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SEPTEMBER 1980 50p

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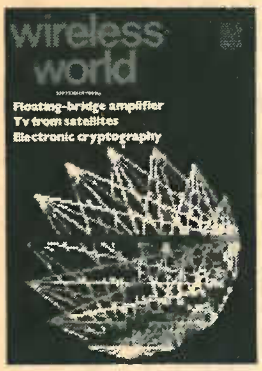

Front cover shows display taken from the screen of the memory-mapped, colour graphics v.d.u., described by S. J. Marchant in the April 1980 issue. Picture by Bill Banks.

IN OUR NEXT ISSUE

***Acoustically small loudspeaker* is a unique design in which the enclosures work below the lowest cavity resonance.**

***Floppy disc store* is a controller and 8in drive intended for the *Wireless World* computer, but adaptable for other designs.**

***Tuner frequency meter* provides digital indication of frequency, mainly for radio receivers, but usable also as a general instrument.**

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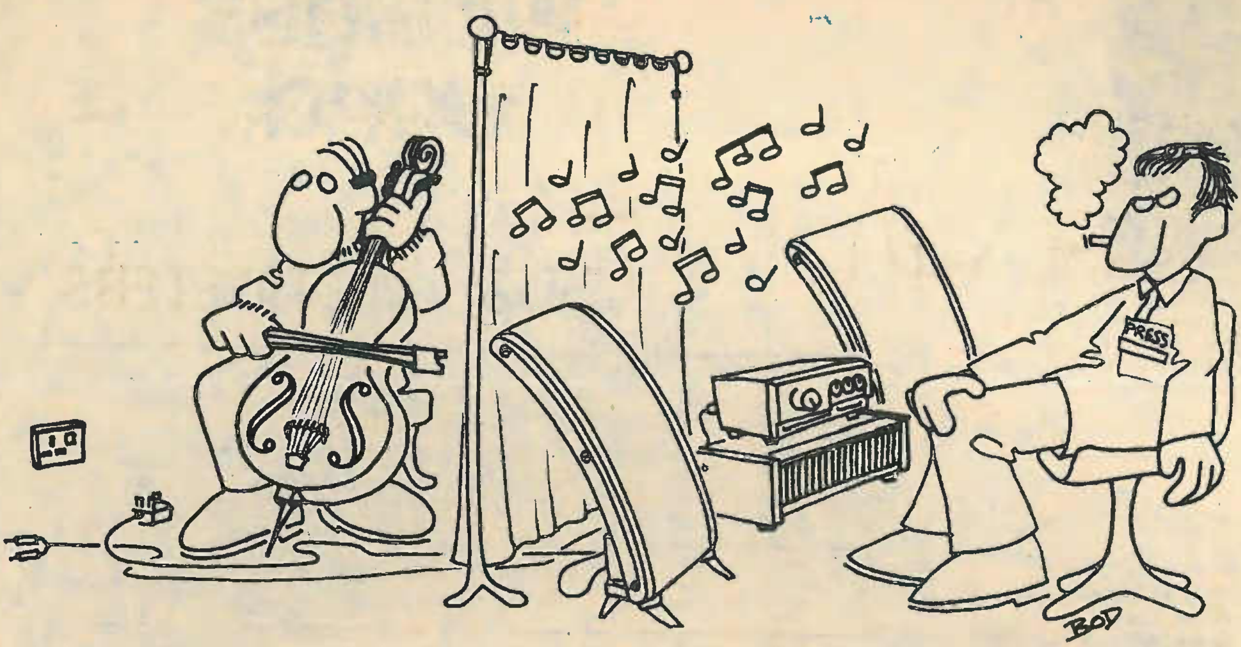
ISSN 0043 6062

wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

SEPTEMBER 1980 Vol 86 No 1536



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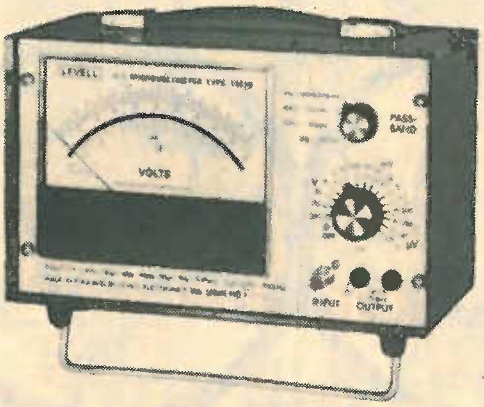
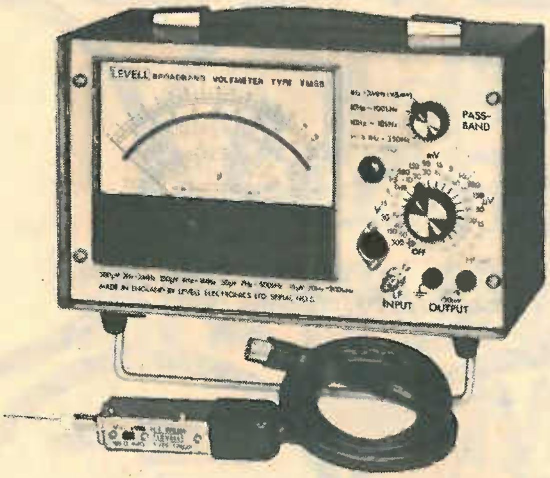


A.C. MICROVOLTMETERS

VOLTAGE & dB RANGES	15µV, 50µV, 150µV . . . 500V fsd. Acc. ± 1% ± 1% fsd ± 1µV at 1kHz. — 100, —90 . . . + 50dB. Scale —20dB/+6dB ref. 1mW/600Ω.
RESPONSE	± 3dB from 1 Hz to 3MHz, ± 0.3dB from 4 Hz to 1MHz above 500µV. TM3B filter switch: LF cut 10Hz, HF cut 100KHz, 10KHz or 350Hz.
INPUT IMPEDANCE	Above 50mV: 10MΩ <20pF. On 50µV to 50mV: >5MΩ <50pf.
AMPLIFIER OUTPUT	150mV at fsd.

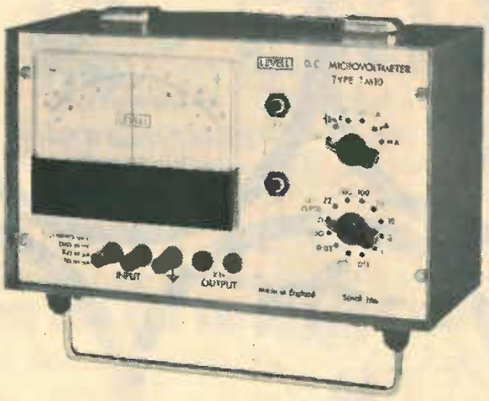
type TM3A £130 **type TM3B £145**



BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES	1mV, 3mV, 10mV . . . 3V fsd. Acc. ± 4%± 1% fsd at 30MHz. —50, —40 . . . +20dB. Scale —10dB/+3dB ref. 1mW/50Ω.
H.F. RESPONSE	± 3dB from 300kHz to 400MHz. ± 0.7dB from 1MHz to 50MHz.
L.F. RANGES	As TM3.
AMPLIFIER OUTPUT	Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

type TM6A £199 **type TM6B £215**



D.C. MICROVOLTMETERS

VOLTAGE RANGES	30µV, 100µV, 300µV . . . 300V. Acc. ± 1% ± 2% fsd ± 1µV. CZ scale.
CURRENT RANGES	30pA, 100pA, 300pA . . . 300mA. Acc. ± 2% ± 2% fsd ± 2pA. CZ scale.
LOG. RANGE	± 5µV at± 10% fsd, ± 5mV at ± 50% fsd, ± 500m V at fsd.
RECORDER OUTPUT	± 1V at fsd into >1kΩ.

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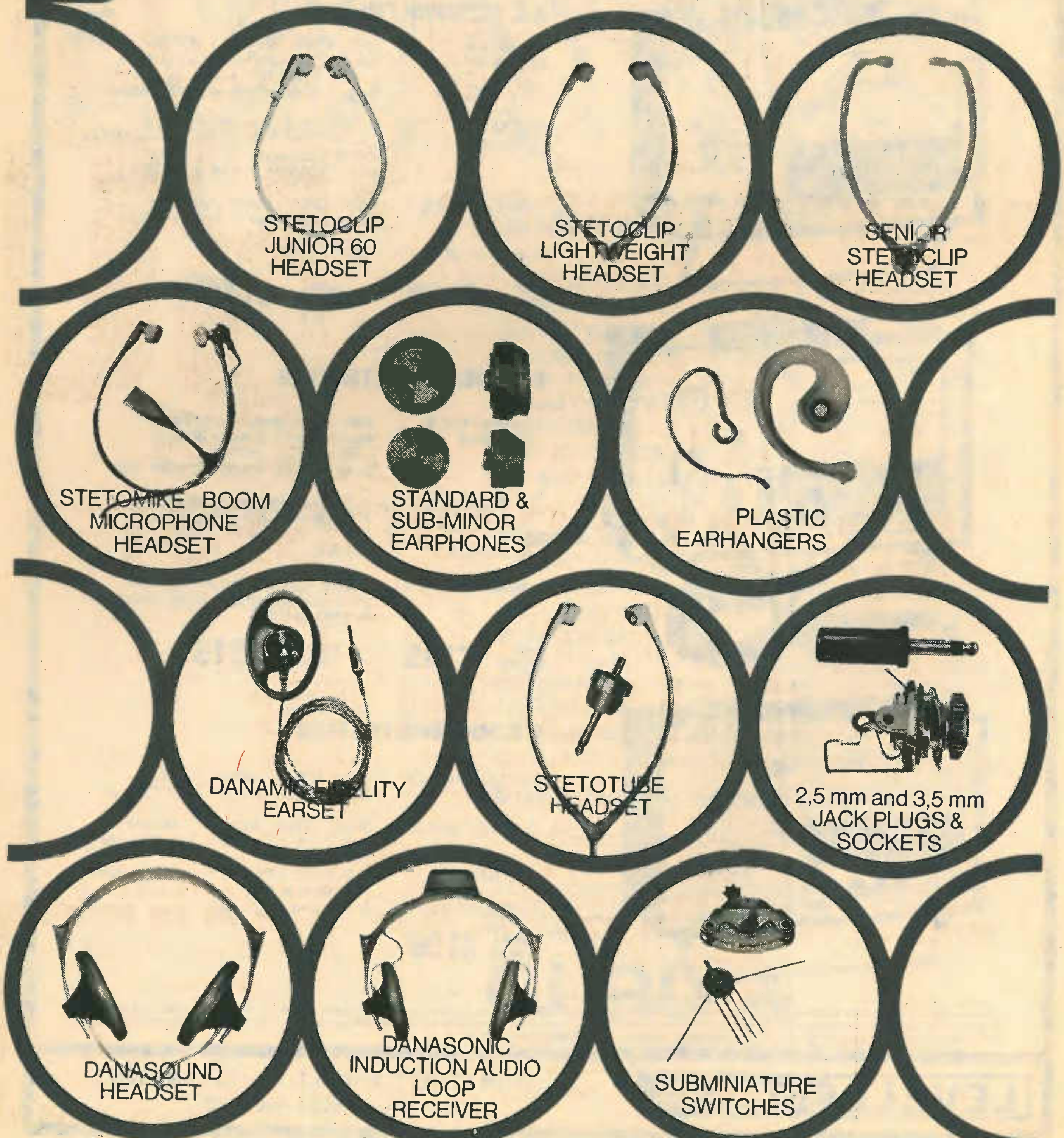

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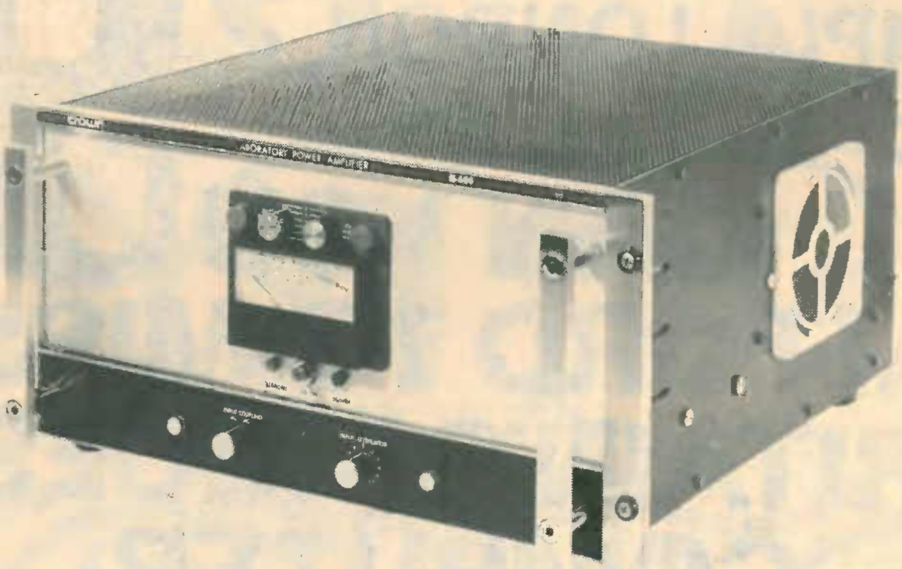

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Remember, its many important features include full four digits, so on mains voltage readings, for example, you might get *240.3* instead of the *240*, which a 3½ digit meter would read.

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

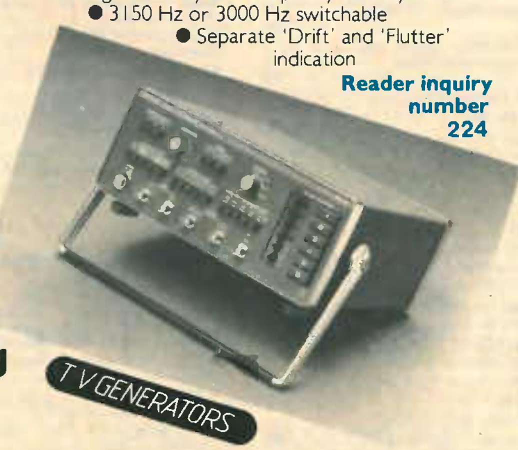
- 100 kHz-125 MHz in 9 overlapping ranges
- Built-in 5 digit counter
- 50mV RF output at 75Ω can be attenuated to over 100dB
- Electronically stabilised output level
- Wobbulator facility

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



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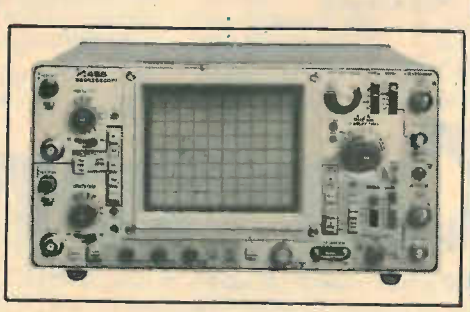

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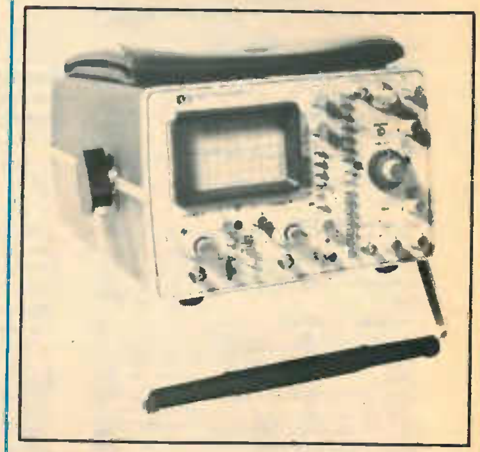

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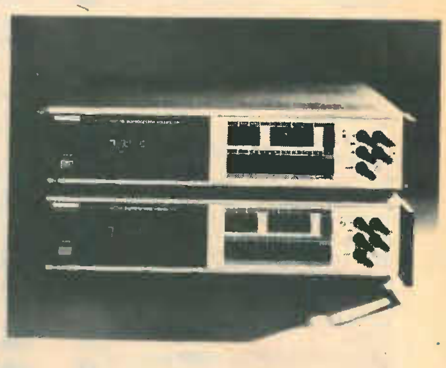
Digital Voltmeters

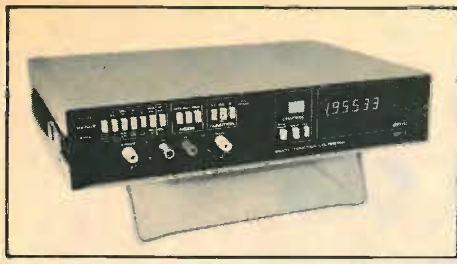


7065 6½ Digit Microprocessor Multimeter Solartron
Scale length 1,400,000, modes: DC, AC, Ohms,
Ranges: = : 10mV–1000V, resolution 1µV, ~ : 100mV–1000V, resolution 1µV, Ω : 10–10MΩ, resolution 1 mΩ,
Typical accuracy: = 0.005%, ~0.1%, Ω0.007%.

£840

7055 5½ Digit Microprocessor Multimeter Solartron
Scale length 200,000, modes DC, AC, Ohms.
Ranges: = : 10mV–1000V, resolution 1µV, ~ : 100mV–1000V, resolution 1µV, Ω : 100Ω–10M Ω, resolution 10mΩ, Typical accuracy: = 0.01%, ~0.1%, Ω0.03%.

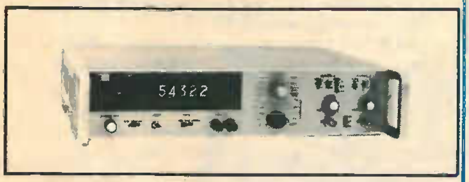
From £715



1051 5½ Digit Multimeter with true RMS Datron
Scale length, 1.99999, modes: DC, AC, true RMS, Ohms, auto range.
Ranges: = V : 10mV–1000V, resolution 0.1μV, ~V : 100mV–1000V, resolution 1.0μV, Ω : 100Ω–10mΩ, resolution 1mΩ, Typical accuracy: = V ±0.004%, ~V ±0.06%, Ω±0.02%.

£980

Digital Counters



5327B 7 Digit Universal Counter Timer and D.V.M. Hewlett-Packard
Modes: Frequency, period, time interval, D.C. Voltage. Frequency range 0 – 550MHz, D.V.M. range 10V – 1000V, resolution 100uV, Counter stability 5 parts in 10^9 short term, counter sensitivity 25mV.

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Modes: Frequency, period, multiple period, Frequency range 0 – 500MHz, Resolution: 1Hz, 110ms typical stability/24H 1 part in 10^7. Maximum sensitivity 10mV.

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8 inch NARTB centre spool, frequency range DC – 20KHz, tape speed 15/16 – 60ips.

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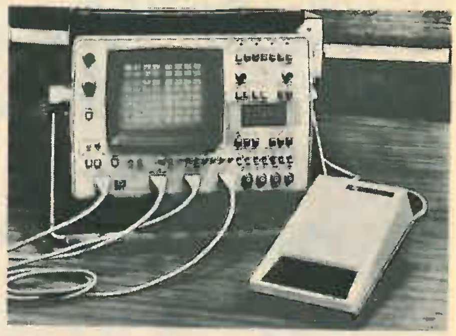

1600A Hewlett-Packard
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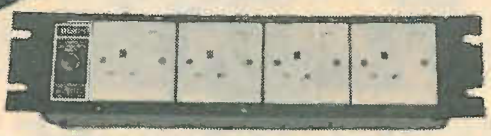

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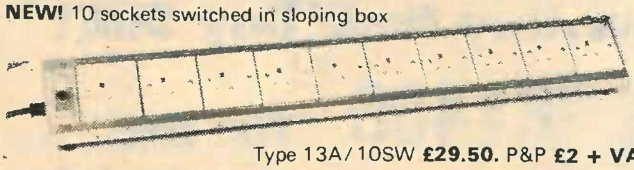

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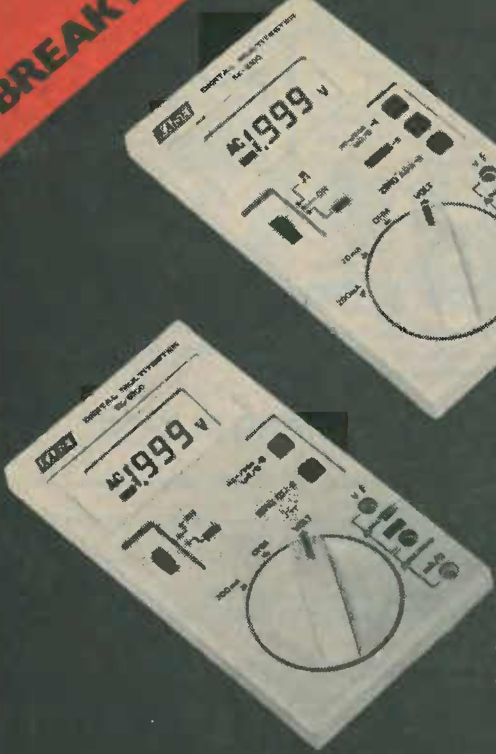
DMM BREAKTHROUGH



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- 10 AMP AC/DC (6110 and 6220 only)

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RANGE HOLD	✓	✓		
UNITS OF MEASUREMENT DISPLAYED	mV, V, mA	mV, V, mA, A	mV, V, mA	mV, V, mA, A
FUNCTIONS DISPLAYED	Ω, KΩ, AUTO, BATT, ADJ, LO, – and AC			
MEASURES DC VOLTAGE TO:	1000V	1000V	1000V	1000V
MEASURES AC VOLTAGE TO:	750V	750V	750V	750V
MEASURES AC/DC CURRENT TO:	200mA	10A	200mA	10A
ZERO ADJUSTMENT	Zeros out minute test-lead resistances for precise measurements			
ACCURACY	0.5%	0.5%	0.8%	0.8%
LOW POWER OHM RANGES	For in-circuit resistance measurements on all models			
BUZZER – Continuity Test	✓	✓		
BUZZER – Over Range Indicator	✓	✓		
COMPLETE WITH	Batteries, pair of Test Leads, Spare Fuse, One Year's Guarantee			
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The finest amplification kits from Crimson Elektrik

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CRIMSON ELEKTRIK Power amplifiers are the most sophisticated on the market today. Yet now with the latest Issue 5 innovations THEY ARE EVEN BETTER! We have included sonic improvements and developed a unique electronic protection circuit which obviates the need for output fuses. In fact, such fuses can seriously degrade the performance of an amplifier. They can blow under heavy drive conditions — even with non-faulty loads (due to thermal fatigue), they can be a time-consuming nuisance and even dangerous to replace, but more importantly they are responsible for 'envelope distortion' i.e., dynamic compression of the signal, even fuses in the feedback loop suffer from the first two disadvantages, and the latter to a lesser extent.

★ ★ ★ ★ BEST VALUE ★★★★

CRIMSON have an enviable reputation for supplying the best value amplifier kits. You can prove this to yourself by checking out the competition in the following crucial areas: ★ professional grade phono sockets for ALL signal connections ★ Silver/Gold plated switch contacts ★ Adequate heatsinking for full-rated output ★ Available from stock ★ Manufactured by a specialist company with a reputation for friendly and helpful service before and AFTER sale ★ Forms the basis for high quality active loudspeaker systems. Considering the advantages of CRIMSON Kits, why choose anything else?

★ ★ ★ ★ ★ SOUND ADVICE ★★★★

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Space precludes us from publishing all our products and prices, below are just a few examples:

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- CP 3000 —(300 WRMS/4 ohms) £58.00

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★ Stereo Moving Coil Pre-Pre Amplifier Module MC1 .... £28.50
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Don't forget, Crimson modules are available throughout the country from all branches of Marshalls and Mail Order from Badger Sound Services and, of course, Crimson Elektrik.

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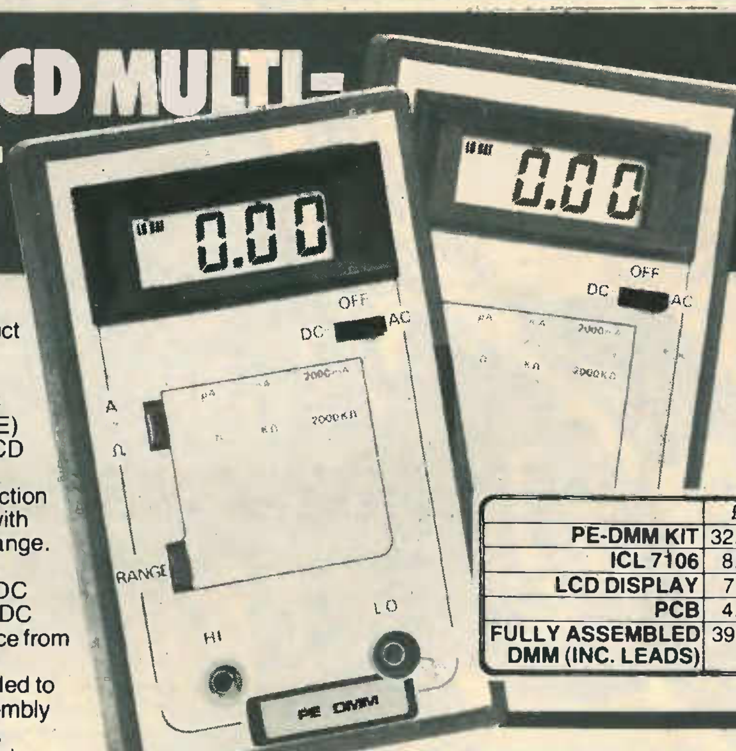
3½ DIGIT LCD MULTI-METER KIT

NEW



Build the Practical Electronics handheld DMM. This superb product offers professional precision with extended battery life. Five function operation (AC and DC VOLTS, AC and DC CURRENT, RESISTANCE) with ability to check diodes. 0.5" LCD display with 'Battery Low' warning. Auto-polarity, Auto-zero. Full protection against transients and overloads with ability to withstand mains on any range. 0.5% basic DC accuracy and 15 different ranges. It measures AC/DC voltages from 0.1mV to 500V. AC/DC current from 0.1μA to 2A. Resistance from 0.1Ω to 2MΩ. 200 hour battery life.

The Kit contains all parts needed to construct the multimeter plus assembly instructions, battery and test leads.

We also offer a calibration service (£5.00 + VAT) and a trouble-shooting and calibration service (£7.50 + VAT). Various other component parts are also available as listed.

The multimeter is also available fully assembled and calibrated at a cost of £39.70 + P&P + VAT.

FEATURED AS A PROJECT IN PRACTICAL ELECTRONICS

	£	P & P	VAT	TOTAL
PE-DMM KIT	32.95	1.00	5.09	39.04
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LCD DISPLAY	7.95	0.50	1.27	9.72
PCB	4.95	0.50	0.82	6.27
FULLY ASSEMBLED DMM (INC. LEADS)	39.70	1.25	6.14	47.09

Lascar Electronics Ltd., Unit 1, Thomasin Road, Basildon, Essex. Telephone No: Basildon (0268) 727383.

To: Lascar Electronics, Unit 1, Thomasin Road, Basildon, Essex.

Please send me Data ☐ **FULLY ASSEMBLED DMM (INC. LEADS)** £47.09 ☐

PE—DMM KIT £39.04 ☐ **ICL 7106** £10.87 ☐ **LCD DISPLAY** £9.72 ☐ **PCB** £6.27 ☐

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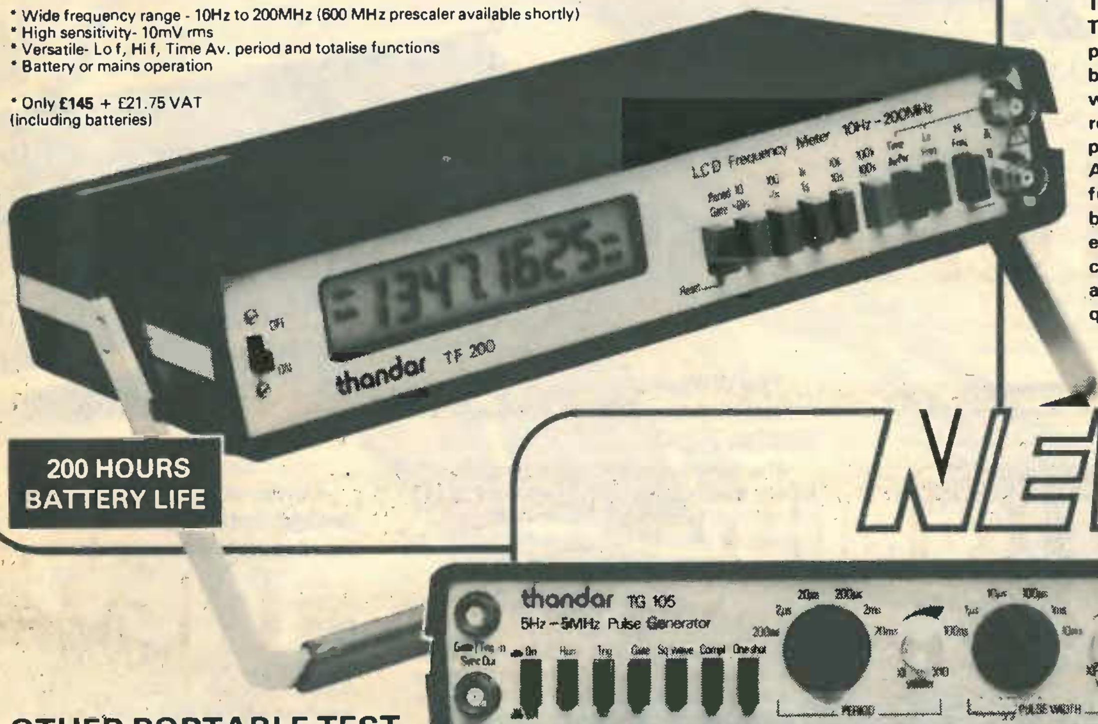

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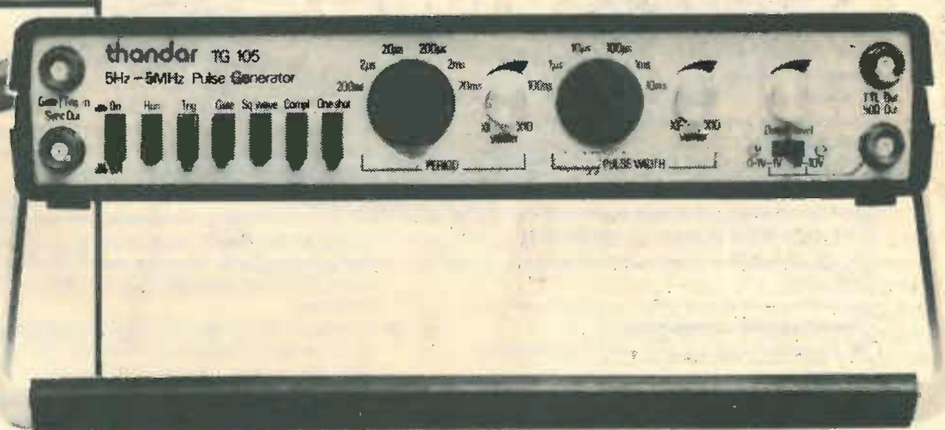

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To help you appreciate its value, the price is shown above with and without VAT. This is so you can compare the ZX80 with competitive kits that don't appear with inclusive prices.

'Excellent value' indeed!

For just £79.95 (*including* VAT and p&p) 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 a cassette recorder and television (black and white or colour); *everything!*

Yet the ZX80 really is a complete, powerful, full-facility computer, matching or surpassing other personal computers at several times the price.

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

The 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 to 26.
- Variable names of any length.
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- 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.
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- All characters printable in reverse under program control.
- Lines of unlimited length.

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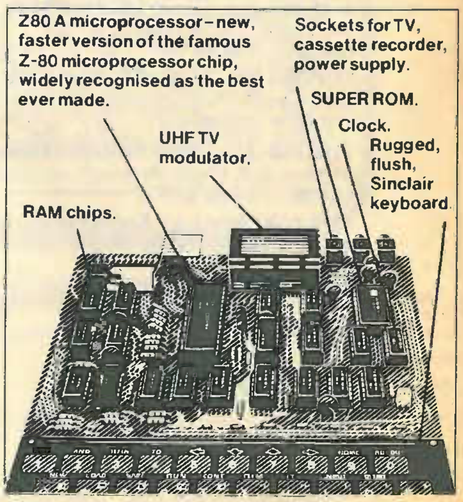
The display shows 32 characters by 24 lines.

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.



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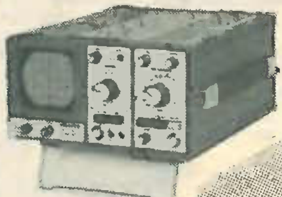

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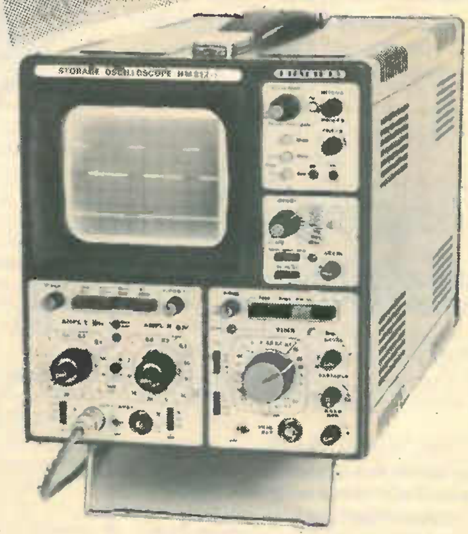

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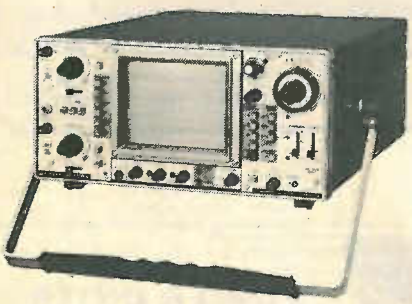

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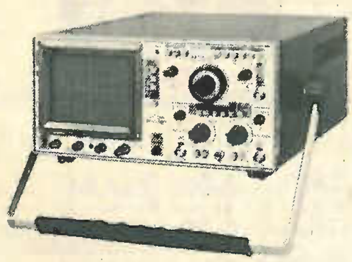

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35MHz.5mV 5 x MAG 1 mV.15MHz Automatic Selection Alternate/Chop (200KHz) and Chop Only Mode Delayed Sweep - One Touch Triggered Delay Variable Hold Off, One Touch X-Y Operation, Auto Focus Internal Graticule High Brightness CRT (Non- illuminated)

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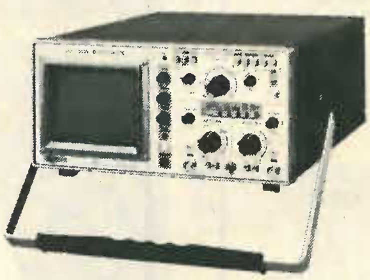
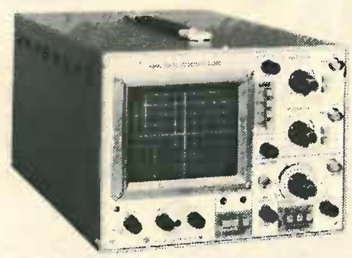


LOW PRICE, HIGH VALUE, DUAL CHANNEL 35MHz SCOPES Models 5530/5530GR

35MHz.5mV 5 x MAG 1mV.10MHz 5530: Illuminated External Graticule 5530GR: Internal Graticule (Non-illuminated) Post-Accelerating High Brightness CRT Vertical Delay Line Built-in One Touch X-Y Operation

ONLY £ 395



A LOWER PRICED, HIGH PERFORMANCE 20MHz SCOPE Model 5520

20MHz.5mV 5 x MAG 1mV.10MHz One Touch X-Y Operation TV Sync. Separator (Trigger) Single Sweep Function High Brightness CRT

ONLY £230

Prices exclude VAT, and are correct at time of going to press.

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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

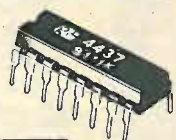
Previewing the most comprehensive audio preamplifier yet...... DC switching of 7 inputs, plus two tape in/outs. 2 low pass, 2 high pass active filters. genuine volume related loudness, 1dB channel matching, with DC volume, balance, bass and treble controls. Suitable for bus/remote control, tape dubbing, 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.

Semiconductors

Radio/Communications ICs

FOR COMPLETE LISTINGS – SEE OUR NEW PRICELIST

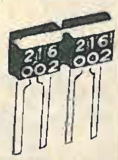
CA3089E	2.11	HA1197	1.61	SD6000	4.31
CA3189E	2.53	CA3123E	1.61	TDA4420	2.59
HA1137W	1.95	TDA1072	3.09	MC1330P	1.38
HA11225	2.47	TBA651	2.53	MC1350P	1.38
HA12412	2.81	TDA1090	3.51	KB4412	2.24
KB4420	1.95	TDA1220	1.61	KB4413	2.24
TBA120S	1.15	TDA1083	2.24	KB4417	2.53
KB4406	0.80	TDA1062	2.24	MC3357P	3.16



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:-

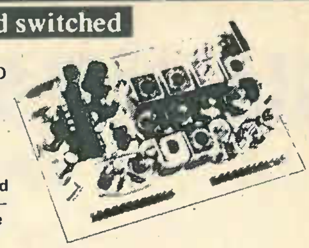
SSB transceiver system : 10kHz to 1000MHz !!

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.

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

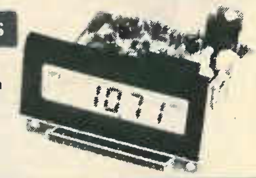
944378-2
£26.45

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



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10.7MHz	25kHz Channel spacing 8pole	£16.67
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34.5MHz	1.3dB loss, 80dB stopband HF first filter in synth. RX	£36.80
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	AM pairs ..	£3.57
USB/LSB	Xtals for 10.7SSB filter	£2.88 ea

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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)

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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

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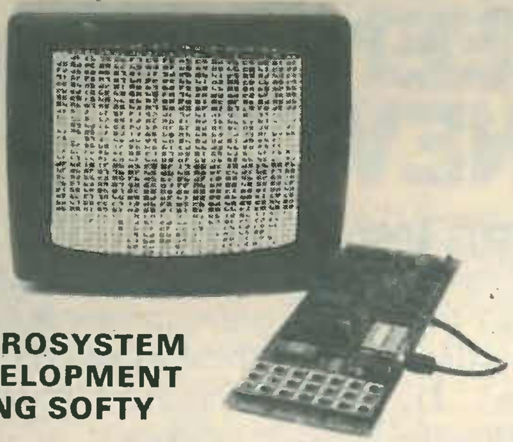

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In the end, when the program is complete and working, the DIL plug is removed and replaced by an EPROM device programmed by SOFTY. **SOFTY is able to program the 2704/2708/2716 family** which have 3 voltage rails

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.

SOFTY Kit-of-parts: (including zero insertion force socket for EPROM programmer). **Price £115** (inc. VAT p&p). **SOFTY built and tested — £138** (inc. VAT p&p). **Built SOFTY power supply — £23** (inc. VAT p&p). Write or telephone for full details.

NEW — SOFTY CONVERSION CARD — EX-STOCK

Enables SOFTY to program the single rail EPROMS 2508, 2758, 2516, (INTEL 2716), 2532.
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MODEL 14 EPROM ERASERS

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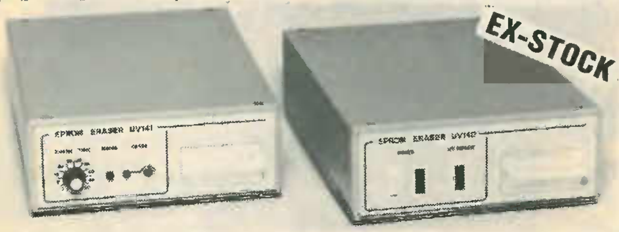

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- Fast erase times (typically 20 minutes for 2708 EPROM)
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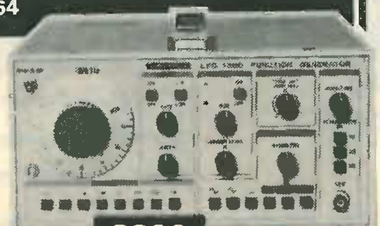

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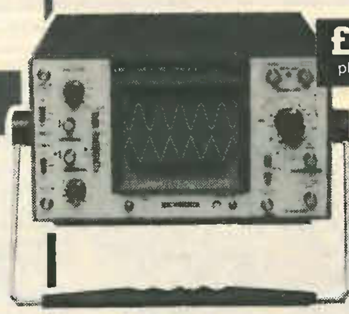

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LBO 513	10 MHz	5 mV	Single Trace	5"
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WW – 066

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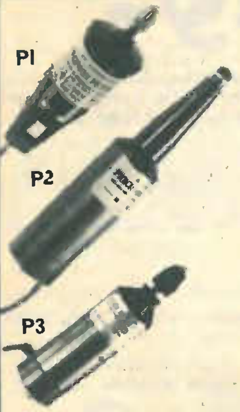

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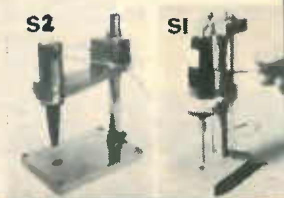

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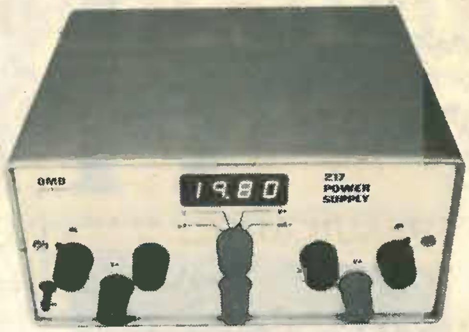

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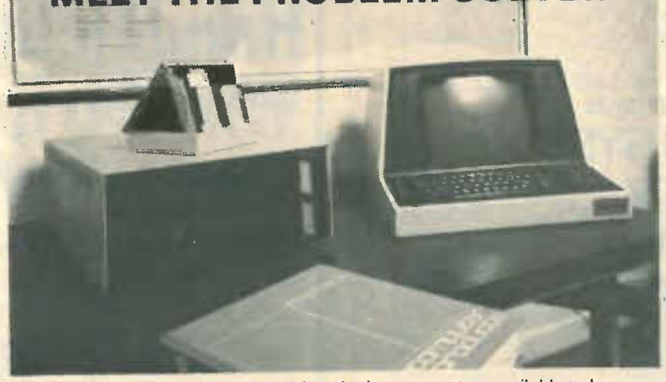

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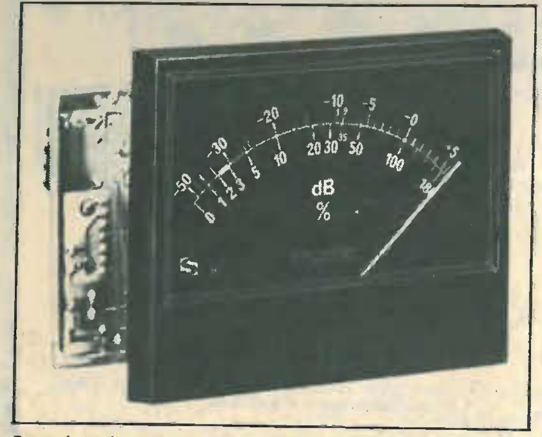

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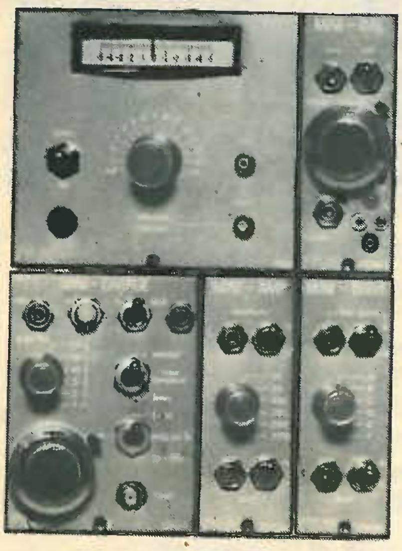

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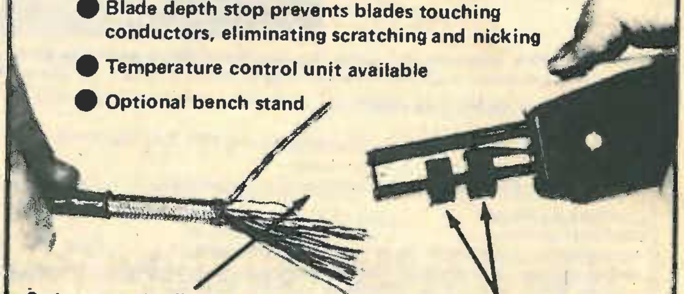

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He who hesitates . . .

Democratic, parliamentary government is a fine thing. Matters of consequence to the community cannot be left to the whims of dictators, unless they happen to be of an unusually benevolent disposition. The imposition of taxes, the control of education, health care, transport – all must be discussed and arranged in a properly democratic manner. But, when ministers are seen to shy away from the decision which must be taken when the talking stops, one can sometimes begin to wish for a benevolent despot, or at least a well-heeled entrepreneur.

In America, Japan and one or two European countries, thousands of millions of pounds worth of investment have been used to build vigorous research, development and production programmes in integrated-circuit technology. In the UK, Sir Keith Joseph hesitated over the second £25 million for Inmos. He would clearly have preferred the company to raise the money from private sources, but only discerned "flickers of interest" from private enterprise. That the interest is only a flicker does not show the City in a particularly adventurous light – it evidently likes to apply its risk capital in an area of slightly less risk – but the decision has to be accepted.

Since the original plan to fund Inmos to the tune of £50 million was made, the company has lived up to its promises and is on schedule with its US operation: nothing has changed. Although the original decision was made by a Labour government, there seems to be no reason why the Tory incumbents should wish to throw away the first £25 million by holding back the second. Inmos have said that they have already lost £36 million in the time spent havering over the second instalment. If it had not been forthcoming, Inmos would almost certainly have survived, but as an American company, possibly raising money from US sources.

The question of whether we need Inmos has been raised. It is somewhat late in the game, after all, to start competing with the established giants, particularly as the said giants are pretty well entrenched in Britain already. One American view is that Europe has no need of a semiconductor manufacturing capability; the application is all, so they say, so why not leave the supply of raw materials – chips – to others? One hesitates to appear churlish in the face of such altruism, but the Americans ought not to be asked to shoulder the whole burden of mountainous profits from semiconductor making.

They do have a very good point, of course. Software and applications development do not run away with the millions in the way that chip design, manufacture and marketing can in the early stages. The UK is already rather good at software (less so at industrial application) so perhaps we should concentrate on this side of the "microelectronic revolution".

If there were a choice, that would possibly be a sensible one. But is there a choice? Is it really in our best interests to leave to foreign companies the conception, design and manufacture of supplies which we are constantly being told will be central to our future economy? Will we then be supplied with the devices we want or those we are told to want? Will we be supplied at all? Having already seen control of many of our established industries pass from our hands in an involuntary way, it hardly seems reasonable to forego a chance of holding on to one of such significance.

It may be that the pathetically small investment in Inmos which is all that is possible, unless private enterprise becomes more enterprising, is far too little and about fifteen years too late, but however small a UK microelectronics industry finds itself to be when the situation stabilizes, a nucleus of capability strong enough to supply special needs and, more important, to attract the necessary brain power, must be kept. This is a decision which carries extremely long-term consequences: future options should not be limited by further haggling over the petty cash.

The floating bridge

New design principle for audio amplifiers

by R. M. Brady

This article describes a design principle which has the advantages of the bridge amplifier but none of its disadvantages. A simple amplifier which drives four ohm, 15-watt speakers using power from a 12-volt car battery is described in part 2 and test results are included. The design is further applied to a 200-watt version suitable for group use.

Bridge amplifiers offer many potential advantages over single push-pull amplifiers: high power, high voltage swing for moderately low-voltage components, lower power dissipation in each transistor, and the capability of operating with high impedance loads, thereby reducing transmission losses and permitting a high damping factor. They are almost essential if power supply voltage is limited as, for example, with a car battery. Present designs, however, are necessarily of complex and cumbersome manufacture, making them expensive and not so reliable. They also have limited bandwidth and poor distortion performance, because of the close coupling between individual halves of the amplifier.

One half controls the instantaneous potential of one output terminal with respect to earth, and the other does the same job on the other terminal. The new system uses one amplifier to control the difference between output terminal potentials, and a second, cheaper amplifier to control a quantity which could loosely be called the sum of these voltages. This amplifier acts merely as a "slave" to the first one, enabling a full voltage swing to occur, but not in any way directly affecting the required output. The second amplifier is capacitively by-passed at high frequencies, where a full voltage swing is not so important in audio work. This bypassing prevents the instability for which bridge amplifiers are renowned.

The simplest version of the circuit requires that the earth (i.e. chassis, screening and mains earth) be floating, changing potential with respect to the power supply. Although this is unusual, it is perfectly safe and acceptable provided steps are taken to prevent stray mains currents from passing through the system.

It turns out that the design of both component amplifiers may be considerably reduced in complexity by using this system. Extras, such as current protection, may be added easily and far more simply to the floating bridge than to conventional amplifiers

The new system has the following advantages over conventional bridge amplifiers:

- wider bandwidth and lower distortion
- optimized voltage swing, because *both* amplifiers must bottom before the output is affected
- saving in cost and complexity
- one output terminal may be earthed
- possibility of using two floating bridges to make a bridge-bridge amplifier

The next section presents the system in block diagram form, contrasting it with a conventional bridge amplifier configuration, and then sub-dividing the circuits for tracing through the feedback loops of the whole system, prior to reading the later paragraphs. The circuits are rather unconventional,

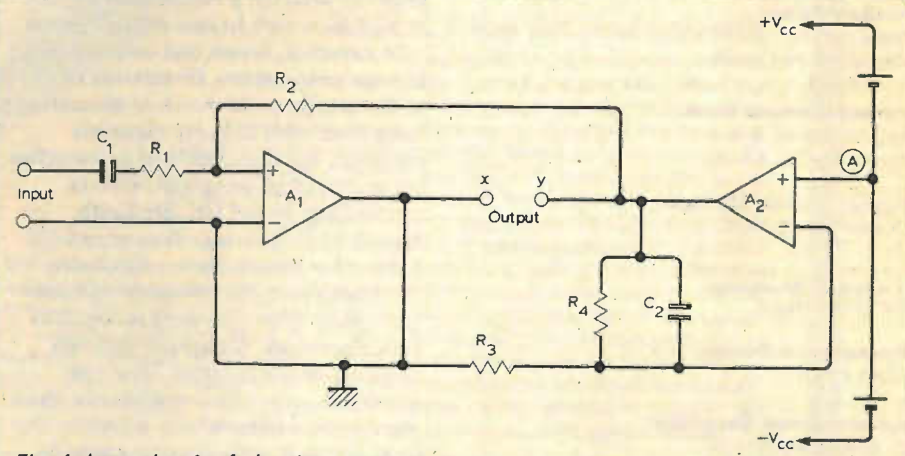


Fig. 1. In version A, A_1 is a high quality amplifier which controls the difference between output terminal voltages, x — y, while A_2 is a cheaper amplifier which controls the sum x + y so that full voltage swing can occur. Note the unusual position of the earth. (x and y are potentials with respect to point A.)

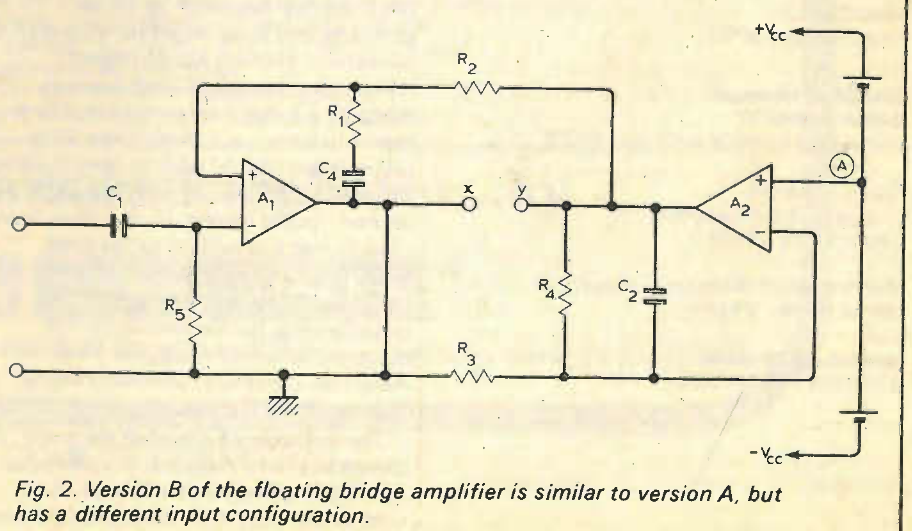


Fig. 2. Version B of the floating bridge amplifier is similar to version A, but has a different input configuration.

and if you do, you may find it good advice to forget temporarily the electronics you have already learnt, and to investigate the circuits from first principles.

Block diagram analysis

Two alternative but similar arrangements of the bridge amplifiers are shown in Figs 1 & 2. Amplifiers are inverting and non-inverting and A_1 is insensitive to the state of the power supply. Output terminals are labelled x and y as shown, being instantaneous potentials with respect to point A, and in both cases the feedback loops are arranged so that at low frequencies A_1 controls the value of $x-y$, and A_2 controls the value of $xR_4+yR_3 \approx x+y$. Capacitor C_2 by-passes A_2 at high frequencies, where large voltage swings are unnecessary. Circuit A, Fig. 1, inverts the signal whereas circuit B, Fig. 2, does not.

First consider a simple-minded approach to a conventional bridge amplifier, Fig. 3. Feedback loops are arranged so that if V is the instantaneous input voltage then $x=GV$ and $y=-GV$, and the output across the load is $x-y=2GV$. Remembering the close coupling between individual amplifiers, imagine that x rises for some reason because of effects in A_1. This causes A_2 to turn on, to keep y constant. The fact that A_2 has turned on affects the value of x, causing A_1 to react each time there is a small phase shift, which can easily be amplified by this mechanism and cause unwanted oscillation. Hideous things can happen at the cross-over point where both amplifiers must conduct simultaneously. The new system almost completely eliminates this coupling effect.

Effect of A_1 in circuit A Fig. 4 shows A_1 and its associated feedback loop. For the present A_2 can be regarded as a sink which will accept any current generated by A_1. In the quiescent state, A_1 stabilizes x—y to its own (ideally zero) offset voltage. Imagine that the potential y rises with respect to x for some reason. The potential at the + input to the amplifier remains at almost earth potential x, so that there is a voltage across R_2 which tends to make a current pass into the + input. This causes A_1 to turn on in such direction as to make a current pass from x to y through the load impedance*, thereby reducing the value of $y-x$ and stabilizing the system. Amplifier A_1 is acting as a virtual earth amplifier, and its voltage gain is R_2/R_1. Because A_1 is insensitive to supply voltages, then any change in potential y with respect to the power supply will not be noticed by A_1 (apart from stray capacitance effects**). As the potential

*Remember Kirchhoff's Law; if current is supposed to disappear down the earth line, where is the circuit supposed to be completed?

**There is also a low frequency coupling, discussed in part 2

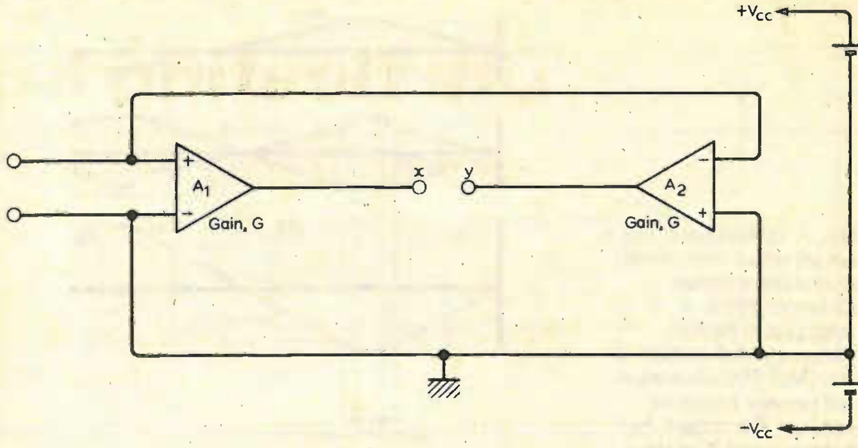


Fig. 3. In the conventional bridge amplifier A_1 and A_2 are identical good quality amplifiers arranged so that output x is proportional to the input and output y is the negative of this. It enables a high maximum voltage swing to occur for a given power supply, but is expensive and prone to instability.

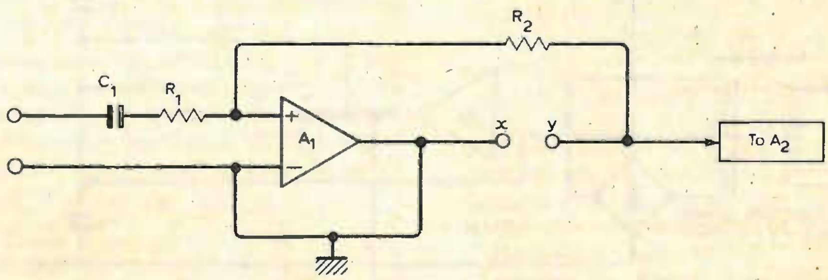


Fig. 4. A_1 amplifier of version A. Ignoring the earth connection, imagine voltage y rises; feedback is arranged so that this causes a current to flow into x, causing x to rise, and so restoring the correct output x — y (i.e. negative feedback). As there is only one earth connection it cannot short out any currents! Amplifier gain is R_2/R_1.

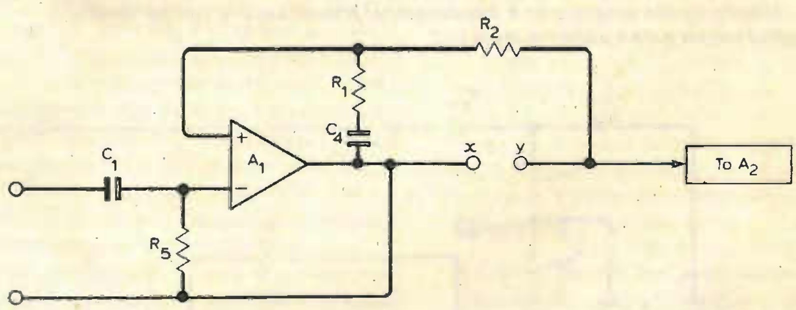


Fig. 5. A_1 amplifier of version B, similar to that of version A, but with slightly different input. Amplifier gain is again R_2/R_1.

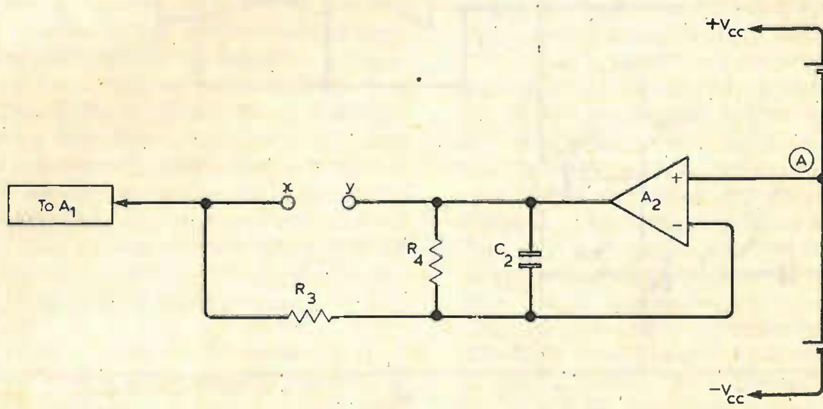


Fig. 6. Cheap amplifier A_2 controls the sum x + y. Normally, this must control the current so that y = —x, which would be the case if $R_3 = R_4$. At high frequencies full voltage swing is not so important and C_2 gives feedback so that y remains constant; this greatly simplifies design.

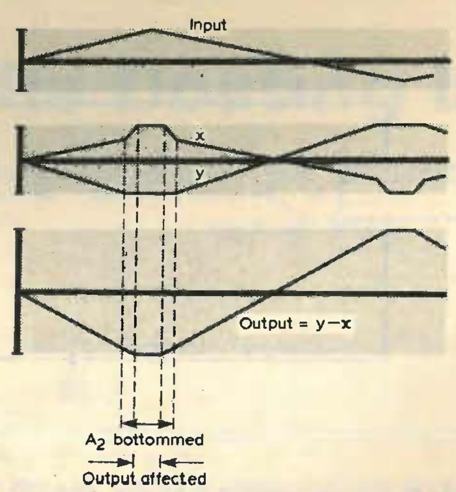


Fig. 7. Operation of the circuit when over-driven with a large signal. Cheap amplifier A_2 is arranged to bottom before the full voltage is reached. This enables a full voltage swing to occur in the output, but bottoming of A_2 does not affect the output.

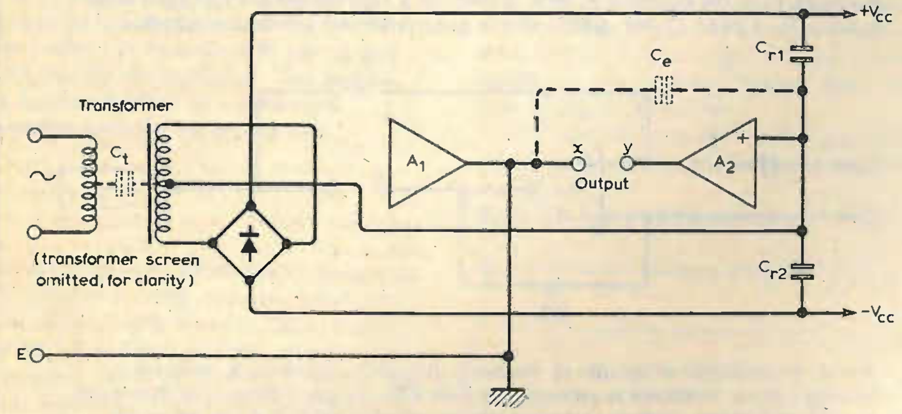


Fig. 8. Simple power supply arrangement in which C_e is stray between earth and the power supply, C_t is the transformer capacitance between the mains and secondary; if an earthed screen is not included then mains currents could pass, destroying the amplifiers. A conventional power supply can be used if a change-of-origin preamplifier is included.

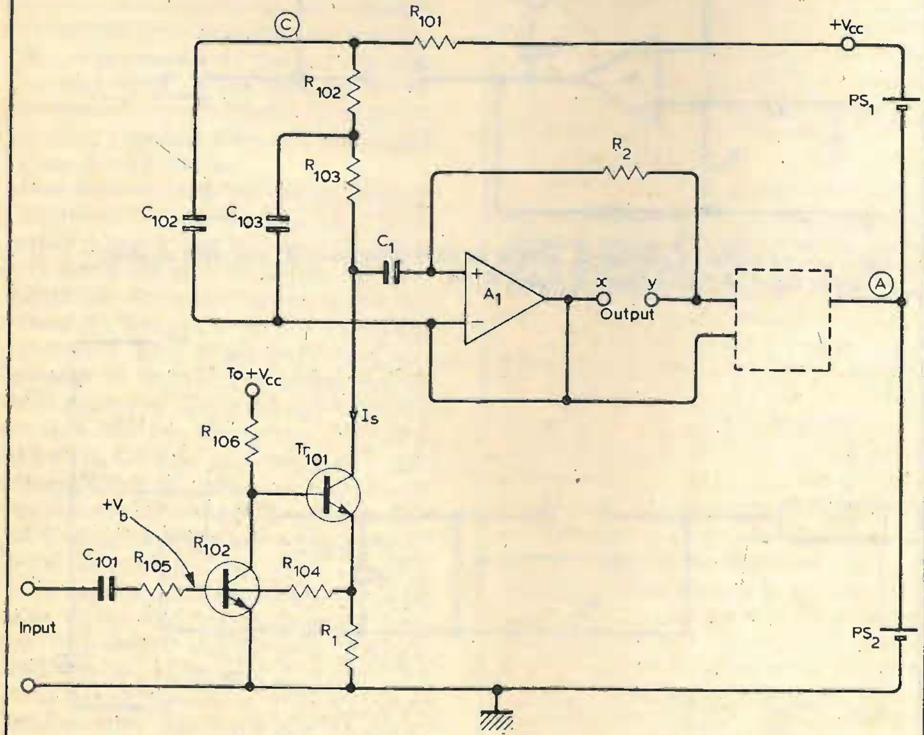


Fig. 9. Change-of-origin preamplifier. Earth is connected to the power supply negative rail, so many floating bridges can be operated on the same power supply. Preamplifier converts the signal into current I_s which passes through R_2 from an a.c. point of view. Output $x - y$ is therefore $I_s \times R_2$.

y with respect to the power supply is the only thing which is affected by A_2, then A_1 is decoupled from A_2. This confers a high degree of stability on the circuit, and enables A_2 to be of cheap design, with poor distortion performance, in what will remain a high fidelity system.

Effect of A_1 in circuit B. Fig. 5 shows A_1 and its associated feedback loop. Resistor R_5 is large-valued, providing bias, so that d.c. conditions are identical with those for circuit A. Imagine that the input voltage rises. This causes A_1 to conduct in such a direction as to cause y to rise with respect to x. Negative feedback is applied through R_2, causing the potential of the + input to rise until it equals that of the − input, and the circuit stabilizes. This happens when the value of $y-x$ is R_2/R_1 times the input voltage. A_1 is again decoupled from A_2.

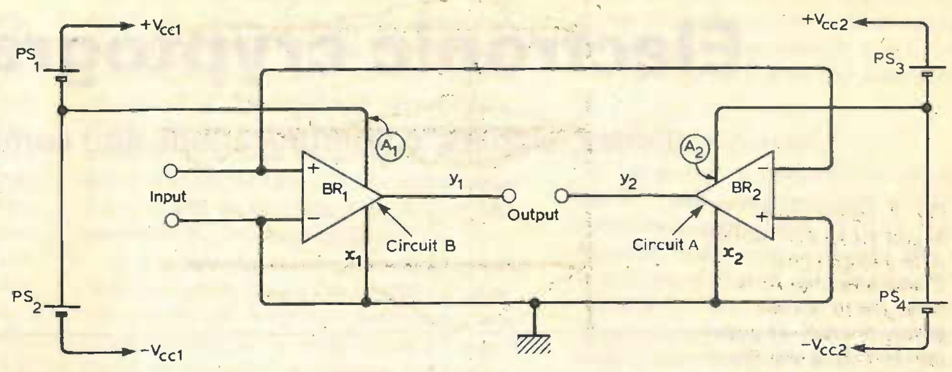
Effect of A_2. Fig. 6 shows A_2 and its feedback loop; C_2 by-passes A_2 at high frequencies. Resistance R_4 will be set nearly equal to R_3 so that at low frequencies A_2 controls the potential of y in such a way that $x+y$ is always equal to the potential at point A. This corresponds to the voltage swings experienced in conventional bridge amplifiers, and has the advantage that the power dissipation is shared equally between component amplifiers. In practice, however, R_4 will be set slightly larger than R_3, so that at low frequencies, A_2 bottoms shortly before A_1 does so. This enables a full voltage swing to occur, and is illustrated in Fig. 7. The system can cope with a poor quality design of A_1, without the required output being appreciably affected. Cost savings can be quite large in this area.

Earthing arrangements. Fig. 8 shows a typical power supply arrangement. Capacitors C_r are reservoirs, C_e the stray capacitance between earth and the bulky components of the power supply, and C_t the stray capacitance between primary and secondary of the transformer.

An apparent problem as regards bandwidth is the effect of capacitance C_e between earth and the floating power supply. Much of this will be contributed by the transformer, and so it is hard to eliminate. A typical value in a design which is not particularly fussy about reducing this capacitance, is around 500 to 1000pF. This capacitance is effectively put across the output, because of the effect of the capacitor in the feedback loop of A_2, and is thus in parallel with a load of typical impedance 8 ohms. It thus only becomes significant at frequencies above about 20MHz and so can be ignored.

The effect of C_t is potentially more serious. Mains current can potentially pass from live, through C_t, via the rectifier to the power rails, through the transistors of A_1 and A_2, and to earth. The high mains voltages involved are capable of destroying the semiconductors in A_1 and A_2. However, it is easily seen that, whilst the system is working

Fig. 10. Bridge-bridge amplifier for the real power maniac! BR_1 and BR_2 are both floating bridge amplifiers, and each have their own power supply. They are connected together similarly to a conventional bridge amplifier (so care with instabilities!). Available voltage swing is four times the voltage of each part of the power supply.



correctly these currents are safely passed. The feedback loop of A_2 causes the potential y to follow that of the power supply, if it rises with respect to x (i.e. earth). Such a rise in y causes A_7 to conduct so as to safely pass any such mains currents. But this does not apply at switch-on, or on failure of some component. It is thus highly desirable to insert an earthed screen, between primary and secondary of the transformer.

A further safeguard, which is necessary for highly inductive loads anyway, is to insert reverse-biased diodes between x and each power rail. This prevents the e.m.f. on the collector of any transistor in A_1 from exceeding the power supply e.m.f. and also prevents any transistors from being reverse-biased. However, if a good screen is included, and any inductive loads are by-passed by the usual C-R network, then this is unnecessary.

Further application: Change of origin device

This section describes how the amplifier can be included in a stereo arrangement, avoiding the unusual earthing arrangement of Fig. 8, and also describes a bridge-to-bridge circuit. It is included here because it follows on naturally from the block-diagram treatment which the bridge amplifier has so far received. If you wish to see how the block-diagram amplifier actually looks in real circuits and actual components you may prefer to jump to part 2 and come back to this section later.

The earthing devices so far described are fine, provided only one amplifier is used with each power supply. Any attempt to operate two such amplifiers from the same supply would result in each A_1 shorting out the other A_1. Fig. 9 shows circuit A with a modification so that many such amplifiers can be operated using one power supply. The input is with respect to the − rail. A similar modification could be made to circuit B type floating bridges.

The transistors are arranged with d.c. feedback, so that in the quiescent state $I_s = V_b/R_1$, where V_b is the base-emitter voltage of Tr_{102}. From an a.c. point of view, they act as a virtual earth amplifier, so that the a.c. signal I_s is equal to $(R_{104}/R_{105}) \times V_{in}/R_1$, where V_{in} is the input voltage.

Because of the effect of C_{102}, C_{103}, R_{101} and R_{102}, a constant current passes through R_{103}, and any a.c. variations in I_s are caused by A_1 to pass through R_2, so that the output e.m.f. is $(R_{104}/R_{105})(V_{in}/R_1)R_2$. Thus the gain is $R_{104}R_2/R_{105}R_1$.

There is no possibility of coupling between the pre-amplifier and bridge amplifier stages, provided that Tr_{101} is sensibly positioned so that its collector is far away from, or screened from, the rest of the control circuitry, and provided that the capacitance between collector and base of Tr_{101} is small. Even with a large capacitance here (say a maximum of 100pF), then a small capacitor between collector and base of T_{102} could safely be included, thus damping out any interaction. This precaution is probably unnecessary: for example, if ZTX304 is used for Tr_{101}, then a working voltage of 70V can be used, but there is a capacitance of only 6pF between collector and base.

Components C_{101} and R_{101} are unnecessary in actual circuits because there is a semi-stabilized voltage point already in the circuit for A_1 which may be used (point C in Fig. 14, part 2). In practical circuits, R_{104} and R_{105} could be replaced by some frequency-dependent circuit: for example, a tone-control or a high or low-pass filter.

Fig. 10 shows the circuit of a bridge-bridge amplifier. Amplifiers BR_1 and BR_2 represent complete bridge amplifier circuits, with inputs + and − and point A, and outputs x_1, x_2, y_1, y_2 and points A_1 and A_2. x is connected internally, in both feedback loops to the "earth" input, but a connection is shown externally for clarity.

Using a "change of origin" device, many bridge-bridge amplifiers could be operated from two supplies, but note that each such two-bridge must carry the same signal. If A is the instantaneous output voltage $x-y$ from one amplifier and B is the output of a second such bridge amplifier connected to the same supplies, then a bottomed state will be reached when the total available supply voltage becomes equal to the largest of A, B and A−B. In the case where A is approximately equal to B then the third condition is never satisfied, and each amplifier can work independently.

If low-level signals are used which require sharp peaks, then this system could be used for carrying a number of different signals – but the high level signal will be clipped, and the low-level signal will not be clipped (if working into a similar load).

The use of change of origin with a two-bridge is likely to be restricted to specialized applications, such as for group P.A. where many amplifiers are required to carry the same signal.

Practical circuits will be given in a second part of this article.

Micro '81

A call for papers has been issued for the Microsystems 81 conference, being held at the Wembley Conference Centre, London from March 11-13, 1981. The first two days are intended for design engineers and those involved in designing and implementing microsystems of all types. Scope includes case studies, communications, design aids, distributed processing, industrial control, interfacing, multimicroprocessors, project management, real time languages, signal processing, software development, standards and testing. The third day is devoted to personal computers and small business systems and their use in commerce, industry and education. Synopses of papers for consideration should be sent by September 12, 1980 to Robert Parry, Microsystems 81, PO Box 63, Westbury House, Bury Street, Guildford, Surrey GU2 5BH.

Microsystems 81 is owned by IPC Business Press and sponsored by *Computer Weekly*, *Microprocessors and Microsystems*, *Practical Computing* and *Systems International*.

Electronic cryptography

Codes, ciphers, communications and computers

Lively controversy in the USA about the degree of security provided by the new NBS data encryption standard poses the question: might data security be better served by going to one of the proposed "public key" systems? The debate has an important bearing on data transmission in the UK, as well as in the USA.

Pat Hawker provides background information as a reminder that even clever coding systems may not be quite as secure as you think.

The marriage of communication technology and computers has proved a fruitful alliance that has already led to many profound advances in the technology of information collection, collation, processing and distribution, affecting government, commerce, industry and not least the citizen concerned with living under the shadow of his electronic dossier. But increasingly important in this cosy family relationship are those out-of-wedlock twins: cryptography and cryptanalysis. This simile is not altogether fanciful: the first true electronic computer, Colossus, was created by Turing and Flowers for that wartime temple of the black art at Bletchley Park.

Diffie and Hellman have pointed out in an important tutorial contribution to the subject that "Until recently cryptography has been of interest primarily to the military and diplomatic communities. Private individuals and even commercial organisations have rarely considered it necessary to resort to encryption for protection of their communication, and those that have, have seldom done so with particular care." The traditional commercial telegraphic code books were developed primarily to reduce the number of words that needed to be transmitted; used in isolation they did nothing to ensure privacy.

But the whole concept of electronic mail, centralized information storage linked with multiple visual display units, the implications of digitalized packet-switching telecommunication networks and the general growth of information technology together pose an increasingly significant threat to the privacy of the individual and to commercial confidentiality.

Electronic storage and transmission of information has opened the way to new forms of traditional crimes — data theft, industrial espionage, sabotage, fraud by deception — and to potential invasion of privacy of the individual. The act of communicating so much information between different locations not only vastly increases the extent and variety of information available to a determined eavesdropper but the same modern technology also makes eavesdropping easier and relatively less costly.

It is not solely a question of data-processing technology. The use of microwave radio relays rather than cable, combined with direct long-distance dialling, allows the interception of public and defence telecommunication traffic without the need for physical tapping of wires and without the eavesdropper being in proximity to the target of his surveillance. The ability to program a computer to select from a flood of messages only those containing key words or specific addresses or telephone or telex numbers makes possible far more selective eavesdropping.

Communication technology, admittedly, discourages the casual listener by multiplexing large numbers of circuits on a single bearer or by the use of high transmission speeds, including burst techniques, and by confining radio signals to narrower, sharper beams and increasingly higher frequencies. But none of these techniques can be expected to defeat the determined eavesdropper. Techniques of steganography, which seek to conceal the very existence of communication, such as pseudo-noise or frequency-hopping transmission or information concealed on sub-carriers within conventional transmissions, cannot be guaranteed to elude for long the attention of listeners equipped with spectrum analysers and the like.

While this article doesn't intend to probe the sensitive area of official monitoring and surveillance services, some idea of the scope of signals intelligence (SIGINT) can be gained from the simple statistic that 40,000 of the Collins R390 family of general-purpose h.f. communication receivers were manufactured post-1950: not all, but a considerable proportion, are likely to have been used for American surveillance work.

The capture by the North Koreans of American cryptographic equipment on the USS Pueblo is said to have made possible the decoding of an enormous store of messages intercepted in previous years — and to have led to the attempted counter-coup of the Hughes deep-sea recovery vessel Glomar Explorer and its vastly expensive efforts to raise the sunken Russian submarine off Hawaii. The Russian "bombardment" of the US embassy in Moscow with microwaves appears to have been an attempt to prevent the Americans intercepting microwave trunk systems, in the manner alleged to have been carried out by the Russians in Washington DC and at consulates in other parts of the USA, almost certainly aided by computer selection of circuits of particular interest.

Modern data transmission, commercial as well as official, is thus facing an increasing desire for better security that can be provided only by cryptography. Messages need to be enciphered in a code that cannot be economically read by an eavesdropper and that conveys sufficient proof of authenticity. Any cryptographic system that is less secure than the users believe represents a major risk. A code thought to be secure invariably tempts users to transmit information that, were such a code not available, would never be entrusted to radio or cable. During World War II the Germans fastened a small plaque on their military radios "Feind hoert mit!" (the enemy listens also) but were so convinced of the security of their Enigma and other secret writing machines that they were prepared to communicate not only tactical information, whose importance would rapidly evaporate, but also strategic and logistic information that remained of value even when it took days or weeks to recover the plain text. This does not mean that all codes need to be absolutely secure, provided that they delay sufficiently the recovery of the plain text or involve the codebreakers in an unduly large and unjustifiable operation.

The techniques of cryptography have progressed from hand codes to machine codes to on-line, all-electronic systems, but the changes in technology have not invalidated the classic principles of the craft.

Basics of cryptography

Over the years cryptography has acquired a specialized terminology that sets it apart from communication engineering with its more familiar signal coding, pulse code modulation and error detection and correction codes. For the history and development of codes and ciphers read Kahn's The Codebreakers (the original hardback edition contains more technical material than the later paperback). Here only a few terms and techniques relevant to modern electronic cryptography are discussed; more details are in the tutorial paper by Diffie and Hellman.

The term cryptography covers both codes and ciphers; in essence a code consists of changing a message into pre-arranged code blocks, for example five-letter or five-figure groups, with each group representing a word or phrase of the original message, known as the plain text. The coded message thus is not directly related to the number of letters or words in the plain text but unless further manipulated any given code group always represents the same phrase. Radio operators, for example, are familiar with the international Q-code which overcomes language difficulties and reduces transmission time but is not intended to provide privacy. An ordinary telephone directory is a form of codebook as a complete address can be reduced to a unique STD number. (However, it would be virtually impossible to decode the number without making an exhausting search through a directory, arranged only in alphabetical order of names.) Codes based on words and phrases are less readily automated than ciphers, though codes may be used within a cipher where personal privacy is needed.

Ciphering is the process of changing the plain text letter by letter so that the enciphered message still contains the original text but with either the position of the letters changed (transposition cipher) or new letters substituted (substitution cipher). Each process may be carried out more than once or a combination of both processes may be used. A simple substitution cipher could consist of simply moving each letter in the plain text a few places along the alphabet (e.g. putting a D for an A, E for a B, etc). This, however, would be extremely vulnerable to cryptanalysis – the art of breaking enciphered messages – by somebody not in possession of the cipher; language structure renders a simple substitution cipher little more than a child's puzzle. Simple transposition ciphers are similarly vulnerable.

To make substitution ciphers more secure, it is common practice to use different substitution alphabets to encipher successive letters of the plain text (polyalphabetic ciphers). For example an A might be changed to B in one position in the plain text but could be any other letter elsewhere. Most modern ciphers are based on polyalphabetic substitutions (or the equivalent in digital terms). The degree of security depends on the use of many substitution alphabets to avoid regular repetition of the use of any one of them. While the use of polyalphabetic ciphers greatly increases security, it brings about a need for the users to have some form of key or running key that is not available to the eavesdropper.

It is a feature of any complex cipher that the users need some form of aide-memoire or *key* to decipher the message, just as a code book or other form of memory is needed for codes. This may take many forms: book ciphers may use words or letters taken in some way from the pages of a readily available book; proverbs or poems may be committed to memory; special key blocks to provide running keys may be printed in a miniature book or pad; in electronic systems a key generator providing a specific stream of 0 or 1 can be in a potted, sealed module.

Historically a further form of secret writing has been important: concealed codes or ciphers, more correctly termed steganography where the users endeavour to conceal the existence of the secret communication. These vary from invisible inks, pin pricks (punctured codes), letter codes with short messages concealed in a long letter, and microdots to radio transmission techniques such as pseudo-noise forms of spread spectrum.

In a complex ciphering system there are two secrets that will, at least initially, be unknown to the eavesdropper: the general form of the substitutions and transpositions (the algorithm) and the key, Fig. 1. To recover the plain text, both need to be known and it may not be necessary for the users to keep both secrets from the eavesdropper. In electronic systems for commercial use, it may even be advantageous to establish and publish an agreed algorithm, the security of the cryptosystem then depending upon the key. It will then be essential that the key should not become available to the eavesdropper and it is necessary to enforce strict rules of key management and key distribution.

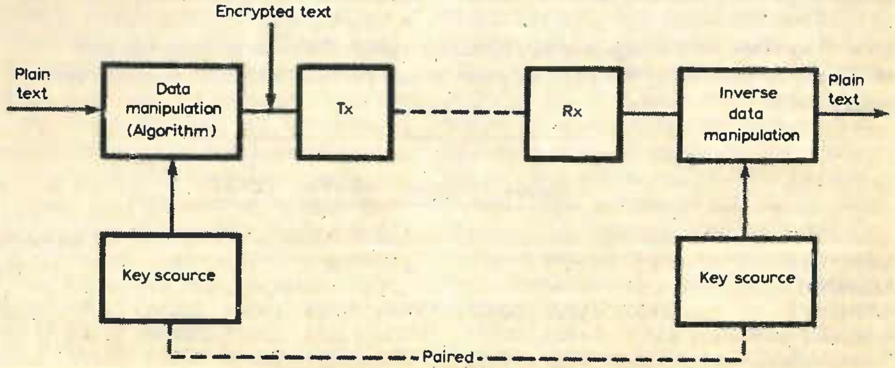


Fig. 1. Simplified outline of conventionally encrypted communication link in which the same running key is used for encoding and decoding with the same form of algorithm.

One-time systems

To be secure a polyalphabetic cipher needs to use a large number of different substitute-alphabets so that each is repeated only rarely. Ideally the same substitute-alphabet should be used only randomly: the users need to be instructed by means of a running key which substitute-alphabet to use for each letter of the plain text, and these instructions should, if possible, be given in a truly random sequence; in other words the sequence indicated by the key should never reoccur. In practice this can be done by means of a "one-time pad" or "one-time tape" containing strings of random letters, figures or binary digits. Such a key may indicate to the user by how much each letter should be shifted along the alphabet; a form of addition (but unlike arithmetical addition with no carry-forward): see Fig. 2.

A true one-time system is unconditionally secure and will defy all forms of cryptanalysis.

Cipher machines

For centuries, most encryption was done painstakingly by hand, aided sometimes by simple abacus-type machines and the liberal use of squared paper. Polyalphabeticity, first proposed in 1466 by the Italian architect Leo Battista Alberti, at the request of the Pope's secretary, gradually established itself as the dominant form of high-grade encryption and was the basis for the first successful coding machines and later for on-line machines. A series of early rotor machines were devised from about 1916 by Hebern, Koch, Damm and Scheribus and a basically similar machine but using six wheels and a drum or cage to generate the key was developed by Hagelin in 1934.

Most machines had a number of interchangeable rotors, electrically wired between input and output contacts as to form a whole series of polyalphabetic substitution ciphers. With say six rotors, there can be some 26^6 letters before the cipher alphabet sequence repeats, although the authorized users (with identical machines and rotors) only had to know which permutation of rotors to use, their initial settings and usually some further permutations made possible, for example, by a manually adjustable jackfield.

Those who devised rotor machines had every reason to believe that they would be secure against all then-known methods of practical cryptanalysis; the combined efforts of codebreakers in Poland, France and at Bletchley Park, and the work of Friedman in the United States, showed this not to be the case. The Enigma-type machines of the Germans and Japanese (more complex forms of a machine developed and patented for commercial use) provided a massive input to the codebreakers for subsequent distribution as Ultra, Purple, etc. Methods of successfully attacking even single short messages in Hagelin cipher text with known plain test, or longer messages without this aid, have been described. Nevertheless there is no evidence that all rotor-type machine ciphers have been broken, even with computer assistance, as it is possible to add to their complexity in many ways, for example by increasing the number of rotors.

Digital coding

In one sense all cipher text intended for telegraphic transmission involves the use of digital codes. Morse code, for example, can be classified as a binary non-return-to-zero digital code. However modern practice is to convert the plain text into digital form particularly for on-line systems and only then make it secret by combining the resultant bit stream with a running key, also in digital form, Fig. 3. If the running-key is used only once (one-time) the resulting cryptosystem can be considered unconditionally secure. On the other hand, if, for example, a simple pseudo-random bit generator is used to provide a shift-register sequence, which need not recur, then it is essential to use non-linear logic. If linear logic is used, Diffie and Hellman claim that the resulting cryptosystem can be broken in a few seconds on a minicomputer. It was this vulnerability that led IBM to investigate non-linear block ciphers in which the plain text is divided into separate blocks, with each block operated on independently. Such a cryptosystem using simple substitution requires an extremely large number of key bits. The IBM approach has therefore been to use relatively few key bits but to subject each block of text to a very complex series of transformations, including both transpositions of order and substitutions based on the derived keys.

The aim has been to produce a computationally secure cryptosystem comprising a large number individual cryptosystems each of which employs the same algorithm yet which can be deciphered only by someone who can generate the correct, though relatively short, unique key sequence. From a manufacturing viewpoint, there are clearly significant advantages if a high proportion of all commercial/industrial data security systems can be made using just one standard encryption algorithm. The user also gains because systems become compatible. In 1977, what might at first sight seem an absurdity was published in the USA: a "standard" for a secret encryption system. But, of course, only the algorithm is public property: the individual short digital sequence used to generate the key stream for the authorized users is still kept secret, involving great care in key management and key distribution. The basic key generator may be in the form of a sealed, potted module.

Digital systems have a further important advantage: their use is not confined to text but, provided that the system is fast enough, it can be applied to real-time digitized speech, thus providing telephone and radiotelephone scrambling or privacy systems much more secure than with the traditional forms of analogue scrambling.

Digital encryption can be applied also to computer installations even where no data transmission links are involved to prevent unauthorized users from withdrawing information or to prevent software piracy.

Cryptanalysis

The moment anything is committed to paper or fed into an electronic store as plain text or as encrypted messages, it becomes vulnerable to an eavesdropper, whether by interception, data theft or physical access. If the encrypted material cannot be read by the eavesdropper with the help of cryptanalysis then it can be deemed secure. Nevertheless a determined eavesdropper in such circumstances will seek to acquire examples of known plain text, for example from message files before they have been enciphered, or after they have been deciphered, or from subsequent release in paraphrased form, or by being re-enciphered into a non-secure cryptosystem. Any code or cipher, even one which like a one-time cryptosystem is defined as unconditionally secure, is in practice only as secure as the circumstances surrounding its use.

An eavesdropper faced with cipher text that cannot be deciphered often retains the encrypted material in the hope that success may come later, when perhaps some of the plain text will have come into possession as described above; or when time has allowed careful observation of what happens after the receipt of the message by the addressee. Many cryptosystems that may be difficult to break into purely from the encrypted messages may reveal their algorithms or their keys when attacked with known text and this information may then open the lock to other messages past and future using the same cryptosystem.

If all else fails a computer can search the encrypted message using all or some of the possible key permutations until a meaningful result is achieved. Modern digital systems may require a very extensive search indeed; a key of 100 binary digits will represent 2^{100} possibilities, a mind-boggling total.

In the years BC (before computers) cryptography depended for absolute security either on keys of unlimited length, great ingenuity in the use of algorithms, or by doubling or tripling the various processes (e.g. double-transposition ciphers). Today the

Fig. 2. Simplified form of polyalphabetic substitution enciphering in which the position of each letter of the original text (plain text) is shifted along the alphabet by an amount determined by the corresponding letter of the key. For example N+B=P. A cipher text letter may thus represent any letter of plain text except itself. If the running key is truly random and of unlimited length the cipher cannot be broken.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

PLAIN TEXT	N	O	W	I	S	T	H	E	T	I	M	E	F	O	R	A	L	L
RUNNING KEY	B	A	C	E	D	Z	O	P	K	R	H	I	G	J	N	S	U	F
SHIFT	2	1	3	5	4	26	15	16	11	18	8	9	7	10	14	19	21	6
CIPHER TEXT	P	P	Z	N	W	S	W	U	E	J	U	N	M	Y	F	T	G	R

Fig. 3. Simplified form of digital polyalphabetic cipher. Random running key acts individually on each bit of the digitized plain text to produce an unconditionally secure cryptosystem.

A/D CODE	A	B	C	D	ETC
	00001	00010	00011	00100	

PLAINTEXT	T	H	E	Q	U	I	C	K	B
DIGITIZED PLAINTEXT	10100	01000	00101	10001	10100	01001	00011	01011	00010
RUNNING KEY	0110	11001	00110	10101	11101	01010	00010	01110	11011
TRANSMISSION	11000	10001	00011	00100	01001	00011	00001	00101	11001

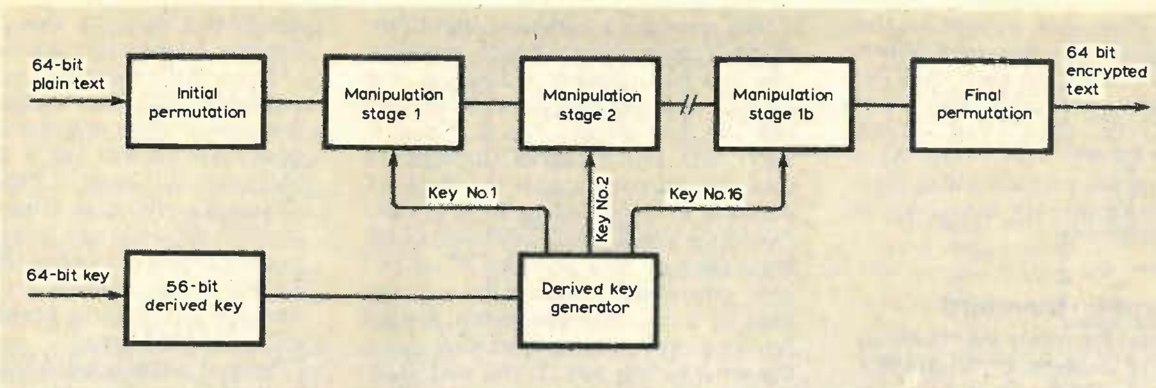


Fig. 4. Basic outline of the NBS data encryption standard in which the plain text is divided into 4-bit bytes and subjected to 18 stages of substitution and transposition.

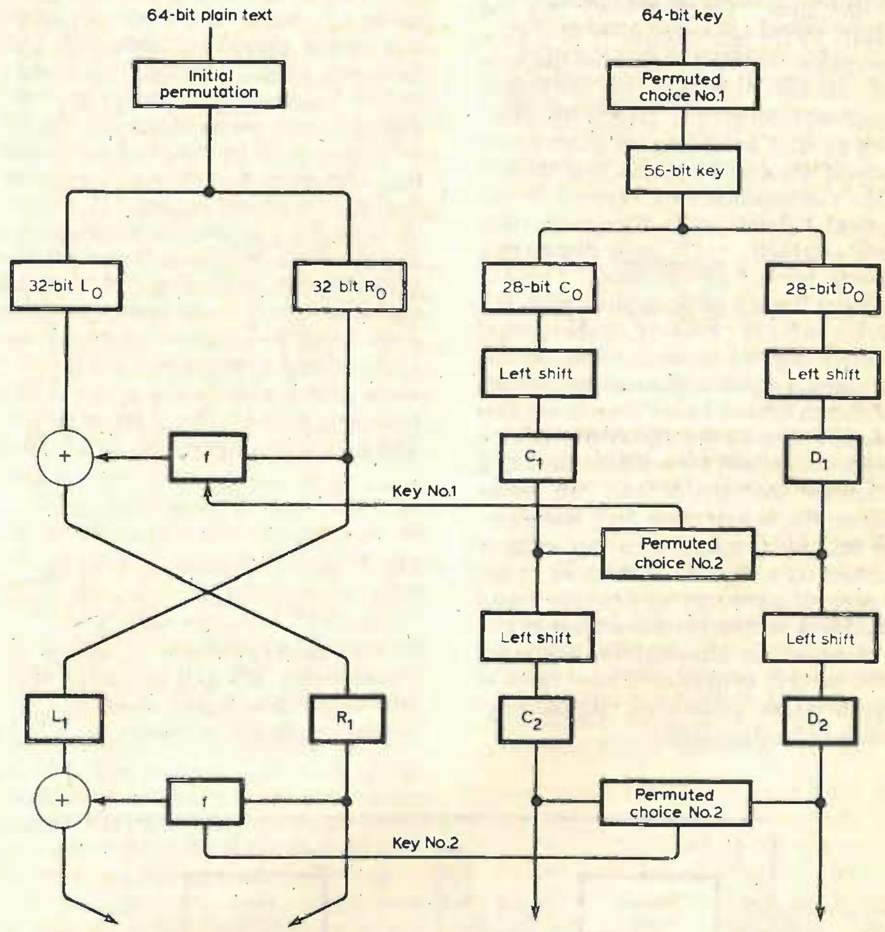


Fig. 5. Basic arrangement of DES shows the form of structure of the data manipulation and derived key generation; pattern is repeated many times and provides non-linear logic.

emphasis is on making the transformations of the plain text so complicated that even with massive computer power it would be totally uneconomical to search out all possible solutions; such ciphers are then termed computationally secure. However not all ciphers that are thought to be secure against computer attack may be so in reality. According to Martin Hellman, "At present mathematicians lack the tools for proving systems to be computationally secure and the history of cryptography demonstrates all too well that supposedly unbreakable systems have hidden flaws".

Security of codes

The so-called one-time pad, that is to say the provision of truly random paired keys of unlimited length, has long been accepted as one of the few systems that are unconditionally secure. The use of such a system however involves many practical difficulties, including the production and distribution of the pads or tapes. If used for multiple-address messages then the loss of one pad puts the entire system in jeopardy; if operated only with paired-users the production and distribution costs become formidable. Physical security of machines is important and personnel may sometimes by suborned.

In practice the cage and keywheels of the Hagelin machine and the rotors of Enigma, Sigaba and the British Typex machines provided the workhorses for high-grade traffic until the development of purely electronic, on-line systems based on digital techniques.

Many systems may be relatively impregnable against a listener who has access only to the enciphered messages, but may be fallible if some or all of the plain text of some of the messages is known. There are various ways in which this situation may arise, either from system faults, human errors or by deliberately inducing the user to send a message of which at least some words will be known to the codebreaker. Then again it is usually necessary for the sender to include key groups which provide instructions for the decoder, or indicate the priority of the message and which may reduce its security. The techniques of traffic analysis, particularly when applied to military communications, can provide valuable intelligence even when the code remains unbroken. Deception techniques, including the holding and subsequent re-transmission of an operational message at a different time, or (where the code can be broken) the alteration of its contents may be less applicable to the commercial than the military scene, but cannot be disregarded altogether. Deception operations which were aided by the use of codes thought to be secure or in which warning check signals were disregarded included the now well-known British "Double-Cross" and the German "North Pole" exploitation of radio links.

Human fallibility, including failure to operate strictly the signalling rules of a system, plays an important role in cryptanalysis. It was once my experience to decode a message made secure by a one-time pad with a plain text that read: "Hawker is not repeat not to have access to the code books". When I duly presented this to the addressee, he laughed and told me to continue decoding his messages as before! Humans have a habit of defeating systems.

The existence of a communications channel carrying coded messages provides a strong temptation to unauthorised users, who seek access to the channel for their own purposes. When the Americans built an elaborate defence microwave network in Vietnam it was regularly used and much appreciated by the Viet Cong. At a lower level, signals personnel may establish their own private networks of communication.

Data encryption standard

During the past few years the relatively open study of modern cryptography, particularly by IBM and at Stanford University, California, is leading to a better understanding of the requirements of systems for the protection of commercial and administrative data transmission. The IBM work has led directly to the establishment of a data encryption standard (DES) for the safe transmission of sensitive (but not highly classified) information. DES is based on work by IBM, including six years development work by Tuchman and Meyers of the Communications Systems Development Laboratory in Kingston, New York originally for a cash-dispensing scheme for a London bank. The US National Bureau of Standards with the advice of the American National Security Agency have established the Standard and provides a test bed for the validation of hardware based on this complex non-linear algorithm device design is checked for malfunctions and to ensure that the output can never contain the key or plain text. However, the establishment of DES has already sparked off a vigorous debate as to the degree of security it provides and whether it would not have been better to develop an alternative, probably more secure, system of a new form of cryptosystem, known as "public-key" systems (third column).

DES provides a ciphering algorithm or set of rules involving both substitution and transposition techniques and capable of being implemented in current l.s.i. technology: Figs 4, 5 and 6. Each data block passes through 18 data-manipulation stages in which 16 different internal coding keys are derived from a 56-bit main key (with 64-bit input coding). This provides 2^{56} or 10^{17} keys, presenting a codebreaker with the need for a truly massive search, always provided that nothing is known about the enciphering key. Diffie and Hellman, advocates of the public key system, pointed out that knowledge of even a quite small part of the basic key would greatly reduce the search required, and that l.s.i. technology now makes it possible to contemplate searches of gigantic proportions. They postulate a decoding machine using a million l.s.i. chips, that could search 10^{12} keys per second, so that even the full 10^{17} keys could be searched in about a day. This modern version of "Colossus" would cost an estimated £10-million, with an average cost per solution of about £2500. While only a very few organisations, including governments, could positively contemplate building such machines, the mere possibility tends to send shivers down the spines of those who are intending to trust their data security to the NBS standard. There is some suspicion, reflected in American comments, that the National Security Agency may not be over-keen to promote the adoption by the business community of codes that they could not themselves break and that they persuaded IBM to opt for a 56-bit key. Memories die hard of NSA's Project Shamrock which is alleged to have scanned all telegraph and telex traffic passing in and out of the United States for key words (British readers feeling complacent should recall the 1967 cable-vetting furore).

Several systems using basically similar techniques have been proposed or developed for application to computers, including home computers, where no data transmission is involved, to prevent unauthorised users from withdrawing information or to prevent software piracy. An 80-bit key is used by Cryptext for a low-cost home computer system and a cryptomicroprocessor has been proposed by Best. The idea is to encipher computer programs or stored data and then decipher them as each instruction is fetched for execution.

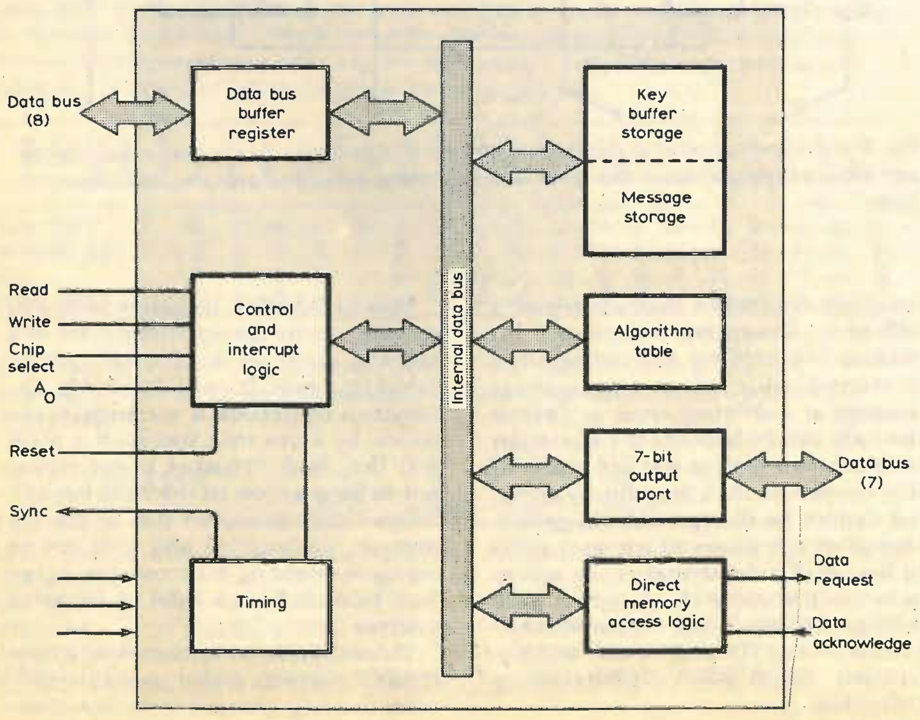


Fig. 6. Simplified arrangement of the NBS-certified Intel 8294 data-encryption 40-pin l.s.i. chip which forms a microprocessor peripheral capable of implementing DES up to speeds of 640 bits/second or at higher speeds by parallel connection of devices.

Public-key systems

Although the DEC algorithm is being widely, if at times hesitantly, welcomed by industry and commerce, and suitable l.s.i. devices are appearing on the market and incorporated in systems, it has to be accepted that it is a system of limited security, even though nobody has yet proved publicly that this is the case. An alternative family of novel cryptographic techniques, known as "public key cryptography" has recently been advocated on the grounds of providing greater security in the long-term, although at present it is at a less advanced state of development.

Public-key systems were first proposed by Merkle, Diffie and Hellman at Stanford University; in these, only the addressess would hold the deciphering key which would not be available to the person enciphering the message or date, Fig 7.

It is claimed that public-key systems overcome the problem of distributing key generators or one-time tapes by separating the enciphering and deciphering functions. In effect they provide a technique by which the sender of the message enciphers it for a particular addressee without herself having the ability to decipher it. The rather convoluted mathematics of public-key cryptography has been set out in some detail by Hellman in *Scientific American* (August 1979) and no attempt is made to reproduce here the 10-page explanation given here.

But, in brief, several systems have been proposed in which the family of enciphering transformations can be separated from the family of deciphering transformations in such a way that given a member of one family it is not feasible to find the corresponding member of the other. Front-runners among these systems are the

RSA public-key cryptosystem devised by Rivest, Shamir and Adleman (whose initials make up the "RSA") and so-called "trapdoor knapsack" system by Merkle and Hellman (trapdoor is meant to indicate a one-way or irreversible function, while the term knapsack is derived from a class of mathematical puzzles that require the solver to determine how many rods of the same diameter, but of differing lengths, would completely fill a given knapsack).

In practice, a public directory would indicate the addresses's encryption key number but not his private individual decryption key. The system depends on the mathematics of number theory, that is the study of the properties of integers. Encryption-decryption "mates" are established by using integers that separate the two algorithms. In a much simplified sense, the system can be thought of as depending more on multiplication than the traditional polyalbabetic shifting (addition) of the running key and the plain or partly coded texts as already outlined in Figs 2 & 3.

In the RSA system, developed at MIT, the security is based on the concept that multiplying is easy to a computer but factoring is extremely difficult. For example, whereas two 100-bit factors can be multiplied electronically in a fraction of a second, the reverse process of factoring them might take a million years even with a one-microsecond instruction time.

All the public key systems that have been proposed face the criticism that compared with the systems based on the DES they are only at a relatively early stage of development – and for this reason may never be fully developed for commercial applications.

An advantage of public key techniques is that they are "read only" systems and so, for example, would not permit data read out from remote instruments (in say a host country) to be doctored en route. Yet at the same time a decryption key could be made available to the host country. Similarly they can also provide an authentic digital signature as it is no longer possible for an addressee, himself or at any of his terminals, to encipher a message purporting to come from the addressor as, of course, can be done with all conventional cryptosystems. The public-key approach clearly has many attractions, especially in eliminating or reducing many of the problems of key distribution and key management.

Secure — but how secure?

At the 1979 British Association meeting, Sir Noman Lindop, former chairman of the Home Office data protection committee claimed that the UK lags behind Europe in enforcing legislation to protect the public from the abuse of computer-stored personal data and that we are becoming "an illicit data haven." While security of data transmission is only one aspect of this subject, it is one that seems likely to be of increasing concern to systems designers. As David Kahn states in his introduction to The Codebreakers — "codebreaking is the most important form of secret intelligence in the world today". Its ramifications are now spreading well beyond the confines of the military, diplomatic and intelligence communities.

Codebreaking can be helped by analysis of the electrical interference radiated by nearby coding equipment or even by directing strong radio signals at the equipment and then analysing what occurs, rather as analysis of the sounds emitted by electromechanical coding equipment could provide an eavesdropper with valuable clues as to its operation. Cryptanalysists are by no means restricted to theoretical methods of solving codes, and for example an electrical fault, or irregular pulse shapes may provide useful information.

Many electronic engineers in the UK are today directly concerned with the implementation of data protection systems; the current American controversy about DES, however, shows the desirability of drawing on the past, pre-electronic history and experience of cryptography. Nobody wants to keep re-inventing the wheel, or more importantly, re-inventing square wheels. The disasters as well as the successes of British cryptography should not be forgotten. How many lives and ships might have been saved if, for example, the Admiralty had heeded Lord Louis Mountbatten's advice, when he was Fleet Wireless Officer in the 1930s, to develop machine codes offering greater security than the hand codes then in use? In the outcome the broadcast instructions to the British and Allied merchant ships were read by the German Beobachter-Dienst until the autumn of 1943 and many of the Royal Navy messages were read in the first year of World War II.

Those American cryptographers concerned at the danger of uncritical acceptance of NBS's DES by industry concur that this is a difficult system to break and that it could well fufil all normal commercial requirements for the next 5-10 years — but stress that users must recognise that it provides only limited security against a determined eavesdropper. The greatest danger of a cryptographic system remains, as always, the false sense of security it may give. □

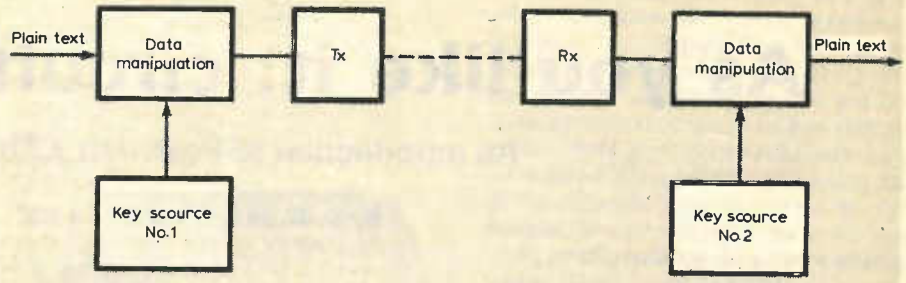


Fig. 7. Simplified outline of a public key system in which the key and basic algorithm used by the sender can be publicly known but each user keeps secret the decoding key. The form of data manipulation used by the sender prevents decoding except by a holder of the particular decoding key for which the message is enciphered.

Further reading

The following sources have been used *passim* in this article:

Whitfield Duffie and Martin E. Hellman, Privacy and authentication: an introduction to cryptography, *Proc IEEE*, vol. 67, no. 3, March 1979 (with extensive biblography).

Martin E. Hellman, Mathematics of public-key cryptography, *Scientific American*, August 1979.

Harvey J. Hinden, LSI-based data encryption discourages the data thief, *Electronics*, June 21, 1979.

John Beaston, One-chip data-encryption unit accesses memory directory, *Electronics*, August 2, 1979.

Harvey J. Hinden, New security planned for data, *Electronics*, August 16, 1979.

Bob German, Encryption the key to security, *Electronics Weekly*, September 12, 1979

Miniature, ten-line telephone exchange.

Several small errors, for which we apologize, crept into this article in the August issue. Firstly, the open contact of A_1 on p.42 should go to the open contact of D_2, not the junction of FC_2 and the 470ohm resistor. Secondly, the make contact connected to the closed contact of D_2 is FC_1, not FC_2. Lastly, in Table 2 on p.45, the relays operated on called-line 2 are SB and HB.

As you like it: circuits *or* fields

An introduction to Poynting's Theorem

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

Like Faraday [Maxwell] looked upon the role of conductors in electricity as a minor one, since they served only as terminations of the lines of force of the surrounding electric field.
Encyclopedia Britannica

Physics offers several other examples of dual representation – light waves and photons, electrons as particles or waves (electron diffraction) – but only in electrical phenomena are the two dual representations, circuit and field, *always* and *exactly* interchangeable. It is only in the present century that there has been such a tremendous development in the techniques of circuit analysis, while earlier scientists such as Faraday (1791-1858), Maxwell (1831-1879) and Poynting (1852-1914) regarded fields as pre-eminent. (It should be added that fields involve the use of vectors, and often difficult geometric problems, whereas circuits involve only the algebraic manipulation of one-dimensional quantities.) The development of waveguide and associated techniques, for which circuit representation is impracticable, may tend to redress the balance.

The first question asked nowadays is "Are fields real?" Those who ask this question overlook the fact that the established alternative to fields is action-at-a-distance. We are so used to the idea of gravitational attraction that it needs an Einstein to remind us of the problem which much concerned people before Newton, namely how can the sun exert a force on a planet across millions of miles of empty space? Electric and magnetic fields were introduced to 'explain' similar remote forces in electromagnetic phenomena and Maxwell showed that such fields could be propagated as waves, in empty space as well as in material media. (See "No radio without displacement current", *Wireless World*, August 1979.) Evidence in support of this idea of electromagnetic fields is the fact that their velocity of propagation can be observed. An interesting example of this is that a circular loop of wire acquires radiating properties, i.e. becomes a useful frame aerial instead of simply an inductor, when the time taken for the magnetic field to spread from one side of the loop to the other becomes a significant part of the period of the alternating current which is producing it.

So acceptable is the concept of fields and waves in substitution for action-at-a-distance that scientists are now looking for gravity waves (without much success so far). It is true that discarding the "luminiferous aether", which was supposed to be an all-pervading medium supporting electromagnetic waves, means that fields which were originally thought of as "states of stress in a medium" must now be regarded as "properties which exist in space", but is this more difficult to accept than other indispensable concepts of modern physics, such as the wave nature of the electron and the quantisation of energy? The difficult concept of wave mechanics (sometimes described in terms of "waves of probability") provides the theoretical basis for the whole of modern solid-state technology. Einstein's proposed solution of the problem of gravitational action-at-a-distance was to enhance Newton's law, that a force-free moving body continues in a straight line, by replacing "straight line" by "shortest line in 'curved' space" with the 'curvature' being due to the presence of mass. The 'curvature' of space by the presence of mass is just as far from everyday experience as fields in empty space. Whichever way you go, modern physics demands faith in something which is not comprehensible in term of everyday experience: the laws of physics demand acceptance because they produce a coherent structure of theory which accords with all experimental evidence.

Let us now look at the simplest example of the circuit/field equivalence, namely the energy stored in a charged capacitor made up of two plane parallel electrodes separated by a dielectric which may be anything from a vacuum to high-permittivity ceramic (Fig. 1). From a circuit viewpoint we say that the work done in transferring charge q from one plate to the other is qv where v is the potential difference between plates at the time of transfer. Since v increases as the charge builds up the total work done (and therefore energy stored) is expressed in terms of the final charge and potential difference as

$$W_c = \tfrac{1}{2}QV \quad \text{(1a)}$$
$$= \tfrac{1}{2}CV^2 \quad \text{(1b)}$$

using the relation $Q = CV$. But according to the theory of electromagnetic fields, the energy stored in the dielectric is $\tfrac{1}{2}DE$ per unit volume where E is the electric field-strength and D is a field quantity equal in magnitude to the charge per unit area of the conducting surface bounding the field ("the surface on which the lines of force end", as Faraday and Maxwell would have said). But E is V/d and D, being equal to the charge per unit area of plate, is Q/A; and the volume occupied by the field is dA. Thus the total field energy should be

$$W_f = (dA)(\tfrac{1}{2}DE)$$
$$= (dA)\tfrac{1}{2}(Q/A)(V/d) = \tfrac{1}{2}QV \quad \text{(2)}$$

which is the same as (1a) so the equivalence works in this case. A minor caveat is that the formula "$\tfrac{1}{2}DE$ per unit volume" has been rigorously proved only for the average over an infinite volume (because the proof depends on the rates at which different vector field quantities vanish at infinity) but it has always worked when applied to particular finite cases.

But what is the significance of the extra field quantity D which was slipped into the derivation of equation (2) and was said to be equal to the charge density at the boundaries of the field? In a well behaved dielectric (linear and isotropic) D is simply equal to ϵE where ϵ is the dielectric constant of the medium. But what is the dielectric constant of a vacuum? This is where we tend to get a conflict between physicists and engineers. Physicists used to use the c.g.s. system of units, in which the dielectric constant of vacuum is unity and so D is equal to E in a vacuum. (Before assuming that they are the same thing, as well as being equal in magnitude, note that it was the rate of change of D, not E, which Maxwell called displacement current.) Some physicists argue that they must be identical, because the only physical entities which really exist

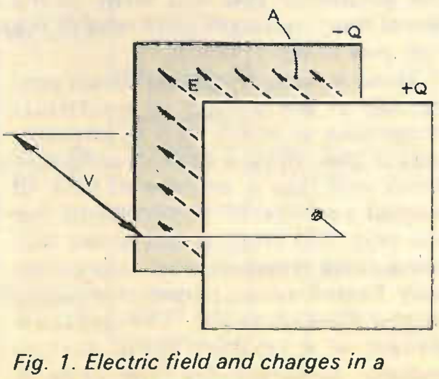


Fig. 1. Electric field and charges in a parallel plane capacitor.

are space and sub-atomic particles; and the difference between D and E in a material medium is due to the reactions to the field of the various charged particles in the medium. From an engineering viewpoint, however, it is convenient to split the fields between "cause" and "effect", the former being independent of the nature of the medium. In electrostatics the total value of D integrated over a surface is equal in SI units* to the enclosed charge from which the "flux of electric induction" D originates (Gauss's theorem). This is always true, whatever the medium, so D can be regarded as a primary field which emanates from charge, the "cause" of any observed phenomenon. Then the electric force field E is an "effect" of which the magnitude is found by dividing D by the dielectric constant ϵ of the medium, which for a vacuum is $\epsilon_0 = 8.854 \times 10^{-12}$. (The units are farads per metre.) The reason why ϵ_0 is not made unity in the SI system is to enable the system to incorporate ampere, metre, kilogram and second as basic units. One can test directly the inverse-square law of force between two concentrated charges, but one will need a constant of proportionality like the gravitational constant in the formula for the gravitational force between two masses. If the formula for force between two charges

$$\text{Force} = \frac{q_1 q_2}{4\pi\epsilon r^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

is to apply with force in newtons, charge in coulombs and distance in metres, then for a vacuum ϵ must be given the value cited above for ϵ_0. The right-hand side of equation (3) can be split by introducing electric field of force E:

$$\text{Force} = q_1 E_2$$

where

$$E_2 = \frac{q_2}{4\pi\epsilon r^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The subject of magnetism has been confused by the use of permanent magnets and is more complicated because the simple (scalar) relationships of electrostatics have to be replaced by vector relationships. The equation for the element of force between two current elements of lengths $\mathbf{dl}_1$, $\mathbf{dl}_2$ and current strengths i_1, i_2 is

$$\mathbf{dF} = \frac{\mu}{4\pi} \cdot \frac{i_1\mathbf{dl}_1 \times i_2\mathbf{dl}_2 \times \mathbf{a}_r}{r^2} \quad \ldots\ldots\ldots (5)$$

where heavy type indicates vector quantities, $\mathbf{a}_r$ is a unit vector in the r direction and the crosses indicate vector or cross products rather than arithmetic multiplications. This also can be split into a current and a field of magnetic force,

$$\mathbf{dF} = i_1\mathbf{dl}_1 \times \mathbf{B}_2 \times \mathbf{a}_r$$

where

$$\mathbf{B}_2 = \frac{\mu}{4\pi} \cdot \frac{i_2\mathbf{dl}_2}{r^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

If B is uniform along the length of a current-carrying conductor, and throughout at right angles to it, equation (6) can be simplified to an arithmetic relation

$$F = Bil \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

which can be used, for example, to predict the force on the coil of a moving-coil loudspeaker. From Maxwell's fourth equation, expressed in terms of H and D rather than B and E,

$$\text{curl}\mathbf{H} = \mathbf{J} + \frac{\mathbf{dD}}{dt} \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

we see that $\mathbf{H}$ depends only on currents and charges ($\mathbf{J}$ is current density) and is independent of the medium. Engineers have long regarded H as a "cause" and called it magnetomotive force, while the magnetic flux B is regarded as an "effect": one has to provide the appropriate magnetomotive force in order to establish the desired flux in a given magnetic circuit. Unfortunately the electric and magnetic systems are not quite symmetrical since in the electric system field D is continuous across a boundary between different media, but in the magnetic system field B is continuous. This is related to the point that 'lines' of D terminate on electric charge while 'lines' of B are always closed loops.

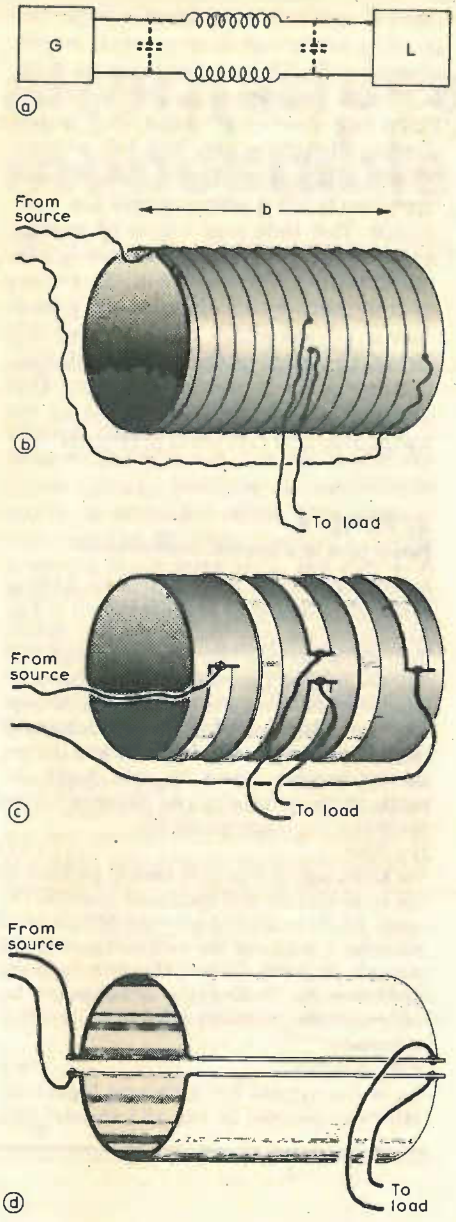


Fig. 2(a). Equivalent circuit of a source G connected by a transmission line to a load L; (b) circuit of (a) simulated with a multi-turn centre-tapped inductor; (c) as (b) but winding of inductor reduced to a few turns; (d) inductor winding reduced to a single centre-tapped turn. (The connecting wires are only indicative and not at all practical.)

After this lengthy digression to establish electric and magnetic fields we can come to Poynting's theorem (proposed by J. H. Poynting in 1883) that the flow of energy in an electrical system which is usually expressed as the circuit quantity vi can alternatively be expressed in terms of the power flow per unit area of a surface drawn through the electric and magnetic fields surrounding the conductors. In vector notation this flow is represented by the Poynting vector

$$\mathbf{P} = \mathbf{E} \times \mathbf{H} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

The vector $\mathbf{P}$ is at right angles to the plane continuing $\mathbf{E}$ and $\mathbf{H}$ and its magnitude is $EH\sin\theta$ where θ is the angle between E and H; and in most cases of interest E and H are at right angles so that the magnitude of P is simply EH. The coaxial cable provides an example in which the fields are known and limited in extent (within the cable); but it involves a little mathematics to deal with the radial non-uniformity of the fields and has therefore been relegated to the appendix. A strip transmission line provides an example with simple rectangular geometry (if one neglects fringing at the edges) and provides an opportunity to enlarge on the measurement of H in amperes per metre.

The circuit shown in Fig. 2(a), with the inclusion of the capacitances in dotted lines, is the lumped equivalent circuit of a transmission line between a source G and a load L. Note that we are not in any way restricted as to frequency. The source G may be simply a battery supplying d.c. or an a.c. generator; and the load may be simply a resistance or a complex impedance. In the latter case there may be a phase angle between electric and magnetic fields, but this is taken care of by the fact that the Poynting vector uses instantaneous values of field and the average power flow is to be found by averaging P over a complete cycle of the alternating current. In Fig. 2(b) the inductive part of the equivalent circuit is shown as a solenoid of length b wound with a fairly large number n_1 of turns of thin wire carrying a small current i_1. The load is inserted at the centre of the inductance. If end effects are neglected, the magnetomotive force is

$$H = n_1 i_1 / b \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

In Fig. 2(c) the coil has been re-wound with a small number n_2 of turns of copper strip carrying a larger current i_2.

* SI units are an international set of units, by now universally adopted, which are mostly identical with m.k.s. units.

As long as $n_2 i_2$ is equal to $n_1 i_1$ the value of H will be the same. In Fig. 2(d) the process has been pushed to the limit, with only one turn. Alternatively the changes can be thought of as taking the original winding with groups of different numbers of turns in parallel instead of in series. Clearly the number of turns, or the series/parallel connection of turns, does not matter as long as the total current circulating around the solenoid is kept constant. For Fig. 2(d) in particular one can write

$H = i/b$ amperes/metre .... (11)

It is a simple matter to squash the inductor of Fig. 2(d) into the strip transmission line of Fig. 3. The magnetic field in the space between conductors will remain unchanged at $H = i/b$ A/m. Assuming for the moment that the resistance of the transmission line is negligible so that the potential difference between the two strips is v throughout the length, then with separation d the electric field is $E = v/d$ volts/metre. The magnitude of the Poynting vector for power flow per unit area through a cross-sectional surface is

$P = EH = (v/d)(i/b)$ .... (12)

But this is per unit area and the area of cross-section is bd so the total power flow is $bdP = vi$.

If the voltage drop along the line is not negligible, the conditions near the upper strip are as shown in Fig. 4. The electric field no longer consists only of the component v/d normal to the strip:

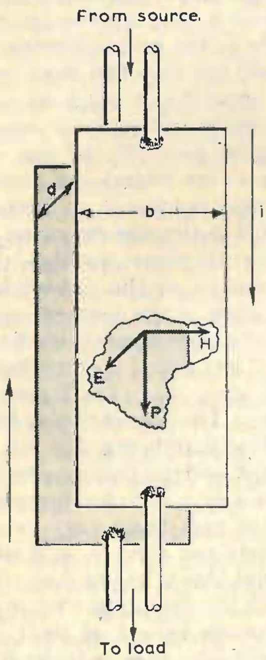


Fig. 3. Strip transmission line.

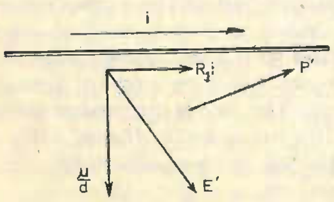


Fig. 4. Directions of fields and of Poynting vector near a lossy plane conductor.

there is also the component $R_1 i$ corresponding to the volt-drop per unit length of conductor. The resultant electric field is E' and consequently the modified Poynting vector P' does not point straight along the gap, but has a component (proportional to $R_1 i$ and H and therefore to $i^2 R_1$) pointing into the conductor. This indicates a flow of energy from the field into the conductor which matches the $i^2 R$ loss. The Poynting vector method of calculating power flow is always exact, and you may use *either* the circuit *or* the field calculation, whichever is more convenient. One obviously uses the field calculation for waveguide and radiation problems.

APPENDIX

Power flow in a lossless coaxial cable.

A cross-section of a coaxial cable having inner and outer radii a and b is shown in Fig. A1. Calculation is simplified if it is assumed that (a) the working frequency is so high that one can neglect penetration of the currents into the conductors and (b) resistive voltage drop along the length of the conductors is negligible. (In fact conditions (a) and (b) are not independent since the skin depth depends on the resistivity.) At distance r from the centre the magnetic field is

$H = i/2\pi r$ .... (A1)

We know that the electric field is greatest at the inner surface and decreases towards the outer, but its relationship to the difference of potential v between the two surfaces is not obvious. By using Gauss's theorem as in the procedure for finding the capacitance between coaxial cylinders it can be found that at radius r

$E = v/r\ln(b/a)$ .... (A2)

(ln is the symbol for a natural logarithm, otherwise denoted by $\log_e$.) The power flow

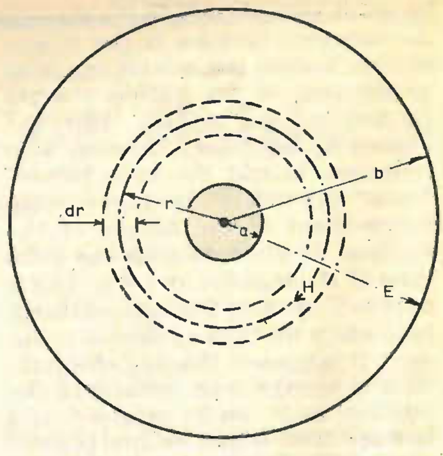


Fig. A1. Cross-section of coaxial line with inner and outer conductors of radii a and b. The direction of power flow, E × H, is into the paper.

dW through an annulus between radii r and $r+dr$ is given by the magnitude EH of the Poynting vector multiplied by the area $2\pi r.dr$ of the annulus. (The direction of the Poynting vector is of course parallel to the axis of the coaxial system.)

$dW = EH \,.\, 2\pi r \,.\, dr = iv \,.\, dr/[r\ln(b/a)]$. (A3)

The total power flow is then

$$W = \frac{iv}{\ln(b/a)} \int_a^b \frac{dr}{r} \quad \text{.............. (A4)}$$

But the value of the integral is $\ln(b/a)$ so

$W = iv$ .... (A5)

If the resistance of the conductors is significant, then just as in the case of the strip line there will be a component of E parallel to the length of the system and a component of the Poynting vector pointing into the conductors to account for the i^2R loss. □

BOOKS

Telecommunication System Engineering, by Roger L. Freeman, is described as "a textbook and ready reference for the student, practising engineer, planner and telecommunication engineer." The view of telecommunications adopted is the widest possible, since in 480 pages radio is only allotted 66, which does seem a little cavalier, to say the least. The main body of the book is therefore concerned with the communication over telephone circuits of voice messages, data and facsimile, in analogue and digital forms.

In the field the author sets out to cover it is difficult to imagine a more complete treatment, starting as it does with a diagram of two telephones, a cable and a battery, and finishing with the concept of digital data networks and the economical technical planning involved in national networks. The author is American, which may mean that some transatlantic terms are unfamiliar, although he has used the UK engineers' term 'bearer,' for example, to denote the signal-carrying medium. The book is published at £17.70 in hardback by John Wiley and Sons Ltd, Baffins Lane, Chichester, West Sussex, PO19 1UD.

Practical Hi-Fi Sound, by Roger Driscoll, is the latest in a long line of books intended to clarify the absurd technospeak so carefully built up by makers of sound equipment. The main difference between this one and a great many of the others is that this author keeps his object well in mind and does not fall prey to the temptation to show his own technical superiority.

The treatment is not detailed, but rather seeks to answer the questions which would be asked by someone who wanted to know some of the background to the present state of audio equipment. The two introductory chapters are concerned with musical sounds and their reproduction, being followed by two sections on equipment, including building instructions for a loudspeaker. The acoustic performance of the listening rooms is dealt with in the final chapter. The book fulfils its avowed purpose admirably and can be recommended. It costs £6.00 and is published by Hamlyn, Astronaut House, Hounslow Road, Feltham, Middlesex, TW14 9AR.

Simple alternatives to the monostable

Using low-cost gates for non-critical timing circuits

by D. Price

In comparison with other i.cs, c.m.o.s. monostables are rather expensive, the 4528 package costing about £1 for two circuits. In a non-critical situation, for example when a reset pulse is required, cheaper solutions are available.

A 4093 NAND Schmitt trigger, costing about 16p per gate, provides the basis for a satisfactory alternative. Referring to Fig. 1, the high input impedance of a c.m.o.s. gate ensures that, in the absence of other constraints, the voltage at B follows the voltage at A. However, gate protection diodes and the bias resistor modify the voltage performance in the following way. After a long quiescent period, the input voltage V_B will be high and the output low. If a negative pulse is applied by G_1, the input to G will go low and the output will go high. After a time determined by R and C, but not equal to RC, the output will fall. The input potential must be kept low for the duration of the pulse, otherwise the output will be prematurely terminated. A positive going excursion from G_1 will drive V_B above the power supply rail but, as soon as a voltage of $V^+ + 0.5V$ is reached, the gate protection diode starts to conduct and dissipates any excess change. The circuit is therefore quickly reset. If the resistor is taken to the negative rail, all of the pulse directions are reversed.

The output pulse length is determined by R and C. As an approximation, assume that the trigger point of the gate is half way between the two power rails. Using the formula $V = V^+e^{-t/RC}$, and substituting $V = V^+/2$ gives $e^{-t/RC} = ½$. Therefore, $t \simeq 0.57RC$.

This principle can be used with two inputs simultaneously as shown in Fig. 2, which gives two gated monostables. However, the NAND property of the gate will not allow the resistors to be connected to the negative rail.

If a slow fall time can be accepted, which is often the case, an ordinary gate can be used as shown in Fig. 3 where a three input NAND becomes a trio of gated monostables costing about 2p each. If an inverted output is required, replace the NAND with an AND gate or take all of the resistors to the negative rail and use a NOR gate.

During the off transition of the gate, both output transistors are switched on and are dissipating power. For this reason, long time constants, i.e. slow transitions, should be avoided. Adding a diode to the external components of the above circuits produces a monostable which is activated while the input is low, and the RC time constant occurs after the input goes high, see Fig. 4. A somewhat more complex arrangement can provide two time constants as shown in Fig. 5. Although this circuit is not a conventional monostable, it is useful if, for instance, a delayed switch on and off is necessary.

A wide range of RC values can be used with c.m.o.s. but, to avoid excessive dissipation and possible damage to the gate protection diodes, capacitor values below 100nF should be used. This does not apply to Fig. 4 and 5 as the circuits do not use the gate diodes. At the other extreme, less than 10pF may cause trouble due to the c.m.o.s. input capacitance, see Fig. 6. The voltage induced at N_B by a negative transition of V_A is $½V_A$, and this may not activate the Schmitt trigger. If the trigger is activated, the time constant will be much shorter than anticipated.

Almost any resistor value above 1kΩ can be used, and for long time constants a reverse-biased diode is a useful high value resistance. The resistance limit of 10^9Ω is set by the input impedance of the gate.

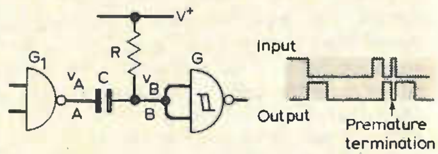


Fig. 1

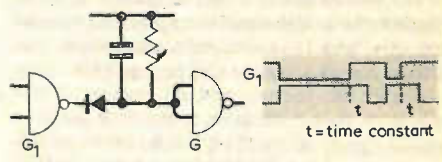


Fig. 4

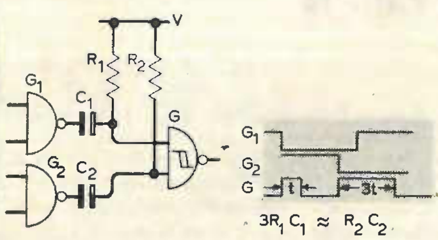


Fig. 2

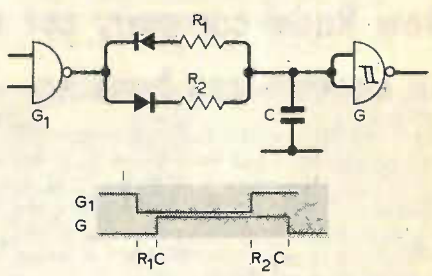


Fig. 5

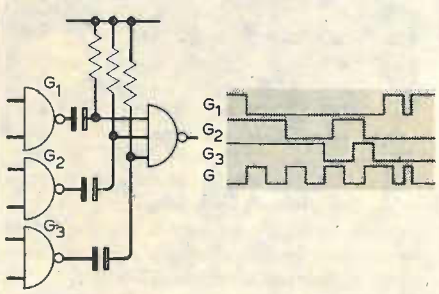


Fig. 3

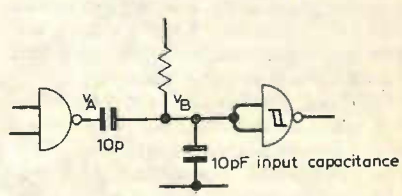


Fig. 6

NEWS OF THE MONTH

'More work on spectrum utilization needed' says CCIR chief

Not enough effort is being put into finding better ways of utilizing the radio spectrum, according to Richard Kirby, director of the CCIR. Speaking at a recent IEE conference in London devoted to this subject he said that studies of spectrum utilization ought to be better recognized as a legitimate and challenging discipline of communication science. Many university faculties and research budgets did not recognize this fact. "The subject may be seen only in a limited perspective of radio interference protection, a necessary but mundane appendage to system development. Or, if seen in a broader perspective, as fundamental study to expand the utility of the spectrum as a resource, there is a question of support; return on investment is uncertain, indirect, and long-term. It is clear that there are not very many Ph.D. theses on spectrum utilization topics. Some of the best talent in communication science ought to be encouraged to explore and develop this field. It would seem to me that the IEE is in a good position to foster this".

Earlier Mr Kirby gave an outline of the work in this field that the CCIR (a permanent body of the ITU) will be doing in the aftermath of the 1979 World Administrative Radio Conference at Geneva. He indicated five main areas: bandwidth-efficient modulation, frequency re-use, domestic and regional satellite systems, the role of h.f. and improvement of equipment standards from the point of view of spurious emissions and unwanted responses.

"First, as regards bandwidth-efficient, interference-resistant modulation: the dominant trend to digital systems for terrestrial and space systems alike, mobile, fixed, and ultimately even television, is being greatly spurred by the rapid development of very large scale integrated circuitry . . . Spread spectrum has already proven advantages for rejection of narrow-band interference and reduction of interfering power spectral density. It remains to be seen whether, by the additional processing gain of correlation codes, an ensemble of spread-spectrum systems can share a given band of spectrum more efficiently than narrow band signals. The new processing technology should have a great bearing on "multi-user communications", i.e. techniques by which one or more transmitters are simultaneously communicating with one or more receivers over a common channel in the radio spectrum. "Packet radio", a related random-access concept, is promising not only for data, but also for speech. A resolution of the WARC has asked the CCIR to give special attention to studies of these new digital techniques which could lead to a whole new approach to channel assignment and the possibility of greatly expanded use of the spectrum compared with present-day frequency division. At the same time, there is increased emphasis on bandwidth conservation schemes. Some television bandwidth compression techniques are very promising. More conventionally, single-sideband is finally being seriously considered for sound broadcasting. The CCIR has been asked to intensify its studies of means of transition to single-sideband broadcasting". The coming h.f. broadcasting conference, while committed to double sideband for the next plan, also had on its agenda the specification of an s.s.b. system suitable for future broadcasting.

"Frequency-re-use is the objective of some of the most important developments in antenna systems for satellites and terrestrial communications alike. It is also the motivation for important propagation research, especially at frequencies below 40GHz where the main features of propagation are already known. Questions such as how much polarization discrimination can be achieved in practice, as under rainfall conditions, and how small antenna beamwidths can be maintained through the atmosphere, might at one time have been considered second-order questions. They are now central to frequency re-use, as are anomalous propagation effects such as ducting and scintillation."

One of the most important technical topics for the future of radio communications was the efficient use of the geostationary satellite orbit. "One method to increase the efficiency of the use of the orbit is by reduction of inhomogeneity. Sharing is more difficult, less efficient, among a variety of beamwidths, power levels, and receiver sensitivities than among a homogeneous set of these system requirements. So only a degree of homogeneity can be sought, in terms of the range of certain parameters. Other aspects being studied are the level of permissible inter-network interference, and the antenna characteristics for both earth stations and satellites." The CCIR preparatory work for a satellite conference in 1984 was centered on a CCIR working party, which would now also consider methods for ensuring equitable access for all countries to the geostationary satellite orbit.

The h.f. part of the spectrum was "seen as the most economical method for thin route intermittent communications which do not yet justify microwave or satellite links . . . It may remain most susceptible to congestion and interference. Thjere is a considerable technical challenge here to make systems more interference resistant."

New Racal company set to cash in on cheque-less banking

A further step in the trend to electronic banking methods has been taken with the formation of a new company, Racal-Transcom Ltd, which the company claims will be a prime mover in eliminating the need for cheque books and paperwork in many financial transactions.

The systems which Racal Transcom intends to introduce will be designed to eliminate much of the paper work which possible users such as banks, credit companies, finance houses, airlines and retail organisations have to cope with.

Announcing the formation of the new company, Ernest Harrison, chairman and chief executive of the Racal Electronics Group said, "Electronic funds transfer will have a major impact on the retail world, and its international growth potential is extremely large. Eventually it could affect almost everyone who makes a purchase, pays for a service or uses a bank."

Racal-Transcom is a subsidiary of Racal-Datacom of Salisbury, Wiltshire and the design team responsible for the development of the new systems over the last two years will be located in separate premises on the same site.

A Racal-Transcom point-of-sale terminal being demonstrated in a busy supermarket. The customer is using a hand-held device to key in her personal code which, for security, must correspond with the encoded account number on her banker's card, which is placed in the terminal. The customer's bank account is automatically debited and the shop's account credited for the goods purchased.

Open Channel (CB) implications in decisions about model control band

Announcing the government's intention to exempt users of model control transmitters, metal detectors and pipefinding equipment from the need to licence such equipment, the Home Secretary said that current holder f licences would be able to "pursue their hobbies exactly as now, and that . . . this will lead to less bureaucratic control and greater freedom for individuals."

He said that he would be bringing forward proposals in the next few months in relation to the Wireless Telegraphy Act 1949 and at a later stage to identify other categories of radio device which can be dealt with similarly.

Approximately 93,000 licences for model control equipment had been issued up to the end of 1979 and when the new regulations come into force, these licences will be formally revoked. A simplified form of the existing operating conditions will be used so that frequency and output power requirements will remain unchanged. In general, users of the model control band (27MHz) are restricted to 1.5W radiated power, and the current licence fee is £2.80 for a five-year period.

The licence fee for pipefinders and metal detector equipment is £1.40 for five years and the number of licences issued has risen from 2,000 in 1972 to 150,000 in December 1979, reflecting the substantial growth in the use of such equipment by treasure-hunting enthusiasts. However, exemption of metal detectors from licence requirements does not in any way absolve users from the need to obtain permission to enter, search and dig land and to keep off protected archaeological sites.

Equipment will no longer be subject to the type-approval procedure, so the exempting regulations will set out the simple technical conditions which will have to be met so as to avoid interference to other radio users. The conditions will be framed so that they cover all existing type-approved equipment.

Almost simultaneous with William Whitelaw's announcement was Timothy Raison's disclosure that the Home Office had received 7,800 letters on the subject of c.b. and 40 petitions carrying thousands of signatures. In replies to questions he said that the annual cost to the Post Office of investigations into complaints of interference to "non-broadcast services" and into all forms of illicit installation or use of radio equipment, was about £1 million. The costs incurred in dealing with illicit use of 27MHz were not recorded separately and "no figures are available for the cost of controlling imports of prohibited equipment."

He also revealed that from 1st January to 30th April 1979, 94 persons were prosecuted in connexion with unlicensed installations or use of c.b. equipment at 27MHz, and a further 135 cases are pending. In 1978 a total of three persons were convicted of such offences and in 1979 the total had risen to 91. Minister of State at the Treasury, Peter Rees, disclosed that 721 sets were seized by Customs and Excise in the first quarter of 1980 and a total of 2,250 during 1979.

One interpretation of these official trends might be that the government wishes to give no more than the appearance of movement on the Open Channel issue. With c.b. enthusiasts becoming more vocal as a result of continuing stalling tactics from both government and Home Office (the discussion document promised in April has not materialized), it may be that licence exemption for model users is a red herring designed to, on the one hand, suggest more freedom of access (it is only an **official** sanction) to the spectrum, and on the other hand to consolidate the decision not to introduce Open Channel at this frequency.

De-regulation could have the effect of encouraging more widespread use of 27MHz by modellers, who might then very jealously guard their spectrum "slot", perhaps even introducing a "self-policing" activity . . . "Kamikaze model aircraft crashes in flames on illicit radio shack."

The only positive conclusion to be drawn from these government pronouncements is that something may well happen at some future date, having been duly considered and fully costed.

News in brief

The Mobile Radio Trade Association, formed in 1978, was set up with the intention of obtaining for its members effective representation with both manufacturers and statutory bodies. The association's aims and an outline of the facilities it can offer to interested companies or fleet operators are available from its offices at 9-11 Lower Addiscombe Road, Croydon, Surrey, Tel: 01-680 4444. The annual membership subscription is £50 plus v.a.t.

South London College will be running a course of eight lectures, the first starting on 14 October, 1980 and the last on 2 December 1980, entitled "Optical Fibre Communications." The course is intended to provide a comprehensive technical introduction to optical communication devices and systems and their application to multi-channel telephony and wideband services. The course fee for London students is £9 and applications should be made to A. A. Rowlands, South London College, Knights Hill, London SE27 0TX. Telephone 01-670 4488.

Plessey expands and contracts

The Secretary of State for Industry, Sir Keith Joseph, officially opened the Plessey p.c.b. plant at South Shields on July 11th, and also formally introduced the new company — Plessey Circuits Ltd.

The aim of the plant, which represents an investment of £5 million, is to produce mainly plated-through-hole (p.t.h.) p.c.bs on a large scale for marketing in the UK and in Europe at competitive prices by using modern masking, etching and plating techniques and a production line which is almost completely controlled by a central computer. V.d.us, strategically placed at each point in the line, give all the information required by the process operator including audible "cautions" and "warnings" of out-of-tolerance conditions such as high etch bath temperature, etc.

The plant has a production capacity of over 2.5 million p.c.bs a year and currently has a workforce of 185 people, which is expected to rise to 300. Plessey pre-tax profits for the year ended March 31, 1980, were 30% up at £60.1 million. In a cold and precise paragraph released in June, the company also refers to "extraordinary items . . . (£4.7 million) . . . "which includes the cost of eliminating the loss-making businesses of Garrard and Plessey Automatica Electrica Portugesa. Losses have also been eliminated on Strowger activity at Edge Lane."

Part of the new facility at Plessey Circuits Ltd, South Shields, showing the drilling and routing area. Eight-spindle drilling / routing machines are in use, providing a hit-rate of up to 350 per minute, with routing rates of 4ft per minute to a positional accuracy of plus or minus 0.0008 in. Tool change is automatically controlled by computer.

Fifty years ago, this 211 lb. wonder, the Blattnerphone, was used to record and reproduce a speech by King George V on a 6mm steel tape. This tape recorder, which was featured during May at the Bridgwater Exhibition (Admiral Blake Museum) 'Broadcasting in the Twenties and Thirties' is considered by some to have been the first suitable for broadcasting.

Unsuspected gremlins at work in hospital computing

According to an item in Reports on Research (Massachusetts Institute of Technology), computer-based administrative and medical information systems in hospitals in the US, are prone to interference by hospital staff. In some cases this interference, which is often accomplished through subtle processes such as non-co-operation in schemes to change from manual to automatic systems, is detrimental to the running of hospitals and may be detrimental to the health of patients.

Alan Dowling, a doctoral candidate in health management and management information systems at MIT's Sloan School of Management, defines staff interference as "instances where a member of the hospital staff deliberately acts or fails to act, so as to oppose, retard, hinder or impede a system's implementation." He says the interference can be overt or covert, violent or non-violent and can range from "passive non-co-operation to physical destruction."

Dowling conducted a survey of 40 hospitals and as a result of findings decided that this form of interference had occurred in at least half of them. He believes the reasons for this behaviour are more complicated than simple resistance to change, although this is an underlying factor. He cites other causes such as human organizational problems which the system may aggravate, difficulty in dealing with hardware and software problems, insufficient resource support for the implementation effort, lack of user involvement, changing staff reward structures and failure to meet staff expectations because of "overselling" the system.

As the number of hospitals attempting to change to computer-based systems grows, so the negative aspects of computer-bashing may be more seriously felt, with direct effect upon patient care. The problem isn't unique to hospitals, according to Dowling, and is fairly widespread in industry, but emerges as more serious in hospitals, where there is a "high rate of turnover among system vendors", suggesting that these problems are generally being ignored.

Where patient care is concerned, as Dowling points out, potentially life-threatening situations could result from a practitioner basing treatment on erroneous data. In his report, he traces three case histories of interference and isolates five major forms of interference. The most common form, he says, is passive resistance, in which a staff member deliberately fails to co-operate with other staff members or system specialists who are trying to implement the system.

In one hospital, the chiefs of several medical departments, themselves opposed to one aspect of a system, quietly ignored the requirement to make their staff available for system training over a prolonged period.

Two-way radio installed in caves

The network of caves below the site of Nottingham Castle is to be served by a two-way radio system, the equipment being supplied by Pye Telecommunications for the City of Nottingham's Technical Services Dept.

These caves are open to the public for guided tours and as a result of difficulties experienced by elderly visitors negotiating the slopes and bends, as well as for security purposes, the city's administrators decided to install a base station at ground level, supplemented by several "Pocketfone" portable two-way transceivers.

The scheme will enable guides, who are not permitted to leave their parties once underground or send a member of the party for help, to summon medical aid instantly.

Marconi to supply military equipment to China

A £40 million contract for the supply of electronics equipment "for defence purposes" has just be signed by Marconi Avionics and China.

The contract calls for delivery of equipment and associated trials and includes the establishment of some manufacture under licence in China. The main body of the work, which the company says will create several hundred skilled jobs in Kent, Essex and Hertfordshire, will consist of engineering, production, on-site trials and product support.

Marconi supplies avionics systems for 150 different aircraft and, in addition to supplying a wide range of electronic equipment for aviation, industrial and military applications, has already established the production of fuel flow measurement equipment under licence in China.

News in brief

Illegal c.b. operator Thomas Hanson, whose callsign is Captain Beaky, will be getting his transmitter back from the Home Office investigators who confisticated it after a raid on his car. Although he was fined £80 for installing and using the equipment in a vehicle, the magistrates at York, where prosecuting council Julian Hay had asked for the £200 set to be forfeited, refused to make such an order.

The International Broadcasting Convention (IBC) will be held from 20 to 23 September 1980 in Brighton, at the Metropole Hotel. Further information is available from the IBC Secretariat, IEE, Savoy Place, London WC2R 0BL.

Newcastle upon Tyne Education Authority is running a course which is designed to prepare students for the Radio Amateur's Examination (RAE). The course begins in September 1980 at Gosforth Secondary School and will run every Tuesday from 7 to 9 p.m. Candidates for the May/June examinations may sit for them at the school and any enquiries should be addressed to the Principal, Gosforth Adult Association, Gosforth Secondary School, Newcastle upon Tyne or by telephoning Newcastle upon Tyne 668439.

Industrial and Trade Fairs Ltd, have announced plans to hold Components '81 at Earls Court, from 9 to 12 June 1981. The event will be known alternatively as the Electronics Components Industry Fair and the company is to invest £400,000 in what the exhibition director, Frank Winter, describes as "a major event on a scale comparable to the Munich and Paris events and to establish and maintain the international credibility for the industry." Full details can be obtained from Industrial and Trade Fairs Ltd, Radcliffe House, Blenheim Court, Solihull, West Midlands B91 2BG.

Universities and companies to unite in industrial robot programme

At a recent press conference held at the headquarters of the Royal Society, officials of the Science Research Council announced a £500,000 five-year programme funding in industrial robotics.

The plans outlined by Peter Davey, the programme co-ordinator, will involve the realisation of university-bred ideas by companies interested in both development of the robots and their exploitation in manufacturing industry. The council says that UK industry has seriously lagged behind its overseas competitors in taking up robotic techniques and current research activity is "sparse". The main aim of the projected programme, according to Davey, will be to "leap-frog" the present generation of robots and devices and to provide the research necessary to take full industrial advantage of the technique as it emerges in the mid 1980s.

A number of vital areas of activity had been identified, including the development of fast-acting tactile, visual and aural sensory devices, modular robot construction, better, cheaper and lighter actuators and linkages and work on the effects of wear on accuracy. Other vital areas of interest include optimization of robot dynamics, research on safety aspects and the development of standards.

The first collaboration will take place between Warwick University, the Basingstoke-based company, Lansing-Bagnall (fork-lift truck manufacturers) and GEC. Lansing-Bagnall's interest lies particularly in the need to produce free-roving industrial vehicles, to replace those currently in use which are controlled by taut wire or by optical means. GEC comes into the picture as the company which will promote the so-called "intelligence" in the machine. The technical problems to be investigated and developed are coincident with those of computing in general — communication problems such as pattern recognition, analysis and processing, speech recognition and generation, improved graphics and displays etc. — typical microprocessor application problems.

Comments were made at the press conference concerning the current main application of industrial robots — in the automotive industry. It was felt that although there is considerable exploitation of robots in this field, the natural growth area lies in flexible manufacturing systems, where a large number of different product types will be demanded by an increasingly sophisticated market.

In response to a question concerning the application of robots to difficult or dirty jobs, such as mining, Mr D. H. Roberts, of GEC, said that such an application could not be considered in the same light as manufacturing needs. He emphasized this by commenting on questions dealing with the possibility of domestic robot development by saying that "Britain will not go broke if the domestic robot does not emerge, but it will if the industrial robot does not."

Not quite the shape of things to come as foreseen by H. G. Wells or Isaac Asimov, but a working robot called Commander Bill. Developed by the Research Group at Warwick University, the robot has been specially designed to operate over rough terrain and to negotiate steps.

Peter Davey felt that, in any event, the domestic robot would have to exist in a very dirty environment, which might preclude cost-effective development of peripheral equipment.

The SRC has produced a handbook outlining plans for the robotics development programme, which includes a summary of the main areas of activity. A firm building robots may be a suitable partner in the scheme if it acts as a "window" through which the academic group may be aware of not just one, but a number of potential applications which can benefit from the proposed work. On the other hand, there are few such firms in the UK and those that do exist tend to be preoccupied with the problems involved in producing their current models.

University or polytechnic groups wishing to take part in the programme, or firms seeking links with such groups, should contact the programme co-ordinator as early as possible to discuss in outline the proposed area of research, and the chance of a formal application being successful. If both factors appear promising, a grant application should be prepared on form RG2 with a supporting case not exceeding 6 pages clearly defining the objectives of the research, the methodology to be employed, project milestones and staff and equipment required.

Also attached should be a letter from senior management in the partner firm to support the programme of work and to give detailed costings of staff, equipment and facilities etc.

Grants will normally be made for periods up to 3 years, or perhaps 4 in special cases. Deadlines for completion of the final application are the SRC's normal ones of 1 April, 15 September and 15 December in any year.

Further details are available from Mr P. G. Davey, Co-ordinator of Robotics Programme, Rutherford and Appleton Laboratories, Chilton, Didcot, Oxfordshire OX11 0QX. Tel. Abingdon (0235) 21900, ext. 6106.

Catching Halley's Comet by the tail

Giotto, the 14th century Italian painter, who was also noted for his observations of Halley's Comet in 1301, is to be commemorated in a related event — the interception of the comet by a satellite. At least, this is the hope expressed by the British Aerospace Dynamics Group, who, under contract to the European Space Agency, have recently completed a feasibility study of the operation.

The satellite, to be called Giotto, will be based upon the GEOS-1 and GEOS-2 designs, and if everything goes according to plan, will be launched early in 1985 or 1986, when the comet makes one of its 76-yearly appearances in the night sky. The object of the mission will be to obtain data from instruments aboard the satellite on the chemical composition of the "coma" region surrounding the nucleus as well as that of the tail. Photographs will be taken of the nucleus and measurements will also be taken of the comet's magnetic field.

In order to make the checks effective, the satellite must pass within 1000km of the nucleus and since only a few hours of observation will be possible, prediction of accurate orbits is vital to the success of the operation. A solid propellant rocket motor will be used to inject the satellite into the comet's orbit and data will be transmitted nearly 100 million miles back to Earth.

A spokesman of British Aerospace Dynamics pointed out that, important as the mission is, there is no guarantee that it will be approved, although recent events seem encouraging. The appropriate ESA committee met in mid-July and gave a favourable report, but has yet to decide how the undertaking will be funded and managed. A definite decision is expected by September 1980.

Government go-ahead for Inmos as censure motion fails

The second charge of £25 million pounds due to Inmos, the state microcircuit company, is to be released by the government and will be supplemented by further amounts up to 22% of this amount depending upon where the production plant is sited in South Wales.

Announcing the plans for Inmos at the crucial moment in the debate on the Opposition's motion of censure on July 29, Mrs Thatcher said that the plans are expected to create 2,000 new jobs. In addition, seven "enterprise" zones will be set up in areas of economic and physical decay.

Sir Keith Joseph said that he had spent a long time over the decision because of the question of siting the new factory. It had originally been the intention to site it in Bristol, where Inmos already has a technological centre. A report on this delay was given in News of the Month in *Wireless World* August 1980.

Both the government and the NEB, of which Inmos is a subsidiary, are reported to be looking for private sector involvement as soon as possible and Sir Arthur Knight, the NEB's chairman, said that he expected the company to be self-financing by 1984. Sir Keith also announced that there will be a second UK production plant set up and, like that in South Wales, will manufacture advanced memory devices.

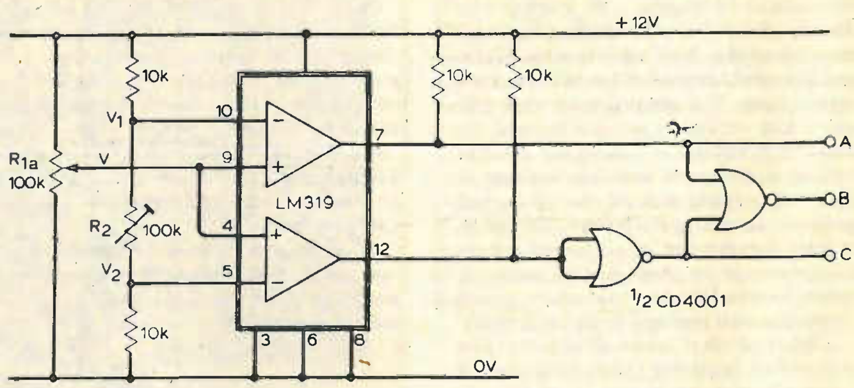
CIRCUIT IDEAS

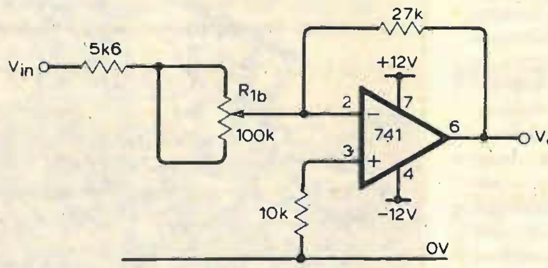
Flexible rate control

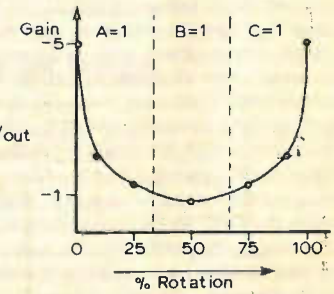
This circuit may be useful for digital tuning or a model control which requires reverse, stop, forward and speed functions from one potentiometer.

Resistor R_{1a} controls digital outputs A, B and C via two comparators so that A is 1 when $0<V<V_1$, B is 1 when $V_1<V<V_2$ and C is 1 when $V>V_2$. The ratios of A, B and C, shown on the graph, can be varied by R_2. R_{1b} controls the analogue output symmetrically about the centre of rotation. The control is non-linear and varies most rapidly at the extremes of rotation. In some applications it may be more useful for R_{1b} to control a RC oscillator.

D. C. Hopkins
Newcastle
Gwent



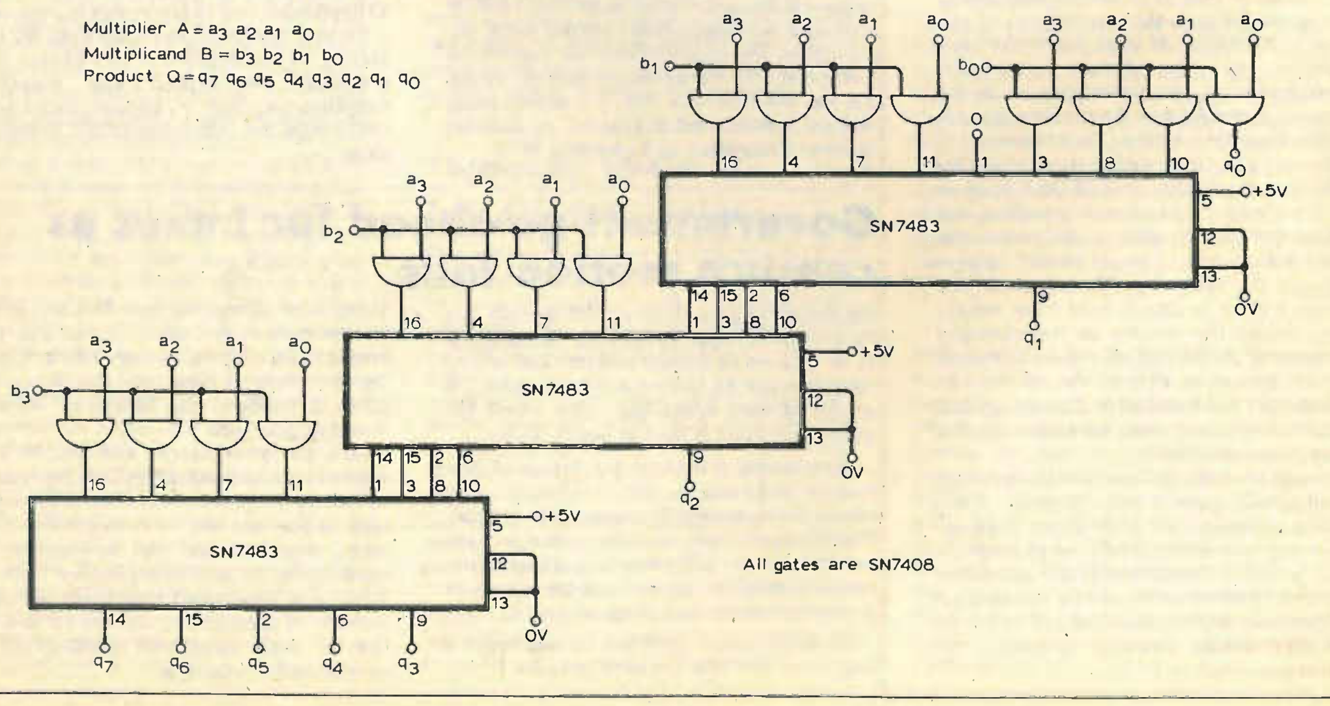




Parallel binary multiplier

Binary multiplication is usually performed by repetitive addition using serial and/or parallel operations. Because parallel multipliers are faster, they are preferable for computing applications. This circuit is a 4×4-bit parallel multiplier which operates in a similar way to conventional written multiplication. The 8-bit product is generated in less than 60ns, and at around half the cost of dedicated circuits such as the 74284 and 285.

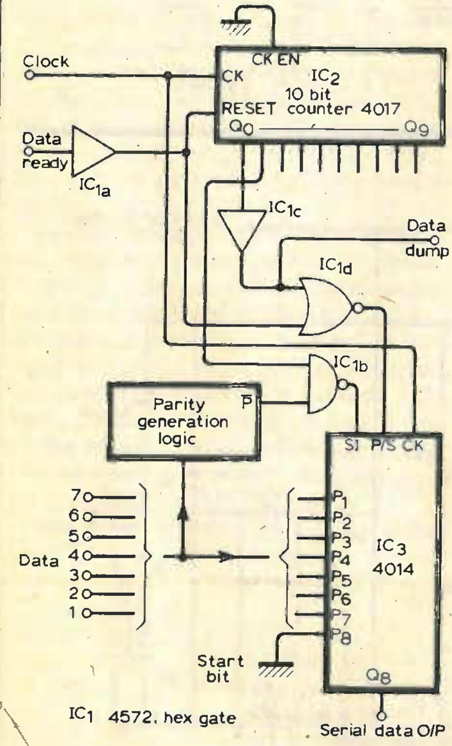
Imaddin Al-Bazz
University of Technology
Iraq

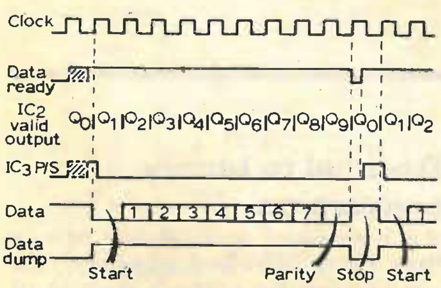


Asynchronous serial data transmitter

When information needs to be sent asynchronously using a start-stop bit format, but the application does not justify a standard u.a.r.t. i.c., this data transmitter can provide a simple solution.

When data is available, the Data Ready line goes high, which removes the reset from the counter and sets the shift register in the parallel mode. At the next positive going clock edge, the start bit and seven data bits are loaded into the shift register, Q0 goes low, Q1 goes high,





and IC_3 reverts to the serial mode. The parity generator output is enabled by Q1, and, on the next clock edge, the parity bit is shifted into the serial input of IC_3. A further clock edge sets Q1 low, so the serial input of IC_3 is held high which produces the stop bit state. Therefore, the serial output consists of a start bit, seven data bits, a parity bit and at least one stop bit. A negative going pulse on the Data Dump output indicates that data has been transmitted and the circuit is ready to accept the next byte.

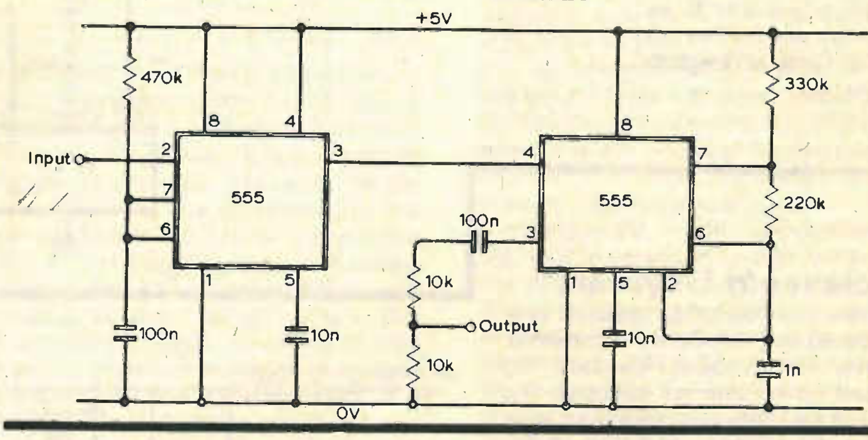
P. M. Gilbert
Malmesbury
Wilts.

Keyboard sounder

When using a keyboard it is helpful to have an audible indication that an entry has registered. This circuit was designed for the scientific computer, and gives a bleep through the television loudspeaker.

An input 555 is connected as a monostable and, when triggered, gives a 50ms pulse. The second timer is connected in the astable mode, and gives a burst of 2kHz when enabled by the monostable. The input requires a negative going pulse, which is available from pin 17, NMI input, of the Z80. The output is fed to the volume control of the v.d.u.

M. A. Wheatley
Maidenhead
Berkshire



Adding capacitance ranges to a multimeter

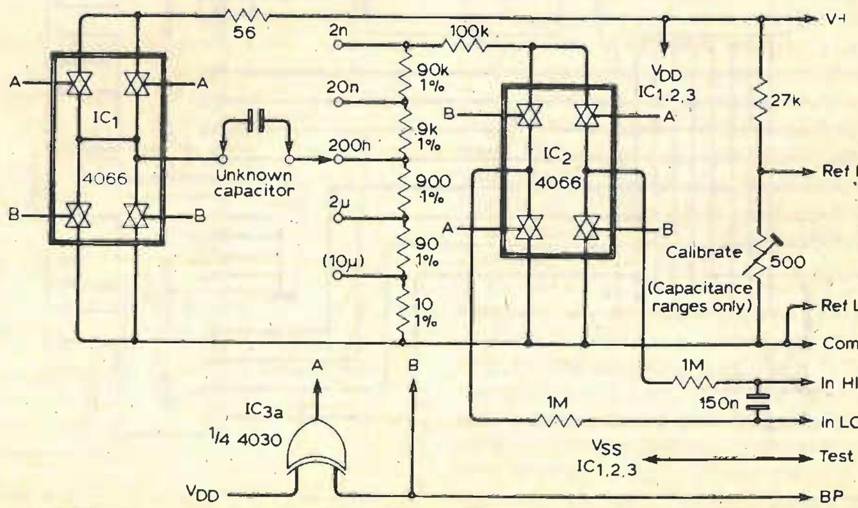
Capacitance ranges can be economically incorporated in 3½ digit l.c.d. multimeters based on the ICL7106. A 4066 is used to generate a square wave with the same frequency as the display backplane drive, and with a pk-to-pk amplitude defined by the internal 2.8V reference of the 7106. A second 4066 forms a full-wave synchronous rectifier. One inverter is required and is formed by an exclusive-OR gate because three gates are needed to drive the decimal points.

The circuit uses precision shunt resistors and offers good linearity up to about 10μF. Beyond this value the linearity deteriorates rapidly because the capacitor no longer has time to charge or discharge completely during each half cycle.

The 7106 operates on the dual-slope principle and, for correct operation, the clock frequency should be adjusted or crystal controlled to reject mains pickup by making the integration interval an integer number of mains cycles. An important advantage of this circuit is that ripple, at twice the backplane frequency, across the 150nF capacitor is automatically rejected in the same way. However, the backplane frequency should be several Hertz removed from the mains frequency to prevent a l.f. beat which would cause fluctuations of the capacitance reading. The clock frequencies listed below provide good stability, even when unscreened test leads are used.

J. B. Cole
Houston
Texas

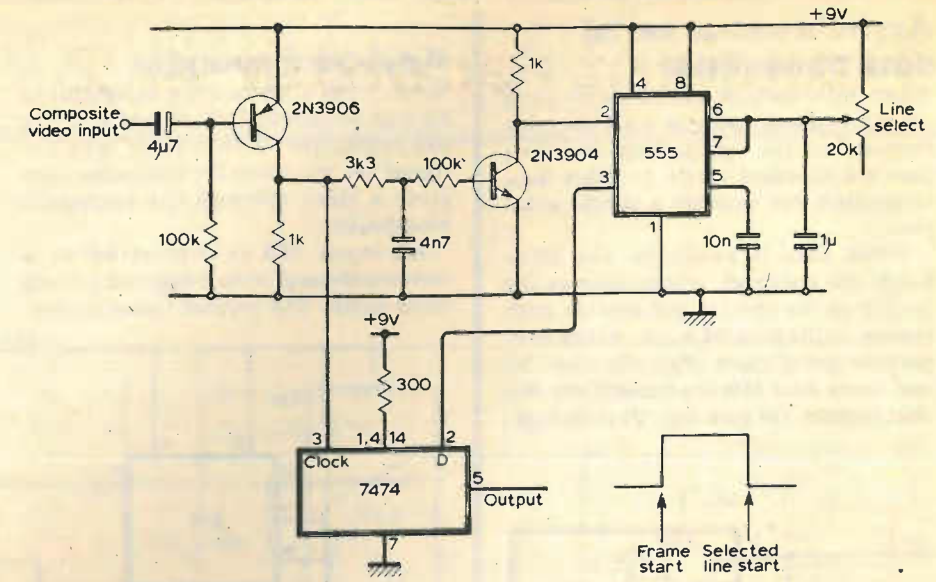
Mains frequency	Clock frequency	Backplane frequency	Readings sec^{-1}
50Hz	50kHz	62.5Hz	3.1
60Hz	40kHz	50Hz	2.5



Video-line trigger

An individual video line or group of lines can be displayed on an oscilloscope by using this simple trigger circuit. The 555 monostable is triggered by a frame pulse derived from the mixed syncs, and generates a pulse of up to 20ms. The flip-flop synchronizes the end of this pulse with the next line sync. pulse to prevent display jitter. Current consumption is typically 30mA.

P. Newman and M. Tierney
Southern General Hospital
Glasgow

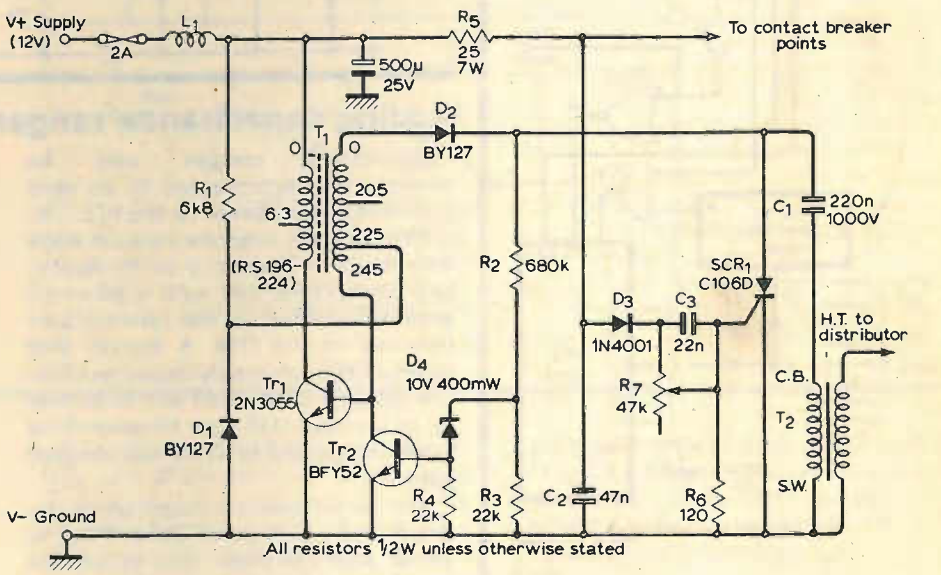


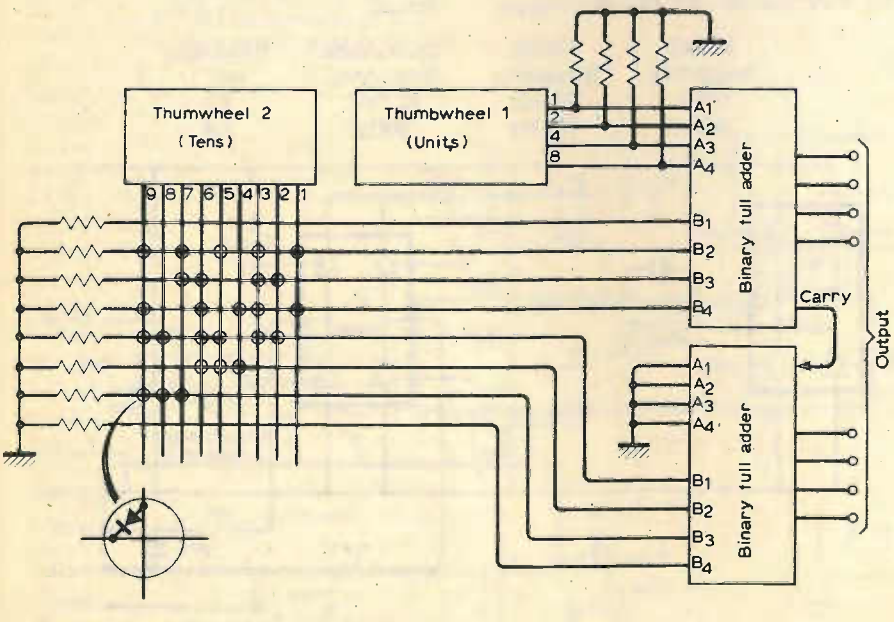
Efficient c.d.i. system

This capacitor-discharge ignition system is based on R. M. Carter's transistor converter, Circuit ideas, Nov. 1975. Tr_1 is biased on by current through R_1, which causes collector current to pass through the primary winding of T_1. Positive feedback from the secondary winding increases the collector current and, at saturation, insufficient base current turns Tr_1 off. Energy stored in the magnetic field of T_1 passes through D_2 and into C_1. This oscillation continues until the charge on C_1 is sufficient to switch Tr_2 on, which then inhibits Tr_1.

The discharge circuit uses a conventional thyristor design. D_3, C_3 and R_7 form a debounce circuit, and R_7 can also act as a rev. limiter. Because the inverter has a quiescent current of about 175mA, it will happily run from two alkaline cells.

W. K. Todd
Colchester
Essex





Decimal to binary conversion

If it is necessary or convenient to load data via thumbwheel switches, this circuit provides a cheap method of conversion provided numbers from 0 to 99 are sufficient. The units thumbwheel is an ordinary b.c.d. type, and the tens thumbwheel is a decimal output version. Each decade feeds the appropriate number into the binary adders, which can be c.m.o.s. or t.t.l.

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Transient recorder — 2

Control and timing signals

by **G. J. Adams** B.Sc., Ph. D.

The logic required for the address counter is shown in Fig.9. The address lines A_1 to A_8 are set low by the reset button. When the counter is enabled, the address counts from 0 to 255 and IC_{33} produces an end signal to mark the end of a single sweep. If the load signal is taken low, the address presented to the external address input appears on A_1 to A_8. Therefore, any memory location can be addressed by an external device.

For normal operation the manual/auto switch is set to the auto position. However, if the contents of the memory need to be examined one word at a time, the manual position is selected. After operation of the reset button, the contents of the first memory location will be displayed on the readout. Operation of the manual clock-switch advances the address by one and displays the contents of the next location.

The circuit shown in Fig.10 provides timing signals for the sample, a-to-d conversion, word storage sequence and the clock signal required for the address counter. Clock 1 and clock 2 outputs, which are t.t.l.-level square-wave signals at the same frequency as the sampling rate, are produced by the voltage-controlled function generator IC_{35}. Five overlapping frequency ranges are provided and variation within each range is achieved by adjusting a 2kΩ potentiometer which is calibrated from 1 to 11. Frequency variation is roughly linear with potentiometer variation, and a ten-turn potentiometer with a turns counter was used in the prototype. The low-frequency limit is adjusted first by setting the turns counter to 1 and setting the potentiometer to give the correct frequency. The upper limit is set by turning the potentiometer to 10 and adjusting R_5 to give the correct frequency. The 470 pF capacitor may require trimming due to stray capacitance.

A separate +15V regulator supplies the oscillator i.c. to prevent modulation of the main +15V line by the clock. This additional regulator also improves the stability of the clock frequency. The main power supply in Fig.11 uses two regulators to provide four supply rails.

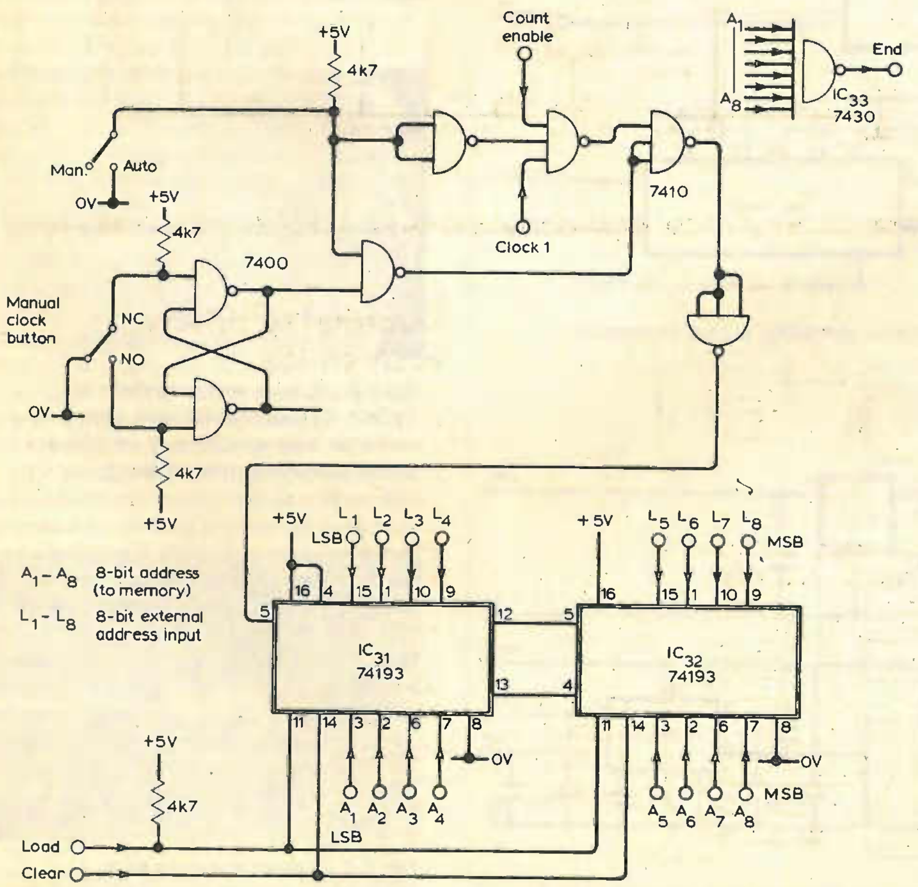


Fig. 9. Counter logic controls the 8-bit memory address.

Increasing the memory

If a larger memory is required, additional stages must be incorporated in the address counter so that the extra memory locations can be addressed. For example, if a third 74193 counter is connected to IC_{32}, in the same way as IC_{32} is connected to IC_{31}, then 12 bits will be available which can address up to 4096 memory locations. IC_{33} will need additional inputs so that the end output is in the low state only when the last memory location is addressed.

If pairs of 256 × 4-bit memory blocks are used to construct an 8-bit memory, the address-input lines, data-input and data-output lines should be connected in parallel. The chip-enable and output-disable lines of each pair of memory blocks can then be driven by the outputs of a decoder whose inputs are the address lines of the additional counter stages. The decoding logic ensures that only one pair of memory blocks is active at a time. An alternative scheme, which is more expensive but reduces the amount of wiring required, is to use 1024 × 4-bit memory blocks.

Operation

To operate the transient recorder, select auto mode and push the reset button. For recording, select a suitable input sensitivity and sampling frequency, and operate the arm button. In this state the input is continually sampled and the digital word is displayed by the l.e.ds. With no input present, the a-to-d converter's full range can be observed by adjusting the offset control. With an input signal connected, the recorder is triggered manually or by a 5V high-to-low edge at the trigger input. Triggering may not occur immediately due to the free-running clock, however, it will occur within one sample period and the exact triggering point is identified by a positive edge at the trigger-acknowledge output. Information stored in the first memory location corresponds to the sample taken immediately before this output. Therefore, although the recorder may not trigger immediately, the stored data is valid from receipt of the trigger signal, and in some cases up to a sample period before this. When all of the memory locations have been filled with data, the recording l.e.d. turns off.

To display the contents of the memory on an oscilloscope, select repetitive mode and a suitable playback rate, i.e. the sampling frequency. When the analogue output is connected to an oscilloscope, recorded data is displayed as a continuous periodic waveform. To plot the data on a chart recorder, operate the reset button, select the single-sweep mode and a low playback rate suitable for the response time of the chart recorder.

Operation of the trigger button then produces a single sweep of the memory contents.

If the recorder is armed unintentionally the reset button can be used, but memory location 0 will have become contaminated.

Fig.12 shows an input and output triangle waveform of the recorder and illustrates the smoothing effect obtained by switching in the low-pass filter. Fig.13 shows a pressure impulse received by a microphone from a loudspeaker. This excitation pulse was obtained from a generator triggered by the trigger acknowledge output of the transient recorder.

Construction of this design is straightforward, but the following precautions should be noted. If a metal case is used it should be connected to earth and also to 0V from the power supply. Even with a low-field transformer, mains-frequency voltages are induced in the chassis, so it is worthwhile to isolate the earth side of the a.c. input socket from the main chassis and connect it to the 0V rail of the input amplifier. This ensures that voltages induced in the chassis do not appear in series with the input signal. Because BNC sockets were used on the prototype, it was found more convenient to isolate the front panel. Separate power supply leads, including 0V, should be used for each board, with connexions made to busbars on the power supply board. If a hexadecimal display is required, suitable l.e.d. types are available such as the TIL311 which can be driven directly by the data-output lines. □

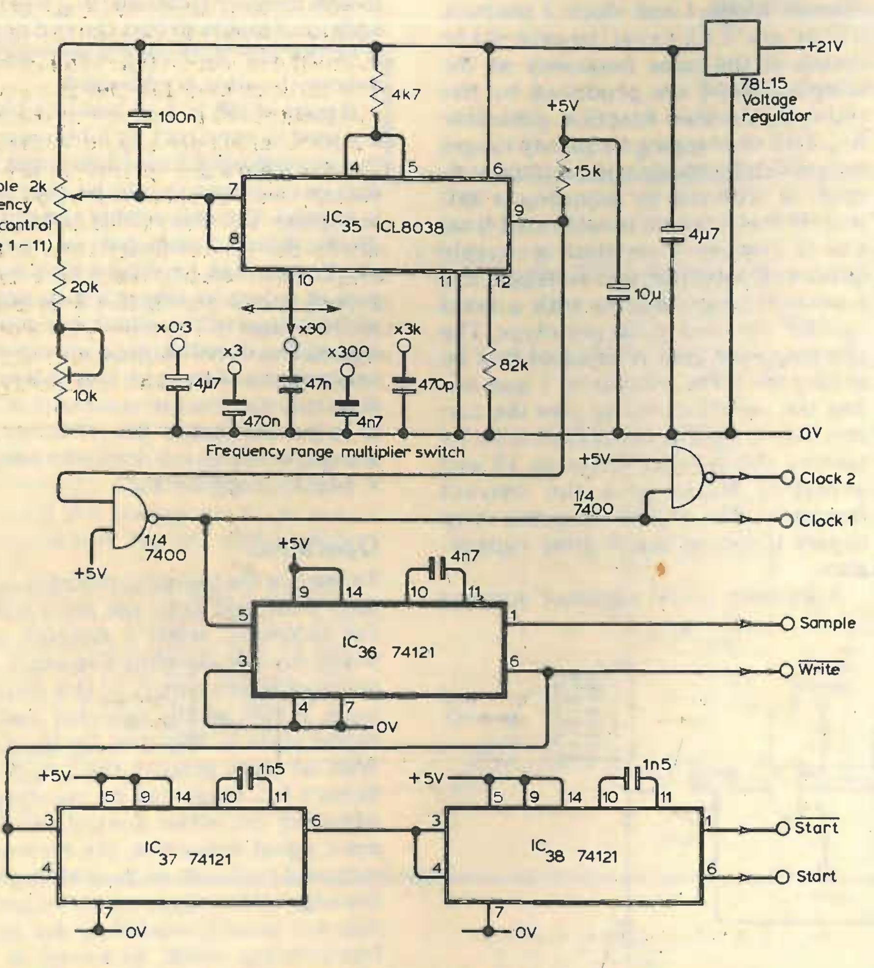


Fig. 10. Clock and timing circuits provide signals for sampling, a-to-d conversion and storage.

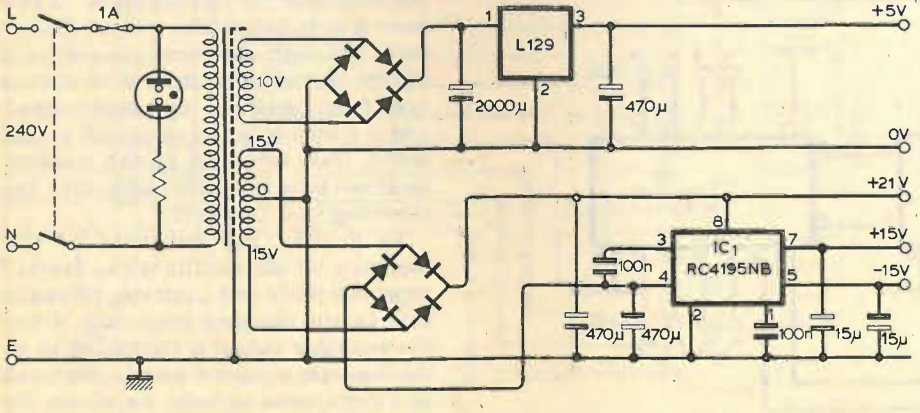


Fig. 11. Power supply. The L129 regulator should be mounted on a heatsink, and a toroidal transformer is recommended.

Fig. 12. (a) Input test waveform at 240Hz, (b) output waveform from d-to-a converter after sampling at 24 kHz, (c) output waveform after filtering.

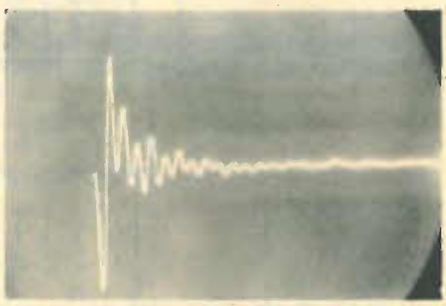


Fig. 13. Impulse response of a loudspeaker system measured using the transient recorder.

Designing with microprocessors

4 — The synchronization problem

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

This article explains the need to synchronize the internal operation of the microprocessor chip with the responses of peripherals. Software and hardware methods of doing this are outlined. Their step-by-step implementation will be discussed in later articles.

When data is to be transferred between two devices, the transmitting device, before it outputs the data, must ensure that the receiving device is able to accept it, otherwise the data will be lost. As communicating devices generally operate at different speeds, their operation must be synchronized, if system malfunction due to speed mismatch is to be avoided. The set of circuits and signals used for this purpose are referred to collectively as *interfaces*. The block diagram of an interface involving two devices, a data source and a data acceptor, is shown in Fig. 1. Its function is to monitor the status signals of the two communicating devices and to generate their command signals in the correct sequence to ensure that they operate in step with each other. In practice an interface accepts external signals for such purposes as initiating a data transfer, putting the system on alert, and so on.

A clear understanding of the synchronization problem and of the available solutions is essential for the design and implementation of microprocessor-based systems, and indeed of any system. We shall start by first describing the nature of the synchronization problem in microprocessor-based systems.

The synchronization problem in microprocessor-based systems is probably best illustrated by considering the steps involved in using a character printer to produce a hard copy of a block of 32 characters stored as bytes in consecutive locations in memory. A simplified block diagram showing the flow of information through a microprocessor chip is shown in Fig. 2 (a). The routing of the data through the microprocessor chip, instead of transmitting it directly to the printer, allows such functions as code conversion, formatting, parity checking and so on, to be performed on the data prior to printing. If no processing is required, a direct link (d.m.a. link) between memory and printer may be established, as we shall discuss in a future article.

The operation of our system, which consists of fetching each byte from memory into the microprocessor chip and printing it, is shown in Fig. 2(b). The flowchart of the software required to fetch and print each byte is shown in Fig. 3. Its implementation in the case of the Motorola 6800 (see instruction set in Appendix), is shown overleaf.

Reference to the manufacturer's manual (1)* indicates that the execution time of a fetch/print loop (statements in locations 0005 to 000F) requires 24 machine cycles. If we assume the execution time of a machine cycle to be around 1μs, the characters will be output to the printer at the rate of around 40,000 per second — far too fast for character printers, which typically will be operating at 30 characters per second. The outputting of data to the printer faster than it can accept it will clearly result in a large proportion of it getting lost. It is therefore necessary for the designer not to output a character to the printer until it is ready to accept it. The most straight-

*See also Appendix

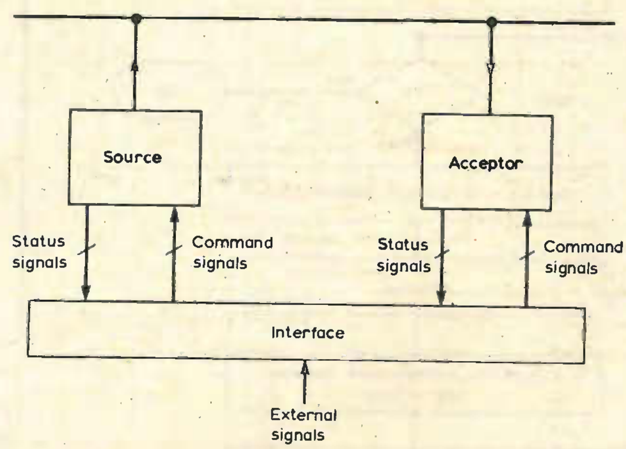


Fig. 1. Block diagram of an interface.

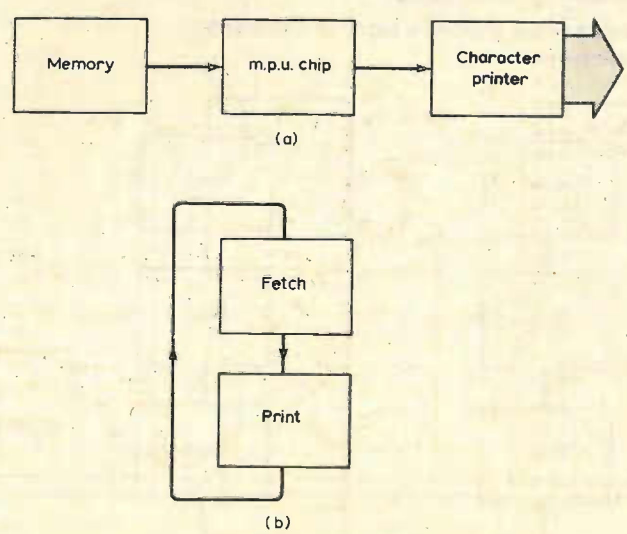


Fig. 2. Block diagrams showing (a) data flow and (b) fetch/print cycle.

forward method is to stretch the fetch/print cycle in Fig. 4. This delay can be implemented using either software or hardware; in the first case we shall refer to it as *software wait* and in the second case as *hardware wait*.

Software wait is implemented by means of a programming loop during which the status of the printer is read into the microprocessor chip and tested. If the printer is found to be busy, the process is repeated. When the printer becomes ready (indicated by its status signals), the microprocessor exits the software wait loop, as shown in Fig. 5. Note that the wait loop may be entered either before or after the print operation.

The step-by-step implementation of microprocessor-based systems using software wait will be discussed in the next article.

Implementation of Fig. 3 processes in Motorola 6800

Hex address	Hex listing	Mnemonics	Comments
0000	CE	LDX # $U350	Load the index register with the initial memory block address
0001	03		
0002	50		
0003	C6	LDAB #$20	Load the block length (hex 20) into accumulator B — hex 20 = decimal 32
0004	20		
L1: 0005	27	BEO L2	Go to L2 if acc. B is zero
0006	09		
0007	A6	LDAA $0,X	Load the next byte to be printed into acc. A
0008	00		
0009	B7	STAA $0400	Print the byte in acc. A
000A	04		
000B	00		
000C	08	INX	Increment the memory block address
000D	5A	DECB	Decrement the block length
000E	20	BRA LI	Go to L1
000F	F5		
L2: 0010	3F	SWI	End

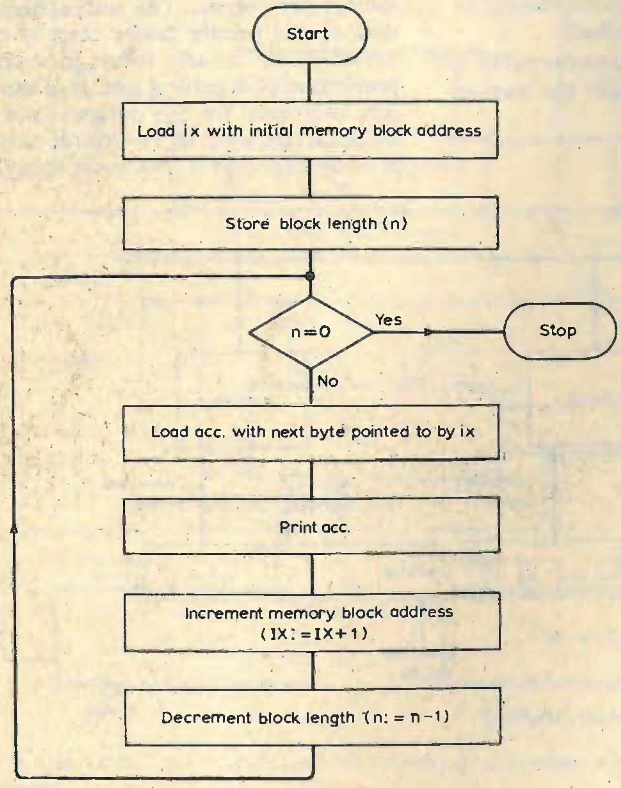


Fig. 3. Flowchart for printing a block of n characters stored in memory.

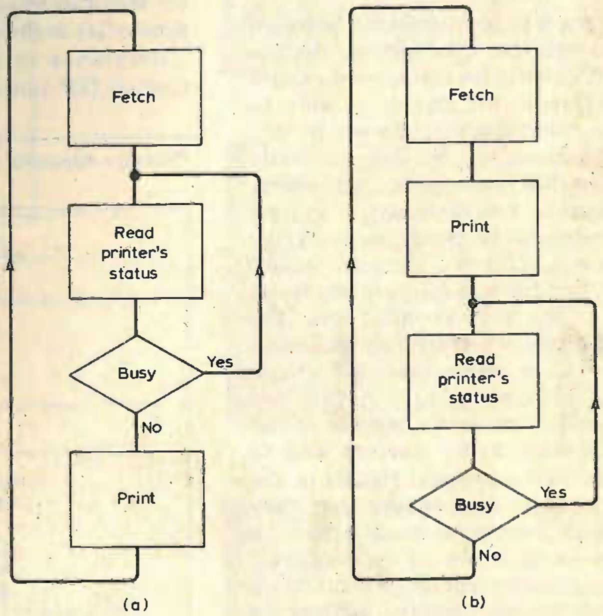


Fig. 5. Flowcharts of software wait loops (a) with wait loop entered before print operation, (b) entered after print operation.

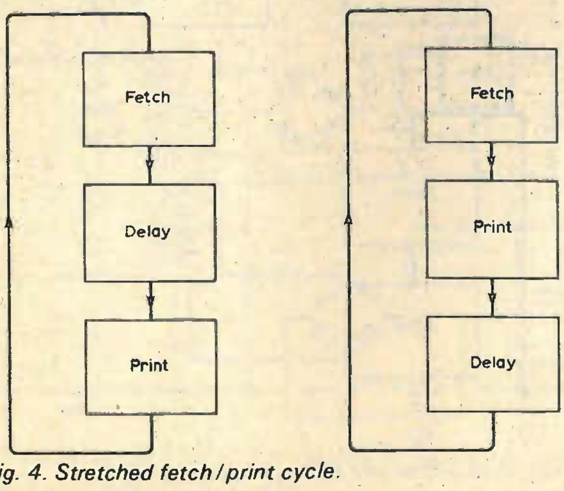


Fig. 4. Stretched fetch/print cycle.

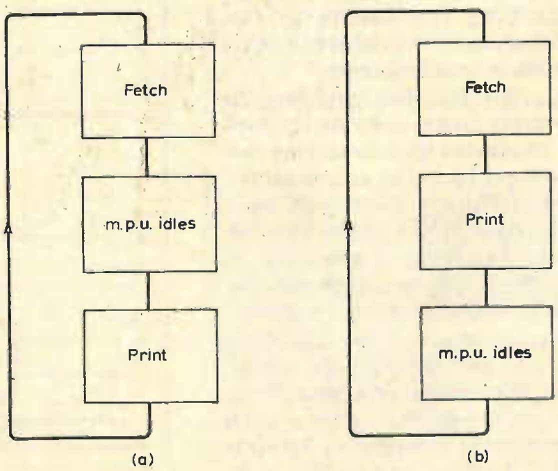
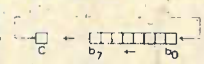
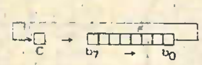
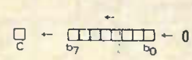
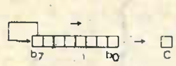
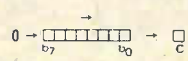


Fig. 6. Flowcharts of hardware wait loops implemented (a) before and (b) after print operations.

Appendix: Motorola 6800 instruction set

(continued on next page)

ACCUMULATOR AND MEMORY OPERATIONS	MNEMONIC	IMMED OP	IMMED ~	IMMED #	DIRECT OP	DIRECT ~	DIRECT #	INDEX OP	INDEX ~	INDEX #	EXTND OP	EXTND ~	EXTND #	INHER OP	INHER ~	INHER #	BOOLEAN/ARITHMETIC OPERATION (All register labels refer to contents)	5 H	4 I	3 N	2 Z	1 V	0 C
Add	ADDA	8B	2	2	9B	3	2	AB	5	2	BB	4	3				A + M → A	↕	●	↕	↕	↕	↕
	ADDB	CB	2	2	DB	3	2	EB	5	2	FB	4	3				B + M → B	↕	●	↕	↕	↕	↕
Add Acmltrs	ABA													1B	2	1	A + B → A	↕	●	↕	↕	↕	↕
Add with Carry	ADCA	89	2	2	99	3	2	A9	5	2	B9	4	3				A + M + C → A	↕	●	↕	↕	↕	↕
	ADCB	C9	2	2	D9	3	2	E9	5	2	F9	4	3				B + M + C → B	↕	●	↕	↕	↕	↕
And	ANDA	84	2	2	94	3	2	A4	5	2	B4	4	3				A • M → A	●	●	↕	↕	R	●
	ANDB	C4	2	2	D4	3	2	E4	5	2	F4	4	3				B • M → B	●	●	↕	↕	R	●
Bit Test	BITA	85	2	2	95	3	2	A5	5	2	B5	4	3				A • M	●	●	↕	↕	R	●
	BITB	C5	2	2	D5	3	2	E5	5	2	F5	4	3				B • M	●	●	↕	↕	R	●
Clear	CLR							6F	7	2	7F	6	3				00 → M	●	●	R	S	R	R
	CLRA													4F	2	1	00 → A	●	●	R	S	R	R
	CLRB													5F	2	1	00 → B	●	●	R	S	R	R
Compare	CMPA	81	2	2	91	3	2	A1	5	2	B1	4	3				A − M	●	●	↕	↕	↕	↕
	CMPB	C1	2	2	D1	3	2	E1	5	2	F1	4	3				B − M	●	●	↕	↕	↕	↕
Compare Acmltrs	CBA													11	2	1	A − B	●	●	↕	↕	↕	↕
Complement, 1's	COM							63	7	2	73	6	3				$\overline{M}$ → M	●	●	↕	↕	R	S
	COMA													43	2	1	$\overline{A}$ → A	●	●	↕	↕	R	S
	COMB													53	2	1	$\overline{B}$ → B	●	●	↕	↕	R	S
Complement, 2's (Negate)	NEG							60	7	2	70	6	3				00 − M → M	●	●	↕	↕	①	②
	NEGA													40	2	1	00 − A → A	●	●	↕	↕	①	②
	NEGB													50	2	1	00 − B → B	●	●	↕	↕	①	②
Decimal Adjust, A	DAA													19	2	1	Converts Binary Add. of BCD Characters into BCD Format	●	●	↕	↕	↕	③
Decrement	DEC							6A	7	2	7A	6	3				M − 1 → M	●	●	↕	↕	④	●
	DECA													4A	2	1	A − 1 → A	●	●	↕	↕	④	●
	DECB													5A	2	1	B − 1 → B	●	●	↕	↕	④	●
Exclusive OR	EORA	88	2	2	98	3	2	A8	5	2	B8	4	3				A ⊕ M → A	●	●	↕	↕	R	●
	EORB	C8	2	2	D8	3	2	E8	5	2	F8	4	3				B ⊕ M → B	●	●	↕	↕	R	●
Increment	INC							6C	7	2	7C	6	3				M + 1 → M	●	●	↕	↕	⑤	●
	INCA													4C	2	1	A + 1 → A	●	●	↕	↕	⑤	●
	INCB													5C	2	1	B + 1 → B	●	●	↕	↕	⑤	●
Load Acmltr	LDAA	86	2	2	96	3	2	A6	5	2	B6	4	3				M → A	●	●	↕	↕	R	●
	LDAB	C6	2	2	D6	3	2	E6	5	2	F6	4	3				M → B	●	●	↕	↕	R	●
Or, Inclusive	ORAA	8A	2	2	9A	3	2	AA	5	2	BA	4	3				A + M → A	●	●	↕	↕	R	●
	ORAB	CA	2	2	DA	3	2	EA	5	2	FA	4	3				B + M → B	●	●	↕	↕	R	●
Push Data	PSHA													36	4	1	A → M_{SP}, SP − 1 → SP	●	●	●	●	●	●
	PSHB													37	4	1	B → M_{SP}, SP − 1 → SP	●	●	●	●	●	●
Pull Data	PULA													32	4	1	SP + 1 → SP, M_{SP} → A	●	●	●	●	●	●
	PULB													33	4	1	SP + 1 → SP, M_{SP} → B	●	●	●	●	●	●
Rotate Left	ROL							69	7	2	79	6	3				M	●	●	↕	↕	⑥	↕
	ROLA													49	2	1	A 	●	●	↕	↕	⑥	↕
	ROLB													59	2	1	B	●	●	↕	↕	⑥	↕
Rotate Right	ROR							66	7	2	76	6	3				M	●	●	↕	↕	⑥	↕
	RORA													46	2	1	A 	●	●	↕	↕	⑥	↕
	RORB													56	2	1	B	●	●	↕	↕	⑥	↕
Shift Left, Arithmetic	ASL							68	7	2	78	6	3				M	●	●	↕	↕	⑥	↕
	ASLA													48	2	1	A 	●	●	↕	↕	⑥	↕
	ASLB													58	2	1	B	●	●	↕	↕	⑥	↕
Shift Right, Arithmetic	ASR							67	7	2	77	6	3				M	●	●	↕	↕	⑥	↕
	ASRA													47	2	1	A 	●	●	↕	↕	⑥	↕
	ASRB													57	2	1	B	●	●	↕	↕	⑥	↕
Shift Right, Logic.	LSR							64	7	2	74	6	3				M	●	●	R	↕	⑥	↕
	LSRA													44	2	1	A 	●	●	R	↕	⑥	↕
	LSRB													54	2	1	B	●	●	R	↕	⑥	↕
Store Acmltr.	STAA				97	4	2	A7	6	2	B7	5	3				A → M	●	●	↕	↕	R	●
	STAB				D7	4	2	E7	6	2	F7	5	3				B → M	●	●	↕	↕	R	●
Subtract	SUBA	80	2	2	90	3	2	A0	5	2	B0	4	3				A − M → A	●	●	↕	↕	↕	↕
	SUBB	C0	2	2	D0	3	2	E0	5	2	F0	4	3				B − M → B	●	●	↕	↕	↕	↕
Subract Acmltrs.	SBA													10	2	1	A − B → A	●	●	↕	↕	↕	↕
Subtr. with Carry	SBCA	82	2	2	92	3	2	A2	5	2	B2	4	3				A − M − C → A	●	●	↕	↕	↕	↕
	SBCB	C2	2	2	D2	3	2	E2	5	2	F2	4	3				B − M − C → B	●	●	↕	↕	↕	↕
Transfer Acmltrs	TAB													16	2	1	A → B	●	●	↕	↕	R	●
	TBA													17	2	1	B → A	●	●	↕	↕	R	●
Test, Zero or Minus	TST							6D	7	2	7D	6	3				M − 00	●	●	↕	↕	R	R
	TSTA													4D	2	1	A − 00	●	●	↕	↕	R	R
	TSTB													5D	2	1	B − 00	●	●	↕	↕	R	R

Hardware wait is implemented by causing the microprocessor chip to enter into *idling state*, during which all the microprocessor activities are suspended without turning off the clock. As in the case of the software wait, the hardware wait may be implemented either before or after the print operation — see Fig. 6.

We shall refer to the idling state as a *wait state*. The microprocessor may remain in a wait state indefinitely. The wait state is entered by pulling a specified pin on an m.p.u. high or low.

Examples. Pulling pin 23 low puts the Intel 8080 in the wait state, and pulling it high brings it out of the wait state — see Fig. 3 in article 1.

In the case of the Motorola 6800 the wait state is entered at the end of the current instruction by pulling pin 2 low. Pulling pin 2 high brings it out of the wait state. The Intel 8085 uses pin 35 in the same way as pin 23 is used in the case of the Intel 8080.

Reference

1. "M6800 Microprocessor System Design Data," Motorola 1976.

Design and implementation of test-and-skip systems will be the subject of the next article.

INDEX REGISTER AND STACK POINTER OPERATIONS	MNEMONIC	IMMED OP	IMMED ~	IMMED #	DIRECT OP	DIRECT ~	DIRECT #	INDEX OP	INDEX ~	INDEX #	EXTND OP	EXTND ~	EXTND #	INHER OP	INHER ~	INHER #	BOOLEAN/ARITHMETIC OPERATION	5 H	4 I	3 N	2 Z	1 V	0 C
Compare Index Reg	CPX	8C	3	3	9C	4	2	AC	6	2	BC	5	3				$(X_H/X_L) - (M/M+1)$	•	•	(7)	↕	(8)	•
Decrement Index Reg	DEX													09	4	1	$X - 1 \to X$	•	•	•	↕	•	•
Decrement Stack Pntr	DES													34	4	1	$SP - 1 \to SP$	•	•	•	•	•	•
Increment Index Reg	INX													08	4	1	$X + 1 \to X$	•	•	•	↕	•	•
Increment Stack Pntr	INS													31	4	1	$SP + 1 \to SP$	•	•	•	•	•	•
Load Index Reg	LDX	CE	3	3	DE	4	2	EE	6	2	FE	5	3				$M \to X_H, (M+1) \to X_L$	•	•	(9)	↕	R	•
Load Stack Pntr	LDS	8E	3	3	9E	4	2	AE	6	2	BE	5	3				$M \to SP_H, (M+1) \to SP_L$	•	•	(9)	↕	R	•
Store Index Reg	STX				DF	5	2	EF	7	2	FF	6	3				$X_H \to M, X_L \to (M+1)$	•	•	(9)	↕	R	•
Store Stack Pntr	STS				9F	5	2	AF	7	2	BF	6	3				$SP_H \to M, SP_L \to (M+1)$	•	•	(9)	↕	R	•
Indx Reg → Stack Pntr	TXS													35	4	1	$X - 1 \to SP$	•	•	•	•	•	•
Stack Pntr → Indx Reg	TSX													30	4	1	$SP + 1 \to X$	•	•	•	•	•	•

JUMP AND BRANCH OPERATIONS	MNEMONIC	RELATIVE OP	RELATIVE ~	RELATIVE #	INDEX OP	INDEX ~	INDEX #	EXTND OP	EXTND ~	EXTND #	INHER OP	INHER ~	INHER #	BRANCH TEST	5 H	4 I	3 N	2 Z	1 V	0 C
Branch Always	BRA	20	4	2										None	•	•	•	•	•	•
Branch If Carry Clear	BCC	24	4	2										C = 0	•	•	•	•	•	•
Branch If Carry Set	BCS	25	4	2										C = 1	•	•	•	•	•	•
Branch If = Zero	BEQ	27	4	2										Z = 1	•	•	•	•	•	•
Branch If ≥ Zero	BGE	2C	4	2										$N \oplus V = 0$	•	•	•	•	•	•
Branch If > Zero	BGT	2E	4	2										$Z + (N \oplus V) = 0$	•	•	•	•	•	•
Branch If Higher	BHI	22	4	2										$C + Z = 0$	•	•	•	•	•	•
Branch If ≤ Zero	BLE	2F	4	2										$Z + (N \oplus V) = 1$	•	•	•	•	•	•
Branch If Lower Or Same	BLS	23	4	2										$C + Z = 1$	•	•	•	•	•	•
Branch If < Zero	BLT	2D	4	2										$N \oplus V = 1$	•	•	•	•	•	•
Branch If Minus	BMI	2B	4	2										N = 1	•	•	•	•	•	•
Branch If Not Equal Zero	BNE	26	4	2										Z = 0	•	•	•	•	•	•
Branch If Overflow Clear	BVC	28	4	2										V = 0	•	•	•	•	•	•
Branch If Overflow Set	BVS	29	4	2										V = 1	•	•	•	•	•	•
Branch If Plus	BPL	2A	4	2										N = 0	•	•	•	•	•	•
Branch To Subroutine	BSR	8D	8	2										See Special Operations	•	•	•	•	•	•
Jump	JMP				6E	4	2	7E	3	3				See Special Operations	•	•	•	•	•	•
Jump To Subroutine	JSR				AD	8	2	BD	9	3				See Special Operations	•	•	•	•	•	•
No Operation	NOP										01	2	1	Advances Prog. Cntr. Only	•	•	•	•	•	•
Return From Interrupt	RTI										3B	10	1		— (10) —					
Return From Subroutine	RTS										39	5	1	See special Operations	•	•	•	•	•	•
Software Interrupt	SWI										3F	12	1	See special Operations	•	S	•	•	•	•
Wait for Interrupt	WAI										3E	9	1	See special Operations	•	(11)	•	•	•	•

CONDITIONS CODE REGISTER OPERATIONS	MNEMONIC	INHER OP	INHER ~	INHER #	BOOLEAN OPERATION	5 H	4 I	3 N	2 Z	1 V	0 C
Clear Carry	CLC	0C	2	1	0 → C	•	•	•	•	•	R
Clear Interrupt Mask	CLI	0E	2	1	0 → I	•	R	•	•	•	•
Clear Overflow	CLV	0A	2	1	0 → V	•	•	•	•	R	•
Set Carry	SEC	0D	2	1	1 → C	•	•	•	•	•	S
Set Interrupt Mask	SEI	0F	2	1	1 → I	•	S	•	•	•	•
Set Overflow	SEV	0B	2	1	1 → V	•	•	•	•	S	•
Acmltr A → CCR	TAP	06	2	1	A → CCR	— (12) —					
CCR → Acmltr A	TPA	07	2	1	CCR → A	•	•	•	•	•	•

CONDITION CODE REGISTER NOTES:

(Bit set if test is true and cleared otherwise)

(1) (Bit V) Test: Result = 10000000?
(2) (Bit C) Test: Result = 00000000?
(3) (Bit C) Test: Decimal value of most significant BCD Character greater than nine? (Not cleared if previously set.)
(4) (Bit V) Test: Operand = 10000000 prior to execution?
(5) (Bit V) Test: Operand = 01111111 prior to execution?
(6) (Bit V) Test: Set equal to result of N ⊕ C after shift has occurred.
(7) (Bit N) Test: Sign bit of most significant (MS) byte of result = 1?
(8) (Bit V) Test: 2's complement overflow from subtraction of LS bytes?
(9) (Bit N) Test: Result less than zero? (Bit 15 = 1)
(10) (All) Load Condition Code Register from Stack. (See Special Operations)
(11) (Bit I) Set when interrupt occurs. If previously set, a Non-Maskable Interrupt is required to exit the wait state.
(12) (ALL) Set according to the contents of Accumulator A.

LEGEND:

OP	Operation Code (Hexadecimal);	00	Byte = Zero;
~	Number of MPU Cycles;	H	Half-carry from bit 3;
#	Number of Program Bytes;	I	Interrupt mask
+	Arithmetic Plus;	N	Negative (sign bit)
–	Arithmetic Minus;	Z	Zero (byte)
•	Boolean AND;	V	Overflow, 2's complement
M_{SP}	Contents of memory location pointed to be Stack Pointer;	C	Carry from bit 7
+	Boolean Inclusive OR;	R	Reset Always
⊕	Boolean Exclusive OR;	S	Set Always
$\overline{M}$	Complement of M;	↕	Test and set if true, cleared otherwise
→	Transfer Into;	•	Not Affected
0	Bit = Zero;	CCR	Condition Code Register
		LS	Least Significant
		MS	Most Significant

Table above is continuation of the Appendix.

Development of a satellite terminal

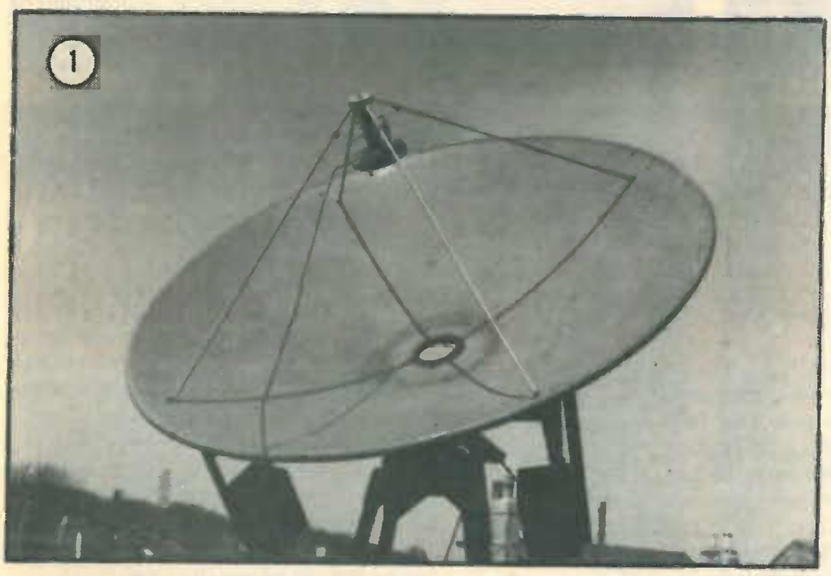
Experimental system for tv reception

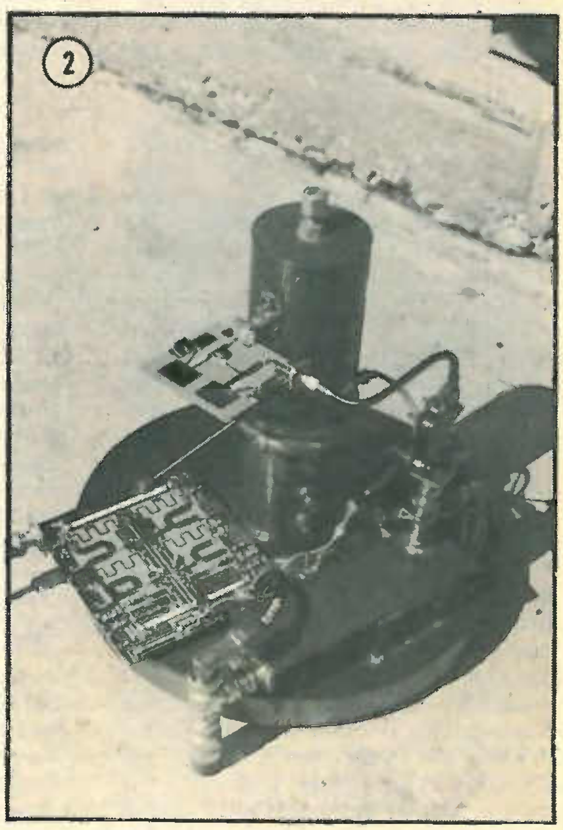
by S. J. Birkill

Development of the author's satellite terminal started in 1975 with the introduction of instructional tv broadcasting to villages in India. The results of his original experiments were published in March 1976. This article describes how the terminal has been modified to receive microwave transmissions, and shows a selection of the author's more recent results.

During 1975 NASA's ATS-6 began a one-year SITE experiment of instructional tv broadcasting to village communities in India. As the transmissions were at 860MHz in the familiar u.h.f. broadcast band, the signals did not need specialized reception techniques, but just a suitable antenna, low noise amplifier and tv receiver equipped with a wideband f.m. demodulator. The SITE broadcasts ended in August 1976, and ATS-6 was manoeuvred westward to a new geostationary location over the Pacific Ocean, out of sight of the UK, for further experiments with US terminals. Since I had been inspired by the ATS results, I was now eager to receive more satellite tv broadcasts. The USSR had a system known as Orbita which used Molniya satellites in 63° inclined orbits, but information was sparse. The Molniya-1 series used frequencies around 1000MHz, and the locus of possible apogees (Molniyas were activated for a six-hour period around apogee, when their orbital characteristics made them appear almost stationary in the northern sky) arced northwards to east and west of a point almost overhead. Signals were received, but they carried f.s.k. data at a low bit-rate. It appeared that the Orbita tv service had been transferred to the Molniya-2 and -3 series, with downlinks in the 4GHz band. At around this time there was news of Russian tv broadcasting tests from one of their first geostationary satellites, Skran, or Statsionar-T. The e.i.r.p. was quoted as 56.5dBW at 714MHz, but the satellite's longitude of 99°E put it well below the eastern horizon.

It became clear that the best results would be achieved in the microwave part of the spectrum and that 3.7 to





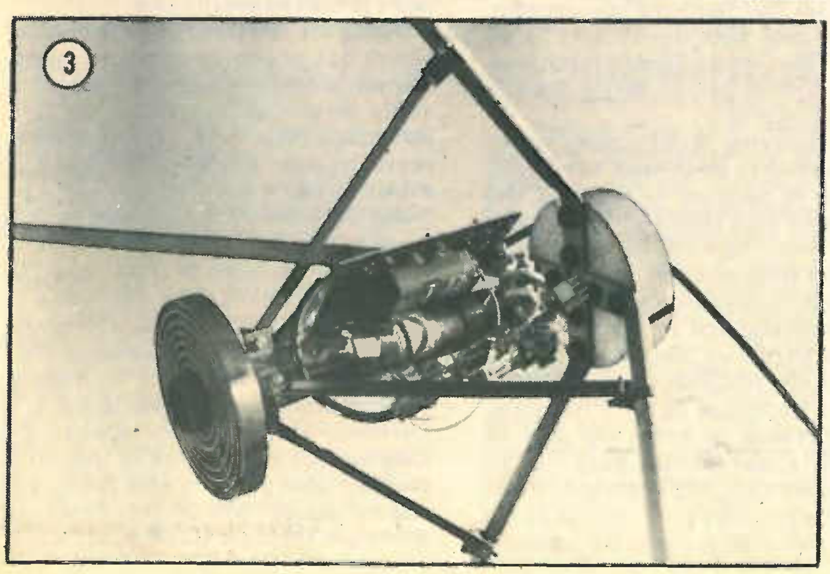


Fig. 1. Sheffield terminal's 8ft dish antenna with 4GHz feed in position. Fig. 2. 4GHz head unit. The GaAs f.e.t. stage is mounted near the top. Fig. 3. 11-12GHz feed system mounted at the prime focus point.



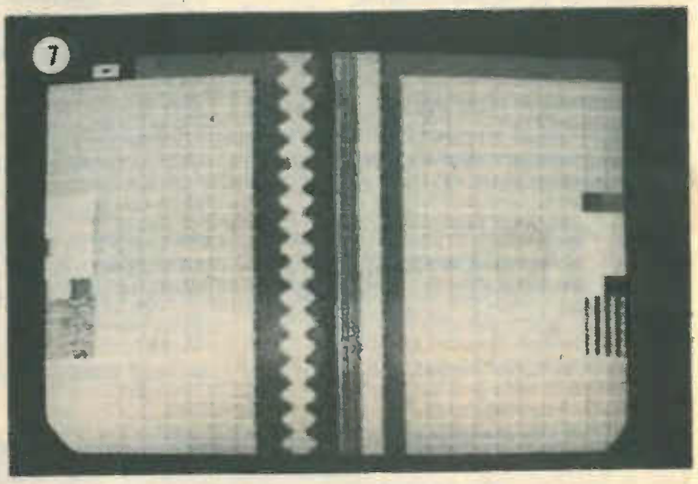



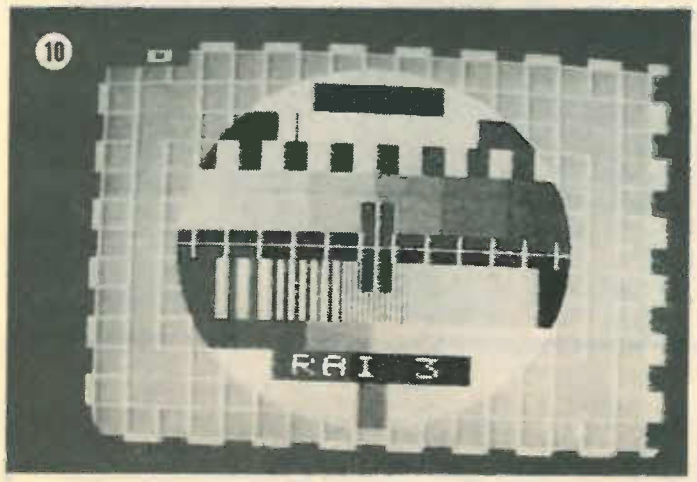
Fig. 4. India's instructional tv experiment received in 1975 from ATS-6 at 860MHz. Carrier/noise density is about 70dB(Hz). Fig. 5. RTVE, received 1977. Relay to Canary Islands via Intelsat half-transponder, hemispheric beam. Frequency 3916MHz, e.i.r.p. 20-25 dBW, c/n density 65dB(Hz). Fig. 6. Sudan, received 1978. Internal distribution via leased half-transponder. Global beam, e.i.r.p. about 20dBW, c/n density 65dB(Hz). Fig. 7. Molniya-3 satellite serving Orbita system with Soviet Central tv. Orbita uses an analogue width-modulated audio pulse in line blanking, and 7.5MHz subcarrier audio. First pulse carries 1kHz tone, second pulse unmodulated. Frequency 3875MHz, e.i.r.p. about 29dBW, c/n density 75dB(Hz).

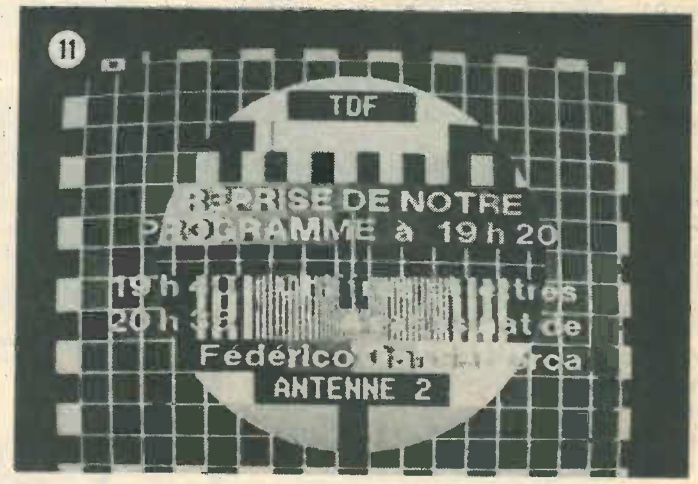
4.2GHz should be explored. The 5ft mesh dish used for ATS-6 was discarded, and I obtained a surplus 8ft solid-surface paraboloid, originally used for terrestrial radio links in the 7GHz region. To resolve pictures from the signals available on 4GHz, an overall system noise temperature of better than 400°K was required. The dish was fitted with a circular polarisation antenna feed, made from a piece of 2in. copper pipe, carrying the downconverter, a low-noise amplifier constructed from two HXTR-6101 devices on a microstrip, and 25dB of wideband u.h.f. i.f. amplification. The amplifier was included so that signals could be carried 50ft to the house without significant breakthrough of local u.h.f. tv broadcast stations. The second converter was installed in the house together with the remainder of the receiver. A modified Varicap u.h.f. tv tuner was used, as for ATS-6, but with facilities for re-inserting syncs., phase-locked to the output of an independently-tuned narrow-band sync. pulse demodulator.

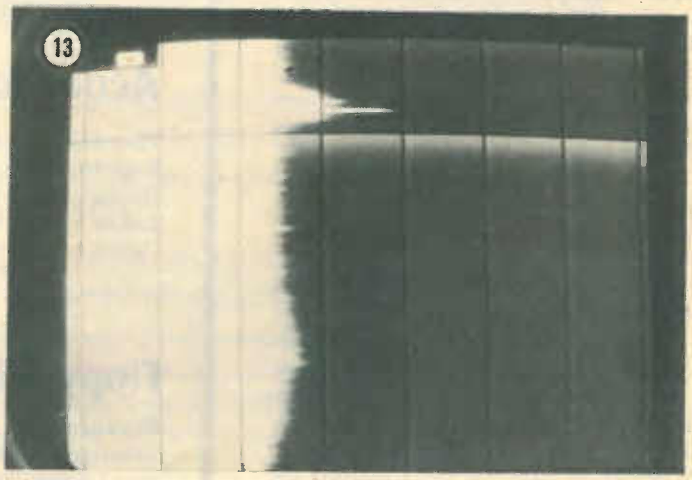
The receiver was aimed at the sun and aligned for maximum solar noise. A figure of 5.5dB above clear sky was achieved on the first day which, with an assumed value for solar noise flux of 8 $\times 10^{-21}$ W/m²/Hz, translated to a G/T of 12.6dB/°K. This gave a predicted overall receiver noise figure of about 3.5dB, which was later confirmed by comparing ground noise with sky noise. When the antenna beam was lowered onto the geostationary orbit arc, my efforts were rewarded by the appearance of RTVE's (Spain) first chain programme via the leased half-transponder 6 of the new Intelsat-IVA (F2) at 29.5°W. This Canary Islands relay is at present carried on the Major Path 1 Intelsat at 34.5°W.

Since receiving RTVE, many other 4GHz satellite tv downlinks have been observed. In addition to carrying the world news and sports events, many nations lease capacity on the Itelsat system for their own use, such as internal tv distribution from studio centres to transmitters, and tv relay to their overseas territories. Because Intelsat's constitution precludes broadcasting activities, reception of their transmissions by private terminals can only be made for experimental purposes to prove equipment performance. However, a rather different situation exists in the USA where a private terminal boom is taking place. Home use of the common carrier traffic on domestic communications satellites is permitted, provided the programme supplier's permission is obtained. For about 3000$ a person can purchase the principal elements of a 10ft satellite terminal, and have access to around 36 full-time tv channels without the video and colour distortions which occur on long distance terrestrial distribution.

During the last three years the Soviet Union has begun to establish Inter-Sputnik, a rival system to Intelsat, with 4GHz downlink satellites in geostationary orbit over the three main ocean regions. To date, two types of satellite have been launched. The Raduga (Rainbow) class, which carry a single tv channel and appear to be similar to the Molniya-3 type, and the Gorizont (Horizon) class with 5 or 6 tv channels in the 3650 to 4000 MHz range. Their orbital stations are assigned Statsionar numbers so the 14°W Atlantic slot for instance, called Statsionar-4, is currently occupied by spacecraft Gorizont-2. Two channels on this satellite use higher power or spot beams and radiate almost 10dB (in this direction) above the standard USSR 4GHz e.i.r.p.







of about 29dBW. Statsionar-4 is the most powerful satellite at this frequency, and can be received even with an indoor antenna.

As the accompanying photographs show, results have been improved since the early tests, due partly to the use of a Plessey gallium arsenide f.e.t., type GAT 5, which reduced the 4GHz system noise temperature to 185°K, a 3dB improvement in sensitivity.

Results have been further improved by the addition of another GaAs f.e.t. stage, a HFET-2202 device from Hewlett Packard. This half-micron gate length f.e.t has a noise figure only slightly above 1dB, and should produce a receiver noise temperature close to 100°K.

Fig. 8. Intersputnik. Coverage of non-aligned nations summit in Havana, received September 1979, Statsionar-4, channel 5, 3875 MHz, e.i.r.p. about 29dBW, c/n density 75dB(Hz).

Fig. 9. Soviet tv received November 1979. News and information programme "Vremya". Statsionar-4, channel 1, 3675 MHz, e.i.r.p. about 37dBW, c/n density 83dB(Hz), SECAM colour.

Fig. 10. Italian tv via USSR satellite, received 1980. RAI feed via Eurovision Brussels, converted to SECAM in Moscow and transmitted to Intersputnik over Statsionar-4, channel 5 at around 29dBW e.i.r.p. Frequency 3875 MHz, c/n density about 78dB(Hz).

Fig. 11. French tv on 11.64 GHz received February 1979. TDF-2 via OTS, e.i.r.p. about 45dBW, c/n density about 85dB(Hz).

Fig. 12. Via Sirio received January 1980. Italian tv on 11.525 GHz, e.i.r.p. estimated at 28dBW, c/n density about 65dB(Hz).

Fig. 13. Video display switched to spectrum analyzer mode to show a portion of the 3.7-4.2GHz band while receiving a tv transmission from a Molniya (Lightning) spacecraft on 3895 MHz. Level increases from left to right, graticule lines are at 10dB intervals. Frequency increases from top to bottom, cursor line is set to 3915MHz. Carrier plus noise/noise ratio of this transmission was 15dB in the analyzer's noise bandwidth.

With the launch of the European Space Agency's OTS satellite in May 1978, I decided to explore a new satellite tv frequency band of 11-12GHz. The sub-bands in this region were destined to ease the congestion experienced by international and domestic systems in the 4GHz band, and provide the new regional (ECS) system for Europe as well as the allocations already made at WARC-77 for satellite tv broadcast downlinks. A new head unit was built around the feed horn, which was made capable of handling either linear (plane) or circular polarisation. The downconverter comprises a single unbalanced diode mixer in stripline, with a Gunn device in a coaxial cavity as the local oscillator. To improve performance, GaAs f.e.t. stages in microstrip construction were subsequently added. Mid-band noise temperature of the 11-12GHz system is around 400°K and, with an antenna gain of around 47dBi, this gives a G/T of 21dB/°K (clear sky) compared with the 4dB/°K being assumed for future direct-broadcast home terminals in this band. The same u.h.f. tunable i.f. is used as for 4GHz, which enables a 500MHz portion of the 11-12GHz band to be tuned for any setting of the Gunn source. High quality pictures have been received from OTS on the wide-deviation 120MHz wide spot-beam channels and on the standard-deviation 40MHz "Euro-beam" transponders. Television from various European broadcasters has been seen via OTS, often with the audio carried in digital "sound-in-syncs." form. However, the transmission schedule is a mystery, with long periods devoted to colour bars.

The Italian experimental satellite Sirio, also on 11-12GHz, has provided tv signals but, with an e.i.r.p. of only 28.5dBW compared with 37 to 45dBW for OTS, pictures are rather noisy as shown in Fig. 12.

The carrier/noise density figures in the captions are more meaningful than a carrier-to-noise ratio because the f.m. demodulator is a variable-bandwidth p.l.l. which can be narrowed at low c/n densities to optimise the trade-off between noise and video distortion over the picture portion of the video modulated signals. So, for a strong signal with a c/n density of 84dB(Hz), the noise bandwidth can be 25MHz and the signal may still exceed the f.m. threshold of about 10dB c/n ratio. But, with a signal of only 65dB(Hz) c/n density, reducing the bandwidth to 1MHz would only recover a 5dB c/n ratio. Therefore, bandwidth must be set to achieve the greatest possible c/n ratio over most of the deviation occupied by the l.f. luminance components of the pre-emphasised signal, perhaps 4MHz, which results in a picture similar to Fig. 12. The receiver can be switched to a 70dB logarithmic spectrum analyzer display, which is very useful when aligning to a satellite or looking for new signals. Fig. 13 shows part of the 4GHz band between 3.85 and 4.20GHz while a Russian Molniya satellite was being received. The level reads from left to right and frequency from top to bottom of the screen.

Later this year the first Intelsat V should be launched for operation over the Atlantic with 4 and 11GHz downlink transponders. The first Soviet "Loutch" 11-12GHz spacecraft is also anticipated. Both satellites will have high e.i.r.ps to allow for periods of high attenuation, caused by atmospheric water vapour in the downlink path, and should be easy to receive in clear weather. Within three or four years Europe may have direct tv broadcasting satellites, and the development of comparatively low-cost terminals for home use will take place.

Plessey and Mullard (Philips) are already working on monolithic low-noise downconverters on gallium arsenide chips. The Japanese already have 12GHz home terminals for the market following extensive tests with the Japanese "Broadcasting Satellite for Experimental Purposes". It is anticipated that the European broadcasting satellites will operate with an e.i.r.p. 15 or 20dB higher than OTS. This should allow reception at the Sheffield terminal, even though their beams will not be directed at the UK.

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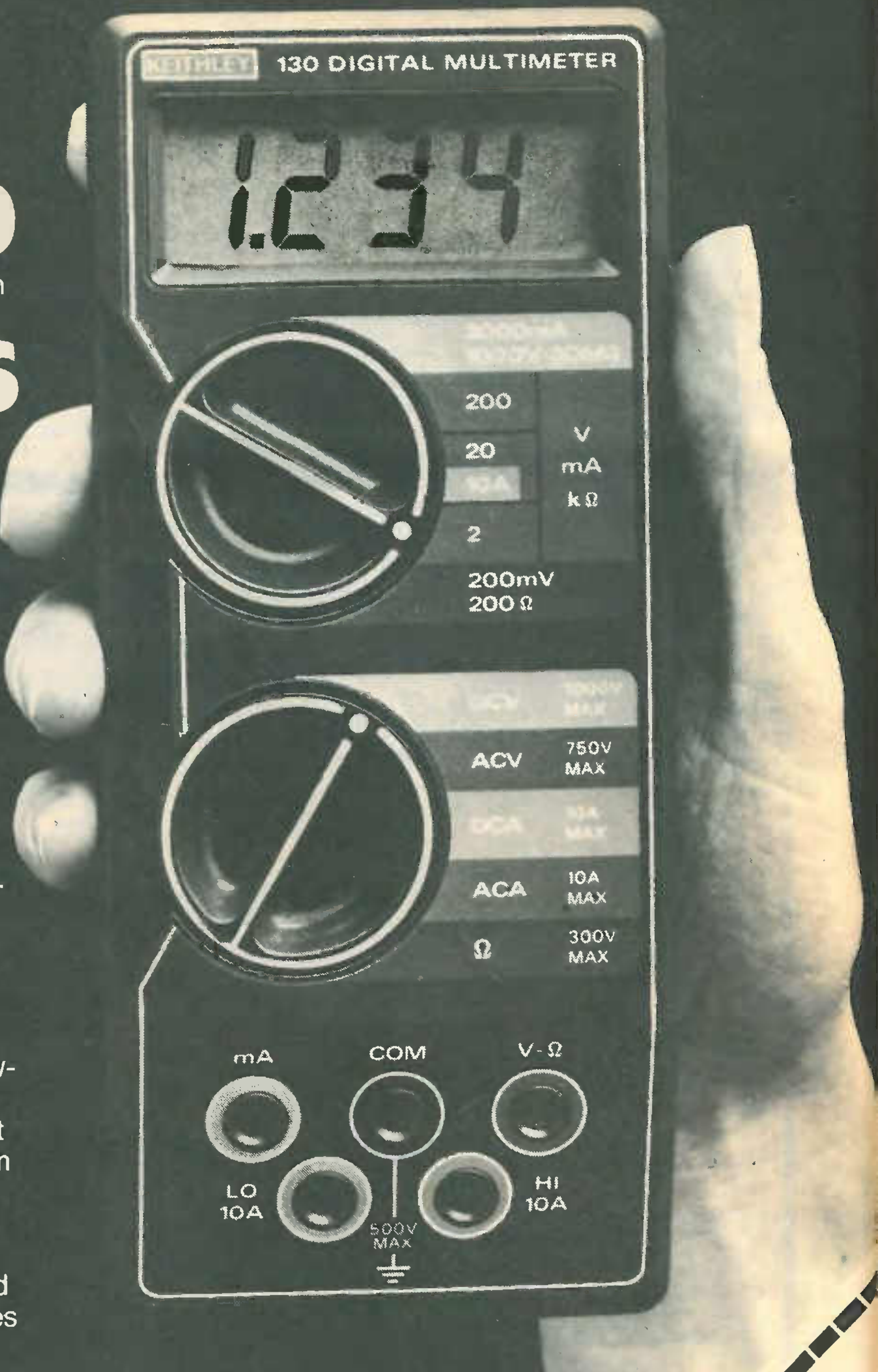

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Graphical communication with microcomputers — 2

Character generation and graphics

by I. H. Witten, M.A., M.Sc., Ph.D., M.I.E.E. Department of Electrical Engineering Science, University of Essex

Dr Witten continues his article on interacting with a microcomputer. This final part goes on with the discussion of raster-scanned displays, finishing with a look at the light-pen and tablet method of input.

Cell-organized displays. To make a display system easily manageable by the programs that generate the pictures, it is necessary to impose a structure on them that allows the raw picture data to be compressed and stored. For example, we saw earlier how line-generating hardware in a point-plotting display processor permits a whole line to be specified by its two end points. The natural structure to impose on a raster-scanned display is a pattern of rectangular cells. Figure 15 shows a 256 × 256 bit-per-point screen, organized as a 32 × 32 array of cells, each one being 8 × 8 dots. There are 64 bits in each cell, so 2^{64} possible patterns can occupy one cell alone. However, most of these patterns are unlikely to be used in a simple picture. Suppose we sacrifice flexibility for convenience and low cost by defining a small repertoire — say 256 — of patterns which may occupy each cell. Then to hold the complete set of patterns we need 256 × 8 × 8 bits — 2 Kbytes, and now a particular pattern can be indicated by an 8-bit pattern number. Since there are 32 × 32 cells on the screen, only 1024 of these numbers, or 1 Kbyte, are needed to hold the screen contents.

This certainly saves some storage. Previously, 8 Kbytes were needed to hold the screen contents on a bit-per-point basis. Now only 1 Kbyte specifies the screen contents, together with 2 Kbytes for the pattern dictionary. The price paid is heavy, though: only a tiny fraction of possible pictures can be displayed. (You may care to verify that the fraction is $1/2^{224}$, which is small indeed!) But the real advantage is one of convenience: now the computer need only wrestle with a 32 × 32 array of cells instead of a 256 × 256 array of dots. Since its storage and bus structure is in terms of bytes and not bits anyway, it is actually easier to handle cell pattern numbers than individual dots. (Recall the difficulty of generating straight lines on a bit-per-point display.)

Figure 17 shows the connexion of a memory-mapped, cell-organized dis-

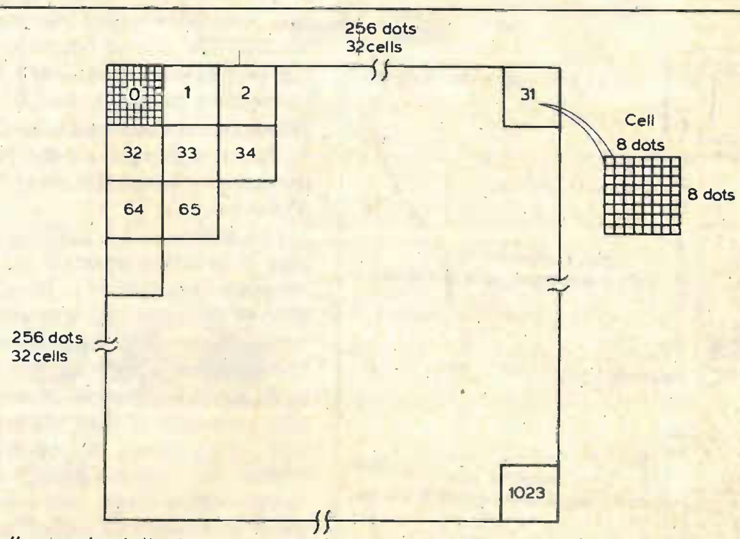

Fig. 15. Cell-organized display with 1024, 8X8 cells.

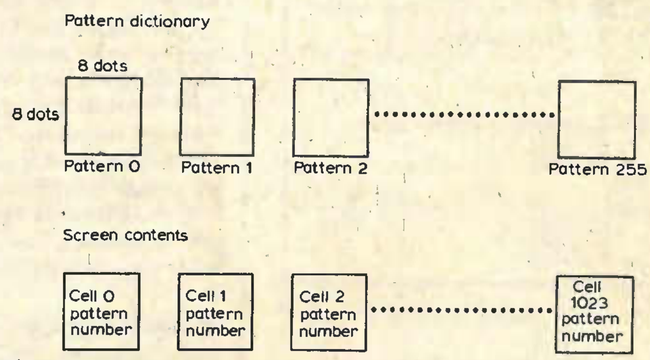

Fig. 16. Pattern dictionary and screen contents for cell-organized display.

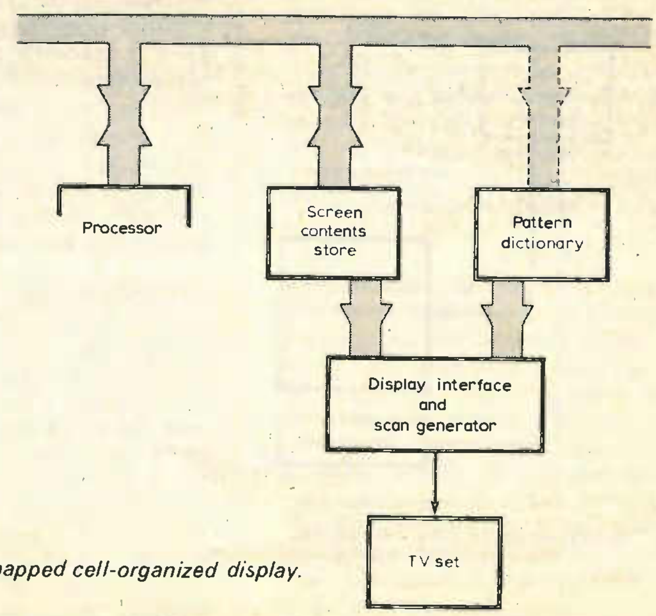

Fig. 17. Memory-mapped cell-organized display.

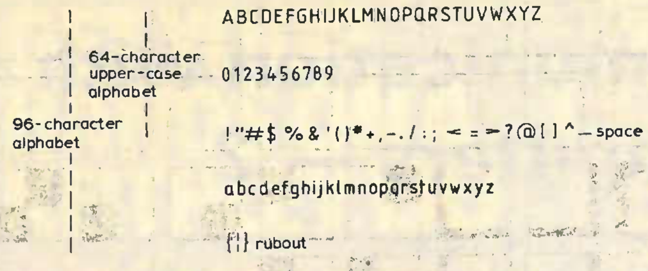

Fig. 18. Standard 64-character and 96-character alphabets.

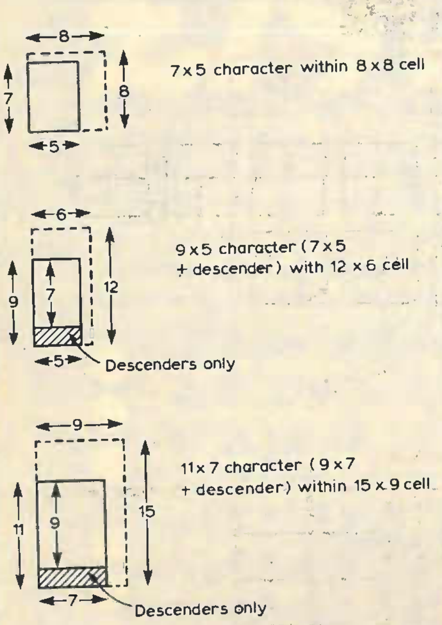

Fig. 19. Common character sizes.

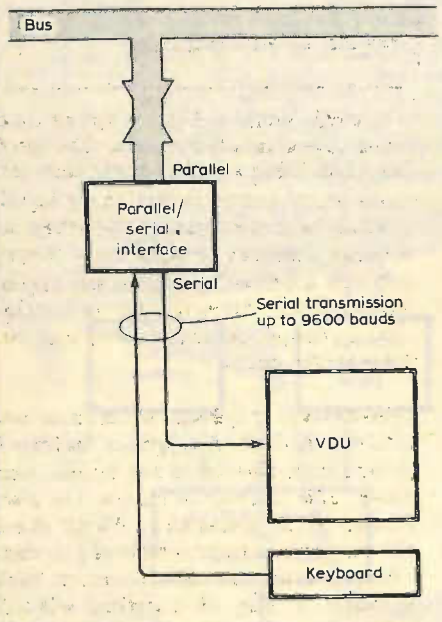

Fig. 20. Connecting a v.d.u. to the bus.

play to the computer bus. As with the bit-per-point system of Fig. 13, the display system is called *memory-mapped* because the screen contents appear to the processor as ordinary store. The connexion between the bus and the pattern dictionary is dashed because it is often not there at all: the patterns are fixed and cannot be changed by the processor.

The success of a cell-organized display in practice depends on the match between the patterns in the cells and the kind of pictures that are drawn on the screen. General cell displays which are intended for line drawings have been built, in which the cell repertoire naturally consists of line segments. However, the number of possible line segments through an 8 × 8 dot cell is unreasonably large, and rotational and axial symmetry is called into play to reduce the dictionary size. Then, the display interface must be able to perform rotation and symmetry transformations, and becomes a display processor which treats the screen contents store more as a program than as a list of pattern numbers. This parallels precisely the development of the display processor for point-plotting displays.

Let us instead examine some rather less ambitious pattern repertoires for cell-organized displays.

Character generation. One obvious use for a cell-organized display is to show text. Cell-organized character displays are called v.d.us (visual display units) — a rather unfortunate term because it gives no indication that only characters can be shown. The screen of Fig. 15 can accommodate 32 lines of 32 characters, each one being on an 8 × 8 grid. Of course, space must be left between neighbouring characters and between successive lines, so the actual character area is normally chosen as 7 × 5 dots.

Character storage. A 7 × 5 dot matrix is quite adequate for upper-case characters, digits, and some special symbols. The standard 64-character upper-case alphabet is shown in Fig. 18, along with the characters that augment it to the standard 96-character upper-and-lower-case alphabet. Although lower-case characters can be written satisfactorily on a 7 × 5 matrix, five of them — g, j, p, q, and y — have tails which should descend below the line if written properly. This needs a 9 × 5 dot matrix, with any one character occupying either the upper or the lower 7 × 5 section; this works because there aren't any characters with both descenders and "risers". Higher-quality text can be obtained with an 11 × 7 matrix, with any given character occupying either the upper or the lower 9 × 7 section. The possibilities are summarized in Fig. 19, where a dotted outline shows the cell containing the character, including inter-character and inter-line space, and the solid line shows the actual size of the characters.

Read-only memory chips with the character patterns already in them are available from a variety of manufacturers. When addressed with the ASCII code of a character, the appropriate dot pattern appears on the output pins. The address of a particular row of dots is usually provided to the character generator and the dots comprising only that row appear at the output. Thus, with 64 characters of 7 × 5 dots each, 9 bits are required to address a particular row of a character and there are 5 output pins giving the dots in that row. This arrangement is especially suited to raster-scan displays, because one line of the raster is generated at a time. In some character generators, the action of "lowering" characters with descenders must be done externally to the chip, the user providing circuitry to detect these five characters and adjust the row address accordingly. The amount of storage required in a character generator is quite small. For our example, we need 512 words of 5 bits to provide the 64-character upper-case alphabet.

A 256 × 256 screen accommodates 32 lines of 32 characters if the character cell is 8 × 8, 21 lines of 42 characters if it is 12 × 6, and only 17 lines of 28 characters if it is 15 × 9. All of these sizes are unrealistically small for text. A normal sheet of typed paper can comfortably hold about 57 lines of 80 characters. To achieve this with a 12 × 6 cell would require a 684 × 480 screen, which is not possible within the British 625-line standard. Many v.d.us compromise with about 24 full-length lines of 80 characters, requiring a 288 × 480 screen. There is currently a great deal of commercial interest in high-quality v.d.us, and special high-resolution screens are built for them, but they don't have the advantage of the mass tv market to bring down the price. However, it is worth noting that a 1125-line high-resolution tv system is under development in Japan, which should accommodate up to 75 lines of high-quality text, with a 11 × 7 character size (15 × 9 cell).

The v.d.u. V.d.us are not, in general, memory-mapped. It is far more convenient for the computer user to regard his text as a linear string, sending it one character at a time to the display device. Usually it is transmitted in serial form by a parallel-to-serial converter attached to the bus, as shown in Fig. 20. The v.d.u. must provide store for the screen contents, but this only needs one byte per character displayed — say 2 Kbytes for 24 lines by 80 characters. In fact, local storage is sometimes provided for a good deal more than this, so that the v.d.u. can retain several screenfuls of text and you can look back to see what was presented a few moments ago.

The v.d.u. itself has to decide what to do when the screen fills up. A scrolling feature is almost universally provided, where the entire screen contents move up as necessary. Continual rapid jumping of the text is irritating and tiring for the reader, and so several lines are scrolled at a time. Smooth scrolling, where the contents move up a dot at a time rather than jumping whole lines is unfortunately rather rare at present, although it does not cause any particular technical problems. Other features which are often provided are blinking of the text on a selected area of screen, reverse video (black text on a white background), half-intensity or double-intensity display, and underlining of parts of the text. These options are switched on and off by control characters (ASCII codes 0000000-0011111) and sent down the line as part of the text, which can unfortunately alter all subsequent characters if a text character is corrupted by noise into a control character!

One really useful feature is the ability to move the current position for text to any point on the screen, so that characters in the middle of the text can be overwritten. A mark called the "cursor" is usually made on the screen at the current writing position, and any input typed on the keyboard appears at the cursor position (which is moved along with each successive character). Then, a questionnaire can be displayed and the cursor moved to the places where the user enters his answers, constraining him to write in the space provided. Cursor control is again dictated by a special character which signals the v.d.u. to interpret the *next* character as the cursor position. Notice that this reinstates the flexibility of a memory-mapped display where a character can be placed at any position on the screen.

Most v.d.us operate at speeds up to 9600 baud. Unlike printers, no extra effort is needed to make a v.d.u. go fast. 9600 baud allows a full screen of 24 × 80 characters to be sent in 2 seconds, which is certainly a high reading rate! However, people often *scan* text much faster than this — how quickly do you read a newspaper? Present v.d.u. technology leaves plenty of room for improvement.

Limited graphics

Pressure to provide limited graphics facilities based on inexpensive raster-scanned displays has come from two directions: home computers and the teletext and viewdata information services. The character-generating read-only memories of most home computers contain an assortment of graphic symbols to draw primitive pictures. Figure 21, for example, shows the 64 symbols of PET, a typical low-priced domestic computer. In order that graphic symbols can abut to form pictures, the inter-word and inter-character spaces are stored explicitly in the character generator and not provided by external hardware as in most v.d.us. PET uses an 8 × 8 cell. The standard 64-character upper-case alphabet of Fig. 18 is provided, together with the 64 graphic symbols or the lower-case letters — software can select which of these latter groups is used. Some of the graphics reflect the game-playing orientation of PET; but the lack of coherent structure of the others makes constructing pictures or charts a rather tedious task. There is no standardization of graphics alphabets in the home computer industry.

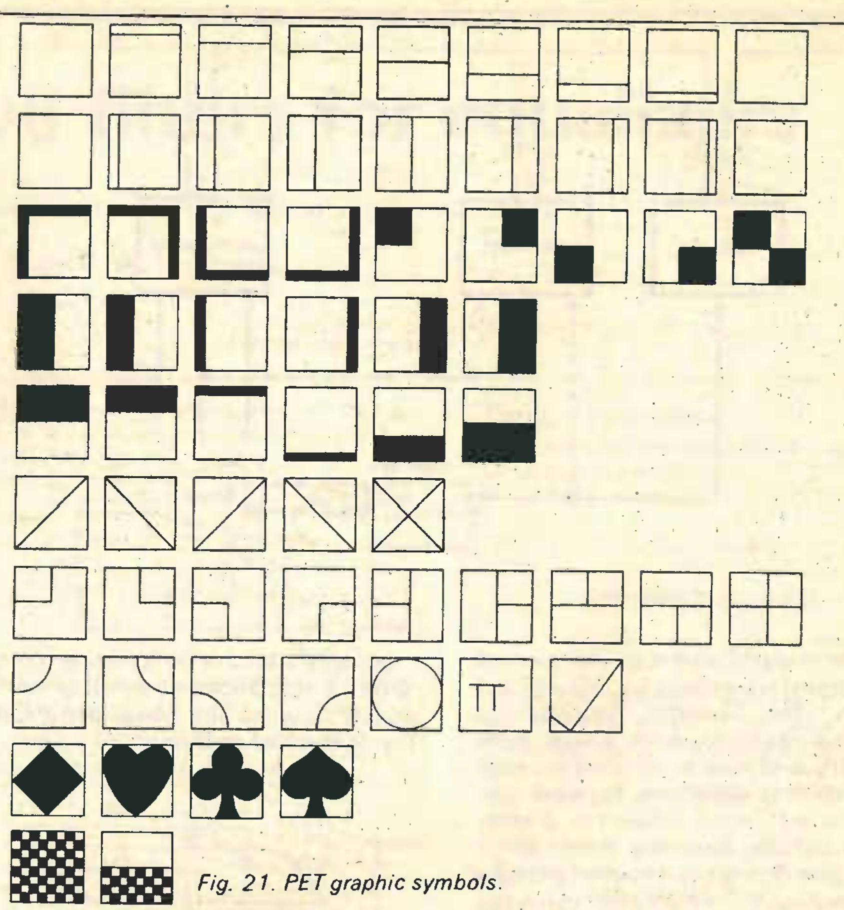

Fig. 21. PET graphic symbols.

Teletext. The teletext scheme for broadcast information defines a graphics standard, and it is possible that this might spread to the microcomputer industry. It uses 64 codes in a systematic way to provide a refinement of its basic 24 × 40 character grid. Each cell is split into the six regions shown in Fig. 22, and a 6-bit word specifies any combination of white and black ones. Thus, an effective 72 × 80 grid is available for graphics, and the picture of Fig. 6 gives an example of the resolution obtained. The teletext cell is not square but has 10 × 8 dots, with a 9 × 5 upper-and-lower-case character matrix. The problem of dividing a cell 10 rows high into three equal portions for the graphic symbols is a continuing challenge for teletext receiver designers! Teletext also has a defined protocol for coping with colour displays by inserting colour-change control characters into the text stream.

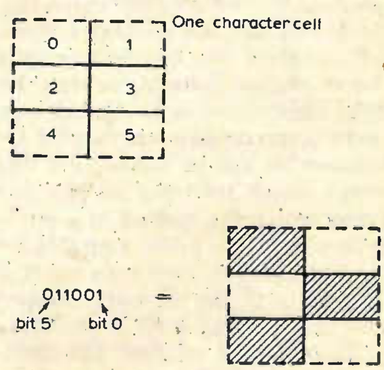

Fig. 22. Teletext graphics.

User-defined graphics. An unusual and interesting limited graphics facility is provided in the Sorcerer home computer. 256 character codes are used instead of the usual 64 or 96. Of these, 128 correspond to pre-defined patterns, which include the 96-character basic alphabet of Fig. 18 together with 32 extra graphics. For the others, the character-generating memory can be altered by the processor, so that the user can define his own graphic symbols. Since the character matrix is 8 × 8, 8 bytes serve to define one character,

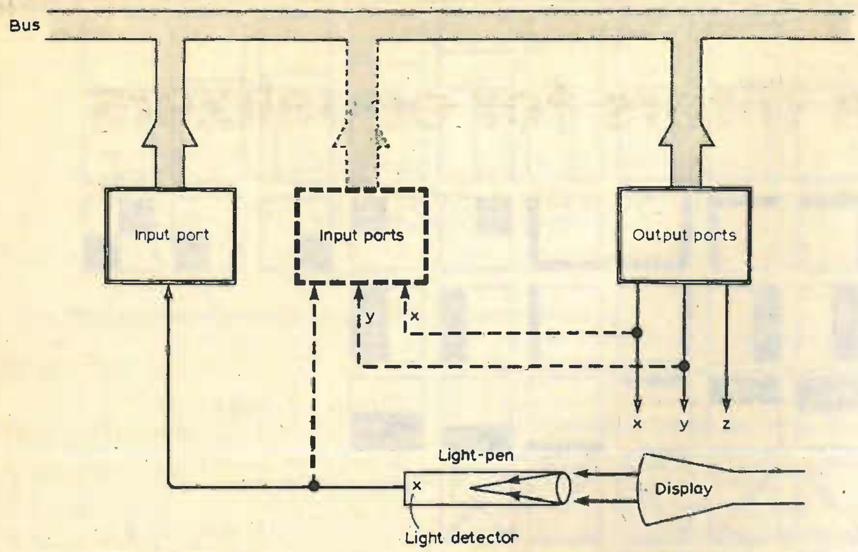

Fig. 23. Operation of a light-pen.

and the read-only and writeable parts of the character generator are each 1 Kbyte. The circuitry required to generate characters from a read/write memory is a little more complex than for read-only memories, because contention will occur when the display reads and the processor writes simultaneously. But the extra power provided is enormous, for the Sorcerer can simulate both PET and the teletext system, as well as others. For example, graphs can be displayed quite accurately by defining eight patterns each with one dot in the centre, at different heights. Or a character set can be defined for line drawings which includes all the line segments which are needed in a particular picture. Or a Cyrillic alphabet for text in Russian. This combines much of the flexibility of the memory-mapped bit-per-point display with a structure that can show text sensibly and simulate systems like PET and teletext.

The light-pen and tablet

Turning now to graphical input, a light-pen is a device that detects whether or not there is a spot of light on the screen at the place it is pointing. It can also signal the exact time the light appears. Recall that the picture is refreshed every 40 msec or so, so that if the pen points at a spot which is brightened up a signal will appear during every refresh cycle. The interrupt mechanism is ideally suited to advising the processor at the time a hit occurs.

The time-of-hit information provided naturally by a light-pen can easily be converted into the position of the hit by adding the hardware shown by dashed lines in Fig. 23. The x and y signals from the output port are routed back to an input port – in practice, this will be before they converted from digital to analogue form – and loaded into two registers there whenever a hit occurs. Then the processor can examine these registers at leisure to ascertain the position of the last hit.

But which kind of information, time-of-hit or coordinates-of-point, is more useful? Suppose the house picture of Fig. 24 is stored as 28 lines:

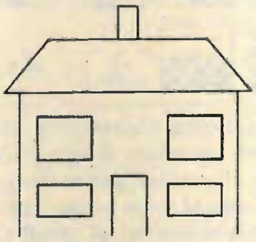

Fig. 24. A house. Timing or coordinates?

and line-generating hardware drives the display. Then, although the x,y coordinates of a hit can in theory be used to determine which line was being drawn, the precise time when it occurred leads to the information much more easily because the processor only needs to examine its last request to the line-generator. In general, the *state of the display processor* at the time of the hit will provide most information about what was actually being drawn at the time, not the coordinates of the hit.

Tracking a light-pen. A light-pen only registers a hit if the spot it is pointing at is actually brightened up during the refresh cycle. If you point it at a blank part of the screen the processor cannot tell where it is. A "tracking cross" is often drawn as part of the picture; this follows the pen around in an attempt to provide light for it to see. For the cross of Fig. 25, if a hit occurs on line 1 the cross should move up, for line 2 it should move to the left, and so on. The processor detects the hits and moves the cross as necessary. If the centre of the cross coincides with part of the picture, then a hit is registered whenever that component of the picture is refreshed, and so the processor can tell what part is being indicated.

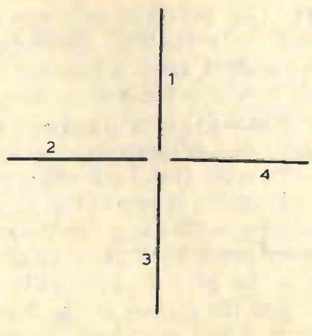

Fig. 25. Tracking cross.

Touch-tablet. Figure 26 illustrates another kind of graphical input device which is entirely independent of any display and provides the coordinates of the pen position.

Current is injected into a uniform resistive sheet through the pen tip, and is measured at one side of the tablet while the other is earthed. The resistive sheet acts as a potential divider, and the ratio of the output to the input current gives one coordinate. Then the connexions are changed so that the other coordinate can be measured.

A particularly interesting feature of the tablet is that a finger can act as the pen, using high-frequency alternating current and capacitive coupling with the sheet instead of d.c. with direct coupling. Effectively, you sit on an electric chair and inject current with your finger. Then, no pen is needed and if the sheet is made transparent and fitted on to a display screen, you can indicate parts of the picture just by pointing at them with a finger.

Fig. 26. An x,y tablet.

This device provides coordinate information and not time-of-hit. However, it can easily be made into time-of-hit by comparing the x,y coordinates from the tablet with those being sent to the display. When they coincide (to within a specified tolerance), a bit interrupt is caused.

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Simple active filters for equalizers

Design examples using simulated inductors

by D. W. Protheroe, B.Sc.

Simple design rules allow construction of filters having any desired value of centre frequency, Q and gain, using simulated inductors. Examples illustrate provision of a symmetrical bandpass to band-stop characteristic, varied with a single control.

The majority of designs published as octave or graphic equalizers feature a number of independently controllable filters allowing boost or cut of specific frequencies within the audio band. These designs fall into two main categories.

- RC bandpass/bandstop filters. A typical system may have a number of active filters either enclosed in a negative feedback loop, Fig. 1 and refs 1, 9, 10, or having their outputs fed to a differential amplifier, Fig. 2 and ref. 8. Problems arise from both these configurations. In Fig.1 noise generated within the active filters is coupled into the output amplifier, the signal-to-noise ratio decreasing as the number of filter sections is increased. This problem is avoided in Fig. 2, but the component values must be carefully calculated to give a symmetrical cut/boost characteristic. Many designs have been published giving only bandpass (presence) or bandstop (notch) characteristics.[2]
- Series LCR filters. This arrangement, Fig. 3, suffers from the disadvantages normally associated with discrete inductors, i.e. size, cost, distortion, refs 2, 3, 4. The present design overcomes this by synthesizing[5] the necessary inductors, using the circuit of Fig. 4.

To duplicate the impedance versus frequency characteristic of an inductor, the input impedance of the circuit must be of the form $R+j\omega L$, and it can be seen in the Appendix that the circuit has an input impedance of $R_1+R_2+j\omega CR_1R_2$. Although many other methoids of simulating inductance have been published (e.g. search under Gyrators), they have suffered from greater complexity or lower performance, often both.

Now add a series capacitor, C_x, to Fig. 4 to give a series LCR circuit, Fig. 5, which may be used in the circuit of Fig. 3 to realise the same function, though the parameters of the inductor are now easily controlled.

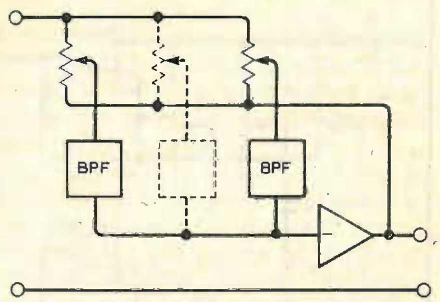

Fig. 1. With active filter enclosed in feedback loop, s/n ratio decreases as number of sections increases.

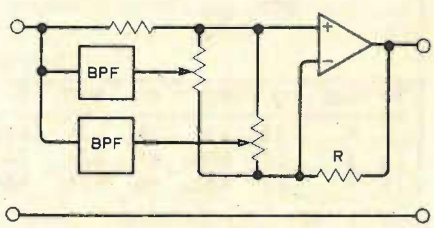

Fig. 2. Alternative circuit using differential amplifier avoids noise problem but component values as critical.

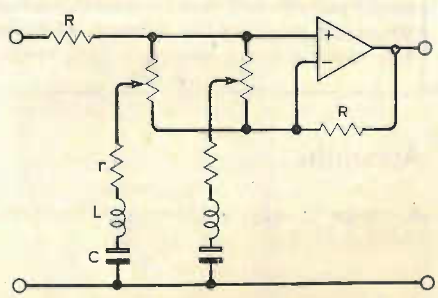

Fig. 3. Simple LCR network introduced symmetrically into forward or feedback paths by potentiometers.

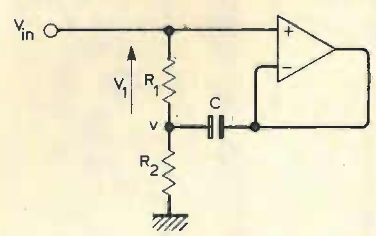

Fig. 4. Two-terminal RC network simulates inductance, value $L=CR_1R_2$.

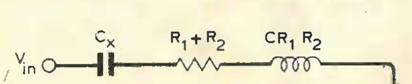

Fig. 5. Series capacitor C_x tunes simulated inductance for use in Fig. 3.

Design procedure

Making use of the standard formulae for series toned circuits:

$$f_o = \frac{1}{2\pi\sqrt{C_xL}}$$

$$\text{and } Q = \frac{1}{r}\sqrt{\frac{L}{C_x}}$$

where the symbols have their usual significance, and r is the equivalent series resistance. Eliminate L thus

$$L = C_xr^2Q^2$$

$$\text{and} \quad C_x = \frac{1}{(2\pi f_0)^2 L}$$

$$\therefore C_x = \frac{1}{2\pi f_0 rQ}$$

$$\text{Also,} \quad L = C_xr^2Q^2 = CR_1R_2$$

$$\therefore C = \frac{C_xr^2Q^2}{R_1R_2}$$

Fig. 3 shows that maximum or minimum gain at f_0 is

$$20\log\left(\frac{R+r}{r}\right)\text{dB}$$

Armed with these equations, filter design becomes a matter of setting the design parameters, taking account of any required component values, and calculating the remaining component values.

Fig. 6 shows an example of a 50Hz notch filter, depth of null variable, Q=50 (say). Synthesized inductance has a value of ~1400H. To enable frequency to be trimmed to off-set the effect of component tolerances, R_1 and R_2 incorporate a potentiometer. Thus f_0 and the notch depth are independently variable.

The value of the potentiometer used as the cut/boost control is non-critical, varying only the control law. The buffer amplifier used in Fig. 4 can be an emitter follower, a Darlington follower, or a 741 follower depending on the load to be driven (the values of C, R_1, R_2) and the performance required. Signal-to-noise ratio and distortion level for the system depend mainly on the differential

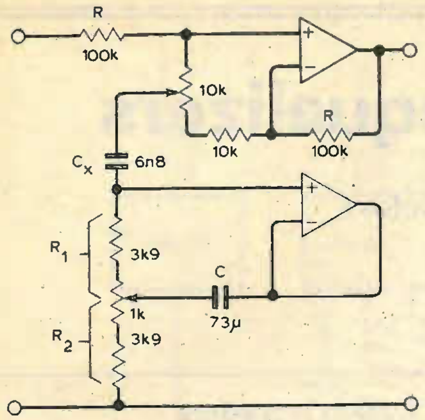

Fig. 6. 50Hz notch filter can be trimmed with lower potentiometer. 10k resistor modifies characteristic to attenuation only.

amplifier used; for most purposes the 741 is sufficient, though increased performance may be achieved with a more specialized amplifier.[6, 7]

Practical applications of this circuit have varied (in frequency) from l.f. variable filters for electrophysiological research, to a five-section tone control for audio systems. Although developed for use at audio and sub-audio frequencies, high frequency operation is dependent only upon the characteristics of the amplifiers used. However, as the frequency of operation is increased, the value and size of a discrete inductor soon reach manageable proportions.

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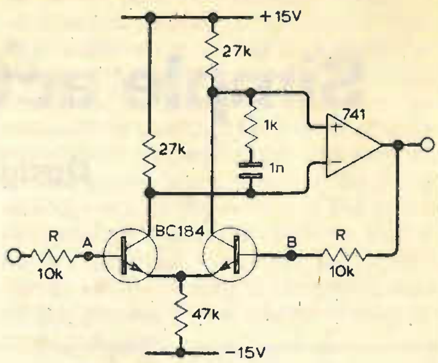
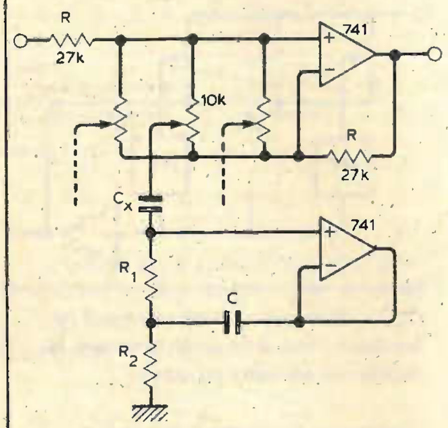
Dave Protheroe was an electronics technician in the psychology department of the City of London Polytechnic, where he constructed prototypes of this filter. Since then he has graduated in electrical engineering and is now lecturing in electronics at Thames Polytechnic. Researching into digital systems design, recent work has centred around applications of digital devices, especially the hardware and software design of a Z80-based microcomputer system.

Practical designs

8-14Hz three-section filter

Application: vibration analysis, electromedical recording. Design criteria: constant bandwidth, control range ±20dB. Values of R_1, R, R_2 were chosen to give the required control range. Q value was then calculated from $Q=f_0$/bandwidth. The underlined equations give the required capacitor values, and the last equation gave the value of R.

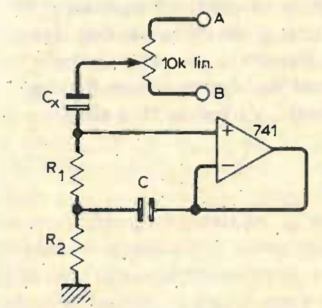




f	BW	Q	C_x	C	R_1,R_2	R
8	3	2.7	1.3μ	40μ	2.7k	27k
11	3	3.7	0.68μ	40μ	2.7k	27k
14	3	4.7	0.47μ	40μ	2.7k	27k

50Hz-2.8kHz five-section equalizer

Application: supplement to audio tone controls. Constant-Q characteristic is required to keep tonal effect of filters constant over the frequency range. In the interests of higher s/n ratio a more complex differential amplifier was used.[7] To avoid slew-rate limiting at high frequencies use faster op-amps e.g. 748, 741S, 531. Control range: ±12dB, consistent with commercial units. Component values chosen as above.



f	Q	C_x	C	R_1,R_2	R
50	1	1μ	4.2μ	1.5k	10k
200	1	0.27μ	1μ	1.5k	10k
800	1	68n	0.27μ	1.5k	10k
3.2k	1	16.8n	68n	1.5k	10k
12.8k	1	4n	16.8n	1.5k	10k

Appendix

A voltage V_{in} is applied to the input terminal of Fig. 4. Then

$$V_1 = V_{in} - v$$

where $v = V_{in}\left(\dfrac{R_2}{R_2 + \dfrac{R_1}{1 + j\omega CR_1}}\right)$

$$\therefore\ V_1 = V_{in}\left(1 - \frac{R_2}{R_2 + \dfrac{R_1}{1 + j\omega CR_1}}\right)$$

Thus

$$i = \frac{V_1}{R_1} = V_{in}\left(1 - \frac{R_1}{R_2 + \dfrac{R_1}{1 + j\omega CR_1}}\right)$$

where i is the current flowing into the input terminal.

$$i = \frac{V_{in}}{R_1}\left(1 - \frac{R_2(1 + j\omega CR_1)}{R_2(1 + j\omega CR_1) + R_1}\right)$$

$$\text{or } i = \frac{V_{in}}{R_1}\left(1 - \frac{R_2 + j\omega CR_1R_2}{R_1 + R_2 + j\omega CR_1R_2}\right)$$

$$z = \frac{V_{in}}{i} = \frac{R_1}{1 - \dfrac{R_2 + j\omega CR_1R_2}{R_1 + R_2 + j\omega CR_1R_2}}$$

$$= \frac{R_1(R_1 + R_2 + j\omega CR_1R_2)}{R_1 + R_2 + j\omega CR_1R_2 - R_2 - j\omega CR_1R_2}$$

i.e. $z = R_1 + R_2 + j\omega CR_1R_2$.

This is of the form required and assumes the amplifier has a gain of unity, a high input impedance, and a low output impedance – conditions easily satisfied. □

American letter

from George Tillett in Chicago

Attendance at the Chicago Summer CES was about 55,000, some 15% less than last year — although the advance bookings were at a record high. The reason, of course, had to do with the uncertain economic situation, but the growing popularity of the January Las Vegas Show might have had an effect too. If there is a recession, some of the exhibitors seemed unaware of it, judging from the number of high-priced luxury items on show. Infinity had a $20,000 loudspeaker system and Lux were showing a $3,000 turntable, while there were several phono cartridges costing over $250. One was priced at $550 and a precision tonearm could be had for a mere $1300! If you are tired of ordinary tv, you can spend anything between $16,500 and $30,000 for a dish antenna so you can watch satellite transmissions.

Video

As at the last Show, video discs were again a centre of attraction and the Pioneer and Magnavox demonstrations were always crowded. Both these models use a laser system, but RCA were showing off their Selectavision player, which uses a stylus pick-up, at a hotel nearby. RCA state that recent modifications include random access and that the price will still be lower than its competitors. Since they have an agreement with CBS they also have access to a wider range of programme material. V.c.rs are fast gaining in popularity and several new six-hour models were to be seen. In the long-playing mode, there is inevitably a loss in definition — particularly with models with reduced track width. The ordinary track width in VHS machines is 58 microns, but when the same heads are used to scan the 19.3 micron width employed in the six-hour mode, the tracks overlap, causing picture degradation, since adjacent tracks are out-of-phase. Now, JVC have come up with a simple — well, relatively simple — solution: two extra narrow-field heads are switched in for the long playing mode.

Sony's AG-300 features a cassette autochanger, permitting 20 hours of recording time, and the programme unit allows the user to record separate programmes on separate cassettes. Other Sony models use Beta-Scan, which lets the user search backwards or forwards at any desired speed up to 20 times normal, with or without a remote control unit. Toshiba has a similar fast scan system, but theirs can flip the tape at 40 times the normal speed.

Sony's latest tv projection uses a ceiling-mounted projector to produce a picture measuring 11½ feet by 5, and a switch allows the size to be changed. Another company, Electron Systems Products, introduced a projection system capable of producing a 20ft picture. It is quite portable, measuring 20 by 28 by 9½ inches, and the extra brightness is achieved by using a liquid-coupled lens with liquid-cooled tubes to increase the light output.

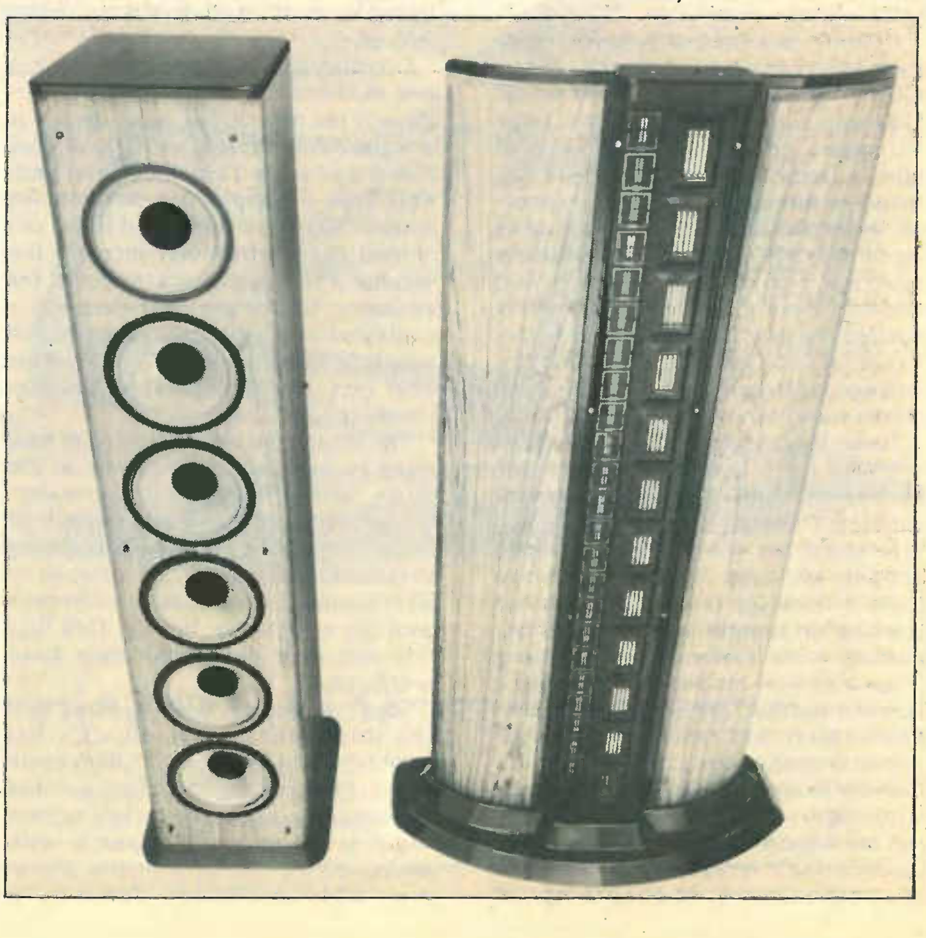
Turning to "ordinary" tv sets, there seems to be a trend towards better audio quality and several models were seen with multi-speakers and separate amplifiers. One model even boasted simulated stereo, using a time-delay circuit.

In spite of the relatively high prices, there appears to be a growing interest in dish antennas to receive satellite transmissions. One company quotes a basic price of $16,500 for a single-channel system, plus $5,000 for each additional channel. The leaflet I picked up also mentions concrete pads: "Try not to think about mounting the antenna on the roof. It weighs 2000 lbs, it is 16 feet in diameter and it makes a great sail." You might ask what programmes are available to justify all this hassle? Well, there are many transmissions intended for cable networks and they carry such intriguing titles as "Showtime", "Galavision", "Calliope" and the "Movie Channel". There is a small licence charge for hotel and apartment users.

Audio

Two or three years ago, receiver makers were committed to a kind of 'power race' to see how many watts they could cram in, but not too many buyers were enthusiastic about the cumbersome 400 watts jobs. So these days the accent is on features such as automatic scanning,

Infinity's Reference Standard.



preset station selection, bar-graphs and so on. Onkyo scooped its competitors with a receiver having a built-in "snap, crackle and pop" remover that works like the SAE and Garrard units, which reverse the phase of the signal before removing narrow-pulse transients. A few genuine Class A amplifiers and receivers were to be seen but there is a definite trend towards a modified Class A circuit where the output stage is biased by the signal. Efficiency is claimed to be comparable with Class B without the switching or crossover problems. Variations are known by several names: Kenwood use the term "Zero Switching" and JVC use the description "Super A", while Fisher prefer "Class-II" and Technics call their arrangement "Synchrobias".

All manufacturers are aware of the problems caused by too much negative feedback and designers have abandoned the use of "brute force" loops of 50 to 60 dB to get some impressive figures. In other words, amplifiers are designed for low distortion before the loop is closed, so that only 15 to 20 dB is necessary. Yet another approach will, I believe, become quite popular — at least for the more expensive models. This is the "feedforward" circuit which involves the use of a separate amplifier to balance out the inherent distortion in the main amplifier. Threshold were the first to use it in their Stasis model, but now Sansui have developed a similar circuit. They introduced the first model at the Show, the AU-DII rated at 120 watts per channel at a distortion less than 0.004%. Frequency response is within +0 and —3 dB from zero to 200 kHz.

Cassette decks now offer better value for money than ever and several models were to be seen priced at well below $160 with metal tape capability, large VU meters, provision for four kinds of tape, a Dolby system and a good all-round performance. The more expensive decks featured such refinements as digital displays, automatic programme selection, end of tape indicators and mic-line mixing. At least 12 models boasted the new Dolby HX (Headroom Extender) circuit while among the dual-speed (3¾ and 1⅞ ips) models were entries from Marantz, BIC, and Fisher.

Turntables are also reasonably priced now and there is quite a selection of direct-drive models under $180. Straight tonearms seem to have almost superseded the old familiar S-shaped designs, although Technics still use them in most of their range. Linear tracking or straight-line arms are becoming more common, and among those seen were models from Technics, Harman-Kardon, Mitsubishi, Yamaha, Phase-Linear and Dennesen. The last named turntable uses a tiny air pump to float the phono cartridge. Lux also have a turntable which employs a pump but this one creates a vacuum to hold down the record so it is really flat. It seems to be an expensive way of doing things, as the price of this model is $3000! Dual were using a special record to demonstrate the virtues of their Ultra Low Mass (ULM) arm and Ortofon phono cartridge. The record carries a 300 Hz signal, but it also has eight uniformly spaced warps. The eight-gram ULM combination plays it with no trouble, but the severe intermodulation produced by a standard 18 gram arm combination could easily be heard.

Once again, the Show was enlivened by a fascinating array of loudspeakers ranging from shoebox models to wardrobe sized behemoths. The most elaborate system was Infinity's new Reference Standard at a cool $20,000. It consists of four modules, 7ft 6 inches high which house two 1.5 kilowatt bass amplifiers as well as the drive units. Each bass column contains six 12 inch drivers and servo feedback is obtained with an accelerometer. Crossover frequency is 70 Hz and the midrange section consists of a vertical stack of 12 planar electromagnetic induction units arranged as a dipole. High frequencies are handled by another stack of 36 planar units. The cabinets are 1 inch thick and some of the sections are sand-filled (remember the Wharfedale baffles?) and the total weight is 1200 lbs. How did it sound? Well, it was unquestionably very, very good and the low frequencies were particularly impressive. After all, a dozen 12 inch speakers can move a lot of air! Although the system is not a true line source, the stereo image was outstanding, but it must be said that the overall gain over a really good pair of $1000 systems is quite small — at least at "normal" listening levels. It's the law of diminishing returns.

Cerwin-Vega were demonstrating a new model, designed to "meet the challenge of the new digital super-discs". It is a three-way system with an 18 inch bass driver and a 12 inch co-axial unit, which has a compression tweeter. An unusual feature of this model is the use of inert gas to effectively increase the volume of the bass compartment of the enclosure. No, the gas can't escape: it is contained in plastic bags. The system stands 52 inches high and it will handle 1000 (yes, one thousand) watts continuous power.

The Ionophone is back again: its new name is "Ionovac" and the one at the Show hailed from West Germany. Crossover point has been moved an octave up to 6 kHz. My old original used to radiate for a considerable distance on all tv bands, which caused some friction with the neighbours, but I'm told that this and other drawbacks have been overcome.

Sony had a large, floor-standing system using four drivers, all with flat diaphragms made from a honeycomb carbon fibre material. The bass speaker diaphragm is about 13 inches square and it is driven by four speech coils, positioned to "ensure a piston movement without flexing". Jumetite, a Canadian manufacturer, were demonstrating the latest version of their system, which uses a horn-loaded ribbon transducer from 600 Hz up — some of the best sound heard at the Show.

The VSC company introduced several low-priced cassette players using a new i.c. with a "bucket-brigade" chip to provide high-speed, intelligible audio playback at speeds up to three times normal. According to the makers, there is a definite interest in the idea from manufacturers of v.c.rs that can operate in the six-hour mode.

Crown introduced the unique PZM microphone at the January Show and again, it was attracting a lot of attention. It uses a new principle of sound detecting, using the pressure zone at an acoustic boundary to eliminate distortion problems common to other microphones — so say the inventors. The active element is a pressure-calibrated electret capsule and it is mounted on a plate measuring 5 × 5 inches. One of the advantages of the PZM is that the frequency response is independent of distance, but the gain in clarity is almost unbelievable. In one demonstration, it was compared with a very expensive German studio microphone in a recording session with a large orchestra. As soon as the PZMs were switched in, the feeling of strain simply vanished. Various models are available and they can be put inside a bass drum or piano, since inputs as high as 150 dB can be handled.

Garrulous gadgets

Talking clocks, calculators and microwave ovens are becoming commonplace and speech quality is improving. One reason is the use of new chips that can synthesize phonemes. It is said there are at least 45 uniquely different sounds needed to phonetically create words in the English language. These, plus 16 other durational alternatives are produced by a new l.s.i. chip made by Votrax. There are also three "pause" phonemes often necessary to separate phrases in continuous speech, so the result is a total of 64 phoneme selections. The duration of each phoneme is fixed, the slowest being 40ms and the fastest 250ms. Pitch variation varies automatically, or it can be controlled by an external "clock". Continuous electronic speech is created by sequencing sounds into recognisable words. For instance, 'phoneme' becomes F-01-N-El-M.

Panasonic were showing a talking calculator which had a female voice with an impeccable British accent — Roedean, if I'm not mistaken. Casio had another which also contained a clock, date memories, a calendar and 12 recorded tunes. The user could program tunes for special occasions such as "Happy Birthday" or "The Wedding March", but one tune could not be changed. The thing plays "Jingle Bells" every Christmas . . . □

Colour tv receiver design

3 — More on the colour decoder; also video outputs, sync processor and timebases

by **R. Wilkinson**, B.Sc.(Hons), M.I.E.E., Decca Radio & Television Ltd

The previous article, in the August issue, ended with an outline of the three-chip colour decoder. The present article continues with further description of this decoder before passing on to other sections of the receiver.

Various sections of the circuit require a number of pulses for the purposes of gating, blanking and clamping. Fig. 10(b) shows the various pulses required and their relative timing and Fig. 10(a) shows how the signals are affected by them.

The "sandcastle" pulse is a convenient way of applying two pulses into one pin of an i.c. Level sensors in the i.c. sort out which width of pulse should go to which section of circuitry.

1. Sandcastle pulse on pin 7 of TDA 2560. The narrow top part of the pulse is used to clamp the luminance signal at black level during the back porch. The actual voltage of this black level is determined by the position of the brightness control. The wider lower part is used to gate the gain-controlled amplifiers which control the saturation and contrast (saturation tracking). During this time (the burst interval) these amplifiers are switched to maximum gain to prevent disturbance to the a.c.c. loop. This pulse must be wide enough to cater for tolerances in broadcast burst position.

2. Sandcastle pulse on pin 15 of TDA 2522. The narrow pulse gates in the burst for use in the subcarrier regenerator section of the i.c. This pulse must be as narrow as possible for optimum noise performance. However, due to the tolerances on broadcast burst position, some degree of adjustment is necessary to the leading edge of this pulse to ensure that all the burst is gated in. If part of the burst is lost, the pull-in range of the subcarrier regenerator a.p.c. loop will be impaired.

The wider part of the pulse is used for blanking the chrominance signal for the whole of the line and field flyback periods. This is needed because the process of gating the gain-controlled amplifiers to maximum gain inevitably produces coloured noise during these periods and this would show on the screen.

3. Luminance blanking. After the narrow part of the pulse 1 has clamped the black level to the voltage set by the customer brightness control, line and field pulses blank the signal during the whole of the line and field flyback periods. Thus these pulses must be derived from the line and field timebases. The luminance signal is blanked to a reinserted level of +1.5V. This luminance signal is then d.c. coupled throughout the remainder of the decoder.

4. Output clamp. A pulse wider than that of the chroma gain switch but narrower than the chroma blanking is required for clamping the colour difference signals before they are added to the luminance signal. The control for each of these clamps is derived from a sample of the video output signal, thus ensuring that the d.c. level of this output signal (and hence the black level on the c.r.t.) is closely controlled within a feedback loop.

The background controls, for presetting the black level of each colour, are also included in this loop.

Video outputs

Video output stages need to drive up to 90V p-p of video at a reasonable bandwidth into a load (the c.r.t. cathode) which has a substantial capacitance. The amplifier obviously needs to present a low output impedance to this load and a simple class A amplifier for this application would dissipate an appreciable number of watts. Consequently, several types of low-dissipation circuit have been developed to overcome this problem. The 70 series chassis uses a class A amplifier with an active load (Fig. 11).

In this circuit the drive is applied to a transistor operating as a high class A amplifier with a high-resistance load thus keeping the dissipation down. As long as this transistor is being turned on (i.e. the signal at its collector is going towards the 0V line) the output impedance is effectively low. However, if the drive to the class A transistor starts to go in a negative direction, trying to turn it off, then the output impedance would effectively be the high resistance collector load. Hence the reason for the second transistor, which acts as an emitter follower for positive going output signals and consequently presents a low output impedance to the c.r.t. cathodes.

To ensure good linearity of the output waveform, feedback is applied over the whole stage, part of which is in the i.c. Here, a sample of the blanking level is also taken and the d.c. level of the output corrected as necessary. The c.r.t. background controls are d.c. potentiometers acting in this part of the circuit.

Sync processor

The purpose of the sync processor or "jungle" i.c. is to select the sync pulses from the video waveform, and use them to phase lock an oscillator running at the same frequency. By careful choice of time constants the phase locking process reduces the effect on the picture of noise and disturbances on the video waveform. The resulting line drive pulses can then be compared in another phase locked loop with flyback pulses derived from the line output stage and the resulting pulses amplified to drive the line output transistor. The sync processor i.c. may also separate out field sync pulses and may produce gating/clamping pulses for the colour decoder.

The TDA2571 used in the 70 series chassis does not contain the second phase-locked loop which compares the line oscillator output with the line flyback pulses. This loop, as we shall see, is contained in the power supply control i.c.

The TDA 2571 contains two major innovations, an adaptive sync separator, and a count-down field sync pulse system. Conventional sync separators are based on the d.c. restoring circuit shown in Fig. 12(a). Tr_1 is biased by R_1 so that it is just on the point of conducting. As each sync pulse comes along it drives Tr_1 hard on, producing the output pulses shown. The time constant $10R_1$ is chosen so that sufficient charge leaks away between pulses to enable each pulse to turn Tr_1 on. This type of circuit is particularly susceptible to noise on the sync pulses and also to "ghosts" or cross-modulation on the received signal. The principle of the adaptive sync separator used in the 70 series chassis is shown in Fig. 12(b).

The video signal is applied to a gain controlled amplifier which amplifies the sync pulse and sets the black level and sync tip level at the two levels shown. A level corrector takes a sample of each of

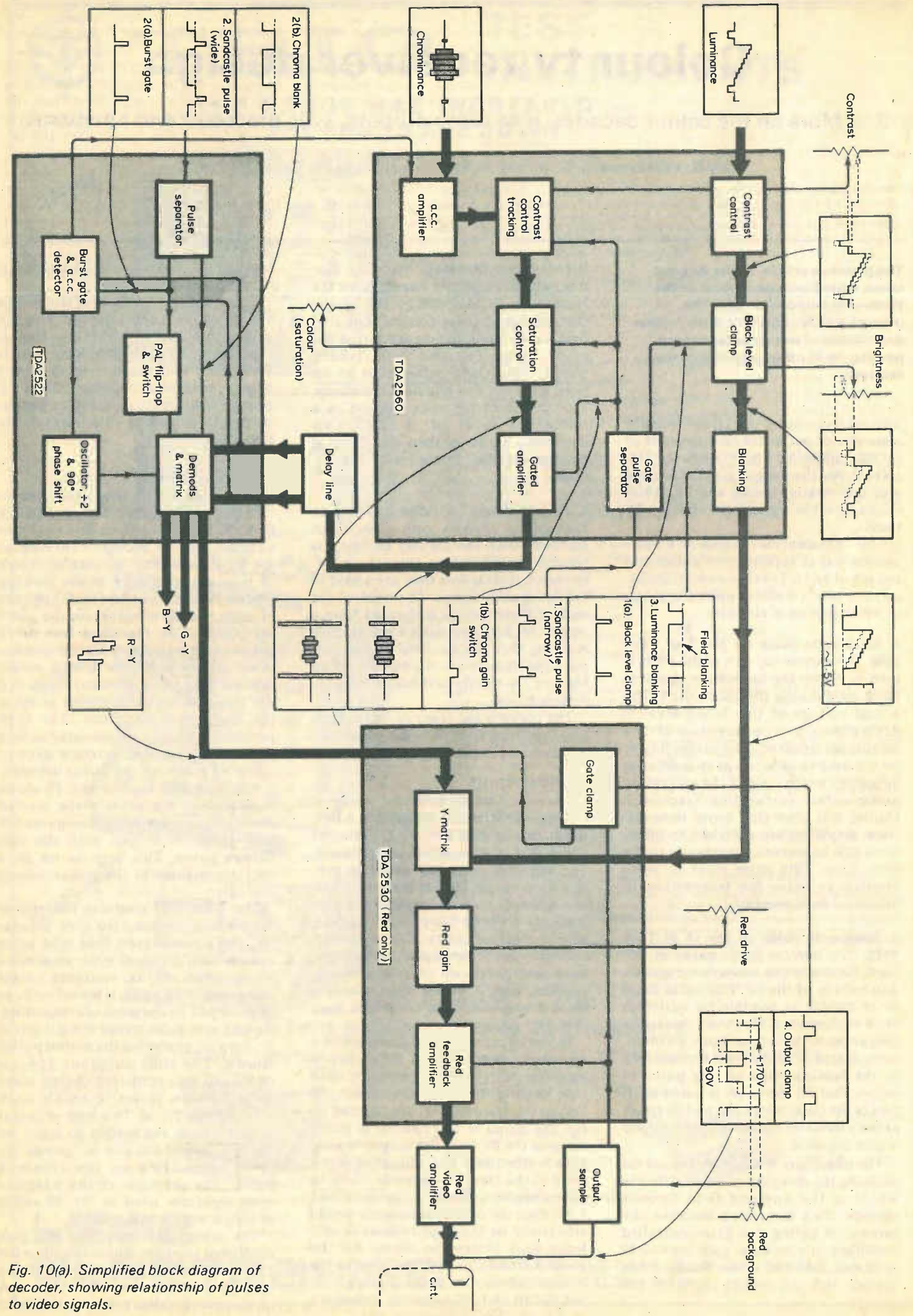


Fig. 10(a). Simplified block diagram of decoder, showing relationship of pulses to video signals.

these levels and corrects the gain of the amplifier as necessary. With the sync pulse having been closely defined, a small slice is taken out of the centre of it and amplified, thus producing a very stable, closely defined sync pulse. This type of circuit has been demonstrated to be markedly superior to the older type of circuit especially under noisy, "ghosty", or cross-modulated signal conditions.

Once the mixed sync pulses have been separated out, a further circuit separates out the field sync pulses. Often simple integration is sufficient, but again poor signals can result in poor or even no field pulses. Obviously the mixed sync pulses from the adaptive type of sync separator give improved field pulses but certain signals can be improved by the use of a field pulse count-down system.

A set of dividers counts down from the line oscillator frequency (in this case 2× line frequency = 31.25kHz) to the field frequency of 50Hz and produce an output pulse at this frequency. A normal integrating sync separator produces a field sync pulse directly from the mixed sync waveform and this is compared with the count-down pulse. If the two are completely in phase for a sequence of complete fields, the counted-down pulse is fed out to the field timebase. If the pulses are not in phase, the integrated pulse is fed out. This procedure guards against incorrect processing of signals which do not have a defined count-down ratio between line and field sync pulses (e.g. some cctv cameras, video games, etc.).

The necessary delay in deciding which pulses to feed out causes a noticeable though not objectionable effect on the picture — on changing sync sources (e.g. changing channels) the picture locks momentarily with the field blanking interval in the centre of the screen before locking normally.

Direct frame sync

It was discovered, early on in the development of the 70 series chassis, that if the cctv camera or video game, or whatever was the non-counted-down source, had a line/field frequency ratio close enough to the true counted-down one, then the i.c. sent out a proper indirect count down pulse. However, a few fields later it would "realise the error of its ways" when the direct pulse had drifted out of phase with the indirect pulse. It then momentarily supplied the direct field sync pulse while it "considered" the situation. Eventually for a few fields, the unlocked source would appear to have a locked line/field relationship and so the i.c. would revert to supplying the counted down pulse. This sequence would repeat itself ad infinitum and the picture would exhibit an irritating slow vertical jitter. For this reason a small sub-panel was fitted to the 70 series main panel to supply direct

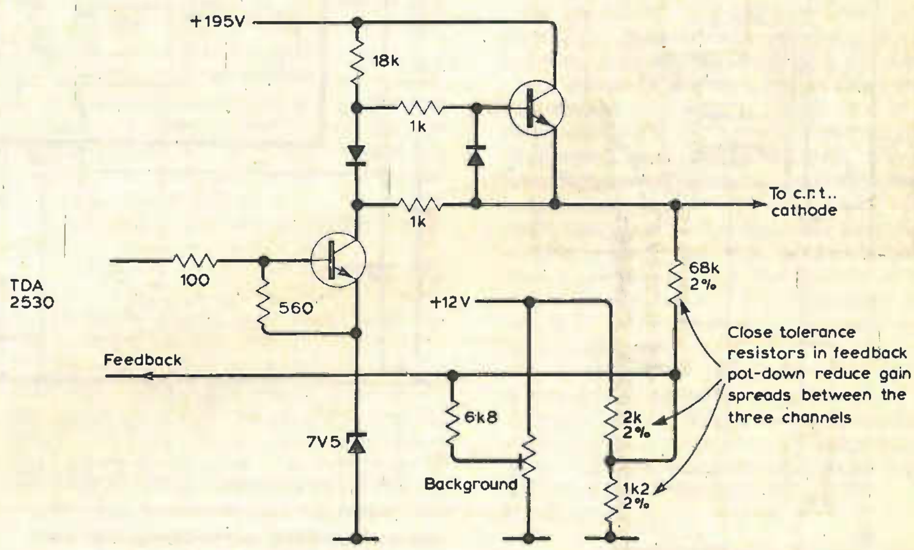


Fig. 11. Video output amplifier (simplified).

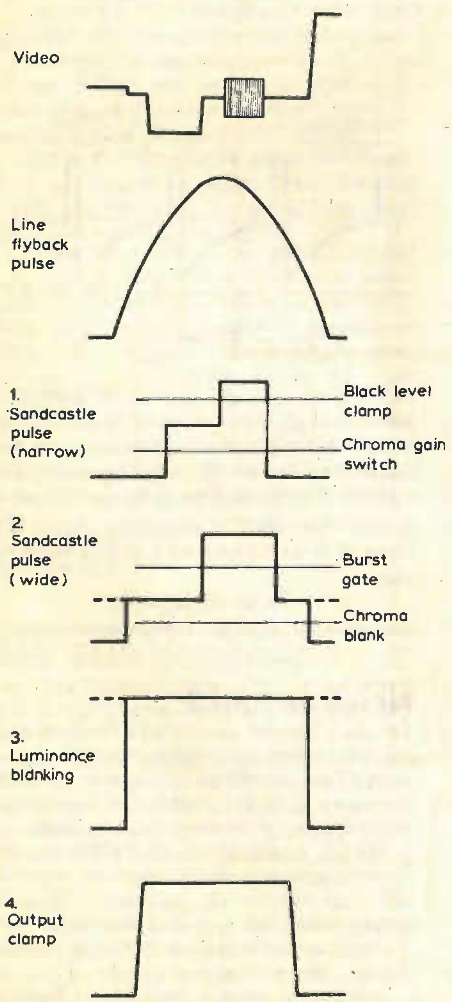


Fig. 10(b). Details of waveforms in decoder (Fig. 10(a)).

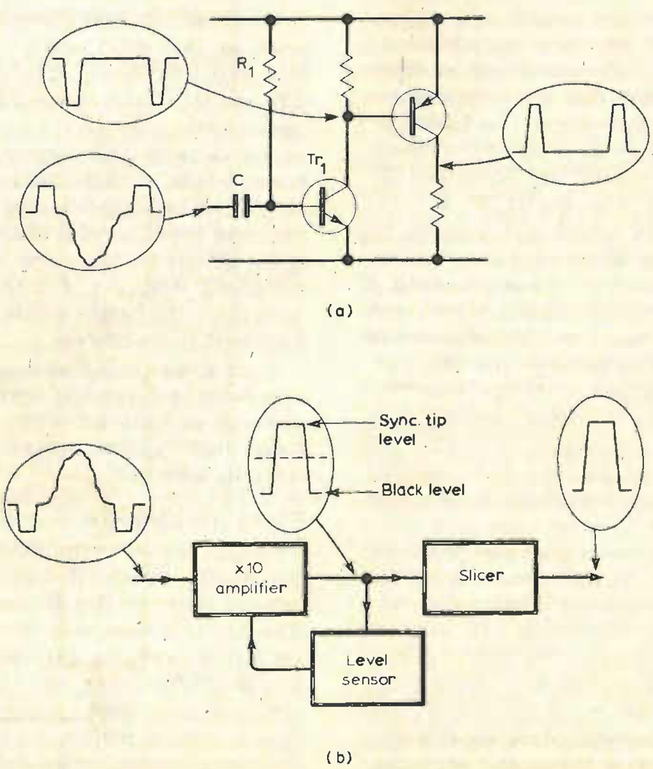


Fig. 12. (a) Conventional sync separator. (b) adaptive sync separator.

field sync when required. The customer channel-select switches are arranged to switch in this feature in conjunction with the a.v. time constant switching for v.c.rs etc.

Line timebase

The requirements of the main output of the power supply are largely governed by those of the line output stage. The least losses (and hence lowest dissipation and highest reliability) occur with low current, high voltage line output devices. The transformer is also simpler in this configuration, acting just as a high impedance supply choke as far as the line scan coils are concerned (Fig. 13). Hence the scan coils are switched

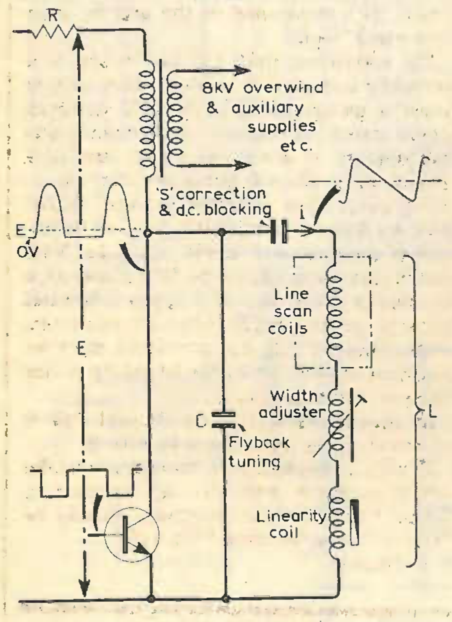


Fig. 13. Simplified diagram of line output stage.

directly across the supply and, consequently, their impedance (which, at 15625Hz, is largely composed of their inductance) and their sensitivity determine the supply voltage. The basic formula used is $E = -L(di/dt)$. The resistor R is required to limit the current in the transistor in the event of a c.r.t. flashover and extra volts must be allowed for the drop across this resistor.

The line output stage is often a secondary power supply itself, the overwind on the t.f. being the source of e.h.t. and focus voltage for the c.r.t. Sometimes tapped windings, scan rectified, are used to produce some supply voltages for the signal circuitry. All these sources add to the current through R and contribute to the volt drop across it.

In the 70 series chassis all the supply lines except one are taken from the s.m.p.s.u. transformer. This avoids any losses due to conversion efficiency in the line output stage. The field timebase h.t. is taken from the line output stage because of the need to "track" the height with the width during c.r.t. beam current variation. When the beam current increases, the supply current

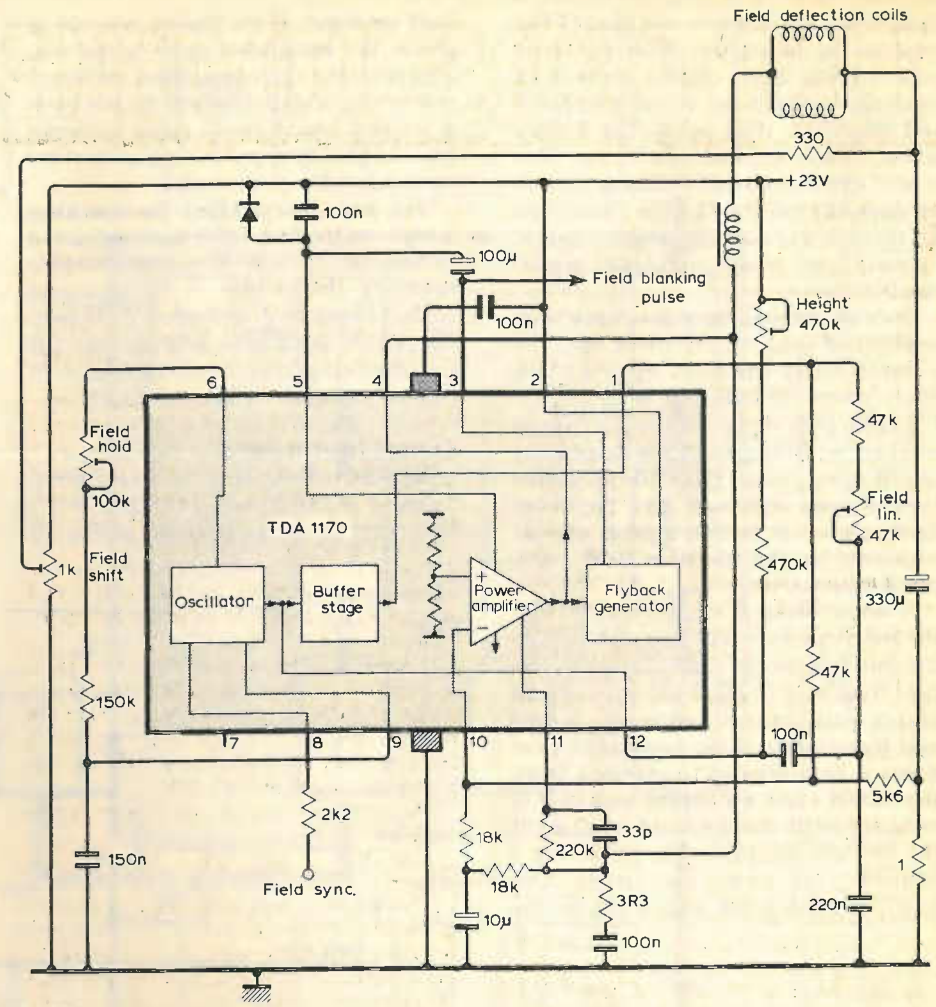


Fig. 14. Block schematic of the TDA1170 field timebase i.c., including oscillator, sawtooth generator and output amplifier.

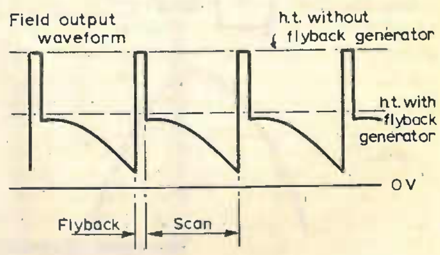
Fig. 15. Field output waveform with and without a flyback generator.

through R increases and so E falls, resulting in a drop in e.h.t. Now both line and field scan sensitivities are affected by variations in e.h.t. and, in general, when the e.h.t. falls the picture on the screen gets bigger. However, when E falls, so does the scan current ($E = -L(di/dt)$ again) and by careful choice of the value of R the "breathing" of the picture width can be reduced to a minimum. However, if nothing further were done, the height would apparently alter with beam current.

Since a scan rectified supply goes up and down in sympathy with E this is a convenient source for the field timebase, enabling the height to "track" with the width.

Field timebase

This uses the well-established TDA1170 which has operated successfully for several years in the 80 series chassis. The i.c. is a complete timebase with oscillator, sawtooth generator and output amplifier (Fig. 14). The output circuit incorporates a flyback generator which helps to reduce power consumption. In some circuits the field flyback is contained within the supply rails and



consequently a good deal of power is wasted (Fig. 15). In the TDA1170 the supply is only sufficient to contain the scan waveform. During flyback, the supply is switched to a value which is double that during scanning. Thus fast flyback is achieved with lower dissipation.

(To be continued)

Notes on Part 2

For space reasons we deleted a few lines from the text under the section "Sound i.f. and output" on page 64 of the August issue. As the author feels the matter is of importance to the design we are printing them here.

The 18V supply for the TDA1190Z is taken from the switched-mode power supply since the large current pulses which the audio output stage takes during bass transients would cause unacceptable picture movement if this supply were scan-derived.

Acknowledgements should have been included to Mullard Ltd for permission to publish Figs 4, 6, 7 and 8. – Ed.

LETTERS TO THE EDITOR

COMMUNITY RADIO

Norman Macleod could have strengthened his arguments about community radio (June/July issue) by reference to the experience of the surprisingly lively pirate broadcast radio in the nation's capital.

1. London has had a community radio station. For about fifteen months until it finally ceased transmitting in the summer of 1979, Radio AMY (Alternative Media for You) attempted a service for the six North London boroughs of Camden, Islington, Haringey, Enfield, Barnet, and Hackney. The rather idealistic collective that ran it had a vision of London divided into five manageable radio constituencies, three north of the river and two south. The six hours of programming included much local news and interviews, even locally produced music and dramatics.

It was the very scope of their ambitions which was their undoing – quite different from the usual deejay shows of the conventional pirate. In the end the collective was too exhausted to carry on – all that work with no possibility of a source of finance. Still, while it lasted and after I had written it up in *Time Out*, there is no doubt it had a substantial following.

2. A number of the spectrum 'holes' referred to in the Fred Wise report are actually used most Sundays by the present generation of pirates. In general, the medium-wave operators start around mid-day and close well before the dusk brings extended propagation and the v.h.f. stations tend to come on in the evening, though one well-established v.h.f. pirate who sometimes uses stereo prefers 12 mid-day to 3 p.m. Readers with the right sort of equipment may like to judge for themselves the extent to which these stations cause interference both within their nominated territory and beyond.

Lest this letter be misunderstood, I am not in favour of unregulated use of the radio spectrum, for all the obvious reasons. But, faced with the poor record of the Home Office Radio Regulatory Department in presenting honest information on the availability of r.f. spectrum space and the politician's lack of vision in restricting broadcast licences to only two bodies, the occasional carefully planned and well engineered demonstration seems entirely admirable.

Lennie Michaels
North London

IEEE BUS STANDARD

Some clarifications are required in the article by P. R. Ellefsen published in your June/July issue.

IEEE-Std. 488 (1978) defines with precision the General Purpose Interface Bus (GPIB), including its electrical and mechanical specifications, and the interface functions. IEC 625-2 will provide further guidance on the GPIB message content and formatting in byte-serial data streams.

In his discussion on the type of data driver required by IEEE-488 (1978) Mr Ellefsen is imprecise in his interpretation of the standard. He writes ". . . some means of allowing one device to control the state of a bus line has to be provided. The available options are twofold: three-state logic, and wired-or. The more universal, and cheaper, wired-or system is used."

1. The GPIB uses binary logic. It is optional to use three-state output stages on gates driving the ATN, EOI, DAV, REN, and IFC lines.
2. By "wired-or" Mr Ellefsen means "open-collector". The RFD and DAC, messages are a "wired-and" combination of all the open-collector gates connected to the $\overline{\text{NRFD}}$ and $\overline{\text{NDAC}}$, lines. The SRQ message is a "wired-or" combination of all the open-collector gates connected to the $\overline{\text{SRQ}}$ line.
3. The DIO1-DIO8 lines may be three-state or open-collector outputs. In the Parallel-Poll Active State these lines must be open-collector.
4. If three-state drivers are selected for $\overline{\text{DAV}}$ and $\overline{\text{DIO1}}$-$\overline{\text{DIO8}}$ then the GPIB data rate can be up to IMbyte/second. To say that "A tacitly agreed limit of 250 kbyte/second is therefore normally accepted" is a serious misinterpretation of IEEE-488.

The maximum data rate permissible on the GPIB is:
(a) 250kbyte/s using open collector data drivers.
(b) 500 kbyte/s using three-state drivers for $\overline{\text{DAV}}$, $\overline{\text{DIO1}}$-$\overline{\text{DIO8}}$ and $\overline{\text{EO1}}$.
(c) IM byte/s using three-state drivers for $\overline{\text{DAV}}$, $\overline{\text{DIO1}}$-$\overline{\text{DIO8}}$, $\overline{\text{EO1}}$ and $\overline{\text{ATN}}$, provided that (i) not more than 15m of cable is used (ii) there is at least one standard termination network per metre of cable, (iii) there are no powered-off instruments on the bus, and (iv) the device capacitance is less than 50pF.

In practice there are few GPIB instruments able to transfer data at even 250kbyte/s; however, this is not a limitation of the bus but of the instruments. In the future it is likely that test systems designers will require and obtain instruments operating at faster data rates.

The GPIB Parallel Poll function is a source of frequent confusion. In the Parallel Poll Enable message (PPE) the Controller instructs the current Listener how to respond to a subsequent Parallel Poll sequence. The interface function will give an affirmative Parallel Poll Response (PPR) in the Parallel Poll Active State (PPAS) only if the local "individual status" device message (ist) corresponds to DIO4 of the last received PPE message. For example, if DIO4 was a '1' the 'ist' must be '1' for an afformative PPR to be sent. If DIO4 and 'ist' are in opposite states then there must be no PPR in PPAS.

Because $\overline{\text{DIO1}}$-$\overline{\text{DIO8}}$ are open-collector outputs and not three-state, the PPR received by the Controller is the wired-or function of all devices whose 'ist' message matches the DIO4 bit of the last PPE command received by each device.

Jonathan Summers
Fairchild Camera & Instrument (UK) Ltd
Bristol

The author replies:
My thanks to Mr Summers for his comments. Regarding drivers, it is quite true that three-state drivers may optionally be used on some lines, usually with the intent of increasing speed, and the end of the section which Mr Summers quoted should read ". . . wired-or system is *generally* used".

I particularly tried to avoid confusion in the article by not referring to the RFD and DAC messages (which are the logical inverse of the state of the NRFD and NDAC lines). It is, however, clear that wired-and of RFD (for example) is equivalent to wired-or of NRFD. I note, incidentally, that Mr Summers occasionally refers to the bus lines by their "high = true" logical names (e.g. $\overline{\text{SRQ}}$). This is a very useful way to refer to the lines when designing interfaces to the bus, but can lead to confusion when referring to the standard which, as I mentioned in the article, uses "low = true" logic.

My statement that 250 kbyte/sec is a generally accepted maximum data rate is based on paragraph 5.2 of the 1975 standard which states: "A standard performance bus will operate at distances up to 20m at a maximum of 250,000 bytes per second . . . using 48mA open collector drivers". However, Mr Summer's explicitly detailed definition of data rates is totally accurate. Note that in paragraph 5.2.3 of the 1978 standard, a warning is given that if a speed-enhanced talker is used to achieve 1Mbyte/s data rates, with standard talkers, problems may be experienced even when the interface is not being used at that rate.

Mr Summers's section on Parallel Poll is extremely lucid, and I thank him for it.

Finally, I should like to correct a mistake which somehow crept into my manuscript. On p.77 the "untalk" message should be "1011111", and "unlisten" "0111111".

P. R. Ellefsen

MILITARY ELECTRONICS

Your News of the Month in the June/July issue reports that according to the Defence Estimates the defence equipment programme sustains about 200,000 job opportunities within the major defence industries and about the same number again indirectly in industry.

It seems to me to be illogical to work for wars in peace-time, even if they are only vaguely anticipated, i.e. by building up one's defences. It was, e.g., a very old Roman precept which said: 'if you desire peace, prepare for war', and, as the late Lord Mountbatten pointed out in a speech shortly before he died, that precept is now "absolute nuclear nonsense".

The defence programme therefore seems to me to be an illogical development of electronics, and also, perhaps, an increasingly dangerous one. Would this not seem to imply that the electronics engineers employed to maintain the defence equipment programme would therefore (a) be better off on the dole, since (b) their knowledge of electronics may even have serious gaps, inconsistencies, or failings?

This policy (to make these jobs redundant) could also help considerably to reduce inflationary pressure in the UK, as well as giving support to pacifism, which is surely the only sensible philosophy in Western Europe at the present time.

Peter G. M. Dawe
Oxford

WHAT'S SO NATURAL ABOUT e?

Die ganzen zahlen hat Gott gemacht, Alles anderes ist menschenwerke

I do not understand why Dr Finlay (December, February, April) wishes to determine e using a ruler and two jam-jars. The mensch who made it was clearly not satisfied with integers. It has always been my wish, however, that these columns should bring light and sunshine into the lives of others, especially my bank manager.

Three jam-jars, I think, will be better, and nothing you can't find, if desperate enough, in the ordinary home. I do not possess a metre rule, but some quick hammering at a ceiling has provided a lath just over a metre long. A tape measure, some sand or sugar, or, if your grocer is old-fashioned, a mixture, and string.

The jam-jars are best replaced by those revolting plastic beakers, with string handles stapled on to make small buckets. The metre rule is drilled at its centre, and pivoted, or hung by string from a convenient support.

A supply of what the French call le Scotch, so described to help to break down the separation of the two cultures, will be useful, or, preferably, draughting tape. Most readers will have this in their homes *(Deuteronomy* Ch.25 v.4).

We now have our balance, the suspended metre rule. I propose to measure from the centre, 500mm. Set one empty bucket at +30 and another at —300 (200 and 530 on the scale).

Use a small coin to trim the balance, mark its position with the tape. Remove it.

Set buckets at +300 and —300. Fill to about one-quarter and then add salt/sand/sugar to get a balance. Remove one bucket and mark it as 'reference standard'. Set the other unit weight at +30 and an empty bucket at —300. Replace the trimmer. Add material to the —300 bucket to get a balance.

Empty the material from —300 into +30. Repeat ten times in all.

Set this bucket, now nearly ¾ full, at —100, and use the standard bucket to measure its weight. The scale reading will be about 260, or e × 100.

The operation is based on the defining equation:

$$\frac{d}{dx}f(x) = f(x)$$

$$\text{and } f(0) = 1$$

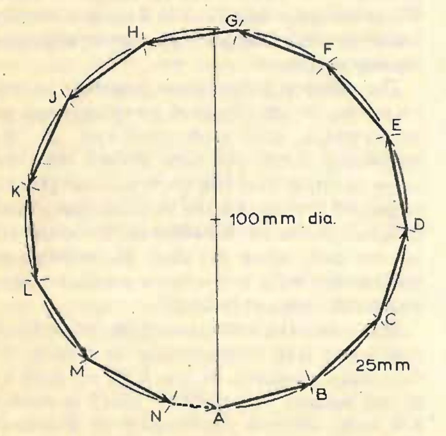


Fig. 1. Determination of π. Each chord, AB, BC etc. to MN is equal to d/4. Rather badly done, this gives π = 3.1.

The process corresponds to finding π by the construction of Fig. 1. As each chord is a short cut the value is always low, and I was surprised to find that on a diagram with 10cm diameter, hastily done, the total path A, B . . . . N, A came to 31cm.

We can draw another form, producing tangents. This gives a high value, again surprisingly close. The corresponding approach to e is to start with the standard buckets fairly full. Material is spooned out of the +30 bucket into the —300 bucket to get a balance, and is then discarded. Again ten steps are taken and the materials remaining weighed against the standard.

The basic experiment can be elaborated. The effect of taking fewer large steps, and more small steps, can be studied: the size of $\delta\epsilon$ from $\epsilon(x)$, $x = 0$, through $x = 0.1, 0.2$ up to 0.9 can be recorded. With rather more stable equipment the explosive growth of e^x as it goes on can be shown.

Finally, there is one feature of this system which I find particularly attractive: you don't need the apparatus at all, or, to put it another way, you can repeat the operation on your adding machine:

$f_0 = 1.00, + 0.1f_0 = 0.1 \rightarrow$

$f_{0.1} = 1.1 + 0.1f_{1.1} = 0.11 \rightarrow$

$f_{0.2} = 1.21 .... 1.32, 1.45 ... f'_{1.0} = 2.56.$

But my little adding machine, the back of an envelope, finds 3 significant figures the limit. A classier machine gave me 2.3579.

Thomas Roddam
London W8

SCIENTIFIC COMPUTER

I would like to thank John Adams and yourselves for such an excellent and timely educational project as the Scientific Computer which appeared in your April to September, 1979, issues. Although I have modified the basic design to permit the use of dynamic random access memories and the use of an unmodified 525-lines 60-field/s television set for video display, Mr Adams's design presented me with the exposure and guidelines which were necessary to undertake such a project as an amateur.

Mr Adams's design utilizing the MM57109 number oriented microprocessor as a peripheral device of the Z80 main microprocessor to handle computations is indeed a novel one. This technique should be very attractive to those developers catering specifically for applications in science and engineering.

BURP Mk II has greatly enhanced the facilities of the computer but still lacks a few very vital functions like string variables, arrays and read/data statements. However, the branching of control to an address in r.a.m. for unrecognized commands, statements and functions allows additional facilities to be added fairly easily. In fact, I have added the use of REM for remarks, LINK N as a statement to link BURP and machine language programs and have changed the multi-statement line separator to the more familiar colon.

I should mention here that, instead of reprogramming my original r.o.ms with the Mk II monitor/interpreter firmware, I have rewritten the Mk II so that it will load and run in r.a.m. at location 15AO to 1D4F. This modified version of BURP Mk II is then saved on cassette tape and re-read into the computer when necessary. This exercise is done only as a temporary means of making use of the added facilities of BURP Mk II and retain the use of my 5-unit code Baudot 50 baud teleprinter until I am satisfied that BURP firmware is sufficiently developed with enough facilities.

My system comprises 3K r.o.m. from 0000 to 0BFF, expandable to 0FFF (4K) and 12K dynamic r.a.m. from 1000 to 3FFF, expandable to 7FFF (28K). The video display remains memory-mapped from 8000 upwards but of necessity comprises half pages of 16 lines by 64 characters per half page, with each displayed half page automatically or manually selectable.

Since the computer makes use of r.a.m. area 1E00 to 1FFF without memory protection, I have transferred the commencement of BURP program loading to 2000. This position prevents long or sequenced BURP programs from extending into memory area used by the computer and also semi-reserves the area 1000 to 1DFF for machine language programs and any additional facility that may be added to the interpreter.

I invite comments from interested persons via P.O. Box 65, St John's, Antigua, West Indies.

Eustace N. Phillip, VP2AX
St John's
Antigua, W.I

TECHNICAL AUTHORS

I was sorry to see that Mr Ronald C. Slater's otherwise comprehensive article on Careers in the Electronics Industry (May issue) should have overlooked so completely the engineers who produce the manuals and other technical publications upon which the success of a product can, and often does, finally depend. The work of the technical author surely deserves — together with that of engineers engaged in the parallel activity of technical training — to be ranked with "the main activities of a typical company". The provision of operating, maintenance and repair information is an essential support service for electronic equipment. It is generally a contractual requirement and a potential customer may be expected to defer the purchase of any new product, however meritorious, unless and until the necessary technical manuals are made available.

It takes an electronic engineer to generate a detailed technical manual for an electronic product, but his engineering attainments must be complemented by a willingness and an ability to communicate graphically and in writing. Unfortunately these are unfashionable attributes and such people are becoming increasingly rare. It is perhaps for this reason that competent technical authors are at long last beginning to be offered the sort of financial reward that their dual ability has always deserved.

The presentation of technical information offers a great deal of scope for expertise and can be highly satisfying. It is a much more creative activity than is commonly supposed. In explaining a circuit or a system in detail, the trained author constantly monitors his work through the eyes, so to speak, of a reader seeking enlightenment; the author thus subjects the design he is describing to a measure of independent critical analysis and this can result in his contributing to the development of a new product as well as to its eventual success in the field.

The growing scarcity of technical authors may well bring serious consequences for the industry. Those concerned with the education of engineers should make it their business to understand the importance of tech-

nical publications work and the possibilities it can offer as an engineering career.
Claud Powell
Leatherhead
Surrey

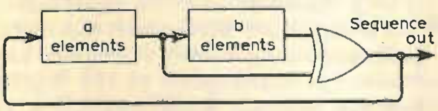
The author replies:
I would like to thank Mr Powell for his comments. While it was made clear that the article was not intended to be an exhaustive list of careers in electronics I would, nevertheless, agree that the technical author occupies an important place in the industry and that they are in short supply as, indeed, are good engineers and technicians of all persuasions. For the engineer, male or female, who has the ability and incliniation it can certainly be a very satusfying task.

It is difficult to comment on technical communications without remarking on the notorious inability of the majority of engineers to communicate effectively. It is a point which has been made time and time again — but one which the educationalists seem reluctant to act upon.
Ronald C. Slater

FEEDBACK FOR P.R.B.S. GENERATORS

With reference to the article by the late Mr Butler in the February 1975 issue on Pseudo-Random Binary Sequence Generators, I think your readers may be interested in the full criteria for feedback selection. Careful choice must be made to ensure the full sequence length of 2^n-1 bits occurs.

If we consider the total shift register broken into two parts, with feedback around the system below, provided that $a \neq 1$ and



$b \neq 1$, if $xa = yb$ where x,y are integers then the system breaks down to being equivalent to two interlaced sequence generators (see later).

To illustrate the point, suppose that $a = 4$, $b = 2$. Logic state p at the output will be dependent on logic states $p-4$ and $p-6$ (four and six clock pulses ago, respectively). Thus even logic states are dependent only on preceding even states, and odd states depend only on odd states. This lack of interdependence causes the system to act as a pair of interlaced, independent, three element generators, so the total sequence length is only $2(2^3-1) = 14$ bits instead of $2^6-1 = 63$ bits.

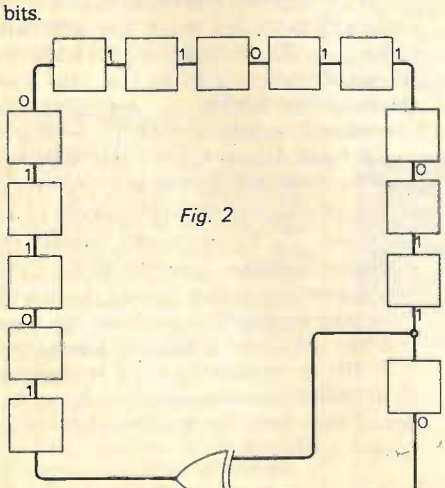


Fig. 2

A different kind of degenerate operation is possible under other conditions. As an example consider a p.r.b.s. generator where $a = 13$, $b = 1$. If the logic outputs should achieve the sequence in Fig. 2, or a shifted version of it (as it would normally do), then it will perpetuate the pattern in a closed loop of three states. This arises because the system described can be analysed as being equivalent to Fig. 3, which is a two-element

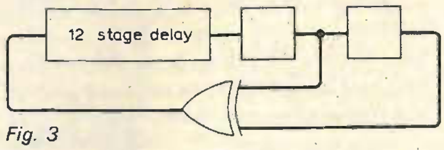


Fig. 3

p.r.b.s. generator with an extra delay, of suitable length to provide positive feedback (since 12 is a multiple of 3).

As a result of the above, rules can be drawn up which must be obeyed for non-degenerate p.r.b.s. operation:

$a \neq (a+b)v/w$ except when $a = 1$ or $b = 1$
$a-x \neq y(2^{(b-x)}-1)$
$b-x \neq y(2^{(a-x)}-1)$
where $w = 1, 2, \ldots, (a+b-1)$.
$v = 1, 2, \ldots, (w-1)$.
$x,y = 1, 2, \ldots$, (smaller of a and b).

A feedback connexion table generated from these equations is given below. There are a few notable differences from Mr Butler's table.

a+b	Non-degenerate values for a
2	1
3	1, 2
4	1, 3
5	2, 3
6	1, 5
7	1, 2, 3, 4, 5, 6
8	3, 5
9	1, 2, 4, 5, 7, 8
10	3, 4, 6, 7
11	2, 3, 4, 5, 6, 7, 8, 9
12	1, 5, 7, 11
13	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
14	2, 3, 4, 5, 6, 8, 9, 10, 11, 12
15	1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14

Note that it is simple to 'construct' these devices in microprocessor systems. I have written a Z80 routine for a 64-element generator in less than 32 bytes.
K. Wood
Ipswich
Suffolk

ILLICIT CB ON 27MHz

A number of people have urged the Government to move quickly on citizens' band radio before illicit use of 27MHz gets out of hand. I have a nasty suspicion that it's already too late. The authorities will never catch these users (they can't even be bothered to catch those who jam v.h.f. amateur radio repeaters continually, where they know the names and addresses of the offenders; how will they catch tens of thousands of illicit c.b.ers?), even with the current wave of indiscriminately stopping anyone and everyone with a non-broadcast antenna on the roof of their car (RSGB cards count for nothing and I now have to carry my licence at all times — not a legal requirement officially).

It's difficult to see what will entice these users on to another band. Certainly, rigs will have to be a good deal cheaper than the £50-£100 black-market price of an American 27MHz rig smuggled into the country, and I don't see that as being economically viable for British manufacturers as there will only be the home market and the chances of even the EEC adopting a system other than 27MHz a.m./s.s.b. must be pretty remote. And there'll always be people who prefer the American mode and its UK illegality and just want to say '10-4' to each other: they'll never give up 27MHz. And there's something to be said for international compatibility. My 2-metre amateur rig is pretty useful anywhere in the world I care to go with a reciprocal licence. Would it not be a good thing to standardise c.b. equipment in a similar way? Then there would be a far greater market to encourage UK manufacturers (who already make the odd frequency synthesiser for Japan) and the possibility of cheaper rigs. Temporary import controls could establish the UK industry, which could then stand or fall on its ability to compete internationally.

What this all comes to is two points. First, 27MHz will never go away; the technical problems are easily sorted out and it really comes down to acknowledging that the present thousands are unlikely to leave the band. Either they are legalised or they aren't. Second, prices for v.h.f. rigs that are above the £50-£100 mark will *ensure* the continuation of 27MHz use and will equally ensure that the average 'citizen' won't be able to afford to use his 'band', leaving the way open for a future government to take the said band away 'because nobody's using it: it was never really necessary'. At best, such a c.b. would be little broader-based, socially speaking, than the amateur bands, which are almost exclusively middle-class. US and illicit UK 27MHz activities are totally classless, at least partially, because everyone can afford a rig.

After long consideration we *may* find that the technical arguments against 27MHz – which are very powerful and generally sensible – must be reconsidered in view of the *social* implications of a v.h.f. citizens' band or indeed any band which requires expensive equipment and isn't already – albeit illicit – in use.
Richard Elen, G8RJX
Croydon

ELECTRONIC IGNITION

I was most interested to read the letter from Mr D. J. Bruyns in the March issue since I have been building and using c-d systems for eight years. Last year I wrote to a well known manufacturer with some constructive criticisms of his design. A few days later I received the offer of a job! My own conclusions are:
1. The capacitor-discharge unit itself is not always to blame for spurious faults, although careful attention must be given to the choice of suitable components; in particular, the thyristor and the capacitor which must tolerate very fast risetimes, high voltage and high temperature.
2. The high output voltage from the coil attached to a c-d unit is susceptible to leakage and arcing caused by damp, dirty or cracked h.t. leads, faulty coil or suppressor caps.
3. C-d ignition does not appear to cope with a weak mixture any better than standard Kettering ignition, possibly because although the voltage can be higher, the duration of spark is much less than that of the standard system.
4. The c-d system does seem to cope with a rich mixture, perhaps because its fast risetime allows it to fire a fouled spark plug.

Note that points 2. and 3. can result in misfiring from a c-d driven system but apparently acceptable performance from standard ignition.
M. T. Pickering
Stockton, Cleveland

WORLD OF AMATEUR RADIO

Long-path and simple aerials

The ability of amateurs using only simple aerials to work long distances by taking advantage of the extremely reliable morning chordal-hop, long-path to Australia, via the dawn and dusk "tilts" in the ionosphere, rather than multi-hop paths, is underlined by the observations of Ron Fisher, VK3OM of Glen Waverley, Victoria. He reports working on 14MHz s.s.b. some 147 different British amateurs under "long-path" conditions during the past year. Of these, 55 of the British stations were using dipole-type aerials, 32 were using ground planes and vertical monopoles, four were using "mobile whips", representing a total of 91 with simple aerials, compared with 56 using beam arrays of various types. He writes: "It is interesting to note that some of the more consistent British stations heard in Australia at this time of day use dipoles; they are not necessarily the strongest signals but often the difference between them and the stronger signals heard at the same time is small, perhaps 1-1½ "S" points. (S-point calibration varies widely between different receivers but this probably represents about 4 to 5 dB).

US reply to the Pecker?

An American h.f. over-the-horizon radar system (Conus OTH-B) has recently begun a nine-months trial from a transmitter site near Moscow (sic), Maine with the receiving site for the backscatter signals about 100 miles away near Columbia Falls. The system is designed to detect moving targets at a range of up to about 1800 nautical miles, using complex digital data processing to isolate targets from the large amount of sea and land backscatter clutter. Twelve 100 kW transmitters are used on a 24-hour basis with any of four centre frequencies between 6.8 and 21.8MHz. The transmitting aerial array comprises 48 elements, 12 for each of the four bands: a ground screen stretches 750ft in front of the array to improve low-angle radiation. The USAF is said to have already spent some $100-million on over-the-horizon radar development, although the American over-the-horizon radar at Orfordness in England was taken out of commission some years ago and the site turned over to BBC External Services.

Although it is stated that the OTH-B signals will cause much less interference to other services than the notorious Russian "Woodpecker", there are fears that the growth of such systems, if they prove successful, may become world-wide and will inevitably affect low-power amateur transmissions. OTH-B signals will have a faster "knocking" rate than the Pecker, varying from about 20 to 60Hz and sounding rather like "mains hum". The system is being operated on a "non-interference" basis and one hopes that this will be achieved in practice. Amateur frequencies are to be avoided.

Local courses for RAE

Evening classes for those wishing to sit the Radio Amateur's Examination are again starting soon in many local adult education centres, with enrolment during early September. Among the towns where courses have been notified to the R.S.G.B. are: Bath, Belfast, Birkenhead, Birmingham, Bracknell, Gosforth, Turnford near Hoddesdon, Langley near Slough, Manchester, Melton Mowbray, Newport, Northampton, Orpington, Scunthorpe, Stockport, Walsall and Weybridge. As this list is probably incomplete, enquiries should be made at local adult education centres.

A second training course for electronics and amateur radio was held in Colombo, Sri Lanka recently with the co-operation of the German national amateur radio society, DARC. There were 29 participants, including students from India and Bangladesh (although amateur licences are not yet available in Bangladesh).

Around the bands

The IARU Region 1 Executive Committee has recommended that the new amateur band between 10,100 to 10,150 kHz (which is expected to become available about 1982) should be for c.w. operation only. This is to enable as many amateurs as possible to make effective use of this band which will be the narrowest of all amateur allocations. The IARU Conference in 1981 (to be held at Brighton from April 27 to May 1) is expected to set up a working group to consider band plans for the 18 and 24MHz bands, although these may not become available to amateurs for several years.

H. L. Wilson, E12W, one of the few European amateurs permitted to use the 50MHz band, has reported making 1552 transatlantic contacts with 600 different stations during the period October 20, 1979 to December 20, 1979, using a transmitter with an output of about 10 watts and a three-element beam aerial. On December 15 he reports that the m.u.f. was observed to rise to 62.75MHz.

According to *Ham Radio*, first news of the initial volcanic eruption at Mount St Helens, Washington on March 27 came from an amateur radio station operated by a camper on the mountain slope. His dramatic transmission ended: "I'm getting the hell out of here" but he, and two other radio amateurs, were among the missing. Some 100 amateurs worked with rescue crews and another 100 at the communications centres: it is claimed that radio proved more effective than the telephone.

W. A. Scarr, G2WS, chairman of the Radio Amateur Invalid and Blind Club, has appealed for a wider understanding and appreciation of the club's aims and activities. RAIBC exists to help handicapped members to participate fully in amateur radio. The club has an RAE tuition course on tape cassettes for blind candidates and this has recently been revised; a number of Datong morse tutors have been donated by friends of the club and are proving successful. Some 50 copies of the club newsletter "Radial" are distributed on tape.

In brief

Kenya has introduced a "type approval" system for amateur radio equipment, charging a fee of $150 which has to be paid again each time any alterations are made . . . Attendance at the RSGB National Amateur Radio Exhibition at Alexandra Palace last May was over 6,600 . . . Dates for the ARRA amateur radio exhibition at Leicester have been changed to November 6, 7 and 8 . . . Sixty years ago — summer 1920 — saw the issue of the first post World War I British amateur licences, including "2FZ" as the callsign of the Manchester Wireless Society . . . It was August 1920 when the weekly concerts for British listeners began from The Hague: PCGG on 1000 metres . . . The Queen's Birthday Honours List included the award of an MBE to Roy Stevens, G2BVN in recognition of his work for amateur radio . . . Basil O'Brien, G2AMV of Wirral, Cheshire is to be the 1981 President of the RSGB . . . Although the "Firewheel" scientific satellite on board the ill-fated Ariane launch last May has been recovered from the sea, the Oscar Phase 3A satellite seems unlikely to be salvaged . . . Forthcoming events include the Scottish Amateur Radio Convention on September 13 and the Welsh Amateur Radio Convention on September 28 . . . Charles Suckling, G3WDH in examining tape recordings of 432MHz "moonbounce" echoes has found that they include further "long delay" echoes.

PAT HAWKER G3VA

NEW PRODUCTS

Four-channel driver i.c.

The L293 is designed to drive inductive loads and can handle currents of up to 1A (2A repetitive peak) with supplies of up to 36V, enabling driving of relays, solenoids, d.c. motors and stepping motors.

The logic section of the device, which may be powered by a separate low-voltage supply, accepts normal logic levels and is provided with six inputs, one for each channel, and two inhibit inputs, each serving two channels.

The four centre pins of the 16 pin d.i.l. package provide thermal conduction for the L293, which has full thermal protection and a maximum power dissipation of 5W. SGS-ATES (U.K.) Ltd, Walton St, Aylesbury, Bucks.

WW301

Adjustable crystal oscillator

Precise frequency setting to within ±0.001p.p.m. is possible with this ovenized crystal oscillator by means of an integral multi-turn trimmer. The Ovenaire 85-1 series is available in a frequency range from 1 to 16MHz, each unit having a t.t.l. output circuit, with a fanout of three, the input of which fully buffers the oscillator circuit to provide load isolation.

Both oscillator and oven-control circuits have built-in voltage regulation and the glass-enclosed crystal has aging figures of $\pm 7\times10^{-8}$/week at the time of shipping to $\pm 1\times10^{-6}$/year after 90 days of operation. Dimensions of the 85-1 units are 44.45×31.75×26.50mm. Walmore Electronics Ltd, 11-15 Betterton St, Drury Lane, London WC2H 9BS.

WW302

Direct-to-wire connector kit

A new Direct-to-Wire Kit which offers 1000 connexions for £39.95, is introduced by Verospeed. The kit contains eight types of connector, interlinked with M100, 10-way ribbon cable, supplied on two reels, and a selection of pre-stripped ribbon cable in various lengths.

Gas-tight connexions, which obviate the use of noble metals to give cost reduction, are achieved by direct insertion of tinned, stranded or solid contacts into the contact assemblies. GTH

contacts, patented by BICC-Burndy, are the basis of the kit, which offers the Research and Development Engineer the ability to incorporate the same products that are used in production, thus eliminating the need for value engineering.

All individual replacement parts are available from Verospeed, and production quantities in excess of 1000 pieces will be quoted for by BICC-Burndy. Verospeed Ltd, Stansted Rd, Boyatt Wood, Eastleigh, Hampshire SO5 42Y.

WW303

Low-profile p.c. relay

With a weight of only 12.5g, this subminiature relay is described as being the lightest of its kind available. The Type SF series low-profile relays are distributed by Diamond H Ltd, and offer a choice of either double-pole, double-throw or four-pole, double-throw contact configurations, with contact ratings of 2A d.c. or 50W, at a maximum of 60V d.c. into resistive loads. Relays with activating coils for operation at either 5, 6, 12, 24 or 28V d.c. are available, each coil having a power consumption of 0.56W.

In addition to the standard basic relay, designated SFA, other more specialized versions are available, including non-polarity, self-latching types, designated SFL, and polarity self-latching types, designated SFB. Further, a variety of alternative contact forms may be incorporated to meet individual user requirements. The terminals of the relays are in standard d.i.l. form and their bifurcated cross-bar contacts are of gold over silver palladium alloy. Diamond H Controls Ltd, Vulcan Road North, Norwich NR6 6AH.

WW304

P.t.f.e. / woven glass laminate

Two new types of laminate have been introduced by the 3M (UK) Ltd., namely Cuclad 217, which has a dielectric constant of 2.17±0.04 and a dissipation factor of 0.0009 at X-band, and Cuclad 233, which has a dielectric constant of 2.33±0.04 and a dissipation factor of 0.0015 at X-band.

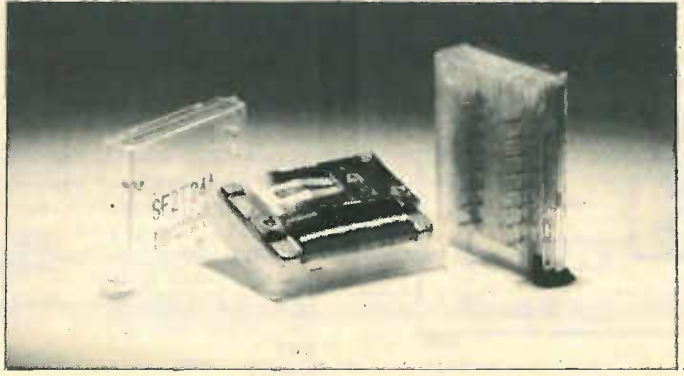
Primarily designed for use in microwave applications, such as computer systems working at sub-nanosecond bit processing times and microwave antennae, amplifiers, filters and couplers, the boards have mechanical strength and dimensional stability equal to similar woven glass products, and offer processing advantages as they do not require "double-etching".

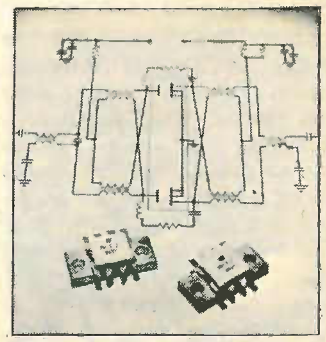
The 217 type is available in thicknesses from 0.010in up to 0.125in, and the 233 type from 0.005in to 0.125in, both types having a standard size of 36×17in, a larger size of 36×34in being available on request. 3M (UK) Ltd, 3M House, PO Box 1, Bracknell, Berkshire RG12 1JU.

WW305

Push-pull r.f. power f.e.ts

Claims of the first r.f. push-pull power f.e.ts using the v.m.o.s technique, are made by Siliconix Ltd. These devices are intended for broadband applications from 2 to 200MHz, and offer the ad-





vantages of enabling reduced amplifier size, and minimizing the costs usually associated with the matching of transistor pairs by encapsulating two matched n-channel enhancement mode f.e.ts in a single package.

The DV 28120D, DV 2880D and DV2840D can deliver up to 120, 80 and 40 watts respectively and give rated outputs of 28 volts with a minimum power gain of 10db at 175 MHz. The units can be used in either class A, B or C configuration. Siliconix Ltd, Morriston, Swansea SA6 6NE.

WW306

New microprocessor

All other single-chip microcomputers are out-performed by the 8051, claim GEC Semiconductors. It fits in at the top of the Intel MCS-48 family, and has an instruction set which includes multiply, divide, subtract with borrow, compare and non-paged jumps. Another of its features is a 'Boolean Processor' which allows very high speed implementation of logical or decision-making operations.

The 8051 is suitable for stand-alone, single-chip controller applications requiring up to 64K bytes of memory, and has itself 4K bytes of p.r.o.m. and 128 bytes of r.a.m. Unlike other processors in the MCS-48 range, the 8051 includes a full duplex u.a.r.t. for serial communication, complete with oscillator and clock circuits. For distributed systems, the serial I/O provides an inbuilt, high-speed multiprocessor protocol. Two 16-bit timer counters and four 8-bit I/O ports are also included.

The 8051 will be available in three versions: the 8051, which has a mask-programmed program memory; the 8571, which has a u.v.-erasable memory and the 8031 which has no internal program memory. GEC Semiconductors Ltd, East Lane, Wembley, Middlesex HA9 7PP.

WW307

Portable radio for the handicapped

A scanning portable radio, ideal for the blind, short-sighted or handicapped, has been developed by Sony (UK) Ltd. The ICF-M20L requires no visual control as raised dots on the touch buttons

allow touch-reading, and "pip-tones" are given to tell the user when the controls are operated correctly and when the radio is scanning. At each receivable station, the scanning stops automatically, and the radio has a memory in which up to seven stations on f.m. and seven stations on m.w./l.w. can be stored and recalled by one touch operation.

Dimensions of the ICF-M20L are 179×85×26mm, and its weight is 380g, including batteries. Sony (U.K.) Ltd, 134 Regent St, London W1.

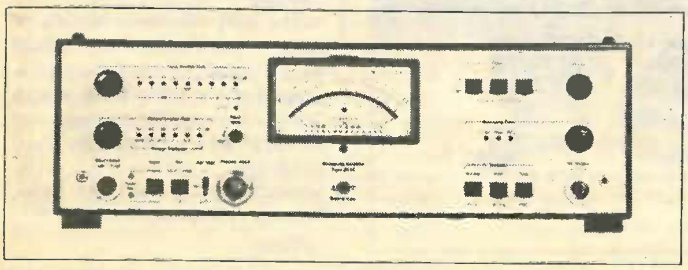
WW308

Wide-range measuring amplifier

Comprehensive measurement of sound, vibration and voltage is possible with the new wide-range amplifier/voltmeter Type 2610, from B&K Laboratories Ltd, in which l.e.d. displays are incorporated for the gain/measuring range and overload indications, and accurate true r.m.s. and peak level detectors plus a max. hold facility enable its use as a precision voltmeter.

High-pass filter and 'A' weighting system for sound measurement, provisions to enable connexion of external filters for frequency analysis, and two versions providing either a.c. lin. or d.c. log. output are also featured. Various microphones, for which polarizing voltages are provided, and vibration transducers, can be used in conjunction with the low-noise amplifier/voltmeter, which complies with the IEC, ANSI and DIN standards for precision sound level meters. B&K Laboratories Ltd, Cross Lances Road, Hounslow, Middlesex TW3 2AE.

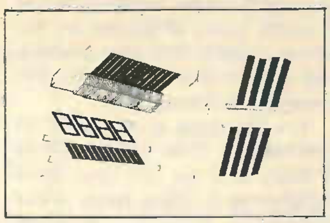
WW309



Conducting elastomer connectors

Connexion between elements which have contact pads as close as 0.010in is possible with the Stax Series 405/2 interconnexion system which uses alternate layers of conducting and insulating silicone-rubber, each 0.002in thick, that are bonded together to form a "block". Clamping of the block to the mating conductors is required to ensure good contact, the pressure required being that which causes the block to deflect by between 5 and 20%.

Elastomer connectors can be used to interconnect components such as displays, i.c. chip-carriers, p.c.bs, leadless hybrid-circuits and flat-cables, and as no soldering is required, and a greater tolerance to misalign-



ment is available than with conventional connectors, time savings can be made where large-scale production is concerned.

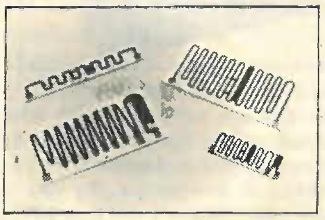
Stax 405/2 low-profile connectors are manufactured by Hulltronics Inc. (USA), and have a temperature range of −50 to +150°C. Symot Ltd, 22a Reading Rd, Henley on Thames, Oxon RG9 1AG.

WW310

High-voltage networks

This new range of custom-built resistance networks is being launched by Welwyn Electric Ltd. Each network is capable of withstanding up to 30kV, provided that the power dissipation of the device is not exceeded, making them particularly suitable for use as high-voltage dividers.

With power ratings of up to 4.5W, the networks can be obtained in a resistance range from 100Ω to 2GΩ, with a stability of 0.5% after 1000hrs of use, and a standard tolerance of ±5%, tighter tolerances being obtainable if required. Other applications in which the networks can be used to advantage are very low inductance and pulse systems, accurate feedback controls, measurement systems and bleeder chains.



Duplicate networks are identical in pattern, shape and electrical characteristics, offering a more consistent performance than can be obtained with discrete resistors. Substrate sizes range from 25×8.5mm to 25×50mm. Welwyn Electric Ltd, Bedlington, Northumberland NE22 7AA.

WW311

Universal vacuum-test fixture

Test heads which are interchangeable and a universal receiver, the section upon which the test heads are mounted, are the main components of this p.c.b. test fixture, the U3000, which holds the circuit under test in position and against the spring-loaded contacts using a vacuum. It is claimed that the "bed of nails" test-heads can be changed in a matter of seconds, an important feature where production costs are to be minimized in the testng of p.c.bs of varying nature and size.

The receiver, which is available for either 30 or 60° test head mounting, is either demountable, in which case a Cannon 156 way terminal connector is usually fitted, or semi-permanently installed into an a.t.e. system.

Each spring-loaded contact consists of a probe, which is made from beryllium copper, plated with either gold or rhodium, and a mating socket. Constant contact between probe and socket is ensured by using a patented "biasing-ball" construction which also precludes current passage through the pressure spring. The contacts are replaceable. The U3000 is made by Pylon and distributed in the U.K. by Teknis Ltd, Teknis House, Meadrow, Godalming, Surrey GU7 3HQ.

WW312

Click-stop pots

Industry-standard potentiometers in either single or tandem-stereo forms, denominated Radiohm P20 and JP20 respectively, are manufactured by East Grinstead Electronic Components Ltd. They are produced in a choice of 12 different linear and non-linear law patterns ranging from 100Ω to 2.2MΩ, and are available in centre-indent, 11 and 21 position variations and with either ¼in or 6mm plastic spindles.

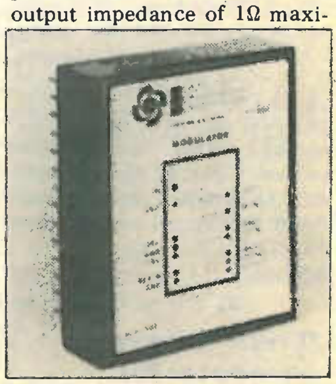
Standard track-dissipation ratings at 40°C are 0.4W and 0.2W for linear and non-linear versions respectively, with a minimum limiting element voltage of 500V d.c. and insulation breakdown voltage of 100V a.c. Normal operating torque over the full 300° rotation is 0.4Ncm, end stop maximum torque is between 60 and 80Ncm, dependent upon style, and maximum axial spindle load is 100N for 5sec.

Various p.c.b. and hard-wiring solder tag terminals are also available, as are integral support brackets, enabling robust assemblies to be achieved. East Grinstead Electronic Components Ltd, Imberhorn Industrial Estate, East Grinstead, Sussex RH19 1RJ.

WW313

High-accuracy modulator

A series of low-cost, high-accuracy modulators with up to ±0.1% linearity has been introduced by Techmation Ltd. The Computer Conversions Corporation model 503 modulator converts d.c. input signals to linear, proportional a.c. output signals: it accepts ±10V d.c., or ±100V d.c. inputs and provides a.c. outputs of 0 to 7V r.m.s. It has an output impedance of 1Ω maxi-



mum and is insensitive to ±10% reference line changes.

Any a.c. output voltage can be provided via internal or external transformers, and the output is short-circuit protected. Gain and zero adjustments are also standard features. Measuring 2.6×3.1×0.625in, the model 503 has an input impedance of 100kΩ and requires a 26V, 400Hz ±5% reference input and ±15V d.c. supply at 50mA maximum. Techmation Ltd, 58 Edgware Way, Edgware, Middlesex HA8 8JP.

WW314

Testing... Testing... Testing...

anywhere!

The New FM/AM 1000s with Spectrum Analyser-we call it the *SUPER-S*

A portable communications service monitor from IFR, light enough to carry anywhere and good enough for most two-way radio system tests. The FM/AM 1000s can do the work of a spectrum analyser, oscilloscope, tone generator, deviation meter, modulation meter, signal generator, wattmeter, voltmeter, frequency error meter-and up to five service engineers who could be doing something else!

For further information contact Mike Taylor

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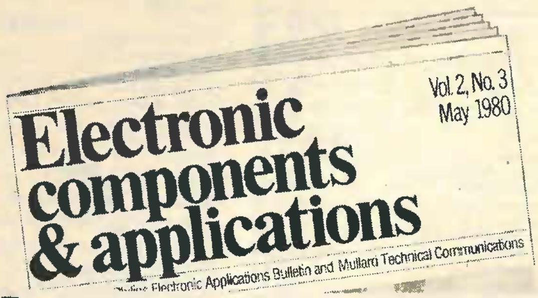

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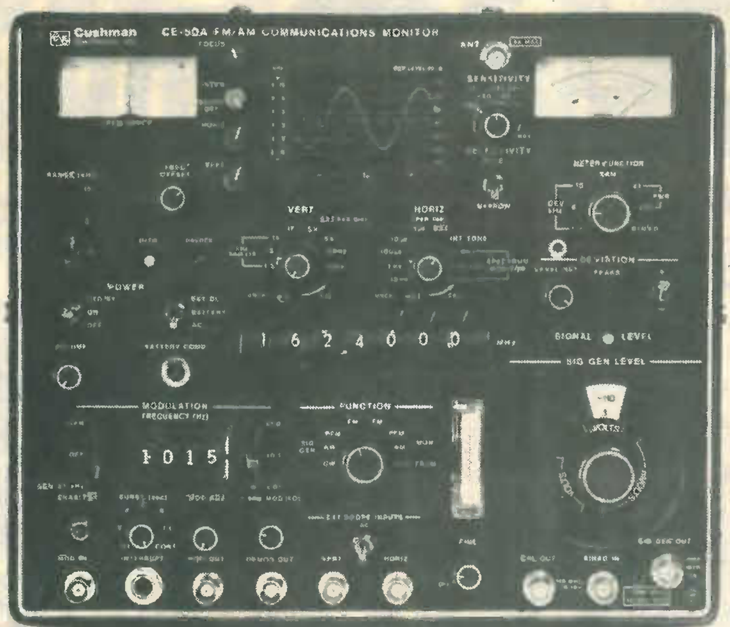

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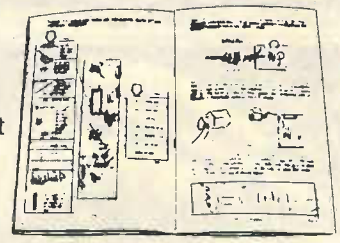

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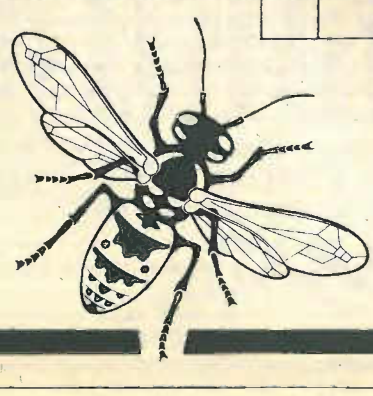

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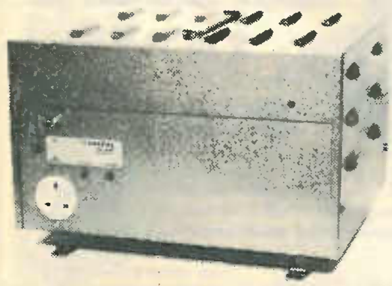

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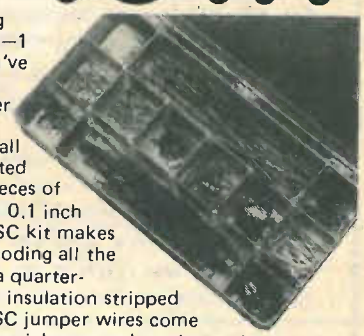

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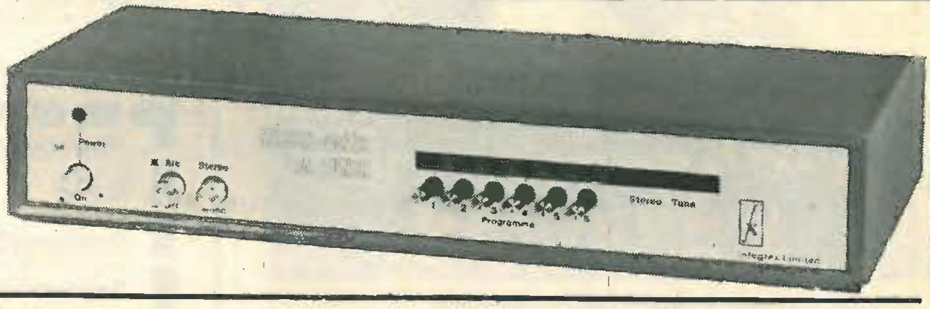

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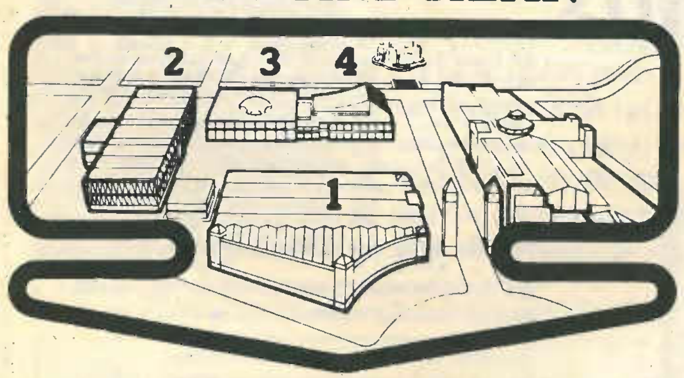

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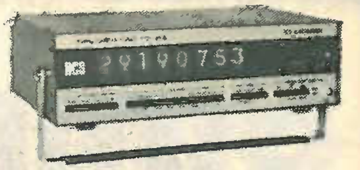

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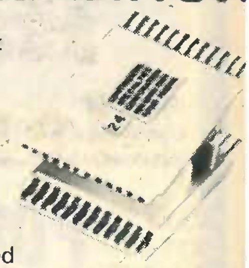

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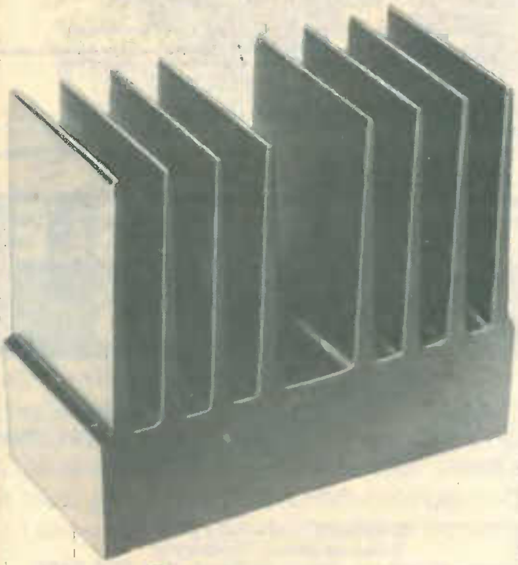

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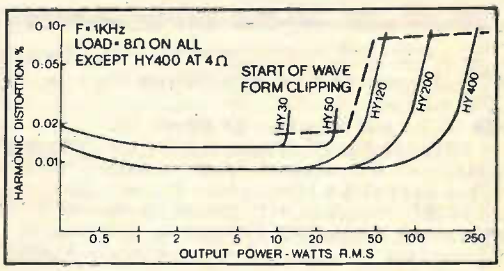
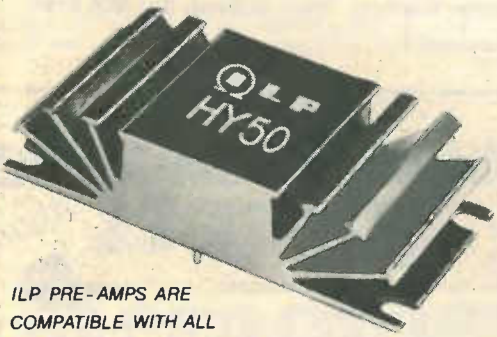


Model	Output Power R.M.S.	Distortion Typical at 1KHz	Minimum Signal/Noise Ratio	Power Supply Voltage	Size in mm	Weight in gms	Price + V.A.T.
HY30	15 W into 8 Ω	0.02%	100 dB	-20 -0- +20	105x50x25	155	£6.34 + 95p
HY50	30 W into 8 Ω	0.02%	100 dB	-25 -0- +25	105x50x25	155	£7.24 + £1 09
HY120	60 W into 8 Ω	0.01%	100 dB	-35 -0- +35	114x50x85	575	£15.20 + £2 28
HY200	120 W into 8 Ω	0.01%	100 dB	-45 -0- +45	114x50x85	575	£18.44 + £2.77
HY400	240 W into 4 Ω	0.01%	100 dB	-45 -0- +45	114x100x85	1.15Kg	£27.68 + £4 15

Load impedance - all models 4 Ω - ∞
Input sensitivity - all models 500 mV
Input impedance - all models 100K Ω
Frequency response - all models 10Hz – 45KHz – 3dB



ILP PRE-AMPS ARE COMPATIBLE WITH ALL ILP POWER AMPS AND PSUs

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ILP Power Supply Units with transformers made in our own factory are designed specifically for use with ILP power amplifiers and apart from PSU 30 and 36 which are smaller PSUs — all the other ILP's own manufactured toroidal transformers are used which are half the size and weight of laminated equivalents. They are also more efficient and have greatly reduced fields of radiation.

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AAY30	0.31
AAY32	0.48
AAZ13	0.21
AAZ15	0.39
AAZ17	0.31
AC107	0.69
AC125	0.23
AC126	0.23
AC127	0.23
AC128	0.23
AC141	0.29
AC141K	0.40
AC142	0.23
AC142K	0.35
AC176	0.23
AC187	0.23
AC188	0.23
ACY17	0.98
ACY18	0.92
ACY19	0.86
ACY20	0.80
ACY21	0.86
ACY39	1.72
AD149	0.80
AD161	0.52
AD162	0.52
AF106	0.52
AF114	0.86
AF115	0.86
AF116	0.86
AF117	0.86
AF139	0.46
AF186	1.38
AF239	0.52
AFZ11	3.16
AFZ12	3.16
ASY26	1.38
ASY27	1.03

ASZ15	1.44
ASZ16	1.44
ASZ17	1.44
ASZ20	1.72
ASZ21	2.30
AU113	1.96
AUY10	2.30
AU110	1.96
BA145	0.15
BA148	0.15
BA154	0.10
BA155	0.12
BA156	0.10
BAW62	0.06
BAX13	0.07
BAX16	0.10
BC107	0.14
BC108	0.14
BC109	0.15
BC113	0.14
BC114	0.15
BC115	0.16
BC116	0.17
BC117	0.20
BC118	0.12
BC125	0.18
BC126	0.23
BC135	0.16
BC136	0.17
BC137	0.17
BC147	0.10
BC148	0.09
BC149	0.10
BC157	0.10
BC158	0.09
BC159	0.12
BC167	0.14
BC170	0.13
BC171	0.12

BC172	0.12
BC173	0.14
BC177	0.17
BC178	0.16
BC179	0.18
BC182	0.13
BC183	0.12
BC184	0.13
BC212	0.15
BC213	0.14
BC214	0.17
BC237	0.10
BC238	0.14
BC301	0.38
BC303	0.38
BC307	0.12
BC308	0.12
BC327	0.23
BC328	0.21
BC337	0.21
BC338	0.20
BCY30	1.15
BCY31	1.15
BCY32	1.15
BCY33	1.04
BCY34	1.04
BCY39	3.45
BCY40	1.15
BCY42	0.29
BCY43	0.29
BCY58	0.18
BCY70	0.17
BCY71	0.20
BCY72	0.15
BCZ11	1.72
BD115	0.52
BD121	1.50
BD123	1.50
BD124	1.50

BD131	0.40
BD132	0.44
BD135	0.39
BD136	0.39
BD137	0.40
BD138	0.46
BD139	0.49
BD140	0.51
BD144	2.30
BD181	1.26
BD182	1.36
BD237	0.46
BD238	0.63
BDX10	1.05
BDX32	2.30
BDY20	1.44
BDY60	1.72
BF115	0.29
BF152	0.21
BF153	0.23
BF154	0.20
BF159	0.26
BF160	0.18
BF167	0.23
BF173	0.23
BF177	0.28
BF178	0.28
BF179	0.29
BF180	0.35
BF181	0.35
BF182	0.35
BF183	0.2
BF184	0.29
BF185	0.29
BF194	0.10
BF195	0.10
BF196	0.12
BF197	0.14
BF200	0.31
BF224	0.23
BF244	0.32

BF257	0.28
BF258	0.30
BF259	0.37
BF336	0.35
BF337	0.35
BF338	0.36
BFS21	4.55
BFS28	2.56
BFS61	0.23
BFS98	0.23
BFW10	0.74
BFW11	0.74
BFX84	0.25
BFX85	0.26
BFX87	0.24
BFX88	0.24
BFY50	0.30
BFY51	0.30
BFY52	0.30
BFY64	0.30
BFY90	1.44
BSX19	0.24
BSX20	0.23
BSX21	0.23
BT106	1.44
BTY79/400R	3.67
BU205	2.02
BU206	2.59
BU208	2.30
BY100	0.52
BY126	0.16
BY127	0.17
BZX61	0.21
Series	
BZY88	0.15
Series	
CRS1/40	0.69
CRS3/06	0.52
CRS3/40	0.86

CRS3/60	1.04
GEX66	1.73
GEX541	4.60
GJ3M	0.86
GM0378A	2.02
KS100A	0.52
MJE340	0.92
MJE370	1.35
MJE371	0.71
MJE520	0.60
MJE521	0.63
MJE2955	1.44
MJE3055	0.86
MPF102	0.35
MPF103	0.35
MPF104	0.35
MPF105	0.35
MPSA06	0.28
MPSA56	0.30
MPSU01	0.41
MPSU06	0.53
MPSU56	0.56
NE555	0.52
NKT401	2.30
NKT403	1.99
NKT404	1.99
OA5	1.09
OA7	0.63
OA10	0.74
OA47	0.16
OA70	0.35
OA79	0.35
OA81	0.35
OA85	0.35
OA90	0.09
OA91	0.09
OA95	0.09
OA200	0.10
OA202	0.10
OA211	1.15
OAZ200	1.15

OAZ201	1.15
OAZ206	1.15
OAZ207	1.15
OC16	2.30
OC20	2.88
OC22	2.88
OC23	3.16
OC24	3.45
OC25	1.04
OC26	1.04
OC28	2.30
OC29	2.30
OC35	1.73
OC36	1.73
OC41	0.92
OC42	0.86
OC43	2.59
OC44	0.69
OC45	0.63
OC71	0.63
OC72	0.63
OC73	1.15
OC74	0.74
OC75	0.74
OC76	0.63
OC77	1.38
OC81	0.74
OC81Z	1.38
OC82	0.74
OC83	0.74
OC84	0.74
OC122	1.73
OC123	2.02
OC139	2.59
OC140	3.16
OC141	3.74
OC170	1.15
OC171	1.15
OC200	1.73
OC201	2.02
OC202	2.02

OC203	2.02
OC204	2.88
OC205	2.88
OC206	2.88
OC207	2.02
OCP71	1.44
ORP12	1.15
R2008B	2.02
R2009	2.59
R2010B	2.02
T1C44	0.35
T1C226D	1.38
TIL209	0.23
T1P29A	0.47
T1P30A	0.48
T1P31A	0.51
T1P32A	0.55
T1P33A	0.79
T1P34A	0.84
T1P41A	0.72
T1P42A	0.81
T1P2955	0.77
T1P3055	0.64
T1S43	0.52
ZS140	0.29
ZS170	0.24
ZS178	0.62
ZS271	0.26
ZS278	0.65
ZTX107	0.13
ZTX108	0.12
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ZTX300	0.14
ZTX301	0.15
ZTX302	0.17
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ZTX304	0.22
ZTX311	0.14
ZTX314	0.23
ZTX500	0.15
ZTX501	0.16

ZTX502	0.18
ZTX503	0.20
ZTX504	0.23
ZTX531	0.23
ZTX550	0.18
1N914	0.06
1N916	0.08
1N4001	0.07
1N4002	0.07
1N4003	0.08
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1N4006	0.09
1N4007	0.10
1N4009	0.07
1N4148	0.07
1N5400	0.15
1N5401	0.15
1S44	0.05
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1S921	0.08
2G301	1.15
2G302	1.15
2G306	1.27
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2N1308	2.30

2N1309	1.38
2N1613	0.29
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2N2218	0.29
2N2219	0.28
2N2220	0.21
2N2221	0.21
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2N2924	0.24
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2N3053	0.20
2N3054	0.58
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2N3441	0.92
2N3442	1.26
2N3614	1.73
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2N3705	0.15
2N3706	0.15
2N3707	0.15
2N3708	0.12
2N3709	0.15
2N3710	0.12
2N3711	0.12

2N3771	2.02
2N3772	2.30
2N3773	3.45
2N3819	0.41
2N3820	0.52
2N3823	0.63
2N3866	0.83
2N3904	0.15
2N3905	0.15
2N3906	0.15
2N4058	0.16
2N4059	0.12
2N4060	0.14
2N4061	0.14
2N4062	0.15
2N4124	0.17
2N4126	0.17
2N4286	0.23
2N4288	0.25
2N4289	0.28
2N5457	0.40
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2S017	7.48
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2S026	13.80
2S103	1.73
2S302	0.86
2S303	0.86
2S322	0.92
2S324	1.44
2S701	1.73
2S745A	0.40
2S746A	0.40

VALVES

A1834	10.35
A2087	13.58
A2134	10.06
A2293	8.62
A2426	17.63
A2521	24.38
A2900	14.43
A3343	25.56
AZ31	1.26
AZ41	1.32
BK448	106.03
BK484	143.35
BS90	52.27
BS810	35.24
BT5	52.61
BT17	96.83
BT19	32.78
BT29	296.70
BT69	301.99
BT75	102.46
BT95	100.15
CBL31	2.30
CL33	2.30
CY31	1.15
C1K	21.30
C3A	11.50
C3JA	23.23
DA41	21.50
DA42	12.30
DA100	52.90
DAF91	0.46
DAF96	1.15
DET22	32.78
DET24	52.90
DF91	0.46
DF96	1.15
DK91	1.21
DK92	1.44
DK96	1.26
DL92	1.26
DL94	1.38
DL96	1.26
DLS10	9.48
DLS15	12.37
DLS16	12.37
DLS19	12.37
DM70	1.44
DM71	1.44
DM160	3.96
DY86/7	0.73
DY802	0.96
E55L	25.17
E80CC	10.13
E80CF	12.96
E80F	14.19
E80L	13.98
E81CC	6.62
E81L	14.06
E82CC	7.03
E83CC	7.16
E86C	12.48
E88C	7.12
E88CC	3.86
E90CC	9.90
E90F	10.38
E91H	5.34
E92CC	9.40
E99F	10.16

E130L	19.39
E180CC	6.86
E180F	9.66
E182CC	9.90
E186F	12.58
E188CC	9.40
E280F	25.88
E283CC	9.02
E288CC	18.54
EA52	23.69
EA76	2.30
EABC80	1.38
EAC91	0.92
EAF42	1.44
EAF801	2.02
EB41	2.30
EB91	1.01
EBC33	2.02
EBC41	1.44
EBC81	1.26
EBC90	0.97
EBF80	0.58
EBF83	1.44
EBF89	0.97
EBL31	2.88
EC90	1.28
EC91	8.69
EC92	1.44
EC157	310.50
ECC33	4.02
ECC35	4.02
ECC40	2.30
ECC81	1.01
ECC82	0.82
ECC83	1.01
ECC84	1.36
ECC85	1.38
ECC86	2.30
ECC88	2.07
ECC89	1.88
ECC91	10.27
ECC189	1.90
ECC807	2.02
ECC808	2.59
ECF80	1.24
ECF82	1.38
ECF86	1.73
ECH35	2.30
ECH42	1.32
ECH81	1.38
ECH83	1.44
ECH84	1.47
ECL80	1.15
ECL81	1.73
ECL82	1.15
ECL83	1.73
ECL84	1.61
ECL85	1.28
ECL86	1.38
EF37A	4.02
EF39	3.16
EF40	1.32
EF41	2.30
EF42	2.30
EF50	1.73
EF54	5.75
EF55	2.88
EF80	0.92
EF83	2.02
EF85	0.92

EF86	1.74
EF89	1.84
EF91	2.07
EF92	6.68
EF93	1.15
EF94	1.24
EF95	6.27
EF98	1.44
EF183	0.92
EF184	0.96
EF804S	12.65
EF805S	8.05
EH90	1.61
EK90	1.24
EL32	1.73
EL33	4.02
EL34TH	2.53
EL34MUI	3.16
EL36	1.84
EL41	1.44
EL42	2.02
EL81	2.88
EL83	4.03
EL84	1.15
EL86	2.88
EL90	1.10
EL91	8.21
EL95	1.51
EL156	27.60
EL360	9.77
EL500/504	2.16
EL509	3.63
EL821	11.46
EL822	12.55
EM34	5.75
EM80	1.26
EM81	1.15
EM84	1.15
EM85	1.44
EM87	1.73
EN32	16.28
EN91	2.94
EN92	6.18
EY51	2.02
EY81	1.89
EY83	2.02
EY84	10.57
EY86	0.96
EY88	2.02
EY500A	2.23
EY802	94
EZ35	97
EZ40	1.44
EZ41	1.44
EZ80	0.96
EZ81	0.96
EZ90	1.38
FW4-500	2.88
FW4-800	2.88
G1.371K	41.40
G551K	12.65
G180.2M	18.42
G240.2D	12.85
G400.1K	19.28
GN4	8.62
GN4A	8.62
GS16	10.35
GT1C	14.38
GU50	14.31
GU51	13.62

GXU1	16.10
GXU2	28.43
GXU3	30.49
GXU4	32.77
GXU50	17.25
GY501	3.16
GZ32	1.44
GZ33	4.60
GZ34	2.88
GZ37	4.60
KT61	4.02
KT66	11.50
KT88	13.80
KTW61	2.02
KTW62	2.02
KTW63	2.02
M8079	12.29
M8080	9.49
M8081	11.30
M8082	9.87
M8083	8.54
M8091	11.99
M8096	4.31
M8097	4.09
M8098	5.29
M8099	5.98
M8100	9.49
M8136	9.75
M8137	9.73
M8140	5.17
M8141	5.52
M8142	7.48
M8144	4.31
M8149	5.86
M8161	9.11
M8162	10.36
M8163	5.17
M8190	5.29
M8195	4.25
M8196	7.47
M8204	6.57
M8212	12.47
M8223	3.80
M8224	4.66
M8225	2.99
M8248	13.32
MU14	1.73
MX119	58.65
MX123	67.85
MX145	58.65
VX151	17.25
MX152	135.70
MX161	166.75
MX163	23.11
MX164	25.88
MX166	142.60
MX168	48.30
N78	10.35
OA2	2.13
OA3	5.69
OA4	4.02
OB2	1.44
OB3	2.20
OC2	3.04
OC3	2.20
OD3	2.20
OZ4	1.84
PC86	1.61
PC88	1.61
PC95	1.49

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

QY5-3000A	333.91
QZ06-20	30.48
R10	5.75
R17	1.89
R18	4.89
R19	1.38
R20	1.66
RG3-250	35.77
RG3-250A	37.49
RG3-1250	36.23
RG4-1250	43.93
RG4-3000	89.64
RR3-250	53.54
RR3-1250	94.83
S11E12	40.25
S130	3.45
S130P	4.03
STV280-40	11.50
STV280-80	24.15
SU41	2.88
SU42	10.35
TD03-10	32.78
TD03-10E	32.78
TD03-29F	33.93
TT15	34.50
TT21	14.16
TT22	18.17
TT100	59.51
TY2-125	69.01
TW4-400	74.07
TY4-500	101.44
TY5-500	178.25
TY6-800	181.70
TY6-5000A	337.51
TY6-5000B	264.50
TY6-5000W	290.98
TY7-6000A	357.49
TY7-6000W	286.33
TZ40	17.25
U18-20	2.88
U19	15.81
U25	1.33
U26	1.66
U37	10.35
UABC80	1.44
UAF42	1.44
UB41	1.44
UBC41	1.73
UBF89	1.38
UCC84	1.26
UCC85	1.38
UCF80	1.32
UCH42	1.38
UCH81	2.67
UCL82	1.20
UCL83	1.66
UF41	1.15
UF42	1.44
UF80	1.66
UF85	1.66
UF89	1.66
UL41	2.88
UL84	1.38
UM80	1.15

UY41	1.44
UY85	1.20
VLS631	15.24
XG1-2500	40.42
XG2-6400	113.50
XG5-500	28.52
XG2-6400	106.15
XR1-1600A	38.53
XR1-3200	93.15
XR1-3200A	93.15
XR1-6400	102.01
XR1-6400A	164.23
YD1120	264.50
YD1240	366.62
Z759	19.32
ZM1000	6.03
ZM1001	6.19
ZM1020	10.83
ZM1021	10.17
ZM1022	10.60
ZM1023	8.81
ZM1040	22.26
ZM1041	19.16
ZM1042	20.44
ZM1051	100.05
1B3GT	2.58
1B24	11.50
1B35A	28.75
1B63	57.50
1R5	1.21
1S5	0.46
1T4	0.46
2AS15	11.50
2C39A	21.85
2C43	20.70
2D21	2.94
2E26	15.34
2J42	89.70
2J55	239.97
2J70A	270.25
2J70B	418.34
2K25	40.25
3-400Z	57.50
3-500Z	63.25
3A5	2.70
3B24	9.20
3B28	8.63
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	18.73
3C45	28.18
3CX100A5	23.00
3E29	29.67
3S4	1.26
3V4	1.38
465A	29.15
4-125A	41.99
4-250A	41.99
4-400A	52.05
4B32	29.16
4C35	46.00
4CX250B	31.63
4CX350A	48.88
4X150A	24.41
4X150D	28.75

5B254M	23.12
5B255M	23.12
5C22	46.00
5J180E	1380.00
5R4GY	2.30
5U4G	3.86
5U4GB	2.90
5V4G	1.75
5Y3GT	0.98
5Z3	1.73
5Z4G	1.75
5Z4G7	1.75
6-30L2	1.79
6AB4	1.44
6AB7	1.73
6AC7	1.61
6AF4A	1.84
6AG7	2.30
6AH6	5.52
6AK5	4.15
6AK6	2.81
6AL5	1.01
6AM4	2.65
6AM5	8.21
6AM6	2.07
6AN5	4.45
6AN8A	3.97
6AQ5	1.10
6AS6	5.73
6AS7G	9.49
6AT6	0.98
6AU5GT	4.97
6AU6	1.24
6AV5GA	4.52
6AV6	0.98
6AX5GT	3.57
6B7	1.73
6B8	2.02
6BA6	1.15
6BA7	5.89
6BA8A	4.31
6BC4	4.27
6BE6	1.24
6BH6	1.75
6BJ6	1.24
6BK4	4.84
6BL6	97.75
6BL7GT	4.44
6BM6	97.75
6BN6	1.89
6BQ7A	4.28
6BR7	4.60
6BR8	2.02
6BS7	4.60
6BW6	4.60
6BW7	1.75
6BX7GT	5.70
6BZ6	2.73
6C4	1.01
CB6A	2.86
6CD6GA	5.83
6CG7	2.62
6CH6	9.78
6CL6	4.12
6CW4	8.83
6D2	1.01
6DK6	3.00
6DQ6B	4.69
6EA8	3.38

6EB8	2.44
6EW6	1.73
6F6	2.02
6F23	1.84
6F28	1.33
6F33	29.90
6H1	14.38
6H2N	1.21
6H3N	1.21
6H6	1.73
6J4	6.10
6J6	6.21
6J7	8.07
6K4N	1.44
6K6GT	1.50
6K7	1.73
6K8	2.02
6KD6	7.31
6L6G	2.88
6L6GA	1.73
6L6GT	2.24
6L6GC	2.88
6L7	2.30
6N2P	1.21
6N3P	1.21
6N7	1.73
6P25	4.14
6Q7	2.53
6R7	2.07
6SA7	1.67
6SC7	1.73
6SF7	1.84
6SH7	1.73
6SJ7	1.84
6SK7	1.50
6SK7GT	3.08
6SN7GT	1.84
6SQ7	1.50
6SR7	1.73
6SS7	2.07
6U5G	2.30
6U8	0.92
6U8A	3.38
6V6GT	1.84
6X4	1.38
6X5GT	0.97
7B7	1.96
7C5	3.40
7C6	2.60
7H7	2.30
7R7	1.73
7S7	2.59
7Y4	1.84
7Z4	2.13
11E3	60.82
12AT6	1.38
12AT7	1.01
12AU6	2.97
12AU7	0.83
12AV6	2.55
12AV7	4.00
12AX7	1.01
12AY7	4.69
12B4A	3.62
12BA6	2.52
12BE6	2.79
12BH7	1.29
12BY7	3.11
12E1	19.67
12E11TT	19.26

12E14	34.50
13E1	123.05
19H4	28.75
19H5	40.25
24B9	53.07
30C15	1.84
30C17	1.84
30C18	1.84
30F5	1.93
30FL1/2	1.28
30FL12	2.07
30FL14	1.84
30L1	1.15
30L15	2.07
30L17	2.07
30P4	1.06
30P19	1.38
30P1	2.88
30P13	2.07
30PL14	1.93
30PL15	2.07
35W4	0.69
50C5	0.81
75B1	5.18
75C1	2.70
85A1	8.63
85A2	2.65
90AG	14.90
90AV	14.90
90C1	2.70
90CG	16.72
90CV	17.50
92AG	14.90
92AV	14.90
95A1	7.19
150B2	3.34
150B3	6.15
150C2	2.13
150C4	2.65
211	6.90
723AB	40.25
803	11.50
805	23.00
807	4.31
811A	18.32
812A	18.26
813	85.87
833A	128.80
866A	15.23
872A	21.47
922	5.01
931A	16.97
1624	2.59
1625	1.96
2050	8.00
4212E	304.75
4212H	304.75
5544	62.10
5545	67.85
5551A	106.03
5552A	143.35
5553A	259.10
5642	6.45
5654	3.93
5651	2.65
5670	5.18
5675	19.91
5687	6.31
5696	4.35

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

Tested Ex-Equipment
4CX250B 5.75

BASES

B7G unskirted	0.17
B7G skirted	0.35
B9A unskirted	0.17
B9A skirted	0.35
Int Octal	0.29
Loctal	0.63
Nuvistor base	0.86
8 pin DIL	0.17
14 pin DIL	0.17
16 pin DIL	0.20
Valve screening cans all sizes	0.35

CRTs

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

5ADP1	40.25
5BP1	11.50
5CP1	11.50
5CP1A	46.00
5FP15A	17.25
5UP7	16.10
DG7-5	28.75
DG7-32	41.40
DH3-91	35.65
DH7-11	78.20
VCR97	13.80
VCR138	11.50

VCR138A	14.38
VCR139A	9.20
VCR517A	11.50
VCR517B	11.50
VCR517C	11.50

Tube Bases Prices on application

INTEGRATED CIRCUITS

7400	0.18
7401	0.18
7402	0.18
7403	0.18
7404	0.20
7405	0.18
7406	0.46
7407	0.46
7408	0.23
7409	0.23
7410	0.18
7412	0.30
7413	0.37
7416	0.37
7417	0.37
7420	0.20
7422	0.23

7423	0.37
7425	0.35
7427	0.35
7428	0.49
7430	0.20
7432	0.35
7433	0.41
7437	0.37
7438	0.37
7440	0.21
7441	0.97
7442	0.83
7447AN	1.04
7450	0.21
7451	0.21
7453	0.21
7454	0.21

7460	0.21
7470	0.40
7472	0.38
7473	0.41
7474	0.46
7475	0.62
7476	0.46
7480	0.63
7482	0.86
7483	1.04
7484	1.15
7486	0.40
7490	0.60
7491	0.92
7492	0.69
7493	0.69
7494	0.92

7495	0.83
7496	0.92
7497	3.45
74100	1.73
74107	0.52
74109	0.81
74110	0.58
74111	0.81
74116	2.02
74118	1.15
74119	1.73
74120	0.95
74121	0.46
74122	0.69
74123	1.15
74125	0.63
74126	0.63
74128	0.69

74132	0.81
74136	0.63
74141	0.92
74142	2.65
74143	2.88
74144	2.88
74145	1.04
74147	2.30
74148	2.02
74150	1.84
74151	0.97
74154	2.02
74155	0.97
74156	0.97
74157	0.86
74159	2.42
74170	2.65
74172	5.06

74173	1.61
74174	1.73
74175	1.04
74176	1.26
74178	1.44
74179	1.44
74180	1.32
74190	1.73
74191	1.73
74192	1.55
74193	1.55
74194	1.44
74195	1.15
74196	1.38
74197	1.26
74198	2.59
74199	2.59
76013N	2.02

TAA570	2.65
TAA630S	4.02
TAA700	4.50
TBA480Q	2.12
TBA520Q	2.65
TBA530	2.28
TBA540Q	2.65
TBA550Q	3.70
TBA560CQ	3.70
TBA673	2.52
TBA700	1.75
TBA720Q	2.65
TBA750Q	2.38
TBA800	1.38
TBA920	3.34
TBA920Q	3.34
TBA990Q	3.34
TCA270Q	3.34
TCA760A	1.59

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D.C. Current	60μA-1.5A	50μA-2.5A
A.C. Current	0.6mA-1.5A	0.5mA-2.5A
D.C. Volts	75m V-600V	75mV-1000V
A.C. Volts	15V-600V	1V-1000V
Resistance	1K-1M	300Ω-500kΩ
Capacity	0.5μF	0.5μF
Accuracy	1.5% D.C. 2.5% A.C.	2.5% D.C. 4% A.C.
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D.C. Voltage:	0.6-1.2-3-12-30-60-120-600-1200V
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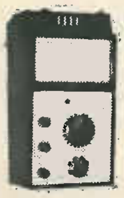

Sensitivity:	16,700Ω/V D.C., 3,300Ω/V A.C.
Current:	0.06-0.6-6-60-600mA D.C., 0.3-3.0-30-300mA A.C.
Voltage:	0.3-1.5-6-30-60-150-300-900V D.C. 1.5-7.5-30-150-300-750V A.C.
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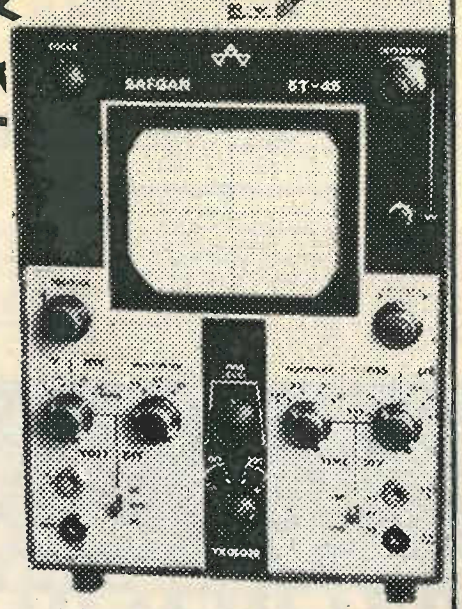

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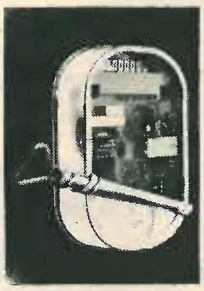

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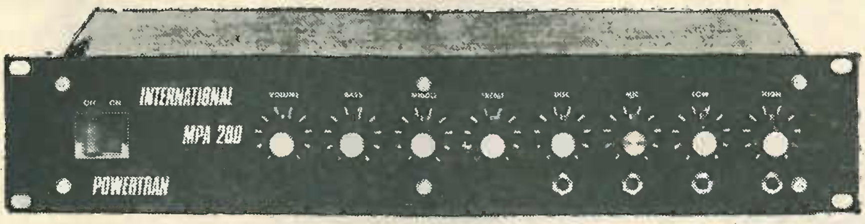

Panel size 19.0" × 3.5". Depth 7.3"

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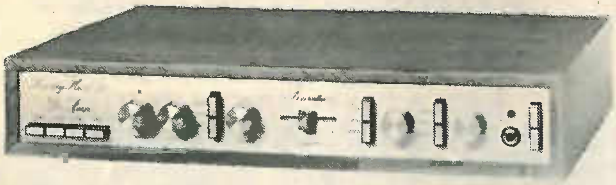
POWERTRAN

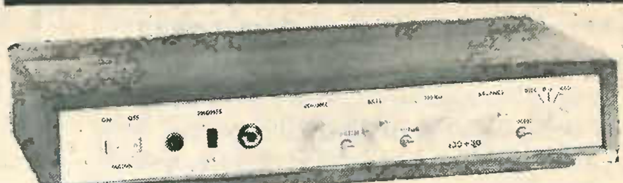
SYNTHESIZER KITS ON PAGE 103. MORE KITS AND ORDERING INFORMATION ON PAGE 101.

All kits also available as separate packs (e.g. PCB, component sets, hardware sets, etc.). Prices in our FREE CATALOGUE.



DE LUXE EASY TO BUILD LINSLEY HOOD 75W STEREO AMPLIFIER £99.30 + VAT

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



T20 + 20 20W STEREO AMPLIFIER £33.10 + VAT

This kit, based upon a design published in Practical Wireless, uses a single printed circuit board and offers at very low cost, ease of construction and all the normal facilities found on quality amplifiers. A 30 watt version of this kit (T30 + 30) is also available for **£38.40** + VAT. MATCHING TUNERS — See our FREE CATALOGUE!

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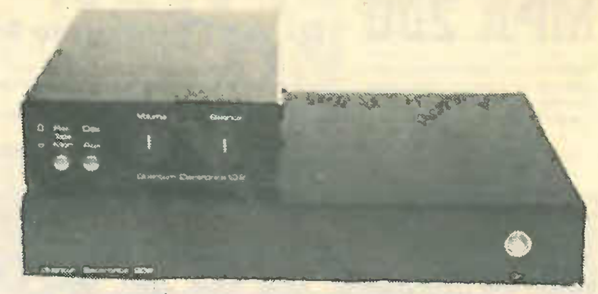

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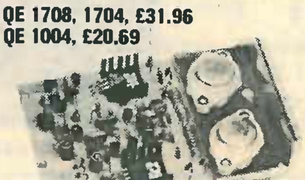

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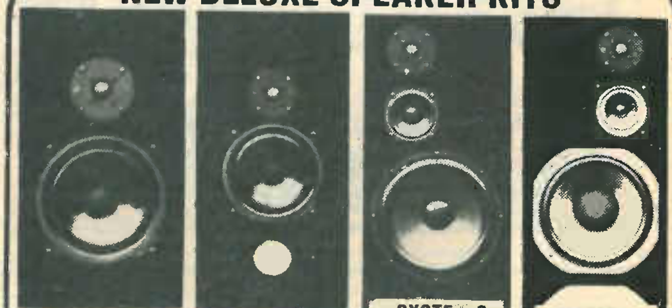

SYSTEM 1 £69.00 **SYSTEM 2 £89.00** **SYSTEM 3 £159.00** **SYSTEM 4 £359.00**

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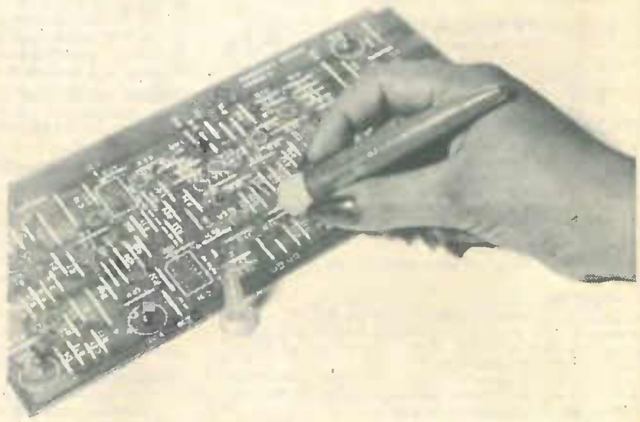

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104	2.0	7.88	1 31
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235	330 330	0-9, 0-9	2.19	0.44
207	500 500	0-8-9, 0-8-9	3.05	0.85
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206	1A 1A	0-15-20-0-15-20	5.09	1.10
203	.5 .5	0-15-27-0-15-27	4.39	1.10
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93	1500	0-115-200-220-240	25.61	0A
95	2000	0-115-200-220-240	38.31	0A
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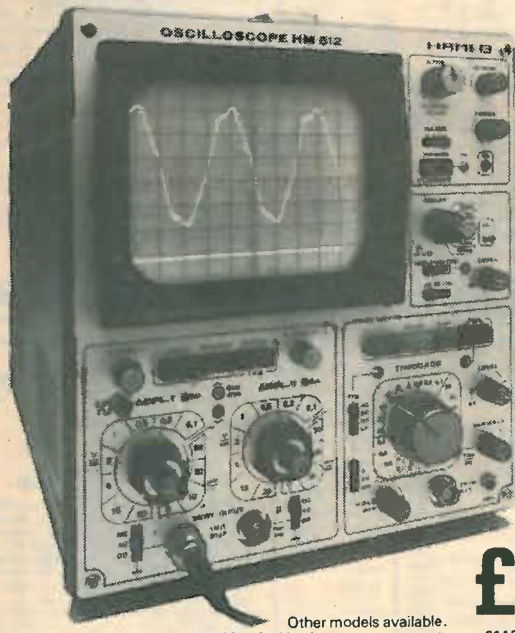

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7448	75p
7473	32p
7474	32p
7475	40p
7476	40p
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74LS47	78p
74LS48	85p
74LS49	99p
74LS73	30p
74LS74	30p
74LS75	39p
74LS86	39p
74LS90	40p
74LS107	40p
74LS123	69p
74LS125	50p
74LS132	79p
74LS138	69p
74LS151	75p
74LS153	75p
74LS155	65p
74LS161	78p
74LS163	90p
74LS164	90p
74LS168	190p
74LS174	99p
74LS175	99p
74LS195	87p
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4014	70p
4015	75p
4016	35p
4017	75p
4018	76p
4019	42p
4020	88p
4021	100p
4022	88p
4023	22p
4024	50p
4025	20p
4026	130p
4027	45p
4028	75p
4029	80p
4030	50p
4031	195p
4033	145p
4035	104p
4036	290p
4037	105p
4038	110p
4039	290p
4040	99p
4041	75p
4042	73p
4043	86p
4044	88p
4045	160p
4047	99p
4048	56p
4049	38p
4050	40p
4051	69p
4052	75p
4053	73p
4054	111p
4055	121p
4056	121p
4059	560p
4060	112p
4063	112p
4066	56p
4067	422p
4068	19p
4069	19p
4070	28p
4071	25p
4072	25p
4075	20p
4076	88p
4077	23p
4078	29p
4081	23p
4082	25p
4085	86p
4086	68p
4089	130p
4093	58p
4094	225p
4095	99p
4096	325p
4098	110p
4099	180p
4501	25p
4502	112p
4503	68p
4507	52p
4508	288p
4510	76p
4511	125p
4512	75p
4514	250p
4515	290p
4516	109p
4518	99p
4520	99p
4521	230p
4526	105p
4527	130p
4528	99p
4529	140p
4531	150p
4532	125p
4538	150p
4543	160p
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75325	325p
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75365	295p
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SPECIAL OFFER! 4K CMOS RAM (1K x 4) 450 NS ONLY £7.95! (8 for £50)

The TC 5514P from Toshiba, CMOS equivalent of the 2114!

- Low Power Dissipation
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- Data Retention Voltage 2V to 5.5V
- Single 5V Power Supply
- 18 PIN Plastic Package
- Full Static Operation
- Three State Output
- Input/Output TTL Compatible
- Fast Access Time 450NS

Toshiba's TC5514P (industry type 6514) is a full static read write memory organised as 1024 words by 4 bits using CMOS technology. Ultra low power dissipation means it can be used as battery-operated portable memory system and also as a non-volatile memory with battery back-up. Operates from a single 5V power supply with static operation, hence no refresh periods and a much simplified power supply circuit design. Three state outputs simplify memory expansion for minimum data retention voltage is 2V, the battery back-up systems needs only simple circuit. Toshiba's original C2MOS technology also means wide operating and noise margins. The TC5514P is moulded in a dual-in-line 18 pin plastic package 0.3 inch in width.

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WITH CALENDAR AND NOXtm CIRCUIT

ONLY **£19.99**
Custom high impact moulded case with ruby lens. **£4.99**
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- Unit operates on either **12 VAC** or **12 VDC.**
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- Reads true **24 HOUR TIME** and **31 DAY CALENDAR.**
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- When used mobile readouts blank iginition is off.
- Special **NOISE SUPPRESSION** and battery reversal circuits.
- Bright ½" LED's show hours, minute and seconds.

Just clap your hands and the time appears for 5 seconds followed by the date for 4 seconds. A low cost 9V transistor battery provides stand by power in the event of power failures up to 4 hours. With the addition of a low cost 12V 300 MA transformer, the unit will work on AC.

SE 01 Sound Effects Kit

NEW

The SE-01 is a complete kit that contains all the parts to build a programmable sound effects generator. Designed around the new **Texas Instruments SN76477** Sound Chip, the board provides banks of MINI DIP switches and pots to program the various combinations of the SLF Oscillator, VCO, Noise, One Shot, and Envelope Controls. A Quad Op Amp IC is used to implement an Adjustable Pulse Generator, Level Comparator and Multiplex Oscillator for even more versatility. The 3¼" x 3" PC Board features a prototype area to allow for user added circuitry. Easily programmed to duplicate **Explosion, Phaser Guns, Steam Trains,** or almost an infinite number of **other sounds.** The unit has a multiple of applications. The low price includes all parts, assembly manual, programming charts, and detailed 76477 chip specifications. It runs on a 9V battery (not included). On board 100MW amp will drive a small speaker directly, or the unit can be connected to your stereo with incredible results! (Speaker not included.)

COMPLETE KIT ONLY £14.99
P&P 67p + VAT

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C106D 400V/5A Sale	30p

THE NEW GI COMPUTER SOUND CHIP

The amazing AY-3-8910 is a fantastically powerful sound and music generator, perfect for use with any 8-bit micro processor. Contains 3 tone channels, noise generator, 3 channels of amplitude controls, 16-bit envelope period control, 2 parallel I/O, 3D/A converters plus much more. All in 40 pin DIP. Super easy to interface to the S-100 or other Busses.
Only **£8.50 + VAT,** including FREE reprint of BYTE '79 article! Also, add £2.25 for 60-page data manual.
"Perhaps the next famous composer will not direct a 150-piece orchestra but, rather, a trio of microcomputers controlling a bank of AY-3-8910s." BYTE July '79.

NEW

ULTRASONIC SENDER RECEIVER KIT

TOTAL SECURITY! Completely invisible ultrasonic (23KHZ) Sound beam works like a photoelectric beam but is unaffected by light, heat or noise. Separate Transmitter and Receiver can be used from 6 inches to 25 feet! A solid object breaking the beam causes an output to go low that will sink up to 150 MA to Drive a Relay, TRIAC, etc. Complete electronics are provided. Works on 12VDC (unregulated) and draws less than 100 MA. Use it for **burglar alarms, object counters, automatic door openers, automatic door bells, electronic rat trap(?) and more.**

ONLY £19.93 P&P 67p + VAT

NEW

WARBLE ALARM Kit

A fun EASY kit to assemble that emits an ear piercing 10 watt dual tone scream. Resembles European siren sound. Great for alarms or toys. Operates from 5-12VDC at up to 1 amp (using 12VDC ● 8 ohm speaker). Over five thousand have been sold. All parts including PC board, less speaker. **ONLY £4.99** P&P 67p + VAT

NEW

LM1871 RC ENCODER/TRANSMITTER LM1872 RC RECEIVER/DECODER

New from National. The LM1871 is a complete six-channel digital proportional encoder and RF transmitter intended for use as a low power, non-voice unlicensed communication device at carrier frequency of 27 MHz with a field strength of 10,000 uV meter at 3 metres. In addition to radio controlled hobby toy and industrial applications, the encoder section can provide a serial input of six words for hard wired, infra-red or fibre optic communication links. Channel add logic is provided to control the number of encoded channels from three to six, allowing increased design flexibility. When used with the LM1872 RC receiver/decoder, a low cost RF linked encoder and decoder system provides two analog and two ON/OFF decoded channels. Super versatile chip. Just out. Just look at the features — low current 9V battery operation — on-chip RF oscillator/transmitter — one timing capacitor for six proportional channels — programmable number of channels — regulated RF output power — external modulator bandwidth control — on-chip 4.6V regulator — up to 80 MHz carrier frequency operation.
LM1871 £5.50 LM1872 £5.50 Pair £10.50.
Data sheets 25p each.

NEW

TUNES SYNTHESIZER

The AY3-1350 is a MOS microcomputer synthesizer of preprogrammed tunes for applications in toys, music boxes and door chimes. The standard device has a set of 25 different popular and classical tunes. In addition there are 3 chimes making a total of 25 tunes.

FEATURES

- Minimal external components
- Automatic switch-off signal at end of tune for power saving
- Envelope control to give organ or piano quality
- Sequential tune mode
- 4 door capability when used as door chime
- Operation with tunes in external PROM if required (2708)
- Single supply (+5V) operation
- Tunes include: STAR WARS, BEETHOVEN'S 9TH and 5TH, JINGLE BELLS, YANKEE DOODLE, STAR SPANGLED BANNER, CLEMENTINE, GOD SAVE THE QUEEN, O SOLE MIO, WESTMINSTER CHIMES, and DESCENDING OCTAVE CHIME PLUS MANY MORE! With detailed specs and instructions.

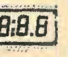
£6.95

NEW

PROGRAMMABLE DUAL OP TRANSCONDUCTANCE AMPLIFIER

New from National Semiconductor, the LM13600 is a programmable dual operation transconductance amplifier designed to be used as a fundamental building block in current controlled amplifiers, filters and oscillators. It can also be used in multiplexers, timers and even sample and hold circuits. It is well suited for use in electronic organs and music synthesizers, because it can modulate waveshapes with ease. The 16 pin LM13600 is programmable over six decades, allowing it to function as a basic building block in a broad range of electronically programmable resistors and filters. A truly remarkable circuit. **ONLY £1.25** + VAT Data 25p.

3½-DIGIT LIQUID CRYSTAL DISPLAY with 'Low bat' indicator



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LCD106 .... £6.45

LED BAR GRAPH AND ANALOG METER DRIVER

New from National LM3914. Drives 10 LED directly for making bar graphs, audio power meters, analog meters, LED Oscillators, etc. Units can be stacked for more LEDs. A super versatile and truly remarkable IC.
Special price: Only **£2.25**
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THE NEW ULN-2232A INTEGRATED MOTION DETECTOR

The most SOPHISTICATED MOTION DETECTOR available!

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- Two Sound Patterns
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- 14-pin Dual In-line Clear Plastic Package

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Combining I2L and Bipolar circuitry, the ULN-2232A Motion Detector is a complex optolinear IC which includes an on-chip photodiode, high-gain logarithmic and linear amps, extensive digital circuitry for sound generation and timing, and high-current output drivers. Add on five small capacitors, a speaker and power source and you turn this state-of-the-art device into a complete Motion Detector sensitive to small changes in light level as a function of time. DETAILED DEVICE DESCRIPTION AND APPLICATIONS INFORMATION INCLUDED WITH EVERY ULN-2232A.

MUSIC FOR YOUR EARS

Bullet's **Electronic Music Maker TM Kit** has a single **28 Pin Microprocessor Chip with ROM** that has been programmed to play the first 6 to 10 notes of the **25 popular tunes** listed below. Each tune can be addressed individually or played sequentially at the push of a button. The 3 chime sequences are activated at any time by separate switch closures, so when used as a doorbell, one door can play songs while two others will play different chimes. The unit has a **5 watt audio Amp and will run on either 12 VAC or 12 VDC.** Construction is very simple, works with any 8 or 16 ohm speaker, or horn speaker (not included). Tunes can be remotely programmed using a single rotary switch (not included), if desired. **Complete Kit £9.95.** 240 V Transformer optional. Tunes: Toreador; William Tell; Hallelujah Chorus; Star Spangled Banner; Yankee Doodle; America America; Deutschland Leid; Wedding March; Beethoven's 5th and 9th; Hell's Bells; La Vien en Rose; Star Wars Theme; Clementine; Marseillaise; O Sole Mio; Santa Lucia; The End; Blue Danube; Brahams Lullaby; Westminster Chime; Simple Chime; Descending Octave Chime; Augustine; Jingle Bells; God Save The Queen; Colonel Bogie.

The XR2266 Decoder/Sense & Drive Chip for toy cars that DRIVE LIKE REAL!

ONLY £5.45!

This versatile 18-pin dual in-line IC combines both the decoder **and** the sense and drive functions to cut remote control car circuitry by **at least** a factor of two! Steering, lights, indicators, speed control — all from the new XR2266 at only **£5.45!**

Ordering information. Unless otherwise stated, for orders under £50 add 50p p&p. Add 15% VAT to total. All devices are brand new, factory prime and full spec and subject to prior sale and availability. Prices subject to change without notice.

Minimum telephone order using ACCESS is £10. If ordering by post with Access, include name, address and card no. written clearly.

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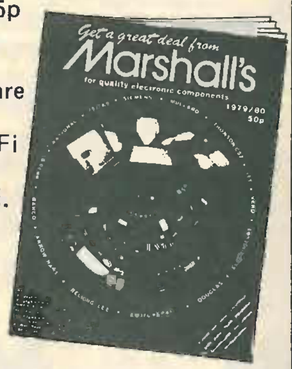

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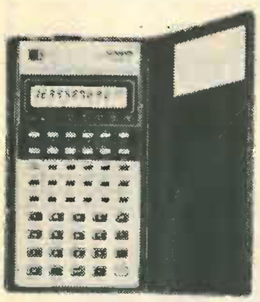
CASIO FX-502P PROGRAMMABLE CALCULATOR



- LINKS UP WITH AN ADAPTOR FOR PROGRAMME — DATA STORAGE ON STANDARD CASSETTES.
- 256-step programme memory and 22 data registers are both protected (non-volatile).
- Up to 10 levels of parenthesis nesting.
- True algebraic logic — easy key operations same as written formulae.
- Battery service life is 1,300 hours. Auto power-off feature is provided.
- Thin and lightweight; easy to carry around.
- Up to 10 programmes available; programme keys otherwise usable as user's functions.
- 51 built-in functions all usable in programmes.
- A variety of "jump" commands. Unconditional jumps, conditional jumps and indirect jump.
- Up to 9 subroutines incorporable: nesting possible up to 9 levels.
- Easy to edit and debug programmes. PAUSE key, random number key, back step/rapid run key.
- Amazing operating speed.

Optional FA-1 Programme Adaptor permits programme/data storage on standard cassette tape recorders for re-entry. Typical storage/re-entry time 9-16 seconds, with a three-digit code for programme reference and identification. Also contains a music switch which converts both calculators into musical synthesisers — duration of notes, rests, tempo, slur and tie are all programmable.

Dimensions are 9.6mm H × 71mm w × 141.2mm D (3/8" H × 2¾" W × 5 ½" D). A comprehensive Programme Manual, Instruction Booklet and leatherette wallet are supplied. FA-1 comes complete with a demonstration cassette with pre-recorded programmes, including games and music.

plus FREE **MASTER PACK**
Software package (R.R.P **£17.95**)
on request with order

MASTER PACK comprises USER MANUAL with basic and advanced programming, etc., PLUS pre-recorded cassette with over 150 ready-to-run programmes. Full cassette library, personal computer programmes, banking, diet, biorhythms, powerful sub-routines and data packing.

FX-502P (R.R.P. £84.95) **£74.95** FA-1 Adaptor (R.R.P. £24.95) **£19.95**

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IMMEDIATE DELIVERY

8050A 4½ Digit LCD DMM with true RMS on AC volts and current DC volts 200mV-1KV, 10μV resolution AC volts. 200mV-750V, 10μV resolution. DC/AC current 200μA-2A, 0.01μA resolution resistance 200Ω-20MΩ, 0.01Ω resolution. Also reads dB direct referenced to 16 stored impedances. Conductance ranges 2mS and 200nS.
£199 mains model
£239 mains battery.

8012A 3½ Digit LCD DMM with true RMS on AC volts and current. DC volts 200mV-1KV, 100μV resolution. AC volts 200 mV-750V, 100μV resolution. DC/AC current 200μA-2A, 0.1μA resolution. Resistance 200Ω-20MΩ, 0.1Ω resolution Low resistance 2Ω and 20Ω, 1mΩ resolution Conductance ranges 2mS-20μS-200nS
£199.00 mains model
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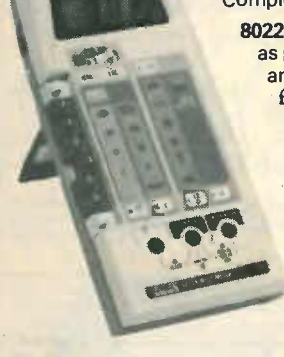
8010A 3½ Digit LCD DMM Same spec as 8012A plus a 10Amp AC/DC current range, but no low resistance range.
£159.00 mains model
£179.00 mains battery.

8024A 3½ Digit hand held LCD DMM with peak hold Level Detector and continuity tester. DC volts 200mV-1KV, 100μV resolution. AC volts 200mV-750V, 100μV resolution. DC/AC current 2mA-2A, 1μA resolution. Resistance 200Ω-20MΩ, 0.1Ω resolution. Conductance 200nS. Peakhold of AC or DC volts and current. Level detector operates around +0.8V reference. Audio tone on level and continuity. **£135.00** carrying case £7.00 extra.



8020A 3½ Digit hand held LCD DMM. spec as per 8024A with extra conductance range of 2mS but no peak hold, level or continuity ranges. Complete with carrying case. **£112.00**

8022A 3½ Digit hand held LCD DMM. Spec as per 8020A but no conductance ranges and slight reduction on accuracy. Was £89.00 now reduced to **£75.00** carrying case £7.00 extra.

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

The warranty period on all items shown is 1 year other than the 8020A which is 2 years.

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5½ digit D.M.M. 8800A-01 £650
5½ digit D.V.M. 8300A £199
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5½ digit. AC/DC volts. 1µv resolution on DC. Autoranging. Variable display time. Resistance down to 1mΩ

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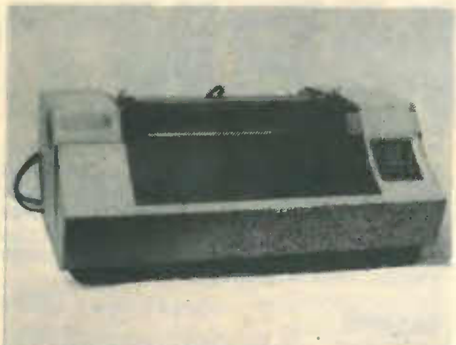
No.1 in Second User Minis & Peripherals



CENTRONICS 101A
Heavy duty Matrix Printer with 64 ASCII upper case character set, 165 cps operation, 132 print positions with adjustable tractor feed, 7×9 dot matrix, parallel input. **£750.00.**

DEC PDP 11/34 Processor.
10½" 128KB MOS. DL11W, KY11B PRICE **£6950.00**

ASR 33 Teletype
Input/Output terminal incorporating paper tape punch and reader 64 ASCII upper case character set, 110 baud operation, even parity keyboard, choice of RS232 or 20 mA interface NOW ONLY £595.00
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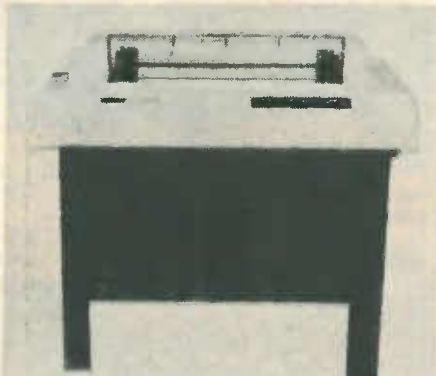
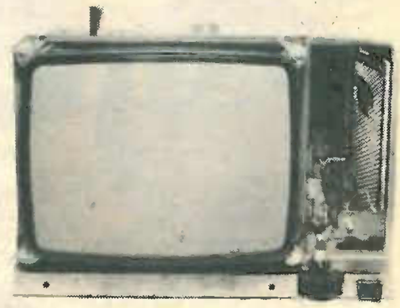
GE TERMINET 1200 RO
High-Speed typewriter-quality Impact Printer with switch-selectable print speeds of 30, 60 and 120 cps. 80 print positions with adjustable pin-feed paper tractor. Full upper and lower case ASCII character set. Current loop (20mA) Interface NOW ONLY **£495.00.** (optional extra — parity card **£50.00**)



DEC LA-11PD 180cps
Matrix Printer, Parallel Input. **£1250.00**



EMI MONITOR
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KB 771 Superb 71-station ASCII Keyboard incorporating separate numeric/cursor control pad and installed in custom-built steel enclosure with textured blue enamel finish. Ideal for the VDU builder. Case dimensions 17¼" × 7½" × 3⅝". Total weight 4kg. PRICE **£89.50**
(mail order total £108.10).

Mail Order Total

KB756 56-station ASCII Keyboard mounted on P.C.B. £45.00 **£53.48**
KB756MF As above, fitted with metal mounting frame for extra rigidity ... £49.50 **£58.65**
KB710 10-key numeric pad, supplied with connecting cable £8.00 **£9.78**
KB701 Plastic enclosure for KG756 or KB756MF £12.50 **£15.24**
KB702 Steel enclosure for KB756 or KB756MF £18.00 **£23.00**
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DB25S Mating connector for KB771 £4.25 **£5.46**
PERK 56-station ASCII Keyboard for PET Complete with PET interface, built-in power supply and steel enclosure £145.00 **£172.50**
Discounts available for quantities

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TEXAS 743 Portable Terminal RS232 ... **£795.00**

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£199 + VAT

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£425 + VAT

Hazeltine H-1000

The low, low priced teletypewriter-compatible video display terminal, offering your choice of transmission speeds up to 9600 baud as well as parity generation and checking.

Specification

SCREEN SIZE — 12" diagonal.
SCREEN CAPACITY — 960 characters; 80 per line x 12 lines.
CHARACTERS — 5 x 7 Dot Matrix; 625-line raster.
CHARACTER SET — 64 ASCII alphanumerics and symbols.
KEYBOARD — TTY format.
INDICATORS — Power On. Parity Error.
PARITY — Parity error indicated by Parity Light and question mark (?) displayed in character position.
TRANSMISSION — Asynchronous. Switch-selectable for any two standard rates up to 9600 baud.
OPERATING MODES — Full/Half Duplex.
MEMORY — High Speed MOS refresh.
STANDARD INTERFACE — CCITT V-24 (EIA RS-232 B/C).
REFRESH RATE — 50 fields per second.

When ordering please specify your choice of switch-selectable baud rates.
Standard: — Either A) 110/300 baud
or B) 300/1200 baud
Optional: A combination of any 2 of the following transmission speeds can be provided at a surcharge of £25.00.
75, 110, 150, 200, 300, 600, 900, 1200, 1800, 2400, 4800, 9600, (N.B.: 900/1800 not compatible with 110/200 respectively).

Hazeltine H-2000

The world's largest-selling teletypewriter-compatible video display terminal. The Hazeltine 2000 sets the standard in features, performance, reliability and value in an ever-expanding list of applications in Universities, Hospitals, Business, Finance and Government.
Features include ★ Switch-selectable transmission rates to 9600 baud ★ Three switch-selectable operating modes — full duplex, half-duplex or batch ★ Direct cursor addressability ★ Dual-intensity video ★ Tabulation ★ Powerful editing capability ★ Remote keyboard ★ Selective or automatic roll-up ★ Teletype compatible ★ Parity select ★ Large screen capacity ★ Clear 5 x 7 matrix character image ★ Full remote command set ★ Format capability ★ Standard peripheral interfaces.

Specification

SCREEN — 12" diagonal. 1998 characters: 74 per line x 27 lines.
CHARACTERS — 5 x 7 Dot Matrix; 625 lines raster.
CHARACTER SET — 64 alphanumerics and symbols. 32 ASCII control codes.
KEYBOARD — Detachable, solid state. TTY design. 10-key numeric cluster plus editing and cursor control keys.
TRANSMISSION — Asychronous. Switch-selectable, for combinations of 5 standard rates, 110 to 9600 baud.
OPERATING MODES — Switch-selectable, full duplex, half-duplex or batch.
MEMORY TYPE — 2048 x 8 RAM.
EDITING FEATURES — Full Cursor Controls plus Insert/Delete Character, Insert/Delete Line, Clear Screen, Clear Foreground Data Only, Tab.
STANDARD INTERFACE — CC ITT V-24 (EIA RS-232 B/C).
REMOTE COMMANDS — Insert/delete Line, Clear Screen, Clear Foreground Data Only, Home Cursor, Address Cursor, Set Background intensity, Set Foreground Intensity, Carriage Return, Backspace, Ring Bell, Transmit, Print.
AUXILIARY OUTPUT — Standard printer interfaces; Standard cassette interface.

Hazeltine MODULAR ONE

The Hazeltine Modular One terminal offers the full range of terminal performances — from simple teletypewriter compatibility to enhanced editing and polling capabilities.
The Modular one is supplied in two different versions. The BASIC MODEL provides the following features: ★ 1,920 character display (80x24) ★ 12-inch bonded ★ Incremental and absolute cursor positioning. ★ Dual video intensity ★ 11-key numeric pad ★ Movable keyboard ★ Choice of 8 transmission rates up to 9600 baud ★ Communication interfaces: EIA RS-232 and current loop ★ Choice of block or blinking underscore cursor ★ Choice of white-on-black or black-on-white display representation.

Optional:

Lower Case	£35.00
Printer Port (parallel)	£70.00
Printer Port (serial)	£70.00
EIA Data Cable	£15.00
Remote Edit	P.O.A.
Current Loop Interface	P.O.A.
Synchronous Interface	P.O.A.
External Baud & Parity Switch	P.O.A.
Also available: EDIT MODEL	£695
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SO LOW EVEN OUR COMPETITORS GASP!

DATA DYNAMICS 390 ASCII PRINTERS

ONLY £135 + CAR + VAT

Printer only version of the world famous Teletype KSR33 but with the additional bonus of being housed in a special attractive sound proof case which cuts down any mechanical noise to a minimum. Also fitted is a unique data detect circuit which automatically turns the machine on and off on receipt/end of data from the computer. Standard features such as ASCII, 110 baud, and RS232 interface enable direct connection to most micros. Supplied in good condition and in working order.

TELETYPE ASR33 I/O TERMINALS

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Fully fledged industry standard ASR33 data terminal. Many features including: ASCII keyboard and printer for data I/O, auto data detect circuitry, RS232 serial interface, 110 baud, 8 bit paper tape punch and ready for off line data preparation and ridiculously cheap and reliable data storage. Supplied in good condition and in working order.
Options: Floor stand **£12.50 + VAT**
Sound proof enclosure **£25.00 + VAT**

ICL TERMIPRINTER 300 BAUD TERMINALS

£325 + CAR + VAT

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

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- 40-512 Mhz
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And Remember All Chip Prices *Include* V.A.T.

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8" Floppy Disk Drives
as new **£225.00 + VAT**

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SUPER CASED VERSION Same as above spec. but housed in attractive two tone moulded, free standing case. Unit also includes an all TTL parallel to serial convertor (no details) etc.

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25 way ex-equip. plug or socket **£1.25**

Edge connectors, gold plated

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All connectors easily cut to size
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LM13600	125p	XR2207	400p
MC1310P	150p	ZN414	90p
MC1458	48p	ZN419C	225p
MC1495L	350p	ZN424E	135p
MC1496	100p	ZN425E	400p
		ZN427E	750p

VOLTAGE REGULATORS
Fixed Plastic TO-220

			−ve	
1A	+ve			
5V	7805	60p	7905	65p
12V	7812	60p	7912	65p
15V	7815	60p	7915	70p
18V	7818	60p	7918	70p
24V	7824	60p	7924	70p
100mA	TO92			
5V	78L05	30p	79L05	70p
12V	78L12	30p	79L12	70p
15V	78L15	30p	79L15	70p

OTHER REGULATORS

LM309K	135p	78HGKC	600p
LM317T	200p	78HO5KC	600p
LM323K	550p	78MGT2C	135p
LM723	37p	79HGKC	700p
		TL497	300p

OPTO-ELECTRONICS

2N5777	45p	ORP60	120p
OCP71	130p	ORP61	120p
ORP12	120p	TIL78	55p

OPTO-ISOLATORS

ILD74	130p	TIL111	90p
MCT26	100p	TIL112	90p
MCS2400	190p	TIL116	90p

LEDS

0.125"		0.2"	
TIL32	55p	TIL220 Red	16p
TIL209 Red	13p	TIL222 Gr	18p
TIL211 Gr	20p	TIL228 Red	22p
TIL212 Ye	25p	Rectangular LEDs (R, G, Y)	30p
TIL216 Red	18p		

DISPLAYS

3015F	200p	NSB5881	570p
DL704	140p	TIL311	600p
DL707 Red	140p	TIL312/3	110p
707 Gr	140p	TIL321/2	130p
DL747 Red	225p	TIL330	140p
747 Gr	225p	7750/60	200p
FND357	120p	**DRIVERS**	
FND500	120p	9368	250p
FND507	120p	9370	300p
MAN3640	175p	UDN6118	320p
MAN4640	200p	UDN6184	320p

TRANSISTORS									
		BFR40	25p	TIP31A	58p	2N3553	240p	40364	120p
AC126	25p	BFR41	25p	TIP31C	62p	2N3565	30p	40408	70p
AC127/8	20p	BFR79	25p	TIP32A	68p	2N3584	250p	40409	85p
AC176	25p	BFR80	25p	TIP32C	82p	2N3643/4	48p	40410	85p
AC187/8	25p	BFR81	25p	TIP33A	90p	2N3702/3	12p	40411	300p
AF116	50p	BFX29	40p	TIP33C	114p	2N3704/5	12p	40594	120p
AD149	70p	BFX30	34p	TIP34A	115p	2N3706/7	14p	40595	120p
AD161/2	45p	BFX84/5	40p	TIP34C	160p	2N3708/9	12p	40673	75p
AU107	200p	BFX86/7	30p	TIP35A	225p	2N3773	300p	40841	90p
BC107/8	11p	BFX88	30p	TIP35C	290p	2N3819	25p	40871/2	100p
BC109	11p	BFW10	90p	TIP36A	270p	2N3820	50p		
BC117	20p	BFY50	30p	TIP36C	340p	2N3823	70p		
BC147/8	9p	BFY51/2	30p	TIP41A	65p	2N3866	90p		
BC149	10p	BFY56	33p	TIP41C	78p	2N3902	700p		
BC157/8	10p	BFY90	90p	TIP42A	70p	2N3903/4	18p		
BC159	11p	BRY39	45p	TIP42C	82p	2N3905/6	20p		
BC169C	12p	BSX19/20	20p	TIP54	160p	2N4037	65p		
BC172	12p	BU104	225p	TIP120	120p	2N4058/9	12p		
BC177/8	17p	BU105	190p	TIP122	130p	2N4060	12p		
BC179	18p	BU108	250p	TIP142	130p	2N4061/2	18p		
BC182/3	10p	BU109	225p	TIP147	130p	2N4123/4	27p		
BC184	11p	BU205	200p	TIP2955	78p	2N4125/6	27p		
BC187	30p	BU208	200p	TIP4055	70p	2N4401/3	27p		
BC212/3	11p	BU406	145p	TIS43	34p	2N4427	90p		
BC214	12p	E300	50p	TIS93	30p	2N4871	60p		
BC237	15p	E308	50p	ZTX108	12p	2N5087	27p		
BC327	16p	E310	50p	ZTX300	13p	2N5089	27p		
BC337	16p	MJ2501	225p	ZTX500	15p	2N5172	27p		
BC338	16p	MJ2955	90p	ZTX502	18p	2N5179	90p		
BC461	38p	MJ3001	225p	ZTX504	30p	2N5191	90p		
BC477/8	30p	MJE340	50p	2N457A	250p	2N5194	90p		
BC516/7	40p	MJE2955	100p	2N696	35p	2N5245	40p		
BC547B	16p	MJE3055	70p	2N697	25p	2N5296	55p		
BC548C	9p	MPF102	45p	2N698	45p	2N5401	50p		
BC549C	18p	MPF103/4	40p	2N706A	30p	2N5457/8	40p		
BC557B	16p	MPF105/6	40p	2N708	30p	2N5459	40p		
BC559C	18p	MPS6531	50p	2N918	45p	2N5460	60p		
BCY70	18p	MPS6534	50p	2N930	18p	2N5485	44p		
BCY71/2	22p	MPSA06	30p	2N1131/2	36p	2N5875	250p		
BD131/2	50p	MPSA12	50p	2N1613	25p	2N6027	48p		
BD135/6	54p	MPSA13	50p	2N1711	25p	2N6052	300p		
BD139	56p	MPSA20	50p	2N2102	70p	2N6059	325p		
BD140	80p	MPSA42	50p	2N2160	350p	2N6107	65p		
BD189	60p	MPSA43	50p	2N2219A	30p	2N6247	190p		
BD232	95p	MPSA56	32p	2N2222A	30p	2N6254	130p		
BD233	75p	MPSA70	50p	2N2369A	25p	2N6290	65p		
BD235	85p	MPSU06	63p	2N2484	30p	2N6292	65p		
BD241	70p	MPSU07	90p	2N2646	45p	2SC1172	150p		
BD242	70p	MPSU45	90p	2N2904/5	30p	3N128	120p		
BDY56	200p	MPSU65	78p	2N2906A	30p	3N140	120p		
BF200	32p	OC28	130p	2N2907A	30p	3N141	110p		
BF244B	35p	OC35	130p	2N2926	9p	3N201	110p		
BF256B	70p	TIP29A	40p	2N3053	30p	3N204	120p		
BF257/8	32p	TIP29C	55p	2N3054	65p	40290	250p		
BF259	36p	TIP30A	48p	2N3055	48p	40360	40p		
BFR39	25p	TIP30C	60p	2N3442	140p	40361/2	75p		

DIODES

BY127	12p
BYX36-300	20p
OA47	9p
OA81	15p
OA85	15p
OA90	9p
OA91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
IS920	9p

HEAT SINKS
For TO220 Voltage Regs. and Transistors 22p
For TO5 12p

BRIDGE RECTIFIERS

1A	50V	19p
1A	100V	20p
1A	400V	25p
1A	600V	30p
2A	50V	30p
2A	100V	35p
2A	400V	45p
3A	200V	60p
3A	600V	72p
4A	100V	95p
4A	400V	100p
6A	50V	60p
6A	100V	100p
6A	400V	120p

10A	400V	200p
25A	400V	400p

ZENERS
2.7V-33V
400mW 9p
1W 15p

TRIACS PLASTIC

3A 400V	60p
6A 400V	70p
6A 500V	88p
8A 400V	75p
8A 500V	95p
12A 400V	85p
12A 500V	105p
16A 400V	110p
16A 500V	130p
T2800D	130p

THYRISTORS

1A 50V	70p
1A 400V	90p
3A 400V	90p
8A 600V	140p
12A 400V	160p
16A 100V	160p
16A 400V	180p
BT106	110p
C106D	45p
MCR101	36p
TIC44	27p
2N3525	130p
2N4444	140p
2N5060	34p
2N5064	40p

LOUDSPEAKERS

Size		
2½	64R	80p
2½	8R	80p
2	8R	90p
1½	8R	100p

MEMORIES

2101-4L	400p
2102-2L	120p
2107B	500p
2111-2	400p
2112-2	300p
2114	300p
2114-2L	500p
4027-3	375p
4044	900p
4116	400p
5101	510p
6810	325p
74S201	350p
82516	325p
ROM/PROMs	
71301	700p
74S188	225p
74S387	350p
74S470	650p
74S471	650p
74S571	650p
82S137	750p
93427	400p
CPUs	
1600	1200p
1802CE	750p
2650A	2000p
6502	1000p
6800	650p
6802	1100p
6809	2500p
8080A	450p
8085A	1200p
1NS8060	1000p
Z80	£10
Z80A	1150p
EPROMS	
1702A	500p
2708	450p
2716 (+5V)	£10
SUPPORT DEVICES	
3242	800p
3245	450p
6522	800p
6532	1000p
6820	500p
6821	375p
6845	2500p
6850	300p
6852	370p
8155	1100p
8205	320p
8212	225p
8216	225p
8224	275p
8226	250p
8228	525p
8251	550p
8253	1000p
8255	550p
8257	900p
8259	950p
Z80P10	650p
Z80AP10	600p
Z80CTC	650p
MC14411	1100p

UART

AY-3-1015P	500p
AY-5-1013P	400p
IM6402	500p
TMS6011NC	400p

CHARACTER GENERATORS

3257ADC	990p
RO-3-2513 U.C.	600p
RO-3-2513 L.C.	700p
SN74S262AN	£10

KEYBOARD ENCODER
AY-5-2376 700p

CRYSTALS

32.768KHz	250p
100KHz	300p
200KHz	370p
1.0MHz	320p
1.008MHz	350p
1.8432MHz	325p
2.00MHz	325p
2.45760MHz	325p
3.276MHz	300p
3.579MHz	175p
4.00MHz	290p
4.194MHz	POA
4.43MHz	125p
5.0MHz	325p
6.0MHz	300p
6.144MHz	300p
7.00MHz	300p
7.168MHz	300p
8.00MHz	300p
8.867MHz	300p
10.00MHz	310p
10.7MHz	300p
12.0MHz	350p
16.00MHz	350p
18.00MHz	300p
18.432	350p
19.968MHz	390p
26.690MHz	350p
27.145MHz	325p
38.6667MHz	350p
48.0MHz	300p
55.5MHz	400p
116.0MHz	350p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	20p	28 pin	30p
16 pin	11p	22 pin	22p	40 pin	40p

WIRE WRAP SOCKETS BY TEXAS

8 pin	25p	18 pin	50p	24 pin	70p
14 pin	35p	20 pin	60p	28 pin	80p
16 pin	40p	22 pin	65p	40 pin	100p

SUBMINIATURE SWITCHES

Toggle	
SPST	60p
SPDT	65p
DPDT	70p
DPDT (centre off)	85p
Push to make	15p
Break	25p
Push latching SPCO	60p
SLIDE DPDT	18p
ROCKER SPST	28p
WAFER	
1P/12W	45p
3P/4W	45p
4P/3W	45p
2P/6W	45p

ANTEX SOLDERING IRONS

C-15W	415p
CX-17W	425p
CCN-15W	425p
X25	440p
SPARE BITS	
C/CX/CCN	50p
X25	50p
SPARE ELEMENTS	
C/CX/X25	180p
CCN	200p
ADCOLA IRONS	
K1000	550p
K2000	550p

TRANSFORMERS
(prim 220/240V)

6-0-6	100mA	90p
9-0-9	75mA	95p
9-0-9 1Amp		330p
0-12V	2A	410p
15-0-15 1A		325p
0-12-15 20-24-30 1A		400p

VEROBOARDS
DIP Breadboar 4.15 × 6.15 325p
(Suitable for 20 × 14 pin or 16 × 16 pin DIL ICs) DIP Breadboard as above with tracks for 31 way connector 375p
V-Q Boards for ICs (No track cutting) 130p

CONNECTOR PLUGS

31 way Plug	120p
31 way Socket	120p
S-100 Busboar	1500p

EDGEBOARD CONNECTORS 0.156" PITCH

2 x 10 way	65p	2 x 22 way	135p
2 x 15 way	100p	2 x 25 way	160p
2 x 18 way	120p		

COUNTERS

74C925	475p
74C928	600p
ICM7216B	2000p
ICM7217A	850p
ZN1040E	700p

TTL & ECL

MC4024	325p
MC4044	325p
10116	70p
10231	350p

SPECIAL OFFERS (subject to stocks)

555	£18/100	7805	£5/10
741	£16/100	7812	£5/10
2114L-3	£4.00	7905	£6/10
2708 (450 ns)	£4.25	7912	£6/10
2708 (650 ns)	£3.75	2114L 450 ns	£24/8
2716 (plus 5V only)	£9.00		
4116 (200 ns)	£24/8	P&P + VAT Extra	

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EXP350 3.6 x 2.1 (Up to 3 x 14 pin ICs)	£3.15
EXP650 3.6 x 2.4 (Up to 1 x 40 pin IC)	£3.60
EXP300 6 x 2.1 (Up to 6 x 14 pin ICs)	£5.75
EXP600 6 x 2.4 (Up to 1 x 40 pin DCs)	£6.30

PROTOBOARD (R) SOLDERLESS BREADBOARDS
Socket Strips/Bus Strips/Binding Posts mounted on sturdy base plate.

PB6	6 x 14 DIL ICs	£9.20
PB100	10 x 14 DIL ICs	£11.80
PB102	12 x 14 DIL ICs	£22.95
PB103	24 x 14 DIL ICs	£34.45
PB104	32 x 14 DIL ICs	£45.95

(The above boards are suitable for all DIL ICs.)

16 KEY KEYPAD (Reed Switches)	450p
UHF Modulator 6MHz	£3.75
UHF Modulator 8MHz	450p
Reed Switches (12VA)	£0.25
LOGIC PROBE	£18.00
SUPERTESTER 680R	£33.00
MICROTEST 80R	£17.00
TMK500	£22.00
Pocket multimeter	£4.75

VEROBOARDS
0.1 (copper clad)

2.5×3.75	65p	Pkt of 100 pins	50p
2.5×5	75p	Spot face cutter	86p
3.75×3.75	75p	Pin insertion tool	118p
3.75×5	80p	Vero Wiring Pen + 2 wire spools + combs	370p
3.75×17	290p		
4.75×17.9	380p	Combs	7p

IC TEST CLIPS

14 pin	£2.60	24 pin	£4.90
16 pin	£2.75	40 pin	£7.90

We carry a large stock of 74 and 74LS TTLs, CMOS, Linears, Memories, etc. and can normally offer ex-stock deliveries. We welcome inquiries for volume quantities both from local and overseas buyers.

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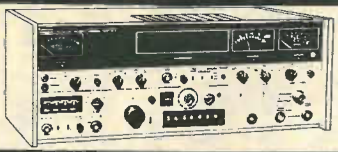
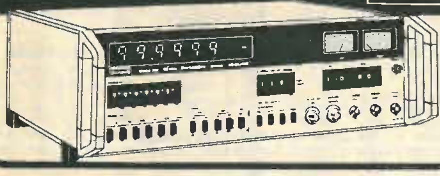


● VHF-UHF ● TX-RX ● 30mW-300W ● AM-FM ● SEMI-AUTOMATIC ● SYNTHESIZED ● SIGNAL GENERATOR ● MODULATION, RF POWER & AF LEVEL METERS ● IF & AF OSCILLATORS ● FREQUENCY COUNTER ● SELCALL & SINAD OPTIONS ● HP, RENT OR LEASE @ £111/m ● SOME MODELS AVAILABLE AT 1979 PRICES.

Quartzlock **QUARTZLOCK LIMITED, NEWNHAM INDUSTRIAL ESTATE, PLYMOUTH PL7 4LU. Tel (0752) 333300. Telex 45438.**

Quartzlock SYNTHESIZED SIGNAL GENERATOR



● 100Hz-100MHz ● AM-FM ● >40dB HARMONIC SUPPRESSION ● FULLY PROGRAMMABLE ● IEC 488 OPTION ● typ 0.3% MOD. DISTORTION ● <10Hz RESIDUAL FM typ ● 0dBV-119dBV ● PHASE NOISE typ >125dBc ● FREQUENCY STABILITY 3:10⁹/DAY ● FROM £1,985.

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

Type AD12-AD24 (illustrated)

2-YEAR GUARANTEE

TYPES AVAILABLE MODEL NO.	AD12	AB24	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
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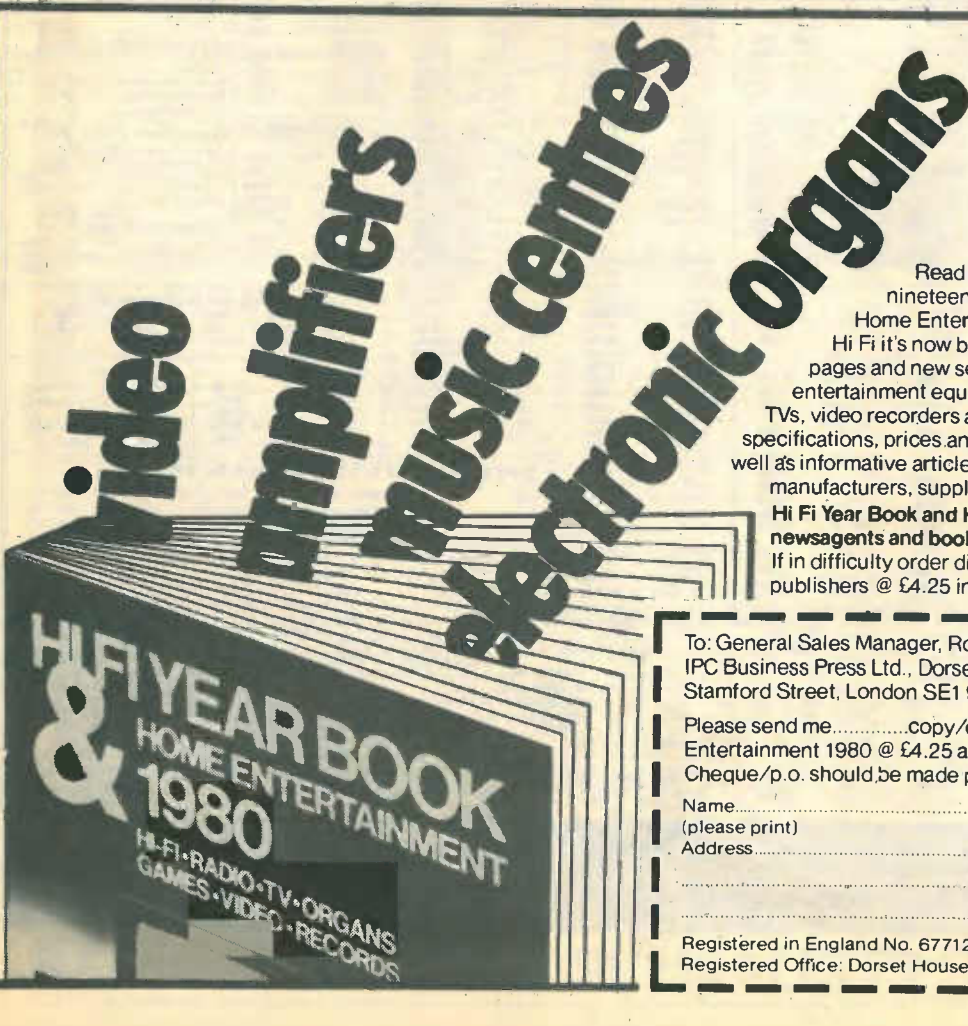

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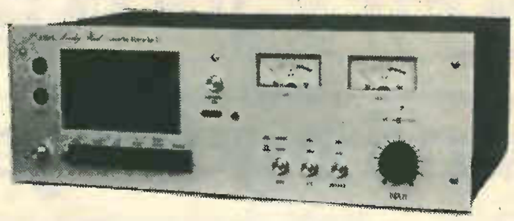
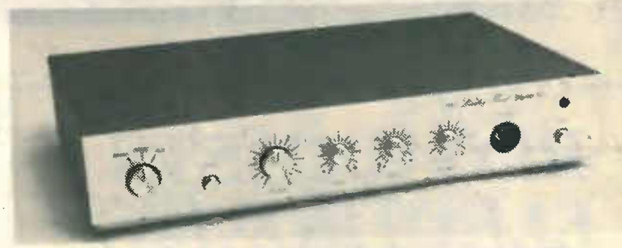
LINSLEY HOOD CASSETTE RECORDER 2



Our new improved performance model of the Linsley Hood Cassette Recorder incorporates our VFL 910 vertical front mechanism 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 30 WATT AMPLIFIER



The very latest amplifier design to be published and in our opinion the best yet. The concept was to produce an amplifier that sounded as good as the authors 75 watt design but which was cheaper and simple to build for applications where the higher power is not needed. This new kit is designed to match the Linsley-Hood Cassette Recorder 2 and a tuner will be available later to make a complete stackable system. A very advanced assembly system has been devised by us to make construction ultra simple and anyone who can solder components in a printed circuit board will find it great fun. Conventional wiring is at an irreducible minimum, only being needed to connect the mains transformer and pilot light. For an amplifier of this quality this kit represents incredible value for money.

All parts can be bought separately at a total cost of £79.12 but complete kits are available at a special introductory discount price of only **£65** + VAT.

STUART TAPE CIRCUITS

(For reel-to-reel decks)

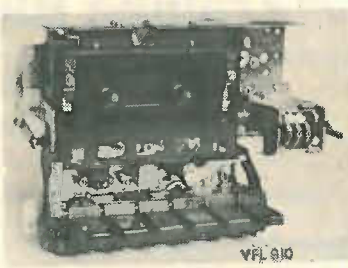
These circuits are just the thing for converting that old valve tape deck into a useful transistorised recorder. Total system is a full three head recorder with separate record and replay sections for simultaneous off tape monitoring. We also stock the heads. This kit is well engineered but does not 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.

SUPER BARGAIN TUNER OFFER

Brand new by famous manufacturer. MW/LW/FM Tuner and Stereo Decoder Board.
Features include capacitor tuned mosfet front end, integrated circuit I.F. strip, and phase locked loop stereo decoder chip. Stabilised power supply and rectifier on board only requires 19V AC at 175MA to power. Size 12½ x 3½ x 1¾.
Supplied complete with circuit diagram and ferrite rod aerial. FM section fully aligned and tested before despatch. Fantastic value at **ONLY £9.99** plus VAT. P.P. £1.

LENCO CASSETTE DECKS AND MOTORS

We have obtained a large quantity of Lenco decks and motors. Decks include the following types: CRV, FFR, SPFF, Mini-TB and Mini-S. There are also a few solenoid controlled decks and some dual Capstan three head units.
The motors include various AC and DC types.
All are going for silly prices.
Let us know your requirements.



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.

CASSETTE HEADS

HS15 SENDUST ALLOY SUPER HEAD. Stereo R/P. Longer life than Permalloy. Higher output than Ferrite. Fantastic frequency response. Complete with data	**7.80**
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 Ferrita 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

We regret that due to the latest increase in postal costs we must now charge for carriage. Please add as follows:

Order up to £10 — 50p
Orders £10 to £49 — £1 P&P
Over £50 — £1.50

Export Orders — Postage or shipping at cost plus
£2 Documentation and Handling

Please send 9x4 SAE for lists giving fuller details and price breakdowns.

Instant easy ordering, telephone your requirements and credit card number to us on Oswestry (0691) 2894

Personal callers are always welcome
but please note we are closed all day Saturday

4118

HART ELECTRONIC KITS LTD
PENYLAN MILL OSWESTRY
SHROPSHIRE
phone (0691) 2894
Telex 35661
Hartel G

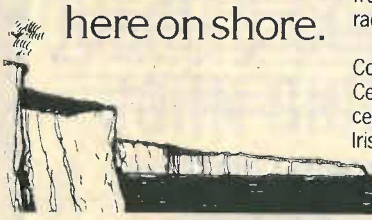
Appointments

Advertisements accepted up to 12 noon Monday, September 1st, for October issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £12.00 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £2.00 per line, minimum three lines.
BOX NUMBERS: £1 extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU).
PHONE: Anthony Hadley, 01-261 8508.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Land a good job...

...Your Radio Officer's qualifications could mean a lot here on shore.



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!

British Telecom 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 £5,381; after 3 years' service this figure rises to around £7,087. (If you are between 19 and 24 your pay on entry will vary between approximately £4,229 and £4,937). 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 Freefone 2281 or write to her at the following address: IE Maritime Radio Services Division (WWB), IS8.1.1.2. Room 304, Landsec House, 23 New Fetter Lane, London EC4A 1AE.

(581)

British TELECOM
PART OF THE POST OFFICE

BROADCASTS ELECTRONICS ENGINEER

ENGINEERING TRAINING DEPARTMENT, EVESHAM, WORCS.

The BBC's Engineering Training Department is situated in the Worcestershire countryside and includes well equipped Radio and Colour Television Studios. There are excellent welfare and club facilities.

Duties: Maintaining a full range of professional radio and television broadcasting equipment. This includes modifications to and commissioning of broadcast equipment, the repair and recalibration of sophisticated instruments. (Appropriate guidance will be given to candidates who are unfamiliar with BBC equipment).

Requirements: Recent experience of maintaining electronic equipment. A good technical knowledge of audio and/or video equipment.

One of the following qualifications is essential:-

A degree from a British University in electronics or electrical engineering.

HNC or HND (Electrical Engineering or Applied Physics).

C & G Full Technological Certificate in Telecommunications.

Salary, depending upon experience, in the range of £6030-£6600 rising to £7455 plus 10% Shift Allowance.

Pensionable Post. Re-location expenses considered.

Further Details: 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, Worcs. WR11 4TF. quoting reference number 80.E.2305/WW.** Closing date for return of application forms, 14 days after publication.

BBC

(617)

Trainee Radio Officers

First-class, secure career opportunities

A number of vacancies will be available in 1980/81 for suitably qualified candidates to be appointed as Trainee 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.

Candidates must have had at least two years' radio operating experience or hold a PMG, MPT or MRGC certificate, or expect to obtain this shortly.

On successful completion of 40 weeks' specialist training, promotion will occur to the Radio Officer grade.

Registered disabled people may be considered.

Salary & Prospects:

TRAINEE RADIO OFFICER: £3859 at 19 to £4549 at 25 and over. On promotion to RADIO OFFICER: £5288 at 19 to £6884 at 25 and over. Then by four annual increments to £9339 inclusive of shift working and Saturday and Sunday elements.

For full details please contact Robby Robinson, our Recruitment Officer, on Cheltenham (0242) 21491, Ext. 2269, or write to him at:

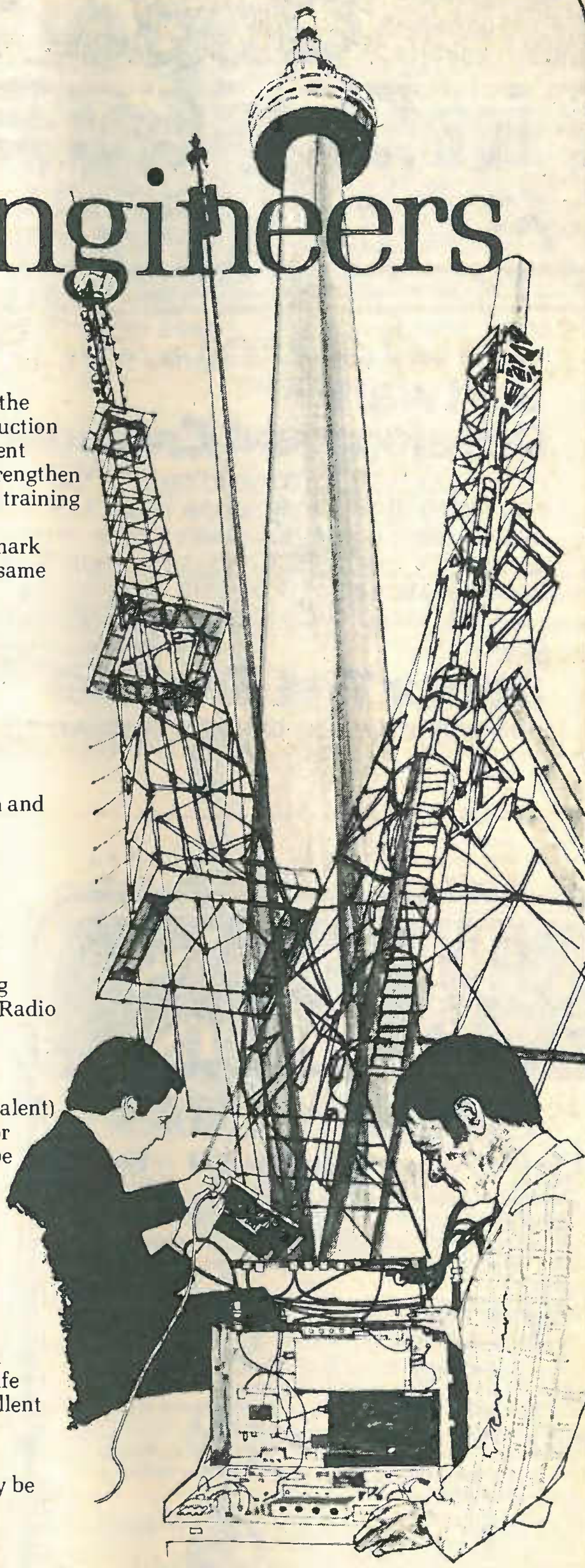
Recruitment Office, Government Communications Headquarters, Oakley, Priors Road, Cheltenham, Gloucestershire GL52 5AJ.

(576)

GCHQ

Aerial Engineers

(Broadcasting Systems)



Our current demanding programme of work includes the expansion of Independent Local Radio and the introduction of the fourth Television Channel. This provides excellent opportunities for Aerial Specialists at all levels – to strengthen our existing expertise and to provide for the future by training those keen on entering this challenging field.
We are small enough for you to be able to make your mark in a professional and friendly environment but at the same time large enough to provide career prospects.

Senior Aerial Systems Engineers
(up to £9600 p.a. under review)

Aerial Systems Engineers
(up to £8350 p.a. under review)

To be responsible for the design and specification – acceptance and commissioning of aerial systems, high and low power filters, channel combining and separating equipment for UHF, VHF and MF services.

Aerial Maintenance Engineers
(up to £8350 p.a. under review)

To be responsible for implementing a programme of preventive maintenance for transmitting and receiving aerials, feeders, combining units and RF filters at TV, Radio and Link Stations. To provide a specialist corrective maintenance service, as necessary.

You should be qualified to degree/HNC level (or equivalent) and have substantial relevant experience (at the senior level supervisory ability is essential). We would also be happy to consider new graduates or those with little experience with a genuine interest in broadcast engineering to start at a trainee level.

You must be fit and able to climb tall structures; you must also hold a current driving licence and be prepared to travel within the U.K. Starting salaries will be according to experience – the figures quoted above are under review. Generous re-location, car and travelling allowances are payable together with free life assurance and personal accident scheme and an excellent contributory pension scheme.

Most of these posts will be based at our Engineering Headquarters, here in Hampshire, although there may be opportunities for appointments at our Regional Engineering bases.

IBA INDEPENDENT BROADCASTING AUTHORITY

Applicants (male or female) should send full details of qualifications and experience as soon as possible to Glynis Powell, IBA, Crawley Court, Winchester, Hampshire, SO21 2QA.

(586)

INNER LONDON EDUCATION AUTHORITY

LEARNING MATERIALS SERVICE TELEVISION CENTRE
Thackery Road, Battersea SW8

VIDEOTAPE ENGINEER (ST3)

The Learning Materials Service produces teaching programmes in colour for ILEA schools and colleges, many of which are marketed throughout the U.K. and abroad. There is a Television Studio and mobile unit and a film unit. The programmes are recorded in the master control section on broadcast standard videotape (CCIR formats A and C). This section carries out all editing and post-production work, and provides large scale duplication on a variety of helical videocassette formats.

A vacancy has arisen in this section, which consists of four senior engineers. Applicants will be expected to have good operational experience of videotape, with a thorough understanding of the technical features, and to have appropriate technical qualifications. A general grounding in colour television theory is essential. The successful candidate will be expected to undertake maintenance of the tape machines and associated equipment, as well as the operational functions. Some overtime is required.

Salary within the scale £7904 to £8498.

Application forms from EO/Estab, 1C Room 365, The County Hall, SE1 Telephone No. 633 7456/8848.

(621)

MANAGEMENT & EXECUTIVE SELECTION

telephone 01-637 9611

COMPUTER & DIGITAL ELECTRONICS ENGINEERS

Our specialist consultants have knowledge and experience that could be *vital* to your career progression. Jobs, Companies (UK & International), Interview and Progression techniques – information and advice for each applicant.
Call Peter Gorton or Howard Wynne *today*.

Suite 201 6 Albany House
324 Regent Street London W1

MANAGEMENT & EXECUTIVE SELECTION

FIELD ENGINEER

Electronic Test and Control Equipment

WEMBLEY

Technicians and Engineers with experience of system assembly, installation or commissioning of electronic equipment are invited to apply for an unusually interesting job, based at Johnson Matthey Services Limited, Wembley, with visits to other Johnson Matthey premises. Good basic training in electronics, backed up by a practical understanding of things electrical and mechanical is essential.

For an application form please write or telephone:
Miss L. Tarbox, Staff Office
JOHNSON, MATTHEY & CO. LIMITED
100 High Street, Southgate, London, N14 6ET
Tel: 01-882 6111

(584)

ARAMCO

The COMPANY WITH A FUTURE ...for ENGINEERS & TECHNICIANS

ENGINEERS £11,450 to £19,200

TECHNICIANS £10,100 to £14,500 per contract year after tax.

Aramco are involved in many varied projects in Saudi Arabia that will last for many years.

The COMMUNICATIONS PROJECTS MANAGEMENT DEPARTMENT is responsible for the communications networks throughout the Eastern Province of Saudi Arabia and need skilled Engineers and Field Technicians in the following fields:-

ENGINEERS & TECHNICIANS for the installation and commissioning of telemetry systems. Field work covers substations, remote terminal units, pipelines etc. You will be involved at module, unit and systems levels using a range of test equipment, digital diagnostic test procedures and control systems.
Engineers should have B.Sc or HNC in Electrical or Electronic Engineering plus minimum of 4 years relevant experience. Technicians should have apprenticeship plus at least 3 years relevant experience.

DATA ENGINEERS with at least 5 years experience in systems engineering on data terminalling equipment and analogue systems
A degree in electrical engineering or computer science is required for these positions.

COMMUNICATIONS ENGINEERS to act as technical consultants and systems planners on specification and design. Degree plus 5 years experience is required.

COMMUNICATIONS ENGINEERS for communications hardware and systems including local distributions and coaxial versus paired cables, multiplexers, multichannel radio bears, VHF/UHF/HF/MF equipment, outside telephone cable plant and telephone/electronic switching.

Contracts are single status and renewable yearly with low-cost air conditioned accommodation and free medical care provided. Good recreation facilities include libraries, cinema, TV, swimming pools etc. Married men receive leave after each 4 month period on a 14, 14 and 25 day cycle. Single men receive 30 days leave at end of each year. Fares Paid.
A valid UK driving licence is required for all the above positions.

Certain senior positions will qualify for married status after satisfactory completion of one year's employment.

Please write with brief career details etc. quoting ref. WW/20/8 to:-

(606)

PMC

INTERNATIONAL RECRUITMENT
5 EAST PARADE,
HARROGATE,
NORTH YORKSHIRE HG1 5LF

UNIVERSITY OF ABERDEEN

ELECTRONICS WORKSHOP SUPERVISOR

(Technician Grade 6)

required for the Department of Psychology. Duties include the design, development, construction and modification of electronic instruments used in research and teaching laboratories — as well as the repair and maintenance of electronic equipment, including video recorders, biological amplifiers and computer peripherals. The work requires a thorough understanding of modern analogue and digital techniques and circuitry.

Applicants should hold an H.N.C. or equivalent qualification and have had 9-10 years' relevant experience.

For suitably-qualified candidate, salary on scale £4884-£5832 with pay award awaited from Pay Comparability Commission, but for candidates with less than the requisite qualifications an appointment on a lower scale would be considered.

Applications by letter, giving date of birth, and details of qualifications and experience, should reach the Secretary, University Office, Regent Walk, Aberdeen, AB9 1FX, by September 15, and quote Ref. No. 124/80.

(583)

REHABILITATION ENGINEERING UNIT

Chailey Heritage

ELECTRONICS TECHNICIAN

(Medical Physics Technician II)

This post offers opportunity for initiative in design and construction of special equipment for disabled children with particular emphasis on research and development.

Applicants should be experienced in current electronics and be prepared to work with clinical staff and patients.

Salary scale £5547-£6918 p.a. (increase pending).

Further details from Technical Director, Chailey Heritage, Lewes, Sussex. Tel: 082 572 2112, Ext. 38.

(610)

Challenging positions at home and abroad

RADIO TECHNICIANS COMMUNICATIONS ENGINEERS

Plessey EAE design, install and maintain communications systems for the oil industry, at home and abroad.

Due to rapid and continuing expansion in our activities, we constantly require Radio Technicians, with experience of HF, MF, VHF and UHF, and Engineers (preferably qualified to HNC level or above) in the fields of Microwave, Multiplex and Tropospheric Scatter.

In the North Sea, earnings are in the range £9,000 to £12,000 p.a. Overseas earnings could be up to £20,000 – plus tax concessions and generous home leave.

The work is demanding, but rewarding, offering you the chance to use your skills and your initiative to the full.

The company is based in Great Yarmouth, with offices in Aberdeen and Lerwick – but where relocation is necessary, we will give generous assistance with removal, legal and temporary accommodation expenses.

Please apply, with details of your career to date, to: Personnel Manager, Plessey EAE Limited, Dept WW, Offshore House, 284/285 Southtown Road, Gt. Yarmouth, Norfolk NR31 0JB Telephone 0493 58541

(530)

PLESSEY EAE

Experimental Officer (Electronics)

Greenford Middx.

Our Research Central Services Unit is undertaking an increasing amount of design and constructional electronics work. The application of microprocessor technology to the scientific effort is particularly important. Whilst routine construction work is undertaken elsewhere there is a great need for a technical officer to help in constructing prototype equipment during the development phase.

Applicants qualified ONC/HNC or equivalent should have previous experience in electronic construction. Some experience with printed circuit boards and an ability to translate circuit diagrams into practice is essential. An interest in the construction of experimental equipment, making use of microprocessors and needing some degree of innovation is required.

Starting salary within the range £4270 to £6450 according to qualifications and experience. Bonus and non-contributory pension scheme.

Please apply to: Miss E. M. Butler, Personnel Department, Glaxo Group Research Ltd., Greenford Road, Greenford, Middlesex UB6 0HE. Tel: 01-422 3434, ext. 180, quoting ref. ZH.334.

Glaxo Group Research Ltd.

(604)

Department of Physics
B.Sc.(Hons.) and B.Sc.
Combined Science

Available as five-year day-release modular courses offering a wide choice of units in science subjects.

M.Sc. The Physical Basis of Electronics

Available as two-year day-release, and two-year and three-year evenings-only courses. For graduates in Physics, Electrical Engineering and allied subjects.

Suitable graduates applying to enter one of these part-time M.Sc. courses in September 1980 are invited to apply also for one of ten Science Research Council bursaries. Students must meet normal S.R.C. requirements for residential and academic qualifications. If the demand for the bursaries exceeds the number available, selection will be competitive. Please ask for further details if required.

H.N.C. Applied Physics

A two-year day-release course, including electronics, vacuum physics, computing and spectroscopy. For technicians and others with suitable O.N.C., A levels or equivalent.

The Physics Department also offers full-time courses leading to B.Sc.(Hons.) in Physics and Physical Electronics, B.Sc.(Hons.) in Combined Science, and M.Sc. in the Physical Basis of Electronics.

Further details of all courses may be obtained from:

The Secretary, Physics Department (Ref. WW6), THE POLYTECHNIC OF NORTH LONDON, Holloway, London, N7 8DB (Tel: 01-607 2789, Ext. 2180).

The Polytechnic of North London

(580)

UNIVERSITY OF NOTTINGHAM
Department of Psychology

A vacancy exists in the Psychology Department for a Grade 6

COMPUTER TECHNICIAN

(male or female). Duties include the design/development of sophisticated on-line equipment for laboratory control plus routine maintenance of the Department's computer laboratory complex. The laboratory is based on a PDP 11-34 master computer with DEC GT40 and LSI 11 slave machines. Expansion of the system, including microprocessor-based developments, is in progress.

Design experience with CMOS/TTL devices is essential and previous computer experience desirable.

Suitable qualifications include HNC (or equivalent) in a relevant subject or ONC with appropriate computer experience.

Salary is in the range £4,884-£5,832 per annum.

Application forms can be obtained from the Establishment Office, University of Nottingham, University Park, Nottingham, NG7 2RD. Telephone Nottingham 56101, ext. 2093. Ref. No. PSY4/80. (574)

Electronic Engineers – What you want, where you want!

TJB Electrotechnical Personnel Services is a specialised appointments service for electrical and electronic engineers. We have clients throughout the UK who urgently need technical staff at all levels from Junior Technician to Senior Management. Vacancies exist in all branches of electronics and allied disciplines - right through from design to marketing - at salary levels from around £4000 to £8000 p.a.

If you wish to make the most of your qualifications and experience and move another rung or two up the ladder we will be pleased to help you. All applications are treated in strict confidence and there is no danger of your present employer (or other companies you specify) being made aware of your application.

TJB ELECTROTECHNICAL PERSONNEL SERVICES,
12 Mount Ephraim,
Tunbridge Wells,
Kent. TN4 8AS.
Tel: 0892 39388

TJB

Please send me a TJB Appointments Registration form:

Name ....

Address ....

....

(9238)

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)

ROYAL COLLEGE OF ART
School of Film and Television
Two additional

ELECTRONICS ENGINEERS

required for the operation and maintenance of its broadcast standard television facility. The Studio is equipped with Philips plumbicon cameras and an RCA TR60 quadraplex VTR. In addition to the studio, 2 editing suites are planned, one equipped with Ampex VPRI and a second IVC 871P.

Experience of closed circuit or broadcast television is essential and a qualification such as ONC or C & G is desirable.

Starting salary will be in the range £5037-£7164 depending on age and experience.

Please write, giving full details of age and experience, to: Assistant Registrar (Staff), Royal College of Art, Kensington Gore, London, SW7 2EU. (577)

ELECTRONICS WORKSHOPS ENGINEER

(INSTRUMENT MAKING)

We are looking for an energetic and technically sound man or woman to join us in this specialist/assistant management post.

You should have proven skills in the fabrication and wiring of control panels and in the making of scientific instruments. You must have the ability to carry out development work without supervision and will preferably have a knowledge of solid state technology and microprocessors.

We see you as holding an appropriate ONC/HNC but would be prepared to offer day release facilities if you are still in the process of gaining your qualification.

We offer a prgogressive salary, pension and life assurance, flexible working hours and assistance with relocation expenses in an appropriate case.

INTERESTED?

Then write or phone for an application form to the Recruitment Officer, Unilever Research Port Sunlight Laboratory, Quarry Road East, Bebington, Wirral, Merseyside, L63 3JW. Tel: 051-645 2000, ext. 8408. Please quote ref. PS715AC.

unilever research

(609)

COMMISSION AGENTS REQUIRED

To sell Electronic Instrumentation Equipment and Components.

Areas to include: N.E. and N.W. ENGLAND, SCOTLAND, THE MIDLANDS AND WALES.

Send details to: DEPT. CTI, P.O. BOX NO. 1, BILLINGSHURST, WEST SUSSEX, RH14 9SD. (571)

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

FOREIGN AND COMMONWEALTH OFFICE TELECOMMUNICATIONS

We have vacancies for

TECHNICIANS

on duties involving the testing, maintenance and repair of machine telegraph and associated electronic equipment in London, and also on the installation of PABX telephone systems in British Government offices overseas. Staff employed on the latter duties are based at Hanslope, near Milton Keynes in Buckinghamshire. Applicants should possess a sound knowledge of basic principles and preferably have some experience with the appropriate equipment. Some knowledge of Radio would be an advantage. The vacancies are in the grade of Radio Technician; opportunities exist for transfer to other types of duty in due course, and the grade is the main source of recruitment, on promotion (subject to the possession of the necessary qualification and satisfactory performance) for our resident overseas maintenance staff.

QUALIFICATIONS REQUIRED:

A City and Guilds Intermediate Certificate in Telecommunications or an equivalent or higher qualification.
An Ordinary National Certificate in Electrical Engineering.
SALARY: is on a scale £4,640-£6,525.
An additional allowance of £780 is paid for working in London. The appointments attract four weeks' paid annual holiday and there are prospects of pensionable employment.

For an application form apply to:

**Recruitment Section
FOREIGN AND COMMONWEALTH OFFICE
Hanslope Park, Hanslope, Milton Keynes MK19 7BH**

(579)

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)

UNIVERSITY COLLEGE, CARDIFF
Applications are invited for the post of

TECHNICIAN (Grade 5)

in the FACULTY OF SCIENCE ELECTRONICS WORKSHOP. Applicants should possess an HNC or equivalent and have a good knowledge of analog and digital techniques; experience with microprocessor-controlled instruments and interface would be an advantage. Salary range: £4257-£4974 p.a. Duties to commence as soon as possible.

Applications, together with the names and addresses of two referees, should be forwarded to the Vice-Principal (Administration) and Registrar, University College, P.O. Box 78, Cardiff, CF1 1XL. Closing date: September 30, 1980. Reference 2067. (573)

Test Engineers & Test Gear Engineers

Move into new areas of Electronics Development and an assured quality of life...

EMI Electronics Ltd. builds quality and reliability into every product. Our reputation for excellence is long established and is a major factor in generating new orders.

The growth of our business here in historic Wells creates the need for more Test Engineers to take us through the 1980's.

As one of the world's leaders in specialised defence electronic systems – particularly the fields of radar, proximity fusing, telemetry and radio modelling we maintain stringent quality standards. You will join one of our professional teams responsible for ensuring that our wide range of "State of the Art" electronic systems on test equipment meet our exacting standards.

We are looking for people with either ONC or HNC Electronics and varying levels of experience of testing or servicing modern detection systems in the electronics industry or armed forces.

We offer competitive salaries, comprehensive benefits and assistance with your relocation to this beautiful part of Somerset.

For further information fill in the coupon and send it to F. M. Taylor, Assistant Personnel Manager, EMI Electronics Ltd., Penleigh Works, Wookey Hole Road, Wells, Somerset, BA5 1AA or phone him for more information on Wells (0749) 72081.

Name ______________________

Address ______________________

____

____

Tel: ______________ Age ________

Current position ______________________

Qualifications ______________________

____

______________________ Ref. W.W. 158

357

EMI EMI Electronics Limited, Wells

A Member of the THORN EMI Group

Roehampton Institute

Digby Stuart
Froebel
Southlands
Whitelands

PSYCHOLOGY TECHNICIAN

(NJC/APTC Grade 2)

Required at DIGBY STUART COLLEGE as soon as possible to take responsibility for establishing and equipping a new technical workshop in the Psychology Department; servicing and maintenance of existing equipment in the Department; and construction of new equipment for use by teaching staff and students. The successful applicant will also be expected to make a contribution to the technical support of the Behavioural Biology Department. Applicants should either have an HNC or City and Guilds Part II qualification in Electronics (or equivalent), or have relevant experience and proven ability to fulfil the above responsibilities.

Salary (subject to review): £4716 to £5202 including London Allowance, according to age, experience and/or qualifications.

Applications in writing, with full details of age, qualifications, work experience and present salary, plus the names and addresses of two referees, to:

R. A. Fennel, Assistant Secretary, Roehampton Institute of Higher Education, Richardson Building, Digby Stuart College, Roehampton Lane, London SW15 5HP,

to arrive not later than 8 September, 1980.

(Applicants should note that, although initially this appointment will be at Digby Stuart, they may be required to work elsewhere within the Roehampton Institute).

(591)

B.B.C.

INSTALLATION TECHNICIAN

We have a vacancy in the Unit which deals with the supply, installation and commissioning of television studio lighting and mechanical equipment. This includes lighting control systems, dimmers, luminaires and their mechanical suspension systems, camera mountings and lenses, servo systems and their controls.

The successful applicant will assist professional engineers in this work and the duties will include supervision of craftsmen, liaison with contractors and other specialists.

Applicants, male or female, must have a good practical understanding of work in at least one of the following fields:-

Electrical Power Control
Mechanical Mechanisms
Electronic Control Systems

The successful candidate will be based in the London area but must be prepared to work anywhere in Great Britain for periods which do not normally exceed four weeks at a time.

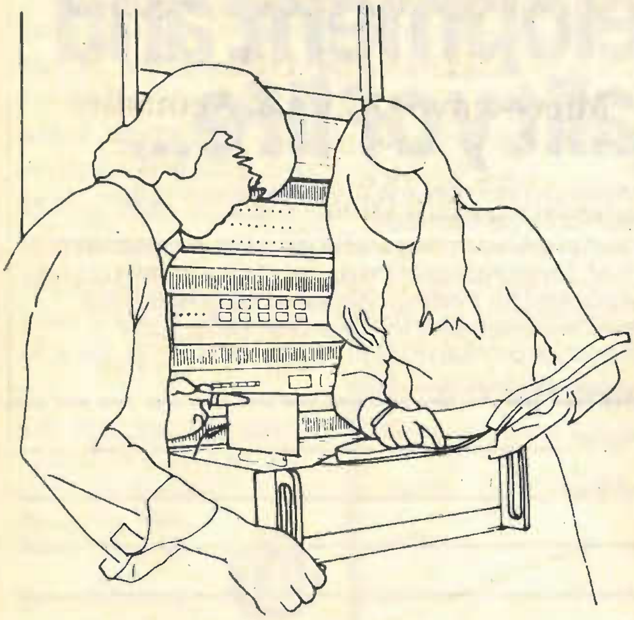
Salary, depending on experience and qualifications, will initially be in the range of £5535 to £5985 rising by annual increments of £225 to a maximum of £7455 per annuAdditional allowances are paid for on-site working, approximately 8% of salary.

4 weeks and 2 days annual leave.

Request for application forms to the Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting reference 80.E.2302/ . . Please enclose an addressed envelope with your application; no stamp is required. Closing date for completed application forms is 14 days after publication.

(608)

Professional Careers in Electronics



All the others are measured by us...

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

Name ________ Age ____

Address ________________

____

Telephone Work/Home (if convenient) ______

Years of experience	0-1	1-3	3-6	Over 6
	☐	☐	☐	☐
Present salary	£3,500-£4,500	£4,500-£5,500	£5,500-£6,500	over £6,500
	☐	☐	☐	☐
Qualifications	None	C & G	HNC	Degree
	☐	☐	☐	☐

Present job ________________

____

P.E.1.

Return this coupon to John Prodger, Marconi Instruments Limited, FREEPOST, St. Albans, Herts, AL4 0BR. Tel: St Albans 59292

marconi instruments

A GEC MARCONI ELECTRONICS COMPANY

(619)

Link Electronics is a successful British Company active in the international sales of Broadcast television and radio equipment. We manufacture a range of studio products from colour cameras to simple D.A.s. We are also one of the largest suppliers of Outside Broadcast vehicles, television and radio studios, all designed and built in Andover for a worldwide market.

TECHNICAL SALES ENGINEER

To be involved in the active selling of television broadcast equipment.
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Employment benefits include excellent salary, generous holidays, free life and health insurance, pension scheme, subsidised meals and relocation expenses.

Please apply for further details and application forms to Jean Smith at the address given below.

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(589)

ITN

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Independent Television News Limited require an Electronic Engineer to service a wide range of broadcast audio equipment, including Sound Mixing desks, Audio Tape Recorders and Film Sound Recording equipment, at their West End Studios.

Applicants should be familiar with microprocessing techniques as applied to sound and machine control systems.

This challenging situation provides an interesting future for the right person.

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Telephone the Personnel Office on 01-637 3144, quoting ref. no. 40763.

(588)

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GRADE I

There is a vacancy in the Technology Unit at the Royal Observatory, Edinburgh, for an electronics engineer to work on the development of prototype astronomical instruments such as photometers, polarimeters, measuring machines and guidance and acquisition systems.

The Observatory provides Technological support to several major national astronomical facilities in the UK and overseas.

Initially the successful candidate will work with Officers at PTO II, III and IV levels designing, developing and commissioning acquisition and guidance systems and other instruments for use on the 3.8 metre Infrared telescope situated in Hawaii.

These systems incorporate a variety of detectors including cooled SIT TV cameras, and microprocessor controlled digital image storage and display. Special techniques are being developed to present complex information in a simplified form to assist astronomers working in a difficult environment.

The successful candidate may be required to work abroad on short term detached duty or on postings of up to three years. It is a pre-requisite of working in Hawaii that a special high-altitude medical examination be taken and passed.

Applicants are expected to have qualifications at degree level in the appropriate subjects leading to corporate membership of an appropriate professional body.

Experience in one or more of the following fields would be an advantage: Detectors, Detector Arrays, CCDs and associated amplifiers, low light level TV Systems, Integration and digital image storage techniques, application of microprocessor hardware and software.

Salary will be in the range £8600-£10200 per annum. There is a non-contributory superannuation scheme.

Application forms from The Personnel Officer, Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ. Application forms should be returned by 1 September, 1980.

(605)

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Candidates must have served an apprenticeship or have had equivalent training. They should normally have 3 years' relevant experience, and hold ONC in Engineering (with pass in Electrical Engineering 'A') or Applied Physics **or** TEC/SCOTEC certificate **or** equivalent qualification in a relevant subject. **Ex-Service personnel** who have had suitable training and at least 3 years' appropriate service (as Staff Sergeant or equivalent) will also be considered.

Salary: £5310-£7170; London £780 more. Starting salary may be above the minimum for those with additional relevant experience. Promotion prospects. Non-contributory pension scheme.

For further details and an application form (to be returned by September 12, 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/5424.**

FOREIGN AND COMMONWEALTH OFFICE

(615)

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Vacancies exist for Lecturers to instruct on digital systems and equipment over a wide range of applications including the expanding field of automatic systems. Applicants should have either a degree or equivalent qualification in electronics with knowledge of digital techniques, or several years' relevant experience. Teaching experience desirable but not essential.

TELECOMMUNICATIONS

A Lecturer is required to instruct in the principles/functioning and maintenance of a wide range of telecommunications systems and equipment. The range embraces HF, UHF and Microwave Systems incorporating the latest microprocessor devices.

Applicants should have a sufficient combination from a degree or equivalent qualification, teaching experience in similar technology and three to four years' practical experience of professional radio communications systems.
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Applications to Frank Braybrook, GEC-Marconi Electronics Limited, Marconi House, New Street, Chelmsford, Essex CM1 1PL. Telephone Chelmsford (0245) 353221 Extension 478.

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(629)

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(607)

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The successful candidate will be required to have considerable experience of work in the National Health Service Physics Department and will be expected to have a good knowledge of present day digital analogue electronic techniques and equipment.

Salary: £7082-£8207 inclusive.

For further information contact the Department of Medical Physics on ext 2350. Application form and job description obtainable from Sector Administration, King's College Hospital, Denmark Hill, London SE5 9RS or telephone 01-274 6222 ext 2408 quoting reference number SA/202.

Closing date: Sept. 12th, 1980.

(612)

QUEEN MARY COLLEGE
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ELECTRONICS ENGINEER

Applications are invited for the newly-created post of ELECTRONICS ENGINEER to provide a wide-ranging advice and design service to research groups in the Physics Department, including Astrophysics, Far Infrared Instrumentation and High Energy Physics. The Department has been designated one of two College centres for advanced work in electronics and further responsibilities and opportunities are expected to develop in consequence. Applicants will be expected to have experience in analogue and digital techniques and minimum qualifications of HNC in Electrical Engineering or a degree in Physics or Engineering. Salary on scale £5052-£8769 p.a. (under review), plus £740 London Allowance, according to age/experience.

Please apply by letter, giving age, qualifications, experience and names of 2 referees, to The Secretary (W.W.), Queen Mary College, Mile End Road, London, E1 4NS. (570)

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UNITED NATIONS

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1. CHIEF, TECHNICAL SERVICES SECTION (P-5)

Supervises and specifies arrangements for the installation, operation and maintenance of equipment associated with the United Nations conference servicing and radio and television programming operations. This includes a wide range of broadcast standard audio and video equipment, simultaneous interpretation installations and electronic voting equipment.
Responsibilities include directing the work of some 100 personnel, design of and supervision of construction of equipment, advising other divisions on technical matters and preparation of budgets.
Should have advanced university degree in relevant engineering discipline, good electronic knowledge, computer experience and management skills particularly in the fields of budgeting projection and cost control, with 13 years' professional experience.
Level P-5 carries net base salary per annum from US \$24,298 (single) and US \$26,298 (with dependants) plus post adjustment from US\$11,627 (single) and US\$12,584 (with dependants) per annum.

VA. 80-D-DAM-109-NY

2. CHIEF, TELEVISION AND FILM UNIT (P-4)

Controls the technical aspects of the United Nations television and film unit which works to full professional broadcast standards.
Is responsible for system development and specifying operational and maintenance techniques and for assessing needs and making recommendations for purchase of equipment.
Supervises the operations in the technical areas and maintains contact with outside TV networks and operators.
Should have advanced university degree in electrical engineering with eight years' professional experience in the operation and maintenance of television and film equipment.
Level P-4 carries net base salary per annum from US\$20,209 (single) and US\$21,755 (with dependants) plus post adjustment from US\$9,779 (single) and US\$10,527 (with dependants) per annum.

VA. 80-D-DAM-108-NY

3. ENGINEER (TELECOMMUNICATIONS) (P-4)

Supervises the technical aspects of conference servicing operations with particular regard to simultaneous interpretation, audio distribution systems and electronic voting equipment.
Responsible for system development and design and for the installation of these facilities both at Headquarters and for conferences away from headquarters.
Should have advanced university degree in an engineering discipline, with eight years' professional experience.

VA. 79-D-DAM-357-NY.

APPLICATIONS: Please complete two copies of United Nations Personal History Form (P.11), or send detailed curriculum vitae to: **Professional Recruitment Service, United Nations, New York, N.Y. 10017, USA.** Mention the date of birth and nationality, and quote the Vacancy Announcement number.

(535)

Do you want to work in electronics as a Technician?

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You should hold or expect to obtain shortly a TEC Certificate in Telecommunications Engineering or the City and Guilds Telecommunications Technician Certificate Part 1 (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 H.M. Forces, your Service trade may allow us to dispense with the need for formal qualifications.

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Applicants possessing the necessary formal qualifications (e.g. TEC or C & G Telecommunications Technician Certificate) but with insufficient practical experience for Radio Technician posts may be suitable for our Trainee Radio Technician posts. Pay scales for these posts are £3,825 per annum at age 19 to £4,640 at age 24. Successful completion of our practical training course will lead to regrading to Radio Technician.

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Government Communications Headquarters

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For a job description and application form, please contact the Area Personnel Officer, Bromley Area Health Authority, "Bassetts," Starts Hill Road, Farnborough, Kent, BR6 7AR. Tel. Farnborough (0689) 53333, Ext. 339. (590)

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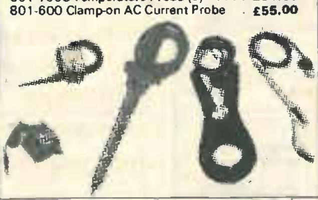

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