1 X_3}$$

Equating real and imag' iary parts

$$A_v = 1 + \frac{X_2}{X_3}$$

$$X_1 + X_2 + X_3 = 0$$

(i) This last condition corresponds to the series resonant condition of X_1, X_2, X_3.
(ii) The constraint cannot be satisfied using three reactances of the same type as there must be at least one capacitive and one inductive for resonance.
(iii) If used with a grounded-emitter (grounded-source) stage with inverting gain then $X_2 > X_3$ and they must be of opposite types.
(iv) To simultaneously satisfy the second constraint, X_1 must be of the same type as X_3.

The above are the conditions resulting from $A_v < 0$. Other conditions obtain for $1 > A_v > 0$ and $A_1 > 1$.

● A comparison of the related LC and RC forms shows the lead/lag cancellation of the former, and the availability of more than one feedback connection for the latter, since the voltages at resonance are all either in phase or in antiphase.

● Because $V_c + V_{L2} = V_{L1} = V_o$ and V_{L2} is antiphase to V_c, then V_c is in phase with V_o and exceeds it i.e. $1 > A > 0$.

For the second form, V_{L2} is antiphase to the output and $A' < 0$.

$$\frac{X_1}{X_3} + \frac{X_2}{X_3} + 1 = 0$$

$$\text{i.e. } \frac{X_1}{X_3} = -A_v$$

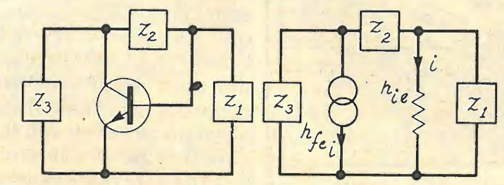
$$X_1 : X_2 : X_3 :: -A_v : A_v - 1 : 1$$

EXAMPLE

A bipolar transistor with $h_{fe(min)}$ of 50 is used with C = 500pF and is required to oscillate at 200kHz. Determine suitable values for L_1, L_2

$$Z_1 = j\omega L_1 \quad Z_3 = j\omega L_2$$

$$Z_2 = \frac{1}{j\omega c}$$



The fraction of the output current flowing in h_{ie} is

$$i = \frac{\frac{Z_1}{h_{ie} + Z_1} . Z_3}{Z_3 + Z_2 + \frac{h_{ie} Z_1}{h_{ie} + Z_1}} (-h_{fe} i)$$

$$\therefore -h_{fe} = \left(Z_3 + Z_2 + \frac{h_{ie} Z_1}{h_{ie} + Z_1}\right)\left(\frac{h_{ie} + Z_1}{Z_1 Z_3}\right)$$

$$= \frac{h_{ie}}{Z_1 Z_3}(Z_1 + Z_2 + Z_3) + 1 + \frac{Z_2}{Z_3}$$

$$= \frac{-h_{ie}}{\omega^2 L_1 L_2}\left(j\omega(L_1 + L_2) + \frac{1}{j\omega_c}\right) + 1 - \frac{1}{\omega^2 C L_2}$$

Equating real and imaginary terms

$$\omega^2 = \frac{1}{(L_1 + L_2)C}$$

$$-h_{fe} = 1 - \frac{1}{\omega^2 C L_2}$$

$$h_{fe} = \frac{(L_1 + L_2)C}{L_2 C} - 1 = \frac{L_1 C}{L_2 C} = \frac{L_1}{L_2}$$

$$\therefore L_1 = 50 L_2$$

$$L_1 + L_2 = \frac{1}{(2\pi 200.10^3)^2 500.10^{-12}}$$

$$= \frac{1}{4\pi^2.5} \approx 5.07\text{mH}$$

$$\therefore 51 L_2 = 5.07\text{mH}$$

$$L_2 \approx 99.4\pi\text{H}$$

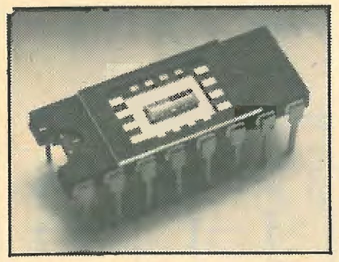
$$L_1 \approx 4.97\text{mH}$$

h_{ie} plays no part in determining the resonant frequency nor in the ratio of the components. But it does affect Q and the behaviour of the circuit for any departures from the nominal conditions.

NEW PRODUCTS

Image sensor

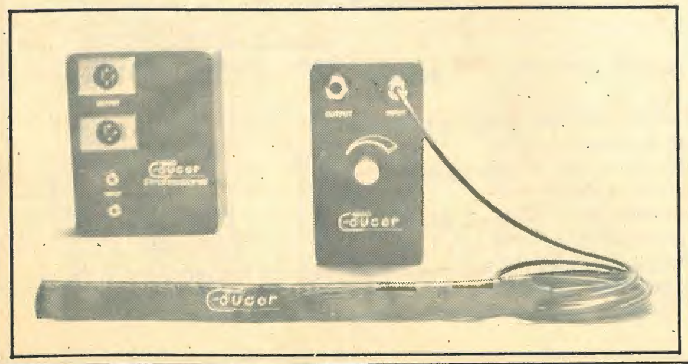
Drive circuits are included in the IPL 64P image sensor i.c., which forms the first item in a new family of devices from Integrated Photomatrix. It can be operated in conjunction with a t.t.l. oscillator and other features include a programmable shift reg-



ister, making operation as a 1 to 64 element array possible. The i.c. is c.m.o.s. compatible and a quartz window extends the spectral response to 250nm, making it suitable for spectrographic applications. The one-off price is £45. Integrated Photomatrix Ltd, The Grove Trading Estate, Dorchester, Dorset.
WW301

Flexible contact transducer

Designed as a self-adhesive acoustic transducer and intended for applications such as the direct amplification or recording of acoustic musical instruments, the "C-Ducer" is a flexible electret transducer in flat tape form available in several lengths to suit various instruments. According to the makers, C-Tape Developments, the device offers a very low noise level, a flat frequency response over the range 10Hz to 5MHz, and is supplied complete with a f.e.t. amplifier, which has a variable output level, permitting control of an external amplifier. Because the device detects vibrations through a solid it is relatively insentitive to airborne signals, partially relieving the typical problem of "howlround," which is induced acoustic feedback. The makers quote many other uses such as that of stress detection, burglar alarms (where "invasive" sounds can be picked off for attention), or situations where a high immunity to electromagnetic or radio frequency interference is a problem. The amplifier/polarizing supply required consists of two PP3 batteries and the amplifier unit is portable. The "professional" range has provision for mains or phantom powering and the price scale begins at £59 plus v.a.t. C-Tape Developments, 128, Grange Rd, Guildford, Surrey. GU2 6QP.
WW302



Versatile microcomputer

The System 80 computer, which is fundamentally a packaged Nascom -2, has been designed for flexibility, several new boards having been introduced. The main housing contains a racking frame which holds a mother board, a power supply, the c.p.u. board and up to four expansion boards. Provision is made for external connection to the boards and the computer has a g.r.p. cover with a keyboard cut-out. A future expansion housing will accommodate a further five boards, mounted on top of the System 80 case. A programmable character generator board uses 2k bytes of static r.a.m. and can accept the Nascom block-graphics r.o.m. The high resolution graphics operate on a cell structure consisting of 112 dots. Up to 128 cells can be produced in the 2k r.a.m. and each cell, once defined, can be displayed anywhere on the screen. A colour board offers high or low resolution for the three main television systems or an r.g.b. output. High resolution uses 6k of static r.a.m. and gives a choice of 16 colours. A dynamic r.a.m. board is available with 16, 32 or 48K bytes and has decoding, buffering and memory support. An input/output board can accommodate three MK 3881 p.i.as, a MK 3882 counter-timer and a 6402 u.a.r.t. The fifth optional board, a floppy disc controller, can handle up to four Siemens double-density, double-sided 5¼in drives using the 1791 i.c. Various link options permit single or double-sided and single or double-density disc to be used and the c.p.u. can be run at 2 or 4MHz. Nascom claim that the larger the system, the more competitive the price becomes. For example, with System 80 supported by 96K of r.a.m., a programmable character generator, a high resolution colour card, and a complete twin disc set, the cost is about £1,750. All parts can be supplied in kit form. Nascom Microcomputers Ltd, 92 Broad St, Chesham, Bucks.
WW303

Sound level exposure time meter

The Department of Employment's "Code of Practice for Reducing the Exposure of Employed Persons to Noise" defines the maximum time for which an employee may be safely exposed to high sound levels in a working day. At 90dBA an employee may work for eight hours but if the level increases to 93dBA (a barely audible increase), the energy content is doubled and the permissible working time reduced to four hours. At a typical discotheque level of 110dBA the exposure limit is less than five minutes per day. In addition to displaying the sound level, the Willie 85E has a linked scale showing the level and the maximum permissible exposure time. The microphone is mounted on a "pull-out" boom to limit case reflections and the list price of the complete unit is £130. It is also available as a full measurement kit complete with calibrator in an attache case, priced at £215. W. C. Willis and Co, Ltd, 6 Methil St, Scotstoun, Glasgow G14 0BH.
WW304

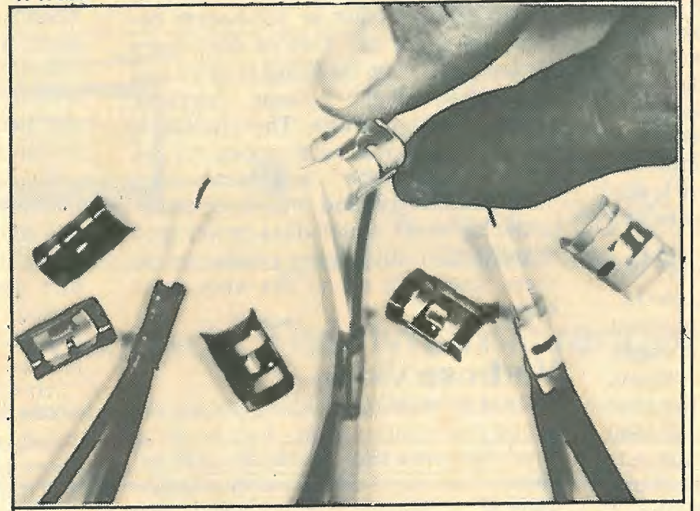
Mobile radio test set

Full system testing of mobile communication receivers and transmitters is the function of the Farnell TTS 520. The test set (lower of the two instruments shown in the photograph) is married to a signal generator and is capable of handling outputs of up to 100W via a suitable IEEE488 interface module. The TTS 520 incorporates an r.f. counter, an automatic modulation meter, a directional r.f. power meter, an a.f. voltmeter, an a.f. synthesiser, a distortion analyzer, an a.f. counter, weighing filters and an r.f. power load/attenuator. Among the measurements Farnell says the test set can handle are transmitter frequency, power output and modulation level, sensitivity, bandwidth and distortion content. Transmitter continuous tone modulation checks can be carried out as can checks on aerial efficiency. Identical tests can be carried out on receivers by means of the SINAD or quieting method. Price of the test set is quoted as "well under £6,000 excluding v.a.t." Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire LS22 4DH.
WW305

WW305

Wrap-around braid connectors

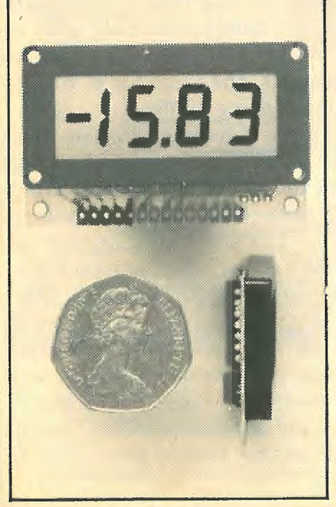
Although a specialised tool is recommended for installation by the makers, Thomas and Betts, the "Shield-Kon" range of connectors can be used to make secure outer braid or foil connections to conventional shielded or co-axial cable in a matter of seconds. Four sizes are available over the range 0.055in to 0.300in in diameter. Thomas and Betts Ltd, Sedgwick Rd, Luton, LU4 9DT.
WW306



WW306

Miniature digital panel meter

The overall measurements of the OEM-1 digital panel meter module, made by Anders Electronics Ltd are 60×38×15mm deep. In spite of being very thin, the unit features a 3½ digit liquid crystal display with ½in digits and can be powered from a single 9V d.c. supply. The current drawn is 1mA and the makers say that the single-chip dual-slope a-to-d converter provides a true differential input with auto-zero and auto-polarity operation drawing a cumulative current of 1pA. Among the unit's operational modes is the display of inputs up to ±200mV directly with an accuracy of 0.1%. Alternatively, it can be connected for differential (i.e. ratiometric) operation, permitting operations such as resistance and temperature measurement. "Quantity" price is £10 per unit, with evaluation samples costing £21.90, plus v.a.t. Anders Electronics Ltd, 48-56 Bayham Place, London NW1 0EU.
WW307

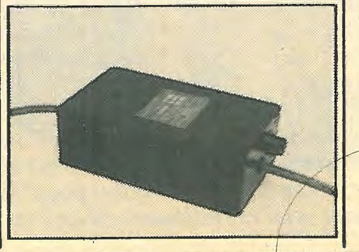


Contemporary-type reverb plate

A "contemporary-type sound" is claimed for the Ecoplate reverberation plate, made by Programming Technologies Inc. of Linolnwood, Illinois. One of its features is a long h.f. decay time giving a "crisp sibilance that is very attractive for contemporary music". The long decay time is in contrast, to the fast h.f. decay of plates like the more natural-sounding EMT plate. A new smaller version, Ecoplate II, was shown at the February London AES convention that measures 173 × 109 × 26cm. If plates are made smaller they must also be made thinner to keep the eigentone density and hence coloration constant. But with a thinner plate, air pressure dampens the higher frequencies, resulting in a loss of high frequency decay time. To offset this, Ecoplate II has been developed to match the characteristics of the larger plates, the makers say, by the use of a "special" metal and damping plate. Reverberation time is adjustable from one to six seconds. Price is £1300 and UK sales are through Turnkey at 8 East Barnet Road, New Barnet, Herts EN4 8RW.
WW308

Power line filters

Protection against surges and transients is the main function of "Kleanpower" line filters, made by Lightning Elimination Associates. The MB series is an extension of the LEA type SE but offers the additional features of protection from noise spikes, r.f.i. and other disturbances which could cause damage or logic errors. Typical applications mentioned by the makers include computers, multiplexers, medical monitoring systems, electronic registers, word processors, communications systems on 200/240V a.c. supplies and has a, maximum current rating of 13A. Lightning Elimination Associates Ltd, Vine Cottage, Moreton, Thame, Oxon.
WW309

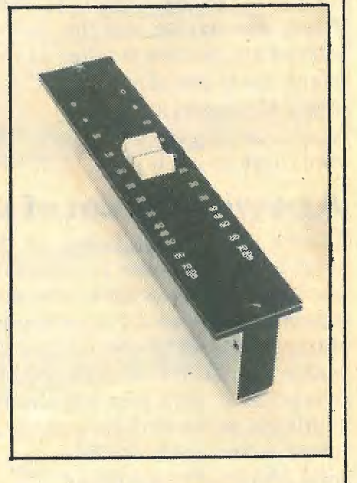


Sealed touch keyboard

Optional X-Y or individual lead-outs and a choice of 12 or 16 key formats are features of the Invader fully sealed touch keyboard. The unit, manufactured by Jack Evans Electronic Distribution has a normal operating temperature range of −29°C to +60°C and each contact will carry up to 100mA at 300V d.c. at a typical contact resistance of 1 milliohm. The makers quote the advantages of a wipe-clean flat surface and very low profile, and the keyboards are fully t.t.l. and c.m.o.s. compatible. Jack Evans Electronic Distribution Ltd, 244 Bath Rd, Hayes, Middlesex.
WW310

Conductive plastic digital fader

A new conductive plastic digital fader offers a direct grey scale 8-bit output from zero to decimal 255 within a stroke length of 102mm. The makers are Penny and Giles and the fader is interchangeable with the company's 1100 and 1500 series faders, making use of identical top plates and fascias. Applications quoted for the fader include driving digital attenuators or direct inputs to a computer. Penny and Giles Group, Mudeford, Christchurch, Dorset BH23 4AT.
WW311



Neon displays

Described as "bright neon orange seven segment displays" by the makers, Impectron, the NEO-8000 range of indicators measure 130×80×9mm, operating at a peak anode supply of 190V and peak anode current of about 5mA. Normal operating temperature range is −10°C to +60°C; the displays are designed for either p.c.b. or socket mounting and the makers expect them to be used in public information displays, vending equipment and industrial control equipment. Impectron Ltd, Foundry Lane, Horsham, W. Sussex.
WW312

SIDEBANDS

By Mixer

Extended view

We get a lot of press handouts from the BBC and IBA. Fairly often, they are about new transmitters and relay stations and, to be perfectly honest about it, we don't often spare them much more than a passing glance as they slither across our desks on their way to the news person. We think we know all about it, you see, having read so many.

So I thought, too, until I read a recent example and took note of some of the figures. Four new relay stations were to be opened, each serving as few as 500 people. One of them was to transmit to an audience of 2500, but three of the four were for 500-600. It struck me as totally admirable that small communities like this weren't being ignored, so I rang the Beeb to ask for more information. (I spoke to the BBC because it was their press release, but the IBA are just as much involved.)

It turns out that a four-channel relay station can cost about £40,000, so that the smallest groups are having about £80 per person spent on them, split between BBC and IBA. In Orkney, where the groups are smaller, the cost has been much higher — around £480 per person. In a year the two broadcasting organizations get through about £8million between them on this sort of filling-in exercise and the communities served are getting smaller as the bigger blank spots are eliminated. Coverage of the UK population is now 98.6% and it would need about another 100 relays like these to get it up to 98.7.

A bewilderment of terms

I think it's time we tidied up the verbiage a bit, because it's beginning to confuse a lot of people who aren't engineers, but who have to know something about electronics so that they can make decisions which could affect everyone. It isn't just beginning either — it's got some of them talking a whole lot of utter cobblers because they've misunderstood definitions.

A recent report for the Department of Industry set out to discover what use industry was making of, to pluck a word out of the air, microprocessors. The information was gathered by telephone, the questions being put to managing directors of companies by interviewers whose main concern in life is not electronics. So, to start with, this was not a very promising approach; not many company directors could, with any confidence, distinguish an integrated circuit from a momentarily-inactive centipede. It was, in fact, a proceeding not unlike a Xingu Indian and a native of Vladivostok discussing Test cricket.

The reason for the difficulty seems to lie in the quantity of different descriptions given to i.cs, some of which mean the same while others don't. Take just a few: integrated circuit, microelectronics, microchip, microprocessor, solid-state, 'new technology', silicon chip, silicon microcircuit, microcomputer — how on earth can we expect a non-specialist to ask or answer intelligent questions when faced with a collection of gobbledygook like that?

For example, if a non-engineer is asked how long his company has been using microchips, microelectronics, silicon microcircuits or solid-state devices, he might say they've used them for ten years, say, meaning they've had small-scale logic, linear circuits, counters and the like. The trouble is that these words are taken to be synonymous with 'microprocessor', 'new technology' and 'microcomputer' to the lay mind, which does rather tend to mean that any survey conducted on these lines will be, at the very least, suspect.

Verbose video

All that exhausting trekking across the sitting room carpet every two or three hours to push the television channel button is now, of course, very much a thing of the Spartan sixties. No one with any claim to the smallest degree of savoir vivre will countenance any more effort than a touch of the button of a remote-control unit. A quick tap on the key-pad and off goes one piece of imported, American life-style propaganda to be replaced by something more mind-stretching like "Blankety Blank". You can even wind down the sound during the commercials without tiring yourself out. What more could one ask?

A good deal, it appears, because there are plans to produce a telly-box that not only does as it is told but tells you it's done it — it talks back. Now, personally, what I like to see in pets, small children, wives and domestic appliances is blind, unquestioning obedience. I do not wish to become involved in tiresome discussion with a garrulous electrical device.

I can see myself becoming visibly annoyed if, when told to switch to "Match of the Day" the creature says "Oh! do you think that's wise? There is a Western on BBC2 which is really rather super — I firmly believe you would be much better off with that." Mind you, if you could instil some semblance of your own tastes into a store in the machine, you would be able to rely on the thing protecting you from nasty shocks. An inadvertent instruction to switch to "Top of the pops" would meet with an offended refusal to do any such thing and a suggestion that you read a good book for the next two hours because there isn't anything worth watching.

Maybe there's something in the idea after all.

Garage gurus

"It'll cost yer, squire," is a remark that garage mechanics learn before they progress to more advanced expressions such as "Mama". The pursed lip, sorrowful shake of the head and low whistle of disbelief are acquired much later in life, on the threshold of manhood and around the time when they learn how not to bat an eyelid when uttering a statement such as "That'll be a fiver, guv," after a cursory glance at the points and a quick polish of the radiator cap.

I exaggerate, of course. Garage mechanics are quite possibly totally admirable to a man, but I usually come upon them in circumstances of such dire discomfort and after such long periods of lonely vigil by the roadside that Sir Galahad himself would appear ill-natured and surly.

Having, at length, arrived on the scene, diagnosis of the trouble is usually rapid, and the fault can be put right there or at the garage, because spares are fairly easy to get hold of and reasonably quick, though expensive, to fit. (I speak as one with some experience of the above scenario.)

In short, on their own ground these chaps are pretty competent, on the whole, even though the prices they charge often do seem to have been calculated by squaring the chassis number. What bothers me is what will happen when microprocessors begin to take over.

It is also a matter for concern to Olaf Lambert, of the Automobile Association. While conceding that chips will make for quieter and more economical cars, he is worried that not many garages are going to be able to afford the test gear to diagnose faults, particularly as the connectors may well be different in different makes of car, in keeping with the VITSOL policy (Variety is the spice of life).

I do so agree. It is not easy to imagine the minor prophet at the local garage explaining the sleeping sickness afflicting one's wheels in terms of microprocessors. "It's yer chips, innit?" he will say. "What yer want is new r.o.m. — soon wear out, these foreign ones", he will remark, casually, mentioning also that he will need to pay a 'high-technology bonus' and that it will therefore cost even more than usual.

It almost makes you hope the oil runs out quickly so that we can all go back to push-bikes.

Simply ahead . . and staying there

I.L.P's PROVEN RANGE OF HIGH PERFORMANCE MODULAR UNITS

- FIVE POWER AMPLIFIERS EACH ENCAPSULATED WITHIN LARGE HEATSINK
- PRE-AMP/ACTIVE TONE CONTROL MODULE COMPATIBLE WITH ALL I.L.P. AMPS AND POWER SUPPLY UNITS
- SEVEN MATCHING POWER SUPPLY UNITS (FOUR WITH TOROIDAL TRANSFORMERS)
- EASY ASSEMBLY DESIGNS WITH WELL PRESENTED INSTRUCTIONS

Chosen in more countries throughout the world than any other U.K. make

I.L.P. constructional modules are different. Whereas most others come with components neatly arranged on open P.C.Bs with little else, I.L.P. modules are encapsulated within totally adequate heatsinks and have circuitry which makes further components unnecessary. As a result, I.L.P. power amplifiers, pre-amp and matching power supply units are infinitely more rugged, impervious to extremes of temperature in use and they can be positioned to requirements. Nor is metal work needed to take away heat connections. I.L.P. modules are made for endless years of optimum service. Circuitry, workmanship and performance are of the highest standards, equal to the demands of the finest loudspeakers, pick-ups, tuners, digital sound sources, etc.

Tomorrow's equipment is likely to be even more exacting than today's so that any amplifier system less than the best will be completely inadequate. Now study the tested and guaranteed specs. for I.L.P. That is why more people in more countries prefer these British designed and made modules.

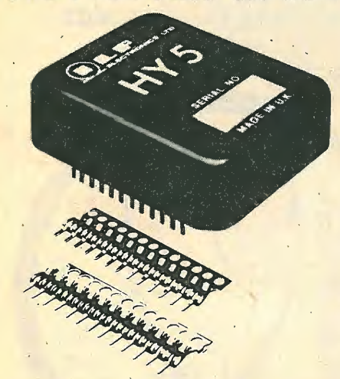
Why toroidal?

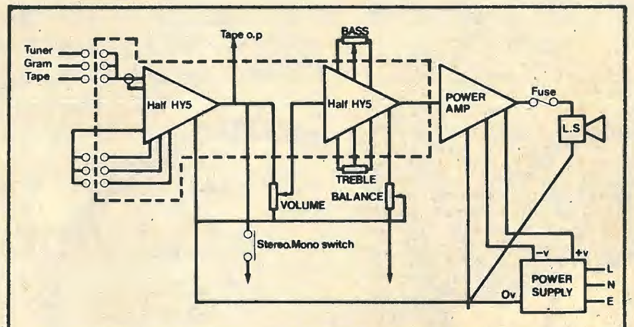
Toroidally wound transformers are more compact than their conventionally laminated equivalents, being only half as high and heavy. Their circular profile ensures greater operating efficiency and as such they are particularly valuable in heavy duty applications. We have our own production section for winding and making toroidal transformers, enabling us to offer this much sought-after type at competitive prices. Four of the larger models in our range are now supplied with this type of transformer.

PRODUCTS OF THE WORLD'S FOREMOST SPECIALISTS IN ELECTRONIC MODULAR DESIGN

AVAILABLE ALSO FROM WATFORD ELECTRONICS, MARSHALLS AND CERTAIN OTHER SELECTED DEALERS

HY5 PRE-AMPLIFIER



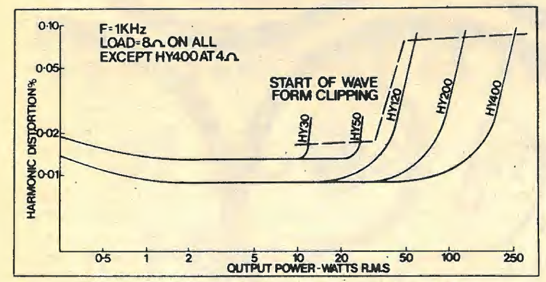


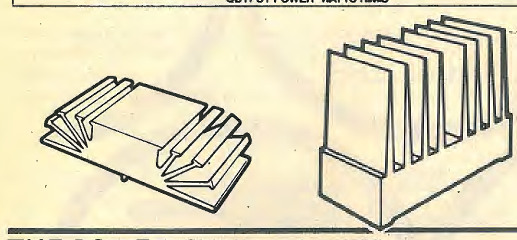
VALUES OF COMPONENTS FOR CONNECTING TO HY5
Volume — 10K Ω log.
Bass/Treble — 100K Ω linear. Balance — 5K Ω linear.

The HY5 pre-amp is compatible with all I.L.P. amplifiers and P.S.U.'s. It is contained within a single pack 50 x 40 x 15 mm. and provides multi-function equalisation for Magnetic/Ceramic/Tuner/Mic and Aux (Tape) inputs, all with high overload margins. Active tone control circuits; 500 mV out. Distortion at 1KHz—0.01%. Special strips are provided for connecting external pots and switching systems as required. Two HY5's connect easily in stereo. With easy to follow instructions.

£4.64 + 74p VAT

THE POWER AMPLIFIERS

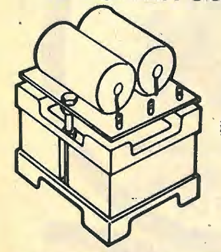




Model	Output Power R.M.S.	Distortion Typical at 1KHz	Minimum Signal/Noise Ratio	Power Supply Voltage	Size in mm	Weight in gms	Price + V.A.T.
HY30	15 W into 8 Ω	0.02%	80dB	-20 -0- +20	105x50x25	155	£6.34 + 95p
HY50	30 W into 8 Ω	0.02%	90dB	-25 -0 +25	105x50x25	155	£7.24 + £1.09
HY120	60 W into 8 Ω	0.01%	100dB	-35 -0- +35	114x50x85	575	£15.20 + £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	1.15Kg	£27.68 + £4.15

Load impedance — all models 4 - 16Ω
Input sensitivity — all models 500 mV
Input impedance — all models 100KΩ
Frequency response — all models 10Hz - 45KHz - 3dB

THE POWER SUPPLY UNITS



I.L.P. Power Supply Units are designed specifically for use with our power amplifiers and are in two basic forms — one with circuit panel mounted on conventionally styled transformer, the other with toroidal transformer, having half the weight and height of conventional laminated types.

PSU 30	±15V at 100ma to drive up to five HY5 pre-amps	£4.50 + £0.68 VAT
PSU 36	for 1 or 2 HY30's	£8.10 + £1.22 VAT
PSU 50	for 1 or 2 HY50's	£8.10 + £1.22 VAT
PSU 60	Toroidal for one HY50	£9.75 + £1.46 VAT
PSU 70	with toroidal transformer for 1 or 2 HY120's	£13.61 + £2.04 VAT
PSU 90	with toroidal transformer for 1 HY200	£13.61 + £2.04 VAT
PSU180	with toroidal transformer for 1 HY400 or 2 x HY200	£23.02 + £3.45 VAT

NO QUIBBLE 5 YEAR GUARANTEE
7-DAY DESPATCH ON ALL ORDERS
INTEGRAL HEATSINKS
BRITISH DESIGN AND MANUFACTURE
FREEPOST SERVICE —see below

★ *ALL U.K. ORDERS DESPATCHED POST PAID*

HOW TO ORDER, USING FREEPOST SYSTEM

Simply fill in order coupon with payment or credit card instructions. *Post to address as below but do not stamp envelope — we pay postage on all letters sent to us by readers of this journal.*

ILP ELECTRONICS LTD.
FREEPOST 5, Graham Bell House, Roper Close, Canterbury, Kent CT2 7EP.
Telephone (0227) 54778 Telex 965780

Please supply . . . .
. . . . Total purchase price £. . . . .
I enclose Cheque ☐ Postal Orders ☐ International Money Order ☐
Please debit my Account/Barclaycard Account No. . . . .
. . . .
NAME . . . .
ADDRESS. . . . .
. . . .
Signature. . . . .

years

danavox

DANAVOX (GT. BRITAIN) LTD.
1 CHEYNE WALK,
NORTHAMPTON NN15PT
TEL. NORTHAMPTON (0604) 36351

of research... "on components and accessories for dictating machines, tele-communications, hearing aids and electroacoustic equipment etc."

WW — 076 FOR FURTHER DETAILS

THINK OF A SHAPE

S 500D — dual channel up to 500W/RMS per channel DC-20 KHZ

Whatever it is, the H|H S' range of power amplifiers will handle it

The H|H S' range is designed to handle heavy industrial usage in the fields of vibrator driving, variable frequency power supplies and servo motor systems.

S 500D
Dual Channel
19" rack mount 3½" high
500w r.m.s. into 2.5 ohms per channel
900w r.m.s. in bridge mode
DC—20 KHZ at full power
0.005% harmonic distortion (typical) at 300w r.m.s. into 4 ohms at 1 KHZ
3KW dissipation from in-built force cooled dissipators

S 250D
Single Channel
19" rack mount 3½" high
500w r.m.s. into 2.5 ohms
Retro-convertible to dual channel
DC—20 KHZ at full power
Full short and open circuit protection
Drives totally reactive loads with no adverse effects

A complete range of matching transformers and peripheral equipment for closed loop, constant current and voltage use are available.
Alternative input and output termination to order. Rack case for bench use built to specifications. For complete data write or call.

Kirkham Electronics

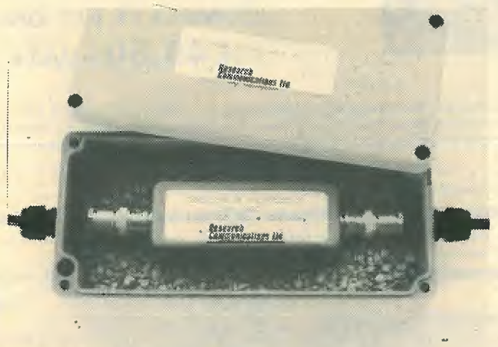
MILL HALL, MILL LANE, PULHAM MARKET, DISS, NORFOLK IP21 4XL
DIVISION OF K.R.S. LIMITED
TELEPHONE (037 976) 639/594

FRANCHISED COMMERCIAL AND INDUSTRIAL AGENTS FOR H|H ELECTRONICS

WW — 064 FOR FURTHER DETAILS

TYPE 80 SERIES UNITS

RF PREAMPLIFIERS, FREQUENCY CONVERTERS SIGNAL SOURCES, ETC....



TYPE 8025 MOUNTED IN TYPE 8036

TYPE 8025	STRIPLINE PREAMPLIFIER 200 MHz.-1500 MHz. Noise factor 1.2 dB.
TYPE 8026	STRIPLINE RF CONVERTER Input 200 MHz.-1500 MHz. Output 1 MHz.-1000 MHz. Noise factor 1.2dB.
TYPE 8027	RF PREAMPLIFIER 1 MHz.-250 MHz. Noise factor 1.0 dB.
TYPE 8028	RF CONVERTER Input 1 MHz.-250 MHz. Noise factor 1.0 dB.
TYPE 8029	WIDEBAND RF PREAMPLIFIER 10 kHz.-150 MHz. without tuning. Gain 40 dB.± 0.5 dB. Noise factor 3.0 dB.
TYPE 8030	VMOS LINEAR POWER AMPLIFIER 40 MHz.-250 MHz. without tuning. 4 watts maximum RF output.
TYPE 8031	VMOS LINEAR POWER AMPLIFIER 30 kHz.-40 MHz. without tuning. 4 watts maximum RF output.
TYPE 8032	HIGH STABILITY PHASE-LOCKED SIGNAL SOURCE 20 MHz.-1000 MHz. 1V. output at 50 ohms max.
TYPE 8033	UHF TELEVISION PREAMPLIFIER Channel group 'A' 21-34, 'B' 39-51, or 'CD' 49-68. Gain 20 dB. Noise factor 1.2 dB. Weatherproof unit.
TYPE 8034	100 kHz.-500 MHz. WIDEBAND MIXER.
TYPE 8035	10 MHz-1500 MHz. WIDEBAND MIXER.
TYPE 8036	MASTHEAD WEATHERPROOF UNIT Designed to completely enclose our standard units.
TYPE 8037	POWER SUPPLY/OUTPUT SPLITTER UNIT Stabilized mains power supply. Provides 4 outputs from one amplifier.

UNITS ARE AVAILABLE FROM STOCK.
CONTACT:

Research Communications
MANUFACTURERS OF COMMUNICATIONS RECEIVING SYSTEMS

RESEARCH COMMUNICATIONS LTD.

PEEL HOUSE ● PORTERS LANE ● OSPRINGE ● FAVERSHAM ● KENT ME13 0DR ● ENGLAND
TELEPHONE: FAVERSHAM 2064 (STD CODE 079 582)

WW—095 FOR FURTHER DETAILS

Cut costs and speed trouble shooting

with the

Huntron Tracker

This easy to use test instrument displays shorts, opens, and leakage in solid state components. Check diodes, unijunctions, bipolars, Darlingtons, J-FET's, MOS FET's, LED's, electrolytics and IC's . . . IN CIRCUIT!
Test pure digital or analogue hybrid boards . . . WITHOUT CIRCUIT POWER!
Current limited to protect delicate devices in the MOS-CMOS family.
Save 20 . . . 30 . . . 40 . . . even 50% of trouble shooting time and recover your investment fast! Exclusive 12 months warranty, available from—

MTL Microtesting Limited
1-15 Butts Road, Alton, Hampshire
Telephone: Alton (0420) 88022.

MTL

WW — 092 FOR FURTHER DETAILS

ORGAN and PIANO KEYBOARDS

	Price inc. VAT	P & P
4-Octave C-C	£32.20	£2.75
5-Octave C-C	£34.50	£2.75
5-Octave F-F	£34.50	£2.75
6-Octave C-C	£36.80	£3.00

DALSTON ELECTRONICS
40a Dalston Lane, Dalston Junction
London, E8 2AZ Tel: 01-249 5624

RECHARGEABLE BATTERIES

TRADE ENQUIRIES WELCOME

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

"Write or call at:

SANDWELL PLANT LTD.
2 Union Drive, Boldmere
Sutton Coldfield, West Midlands 021-354 9764

See full range at TLC, 32 Craven street, Charing Cross, London WC2.

WW—048 FOR FURTHER DETAILS

8K ON BOARD MEMORY!
5K RAM, 3K ROM or 4K RAM, 4K ROM (link selectable). Kit supplied with 3K RAM, 3K ROM. System expandable for up to 32K memory.

2 KEYBOARDS!
56 Key alphanumeric keyboard for entering high level language plus 16 key Hex pad for easy entry of machine code.

GRAPHICS!
64 character graphics option — includes transistor symbols! Only £18.20 extra!

MEMORY MAPPED
High resolution VDU circuitry using discrete TTL for extra flexibility. Has its own 2K memory to give 32 lines for 64 characters.

KANSAS CITY
Low error rate tape interface.

NEW FACTORY UP! PRICES DOWN!
INCREASED CAPACITY AT OUR BIG NEW FACTORY MEANS MANY PRICES DOWN! ALL OTHERS FROZEN!

Cabinet size 19.0" × 15.7" × 3.3"

Television not included in price

2 MICROPROCESSORS
Z80 the powerful CPU with 158 instruction including all 78 of the 8080, controls the MM57109 number cruncher. Functions include +, —, *, /, squares, roots, logs exponentials, trig functions, inverses, etc. Range 10^{-99} to 9×19^{-99} to 8 figures plus 2 exponent digits.

EFFICIENT OPERATION
Why waste valuable memory on sub routines for numeric processing? The number cruncher handles everything internally!

RESIDENT BASIC
With extended mathematical capability. Only 2K memory used but more powerful than most 8K Basics!

1K MONITOR
Resident in EPROM.

SINGLE BOARD DESIGN
Even keyboards and power supply circuitry on the superb quality double-sided plated through-hole PCB.

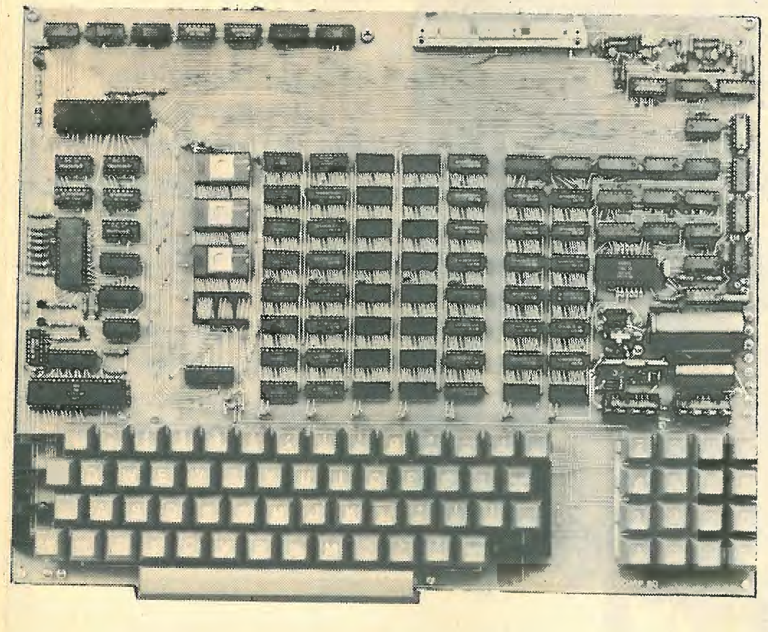
COMPLETE KIT NOW ONLY £225 + VAT!

POWERTRAN

PSI Comp 80. Z80 Based powerful scientific computer Design as published in Wireless World.

The kit for this outstandingly practical design by John Adams published in a series of articles in Wireless World really is complete!

Included in the PSI COMP 80 scientific computer kit is a professionally finished cabinet, fibre-glass double sided, plated-through-hole printed circuit board, 2 keyboards PCB mounted for ease of construction, IC sockets, high reliability metal oxide resistors, power supply using custom designed toroidal transformer, 2K Basic and 1K monitor in EPROMS and, of course, wire, nuts, bolts, etc.



KIT ALSO AVAILABLE AS SEPARATE PACKS
For those customers who wish to spread their purchase or build a personalised system the kit is available as separate packs e.g. PCB (16"×12.5") £43.20. Pair of keyboards £34.80. Firmware in EPROMS £30.00. Toroidal transformer and power supply components £17.60. Cabinet (very rugged, made from steel, really beautifully finished) £26.50. P.S. Will greatly enhance any other single board computer including OHIO SUPERBOARD for which it can be readily modified. Other packs listed in our FREE CATALOGUE.

PSI COMP 80 Memory Expansion System
Expansion up to 32K all inside the computer's own cabinet!

By carefully thought-out engineering a mother board with buffers and its own power supply (powered by the computer's transformer) enables up to 3 8K RAM or 8K ROM boards to be fitted neatly inside the computer cabinet. Connections to the mother board from the main board expansion socket is made via a ribbon cable.

Mother Board:	Fibre glass double sided plated through hole PCB 8.7"×3.0" set of all components including all brackets, fixing parts and ribbon cable with socket to connect to expansion plug	**£39.90**
8K Static RAM board	Fibre glass double sided plated through hole PCB 5.6"×4.8"	**£12.50**
	Set of components including IC sockets, plug and socket but excluding RAMs	**£11.20**
	2114L RAM (16 required)	**£5.00**
	Complete set of board, components, 16 RAMS	**£89.50**
8K ROM board	Fibre glass double sided plated through hole PCB 5.6"×4.8"	**£12.40**
	Set of components including IC sockets, plug and socket but excluding ROMs	**£10.70**
	2708 ROM (8 required)	**£8.00**
	Complete set of board, components, 8 ROMs	**£78.50**

Value Added Tax not included in prices

PRICE STABILITY: Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until July 31st, 1980, if this month's advertisement is mentioned with your order. Errors and VAT rate changes excluded.

EXPORT ORDERS: No VAT. Postage charged at actual cost plus £1 handling and documentation.

U.K. ORDERS: Subject to 15% surcharge for VAT*. NO charge is made for carriage. *Or current rate if changed.

SECURICOR DELIVERY: For this optional service (U.K. mainland only) add £2.50 (VAT inclusive) per kit.

SALES COUNTER: If you prefer to collect your computer from the factory, call at Sales Counter. Open 9 a.m.-12 noon, 1-4.30 p.m. Monday-Thursday.

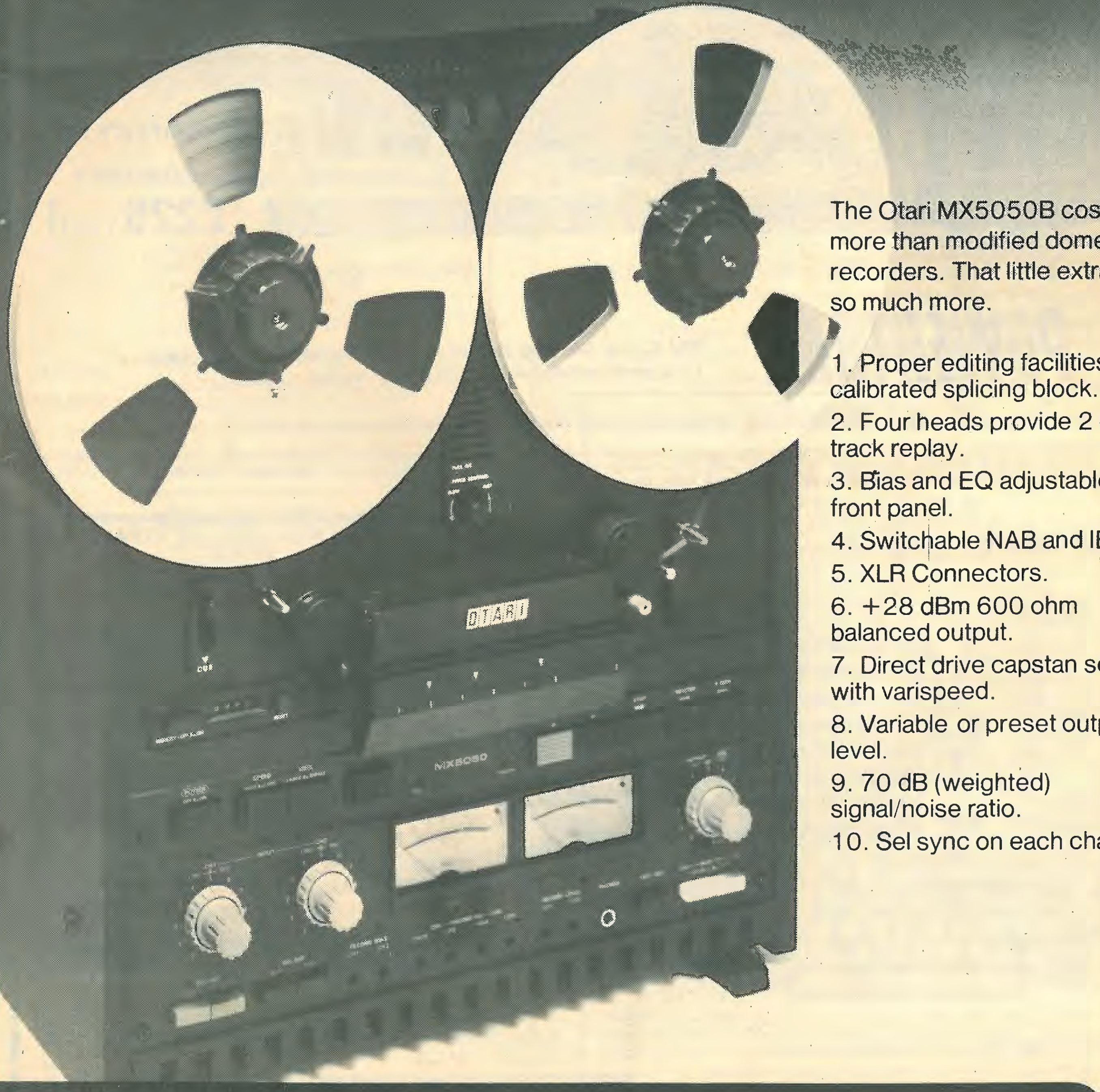
NEW FACTORY ON SAME INDUSTRIAL ESTATE ADDRESS AND TELEPHONE NUMBER UNCHANGED

POWERTRAN COMPUTERS

(a division of POWERTRAN ELECTRONICS)
PORTWAY INDUSTRIAL ESTATE ANDOVER HANTS SP10 3NN
ANDOVER (0264) 64455

"We've £150,000 worth of recording gear working 24 hours a day — all fed from the OTARI MX5050B. On a cost effectiveness basis alone the MX5050B is unbeatable, but when taking into account sheer professionalism and performance, it is unequalled by recorders three times the price."

Mike McLoughlin, Chief Engineer, Independent Tape Duplicators, Aylesbury.



The Otari MX5050B costs little more than modified domestic recorders. That little extra buys so much more.

1. Proper editing facilities with calibrated splicing block.
2. Four heads provide 2 or 4 track replay.
3. Bias and EQ adjustable from front panel.
4. Switchable NAB and IEC EQ.
5. XLR Connectors.
6. +28 dBm 600 ohm balanced output.
7. Direct drive capstan servo with varispeed.
8. Variable or preset output level.
9. 70 dB (weighted) signal/noise ratio.
10. Sel sync on each channel.

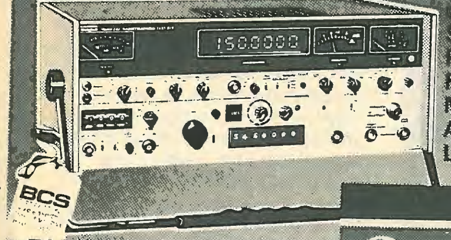
OTARI from ITA

1-7 Harewood Avenue, Marylebone Road, London NW1. Tel: 01-724 2497. Telex: 21879.

WW—096 FOR FURTHER DETAILS

RADIO TELEPHONE TEST SYSTEM

CHARACTERIZES RECEIVER & TRANSMITTER THOROUGHLY MEASURING VHF & UHF SENSITIVITY SELECTIVITY POWER FREQUENCY, MODULATION. ALSO IF. AF. OSC & LEVEL TESTS

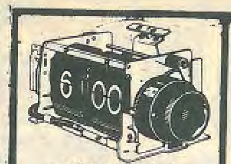


PLYMOUTH PL7 4LU
Tel: 333300

Quartzlock

WW — 058 FOR FURTHER DETAILS

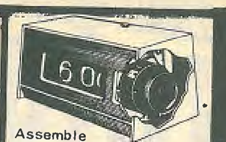
DIGITAL 24 HOUR CLOCK



MECHANISM WITH ALARM

£5.00

THREE FOR £13.50



Assemble it in an evening!
MECHANISM & CASE
Inc.assembly instructions

£6.99

- SILENT RUNNING
- LARGE ILLUMINATED NUMERALS

AS USED IN BRAUN DIGITAL CLOCKS

MECHANISMS 10 FOR £39. 100 FOR £300

- AC MAINS
- SIZE 6⅜ x 2⅜ x 2¾

Your receipt is a 2-year guarantee

HALF PRICE OFFER

HENRY'S Radio

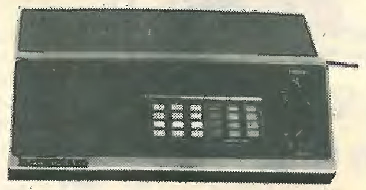
HENRY'S RADIO
404 EDGWARE ROAD,
LONDON W2 1ED

EXPORT ENQUIRIES INVITED
01-723 1008

DELIVERY FROM STOCK

AIR — MARINE — COMMERCIAL VHF/UHF MONITOR RECEIVER

Bearcat 220F



Frequency Range: 66-88, 118-136, 144-174, 450-512 MHz
Sensitivity: Better than 0.8μV for 10 dB
Send for details.

VHF FM MOBILE
2 WAY RADIO

Model **CT210** **NEW** Model **CT210**

- 10 watts RF power
- Up to 12 channels
- Home Office Approved
- Made by us in the UK
- Modular construction
- Small physical size

Export enquiries welcome

COM-TEK (MIDS) Ltd Reg office **506 Alum Rock Road, Birmingham B8 3HX**
Tel: 021-326 6343 Telex 339938

WW — 057 FOR FURTHER DETAILS

NEW, GUARANTEED, FULL SPEC. COMPONENTS

L.E.D.s .125 and .2

	RED	YELLOW or GREEN
1+	.08	.11
100+	.069	.10
1000+	.058	.09

1N4148 Diodes

1+	.02
100+	.016
1000+	.013

CARBON FILM RESISTORS E12 SERIES

Prices per 100. Larger and Mixed Quantity prices available.

.25W	
100 off one type	.70p
500 off one type	.64p
1000 off one type	.58p
.5W	
100 off one type	.90p
500 off one type	.80p
1000 off one type	.72p

T.I. LOW PROFILE I.C. SOCKETS

	1+	100+	500+
8pin	.075p	.068p	.06p
14pin	.09	.082	.073
16pin	.10	.096	.085
18pin	.125	.113	.10
20pin	.14	.126	.113
22pin	.15	.135	.12
24pin	.15	.135	.12
28pin	.16	.145	.125
40pin	.24	.215	.19

Please add £1.50 handling charge and 15% V.A.T.

We also stock transistors, diodes, TTL, CMOS, capacitors, instrument cases, switches, connectors etc. Free trade catalogue available. All enquiries welcome.

HARRISON BROS.
ELECTRONIC/DISTRIBUTORS
22 Milton Road, Westcliff-on-Sea, Essex
Telephone: Southend 32338

WW — 090 FOR FURTHER DETAILS

FOTOLAK

POSITIVE LIGHT SENSITIVE AEROSOL LACQUER

Enables YOU to produce perfect printed circuits in minutes! Method: Spray cleaned board with lacquer. When dry, place positive master of required circuit on now sensitized surface. Expose to daylight, develop and etch. Any number of exact copies can of course be made from one master. Widely used in industry for prototype work.

FOTOLAK	£2.00
Developer	30p
Ferric Chloride	50p

Pre-coated 1/16" Fibre-glass board	
204mm x 114mm	£1.50
204mm x 228mm	£3.00
408mm x 228mm	£600
467mm x 305mm	£9.00

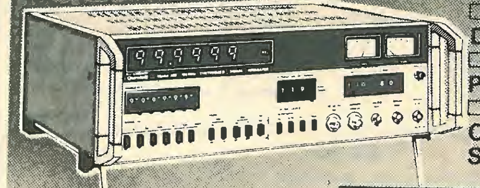
Plain Copper-clad Fibre-glass.	Single-sided	Double-sided
Approx. 3.18mm thick sq. ft.		£1 50
Approx. 2.00mm thick sq. ft.	£2.00	
Approx. 1.00mm thick sq. ft.	£1.50	£1.75
Clear Acetate Sheet for making master, 260mm x 260mm		12p

Postage and packing 65p per order. VAT 15% on total

G. F. MILWARD ELECTRONIC COMPONENTS LIMITED
369 Alum Rock Road, Birmingham B8 3DR. Telephone: 021-327 2339

SYNTHESIZED SIGNAL GENERATOR

- 100kHz to 100MHz
- > 40dB HARMONIC SUPPRESSION
- < 1% FM DISTORTION
- FULLY PROGRAMMABLE
- 1μV to 1V OUTPUT 1dB STEPS



PLYMOUTH PL7 4LU
Tel: 333300

Quartzlock

WW — 059 FOR FURTHER DETAILS

To obtain further details of any of the coded items mentioned in the Editorial or Advertisement pages of this issue, please complete one or more of the attached cards entering the reference number(s). Your enquiries will be passed on to the manufacturers concerned and you can expect to hear from them direct in due course. Cards posted from abroad require a stamp. These Service Cards are valid for six months from the date of publication.

Please Use Capital Letters

If you are way down on the circulation list, you may not be getting the information you require from the journal as soon as you should. Why not have your *own* copy?

To start a one year's subscription you may apply direct to us by using the card at the bottom of this page. You may also apply to the agent nearest to you, their address is shown below.

OVERSEAS SUBSCRIPTION AGENTS

Australia: Gordon & Gotch (Australasia) Ltd, 380 Lonsdale Street, Melbourne 3000, Victoria

Belgium: Agence et Messageries de la Presse, 1 Rue de la Petite-ILE Brussels 7

Canada: Davis Circulation Agency, 153 St. Clair Avenue West, Toronto 195, Ontario

Cyprus: General Press Agency Ltd, 131 Prodromou Street, P.O. Box 4528, Nicosia

Denmark: Dansk Bladdistribution, Hovedvagtsgade 8, Dk. 1103 Kobenhavn.

Finland: Rautakirja OY, Koivuvaarankuja 2, 01640 Vantaa 64, Finland.

France: Dawson-France S.A., B.P.40, F-91121, Palaiseau

Germany: W. E. Saarbach GmbH, 5 Koln 1, Follerstrasse 2

Greece: Hellenic Distribution Agency, P.O. Box 315, 245 Syngrou Avenue, Nea Smyrni, Greece.

Holland: Van Ditmar N.V., Oostelijke Handelskade 11, Amsterdam 1004

India: International Book House, Indian Mercantile Mansion Ext, Madame Cama Road, Bombay 1

Iran: A.D.A., 151 Khiaban Soraya, Tehran

Israel: Stelmatzky's Agency Ltd, Citrus House, P.O. Box 628, Tel Aviv

Italy: Intercontinental s.a.s. Via Veracini 9, 20124 Milano

Japan: Western Publications Distribution Agency, 170 Nishi-Okubo 4-chome, Shinjuku-Ku, Tokyo 160

Lebanon: Levant Distributors Co., P.O. Box 1181, Makdesi Street, Halim Hanna Bldg, Beirut

Malaysia: Times Distributors Sdn. Bhd., Times House, 390 Kim Seng Road, Singapore 9, Malaysia.

Malta: W. H. Smith Continental Ltd, 18a Scots Street, Valleta

New Zealand: Gordon & Gotch (New Zealand) Ltd, 102 Adelaide Road, Wellington 2

Nigeria: Daily Times of Nigeria Ltd, 3 Kakawa Street, P.O. Box 139, Lagos

Norway: A/S Narvesens Kioskompani, Bertrand Narvesens vei 2, Oslo 6

Portugal: Livaria Bertrand s.a.r.l Apartado 37, Amadora

South Africa: Central News Agency Ltd, P.O. Box 1033, Johannesburg

Spain: Comercial Atheneum s.a. Consejo de Ciento, 130-136 Barcelona 15

Sweden: Wennegren Williams A B. Fack S-104, 25 Stockholm 30

Switzerland: Naville & Cie SA, Rue Levrier 5-7, CH-1211 Geneve 1 Schmidt Agence AG, Savogelstrasse 34, 4002 Basle

U.S.A.: John Barios, IPC Business Press, 205 East 42nd Street, New York, N.Y. 10017

CUT HERE

Postage will be paid by Licensee

Do not affix Postage Stamps if posted in Gt. Britain, Channel Islands or N. Ireland

BUSINESS REPLY SERVICE
Licence No. 12045

2

WIRELESS WORLD,
PRODUCT REPLY SERVICE,
429 BRIGHTON ROAD,
SOUTH CROYDON,
SURREY
CR2 9PS

CUT HERE

Enquiry Service for Professional Readers

WIRELESS WORLD — Wireless World, May 1980 WW 065

WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....
WW	WW	WW ....

Please arrange for me to receive further details of the products listed, the appropriate reference numbers of which have been entered in the space provided.

Name ....

Name of Company ....

Address ....

....

Telephone Number ....

PUBLISHERS USE ONLY			A/E			

Position in Company ....

Nature of Company/Business ....

No. of employees at this establishment ....

I wish to subscribe to Wireless World ☐

VALID FOR SIX MONTHS ONLY

CUT HERE

Wireless World: Subscription Order Form

To become a subscriber to Wireless World please complete the reverse side of this form and return it with your remittance to:

Subscription Manager,
IPC Business Press,
Oakfield House, Perrymount Road,
Haywards Heath, Sussex RH16 3DH,
England

Enquiry Service for Professional Readers ONLY.

WIRELESS WORLD Wireless World, May 1980 WW 065

WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....

Please arrange for me to receive further details of the products listed, the appropriate reference numbers of which have been entered in the space provided.

Name ....

Position in Company ....

Name of Company ....

Address ....

....

Telephone Number ....

Nature of Company/Business ....

No. of employees at this establishment ....

VALID FOR SIX MONTHS ONLY

CUT HERE

Do not affix Postage Stamps if posted in Gt. Britain, Channel Islands or N. Ireland

Postage will be paid by Licensee

BUSINESS REPLY SERVICE
Licence No. 12045

2

WIRELESS WORLD,
PRODUCT REPLY SERVICE,
429 BRIGHTON ROAD,
SOUTH CROYDON,
SURREY
CR2 9PS

CUT HERE

Wireless World Subscription Order Form Wireless World, May 1980 WW 065

UK subscription rates
1 year: £9.00

Overseas ***1 year:*** £12.00

USA & Canada subscription rates
1 year: $31.00

Please enter my subscription to Wireless World for 1 year

I enclose remittance value..........**made payable to**
IPC BUSINESS PRESS Ltd.

Name..........

Address..........

....

....

CUT HERE

OVERSEAS ADVERTISEMENT AGENTS

Hungary Mrs. Edit Bajusz, Hungexpo Advertising Agency, Budapest XIV, Varosliget – Telephone: 225 008 – Telex: Budapest 22-4525 INTFOIRE

Italy Sig. C. Epis Etas-Kompass, S.p.a. – Servizio Estero, Via Mantegna 6, 20154 Milan – Telephone 347051 – Telex: 37342 Kompass

Japan Mr. Inatsuki, Trade Media – IBPA (Japan), B212 Azabu Heights, 1-5-10 Roppongi, Minato-Ku, Tokyo 106 – Telephone : (03) 585-0581

United States of America Ray Barnes, *IPC Business Press 205 East 42nd Street, *New York*, NY 10017 – Telephone: (212) 689 5961 – Telex: 421710
Mr. Jack Farley Jnr., The Farley Co., Suite 1548, 35 East Wacker Drive, *Chicago*, Illinois 60601 – Telephone: (312) 6 3074
Mr. Victor A Jauch, Elmatex International, P.O. Box 34607, Los Angeles Calif. 90034 U.S.A. Telephone: (213) 821 8581 Telex: 18 – 1059.
Mr. Jack Mentel, The Farley Co., Suite 605, Ranna Building, Cleveland, Ohio 4415 – Telephone: (216) 621 1919
Mr. Ray Rickles, Ray Rickles & Co., P.O. Box 2008, *Miami Beach, Florida* 33140 – Telephone: (305) 532 7301
Mr. Jim Parks, Ray Rickles & Co., 3116 Maple Drive N.E., Atlanta, Georgia 30305. Telephone: (404) 237 7432
Mike Loughlin, IPC Business Press, 15055 Memorials, Ste 119, Houston, Texas 77079 – Telephone: (713) 783 8673

Canada Mr. Colin H. MacCulloch, International Advertising Consultants Ltd. 915 Carlton Tower, 2 Carlton Street, Toronto 2 – Telephone (416) 364 2269

*Also subscription agents

reprints

If you are interested in a particular article/special Feature or advertisement published in this issue of

WIRELESS WORLD

why not take advantage of our reprint service.

Reprints can be secured at reasonable cost to your own specifications providing an attractive and valuable addition to your promotional material. *(Minimum order 250.)*

For further details contact:
Brian Bannister, IPC Electrical-Electronic Press Ltd. Phone: 01-261 8046 or simply complete and return the form below.

To: Brian Bannister, Reprints Department
Dorset House, Stamford Street
London SE1 9LU

I am interested in . . . . copies of the article/advertisement headed . . . . featured in

WIRELESS WORLD

on page(s) . . . . in the issue dated . . . .

Please send me full details of your reprint service by return of post.

Name . . . .
Company . . . .
Address . . . .
. . . . Tel. No. . . . .

MAIL ORDER PROTECTION SCHEME (Limited Liability)

If you order from mail order advertisers in this magazine, except for classified advertisements, and pay by post in advance of delivery, Wireless World will *consider* you for compensation if the advertiser should become insolvent or bankrupt, provided

1. You have not received the goods or had your money returned; and
2. You write to the publisher of Wireless World explaining the position not earlier than 28 days from the day you sent your order and not later than 2 months from that day.

Please do not wait until the last moment to inform us. When you write, we will tell you how to make your claim and what *evidence* of payment is required.

We guarantee to meet claims from readers made in accordance with the above procedure as soon as possible *after the advertiser has been declared bankrupt or insolvent* up to a limit of £3,550 per annum for any one advertiser so affected and up to £10,000 per annum in respect of all insolvent advertisers. Claims may be paid for higher amounts, or when the above procedure has not been complied with, at the discretion of Wireless World; but we do not guarantee to do so in view of the need to set some limit to this commitment and to learn quickly of readers' difficulties.

This guarantee covers only advance payments sent in **direct** response to an advertisement in this magazine (not, for example, payments made in response to catalogues, etc., received as a result of answering such advertisements. Personal advertisements are excluded.

Electronic Brokers

No.1 in Second User Test Equipment

A.C. VOLTMETERS

BOONTON
True R.M.S. Voltmeter 93A £375
BRUEL AND KJAER
Electronic Voltmeter 2409 £225
FLUKE
AC/DC Differential Voltmeter 883AB £975
HEWLETT PACKARD
True R.M.S. Voltmeter 3400A £415
MARCONI INSTRUMENTS
Log Voltmeter/Amplifier 7563A £445
A.C. Voltmeter 400E £225
A.C. Voltmeter 400F £195
A.C. Voltmeter 400EL £225
Valve Voltmeter TF 2600 £175
Valve Voltmetej TF 2604 £250
R.F. Millivoltmeter TF 2603 £525
PHILIPS
A.C. Millivoltmeter PM2454B £299

ANALYSERS

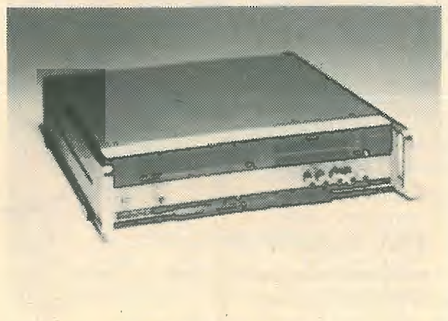
BIOMATION
Logic Analyser 1650D £3900
GENERAL RADIO
Vibration Analyser 1911A £2100
HEWLETT PACKARD
Spectrum Analyser 141T c/w 8552A & 8554L £5250
Logic Analyser 1600A £1850
Wave Analyser 310A £950
Network Analyser System 8407A/8412A £3500
MARCONI INSTRUMENTS
Wave Analyser TF 2330A £725
SOLATRON
Frequency Response Analyser 1172 £3900

BRIDGES

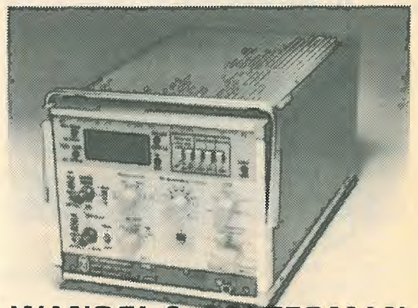
A.V.O./B.P.L.
Capacitance Bridge CZ154/5 £995
GENERAL RADIO
Immitance Bridge 1607A £750
LCR Brdige (0.05%) 1608A £1195
MARCONI INSTRUMENTS
Universal Bridge TF 1313 £395
Universal Bridge TF 1313A £790
In Situ Bridge TF 2701 £325
'Q' meter TF 1245A, c/w TF 1246 & TF 1247 £1450
'Q' meter TF1245 c/w TF1246 and TF1247 £950
ROHDE AND SCHWARZ
Inductance Meter LRT £475
Capacitance Meter KRT £475
WAYNE KERR
Universal Bridge B 642 £695
Source and Detector SR 268 £950
A.C. Testamatic A60 £1500
Universal Bridge B221 (0.1%) £275

D.V.M.'S AND D.M.M.'S

DATRON
5½ digit D.V.M. 1051 £995
FLUKE
3½ digit D.M.M. 8022A (New) £89
3½ digit D.M.M. 8020A £99
4½ digit D.M.M. 8600A £285
5½ digit D.M.M. 8800A £599
5½ digit D.M.M. 8800A-01 £650
PHILIPS
Autoranging D.M.M. PM 2514 £125
3½ digit D.M.M. PM 2522 £175
4 digit D.M.M. PM 2527 £299
Autoranging D.M.M. PM 2527 £400



HEWLETT PACKARD
5½ digit D.M.M. 3490A
AC-DC Volts and Resistance
Self Check Facility £550



WANDEL & GOLTERMAN
Digital Error Rate
Measuring Set Up. PF-1
Comprising PFG-1 @ £995
PFM-1 @ £1495

MARCONI INSTRUMENTS
R.C. Oscillator TF 1370A
10 Hz-10MHz £275

HEWLETT PACKARD
Network Analyser System
8407A/8412A. 110MHz £3500

SCHLUMBERGER
5½ digit D.M.M. A243 £595
Microprocessor D.M.M. 7065 £1150
Microprocessor with processor option £1450
Microprocessor D.M.M. 7055 £975
Microprocessor with processor option £1300

FREQUENCY COUNTERS

ADVANCE
500MHz Counter TC 15 & TC 15 P1 £495
FLUKE
250MHz Multifunction Counter 1911A-01 £380
500MHz Multifunction Counter 1912A £480
125MHz Multifunction Counter 1925A £405
Counter Tracer 1953A opt. 15 & 16 £850
PHILIPS
1GHz Timer Counter PM 6615 £795
80MHz Universal Counter PM 6611/02 £350

OSCILLOSCOPES

COSSOR
35 MHz Dual Trace CDU 150 £395
75 MHz Dual Trace 4100 £695
HEWLETT PACKARD
75 MHz Dual Trace 1707A £725
High Sensitivity Single Trace 130C £250
75MHz Dual Trace 1707B £925

MARCONI INSTRUMENTS
X-Y Display TF 2213/1 c/w Memory Unit TK 2214 £790
PHILIPS
15MHz Dual Trace PM 3211 £450
25MHz Dual Trace PM 3212 £625
120MHz Dual Trace PM 3260 £1095
120MHz Dual Trace PM 3261 £1250
TEKTRONIX
10MHz Dual Trace Battery/Mains 326 £795
25MHz Storage Scope 434 £1600
10MHz Storage Scope 564B model 121N c/w 3A6 & 3B3 £950
35MHz Dual Trace T932 £550
1MHz Miniscope/D.M.M. 213 £950
W. Diff. Plug In £295
1A6 Plug In £199

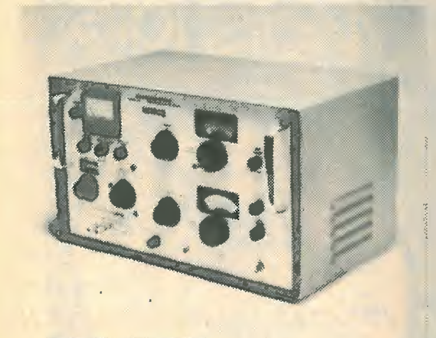
RECORDERS

PHILIPS
Single Channel Recorder PM 8110 £225
RACAL
F.M. Recorder Store 4 £2600
SHANDON SOUTHERN
6 Channel U/V Recorder 10-650 £725
WATANABE
6 Channel Chart Recorder MC 641 £2250
YOKOGAWA
Chart Recorder 3047 £530

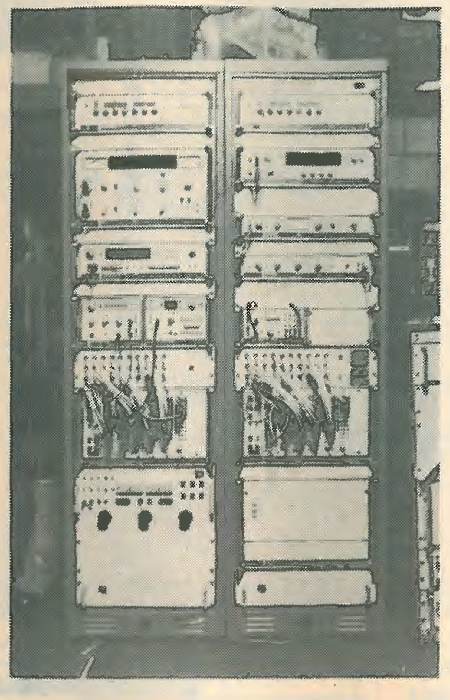
49/53 Pancras Road London NW1 2QB Tel: 01-837 7781. Telex 298694

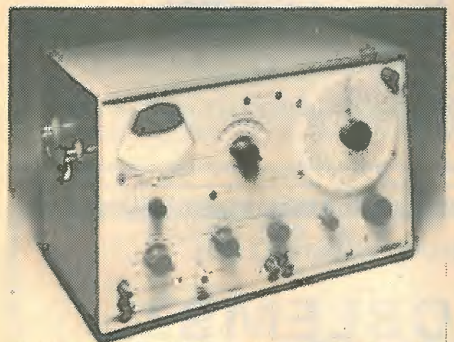
Unless otherwise stated all equipment offered in the Electronic Brokers advertisement is refurbished and in the case of Test Equipment also calibrated. Test equipment is guaranteed for 12 months; computer peripherals for 3 months.

WW — 100 FOR FURTHER DETAILS



BOONTON
Inductance Bridge 63H
0-110mH 0.25%
50KHz-500KHz £2750





MARCONI INSTRUMENTS
Wave Analyser TF2330
Frequency Range
20Hz-50KHz £395

WANDEL & GOLTERMAN
Complete P.C.M. System
— ANDIMAT P.O.A.

SIGNAL SOURCES

HEWLETT PACKARD
Variable Phase, Sine and Signal Generator 203A £495
Oscillator 10Hz-10MHz 651B £415
V.H.F. Oscillator 3200B £495
Decade Oscillator 4204A £750
U.H.F. Signal Generator 612A £850
V.H.F. Signal Generator 608F £450
MARCONI INSTRUMENTS
A.F. Oscillator TF 2000 £325
A.F. Oscillator TF 2100 £150
A.M. Signal Generator. TF801D/8S £550
L.F. Oscillator TF 2102/1M1 £195
U.H.F. Signal Generator TF1060/3 £650
Two Tone Source TF 2005R £295
H.F. Generator TF 144H/4 £750
PHILIPS
Function Generator PM 5108 £250
Function Generator PM 5127 £395
Function Generator PM 5167 £725

MISCELLANEOUS

ADVANCE
Pulse Generator PG 59 (CT 600) £595
Off Air Frequency Standard OFS 2B £200
AVO
Valve Tester VCM 163 £475

BRUEL KJAER
Sound Level Meter 2203 & Microphone 4145 £450
DATALABS
Power Line Disturbance Monitor DL019 £300
FLUKE
DC Differential Voltmeter 895A £950
Meter Calibrator 760A/AF £2150
GENERAL RADIO
Sound Level Meter 1933 £2000
Cassette Recorder 1935
HEWLETT PACKARD
Power Meter 432A & 478A £450
Sweeper & Marker Generator 8601A & 8600A £1950
DC Microvolt-ammeter 425A £250
AC/DC Differential Voltmeter 741B £695
Vector Impedance Meter 4815A £1950
LYONS
Pulse Generator PG 22 £225
MARCONI
M.F. Attenuator TF 2162 £135
A.F. Power Meter TF 893A £185
Transmission Test Set TF 2332 £425
Transmission Test Set TF 2333 £600
P.C.M. Regenerator Test Set 0A 2805A £3500
P.C.M. Multiplex Tester TF 2807 £1800

ROHDE AND SCHWARZ
Stereocoder MSC £850
TEKTRONIX
Pulse Generator 2101 £420
Time Mark Generator 184 £275
Time Mark Generator 2901 £395
TEXSCAN
Sweep Generator VS 40 £650
WAVETEK
Sweep Generator 135 £275
Programmable Phase Meter 755 £550

Also large stock of Wandel & Goltermann and Siemens Level Oscillators, Receivers, Sweep Systems etc. Phone us with your requirements.

ONLY SMALL SELECTION OF OUR VAST STOCKS SHOWN HERE — SEND FOR LATEST CATALOGUE

Electronic Brokers unique catalogue contains 62 pages plus update of second user Test Equipment, and Mini Computers and Peripherals. Vast lists of Signal Sources, Oscilloscopes, DVMs, Counters, Recorders, DEC Compuzers, VDUs, Teletypes, etc. Largest stocks— most cost effective.

LATEST EDITION. SENT FREE IN UK
Airmail to overseas addresses £2.00

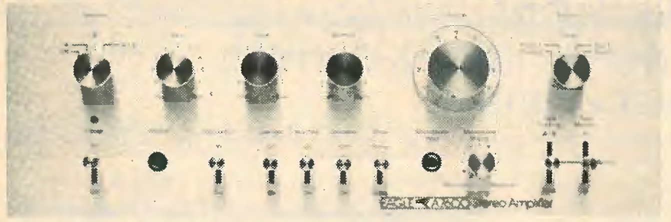
49/53 Pancras Road London NW1 2QB Tel: 01-837 7781. Telex 298694

Hours of Business: 9 a.m.-5 p.m., Mon.-Fri. Closed lunch 1-2 p.m.
Add 15% VAT to ALL PRICES

A copy of our trading conditions is available on request.
Carriage and Packing charge extra on all items unless otherwise stated.

WW — 100 FOR FURTHER DETAILS

HI-FI SEPARATES



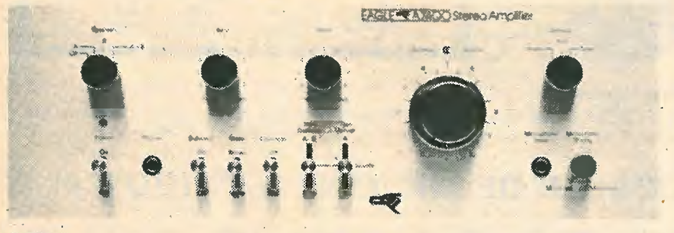
A7600

The top-of-the-range is the A7600 75 watts per channel amplifier. With enough power to fill a hall, it gives you a unique range of facilities.

Connect not just one cassette deck, but two (or a reel-to-reel recorder) and use it for tape transfers and dubbing. The monitor switch lets you check the quality as you go. Connect two turntables if you wish. And use the microphone mixing facility as well.

There's never been such a sophisticated amplifier for such a reasonable price before.

PRICE £77.40 EX. V.A.T.



A7400

If 50 watts per channel is all you need, then go for the A7400. It has virtually all of the features of the A7600 except for the second turntable facility.

And if you want to fill your house with crystal clear sound, then choose the medium priced A7400.

PRICE £65.54 EX. V.A.T.

T7400 TUNER (not shown)

A medium wave and FM (VHF) tuner matched perfectly to the two amplifiers shown.

PRICE £65.54 EX. V.A.T.

EAGLE

KEW 6

KEW 6. Current ranges Amps 150-30 AC. Voltage ranges 600-300-150 AC. Resistance ranges (mid-scale) 300 ohms (25 ohms). Jaw size 27mm/1 inch. Accuracy A/V ± 3. (% FSD) Ω± 3. Overall length 190mm. Approx. weight 285g. **PRICE £25.95** EX. V.A.T.

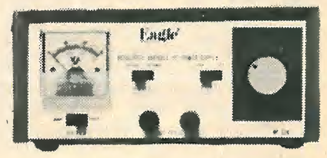
HME 450

HME 450. De-luxe padded headphone and earpieces. This is essential for long periods of use, e.g. advanced language classes.

Conforms to C.E.T. UNSPEC No. 17.

EDUCATIONAL/INDUSTRIAL HEADPHONES

PRICE £3.95 EX. V.A.T.

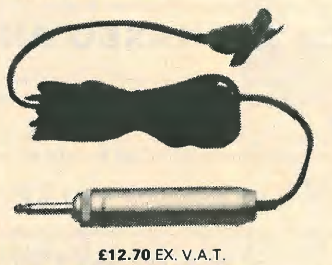


RP 124

- 0 to 24V DC from mains
- 1 Amp load

Semi-regulated bench power supply with variable output in two ranges, 0 to 12V DC and 12 to 24V DC via changeover switch. The meter can be switched to show output voltage or current drain.
Voltage: 220 to 240V AC in % to 24V DC out.
Max current: 1 Amp
Regulations: 5% no load to full load
Dimensions: 85 x 185 x 105mm.

PRICE £27.75 EX. V.A.T.



£12.70 EX. V.A.T.

TIECLIP CAPACITOR

PRO M5

Omnidirectional
Impedance: 600 ohms
Sensitivity: 1.10mV (—59 dBV)
Frequency response: 70-2000Hz
Battery type: Ever Ready HP7
Cable: 5.8 metres, low noise
Connector: ¼" (6.35mm) Jack Plug
Supplied in transportation box complete with tieclip.

EAGLE in our **1980** catalogue you will find a full range including: Sound Systems, Hi-Fi Separates, Loudspeakers, Cartridges, Radios, Cassette Recorders, Headphones, Microphones, In-Car Entertainment, Aerials, Speaker Units, Intercoms, Telephone Amplifiers, Test Meters, Public Address Systems, Industrial Intercoms, Fire Security, Test Equipment, and much more.

A.C. ADAPTOR (Battery Charger) 120 vac input, 5.8 vdc, at 200 mA output. USA type mains plug to 3.5mm jack plug. Brand new & boxed. **£1.25 each.**
A.C. ADAPTOR (Battery Charger) 117 vac. input, 4.5 vdc at 150 mA output. USA type mains plug to 2.5 mm jack plug. Brand new and boxed. **£1.00 each.**
VARICAP TUNER HEADS, 4 button type, 22K res. with AFC switch & station indicator. Brand new. **£2.00 each.**
SCREWS. Pack of nuts, bolts, washers, tags, self taps etc. Mixed BA & metric. Sold by weight. **£2.00 per Kilo.**
LOW VOLTAGE ELECTROLYTICS. Pack of mixed values & voltages. Approx. 150 items. **£1.50.**
JAYBEAM STARBEAM UHF set top aerials. Brand new & boxed. **£2.00 each.**
MODERN TELEPHONES Type 746 with dials, colour cream, used but new condition. **£8.00 each.**
ERSIN MULTICORE SOLDER. 3 core solder wound on a plastic reel. 20 swg. Ally 60/40 tin lead. Available in 500 gm reels. **£5.70 each.**
CHANNEL MASTER COLORATOR aerial rotator Model 9502. Rotation speed 1 rpm, gear ratio 3200:1, 3 conductor wire for economy, pinpoint positioning to within one degree. Few only at **£45.00.** We also stock Jaybeam T.V. and Radio aerials. SAE for lists.
ISEP SLOTTED HORIZONTAL RAIL available in 9ft. lengths. **£4.00 each.**
WATCH STRAPS. Black stainless steel **50p each.** Black plastic **25p each.** Watch spring bars 10p each. Discount for Quantity.
RADIOGRAM lid pumps **£1.00 each,** 2 for **£1.50.**
RIBBON CABLE 19 way decimal coded, 4 metres for **£1.25.**
BYX25-100 & BYX25R Rectifiers. 1000v 20A mounted on finned heatsink. Ex-Equip. **£1.25 each.**
BZY93C75 Diodes. 75v 20W Zener mounted on finned heatsink similar to above. Ex-Equip. **75p each.**
BNC RIGHT ANGLED PLUGS. 75 ohm type GE 37502 C12 **50p each** or 12 for **£5.00.**
LARGE range of die-cast boxes.
XTALS. 10.7MHz HC6U type **£2.00 each.**
CONVERTER 12V to 24V 2 Amp built-in die-cast box, brand new ex. equipment supplied with circuit diagram. **£5.00 each.**
AIRTECH UHF FILTER. Duplexer Model M450-4A 4 cavity type fitted with "N" type connectors. **£25.00 each.**

RADIOTELEPHONE EQUIPMENT
PYE WESTMINSTER W15AM high band & low band available, Sets complete and in good condition but are less speakers, mikes, cradles and LT leads (sets only) **£70.00 each.**
PYE WESTMINSTER W15AMB (Boot Mount) low band complete with control gear and accessories, and in good condition **£80.00 each.**
PYE WESTMINSTER W30AM low band, sets only no control gear, complete and in good condition. **£45.00 each.**
PYE BASE STATION F27 Low & High band, few only at £75.00 each.
PYE BASE STATION F30 AM Low & High band, with & without T/T. Prices from **£220.00 each.**
PYE CAMBRIDGE AM10B (Boot Mount) low band, 12.5 kHz, sets only, no control gear, good condition. **£20.00 each.**
PYE UHF LINK U450L Base Station Tx **£15.00,** R x **£15.00,** or **£25.00** for the two. Sold as seen.
PYE BC14 Battery Charger for PF1 (pocketfone) batteries, will charge up to 12 Tx batteries & 12 Rx batteries at the same time. **£15.00 each.**
PYE RTC Controller Units, for remotely controlling a VHF or UHF fixed station radiotelephones over landlines. **£20.00 each.**
PYE PF1 Pocketfones, suitable for conversion to 70cm, sets complete but less batteries, supplied with service manual. **£26.00** per pair.
PYE TELECOM Yagi aerials. 4 element, very rugged construction, 71.1 mHz (ideal for four metres). Brand new, **£10.00.**

SEMICONDUCTORS
BFY50 Transistors 4 for **60p.**
BSX20 (VHF osc/mult) 3 for **50p.**
BC108 (metal can) 4 for **50p.**
BC109 (metal can) 4 for **50p.**
2N3819 fet. 3 for **60p.**
BC158 PNP Silicon. 4 for **50p.**
741CG Op Amps. 4 for **£1.00.**
TIP 2955 Silicon PNP. 2 for **£1.50.**
LM309K 5v Regulator **£1.00.**
BCY72 Transistors. 4 for **50p.**
BC107 (metal can). 4 for **50p.**
PCB108 (plastic BC108). 5 for **50p.**
BF152 (UHF amp/mixer). 3 for **50p.**
BC148 NPN Silicon. 4 for **50p.**
BAY31 Signal Diode. 10 for **35p.**
SCR400V at 3A stud type. 2 for **£1.00.**
1N4148 (1N914) diodes 10 for **25p.**
LM340/12 12v Regulator. **£1.00.**

IC TEST CLIPS, clip over IC while still soldered to pcb or in socket. Gold plated pins, ideal for experimenters or service engineers. 28 pin DIL **£1.75.** 40 pin DIL **£2.00.** Or save by buying one of each for **£3.50.**
IC AUDIO AMP. PCB. Output 2 watts into 3 ohm speaker. 12 volt DC supply. Size approx. 5½" x 1½" x1" high with integral heatsink, complete with circuits. **£2.00 each.**
NICAD CHARGER CONVERTER PCB. (Low power inverter.) Size 4" x 1¾" x 1" high, 12v dc supply. 60v dc output through pot on pcb for charging portable batteries from mobile supply. Only needs one BFY50/51/52 or similar transistor which can be mounted direct on the pcb pins on the board fitted with a star type heatsink (not supplied). **£2.00 each.**
10.7 MHz SSB XTAL FILTERS (2.4 kHz Bandwidth.) Low imp. type. Carrier and unwanted sideband rejection min —40db (needs 10.69835 & 10.70165 xtals for USB/LSB, not supplied). Size approx. 2" x 1" x 1". **£10.00 each.**
LOW PASS FILTERS. (Low imp. type.) 2-9 MHz, small metal encapsulation. Size 1½" x ¾" x ¾". **75p each.**
BSR AUTOCHANGE RECORD PLAYER DECKS with cue device. 33-45-78 rpm for 7", 10", 12" records. Fitted with SC12M Stereo Ceramic cartridge and styli. Brand new. **£12.00 each.**
XTALS FOR TV SYNC GEN. 20.25 kHz for 405 line. B7G glass type. **£2.00 each.**
RED LEDs (Min. type). 50 for **70p.**
VIDICON SCAN COILS (Transistor type, but no data), complete with vidicon base, **£3.50 each.** Brand new.
UR41 ATTENUATOR CABLE. Nominal 72ohm, overall dia. approx. ¼", Att. per 100ft: 100 MHz 218dB, 200 MHz 316dB, 600 MHz 449dB, 3000 MHz 625dB. Ideal for Rx or Low power Tx fixed attenuators. Supplied with annenuation graph. 4 metres for **£1.00.**
HIGH QUALITY RELAYS, 4 pole C/O. 3A contacts, 12V DC coil, 150 ohm. Size approx. 1" x ¾" x 1¼", with plastic covers. **80p each** or 2 for **£1.50.**
OSMOR REED RELAY COILS (for reed relays up to ⅛" dia. not supplied), 12V, 500ohm coil. 2 for **50p.**
RIGHT ANGLED UHF SERIES ADAPTORS, PL259 to SO239 **£1.00 each.**
BACK-TO-BACK SO239 SOCKETS, £1.00 each.

1980 CATALOGUE contains 104 pages. Send only 95p and you will also receive 3 bi-monthly Shortform Catalogues, to keep you up to date with special offers and latest prices. Catalogue includes products by Eagle, Weller, Draper, Spiralux, Knipex, Servisol, Jaybeam, Vero, Amtron, Yaesu and microwave modules. Books by Barnard's and Babani, Newnes and others.

TERMS OF BUSINESS: Cheques or P.O. with order, made payable to B. Bamber Electronics, or phone your Access or Barclaycard No. Please add **15% VAT** on all goods advertised after adding postage as applicable.
CARRIAGE: Orders under £5.00 nett invoice add 75p. Orders over £5.00 but less than £20.00 add 50p. Orders over £20.00 carriage paid. **Callers welcome.** Tues.-Sat. 9.30 a.m.-5.30 p.m.

B. BAMBER ELECTRONICS
DEPT. W.W., 5 STATION ROAD, LITTLEPORT, CAMBS CB6 1QE
TEL: ELY (0353) 860185

TERMINAL BARGAINS

ITEL Model 1051

- ★ IBM GOLFBALL Typewriter
- ★ RS 232/V24 Interface
- ★ Full upper/lower case character set
- ★ Paper tape reader/punch
- ★ Works as stand-alone word processor
- ★ Full technical information available
- ★ **£375.00**

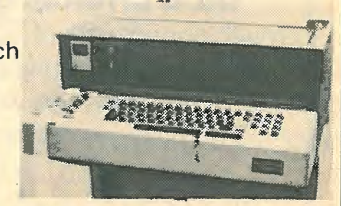
DI/AN Model 3030

- ★ 30 cps KSR terminal similar to DECwriter
- ★ 110, 150, 300 BAUD
- ★ Upper/lower case
- ★ Compact, desk top size
- ★ Optically isolated RS 232 interface
- ★ £395.00 (also available with tape reader/punch at **£750.00**

DATA DYNAMICS KSR 390

- ★ Printing terminal
- ★ RS 232 interface
- ★ Optional stand available at no extra cost
- ★ In first-rate condition
- ★ **£175.00** (ASR teletypes available from **£275.00**)

OLIVETTI Model 318/328

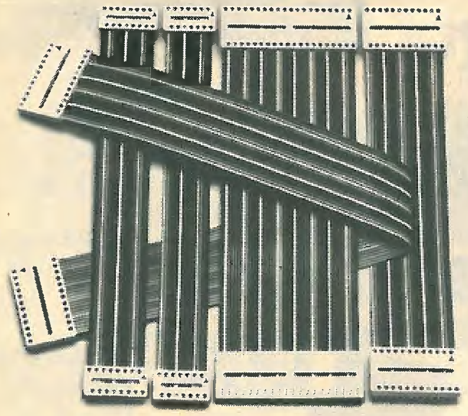


- ★ ASCII coded
- ★ Paper tape reader and punch
- ★ TTY compatible interface
- ★ RS 232 line unit
- ★ Free optional stand
- ★ **£100.00** (correspondence quality u/l case version available at **£250.00**)

COMPUTER APPRECIATION 86 High Street, Bletchingley, Surrey 0883 (Godstone) 843221

AP DIP Jumpers Lowest Prices in the UK!

Compare These Prices!

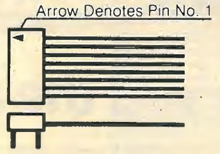


FLAT RIBBON CABLE ASSEMBLIES WITH DIP CONNECTORS

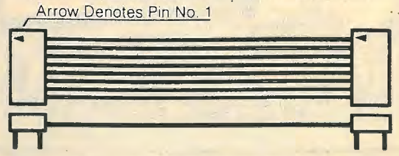
AP DIP Jumpers are the low-cost, high quality solution for jumpering within a PC board; interconnecting between PC boards, backplanes and motherboards; interfacing In-out/Output signals; and more.

All assemblies use ribbon cable. Standard lengths are 6, 12, 18, 24 and 36 inches.

SINGLE-ENDED DIP JUMPERS



DOUBLE-ENDED DIP JUMPERS



- **Available with 14, 16, 24 and 40 contacts.**
- **Mate with standard IC sockets.**
- **Fully assembled and tested.**
- **Integral molded-on strain relief.**
- **Line-by-line probeability.**

Faster and Easier is what we're all about.

- ★ Ex stock delivery
- ★ Ask for free catalogue
- ★ All prices for 1 off. Huge discounts for quantity.

SINGLE ENDED

PINS	36"
14	£1.75
16	£1.94
24	£3.00
40	£5.03

DOUBLE ENDED

PINS	6"	12"	18"	24"	36"
14	£1.81	£1.96	£2.12	£2.27	£2.57
16	£1.99	£2.16	£2.33	£2.50	£2.85
24	£3.11	£3.38	£3.64	£3.90	£4.43
40	£5.20	£5.64	£6.08	£6.53	£7.41

AP PRODUCTS INCORPORATED
PO Box 19
SAFFRON WALDEN ESSEX
Tel: (0799) 22036

"HOW CAN I BE SURE OF BUYING THE RIGHT VIDEO?"

It's easy to make mistakes when buying video equipment.

Buy the cheapest and you may soon find that it can't meet the varying needs of all the people (in marketing, management, training and security, for example) who will want to use it.

Buy the most expensive and you could literally waste thousands on features never used.

Forget compatibility and the future and you could find yourself spending more money on extra equipment – or discarding equipment you've just bought.

WIDE CHOICE. GOOD ADVICE.

Through our network of Video Centres, we at Bell & Howell distribute one of the largest video ranges in the U.K. This means that we can offer well-founded advice about the many options and thus help you avoid investing in mistakes. So talk to us before buying video. Ask us "What's right for me?"

We answer that question by first helping you to define how you're going to use a video system.

We pose the questions buyers often forget to ask (and sellers sometimes ignore). Who will use it? When? And where? Is colour necessary? Do you want to edit your own programmes? Will you use tapes from libraries or other companies? Will you want a lot of duplicate tapes?

From your answers we can build up a video package to meet your exact needs. It could be a simple monochrome camera with a VHS video recorder. Or a sophisticated three-tube colour camera with portable recorder, monitor and electronic editing suite. Whatever it is, we make this promise.

If you don't need something, we'll tell you so. If you do need it, we can supply it – all the way to a total video system which, because it has been tailored to your individual needs, will be right for you.

AND SUPERSHIELD.

No matter what you buy from the Bell & Howell video range, our unique Supershield warranty will guarantee you free adjustments, repairs or replacements (except for tapes and tubes) for two years after purchase. And if the job can't be done on the spot, we'll provide transport to and from a specially equipped Supershield video workshop.

Like our practical advice, that's also free. Because we believe Service starts before a sale and continues long, long after.

Let Bell & Howell show you the answer.

To Pieter Glas, Bell & Howell A-V Ltd., Freepost, Wembley, Middlesex HA0 1BR.
I'd like to discuss video with Bell & Howell.

Name ______

Organisation ______

Address ______

WW 5

BELL & HOWELL
BELL & HOWELL
BELL & HOWELL

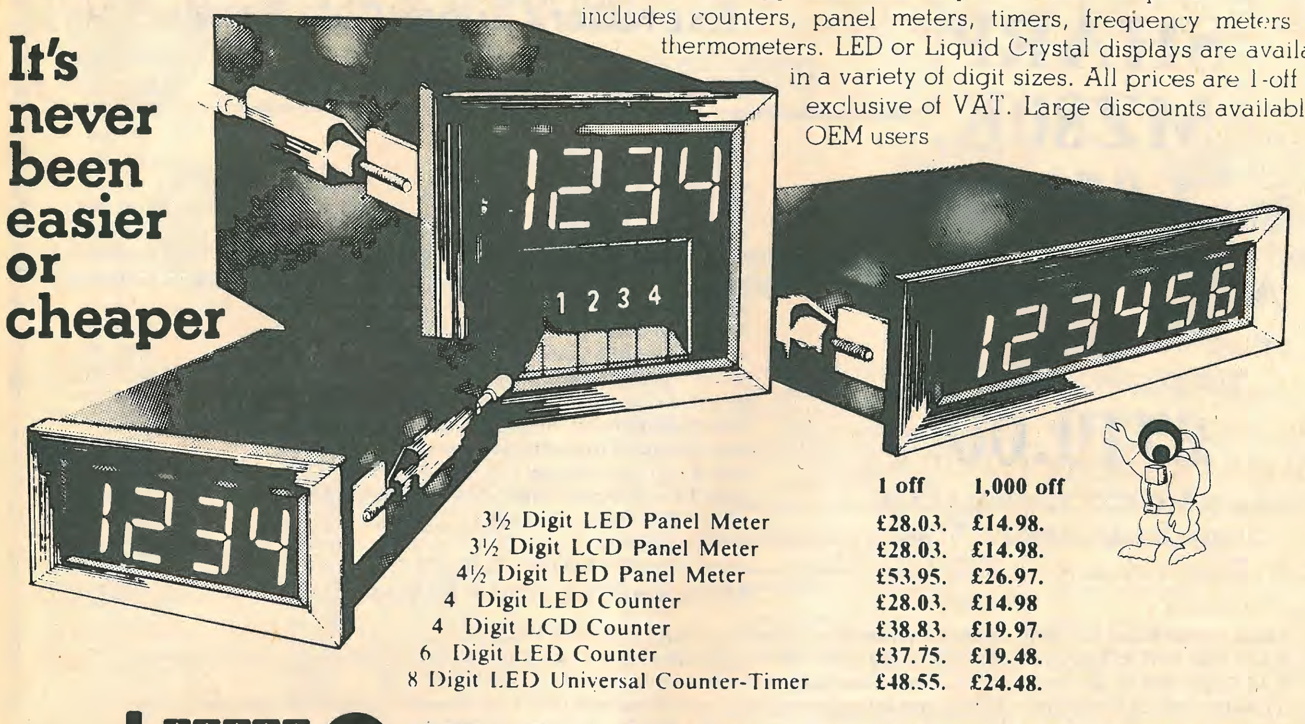
JVC CAMERAS. JVC RECORDERS. JVC STUDIO EQUIPMENT. JVC MONITORS. ELECTROHOME MONITORS. FUJI VIDEO TAPES.

WW — 100 FOR FURTHER DETAILS

..GO DIGITAL IN 1980..

Lascar's new range of DIN-Cased Digital Display Products are low-cost, compact alternatives to electro-mechanical products. They give high levels of accuracy and enhance the appearance of any instrument or panel. The range includes counters, panel meters, timers, frequency meters and thermometers. LED or Liquid Crystal displays are available in a variety of digit sizes. All prices are 1-off and exclusive of VAT. Large discounts available to OEM users

It's never been easier or cheaper



	1 off	1,000 off
3½ Digit LED Panel Meter	£28.03.	£14.98.
3½ Digit LCD Panel Meter	£28.03.	£14.98.
4½ Digit LED Panel Meter	£53.95.	£26.97.
4 Digit LED Counter	£28.03.	£14.98
4 Digit LCD Counter	£38.83.	£19.97.
6 Digit LED Counter	£37.75.	£19.48.
8 Digit LED Universal Counter-Timer	£48.55.	£24.48.

Lascar Electronics UNIT 1, THOMASIN ROAD, BURNT MILLS INDUSTRIAL ESTATE, BASILDON, ESSEX SS13 1LH TEL: BASILDON (0268) 727383

WW — 093 FOR FURTHER DETAILS

People in the know, keep in touch.

Call your secretary, factory manager, accountant or even hold a conference – all at the press of a button using the first easy to install 100% British designed and manufactured Duplex Intercom System.

Featuring: Operation on a 6 wire system. • Plug in anywhere on the system. • Retain identity station number. • Up to 56 stations. • Two speech channels. • 24 Volt supply. • All from the smallest central unit available and of course the least expensive.

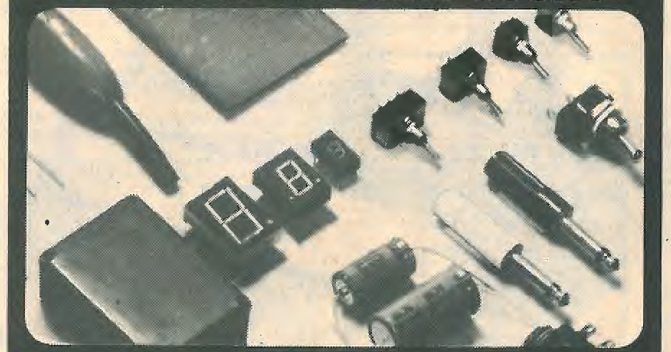
Barkway keeps you in touch...
Write or phone NOW for further details.

Barkway Electronics Ltd.,
Barkway, Royston,
Herts SG8 8EE, England.
Tel: Barkway (0763 84) 666
Telex: 817651 BARCOM G

Barkway

WW — 101 FOR FURTHER DETAILS

ELECTROVALUE
COMPONENTS THAT COUNT



SIEMENS	NASCOM	VERO
SEMI-CONDUCTOR CAPACITORS FERRITES	MICRO COMPUTERS AND ANCILLARIES	BOARDS CASES & KITS
ISKRA RESISTORS	RADIOHM POTENTIOMETERS / OPTO-ELECTRONICS	BREADBOARDS / SOLDER TOOLS / SWITCHES / CATALOGUE 10

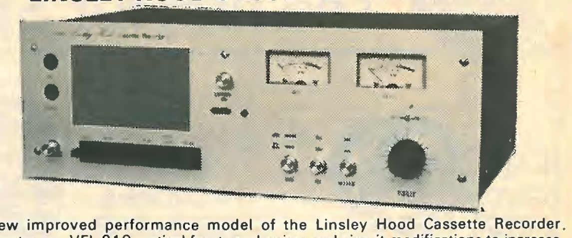
GOOD DISCOUNTS AND FREE POSTAGE ON U.K. ORDERS OVER £5.75
COMPUTER-CONTROLLED SERVICE AIDS PROMPT DELIVERY
128-PAGE CATALOGUE FREE FOR THE ASKING

ELECTROVALUE LTD., 28 (W5), St. Jude's Road, Englefield Green, Egham, Surrey TW20 0HB. Phone: 33603 (London 87) **STD 0784. Telex 264475.**

NORTHERN BRANCH (Personal Shoppers Only): 680 Burnage Lane, Burnage, Manchester M19 1NA. Phone (061) 432 4945.

J. L. Linsley Hood High Quality Cassette Recorders

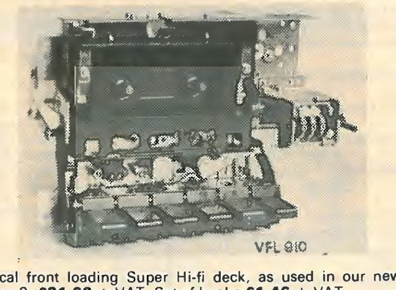
LINSLEY HOOD CASSETTE RECORDER 2



Our new improved performance model of the Linsley Hood Cassette Recorder, incorporates our VFL 910 vertical front mechanism and circuit modifications to increase dynamic range. Board layouts have been altered and improved but retain the outstandingly successful mother and daughter arrangement used on our Linsley Hood Cassette Recorder 1.
This latest version has the following extra features. Ultra low wow-and-flutter of .09% — easily meets DIN Hi-fi spec. Deck controls latch in rewind modes and do not have to be held. Full Auto stop on all modes. Tape counter with memory rewind. Oil damped cassette door. Latching record button for level setting. Dual concentric input level controls. Phone output. Microphone input facility if required. Record interlock prevents re-recording on valued cassettes. Frequency generating feedback servo drive motor with built-in speed control for thermal stability. All these desirable and useful features added to the excellent design of the Linsley-Hood circuits and the quality of the components used makes this new kit comparable with built-up units of much higher cost than the modest **£94.90** + VAT we ask for the complete kit.

LINSLEY HOOD CASSETTE RECORDER 1

We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, easily built and tested layout. All these features added to the high quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our new HS15 Sendust Alloy record/play head, available separately at **£7.60** plus VAT, but included FREE as part of the complete kit at **£81.50** plus VAT.
REPRINTS of the 3 articles describing this design **45p** No VAT.
REPRINT of Postcript article **30p** No VAT.



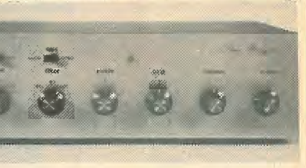
VFL 910. Vertical front loading Super Hi-fi deck, as used in our new Linsley-Hood Cassette Recorder 2. **£31.99** + VAT. Set of knobs **£1.46** + VAT.

SUPER BARGAIN OFFER
LENCO FFR CASSETTE DECK

For those who missed our recent bargain CT4s we now are delighted to be able to offer Brand New Lenco FFR Decks complete with motor speed and auto-stop control board fitted and tested. These will operate with any supply between 9 and 16 volts. This deck can be used for both record and playback applications and is fitted with an erase head. A mono record/play head is fitted and we can supply an extra stereo head, if ordered with the deck at the very special price of £2 plus VAT. We also supply, with each deck and completely FREE, one of our specially moulded escutcheons. This deck would normally cost about £25 but we are able to offer them, while they last, at only £9.99 plus VAT.

BAILEY 30 WATT AMPLIFIER

We have now completed our redesign of this popular amplifier to make it as easy to build as our latest kits. The power amplifiers are complete modules plugging into a power supply master board, all possible wiring has been eliminated but faith has been maintained with the existing metal work to enable owners to update if they wish. Send for full details in our list.



LINSLEY HOOD 30-WATT AMPLIFIER

Advanced new cost-effective amplifier of impeccable specification from the 'master'. Published in the January and February issues of Hi-Fi News. We are supplying full kits to our usual professional standard.

STUART TAPE CIRCUITS
(For reel-to-reel decks)

These circuits are just the thing for converting that old valve tape deck into a useful transistorised recorder. Total system is a full three head recorder with separate record and replay sections for simultaneous off tape monitoring. We also stock the heads. This kit is well engineered but does not have the detailed instructions that we give with our more recent designs. We would not therefore recommend it to beginners. Reprints of the original three articles 45p. Post free. No VAT.

CASSETTE HEADS

HS15 SENDUST ALLOY SUPER HEAD. Stereo R/P. Longer life than Permalloy. Higher output than Ferrite. Fantastic frequency response. Complete with data	7.60
HC20 Stereo Permalloy R/P head for replacement uses in car players, etc.	4.25
HM90 Stereo R/P head for METAL tape. Complete with data	7.20
H561 Special Erase Head for METAL tape	4.90
H524 Standard Ferrite Erase Head	1.50
4-Track R/P Head. Standard Mounting	7.40
R484 2/2 (Double Mono) R/P Head. Std. Mtg.	4.90
ME151 2/2 Ferrite Erase. Large Mtg.	4.25
CCE/8M 2/2 Erase. Std. Mtg.	7.90

We are the actual importers of these heads and invite Trade/quantity enquiries.
All prices plus VAT

ALL UK ORDERS ARE POST FREE
Please send 9x4 SAE for lists giving fuller details and price breakdowns.

Personal callers are always welcome
but please note we are closed all day Saturday

Instant easy ordering, telephone your requirements and credit card number to us on Oswestry (0691) 2894

4118

HART ELECTRONIC KITS LTD
PENYLAN MILL OSWESTRY
SHROPSHIRE
phone (0691) 2894
Telex 35661
Hartel G

ROHDE & SCHWARZ

TV Demodulator. AMF. 55-90MHz
Selective UHF V/Meter. Bands 4 & 5. USVF
Selectomat Voltmeter USWV. **£450.**
UHF Sig. Gen type SDR 0.3-1GHz. **£750.**
UHF Signal Generator SCH. **£175.**
XUD Decade Synthesizer & Exciter.
Videoskop SWOF with sideband adapter.
Modulator/Demodulator BN17950/2.
Video Test Signal Generator type SPF.
UHF Sig. Gen. type SCR. 1-1.9GHz.

MARCONI

TF2360R TV Transmitter Sideband Analyser.
TM6936R UHF Converter for above.
TF1101 RC oscillators **£65.**
TF1099 20MHz sweep generator.
TF1041B Valve Voltmeter **£65.**
TF1152A/1. Power meter. 25W. 500MHz. **£75.**
TF1020A Power Meter. 100W. 250MHz. **£85.**
TF890A/1 RF Test Set. **£395**
TF1400 Pulse Generator **£65.**
TF675F Pulse Generator.
TF1066 AM/FM Signal Generator. **£550.**
TF 801B/3S Signal Generator **£175.**

BECKMAN TURNS COUNTER DIALS

Miniature type (22mm diam.). Counting up to 15 turn "Helipots." Brand new with mounting instructions. Only **£2.50 each.**

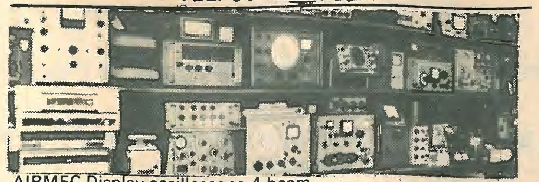
KAY ELEMETRICS SONA-GRAPH
Sona-Graph model 7029A. 5-16000Hz Spectrum Analyser with type 6076C Plug-in unit. For the spectrogrphic Analysis of transient sounds such as speec, voice, doppler shifts, explosions etc. Supplied in excellent condition with handbooks.

ADVANCE CONSTANT VOLTAGE TRANSFORMERS
Input 190-260V AC. Output constant 220 Volts. 250W. **£25.** (£2 carriage)

PYE RESISTANCE BOXES
5 decade resistance boxes measuring from 11.111 ohm to 0.001 ohm **£20**

LABORATORY OVENS. — Gallenkamp, 3 cu. ft. **£145.** Also Morgan Grundy 1 cu. ft. **£55.**
20-WAY JACK SOCKET STRIPS. 3 pole type with two normally closed contacts. **£2.50 each** (+25p pp). Type 316 three pole plugs for above — **20p ea.** (pp free).

P. F. RALFE ELECTRONICS
10 CHAPEL STREET, LONDON, NW1
TEL: 01-723 8753



AIRMEC Display oscilloscope 4 beam
AIRMEC 314A Voltmeter. 300mV(FSD)-300V.
LEVELL TG66A-1 Decade oscillator.
DERRITRON 1KW Power Amplifier with control equipment for vibration testing etc.
SOLARTRON CD1740 Dual-Beam Oscilloscope. £475.
GERTSCH Frequency Meter and Dev. Meter. 20-1000MHz. **£350.**
HEWLETT PACKARD 302A Wave Analyser.
HEWLETT PACKARD 695A Sweep Oscillator **£350.**
BOONTON 202H AM/FM Signal Generator

SE Labs Dual-Beam oscilloscope type EM102 c/w EM515 plug-in unit. DC-15MHz. Mains or 12V Battery operated. Solid-state. 8x14x18ins. **250 + VAT.**

SOLARTRON LM1420.2. DVM. 6 ranges to 1KV.
MUIRHEAD type K-134-A Wave Analyser. Portable.
RADIOMETER AFM/1. Dev/Mod Meter. 3.5-320MHz. **£185.**
HEWLETT PACKARD 608C Signal generator. 10-480MHz.
WEINSHEL Power supply Modulator type MO3.
BRUEL & KJOER type 1504 Deviation Bridge
BRUEL & KJOER Vibration equipment 1018.
BRUEL & KJOER Frequency analyser 2105
BRUEL & KJOER Microphone amplifier 2603 **£195.**
BRUEL & KJOER Type 3301 Automatic frequency response recorder 200Hz. **£750.**
MUIRHEAD-PAMETRADA D489EM Wave Analyser
TEKTRONIX 555 scope with plug-ins types CA (2 off), 21, 22
TEKTRONIX 515A Oscilloscope
TEKTRONIX 545 main frames. **£210.** Choice of plug-in units extra
TEKTRONIX 585A oscilloscope with '82' P.I. DC-80MHz
NOTICE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first-class operational condition and most items carry our three months' guarantee. Calibration and certificates can be arranged at cost. Overseas enquiries welcome. PLEASE ADD 15% VAT TO ALL PRICES.

DC POWER SUPPLIES

★APT 10459/8. 12-14V. @ 5 Amps. **£25.** (£2 p.p.)
★APT 10459/8. 24V. @ 5 Amps. **£25.** (£2 p.p.)
★We can supply the above power supply at any fixed voltage between 5V and 36V at 5A. **£25.**
★Mullard Dual supplies. Brand new with handbook. Pos & Neg 12V. at 1A and 0.4A respectively. Dimensions 9x4x5ins. **£10.00** +(£1 p.p.)
★FARNELL Current limited. Dimensions 7x5x4ins. Following types available. 5 Volts @ 3A. **£15.** 13-17 Volts @ 2A. **£15.** 27-32 Volts @ 1A **£15.** Plus £1.50 each postage.
All the above power supply units are 230V. AC input and are stabilised and regulated and fused. All are fully tested before despatch and guaranteed in first-class order throughout. As with all our equipment there is a money-back guarantee if not completely satisfied.

MODULATION METERS

AIRMEC 210 3-300MHz. AM/FM.
RADIOMETER AFM/1 3.5-320MHz. AM/FM.
RACAL 409 3-600MHz. AM/FM.

'CENTAUR' INSTRUMENT COOLING FANS

Made by Rotron Holland. These are very high quality, quiet running fans, specially designed for the cooling of all types of electronic equipment. Measures 4.5x4.5x1.5in.
Airflow 90 cu/ft/minute. These are ex-equipment fans supplied in excellent condition, fully tested before despatch. Prices as follows: 115V.AC: **£4.50.** 230V.AV.: **£5.00.** Small type fans as above but measures 8x8x3.8cms. 26cu/ft/minute. 115V.AC **£4.00.** Carriage on any of the above fans is 35p ea. Finger guards available for the larger type at **50p** each. (RS price for these fans is £12.50 each!!).

Superboard II

NOW £159.95

At these prices why waste time and money on unauthorised kit copies? Just a little more in price than Sinclair for a whole lot more and fully expandable !

610 Expansion Board 8k RAM **ONLY £159.95** + VAT
IP CD3P Minifloppy Disc, Cased, PSU, 2 copies Dos **ONLY £289**+VAT
Set of 4k RAM (Superboard users only) **ONLY £28** + VAT
Plastic Case, Beige **ONLY £26**+VAT
Challenger IP-Metal Cased, Superboard, PSU modulator **ONLY £208** +VAT

Super Print 800

80 COLUMN HIGH PERFORMANCE IMPACT PRINTER

The ideal companion for PET, APPLE, TSR80, Exidy, Superboard, Compukit, Ohio Challengers and most micro's

NEW

Rugged metal enclosure makes it ideal for home computing, small business systems, data logging etc.

**RS–232, 20mA, IEEE 488 and Centronics I/O*
**16 Baud Rates to 19,200*
**60 Lines per minute - Bidirectional*
**5 print densities 72,80,96,120 or 132 Chr/Line*
**Self Test Switch*
**Tractor and Fast Paper Feed/Graphics*

Model 800st **ONLY £389** + VAT

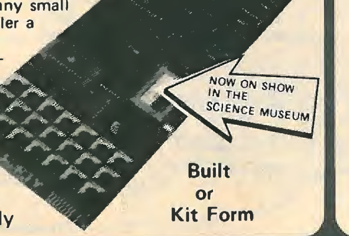
SOFTY

INTELLIGENT EPROM PROGRAMMER

Connects Directly to TV.

Develop, Copy, Burn, Verify 2708,& with mod 2516

Softy is a versatile product and each application will be different by definition. When Softy is connected via a serial (RS 232) or parallel link with any small computer capable of supporting an assembler a simple and Capable Product Development System is performed. For product developments less than 2k of firmware Softy may be the only development tool you need.

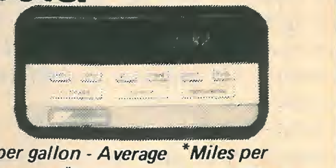


ONLY £120+VAT Built & Tested
£100+VAT Kit
£20+VAT Built - Power Supply

Built or Kit Form

ZT Driving Computer

ADD A NEW DIMENSION TO YOUR CAR WITH COST EFFECTIVE FUEL MANAGEMENT



**Miles per gallon - Instant *Miles per gallon - Average *Miles per hour - Instant *Miles per hour - Average *Gallons used since fillup *Miles to empty *Elapsed Time *Time to empty *Time on trip *Miles on trip*

Accuracy: Time: + 30 secs/month
Speed: + 0.5 mph - Instant
+ 0.005 mph - Average
Fuel Used: + 3%

Takes only about 2 hours to fit
ONLY £77.50 + VAT

Mighty Micro
In association with Watford Electronics

Please add VAT at 15%. Carriage extra, will advise at time of order. Official orders welcome. Product details on request. Trade and export enquiries welcome
33 CARDIFF ROAD, WATFORD, HERTS. WD1 8ED
Tel: (0923) 38923 (Sales) or 40588/9 Open 9 am to 5.30 pm Mon.-Sat.
Close to Watford Football Ground. Nearest Station - B.R. Watford

BUY IN CONFIDENCE - In the event that we are unable to deliver your goods within 7 days, we do not bank your remittance until such time we have the goods to despatch. If on receipt of your order, the goods do not meet with your satisfaction, return within 7 days for full refund. All goods covered by manufacturers guarantee

WW — 097 FOR FURTHER DETAILS

Careers in the electronics industry

Types of work available and what you need for them

by **Ronald C. Slater,** F.I.E.R.E. TJB Electrotechnical Personnel Services

This review sets out some of the careers which the electronics industry has to offer, the academic qualifications which are needed and the possible rewards. It is intended to help those who are already employed in the industry but who, for one reason or another, are not satisfied with their present career paths; those who are training for a career in the industry but who have not yet started work and, last but by no means least, the younger readers who, though they have an interest in radio or electronics, have not yet decided on their careers.

Perhaps the first question to be asked is 'Can the electronics industry provide a worthwhile career at all?' This question is not so absurd as it may seem, especially if it is qualified by the words 'in the UK'. Only a decade or so ago it may have been thought that the steel industry or the automobile industry could offer a worthwhile career; the position now is somewhat more doubtful. A young man or woman embarking on a career may have a working life of some 40 years ahead of him or her. It would indeed be rash to forecast the path of any industry over so long a period, especially one such as electronics where changes and advances in technology are so rapid. Yet, while it would be foolhardy to forecast the changes in technology, it can be predicted with almost complete certainty that more and more sophisticated forms of communication will be demanded, that more and more processes in commerce and industry will become automated, and that the use of electronics, in one form or another, will become more widespread in industry, commerce, and the home.

Hand-in-hand with this will go an increasing demand for electronic engineers and technicians at all levels, to design, produce, test, install and service an expanding conglomeration of even more sophisticated equipment.

Education and qualifications

Twenty or thirty years ago formal qualifications were of very much less importance than they are today and many persons rose to the top of the engineering professions by dint of experience, perseverance and 'green fingers'. In the intervening years qualifications have assumed ever increasing importance, partly due to the advancing sophistication and complexity of technology and partly to the increasing availability of technical education. Thus, although it still may be possible to succeed without formal qualifications it is increasingly difficult to do so and almost certainly the entry point on the career ladder will be determined by the educational course which has been followed and by the qualifications which have been attained.

Although in terms of employment there will be considerable overlap, technical personnel in the electronics industry can, in general, be divided into the three grades recognised by the Engineers Registration Board. These are 'Technicians', 'Technician Engineers' and 'Chartered Engineers'. To become registered in any of these grades needs specified academic attainments plus a laid down period of training, experience and responsibility. Registration will normally be made through an appropriate society or institution. For Technicians and Technician Engineers these are the Society of Electronic and Radio Technicians (SERT) and the Institution of Electrical and Electronics Technician Engineers (IEETE); for Chartered Engineers there are also two institutions, these being the Institution of Electrical Engineers (IEE) and the Institution of Electronic and Radio Engineers. Anyone who is seriously attempting to carve a career in electronics should strive for corporate membership of an appropriate professional society or institution; not only for the qualification and the letters it allows one to append after one's name but for the facilities it provides for mixing with persons with similar professional interests and for keeping up-to-date with advances in technology.

Full details of the requirements for registration as a Technician, Technician Engineer or Chartered Engineer are available from the organisations mentioned above, all of which are in the London telephone directory. Very briefly, the choice of 'academic' requirements at present is as follows:

More and more women are making successful careers in electronics. Padmini Sathiaseelan, who won an award in the 1979 "Girl Technician of the Year" competition, is a development engineer at Rank Hi-Fi. She has a B.Sc. (Eng.) degree, having specialised in electronics and communications, and in her present work on acoustics has contributed to the development and design of a new range of loudspeakers.

Technicians

Ordinary National Certificate (ONC) in Engineering with at least one electrical subject.

Approved TEC (Technician Education Council) Certificates and Diplomas in electronics and communications.

City and Guilds of London Institute Part II Certificate in one of the following:

Course 271 — Telecommunications Technicians.

Course 282 — Electrical Technicians (with at least one electronics subject).

Course 272 — Radio and Television Electronics Technicians.

Course 172 — Final Certificate in Electronics Servicing.

Some training courses in the Armed Services are also acceptable, e.g.

Royal Navy — Artificers and Mechanicians in appropriate trades.

Army — Class I Technicians in appropriate trades.

Royal Air Force — Electronic Air or Ground Technicians.

Technician Engineers

Approved TEC Higher Certificates and Diplomas.

Higher National Certificate or Diploma (HNC or HND) in Electrical and Electronic Engineering.

City and Guilds Full Technological Certificate in an appropriate course.

Chartered Engineers

A university or CNAA (Council for National Academic Awards) degree in Electrical and/or Electronic Engineering. Some degrees in associated disciplines such as Physics and Mathematics may also be acceptable.

HND in Electrical and Electronic Engineering plus the CEI (Council of Engineering Institutions) Part II Examination.

The CEI Part I and Part II Examinations.

In all three grades there are certain other qualifications which may be acceptable. There are also several changes which are imminent, particularly in the Technician and Technician Engineer qualifications. Full advice on these will gladly be given by the institutions. It is also a good idea to seek advice from them before embarking on a course of study.

The course of study followed by a young person may be dictated by personal circumstances, such as the mundane need to earn money at an early age. In general, it is possible to obtain Technician or Technician Engineer qualifications by part-time study, e.g. evening classes, day release, block release, or a combination thereof. To obtain qualifications to Chartered Engineer level full-time study is almost essential and this usually will be in the form of a three- or four-year degree course. This, in turn, usually means that it will not be possible to go into full-time paid employment before the age of 21 or 22. Education Authority grants and sponsorships from companies are, of course, available to ease the financial difficulties.

Alternatively the course to be followed may be determined by the failure to secure the necessary 'A' levels for admittance to a degree course.

However, even if none of these limitations applies the question still remains, how high should one aim? Ambition is undoubtedly a very good thing, but it must be a realisable ambition; if it is not, then it can only lead to frustration and discontent. It really comes down to the not easy task of knowing oneself and one's capabilities. We do not all have the ability to become a director of research or the managing director of a large company. It is better, far better, to become a first-rate technician than a mediocre chartered engineer.

There is just one further thing to be said about education and that is quite simply that it is not a 'once and for all exercise'. It is, or should be, a continuing process that will go on for the whole of a person's career. This is particularly necessary in an industry such as electronics where technical advances are so rapid. This continuing education may take the form of 'in-house' courses, short courses at educational establishments, attendance at colloquia and conferences or diligent reading of professional journals and the technical press.

Types of jobs

In electronics there is a very wide range of jobs and careers available, and within the confines of this article it is not possible to give an exhaustive list. In addition the names used to describe various tasks may vary considerably from company to company and, particularly in the smaller companies, there may be considerable overlap in the tasks one is called upon to perform. The following, however, represents the main activities of a typical company:

- Research
- Design and development
- Production engineering
- Quality and reliability engineering
- Test
- Sales and marketing
- Installation and commissioning
- Service

Which of these you go into may be decided by a number of factors such as educational attainments and personal inclinations, plus, of course, the availability of jobs at the right time and in the desired location. The following paragraphs outline the qualifications and personal attributes which are generally necessary in the various sectors.

Research. The primary reason for research is to extend the frontiers of knowledge. A great deal of fundamental research is carried out in universities and, to some extent in polytechnics. Much original work is also done in the very fine research laboratories of the larger manufacturers. Many research projects will require the services of multidisciplinary teams which may consist of materials scientists, physicists, mathematicians, electronic engineers, chemists etc. To take an active part in research will generally require the acquisition of highly specialised knowledge and will usually call for at least a good first degree and possibly a second degree (e.g. M.Sc., Ph.D.). It also calls for a questioning mind, an ability for innovation and creativity and the pertinacity to continue to seek for a solution where none seems possible. In terms of self-esteem and inner satisfaction the rewards of successful research can be very great, but not all research is successful and it is also necessary to be able to accept defeat, possibly after months, or even years, of endeavour. To be a leader, manager or director of research it is also essential to have that fine judgement to know which projects should be pursued and which should be abandoned.

Design and development. The purpose of design and development is to produce something which can be manufactured and sold. The 'something' may range from a single component such as a resistor or capacitor through to a complex computer-controlled data communication system. It may be a oneman task or it may need the expertise of a number of multidisciplinary teams and it may call for the assistance of outside specialist companies in, for instance, the design and supply of large scale integrated circuits.

In most cases the precise objective will be known and the design and development work may have to be carried out within the constraints of a tight performance specification and against a rigid time scale while at the same time taking account of national, international or military standards.

The most usual qualification for a design and development engineer is a degree in electrical and/or electronic engineering or a related subject such as physics or computer science, but other qualifications such as HND and HNC are often acceptable, especially if backed up by relevant experience.

Apart from technical knowledge the design phase of the project will, more often than not, call for original and innovative thinking and a disciplined and logical approach, plus in many cases, a fair degree of commercial awareness. Also it will often involve close liaison with a customer's own technical staff and the ability to quickly appreciate a problem outside of one's own discipline, as for instance, when electronic equipment is being designed to control some other non-electronic function of process.

Between the original concept, design and building of a laboratory model and the engineering of a product suitable for manufacture and marketing there is often a long path to tread; this is the development phase. This may call for close liaison with component suppliers and with internal departments such as test, production, quality assurance and the drawing office. Thus it requires a knowledge of the availability of materials and components, of manufacturing processes and costs. There's no use in developing a product which cannot be manufactured by the means available or which cannot be produced at a competitive price. Except for the very simplest of products the design and development engineer must have the ability and willingness to work as a member of a team, which very often will be of a multidisciplinary nature. Another essential asset which is often overlooked and neglected by the budding D & D engineer is the ability to communicate. The finest or most revolutionary ideas in the world are completely and utterly useless if they cannot be communicated to others.

To be involved in the design and development of a successful product can be a very satisfying experience. It can also offer a very worthwhile career progression from, say, engineer to senior engineer to section leader to project leader and all the way up to development manager and technical director. Furthermore a few years in design and development can be a very useful stepping stone to a successful career in other areas, such as sales and marketing, production and general management.

So far research and design and development have been treated as the preserve of the holders of degree, or near degree level qualifications. However, in research laboratories and in design and development departments there are many openings for technicians and technician engineers; as assistants to the engineers, for the building and testing of prototypes, for the maintenance of test equipment etc. Most forward looking companies will help their more promising technicians to obtain higher qualifications by sending them on day release or block release or by sponsoring them for sandwich degree or HND courses. There are indeed many men who have entered the electronics industry as apprentice technicians and who, at the company's expense, have progressed through ONC and degree courses and subsequently to positions of high responsibility.

Production engineering. Production is really what industry is all about, yet many, far too many, well qualified technicians and engineers in the UK shy away from it and seem almost to regard it as a dirty word. This is in direct contrast to most other industrialized countries where a large proportion of engineering graduates take up employment in the manufacturing sector. This is probably one factor in explaining why Britain's production record has been so poor in recent years.

For many the words 'production' and 'factory' still conjure up pictures of the dark satanic mills, but modern production, in the electronics industry at least, is not like that. More often than not it will take place in a clean, well lit and congenial environment. It offers a wide range of jobs for junior technicians right through to the best graduates. These include production planning and co-ordination, production equipment maintenance, and, of course, production management. For the person who likes solving problems, seeing the fruits of his labours and who likes working with people it has a great deal to offer. It is also an area where able persons with qualifications can expect promotion with a clear way open to the very top.

Quality control and quality assurance. Although quality assurance and quality control are closely related to production many companies arrange these activities as a separate department. Again, although many of the attributes necessary for a quality control engineer and a quality assurance engineer are similar their functions are slightly different. Quality control is a process through which actual performance is measured and compared with standards and specifications and, if necessary, remedial action is taken. Quality assurance, on the other hand, provides the evidence needed to ensure that the quality function is being properly performed and includes activities such as quality auditing, quality assurance analysis and qualification approval of products.

Generally both QA and QC engineers will be expected to have a minimum qualification of HNC. They must both have, or be willing to acquire, a knowledge of specifications, measurement methods, methods of assessment and an understanding of the manufacturing processes. It is very much a job for the person who is interested in statistics and statistical analysis. With the increasing use of electronics in applications where failure cannot be tolerated the quality function is becoming ever more important. It is, in a way, becoming a profession in its own right and the demand for QA and QC engineers is very good.

Test. For many young technicians the test department will form their first introduction to the electronics industry; that will also be true for a number of new graduates. While the basic task of a test department is to measure whether a component, sub-assembly or a complete equipment meets the specified criteria, there is obviously a great deal of difference between the knowledge and skill required to test a single component or small sub-assembly and those needed to deal with a large complex system. At the higher levels the work will not only involve actual testing but will also include test planning, drawing up test schedules, devising test methods and, in

Some people stay in the industry a long time. Wilf Williams, a senior production engineer at Eddystone Radio, has just celebrated his 50th year with the company. He started as a 15 year old "radio mechanic" in 1930.

some cases the design of special test equipment. Furthermore, with the influx of advanced automatic test equipment it may also call for further skills, such as computer program writing. Test engineering can offer a good career in its own right; the chief test engineer is usually a person of some importance in his organisation. It also provides a good grounding for a career in other areas such as development or production engineering.

Sales and marketing. A product without a customer is about as much good as a sick headache and, since few products sell themselves, the role of the salesman or sales engineer is a vital one. Unfortunately many people, engineers and careers advisers among them, somehow conjure up a rather strange picture of a salesman. They either see him as a rather woebegone character peddling his wares from door to door or as a smooth talking 'Flash Harry' who spends most of his time driving around in a company car and eating expense account lunches. True, a technical salesman may have to knock on a few doors and will almost certainly have a company car, but he or she will be very far from those fictitious pictures. First, he or she needs to have a thorough knowledge of his products, and this generally means a good engineering education and background. For this reason many companies prefer to recruit their sales engineers from people who have spent several years in other sectors of the industry such as development or production.

The sales engineer needs the ability and willingness to understand the customers' problems and has to be able to communicate enthusiasm, to stay calm

under pressure, to be self-motivated and self-disciplined, to be able to accept setbacks and failures philosophically, and to be at ease with other people whether they be other engineers or top management. The latter is very necessary for the sales engineer selling capital equipment worth, perhaps, many thousands of pounds. Above all he or she must really want to sell and to succeed. It is, perhaps, a rather formidable list of requirements and, certainly, selling is no easy way out for the person who wants a quiet life. On the other hand, for the person who has the necessary attributes it can be an exciting and rewarding life both in terms of job satisfaction and financial benefit. A career in sales engineering is open to persons with all levels of qualification provided that they are sufficient to allow a complete understanding of the product being sold. Clearly, the more complex and advanced the product the greater is the knowledge needed to understand it. Some of the virtues which go to make a successful sales engineer, such as the ability to communicate enthusiasm and to deal effectively and comfortably with people at varying levels, are also among the requisites for successful general management and this is one of the ways in which a sales engineer may progress.

Marketing is allied to sales engineering but is somewhat wider in scope, embracing subjects such as marketing strategy, publicity, possibly pricing and pricing agreements, and is an area into which a sales engineer may transfer.

Installation and commissioning. In many instances, particularly in the case of large equipments or systems, a manufacturer will supply a team to install and commission the equipment; that is, to ensure that it is working satisfactorily before it is handed over to the customer. The 'team' may consist of anything from one person upwards and the installation and commissioning time may be anything from a few hours to several months or more. It is a job which will usually entail periods spent away from home and it will often involve considerable travel both in the UK and overseas; it may also necessitate working unusual hours. For the man or woman who likes to do a practical job combined with travelling and working in different places it can be an enjoyable and rewarding way of life.

A large number of installation and commissioning engineers will come from the ranks of technicians and technician engineers but there are also good openings for graduates, both in a supervisory role and in dealing with the larger and more complex equipments and systems.

Service. Service engineers and technicians are basically of three types: 'in-house', 'field' and 'site'. The in-house service technician will spend his or her time on fault diagnosis and repair in the company's own premises. The field service technician will be working away from the company's premises and will usually have a number of 'customers' within an allotted geographical area. The site service technician will be working permanently on the premises of one of the firm's customers. Each has its advantages and disadvantages. In-house service will usually mean regular hours and working alongside other people, with help close at hand if needed. Field service will entail a certain amount of travel, often working on one's own, and possibly working out of normal hours; thus it calls for self-reliance and self-motivation; on the other hand it provides a certain amount of freedom and often the use of a company car. In site service a person may be working alone but far more likely he or she will be a member of a team; in many instances where site service engineers are employed the equipment concerned will be working round the clock and the service engineers will be expected to work on a shift basis — for which they will, naturally, be compensated.

Many technicians and technician engineers will be employed in servicing but there are many openings for graduates, especially in dealing with the more sophisticated systems where skills such as diagnostic programming may be required. Servicing is a good career for people who like solving problems and 'putting things right'. Field servicing, which provides direct contact with the customer, can be a good stepping off point for a subsequent career in sales engineering.

Specialisation

So far the electronics industry has been treated as an entity and no mention has been made of specialisation. Should one concentrate on analogue techniques or digital techniques? Is there a better future in communications or computers or consumer electronics etc, etc? These questions (and the answers!) are important to everyone in, or entering, the industry but they are, perhaps, of special relevance to the design and development engineer. To attempt to answer them would need another article but a few general remarks may be helpful.

In the first place it will usually be necessary to specialise to some extent, even if only on a temporary basis to deal with the job in hand. Whether or not one should specialise completely and permanently is open to question, but if one decides to do so then clearly it should be in an area which is likely to have a reasonably long future. In any case it is advisable to retain some adaptability by reading as widely as possible outside of one's specialisation. So far as the digital versus analogue argument is concerned this is also a very open question. It is true that the trend in many spheres is towards digital techniques. It is also true that the microprocessor will make an impact in many areas of electronics, even though it may not be the wonder of the age as proclaimed by the lay press. However, it is equally true that there is a widespread demand for good analogue designers and this is likely to continue. Indeed, as a result of the enthusiasm with which so many young engineers have followed the digital and microprocessor trail, acute shortages are becoming apparent in other areas. For example, good r.f. designers are now beginning to have a scarcity value. In other words do not necessarily do what everyone else is doing and do not necessarily try to get on the band wagon of the day — less popular areas may pay off better in the long run.

Most of the above remarks also apply when one is considering the various sectors of the industry such as communications, computers, instrumentation, avionics, components. Excellent careers are available in most sectors and what you choose is really a matter of personal inclination and interest. It may be worth emphasising again that it is not always the superficially most glamorous sector which offers the most interesting and rewarding career. For example, many engineers shy away from component technology whereas in fact this is the sector where many major advances originate.

Footnotes

Because of limited space many points have been treated very briefly and some not at all. One of these is the not unimportant matter of salaries. The only thing that can be said here is that in the past year or two there has been a significant upward trend in the salaries of technicians and engineers. For example in 1975 the average starting salary for a university graduate going into his or her first job was between £2300 and £2600; this year it will be between £4500 and £5200 p.a. Other salaries have increased proportionately. A look through the Appointments section of this issue of *Wireless World* will give some idea of the going rates.

Finally, a word about geographical location. Although companies who manufacture or use electronic equipment are to be found throughout the UK there are many areas where they are very thin on the ground and other areas where they are concentrated. It is clearly rather pointless to decide to live in say, Abermuirig and pursue a career in the design of r.f. instrumentation if the nearest appropriate company is 200 miles away. In other words, to pursue a successful career it is necessary to go where the work is. The difficulties of moving from place to place are not overlooked or minimized but it may sometimes be necessary and many companies now pay relocation expenses on a very generous scale. □

Appointments

Advertisements accepted up to 12 noon Tuesday, May 6th for June issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £10.00 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1.50 per line, minimum three lines.
BOX NUMBERS: 70p extra. (Replies should be addressed to the Box Number in the advertisement. c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Mike Thraves 01-261 8508.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

---

ivs

TELEVISION BROADCAST ENGINEER

We require an Engineer to join the staff of our rapidly expanding Video Cassette Duplicating Facility. The candidate should have a minimum of three years' experience in broadcast television with specific knowledge of Quad and Helican Scan, VTRs, flying spot Telecines and related systems.

The candidate should be qualified to HNC, full technical certificate, degree or equivalent qualification. The job reports to the Technical Manager and the successful candidate will be responsible for maintenance of equipment, supervision of technical trainees and the installation of additional facilities. An excellent salary will be offered, commensurate with qualification and experience.

Please reply in confidence to: **I.V.S. (U.K.) LTD., 32 Eveline Road, Mitcham, Surrey, or telephone: 01-648 6235.**

(270)

Career move in Electronics

Our clients are major companies in avionics, defence, microprocessors, microwave, communication systems, radar, T.V./Hi-fi, electronics and other fields.

This is an opportunity to secure a sound financial future for yourself and to become involved with the latest developments in electronics technology in either service or manufacturing.

If you are interested in obtaining a career with a future **contact Alan Elmes on 0763 852453 for the latest in Electronic Vacancies.**

PROSPECT RECRUITMENT
ELECTRONICS DIVISION
PROSPECT HOUSE, GUILDEN MORDEN, ROYSTON, HERTS, SG8 OJS

ELECTRONICS TECHNICIANS

S. LONDON **to £6,000 p.a.**

Electronics technicians are required for interesting work in the Production Engineering Department of Dolby Laboratories.
Duties will involve prototype work and the design manufacture and maintenance of A.T.E. and assembly equipment.
Qualifications: Several years' experience in electronics and an ability to work without close supervision. Sound constructional abilities essential.
For application forms contact:

Phil Marshall
DOLBY LABORATORIES INC.
346 CLAPHAM ROAD
LONDON, SW9
TEL. 01-720 1111

(271)

FOREIGN AND COMMONWEALTH OFFICE
has vacancies for

BROADCAST RELAY ENGINEERS

to serve a one-year contract (unaccompanied) tour of duty on the island of Masirah (off the coast of Oman).

Applications are invited from engineers with experience of the operation and maintenance of high-powered radio transmitters, and who hold a third-year City and Guilds Certificate in Telecommunications or its equivalent.

SALARY: £16,852 per annum plus a tax-free allowance of £1,185 per annum for a single officer or £3,040 per annum for an unaccompanied married officer.

Please apply to:

Recruitment Section
Foreign and Commonwealth Office
Hanslope Park, Hanslope
Milton Keynes, MK19 7BH

(283)

Computer and Electronics Engineers and Technicians

Can you grow at 30% per year and more?

We do — and to help us maintain our expansion plans, we need dynamic engineers at our new multi-million pound, minicomputer manufacturing facility at Ayr in the West of Scotland.

Hardware Support Engineers

We are looking for people with experience of 16 bit minicomputers and their associated peripherals to plan and monitor the introduction of new models over the next few years and to provide technical support to the production department on hardware and systems problems.

Some travel to our parent company in Maynard, Massachusetts, would be required in the course of your duties. Product specific training would be provided where necessary.

Production Engineers

We need Production Engineers with experience of assembly and test measures and procedures to undertake process specification and method improvement programmes in our systems test areas, where computers are tested for reliability prior to shipment to the customer's site.

These positions would suit engineers from similar disciplines or customer engineers who wish to return to a manufacturing environment having gained experience of the types of problems seen in the field.

Systems Test Technicians

Responsible for test and repair on a full range of minicomputer systems. These systems include: C.P.U.'s of various memory sizes; Disc drives; Mag tapes; V.D.U.'s; Printer's, etc.

Test methods include the running of diagnostic software and customer operating systems to a high level of acceptability and quality.

The people we are looking for will have at least 2-3 years experience in the electronics industry and preferably in computers.

Comprehensive in-house training is available on a wide range of our products (i.e. hardware and software).

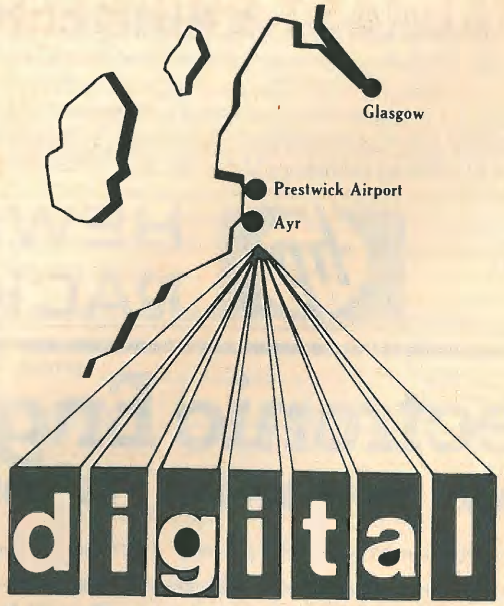
To the right people we offer very competitive salaries and the wide range of benefits you'd expect from the world's largest manufacturer of minicomputers. Full relocation assistance is available where applicable.

Our Ayr facility provides an excellent working environment and Ayr itself is a pleasant coastal resort situated some thirty miles south west of Glasgow, five miles from Prestwick International Airport and has good road and rail networks south and north. The area affords first-class housing, medical, educational and social facilities, plus a wide range of recreational pursuits (golf, fishing, sailing, etc).

If you have a degree, HNC or equivalent in an appropriate discipline, together with relevant experience — we'd like to hear from you.

Write or 'phone:

Gus Gannon
Digital Equipment Scotland Limited
Mosshill, Ayr, Scotland
Tel: Freefone 8508



Make our future your future

(260)

Electronics & Computer Test
To £7,500

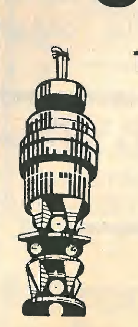
Use your C&G/ONC/HNC/Forces Training and good DIGITAL/ANALOGUE/RF experience to advantage. Working with state-of-the-art MINI/MICRO PROCESSOR; LASER; ATE; COMMUNICATIONS; NUCLEONIC; CCTV and similar equipment. Most UK areas; from Technician to Manager.

For free confidential counselling and practical career advice contact GRANT WILSON ref: GW470.

TECHNOMARK, 11 Westbourne Grove, London W2 4UA.
Tel: 01-229 9239 (01-229 4218—24 hrs).
Engineering Recruitment Consultants. (9402)

CAPITAL
APPOINTMENTS LTD.

CAPITAL HOUSE
29-30 WINDMILL STREET
LONDON W1P 1HG
TEL: 01-637 5551



THE UK's No. 1 ELECTRONICS AGENCY

Design, Dev. and Test to £9,000
Ask for Brian Cornwell

SALES to £12,000 plus car
Ask for Ken Sykes

FIELD SERVICE to £8,000 plus car
Ask for Paul Wallis

We have vacancies in ALL AREAS of the UK

Telephone: 01-637 5551 (3 lines)

Degree Level Electronics Engineers

£9115 **Manchester-based**

to work on special projects at our studios.

The work will involve installation and troubleshooting on advanced video and sound equipment and the provision of specialist maintenance advice and assistance to our operational engineering staff. Some travel to manufacturers in the UK and possibly overseas will be needed.

The right people, men or women, will be under 30, graduate or HND, with a thorough knowledge of sophisticated digital and analogue technology, ideally in broadcast or CCTV applications.

Conditions of service include 23 days holiday with generous pension and free life assurance benefits. Assistance with re-location is available.

Write to me with full details of your qualifications and experience by Wednesday April 23rd.

Bob Connell (Ref. G7), Granada Television Ltd., Manchester M60 9EA.

GRANADA TELEVISION

(327)

ST. GEORGE'S HOSPITAL, S.W.17

AN OPPORTUNITY IN ELECTRONICS

A vacancy exists in the Electronics Section of the Physics Department at St. George's Hospital, S.W.17. The work of this section includes the design, development and manufacture of a wide range of medical and research instruments.

Experience with both digital and analogue devices would be very desireable.

Appointment will be made to Medical Physics Technician Grade III for the person with the appropriate skill and experience.

Present salary scale: £4,605-£5,952 + £398 London Weighting per annum.

Minimum academic qualifications are O.N.C. or equivalent, but an H.N.C. in electronics or an allied subject would normally be expected.

For further details of the post, contact Mr. D. Ritchie, Chief Technician, Department of Medical Physics, on 01-672 1255, Ext. 4058.

Application forms and job descriptions are available from Mrs. Katherine Goodacre, Administrative Assistant, St. George's Hospital, Blackshaw Road, Tooting, SW17 0QT.noel. No. 01-672 1255, Ext. 4121.

(306)

HAMPSTEAD HIGH FIDELITY LTD.

require an experienced, competent and responsible

SERVICE ENGINEER

for field and bench work.

The applicant must be conversant with all aspects of quality **HI-FI equipment.** A presentable appearance and ability to converse intelligently with customers, is essential. Salary £5500 with review after four months.

Apply in writing giving full details of experience to:

The Director
HAMPSTEAD
HIGH FIDELITY LTD.
63 Hampstead High St.
London, NW3

(322)

TRAINING IN BROADCASTING OPERATIONS

The BBC requires technical staff to instruct at its Training Centre near Evesham, Worcestershire.

Duties will involve contributing towards the operational training of Technical Staff in Television and/or Radio Broadcasting. This includes instructing Technical Operators who are responsible for sound coverage, audio mixing, camera work and lighting in Television or operating Network Continuity Suites in Radio.

The starting salary will be in the range £6,505 to £7,830 depending upon experience and qualifications, rising to £9,130.

The Training Centre, which is situated in the Worcestershire countryside has Radio and Colour Television Studios using the latest broadcasting equipment.

Candidates, male or female, should have recent experience in some aspect of Technical Operations or Engineering in the Broadcast or Closed Circuit field and a good technical knowledge of audio or video equipment. They should preferably have a qualification of H.N.C. or C. & G. Full Technological Certificate in Telecommunications or equivalent. Consideration will be given to providing appropriate training to otherwise suitable applicants who do not hold these qualifications.

Excellent welfare and club facilities. Pensionable posts. Re-location expenses considered.

If you would like to hear more and receive an application form, please send a stamped addressed envelope of at least 9" x 4" to **Head of Technical Operations Training Section, Engineering Training Department, Wood Norton, Evesham, WR11 4TF,** quoting reference number 80.E.4019/WW.

Closing date for return of application forms 14 days after publication.

BBC *ENGINEERING TRAINING DEPARTMENT*

(279)

Radio Communications Electronics Engineers and Software Designers

Mid-Sussex—S.W. London **Salaries up to £8,000**

To join our expanding R&D Laboratories covering a wide range of R.F. spectrum, from L.F. to V.H.F. Equipments include transmitters and receivers for marine- and land-based use, radio navaids and radio monitoring remote computer-controlled systems.

Electronics Engineers should have experience in transmitter or receiver design, analogue or digital circuit design, microprocessor applications. Software Designers should be experienced Programmers with an interest in control, signal processing or navigational software.

Attractive salaries are complemented by excellent prospects and generous benefits.

Contact: **David Bird, Redifon Telecommunications Limited, Broomhill Road, Wandsworth, London, S.W.18. Phone: 01-874 7281** (reverse charges).

(9938)

LEEDS BRADFORD AIRPORT

AIR TRAFFIC ENGINEER

Air Traffic Engineer required to undertake maintenance of all ground communications and navigational equipment including ILS, Radar, CRDF on a watchkeeping basis. Applicants must be fully experienced in ILS and Radar maintenance and hold appropriate technical qualifications. Salary in accordance with Local Government grade T3 to T5 (£4,080-£5547 per annum), commencing salary dependent upon experience and qualifications. In addition, the post attracts payment of 14% of basic salary for shift working and approx. 16% enhanced payments for weekend working. The result of a Comparability Study is pending. National Joint Council Conditions for Local Authorities apply to the position and in addition a car allowance is payable for journeys to and from the place of work. Applications, stating age, experience and full details of education and technical training should be forwarded to: **The Airport Director, Leeds Bradford Airport, Yeadon, Leeds, LS19 7TZ, by May 2, 1980.**

(284)

DOLBY SYSTEM

TECHNICIAN

Dolby Laboratories manufacture professional audio noise reduction equipment which is widely used by major recording studios.

Working closely with our application engineers the person appointed will maintain studio and theatre replay equipment in our listening room as well as assisting in the construction of specialised equipment.

The successful applicant will be familiar with audio equipment and will be able to construct prototypes from circuit diagrams with the minimum of supervision. Aged between 18 and 30 he, or she, will probably have experience in the service or manufacture of audio equipment.

Salary is negotiable dependent on experience.

Write or telephone:

John Iles or Elmar Stetter

DOLBY LABORATORIES INC.

346 Clapham Road
London SW9 9AP
Telephone: 01-720 1111

(274)

How to cut through the old boy network

You can't possibly cover all the job advertisements by yourself.

And what about all those jobs that are never advertised because other good people hear about them first? —YOU MISS OUT.

Break into that closed circle by enrolling with Lansdowne. We'll thump your career details onto the desks of senior managers at thousands of companies — except those you ask us not to approach.

They'll consider you for the immediate jobs and they'll have you on file for the future.

When they want you they'll ring you — not us — and you're immediately shortlisted for a job you might never have heard about.

Just fill in the coupon and send for our Career Summary Form and explanatory leaflet.

And do it at once because it's the only one that's worth thousands of applications.

Stuart Tait, Lansdowne Appointments Register, Design House, The Mall, London W5 5LS.
Tel: 01-579 2282 (24 hour answering service)

Our clients would like to meet men and women, aged 20-40, earning between £4,000-£8,500 in any of the following:

- TEST ENGINEERING ☐
- CALIBRATION ENGINEERING ☐
- ELECTRONICS ENGINEERING ☐
- ELECTRONICS SALES ☐
- SERVICE ENGINEERING ☐
- DEVELOPMENT ENGINEERING ☐

Mr./Mrs./Miss ____________

Address ____________

(324)

Stuart Tait, Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 2282 (24 hour answering service) WW 16/4

Lansdowne

Technical and Operational Training

Thames Television will be running its Technical Training Scheme beginning September 1980. The course will be of 9 months duration and traineeships will be available in the following areas:-

1) Technicians covering VTR, Telecine and Vision Control operations and maintenance;
2) Engineering, covering planning, design and installation;
3) Television Camera Operations;
4) Television Sound Operations;
5) Film covering Camera, Sound, Editing.

The course will consist of 5 months broad based training and 4 months specialist training and will take place at the Training Centre, Teddington, with additional experience gained on attachment at each of the Company Sites.

Salary during training will be 1-3 months £4,400 per annum, 4-9 months £5,000 per annum.

Successful Trainees will then be absorbed into operational departments at one of the Company's sites and go on to a salary structure applicable to the grade.

Candidates should preferably be 20-30 years of age and have academic qualifications, specialist training or experience relevant to their chosen area.

For an application form and full details please write (indicating area of preference) to:-

Miss Pat Evans, Staff Relations Dept., Thames Television Ltd., Teddington Lock, Middlesex. Tel: 01-977 3252, ext. 325.

THAMES
LONDON'S WEEKDAY ITV

TEST ENGINEERS NEEDED

By Electrosonic, leaders in the fields of lighting control and audio visual systems. Work will involve testing analogue, digital and microprocessor circuits. Applicants should be qualified to ONC or HNC level and have experience in analogue and testing digital techniques.

Salary will be around £5,000, please contact:

Mr. A. Kidd
Electrosonic Ltd.
815 Woolwich Road
London SE7
or **Tel: 01-855 1101 ext. 37**

(323)

"Whoever heard of a Resident Field Engineer?" — Major Installation

If you're an experienced Field Engineer and you're tired of travelling, this is an ideal opportunity to enjoy the best of both worlds.

To ensure our Burroughs equipment is professionally maintained we are now looking for a resident FIELD ENGINEER.

You will be part of a team responsible for the maintenance of 3 large scale (B6800), 3 medium scale (B1800), 24 small scale (B90) computer systems and peripherals and over 150 terminals which are linked to these various systems.

For this challenging position, we prefer that you are qualified to HNC or equivalent level. Engineers experienced in the maintenance of any major computer systems will be considered. We will provide all necessary training on our mainframes and peripherals as part of the successful applicant's personal development.

You will be offered an attractive salary and excellent conditions of employment.

If you're looking for more stability and excellent career prospects contact:

Recruitment Manager, Ref. WW,
Burroughs, Cumbernauld G68 0BN.
Telephone 023-67-35457.

An Equal Opportunity Employer.

Burroughs

(313)

VIDEO RECORDING EQUIPMENT SERVICE ENGINEER

With the outstanding success in marketing a new range of airborne and high speed video tape equipment we need to appoint a top rate video service engineer. Full product training will be given in either America or Japan to a suitably qualified or experienced person.

The successful applicant will probably be aged between 25 and 35. A Company car will be provided, after a probationary period, as extensive travel within the UK will be necessary.

We pay top rates and the salary will be commensurate with experience and ability. We offer 4 weeks' annual holiday, free life assurance, sick scheme and free canteen facilities.

For further details and application form please apply to:

JHPI

Ann Janes
Personnel Officer
John Hadland (P.I.) Ltd
Newhouse Laboratories
Newhouse Road, Bovingdon
Hemel Hempstead
Herts. HP3 0EL

(218)

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:

Trainee Radio Officer	Radio Officer
Age 19 **£3271**	Age 19 **£4493**
Age 20 **£3382**	Age 20 **£4655**
Age 21 **£3485**	Age 21 **£4844**
Age 22 **£3611**	Age 22 **£4989**
Age 23 **£3685**	Age 23 **£5249**
Age 24 **£3767**	Age 24 **£5559**
Age 25+ **£3856**	Age 25+ **£5899**

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.

GCHQ

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

(109)

LWT
London Weekend Television

require

ELECTRONIC ENGINEERS

to work in their Projects Dept. The work will include the selection, purchase, installation and commissioning of the electronic equipment used in television studios and O.B. vehicles. Applicants should be H.N.C. standard but engineers with suitable Broadcast Television experience will be considered. Salary will be in the range of £5501 to £7482 rising to £8325 p.a. increasing July 1, 1980, to £6716 to £8495 rising to £9465 p.a. Applications to be made to:

Personnel Department
LONDON WEEKEND TELEVISION
Kent House, Upper Ground, London, SE1 9LT

(278)

Land a good job

Your Radio Officer's qualifications could mean a lot here onshore

If you're thinking of a shore-based job, here's where you'll find interesting work, job security, good money, and the opportunity to enjoy all the comforts of home where you appreciate them most – at home!

The Post Office Maritime Service has vacancies at Portishead Radio and some of its other coast stations for qualified Radio Officers to undertake a wide variety of duties, from Morse and teleprinter operating to traffic circulation and radio telephone operating.

To apply, you must have a United Kingdom Maritime Radio Communication Operator's General Certificate or First Class Certificate of proficiency in Radio-telegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic. Preferably you should have some sea-going experience.

The starting pay at 25 or over will be about £5381; after 3 years' service this figure rises to around £7087. (If you are between 19 and 24 your pay on entry will vary between approximately £4229 and £4937). Overtime is additional, and there is a good pension scheme, sick-pay benefits, at least 4 weeks' holiday a year, and excellent prospects of promotion to senior management.

For further information, please telephone Kathleen Watson on 01-432 4869 or write to her at the following address: IE Maritime Radio Services Division ( ), IS8.1.1.2, Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

(299)

COLOUR TELEVISION

If you have experience in television or test equipment engineering, there could be an interesting and rewarding future for you at Rediffusion Consumer Electronics Ltd. We are currently manufacturing an advanced range of colour television receivers at our factories in County Durham and Cleveland and wish to make the following appointments.

GROUP LEADER – Test Equipment

Effective testing of television receivers plays an important role in ensuring that our very high quality standards are maintained, and we now wish to appoint an experienced engineer of proven ability, to control a team of engineers and technicians responsible for all aspects of production test equipment.

Responsibilities will include the calibration and maintenance of a sophisticated range of test and signal origination equipment, employing both digital and analogue techniques. Although some test gear is designed and constructed locally, close liaison will be required with the design team, based at Chessington, Surrey, both to keep abreast of new developments and influence the new design of new equipment in the light of production experience.

SENIOR ENGINEER – Production Support

A senior engineer with a sound understanding of television systems and receiver circuits is required to assist production departments with technical problems arising during receiver manufacture. Responsibilities will include investigation of design problems, component fault assessment and the origination of quality assurance procedures to check that the product conforms to design specifications.

Both positions are based at our factory in Bishop Auckland, County Durham, which is within easy reach of attractive countryside and has excellent road, rail and air connections. A wide range of good quality housing is available and assistance with re-location expenses will be available where appropriate.

Attractive salaries will be offered, together with the benefits of a good pension scheme, free life insurance and 4 weeks' holiday with a choice of leave period.

If you are interested in these challenging positions and would like more details, please write to or telephone:

Mr. D. Abbott
Engineering Product Manager
Rediffusion Consumer Electronics Ltd.
Fullers Way South
Chessington, Surrey KT9 1HJ
Telephone: 01-397 5411

REDIFFUSION

(276)

Support Engineer
SWINDON

We are looking for a Support Engineer to become involved in professional technical support to a sophisticated production test area in the semiconductor industry. Production equipment consists mainly of computer-based test systems and instrumentation.

You should hold HNC/City & Guilds Tech. Certificate or equivalent in electronics. Experience of DEC and Teredyne equipment would be desirable but training will be given where necessary.

The normal range of fringe benefits expected from a large company plus a competitive salary and a good working atmosphere are part of what we have to offer. In addition you would be working in the industry of the future: The exciting world of microelectronics.

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

PLESSEY

(288)

I didn't get where I am today by not using an agency — C.J.

FIELD SERVICE ELECTRONICS ENGINEERS

Register now and get somewhere tomorrow.
01-464 7714 ext 502 (24hrs)

LOGEX

ELECTRONICS RECRUITMENT SERVICE
309 HIGH ROAD, LOUGHTON, ESSEX, IG10 1TD
01 502 1589/0937 01 464 7714 EXT 502 (321)

TOP JOBS IN ELECTRONICS

Posts in Computers, Medical, Comms, etc. ONC to Ph.D. Free service.

Phone or write: **BUREAUTECH, AGY, 46 SELVAGE LANE, LONDON, NW7. 01-906 0251.**

(8994)

Product Evaluation Engineer

Dixons are Britain's leading and most successful photographic and home entertainment specialists. We are now looking for a product evaluation engineer for audio, video and similar electronic products.

This interesting vacancy, based at Edgware, has arisen from an internal promotion. You would be responsible for accurately assessing the specifications and performance of new and sometimes untried products. This information is vital to the success of our marketing department and you will often be working under pressure to meet tight deadlines.

The person we are looking for will have the technical skill and ability to devise and implement appropriate test systems. He or she will also need to be self-motivated and able to work unsupervised.

Preference will be given to applicants who possess a City & Guilds (Full Technical Certificate), ONC or HNC qualification or equivalent. Test and calibration experience, preferably in radio and TV will be a great advantage. Some knowledge of current safety specifications for consumer electronic products would also be useful.

The successful applicant can expect an attractive salary which reflects the importance and responsibilities of the job. Other benefits include a subsidised restaurant, four weeks' holiday, excellent pension and insurance schemes and generous staff discount.

If you are interested in this opportunity to broaden your career with a dynamic and rapidly expanding company, contact Janet Gearing on Stevenage 4371, or write to her giving brief details at Dixons Photographic (UK) Ltd., Camera House, Cartwright Road, Stevenage, Herts.

Dixons

A GREAT COMPANY TO BE WITH (289)

OXLEY®

RESEARCH ENGINEER

Oxley Developments Company are Manufacturers and Consultants in the field of passive electronic components and supply into the control systems, instrumentation and communications industries throughout the world.

We are currently seeking a Research Enginner with a natural enthusiasm, backed up by extensive experience of radio and electronic design and development. Whilst a high standard of academic achievement is a prime requirement, considerable importance is also attached to the practical application of knowledge.

Oxley Developments Company is privately owned and has enjoyed steady and consistent international growth built upon an extensive range of unique products specially developed to fulfil needs within industry. As a result, the successful candidate will have unrivalled opportunities to expand work horizons and to pursue professional advancements both at home and abroad.

The factory and research facilities are located on the edge of the Lake District National Park.

In the first instance, please request an application from from:

The Personnel Director
Oxley Developments Company Limited
Priory Park, ULVERSTON
Cumbria LA12 9QG
Telephone: (0229) 52621

(262)

ELECTRONIC ENGINEERS: PERMANENT or CONTRACT TRAINEES to MANAGEMENT

We can offer you a vast selection of Field Service or internal vacancies across the U.K. Find out more by either phoning CRAYFORD (0322) 51923, Ext. 4, or send the slip below to:

CLIFFORD EDWARDS LTD., 5 Crayford High Street, Crayford, Kent WW01

Name ....

Address ....

.... Phone ....

(328)

Electronics R&D

Join us in the forefront of technology

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.WW 1), H.M. Government Communications Centre, Hanslope Park, Milton Keynes MK19 7BH.

186

Medical Equipment for Hospitals

A vital role for Electrical/Electronic Engineers

These opportunities are in the Scientific and Technical Branch which provides the scientific, engineering and other professional services essential to the provision of medical apparatus, instrumentation and supplies to hospitals.

The successful candidates will join a London-based team working on the specification, laboratory testing, inspection and quality control of a wide range of medical electrical and electronic equipment used in the National Health Service. Some UK travel required.

Candidates must have a degree or an equivalent qualification in electronics or electrical engineering, at least 2 years' training in electrical engineering, and subsequent experience in the design, testing and/or inspection of electronic equipment. Experience of medical electrical equipment advantageous.

Salary *(under review)* starting between £5955 and £7680 depending on qualifications and experience. Promotion prospects. Non-contributory pension scheme.

For further details and an application form (to be returned by 8 May 1980) write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). *Please quote T(23)85.*

Department of Health and Social Security

(311)

Essex County Council
CHELMER INSTITUTE OF HIGHER EDUCATION

SENIOR TECHNICIAN

A with Degree Allowance is required to assist in research work. The person appointed should be prepared to travel on a limited basis.

Salary: T3/T4 £4080-£5067 per annum.

The person appointed will have at least an ONC or OND, but an HNC in digital electronics or telecommunications will be preferred. Experience in prototype construction and interpretation of developmental circuit drawings, and in the field of radio communications, microprocessors and radio circuitry, both transmitters and receivers, will be an advantage.

Application forms and further details available from the Institute Secretary, Chelmer Institute of Higher Education, Victoria Road South, Chelmsford, CM1 1LL. Closing date 2nd May 1980. Telephone: Chelmsford 354491, Ext. 221. (302)

Piccadilly Radio require a

BROADCAST ENGINEER

grade I.L.R.2 to be involved in all aspects of station engineering. Preference will be given to people having experience in this field.

***Apply:* Phil Thompson**
Chief Engineer
Piccadilly Radio
P.O. Box 261
Manchester M60 1QU

(9993)

CORPORATION OF LONDON

Department of Architecture and Planning

SENIOR ELECTRONICS ENGINEER

£6878 to £8165 inclusive
(under review)

Applications are invited from suitably qualified and experienced Engineers with wide experience in Electronics. This is a new post and the person appointed will be responsible for, among other things, advice, installation, operation and maintenance of telecommunications and electronic equipment. Matters covered besides public address systems for important State and other functions at Guildhall and elsewhere, will include fire alarms, call systems, television, surveillance, computer and other applications. Liaison with BBC and ITV regarding outside broadcasts from Corporation premises will be required.

Job Outlines and application forms from City Architect and Planning Officer, Guildhall, London EC2P 2EJ, 01-606 3030, extension 2725.

(332)

TECHNICIANS, ELECTRICAL/ELECTRONIC, required to support Academic staff in teaching and/or Research Laboratories. Work involves maintenance, construction and setting up of Electronic experiments for Teaching and Research. Opportunity to work in an environment of Electronics being continually up-dated. Salary according to experience in range £4,374-£4,872 or £4,728-£5,325 inclusive of London Weighting. Application form from Personnel Officer (Technical Staff EE10) University College London, Gower Street, WC1E 6BT. (298)

RADIO ENGINEERS. Permanent positions overseas. Tax free salaries, first-class accommodation and conditions. Apply SPS EXECUTIVES (Ref 1726), Recruitment Consultants, Delme Court, West Street, Fareham, Hampshire, or better still telephone (0329) 235611/236857. (287)

VIDEO ENGINEERS required by Studio 99 Video for high level design, development and installation work on professional TV systems for industry, often to broadcast standard. Varied assignments, excellent working conditions in well-equipped new premises in N. London, good salary, and company car, company pension, plus four weeks' holiday. — Call Eva Parnell, 01-328 3282. (318)

TESTERS, TEST TECHNICIANS, TEST ENGINEERS. Earn what you're **really** worth in London working for a World Leader in Radio & Telecommunications. Phone Len Porter on 01-874 7281, or write: REDIFON TELECOMMUNICATIONS Ltd., Broomhill Road, Wandsworth, London, SW18. (9856

Radio Technicians
Work in Communications R&D and add to your skills

At the Government Communications Headquarters we carry out research and development in radio communications and their security, including related computer applications. Practically every type of system is under investigation, including long-range radio, satellite, microwave and telephony.

Your job as a Radio Technician will concern you in developing, constructing, installing, commissioning, testing, and maintaining our equipment. In performing these tasks you will become familiar with a wide range of processing equipment in the audio to microwave range, involving modern logic techniques, microprocessors, and computer systems. Such work will take you to the frontiers of technology on a broad front and widen your area of expertise — positive career assets whatever the future brings. In the rapidly expanding field of digital communications, valuable experience in modern logic and software techniques will be gained.

Training is comprehensive: special courses, both in-house and with manufacturers, will develop particular aspects of your knowledge and you will be encouraged to take advantage of appropriate day release facilities.

You could travel — we are based in Cheltenham, but we have other centres in the UK, most of which, like Cheltenham, are situated in environmentally attractive locations. All our centres require resident Radio Technicians and can call for others to make working visits. There will also be some opportunities for short trips abroad, or for longer periods of service overseas.

You should be at least 19 years of age, hold or expect to obtain shortly the City and Guilds Telecommunications Technician Certificate Part I (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are, or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

Registered disabled people may be considered.

Pay scales for Radio Technicians start at £3900 per annum, rising to £5530, and promotion will put you on the road to posts carrying substantially more; there are also opportunities for overtime and on-call work, paying good rates.

Get full details from our **Recruitment Officer, Robby Robinson, on Cheltenham (0242) 21491, Ext 2269,** or write to him at **GCHQ, Oakley, Priors Road, Cheltenham, Glos GL52 5AJ.** We will invite suitable applicants (expenses paid) for interview at Cheltenham.

GCHQ

Recruitment Office

Government Communications Headquarters

Oakley, Priors Road, Cheltenham GL52 5AJ (9813)

APPOINTMENTS IN ELECTRONICS £5 – £10,000

Take your pick of the permanent posts in:

MISSILES — MEDICAL
COMPUTERS
RADAR — COMMS
MICROPROCESSOR
HARDWARE — SOFTWARE

For free expert advice and immediate action on salary and career improvement, 'phone or write to, Mike Gernat BSc.

Technomark
Engineering and Technical Recruitment
11 Westbourne Grove
London W2. 01-229 9239 (9257)

CHELSEA COLLEGE
University of London

MICROPROCESSOR SOFTWARE SPECIALIST

A SOFTWARE SPECIALIST is required to develop software for microprocessor applications, on mainframe and development systems. The Centre runs a Harris interactive computing system for general use and it is planned to use this to develop high-level language tools for microprocessor programming. In turn, the mainframes will connect to various development systems in the Laboratory. The post offers an opportunity to an enthusiastic microprocessor specialist to participate in the planning and development of a major new College facility.

Candidates should have a degree in Computer Science or Physical/Engineering Sciences. Industrial and/or research experience with microprocessors would be an advantage.

Salary will be in the range £5792-£9509 p.a. inclusive.

Further details and an application form may be obtained from the Personnel Officer, Chelsea College, Chelsea Manor Street, London SW3 3TW. (333)

GRADUATE ELECTRONICS ENGINEER required to work on interesting applications of electronics to medicine. Applicants should have digital design experience and be interested in working with microprocessors and microcomputers. Day release may be possible to study for a higher degree. For further information, please contact Miss J. Newbigin, Personnel Department, Charing Cross Hospital (Fulham). Tel: 01-748 2040 ext. 2992, and for more details contact Mr. A. Brewer on ext. 2593/3. (295)

ARTICLES FOR SALE

TELEQUIPMENT D66A, mint condition, £300. Radford DMS 3 £100. Woelke ME102B wow and flutter meter £90. All mint condition. Property of Hi-fi Reviewer. — Woking 4866. (281

TEXAS TMS 270 8JL eproms, available at £4 each. No VAT, no postage. — J. Hawthorne, 23 Iver Lane, Cowley, Middx. Tel. Uxbridge 36428 evenings. (268)

ARTICLES FOR SALE

NOSTALGIA — COLLECTING
THE VINTAGE WIRELESS COMPANY 1920 to 1950

Receivers, valves, components, service data, historical research, books, magazines, repairs and restorations. A complete service for the collector and enthusiast of vintage radio.

S.a.e. with enquiry and for monthly news sheet

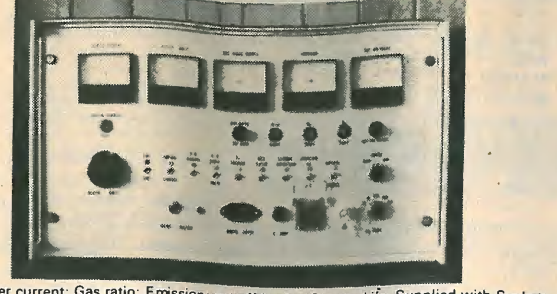
1980 catalogue £1
Closed Monday (Ansaphone)

THE VINTAGE WIRELESS COMPANY
64 Broad Street, Staple Hill, Bristol BS16 5NL
Tel: Bristol 565472 (177)

ENCAPSULATING, coils, transformers, components, degassing, silicone rubber, resin, epoxy. Lost wax casting for brass, bronze, silver, etc. Impregnating coils, transformers, components. Vacuum equipment low cost, used and new. Also for CRT regunning metallising. Research & Development. Barratts, Mayo Road, Croydon, CR0 2QP. 01-684 9917. (9678

ARTICLES FOR SALE

PROFESSIONAL CRT TEST SET



Tests; Heater current; Gas ratio; Emission; cut-off Leaks; Shorts; Life. Supplied with Sockets and adaptor box to cover most types of tubes. **£1,244 plus VAT.**

WESTERN-WHYBROW ENGINEERING, Praa Sands Cross, Penzance TR20 9QT.

SAE please for descriptive leaflet.

WESTERN-WHYBROW can supply everything for professional TV tube rebuilding up to a complete plant. (316)

COMPUTER PERIPHERALS

N.C.R. CRAM memory system 149 M bytes storage 8 bit TTL parallel I/O. Like 384 floppy discs in one unit! Needs 3 Ph supply **£500**

Fixed head sealed disc unit 1 M bits storage, includes R/W electronics but no controller **£60**

A.S.R. 33 Teletype V.24 interface with paper tape reader and punch. Reasonable working order **£175**

CHROMATRONICS, COACHWORKS HOUSE RIVER WAY, HARLOW, ESSEX CM20 2DP TELEPHONE: (0279) 418611 (266)

TIME WRONG?

MSF CLOCK is ALWAYS CORRECT — never gains or loses, 8 digits show Date, Hours, Minutes and Seconds, auto. GMT/BST and leap year, also second-in-a-month STOP CLOCK and parallel BCD output, ideal for navigation, synchronising events, astronomy, etc., receives Rugby time signals, 1000Km range, ABSOLUTE TIME, £48.80.

60KHZ RUGBY RECEIVER, as in MSF Clock, built-in antenna, serial data and audio outputs, £13.70.

V.L.F.? 10-150KHz Receiver, £10.70. Each fun-to-build kit includes all parts, printed circuit, case, postage, etc. Money-back assurance so SEND off NOW.

Cambridge Kits, 45 (WE) Old School Lane, Milton, Cambridge. (272)

BURGLARS

Safeguard your home, shop, etc., from burglars and vandals with the best D.I.Y. equipment available.

Send S.A.E. for comprehensive price list. e.g. £6 for one of our fully weather-proofed steel Bell-Boxes the professionals use.

Lawrence, 42/45 New Broad Street, London, EC2M 1QY.

"Don't buy in Kits buy in Bits" (277)

CABLE SOCKET WITH LEAD

1m length (approx. 3.3' 1) **50p ea.**; or 3 for **£1.**

Phone: Mr Galita 01-543 2515 or 01-404 5011 (325)

LAB CLEARANCE: Signal Generators; Bridges; Waveform, transistor analysers; calibrators; standards; millivoltmeters; dynamometers; KW meters; oscilloscopes; recorders; Thermal, sweep, low distortion true RMS, audio Flt, deviation. Tel. 040-376236. (8250

500 WATT Boozy & Hawkes amplifier. 16 and 30 watt paging amplifiers. Creed teletype No. 7s. Tel. (0622) 50350. MKS, Upper Stone St., Maidstone, Kent. (9442)

GWM RADIO LTD., 40/42 Portland Road, Worthing, Sussex. Tel: 0903 34897 for surplus supplies. AVO 8 £43, Model 7 MK II £32 inclusive P x P receivers. Eddystone 730's Atlanta Marine, B40 ex-Govt. 40ft pneumatic masts by Scam Clark. Type 76 telephones. S.a.e. for details. AVO movements. All types of radio telephones, large or small quantities bought and sold, many one off items in stock. No lists, we are worth a vist, wholesale and retail.

TEKTRONIX OSCILLOSCOPE Type 545B, complete with CA D/trace plug-in, and full technical handbooks, first-class condition, £240 inclusive. Also L/D/IAI plug-ins. — Bournemouth 0202 291481. (267)

A POWERFUL WORD PROCESSOR AT £950 PLUS VAT. IBM golfball typewriter linked to twin magnetic tape cassette (or twin magnetic card) memory stations. Comprehensive edit/search and formatting operations. Autotype (specialists in reconditioned Word Processors), Abingdon 831245 and Otford 3256. (132

MARCONI INSTRUMENT SIGNAL GENERATOR TF995B/2 for sale, offers around £500. Usage to date 1 hour. Marconi Instrument Pulse Modulator TF2169 for use with the above. Usage to date 10 hours. Offers around £100. Purchasing Department, Open University, Sherwood House, Sherwood Drive, Bletchley, Milton Keynes. (297)

With 38 years' experience in the design and manufacturing of several hundred thousand transformers we can supply:

AUDIO FREQUENCY TRANSFORMERS OF EVERY TYPE

YOU NAME IT! WE MAKE IT!

OUR RANGE INCLUDES

Microphone transformers (all types), Microphone Splitter/Combiner, transformers. Input and Output transformers. Direct Injection transformers for Guitars, Multi-Secondary output transformers, Bridging transformers, Line transformers, Line transformers to G.P.O. Isolating Test Specification Tapped impedance matching transformers, Gramophone Pickup transformers, Audio Mixing Desk transformers (all types). Miniature transformers, Microminiature transformers for PCB mounting. Experimental transformers, Ultra low frequency transformers. Ultra linear and other transformers for Valve Amplifiers up to 500 watts. Inductive Loop Transformers. Smoothing Chokes, Filter inductors. Amplifier to 100 volt line transformers (from a few watts up to 1000 watts), 100 volt line transformers to speakers. Speaker matching transformers (all powers). Column Loudspeaker transformers up to 300 watts or more.

We can design for RECORDING QUALITY, STUDIO QUALITY, HI-FI QUALITY, OR P.A. QUALITY. OUR PRICES ARE HIGHLY COMPETITIVE AND WE SUPPLY LARGE OR SMALL QUANTITIES AND EVEN SINGLE TRANSFORMERS. Many standard types are in stock and normal dispatch times are short and sensible.

OUR CLIENTS COVER A LARGE NUMBER OF BROADCASTING AUTHORITIES, MIXING DESK MANUFACTURERS, RECORDING STUDIOS, HI-FI ENTHUSIASTS, BAND GROUPS, AND PUBLIC ADDRESS FIRMS. Export is a speciality and we have overseas clients in the COMMONWEALTH E.E.C., USA, MIDDLE EAST etc.

Send for our questionnaire which, when completed, enables us to post quotation by return.

SOWTER TRANSFORMERS

Manufacturers and Designers
E. A. SOWTER LTD. (Established 1941), Reg. No. England 303990
The Boat Yard, Cullingham Road, Ipswich IP1 2EG
Suffolk. P.O. Box 36 Ipswich IP1 2EL, England
Phone: 0473 52794 & 0473 219390 (141)

POLYSKOP SWOB 1 with 1 probe, 1 input cable, 1 inline attenuator, 1 adaptor R&S-BNC, 1 adaptor R&S-N. plus manual book. The lot £395. Signal generator TF 801D/8/S freq. 10 MH/z-485 MH/z £285. Pulse gen. modular CT578/3 with P1A, P2A & p6 plug-in units £95. A226 programmer. The A226 programmer is a simple means of automating any Master Series Digital Voltmeter. It provides programming of DVM range and mode, off-limit detection and scanning of analogue inputs. Mint condition. £95 only. Gaumont-Kalee Wow & Flutter meter, £48. Cohu D.C. Voltage standard type 303B, £195. HP 624C X-Band test set freq. 8.5 GH/z-10GH/z, £195. Pulse generator Type 109 Fast Rise, £95. Plug-in Unit Type 10AL, £95. N Type £50. Valve Voltmeter Type 613C, £75. R&S Noise Generator, 3-1000 MH/z 50 OHMS £95. Eddystone Communication Receiver Type 770S £450. Tektronix Oscilloscope Type 585 with L Plug-in Unit, £165. CDU 150 Oscilloscope £295. All goods subject to VAT and being unsold in the meantime. P&P extra or by arrangment. — Please phone Mr. Galka, 01-543 2515 or 01-404 5011. Personal callers welcome by appointment only. (326)

TEKTRONIX 555 dual beam 'scope. 30mhz four plug-ins plus probes, trolley and manuals. Bargain, £375. Tel. 0202 875065 (Bournemouth). (285)

TEST EQUIPMENT. Audio & R.F. Signal Generators Grip Dip and S.W.R. Meters. Transistor Testers. Reg. P.S.U. Send s.a.e., stating requirements, to TELERADIO, 325 Fore Street, London N9 0PE. (292)

MARCONI COUNTER TF2401A. Offers requested for the above. Information available from the Supplies Officer, Luton Borough Council. Tel. Luton 20613. Closing date 30.4.80. (293)

NEW 1980 Ed. WORLD RADIO T.V. HANDBOOK

COMPLETE DIRECTORY OF INTERNATIONAL RADIO & T.V. Price: **£9.50**

1980 THE RADIO AMATEUR'S H/B by ARRL Price: **£8.00**

UNDERSTANDING MICROPROCESSORS by Texas Ins. Price: **£4.00**

HOW TO USE INTEGRATED CIRCUIT LOGIC ELEMENTS by J. W. Streater Price **£4.50**

HIGH PERFORMANCE LOUDSPEAKERS by M. Colloms Price: **£5.70**

VIDEOCASSETTE RECORDERS THEORY & SERVICING by G. P. McGinty Price: **£8.95**

RADIO & ELECTRONIC LABORATORY H/B by M. G. Scroggie Price: **£18.95**

A PRACTICAL INTRO. TO ELECTRONIC CIRCUITS by M. H. Jones Price: **£5.25**

PRINTED CIRCUITS H/B by C. F. Coombs Price: **£25.35**

INTRODUCTION TO VLSI SYSTEMS by C. Mead Price: **£12.00**

★ALL PRICES INCLUDE POSTAGE★

THE MODERN BOOK CO.
Specialist in Scientific & Technical Books
19-21 PRAED STREET LONDON W2 1NP
Phone 402-9176
Closed Sat. 1 p.m. (8974)

ARTICLES FOR SALE

THE SCIENTIFIC WIRE COMPANY

PO Box 30, London, E.4.

ENAMELLED COPPER WIRE

SWG	1lb.	8oz.	4oz.	2oz.
10 to 19	2.65	1.45	.75	.60
20 to 29	2.85	1.65	.90	.70
30 to 34	3.05	1.75	1.00	.75
30 to 40	3.40	1.95	1.15	.84
41 to 43	4.55	2.55	1.95	1.30
44 to 46	5.05	3.05	2.15	1.70
47	8.00	5.00	3.00	1.80
48	15.00	9.00	6.00	3.30

SILVER PLATED COPPER WIRE

14 & 16	4.50	2.25	1.44	.90
20 & 22	5.00	2.85	1.74	1.06
24 & 26	5.70	3.31	2.00	1.22
28 & 30	6.67	3.86	2.35	1.44

Prices include P&P and VAT.
SAE brings list of copper & resistance Wires.
Dealer Enquiries invited. (9063)

INVERTERS

High quality DC-AC. Also "no break" (2ms) static switch, 19" rack. Auto Charger.

COMPUTER POWER SYSTEMS
Interport Mains-Store Ltd.
POB 51, London W11 3BZ
Tel: 01-727 7042 or 0225 310916 (9101)

GOING ON HOLIDAY???
BEAT THE BURGLAR
THE PROFESSIONAL WAY

MICROWAVE INTRUDER ALARMS

Commercial instruments by famous manufacturer. These units are complete in plastic housing with mounting spigot, they are in good used condition, checked and guaranteed working. Similar specification to units recently described in constructional article in this magazine (Feb.-March). Require 12-volt supply at approx. 200mA. Price £30.00 + £2.00 P & P per unit + VAT @ 15% on total.
ELECTRONIC WORKSHOPS
5 Burston Road, Putney
London SW15 (300)
Phone (01-789) 3989 or 01-373 0439

INVERTERS

GEC Elliott 45 KVA 415/3/50 Static Inverter. No-break Auto. Charge. New, unused.
GEC Elliott 15 KVA 240/1/50 Static Inverter. New, unused.

For full details and inspection please contact:
Mr. G. Peabody
Walker & Partners Ltd.
Staveley, Derbyshire S43 3JN
Telephone: 0246-87-2147
Telex: 547323 (144)

BURGLARS

Safeguard your home, shop, etc. from burglars and vandals with the best D.I.Y. equipment available. Send S.A.E. for comprehensive price list. E.g. £6 for one of our fully weather-proofed steel Bell-Boxes the professionals use.
Lawrence, 42/45 New Broad Street, London EC2M 1QY
"Don't buy in Kits, buy in Bits" (335)

COLOUR, UHF AND TV SPARES (miniature size 4½ x 3½ x 2⅛). New Saw Filter IF Amplifier plus tuner (complete and tested for sound and vision, £28.50, p/p £1. TELETEXT, Ceefax and Oracle in Colour, Manor Supplies "easy to assemble". Teletext kit including Texas Tifax XM11 Decoder. External unit aerial input, no other connections to set. Wide range of facilities in colour include 7-channel selection, Mix, Newsflash and Update. (Price: Texas Tifax XM11 £130, Auxiliary Unit £88, Case £14.80, p/p £2.50). Demonstration model at 172 West End Lane, NW6. Also latest Mullard Teletext 610LVM module available. Call, phone or write for further information. COMBINED COLOUR BAR AND CROSS HATCH GENERATOR KIT (MK 4) UHF aerial input type. Eight pal vertical colour bars, R-Y, B-Y, Grey scale etc. Push-button controls £35 p/p £1; Battery Holders £1.50; Alternative Mains Supply Kit £4.80; De Luxe Case £4.80; Aluminium Case £2.60. Built and tested (battery) in De Luxe Case £58, p/p £1.20. CROSS HATCH KIT, UHF aerial input type, also gives peak white and black levels, battery operated £11 p/p 45p. Add-on Grey scale kit £2.90 p/p 35p; De Luxe Case £4.80; Aluminium Case £2 p/p 85p. Built and tested in De Luxe Case £23.80 p/p £1.20. UHF SIGNAL STRENGTH METER KIT £16.80, alum. Case £1.50, De Luxe Case £4.80 p/p £1. CRT TEST AND REACTIVATOR KIT for Colour and Mono £20.80, p/p £1.30; TV 625 IF Unit for Hi-fi amps or tape rec. £6.80, p/p 75p. Surplus Bush IF panels. A816 £2.80, TV312 (single IC) £5. BC5600 (Exp) £5, A823 (Exp) £2.80 p/p 85p. Bush A823 (A807) Decoder panel £7.50 p/p £1. A823 Scan Control panel £3.50, blue lat, 75p. Philips G6 single standard convergence unit £3.75 p/p 90p. GEC 2040 ex rental panels, Decoder £5, Time Base £5 p/p 90p. Thorn 3000 ex rental panels, Video, Decoder, frame, IF £5 p/p 90p. Colour Scan coils, Plessey £6, Yoke £3.50, blue lat, 76p (Mullard also available). Mono Scan coils Philips/Pye £2.80. Thorn £2.80 p/p 85p. Philips G8 Decoder panels, salvaged for spares £3.80 p/p 90p. Varicap UHF tuners Gen Instruments £3.50, ELC 1043 £4.50, ELC1043/05 £5.50; Philips G8 £5.50 p/p 35p. Salvaged UHF Varicap tuners £1.50 p/p 35p. UHF/VHF ELC2000S Varicap tuner £8.50 p/p 65p. Varicap control units, 3 pos. £1.20, 4 pos. £1.50, 5 pos. £1.80, 6 pos. (special offer) £1.80, 7 pos. £3.80 p/p 45p. Touch Tune control unit Bush 6 pos. £5 p/p 75p. UHF transtd tuners, rotary incl. slow motion drive £2.50, 4 pos. push button £2.50, 6 pos. push button £4.20 p/p £1. (Thorne, GEC, Bush, Decca, etc., special types available, details on request). Delay Lines DL20, DL5 £3.50, DL1 80p p/p 65p. Remote Control Thorn-type Transmitter, receiver £2 pair p/p 45p. Large selection of lopts, triplers, mains droppers, and other spares for popular makes of colour and mono receivers. MANOR SUPPLIES, 172 WEST END LANE, WEST HAMPSTEAD, LONDON NW6, SHOP PREMISES, EASILY ACCESSIBLE, WEST HAMPSTEAD-BAKERLOO, JUBILEE TUBE, and BRITISH RAIL N. LONDON (RICHMOND-BROAD ST.) and ST. PANCRAS-BEDFORD. BUSES 28, 159, 2, 13. Callers welcome. Thousands of additional items available at shop premises not normally advertised. Open daily all week including Saturday (Thursday half-day). MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON NW11 9HT. Tel. 01-794 8751. All prices subject to 15% VAT.

TEKTRONIX TYPE 545 OSCILLOSCOPE with 1A2 dual-trace plug-in and instruction manual. Good working order. £175.

FRIDEN MODEL 1 FLEXOWRITER automatic typewriter with 8 channel paper tape reader and punch. Good working order. £35. — Tony Frost, 01-874 9889 evenings. (209)

TO MANUFACTURERS, WHOLESALERS & BULK BUYERS ONLY

Large quantities of Radio, T.V. and Electronic Compinents.
RESISTORS CARBON & C/F ⅛, ¼, ½, ⅓. 1 Watt from 1 ohm to 10 meg.
RESISTORS WIREWOUND. 1½, 2, 3, 5, 10, 14, 25 Watt.
CAPACITORS. Silver mica, Polystyrene, Polyester, Disc Ceramics, Metalamite, C280, etc.
Convergence Pots, Slider Pots, Electrolytic condensors, Can Types, Axial, Radial, etc.
Transformers, chokes, hopts, tuners, speakers, cables, screened wires, connecting wires, screws, nuts, transistors, ICs, Diodes, etc., etc.
All at Knockout prices. Come and pay us a visit. Telephone 445 2713 445 0749.
BROADFIELDS & MAYCO DISPOSALS
21 Lodge Lane, N. Finchley, London, N.12. 5 mins. from Tally Ho Corner. (9461)

STC 4001 TWEETERS bargain clearance offer, 2 for £6, 4 for £10, £1.50 p&p. — Seasim Ltd., The Paddocks, Frith Lane, London N.W.7. (319)

CCTV EQUIPMENT FOR SALE, consisting of 7 Grundig FA 41 cameras, 1 FA 30 with motorised zoom lens, 2 Shibaden HV 16S cameras and 3 HV 15, 21 lens various, 9 heavy duty Dennard camera housings with heaters and wipers, 1 Grundig and 1 Dennard Pan and Tilt unit, 65 E.M.I. Vidicon types 9677C and M, 3 Sets G.P.O. approved video line transmission equipment, 500 yards of 22-way multicore TV cable, this equipment is a mix of new, soiled and second-hand and is sold as seen and as such is open to offers either as a whole or separately.— Telephone 01-346 9271. (320)

SPECIAL PURPOSE and high power valves of Eimac and Varian wanted: 304TL, 4-125A, 4CX1000A, etc. 53, 6L6, 7N7, 7F7 valves also desired. — Ted, W2KUW, 10 Schuyler Avenue, North Arlington, New Jersey 07032 (USA). (829)

PCB. FIBREGLASS OFF-CUTS, £3 per lb inclusive. Electronic Mail Order Ltd., Ramsbottom, Bury, Lancs BL0 9AG. (301)

FLUKE DMM Model 8600A-01 mains/battery, c/w carrying case, manual and test leads, little used, £240. — Erith (Kent) 30556. (269)

Private enquiries, send 13p in stamps for brochure
THE QUARTZ CRYSTAL CO. LTD.
Q.C.C. WORKS, WELLINGTON CRESCENT
NEW MALDEN, SURREY. 01-942 0334 & 2988 (8493)

THINKING OF RENTING A TELEPHONE ANSWERING MACHINE?

THEN STOP!

Did you know that for the equivalent of just one year's rental you could actually buy one outright?

For details write to:
Javal Supplies Ltd. (Dept. 2C), 120 Alexandra Road, Burton-on-Trent, Staffs DE15 0JB or telephone (0283) 47427 any time. (337)

CONSTRUCTOR? MANUFACTURER? DISTRIBUTOR? RETAILER?
Continuous supplies of factory fresh

NI-CADS

'AA' size, 500 mAh. 1.2 volts
From 87p down to 58p
(+ VAT)!!

South Midlands Communications Ltd., Osborn Road, Totton, Southampton SO4 4DN. Phone (0703) 867333. Telex 477351 SmComm G. (314)

EQUIPMENT WANTED

TO ALL MANUFACTURERS AND WHOLESALERS IN THE ELECTRONIC RADIO AND TV FIELD

BROADFIELDS & MAYCO DISPOSALS

will pay you top prices for any large stocks of surplus or redundant components which you may wish to clear. We will call anywhere in the United Kingdom.

21 LODGE LANE
NORTH FINCHLEY, LONDON N12 8JG
Telephone Nos. 01-445 0749/445 2713
After office hours 958 7624 (9123)

AGENTS

EXPANDING British manufacturer requires sales agent for the following: 1 top quality audio amplifiers. 2 Medical electronic equipment. Details of experience should be submitted. Overseas enquiries welcome. — Box No. WW 309. (309

ENTHUSIASTS

AMATEUR ELECTRONICS / Microprocessor enthusiast. Wishes to contact similar minds for exchange of ideas on household automation. Coventry / West Midlands area preferred. — Box No. W.W. 304. (304

SERVICES

PRINTED CIRCUIT MANUFACTURE. Very fast, reliable service. Lowest prices. Prototypes welcome. Inhouse photography. Phone 06474-573 for instant quote or write to AKTRO-NICS Ltd., 42/44 Ford Street, Moretonhampstead, Devon. (9857

REPETITION SHEET METALWORK on Wiedemann turret press. Long/short runs. Highly competitive. Quick deliveries commission for introductions. — EES Ltd., Clifford Rd., Monks Rd., Exeter. 36489. (8060

DESIGN SERVICE. Electronic Design Development and Production Service available in Digital and Analogue Instruments, RF Transmitters and Receivers for control of any function at any range. Telemetery, Video Transmitters and Monitors, Motorised Pan and Tilt Heads etc. Suppliers to the Industry for 16 years. Phone or write Mr. Falkner, R.C.S. Electronics, 6 Wolsey Road, Ashford, Middlesex. Phone Ashford 53661. (8341

SMALL BATCH PCB's produced from your artwork. Also **DIALS, PANELS, LABELS.** Camera work undertaken. **FAST TURNAROUND.** — Details: Winston Promotions, 9 Hatton Place, London EC1N 8RV. Tel. 01-405 4127/0960. (9794

SERVICES

TV TUBE REBUILDING!

We can offer the most complete range of electron guns, parts and tube components. All gun types for black and white, also high definition guns for monitor tubes. A wide range of colour guns, to suit European/American and Japanese tube types.

We also offer equipment for testing and manufacturing. *Prices, catalogue and technical advice on request.*
ALGOGRIFF p.v.b.a.
(Electronics & Equipment)
LISPERSTEENWEG
196 2500 Lier/Belgium
Tel: 031/802387. Telex: 35371 (101)

TEST EQUIPMENT CALIBRATION AND REPAIR

Quick turn round, attractive rates, ring for details on **Southampton (0703) 431 323**

DUTCHGATE LTD.
94 Alfriston Gardens, Sholing Southampton (9385)

SHEET METAL WORK fine or general front panels chassis, covers, boxes, prototypes. 1 off or batch work fast turnround. 01-449 2695. M. Gear Ltd, 179A Victoria Road, New Barnet, Herts. (9908

PCB MANUFACTURE including circuit design, artwork (P.TH) 2:1 reduction photographic service. Drilling/profiling, assembling/testing. Single/double-sided boards. Any intermediate stage undertaken. Prototype service available.— Ring (0621) 741560 or write Mayland PCB Co Ltd, 4 The Drive, Maylandsea, Chelmsford, Essex CM3 6AB. (121

RAPID PCB SERVICE prototypes and prod. Runs up to 500 off, from your artwork. 5p per sq. in. min. order £5. Panel screening and a/work service facilities. Etch-Print, Braintree 40281. (308

EURO CIRCUITS

Printed Circuit Boards — Master layouts — Photography — Legend printing — Roller tinning — Gold plating — Flexible films — Conventional fibre glass — No order too large or too small — Fast turnround on prototypes. All or part service available NOW! (9630)
EURO CIRCUITS TD.
Highfield House
West Kingsdown
Nr. Sevenoaks, Kent. WK2344

MICROPROCESSOR CONSULTANCY SERVICE, Design and Programming. For details write to C. J. Tech, 33 Heathfield Road, Kingsheath, Birmingham B14 7BT. (3841

DESIGN DEVELOPMENT MANUFACTURE. We can offer a high quality, professional service, covering all aspects from original design to small batch production. Digital/Analogue prototypes welcome. For competitive pricing and quick delivery phone Mr. Flower, Digitalis Ltd., 9 Milldown Road, Goring-on-Thames, Oxfordshire. Tel: 049 14 3162. (9925

ELECTRONICS DESIGN SERVICE. Prototype analogue or digital circuits designed and built. Speciality instrumentation for noise and vibration measurement. Contact R. A. Redwood, 22 Church Road, Eastleigh, Hampshire. Tel. 0703 616182 evenings and weekends. (307

A COMPLETE SERVICE to manufacturers. Assembly, cable forming and testing. Also a prototype PCB service and component scheduling at competitive prices. Small or large runs with quick turn-round to high standards. Contact the professionals — Techtronic Services, Staincliffe Mills, Dewsbury, W. Yorks. Tel (0924) 409040 TX 556267. (310

ELECTRONICS DESIGN SERVICES. Microprocessor hardware and software. Design facilities have now been added to the established expertise and comprehensive test facilities previously available for Analogue and Communications Design. — For fastest results please phone Mr Anderson, Andertronics Ltd., Ridgeway, Hogs Back, Seale (nr. Farnham) Surrey. 02518-2639. (275)

CAPACITY AVAILABLE

I.H.S. SYSTEMS

Due to expansion of our manufacturing facilities we are able to undertake assembly and testing of circuit boards or complete units in addition to contract development.

We can produce, test and calibrate to a high standard digital analogue and RF equipment in batches of tens to thousands.

Telephone to arrange for one of our engineers to call and discuss your requirements, or send full details for a prompt quotation.

TEL. 01-253 4562
or reply to Box No. WW 8237 (8237)

ELECTRONIC DESIGN SERVICE. Immediate capacity available for circuit design and development work, PC artwork, etc. Small batch and prototype production welcome. — E.P.D.S. Ltd., 93b King Street, MAIDSTONE, Kent. 0622-677916. (9667

PROTOTYPE SERVICE capacity available to produce your prototypes or small batch quantities from samples or drawings, also PCB artwork design and manufacture. — Lintek Electronics, 14 Adam Close, Coxheath, Kent. Tel. 0622 679584. (282

PCBs Production runs or prototypes

Assembly to sample or drawings
★ *Design Service if required*
★ *Quick response to demand*
★ *Expert hand soldering*
★ *Nothing too large or too small*

Telephone or write:
SEAHORSE ELECTRONICS LTD.
Unit 2, Picow Farm Road
Service Industry Estate
Runcorn, Cheshire
Tel. Runcorn (09285) 75950 (9950)

K.A.H. ELECTRONICS LTD.

CONSULTANTS - DESIGNERS ASSEMBLERS

SPECIALISTS IN MICRO-BASED SYSTEMS

50 Flixton Road
Urmston, Manchester
Tel: 061-748 3878 (9919)

BATCH PRODUCTION wiring and assembly to sample or drawings. McDeane Electricals, 19b Station Parade, Ealing Common, London, W5. Tel. 01-992 8976. (169

ARTICLES WANTED

WW — 056 FOR FURTHER DETAILS

WANTED

Test equipment, receivers, valves, transmitters, components, cable and electronic scrap, any quantity. Prompt service and cash. Member of A.R.R.A.

M & B RADIO
86 Bishopsgate Street
Leeds LS1 4BB
0532-35649

We will purchase your surplus and obsolete Telephone Equipment and Electronic Components. Anything considered, from Relays to Complete Exchanges.
Contact:
TELECOMM. SPARES
Lea Valley (0992) 716945 (137)

HU-GO offer prompt settlement for surplus electronics components, TV/audio spares are of particular interest. Contact Miss Hughs, 9 Westhawe, Bretton, Peterborough. Tel. 265219. (9731)

TURN YOUR SURPLUS Capacitors, transistors, etc, into cash. Contact COLES-HARDING & Co., 103 South Brink, Wisbech, Cambs. 0945-4188. Immediate settlement. We also welcome the opportunity to quote for complete factory clearance. (9509

STORAGE SPACE is expensive, why store redundant and obsolete equipment? For fast and efficient clearance of all test gear, power supplies, PC boards, components, etc., regardless of condition or quantities. Call 01-771 9413. (8209

WANTED

ANGLIAN INDUSTRIAL AUCTIONS

We sell by auction, all radio and electronic components and equipment. Why not let us sell your surplus and end of production materials. All entries must be received at least 21 days prior to sale.

For entry forms or catalogue of next auction contact:

B. BAMBER ELECTRONICS
5 STATION ROAD
LITTLEPORT
CAMBS. CB6 1QE
TEL: (0353) 860185 (263)

DEAD OR ALIVE

SPOT CASH

paid for all forms of electronics equipment and components.

F.R.G. General Supplies
550 Kingston Road
London SW20 8DR
Tel: 01-404 5011
Telex: 24224. Quote Ref. 3165 (8742)

WANTED: Recording equipment of all ages and varieties. (California, U.S.A.). Tel. (415) 232-7933. (9814

FIELD STRENGTH METER for TV and FM wanted. Contact Mr Pedersen Salliva, 24, 4620 Vagsbygcl, Norway. (303

WHOLESALE electronic component suppliers required for company starting in mail order market. Prices, info. to Box No. WW 305. (305

WANTED, SEMICONDUCTORS and clean new surplus components. Hewitts, 52 Barkby Road, Syston, Leicester. (294)

CAPACITY AVAILABLE

CIRCOLEC

for Electronic/Electro-Mechanical Assembly. We offer the following versatile and quality service for small to large batches.

PCB and Final Assembly, Repairs and Servicing, Inspection and Functional Test, Prototypes and Associated Services, and modifications.

For competitive prices and fast turnaround, contact Circolec. Tel: 01-767 1233: 1 Franciscan Road, Tooting, S.W.17. (273)

SMALL BATCH productions wiring assembly to sample or drawings. Specialist in printed circuits assembly. Rock Electronics, 42 Bishopsfield, Harlow, Essex 0279 33018. (9094

PCB ARTWORK DESIGN SERVICE with component notation masters and assembly drawings. PADS Electrical Ltd, 01-850 6516, 45 Southwood Road, New Eltham SE9. (7905

MEDIUM SIZED COMPANY with capacity for sheet metal work and wiring assembly requires immediate sub-contract work. Tel. 01-261 1677. (296)

PCB ASSEMBLY CAPACITY AVAILABLE

Low or high volume, single or double sided, we specialise in flow line assembly.

Using the Zevatron flow soldering system and on line cutting, we are able to deliver high quality assemblies on time, and competitively priced.

Find out how we can help you with your production. Phone or write. We will be pleased to call on you and discuss your requirements.

TW ELECTRONICS LTD.
120 NEWMARKET ROAD
BURY ST. EDMUNDS, SUFFOLK
TEL: 0284 3931
Sub-contract assemblers and wirers to the Electronics Industry' (9068)

BOOKS

FREE 1980 AMTRON CATALOGUE with new range of kits and equipment cabinets. Send S.A.E. Amtron UK Ltd., 7 Hughenden Road, Hastings, Sussex TN64 3TG. Tel. Hastings 436004.

INDEX TO ADVERTISERS MAY
Appointments Vacant Advertisements appear on pages 138-151

PAGE

OVERSEAS ADVERTISEMENT AGENTS:
France & Belgium: Norbert Hellin, 50 Rue de Chemin Veat, F-9100, Boulogne, Paris.

Hungary: Mrs Edit, Bajusz, Hungexpo Advertising Agency, Budapest XIV, Varosliget.
Telephone: 225 008 — Telex: Budapest 22-4525 INTFOIRE

Italy: Sig C. Epis, Etas-Kompass, S.p.a. — Servizio Estero. Via Mantegna 6, 20154 Milan.
Telephone: 347051 — Telexb; 37342 Kompass.

Japan: Mr. Inatsuki, Trade Media — IBPA (Japan), B.212. Azabu Heights, 1-5-10 Roppongi, Minato-ku, Tokyo 106. Telephone: (03) 585 0581.

United States of America: Ray Barnes, IPC Business Press, 205 East 42nd Street, *New York*. NY 10017 — Telephone: (212) 689 5961 — Telex: 421710.
Mr Jack Farley Jnr., The Farley Co., Suite 1584, 35 East Wacker Drive, *Chicago,* Illinois 60601 — Telephone: (312) 63074.
Mr Victor A. Jauch, Elmatex International, P.O. Box 34607, *Los Angeles,* Calif. 90034, USA — Telephone (213) 821-8581 — Telex: 18-1059.
Mr Jack Mentel, The Farley Co., Suite 650, Ranna Building, *Cleveland,* Ohio 4415 — Telephone: (216) 621 1919.
Mr Ray Rickles, Ray Rickles & Co., P.O. Box 2028, *Miami Beach,* Florida 33140 — Telephone: (305) 532 7301.
Mr Tim Parks, Ray Rickles & Co., 3116 Maple Drive N.E., *Atlanta,* Georgia 30305. Telephone: (404) 237 7432.
Mike Loughlin, IPC Business Press, 15055, Memorial Ste 119, *Houston,* Texas 77079 — Telephone (713) 783 8673.

Canada: Mr Colin H. MacCulloch, International Advertising Consultants Ltd., 915 Carlton Tower, 2 Carlton Street, Toronto 2 — Telephone: (416) 364 2269.
*Also subscription agents.

Printed in Great Britain by QB Ltd., Sheepen Place, Colchester, and Published by the Proprietors IPC ELECTRICAL-ELECTRONIC PRESS LTD., Dorset House, Stamford Street, London, SEI 9LU, telephone 01-261 8000. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm, Dawson Subscription Service Ltd, Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd: William Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Distribution Inc., 14th floor, 111 Eighth Avenue, New York, N.Y. 10011.

WW—004 FOR FURTHER DETAILS