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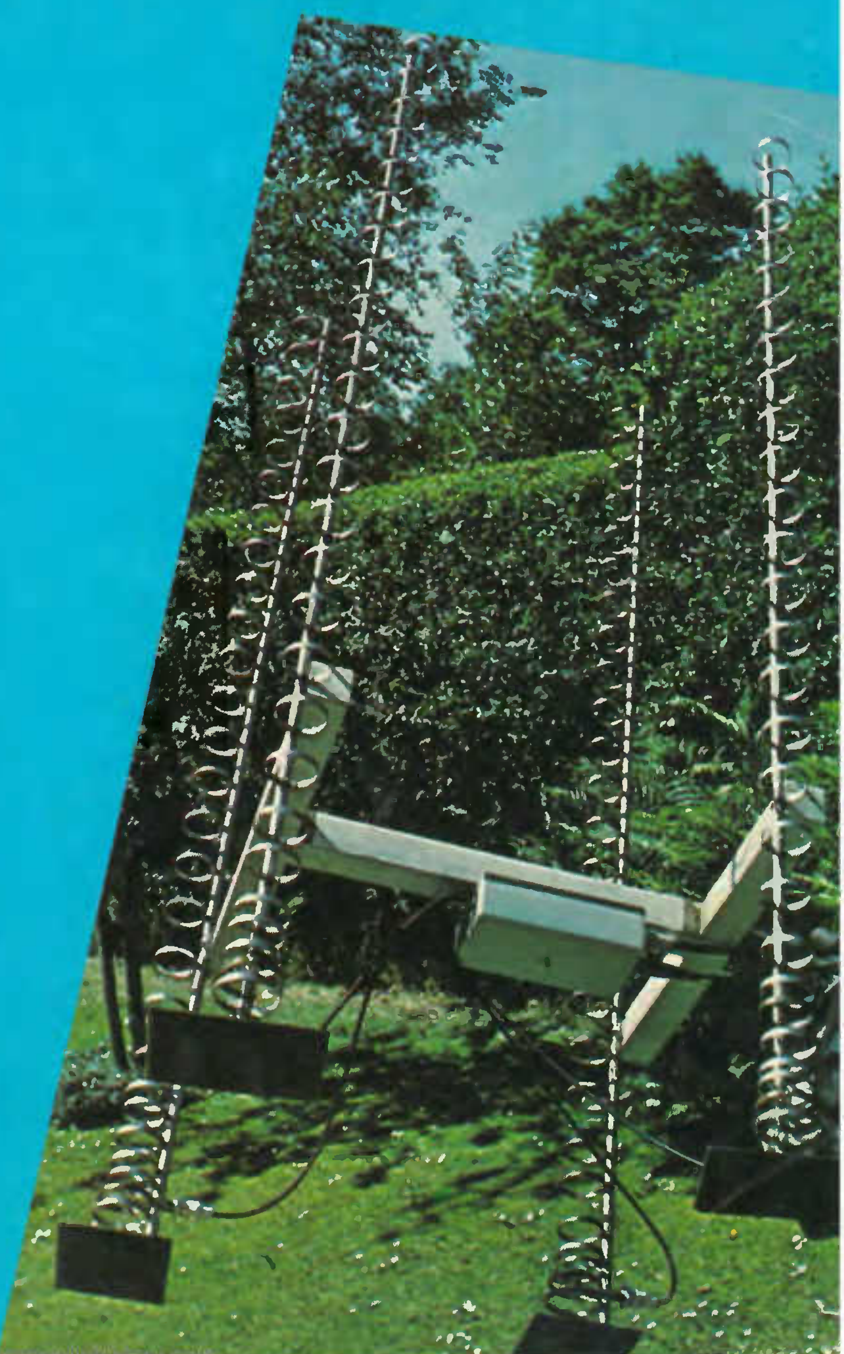

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ELECTRONICS/TELEVISION/RADIO/AUDIO

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Front cover shows the aerial of Mr Christieson's satellite receiver, with some images produced by the system.

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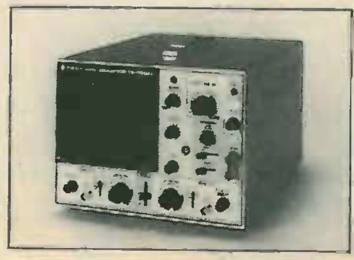

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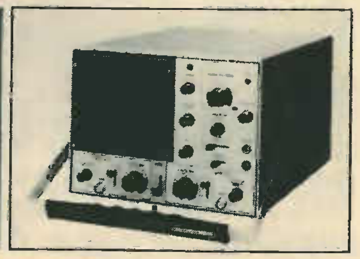

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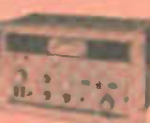

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TA8E Dual Cassette drive and ctrl £525.00
TC08 DECtape control (old type. as-is) £50.00
VK8E Graphics Controller £250.00

MISC PERIPHERALS
PC11A Paper Tape Reader/Punch with unibus control module £1250.00
TU60 Twin Cassette drive, new condition, no control £500.00

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DEC
LA34/LA38 DECwriter IV Desktop KSR Terminal RS232, inc. tractor feed, paperout cable and keypad options £495.00
LA36 DECwriter II free-standing KSR Terminal, available with either 20mA or RS232 .... £595.00
LA180PD freestanding matrix printer, with parallel interface £750.00
Price with E1A option £925.00
VT52 DECscope, as new condition £525.00
VT55 Graphics Terminal with integral hard copier. £995.00
VT100 DECscope, as new £695.00

LSI11 C.P.U., MEMORY, OPTIONS
DEC
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BA11MF 3½" expander box £625.00
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DRV11 Parallel Interface £115.00
KD11F CPU module with 4K ram £250.00
MSV11B 4K ram £95.00
MSV11C 16K ram. £325.00
RXV11 Dual Floppy Disk Drive and control £1350.00

POWER SUPPLIES
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H720 Power supply for BA11 Expander Box. BRAND NEW SURPLUS £175.00

PDP8A C.P.U.
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PDP8A Processors, systems and add-on memory usually available.

PDP8A MEMORY
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MM8AA 8KW Core. £500.00
MM8AB 16KW Core £995.00

CABINETS
DEC
A selection of 6ft, 4ft and low-boy cabinets usually available — please ring for latest stocks.

MISCELLANEOUS
Calcomp
Drum Plotter model 565 .... £1250.00
Data General
Nova 1210 CPU type 8133-2 with 4KW "AS IS" £395.00
Houston Instruments
Flat bed Plotter type DP3 — 1/5 .... P.O.A.
Racal
Modem type LS126. .... P.O.A.

PRINTERS
Centronics 101A.
Heavy Duty Matrix printer with 64 ASCII upper case character set 165 cps operation 132 print positions with adjustable tractor feed. Parallel input. Special offer a few only remaining £295.00

Diablo Hyterm 1620
Daisy-Wheel KSR (keyboard-send-receive) model with standard RS232 interface, 45 cps print speed, 110/150/300 baud, switch-selectable parity top-of-form selector. Graphics capability under software control £1,275.00

Diablo 1355
Receive-only daisy wheel printer with parallel interface £895.00

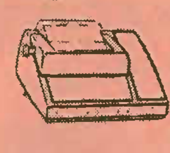
Selkosha GP80.

BRAND NEW — LOW COST MATRIX PRINTER IDEAL FOR MICROPROCESSOR USERS SUCH AS HOBBYISTS & EDUCATIONALISTS OR ANY LOW-BUDGET APPLICATION

- ★ Full upper/lower case ASCII PLUS GRAPHICS Mode
- ★ 80-column printing with adjustable tractor feed
- ★ Standard and double-width characters (12 cpi and 6 cpi)
- ★ 30 cps print speed with 1-line buffer
- ★ Standard parallel (Centronics-type) interface
- ★ Optional interfaces available for RS232, IEEE488, Tandy, PET, Apple II
- ★ ONLY .... £199.00 (Mail order total .... £234.60)

Tally 1602
160 cps Matrix Printer with full 96 upper/lower case ASCII character set 7 × 7 dot matrix 132 columns with adjustable tractor feed bidirectional printing, double-width character feature self test facility Centronics-type parallel interface £875.00

Teletype.



Low Cost Printer Offer.
Teletype 33 printer mechanism including case but no keyboard or electronics, 64 upper case ASCII, 10 cps, pinfeed platen, ideal for the electronic hobbyist ONLY £85.00

PAPER TAPE PUNCHES
Digitronics.
P135/20 paper tape punch Solenoid-actuated unit capable of punching 5 to 8 channel tapes at speeds up to 35 cps.
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LOW COST VDUs
Hazeltine.

H1000 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. 12 × 80 display upper case ASCII, RS232 interface, choice of baud rates Standard baud rates either (a) 110/300 or (b) 300/1200. (£25 surcharge for other combinations up to 9600 baud).
SUPER VALUE £199.00

H2000 Superb spec, including full XY cursor addressing and edit facility. 27 × 74 display, upper case ASCII, RS232 interface, switch-selectable baud rates £299.00

H2000C NOW ALSO AVAILABLE with 25 × 80 line format and C-MOS logic £375.00

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Hazeltine 1500 from £575.00
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Tektronix
4010-1 Graphics Terminal with high-resolution graphics mode standard alphanumeric mode, printer port, integral stand £1,750.00
4014-1 Graphics terminal with enhanced graphics £6950.00
611 XY Storage monitor some with brand new tube .... from £1150.00 to £1500.00

KEYBOARDS
New ASCII Keyboards
KB756MF 56-station keyboard with full upper/lower case ASCII, parallel input, mounting frame for extra rigidity power requirements +5V, −12v .... £39.00 (mail order total. £47 15)
KB771MF as per 756MF but with 71 keystations incorporating numeric pad and cursor control keys .... £65.00 (mail order total) £77.05
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SURPLUS ASCII KEYBOARDS
Clare-Pendar KB3, 63 Station reed-switch ASCII Keyboard with ROM and tested working, circuit diagram supplied .... £35.00 (mail order total £41 98)
Clare-Pendar KB3 63-station reed-switch keyboard **untested and without ROM** (circuit supplied) .... £15.00 (mail order total. £18 98)

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HM 203 PORTABLE OSCILLOSCOPE (ILLUSTRATED)
Dual Trace. DC to 20MHz. 8 × 10cm display. Risetime 17.5nS. Sensitivity 5mV/cm-20V/cm. Timebase 0.5µs-0.2s. X5 magnifier. X-Y operation. Auto or variable trigger. Channel 1, Channel 2, line and external. Coupling AC, or TV low pass filter. Weighs only 6Kg. Size (m.m.) H. 145, W. 285, D. 380.
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HM 307 OSCILLOSCOPE
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NEW MODEL.

HM 412-5 OSCILLOSCOPE
Dual Trace. DC to 20MHz. 8 × 10cm rectangular display with internal graticule. Risetime 17.5nS. Sensitivity 5mV/cm-20V/cm. Timebase 0.5µS-0.2S. X5 magnifier. X-Y operation. Z modulation. Auto (peak value) or variable trigger. Channel 1 or 2, altern. Ch. I/II, line ext. Sweep delay. Variable hold-off time. Weight 7.5Kg.
Still at only £350.00

HM 512-8 OSCILLOSCOPE
Dual trace. DC - 50MHz. Risetime 7nS. 5mV/cm-20V/cm. Timebase 100nS/cm-2S/cm. X5 magnifier. X-Y operation. Z modulation. Sweep delay and delay line permits viewing of leading edge.
THE BEST PRICED 50MHz SCOPE ON THE MARKET AT £580.00

All the above scopes are available with P7 long persistence C.R.T's (except HM 307) prices on application

The above prices do not include carriage or VAT (15%). Please send for Technical Literature.

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Fluke

* BRAND NEW JUST RELEASED NOW 2 YEAR WARRANTY.

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3½ Digit hand held LCD. DMM. AC/DC volts, DC/AC current, resistance, diode test. 0.25% basic DC accuracy. Overload protection. Vinyl carrying case C90 £8.00 .... £75.00

* Fluke 8021B.
Same spec as 8022B with additional audio tone for continuity. Vinyl case C90 £8.00 .... £85.00

*Fluke 8020B
3½ digit 0.1% basic DC accuracy. DC/AC volts, DC/AC current, resistance, diode test and conductance. Continuity beeper. Vinyl case C90 £8.00 .... £117.00

*Fluke 8024B
3½ digit. 0.1% basic DC accuracy. DC/AC volts, DC/AC current, resistance. Diode test, conductance, logic + continuity detect + temperature. Peak hold on voltage and current functions, continuity beeper. Vinyl case C90 £8.00 .... £155.00

FLUKE 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. **£245** mains model **£285** mains battery.

FLUKE 8012A
3½ Digit LCD DMM with true RMS on AC volts and current. DC volts 200mV-1KV, 100µV resolution. AC volts 200mV-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 **£218.00** mains model **£244.00** mains battery.

FLUKE 8010A
3½ Digit LCD DMM Same spec as 8012A plus a 10Amp AC/DC current range, but not low resistance range. **£167.00** mains model **£193.00** mains battery.
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 above prices do not include carriage or VAT (15%). Please send for Technical Literature.

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I.C.E.

680G MULTIMETER (ILLUSTRATED) 48 RANGES
DC volts: 100mV-2-10-50-200-500-1000V AC volts: 2-10-50-250-1000-2500V DC current: 50-500µA-5-50-500mA-5A AC current: 250µA-2.5-25-250mA-2.5A Resistance Ω × 1-Ω × 10-Ω × 100-Ω × 1000 and LowΩ, full range 1Ω-10MΩ Up to 100MΩ can be measured using ext. AC supply. dB scale -10 to +22dB. OdB = 1mW into 600Ω Sensitivity DC 20KΩ/V, AC 4 KΩ/V. Accuracy 2.0% AC and DC. Battery Eveready No. 8 Overload capability 1000:1 on resistance ranges. Protected by internal 3ΩFuse. Size with case 10.8 × 11 × 3.7cm. Meter size 10cm. Supplied with leads and carrying case

£24.50

680R HIGH ACCURACY MULTIMETER 80 RANGES
DC volts. 100mV-2-10-50-200-500-1000V AC volts: 2-10-50-250-1000-2500V DC current: 50-500µA-5-50-500mA-5A AC current: 250µA-2.5-25-250mA-2.5A X2 switch on all voltage and current ranges except 2500V AC setting. Resistance: Ω × 1-Ω × 10-Ω × 100-Ω × 1000 and LowΩ, full range 1Ω-10MΩ, up to 100MΩ can be measured using ext. AC supply. dB scale —10 to +22dB. OdB = 1mW into 600Ω Sensitivity DC 20KΩ/V, AC 4KΩ/V. Accuracy DC 1%, AC 2%. Battery Eveready No. 3. Overload capability 1000:1 on resistance ranges. Protected by internal 3Ω fuse. Size with case 13.7 × 10.4 × 5.4cm. Meter size 12cm. Supplied with leads and carrying case.

£32.00

MICROTEST 80 POCKET SIZED MULTIMETER 40 RANGES
DC volts. 100mV-2-10-50-200-1000V AC volts: 1.5-10-50-250-1000V DC current: 50-500µA-5-50-500mA-5A AC current: 250µA-2.5-25-250mA-2.5A Resistance: Ω × 1-Ω × 10-Ω × 100 and Low Ω, full range 1Ω-5MΩ dB scale —10 to +22dB, odB = 1mW into 600Ω Sensitivity: DC 20KΩ/V, AC 4KΩ/V Accuracy 2% AC and DC. Battery Mallory RM 625N Overload capability 1000:1 on resistance ranges. Protected by internal 3Ω fuse. Size with case 9.3 × 9.6 × 2.3cm. Meter size 8.5cm. Supplied with leads and carrying case.

£16.60

Please add £1.50 carriage per meter plus 15% VAT on total meter and carriage price. Send for Literature.

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Electronic Brokers

Sinclair ZX81 Personal Computer- the heart of a system that grows with you.

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand – over 50,000 in the first 3 months!

Today, the Sinclair ZX81 is the heart of a computer system. You can add 16-times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

Lower price: higher capability

With the ZX81, it's still very simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, *and* to drive the new ZX Printer.

New BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs.

Kit: £49.95

Higher specification, lower price – how's it done?

Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

New, improved specification

- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer.
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

Built: £69.95

Kit or built – it's up to you!

You'll be surprised how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.

16K-byte RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

With the RAM pack, you can also run some of the more sophisticated ZX Software – the Business & Household management systems for example.

sinclair ZX81

6 Kings Parade, Cambridge, Cambs., CB2 1SN.
Tel: (0276) 66104 & 21282.

Available now- the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics *and* highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further intructions.

At last you can have a hard copy of your program listings – particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

How to order your ZX81

BY PHONE – Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST 7, Cambr'dge, CB2 1YY. Order

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack.	18	49.95	
	Sinclair ZX Printer.	27	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

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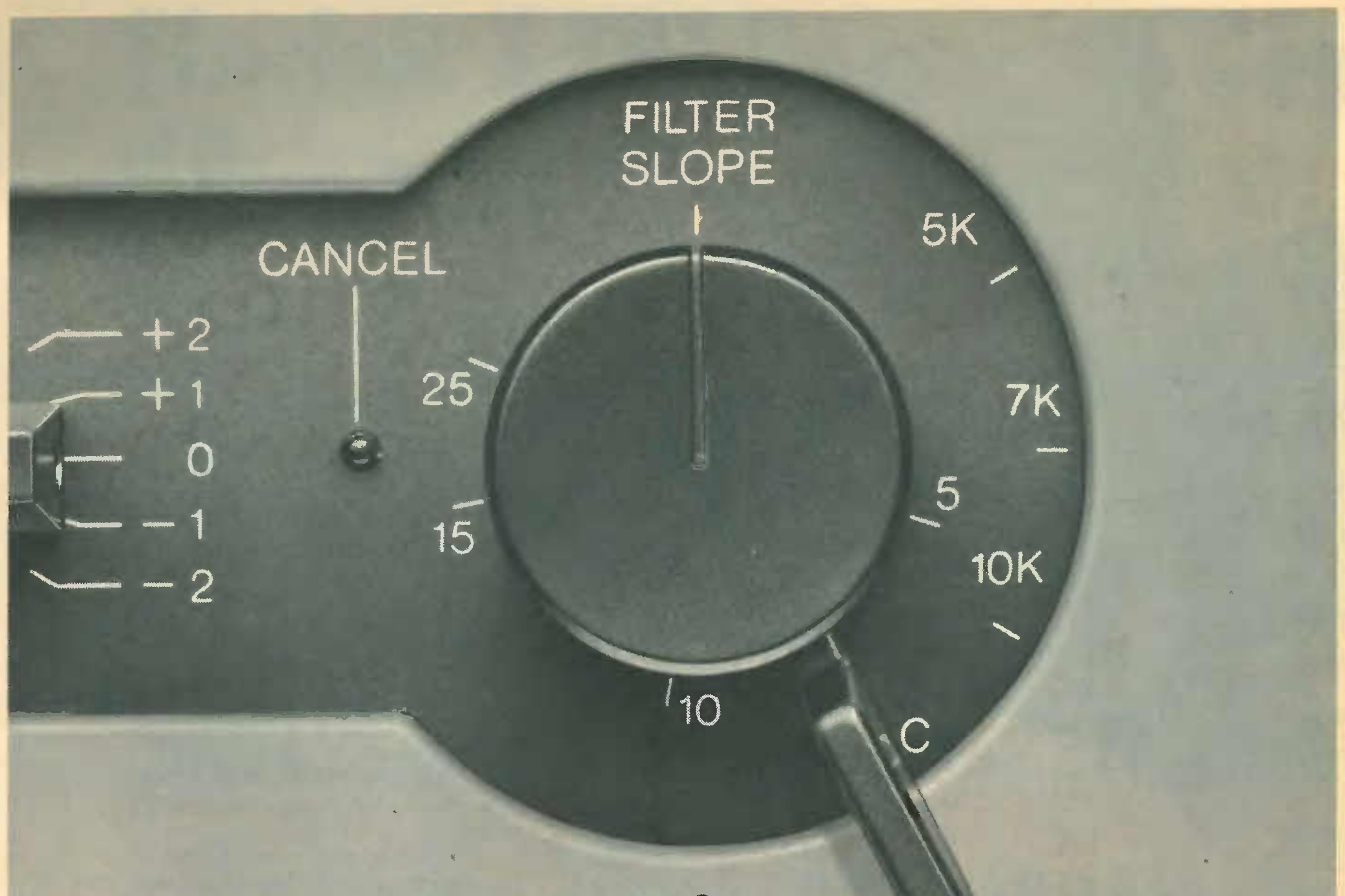

If everything were perfect...

. . . a control unit would consist of a volume control and a programme selector switch.

In practice, correctly designed tone controls can make a significant contribution.

For a constant sound level, replay from a gramophone record produces distortion which increases very rapidly at high frequencies — doubling in fact for every major third increase in pitch.

There comes a point when the contribution of this distortion is increasing at a greater rate than the musical content and this is what decides the optimum setting of the comprehensive Quad filter system, an essential and integral part of every Quad pre-amplifier.

The rate of attenuation can be set anywhere between 0 and 25dB per octave starting at one of three frequencies 5k, 7k, or 10kHz and an appropriate setting can be found for each record to provide more of the music and less of the distortion.

To learn all about the Quad 44 write or telephone for a leaflet.

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QUAD
for the closest approach to the original sound

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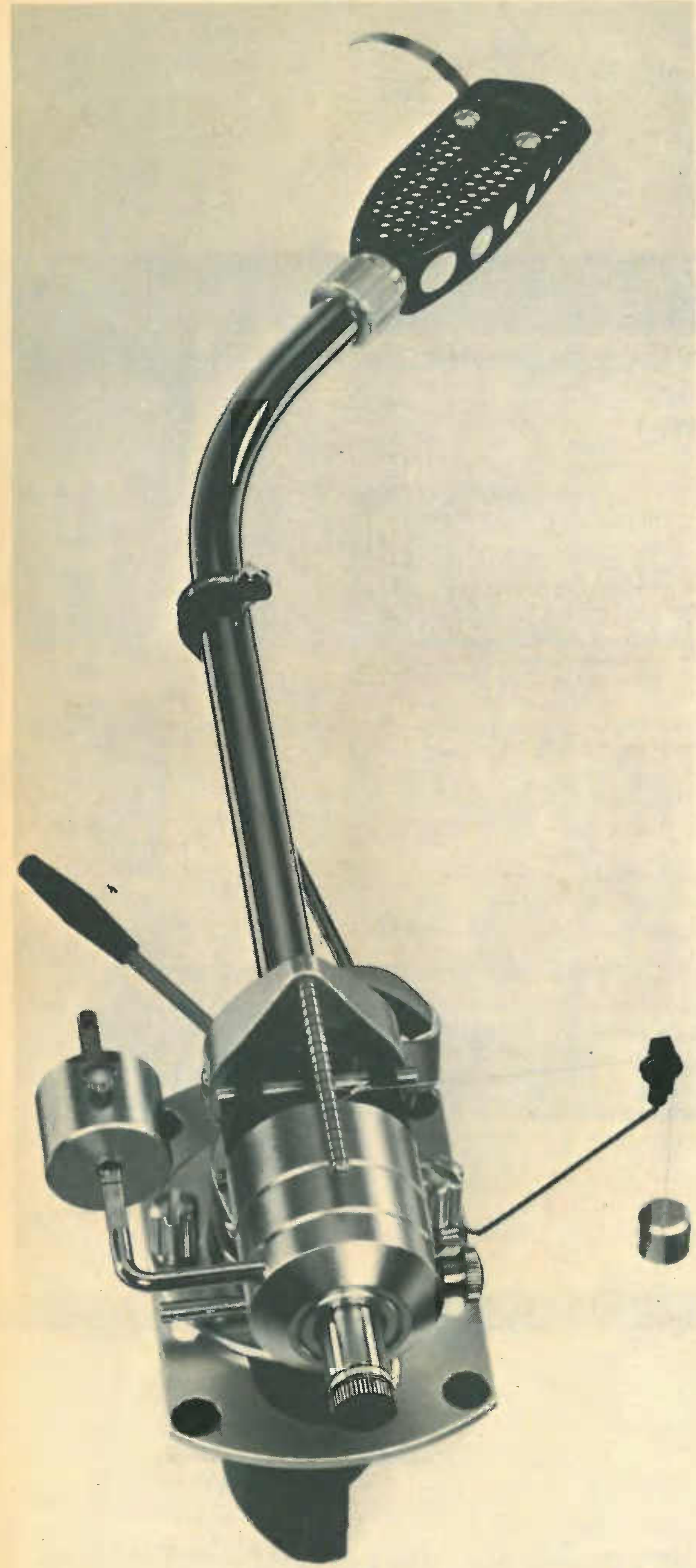

Model 3009-R

This new arm is a 9" version of the Model 3012-R and is suitable for standard decks.

Special features include:

- Thin-walled stainless steel tone arm.
- New design lateral balance system with longitudinal and lateral fine adjustment for cartridges weighing from 1½ - 26 grams, or plug-in heads up to 33½ grams.
- Extra-rigid low mass shell with double draw-in pins.
- Geometry optimised for 12" records.

The 3009-R has a typical effective mass of 12.7 grams and is intended for cartridges requiring a vertical tracking force of 1.5 grams and upwards. It is therefore particularly suitable for the many MC's in this category.

Easily adjustable and an excellent choice where the rapid interchange of cartridges is a requirement.

Full details will be sent on request.

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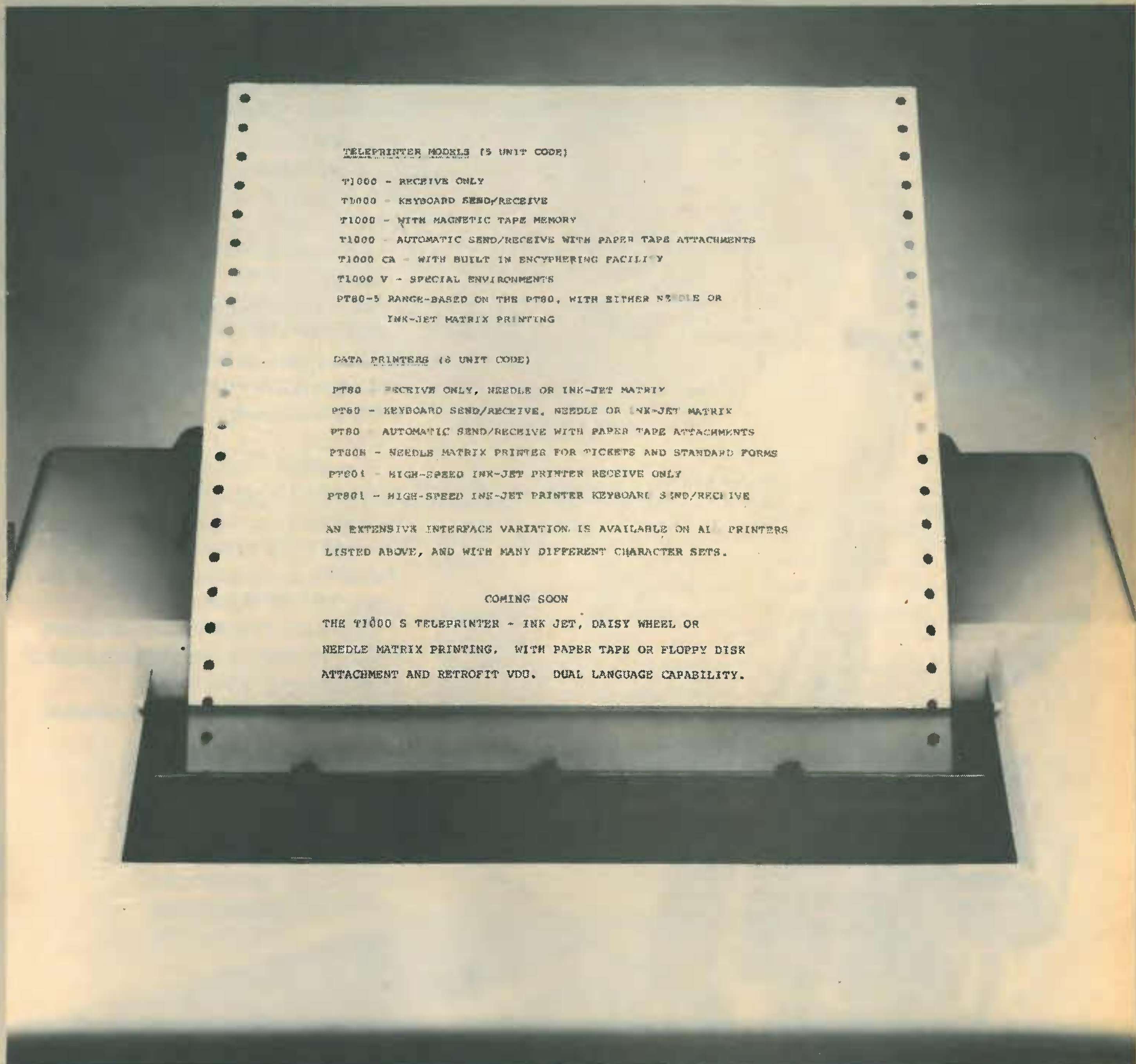
SIEMENS



Siemens-Printer terminals are our business

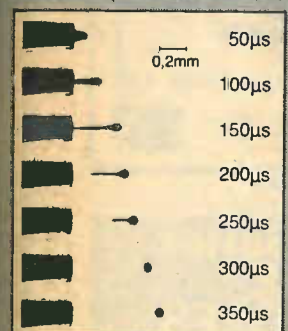
A quiet word...

The characteristics of an ideal printer, whether it be for use as a teleprinter or a printer terminal might be stated as an efficient, quiet machine that can produce high quality text on plain paper in clear, indelible script.

Siemens' Model 1000 teleprinter and the versatile PT80 series printer terminals possess these attributes and many more. Indeed they are designed to satisfy a variety of today's text and communication requirements.

Teleprinters and Data printers for the office

The conventional teleprinter, has been greatly refined over the years but some machines still need frequent maintenance checks and are too noisy for use in an open office. However, Siemens' development of printing mechanisms has allowed the noise producing parts to be reduced. This, together with the introduction of advanced electronic techniques have been built into the Model 1000 teleprinter.



This teleprinter offers many advantages over more conventionally styled teleprinters, the most significant features being quietness of operation and the extensive use of electronics to replace mechanical parts. The Model 1000 is so quiet it can be used in an open office, eliminating the necessity for a separate telex room housing a 'chattering' teleprinter.

The use of electronics also greatly reduces the need for preventive maintenance and regular periodic checks and, furthermore, makes for a smaller, more economical, easier-to-use machine. A prominent feature of the Model 1000 is the easily replaceable daisy wheel, and typewriter style red and black ribbon.

Variants for different purposes

Siemens Model 1000 teleprinters are made in a number of variants. For example, receive-only versions, with paper tape attachments, and magnetic tape memories for bulk message storage and editing are available. For use in special environments there is a Model 1000 V designed for military type applications.

Model 1000 S

The teleprinter Model 1000 S is an exciting new development using the latest technological advances. The versatility of the Model 1000 S is illustrated by the fact that it will produce both latin and non-latin script and switch between them when required e.g. Arabic, Greek, Cyrillic, Hangul or Farsi. The Model 1000 S is available with either a daisy-wheel, a needle-printer head, or an ink-jet. Optional items include a visual display unit and floppy disk message store.

Security – a growing problem

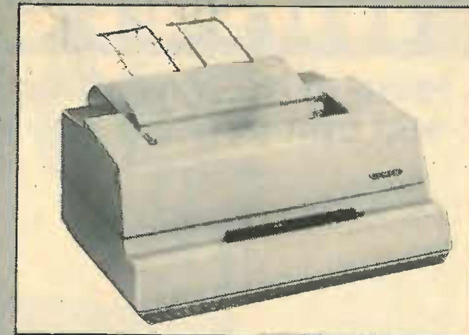
Industry, commerce, Government departments, and large international concerns and institutions frequently have a communications security requirement. The Model 1000 CA (Cryptographical Application) gives the message originator and recipient protection from any electronic 'eaves-dropping'. This is done by encyphering and decyphering the message through a built-in cryptographic device. This machine has been designed to be compatible with all standard telegraph circuit options.

PT80 – a concept for today

The PT80 printer terminals are a result of many years' operational experience in both text and data communications. In essence, these machines are electronic terminals suited to a wide range of communications and data networks as well as process control.

The PT80 printer terminal uses either a 12 needle printing head for refined print quality, or alternatively the Siemens revolutionary ink-jet mechanism to achieve the ideal particularly in respect of minimal noise. The PT80 uses the ink-jet principle to attain a printing speed of up to 270 characters per second. The principle is featured very simply in the illustration on this page, with the droplet being ejected by means of a shockwave which causes a momentary increase in pressure in the nozzle.

What happens immediately afterwards in front of the nozzle orifice is shown in our illustration. The shockwave in the nozzle is generated by a piezo-electric transducer to which a voltage is momentarily applied. Siemens has ensured that ink is ejected only as and when needed.



Versatility

As with Siemens' Model 1000 teleprinters a number of PT80 variants are available to suit specific requirements. For example, there are receive-only machines with needle or ink-jet printing, a teleprinter (PT80-5) and a variant with paper tape attachments for automatic send/receiver. There is also a wide variety of character sets and an extensive range of interface modules to suit most telecommunications and data peripheral requirements.

PT80-H

Also available is the PT80-H, designed to print airline-style tickets, multi-part forms and continuous pre-printed stationery. This machine has the ability to recognise the validity of each ticket by series and type and adjust the print format accordingly. It can also be fitted with an integral guillotine, so that forms can be cut to size as they are used.

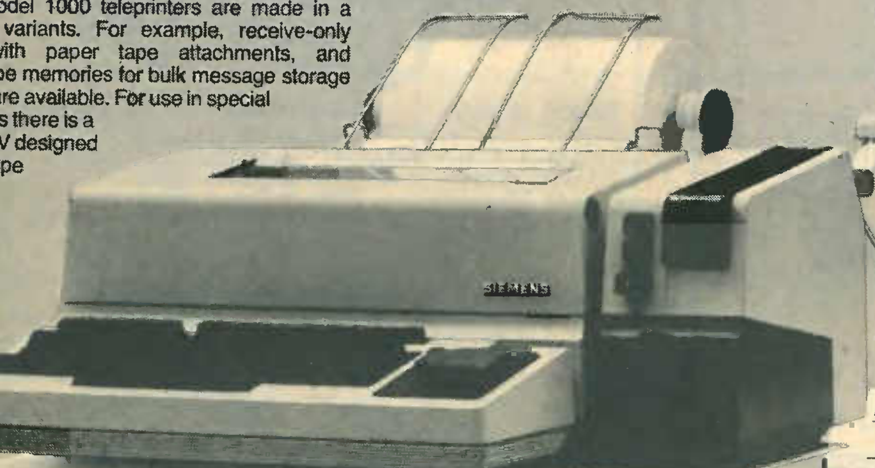
Easy servicing

Again, as with the Model 1000 teleprinter, these printer terminals are based on the modular design concept. For example, plug-in modules of the PT80i enable a fast and therefore economical service support.

Operational flexibility

PT80 machines generally operate with seven-bit codes or alternatively the PT80-5 teleprinter variant uses the five-bit code. The standard terminals are suitable for operating at speeds of up to 600 baud, the teleprinter variant at up to 200 baud, and the PT80i up to 4800 baud. All the PT80 terminals satisfy the requirements for a flexible character set.

Notwithstanding their advanced specification, the PT80 range of printer terminals is compact and simple to use and along with the Model 1000 teleprinters they are perfect examples of 'quiet words from Siemens'.



For full information, cut out the coupon and send to Marketing Services Dept., Siemens Ltd., Siemens House, Windmill Rd. Sunbury-on-Thames, Middlesex TW6 7HS. Or telephone Sunbury-on-Thames (09327) 85691. Tx. 8951091.

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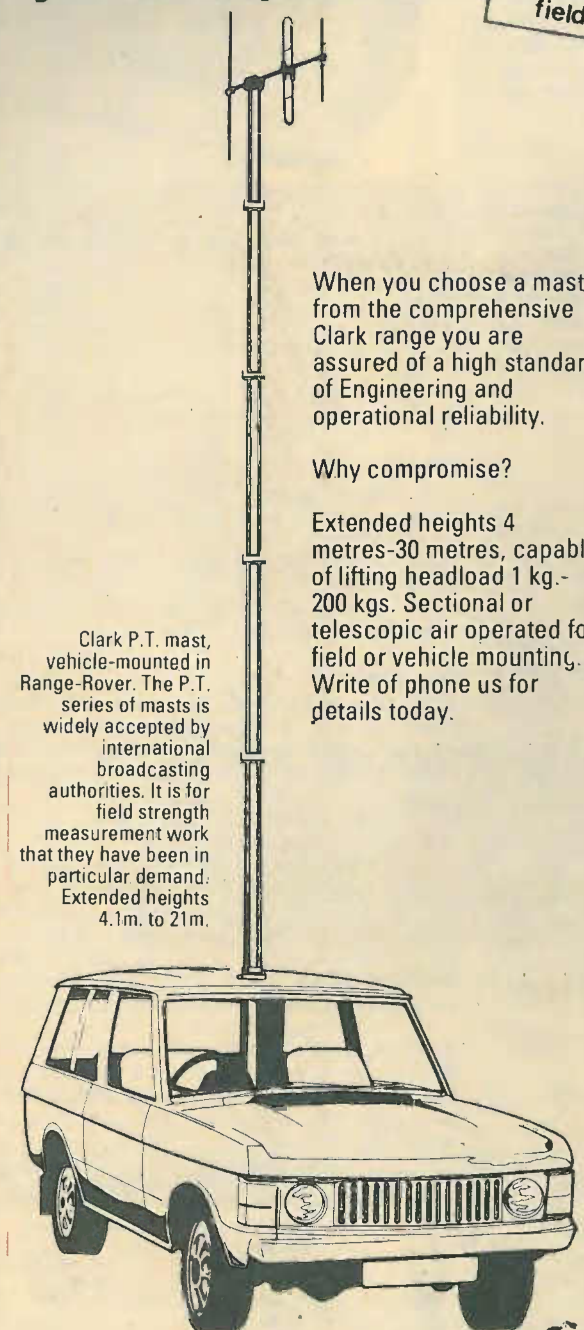

Clark P.T. mast, vehicle-mounted in Range-Rover. The P.T. series of masts is widely accepted by international broadcasting authorities. It is for field strength measurement work that they have been in particular demand. Extended heights 4.1m. to 21m.

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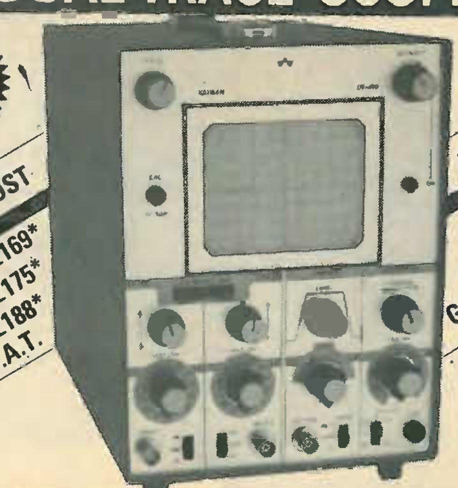
SAFGAN DT-400 Series BRITISH MAKE DUAL TRACE 'SCOPES

NEW 20MHz

LOW COST

DT-410 £169*
DT-415 £175*
DT-420 £188*
* Ex V.A.T.

RELIABLE WITH 18 months GUARANTEE



DT-410, 10 MHz	DT-415 15MHz	DT-420 20MHz

★ CH1, CH2:5mv/div–20v/div.
★ Time Base: 1 sec/div–100ns/div.
★ XY Facility: Matched XY inputs.
★ Trigger: Level control, ± Slope selection.
★ Auto, Normal, TV Triggering.
★ External Trigger
★ Z-Modulation.
★ CAL output 1v 1kHz.
★ Graticule blue ruled 8x10 div. (4in. CRT).
★ Size: H215mm, W165mm, D280mm.
★ Weight: 4kg.

PROBE (XI-REF-X10) £10.50

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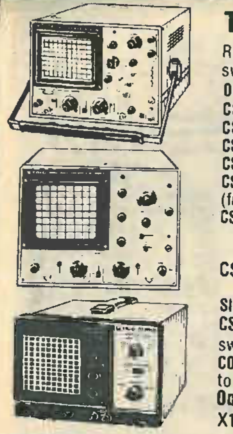

TRIO OSCILLOSCOPES

Range of mains operated Scopes with 5" displays, triggered sweep (UK c/p **£3.50**)

DUAL TRACE
CS1562A 10 MHZ; 10 MV; 1 micro sec. £267.95
CS1560A II 15 MHZ; 10mV; 0.5 micro sec. £341.55
CS1566A 20 MHZ; 5mV; 0.5 micro sec. £363.40
CS1577A 35 MHZ; 2mV; 0.1 micro sec. £523.25
CS1830 Mk II 30MHZ, 2mV, 0.2 micro sec. (fitted delay line) £626.75
CS1575 5 MHZ, 1mV, 0.5 micro sec. Multi display Audio scope. £312.80

CS1820 20 MHZ, 2-5 mV 1 micro delay sweep £483.00

SINGLE TRACE
CS1559A 10 MHZ, 10mV, 1 micro sec. 5" display Triggered sweep (UK c/p **£3.50**) £251.85
CO1303D 5 MHZ, 10mV, low sweep for observation below 1 HZ and up to 450 MHZ, 75mm display (UK c/p **£2.00**) £124.20
Optional probes – all models.
X1 £7.95 X10 £9.45 X1-X10 £10.50 X100 £16.95

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Reliable low cost portable instruments, bench models all 25.5 x 15 x 5cm. Generators mains operated rest battery (supplied). UK c/p Hand models 65p, bench £1.15)

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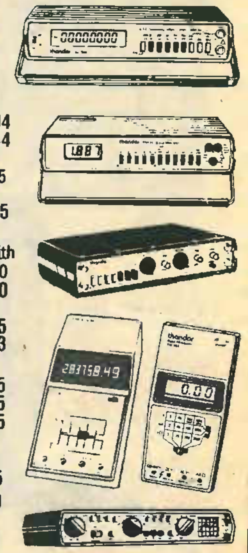
TM354 Hand held, DC 2A, 2m ohm, 1mV – 1000V DC, 500v AC. £45.94
TM352 Hand held, DC 10A, Hfe test. Continuity test £57.44
TM353 Bench, 2A AC/DC, 1000V AC/DC. 20M ohm. Typical 0.25% New low price £86.25
TM351 Bench, 10A AC/DC, 1000V AC/DC. 20M ohm Typical 0.1% £113.85

FREQUENCY COUNTERS (8 Digit)
PFM200A Hand held LED 200 MHZ. 10mV (600 MHZ with TP600) £67.50
TF040 Bench LCD. 40 MHZ, 40mV (400 MHZ with TP600) £126.50
TF200 Bench LCD. 200 MHZ. 10-30mV (600 MHZ with (TP600) £166.75
TP600 600 MHZ ÷ 10 Prescaler 10 mV £43.13

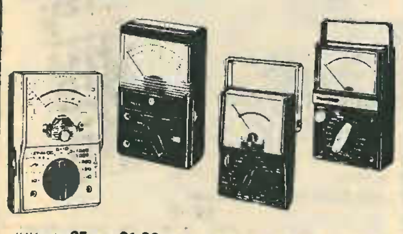
GENERATORS (All bench models) mains operated
TG100 Function. 1 HZ-100 KHZ. Sine/SQ/Triangle/TTL £90.85
TG102 Function. 0.2 HZ-2 MHZ. Sine/SQ/Triangle/TTL £166.75
TG105 Pulse. 5 MHZ-5HZ (200nS-200mS) various outputs £97.75

OSCILLOSCOPE (Bench model low power portable) 10 MHZ 2" trace. 10mV. 0.1 micro sec. All facilities. Model SC110 £159.85
(Rechargable battery pack **£8.63**, AC adaptor/charger £5.69

OPTIONAL ITEMS
Carry case (bench only) **£6.84** AC Adaptors (state model) **£5.69**



MULTIMETERS



(UK c/p **65p** or **£1.00** for two)
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KRT101 10 range pocket 1K/Volt £4.50
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NH55 10 range pocket 2K/Volt £6.50
AT1 12 range pocket Deluxe 2K/Volt £7.75
ST5 11 range pocket 4K/Volt £8.50
NH56 22 range pocket 20K/Volt £11.95
YN360TR 19 range plus Hfe Test 20K/Volt £13.50
ST303TR 21 range plus Hfe Test 20K/Volt £15.95
KRT5001 16 range – range double 50K/Volt £16.50
AT1020 19 range Deluxe plus Hfe Test 20K/Volt £16.95
ETC5000 As KRT5001 plus colour scales 50K/Volt £17.95
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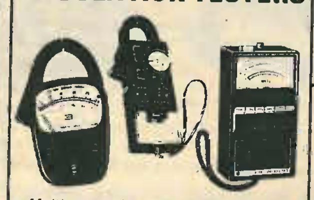
TMK500 23 range. Plus 12A DC Plus Cont. Buzzer 30K/Volt £22.75
AT205 21 range Deluxe 10A DC 50K/Volt £25.75
C7080 26 range large scale 10A DC. 5KV AC/DC 20K/Volt £27.50
AT210 23 range Deluxe 12A AC/DC 100K/Volt £31.00
360TR 23 range Large scale 10A AC/DC Hfe Test 50Meg ohm. 1KV AC/DC 100K/Volt £34.95

CLAMP-ON-METERS INSULATION TESTERS



Multi-range clamps all with resistance range, carry case & leads. Also digital and DC clamp in stock (UK c/p **75p**)
ST300 300A 600V 9 ranges £25.95
ST310 300A 600V 9 ranges £29.95
K2602 150A, 600V, AC 7 ranges £35.95
***K2606** 300A, 600V, AC 8 ranges £44.00
K2803 300A, 600V, AC 9 ranges £53.95
K2903 900A, 750V, AC 9 ranges £77.50
K2103 1000A, 750V, AC 9 ranges £95.00
*Optional temperature probe £13.80

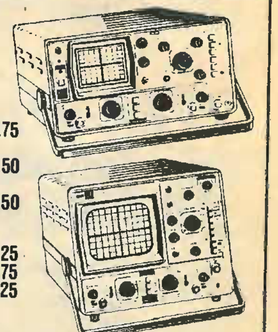
ELECTRONIC INSULATION TESTERS
Battery operated complete with carry case (UK c/p **£1.00**)
YF500L 500V/100Meg. Plus 0-100 ohm £55.00
K3103 600V/100Meg. Plus 0-2.6K ohm £95.00
K3106 500V & 1000V, 1000 & 2000Meg. £104.00
K4101 Earth resistance tester **£136.50**
M500 Hand cranked insulation tester 500V/100Meg. **£67.50**

CROTECH OSCILLOSCOPES

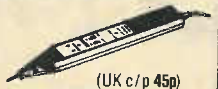
Range of Portable Scopes mains and battery operated. Plus special features (UK c/p **£3.00**)

3030 Single trace 15 MHZ, 5 mV. 0.5 micro secs. Plus built in component tester, 95mm tube £166.75
3131 Dual trace 15 MHZ, trig to 35 MHZ, 5mV, 0.5 micro sec. 130mm tube, plus component tester. £264.50
3034 Battery-mains dual trace 15 MHZ, trig to 20 MHZ, built in Nicads, 5mV, 0.5 micro secs. (Eliminator charger optional **£28.75**) £356.50

Also Available 3033, single trace 3034 £293.25
3035, 130mm 3030 £189.75
3337, dual 30 MHZ, 130mm £408.25
(Optional Probes all models – see Trio above)



LOGIC PROBE



(UK c/p **45p**)
Leader LDP076 50 MHZ. 10MEG ohm, 10n Sec. with carry case **£56.90**

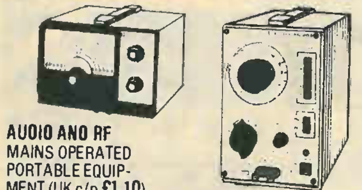
DIRECT READ HV PROBE

(UK c/p **65p**)
0/40KV: 20K Volt **£18.40**

OSCILLOSCOPE PROBE KITS

(UK c/p 50p per 1 to 3)
Available BNC plug or Banana
X1 **£7.95** X10 **£9.45**
X1-X10 **£10.50**
Also X100 (BNC only) **£16.95**

TRIO GENERATORS



AUDIO AND RF
MAINS OPERATED PORTABLE EQUIPMENT (UK c/p **£1.10**)
SG402 6 range RF 100 KHZ – 30 MHZ ± 1.5. INT/EXT MOD. 100 mV o/p Variable **£68.00**
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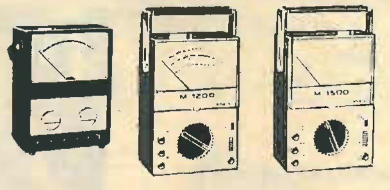
AG203 5 band 10 HZ – 1 MHZ. Sine/Square: 0.5dB deviation. Distortion Max. 0.1% Switched Alternator & variable. **£126.50**
ALSO IN STOCK Newtronics 200P & 200SPC 0.002 HZ 5.5 MHZ Generators (200 SPC with 100 MHZ counter)

PROFESSIONAL MULTIMETERS



(UK c/p **£1.50**) All featuring AC/DC Volts/Current & Ohms ranges.
M1500 43 range 20K/Volt: AC/DC 10A **£53.50**
M1200 30 range 100K/Volt: AC/DC 15A 200 Meg ohm. **£67.50**
K1400 26 range large scale 20K/Volt: 10A AC/DC: 20 Meg ohm: 5kV AC/DC **£79.95**
K200 39 range 10 Meg ohm input. 25 HZ-1 MHZ **£95.00**
OPTIONS Cases: M 1500 & 1200 **£16.50**: K1400 **£19.00**
Temperature Probe for K1400 **£13.80**

THURLBY DIGITAL MULTIMETER

4¾ Digit. 0.05% 7 Function LCD
Made to exacting standards in UK
30 ranges: 1200V DC, 750V AC, 10A AC/DC, 32 Meg ohm. Also includes frequency measurement to 4 MHZ and 4 KHZ output.
Price is with batteries, test leads and mains adaptor.
(optional carry case **£20.45**)
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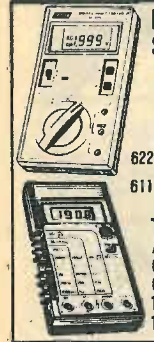

LCD DIGITAL MULTIMETERS
SPECIAL PURCHASE-LIMITED PERIOD ONLY

6220 Reliable 22 range hand held 3½ digit LCD with volt/ohms auto range, unit and range signs, 10 amp AC/DC, battery warning, lower power ohms range:
Model 6110 Also has range hold, continuity buzzer and improved accuracy. All models high quality rotary operation. Resolution 0.1 milli volt: 10-Micro amp: 0.1 ohm.
6220 1000v DC: 0.2/10A AC/DC: 600v AC: 2meg ohm. Was £55.95 **NOW £42.95**
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THIS SPECIAL OFFER IS QUALITY WITH VALUE
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6200 20/200mA version of 6220 (i.e. no 10 amp) £37.95
6100 0.2A version of 6110 (i.e. no 10 amp) £49.95
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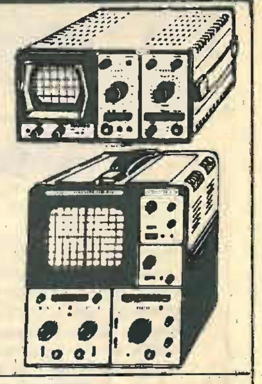
189m 30 range with Hfe checker, 10 amp AC/DC £69.95

HAMEG OSCILLOSCOPES



Range of top quality scopes for Amateur and Professional (UK c/p '307' **£3.00**, other **£4.00**)
307 Single trace 10 MHZ: 5mV: 0.5 micro sec. Plus built in component tester. 6 x 7cm display. £158.70
(Optional carry case **£18.40**)
203 Dual 20 MHZ: Trig to 30 MHZ: 5mV: 0.5 micro secs: 8 x 10cm display (replace model 312) £253.00
412-5 Dual 20 MHZ delayed sweep: trig to 40 MHZ: 5mV: 0.1 micro sec. 8 x 10cm display. £402.50
512 Dual 50 MHZ. Delayed sweep: Single sweep: Delay line: Trig to 70 MHZ: 5mV: 0.1 micro sec. 8 x 10cm display £667.00
Options 203/412/512 Viewing hood £6.90
Component tester 203, 412, 512 £46.00
Carry case (state model) £21.85
Optional Probes (All models) X1 **£8.50**: X10 **£10.50**
X1-X10 **£12.95**: X100 **£16.95**

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MAX100 100 MHZ Counter. Battery operated. 8 Digit 30mV typical. Bench portable LED £89.00
MAX50 6 Digit 50 MHZ Hand held LED £56.00
MAX550 2 range 6 Digit 550 MHZ hand held LED £97.75
PS500 500 MHZ prescaler for MAX50/100 £34.50
Circuit Powered Logic Probes Pulser and Monitors (UK c/p 65p)
LP1 DTL/TTL/CMOS: 10 MHZ. 100K ohm: Pulse: Memory £35.50
LP2 DTL/TTL/CMOS: 1.5 MHZ. 300K ohm: Pulse £19.95
LP3 DTL/TTL/CMOS: 50 MHZ. 500K ohm: Pulse: Memory £55.95
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DP1 Digital Pulse. Single shot or 100pps. £58.50

KEITHLEY PROFESSIONAL DIGITAL MULTIMETER

Model 130, 25 range. Easy to hold and use LCD DMM. Size 7 x 3.1 x 1.5
Ranges
DC Volts 200mV-1000V 0.5% 100 micro volt
AC Volts 200mV-750V 1% 100 micro volt
DC current 2mA-10AMP 1-2% 1 micro amp
AC current 2mA-10AMP 2% 1 micro amp
Resistance 200 ohm-20 Meg 0.5% 0.1 ohm £102.35

PROFESSIONAL TRANSISTOR CHECKERS UK C/P £1.50
All feature auto test and matching.
LTC 906A plus DC Parameters £111.55
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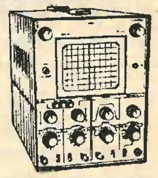
Also LTC 905 semi conductor curve trace (use with scope) £95.45

SAFGAN PORTABLE OSCILLOSCOPES



Range of low cost Dual Trace Scopes mains operated. Made in UK to exacting standards. Available as 10 MHZ: 15 MHZ or 20 MHZ. All feature 5mV sensitivity; 0.5 micro sec: 6.4 x 8cm display. (UK c/p **£2.50**)
DT410 Dual 10 MHZ £194.35
DT415 Dual 15 MHZ £201.25
DT420 Dual 20 MHZ £216.20
Optional probes available (see Hameg above)

SABTRONICS EQUIPMENT

New reliable range of DMM's and frequency computers with those extra facilities and competitive prices. All battery operated (supplied). Except 5020A mains. Optional mains eliminators available.
8 DIGIT COUNTERS 0.1 HZ to 10 HZ Res. 10mV sensitivity to 100 MHZ (UK c/p **£1.00**)
8110A 20 HZ-100 MHZ in 2 ranges £95.45
8610A 20 HZ-600 MHZ in 3 ranges £113.85
9 DIGIT COUNTERS 30mV sensitivity to 1GHZ. Resolution 0.1 HZ-10 HZ
86108 10 HZ-600 MHZ in 3 ranges. £125.35
80008 10 HZ-1GHZ in 3 ranges £184.00
FUNCTION GENERATOR (UK c/p **£1.00**) with mains adaptor
5020A 1 HZ-200 KHZ Sine/Square/Triangle/TTC Freq. sweep. Low distortion £98.90
DIGITAL MULTIMETERS Two LCD hand held – one with temperature range. Also LCD and LED Bench models.
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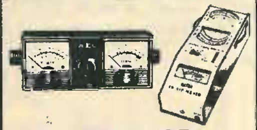
2037A As 2035A with –50°C to + 150°C Temp. range 0.1° resolution £109.25
2010A 3½ Digit LED. Auto decimal & minus. 10A AC/DC: 20Meg ohm etc. £95.45
2015A LCD version of above. **£109.25**
(c/p 2035/37A 65p: All others **£1.00**)

Options Touch & hold Probe for DMM's £14.95
Battery eliminators (state model) £5.69

VARIABLE REGULATED POWER SUPPLIES

Mains operated regulated single metre (UK c/p **£1.50**)
241 0/12-0/24V 1 amp £35.00
154 5-15 volt 3 amp £44.00
423 0/12-0/24V 3 amp £54.00



AMATEUR/CB

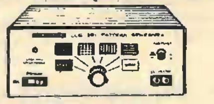
KDM6 1.5 to 250 MHZ Dip meter 6 ranges £38.50
SWR9 3-150 MHZ SWR + F/S £9.50
SWR50 Twin meter SWR + Power 1KW max. £13.95
310 Single meter SWR + Power 10W £8.95
110 SWR/Power/FS-10/100W £11.95
171 As '110' Twin meter £14.50
175 SWR/FS/AE Match (40 MHZ) £13.80
176 As '175' + 0/5/50 Watt power £16.95
178 As '175' + 0/10/100W + MOD Scale £19.50
HM20 SWR meter Plus 20K/Volt 19 range Multimeter £28.95
(Note: SWR-Power ETC to 144/150 MHZ)
Just a selection of a huge range in stock – send for latest lists including professional ranges.

POWER SUPPLIES

13.8 volt. Output regulated mains operated (c/p **£1.00**)
3 to 5 amp £15.50
5 to 8 amp £17.95

LASCAR BENCH MULTIMETER

3½ Digit LCD Made in UK: 25 ranges with basic 0.1% accuracy: 2A AC/DC with 0.1, Microamp resolution: 1KV AC/DC 20Meg ohm ETC.
LM100 £89.00 (UK c/p **£1.00**)
Also model LM2001 hand held model 2Meg ohm. 2A AC/DC ETC. **£57.70** (UK c/p **65p**)



TV COLOUR BAR PATTERN GENERATORS

PAL UHF and VHF Models
LGC393 VHF 6 pattern £143.75
LCG392u UHF 15 pattern £228.85
LCG392v VHF 15 pattern £231.15
LCG399 VHF/UHF 13 pattern £572.70

LEADER AUDIO RF FM TV GENERATORS

High quality mains operated equipment (UK c/p **£1.50**)
LSG16 RF Generator (matches LAG26) 5 ranges 100 KHZ-100 MHZ (300 MHZ harmonics). Int/Ext MOD: 100mV o/p: ± 1.5% accuracy £63.25
LSG 231 FM Stereo Generator 100 ± MHZ, all facilities £211.60

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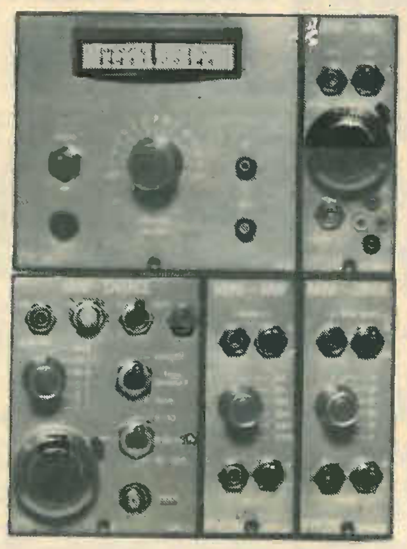

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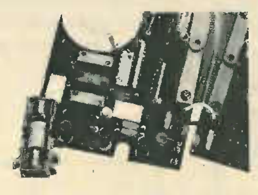

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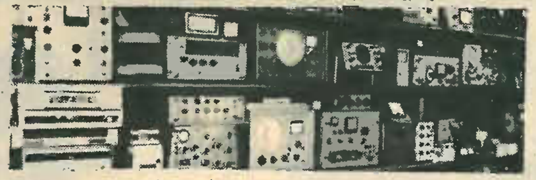

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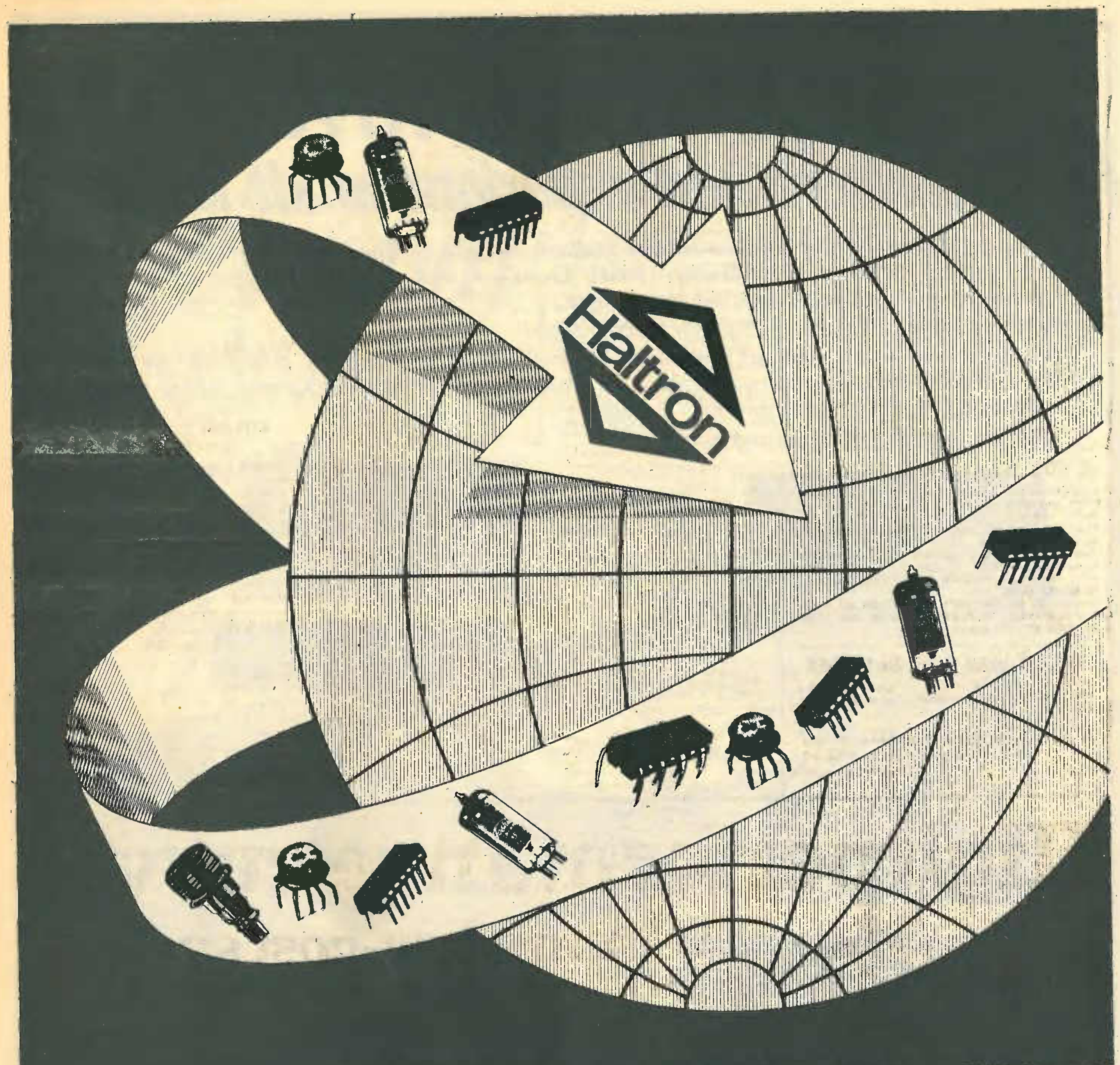

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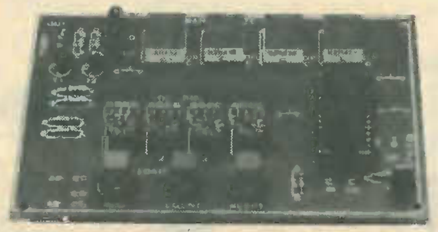

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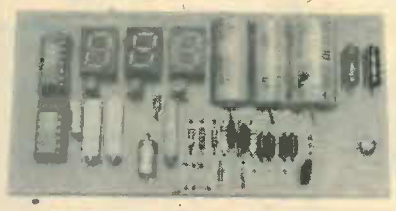

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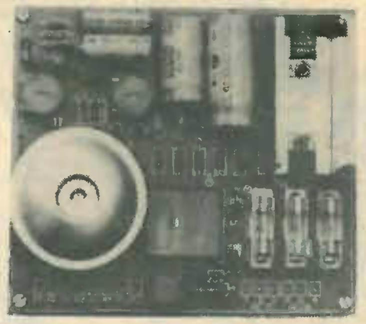

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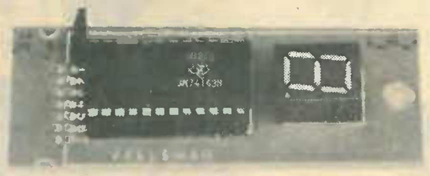

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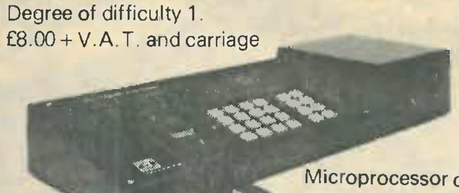

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- 2K byte STATIC RAM STANDARD (expandable to 4K byte)
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- length: 420mm
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- weight 3.75Kg

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- blank test
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Electronics and the muse

An article in this issue describes electronic equipment for disseminating images and sound in a way that is new to British citizens – subscription television. The technical novelty of the system makes it worthy of note, but on looking at the feature film programme material being put out one has difficulty in suppressing a big yawn – all good, middle-of-the-road stuff, undemanding, commercially well proved, with the obligatory sprinkling of 'X' Certificates and with all the calculated appeal of the completely predictable. Much the same can be said of those other relatively new electronic entertainment outlets, the video cassette and the video disc, and no doubt will again be said when satellite broadcasting arrives.

What a failure of the imagination, what an opportunity lost! We produce a technology for recording and conveying information, in sound and images with movement and colour, offering a capacity and versatility far exceeding anything previously known in its power to communicate the finest expressions of the human spirit, in art, intellect and the whole range of human endeavour – and what do we do with it? We deliver it into the itching palms of software merchants whose only concern is to maximize audiences and whose criteria are based on what will enable them to survive commercially in the competitive world of the entertainment business. We do this not so much by default but because we have to – because it is often these people who are our paymasters. Technical achievement notwithstanding, the bulk of our work in this area seems to be devoted to the modernization of cultural poverty. We are in the business of engineering the pollution of public taste and standardizing the shoddy to make it seem the norm.

It will be unfortunate if, on the present showing, these are the kind of alternative programme outlets that the pundits predict will be replacing to a great extent the output of the conventional broadcasters. It has been frequently claimed that the latest technology, in promising greater freedom of choice in electronic entertainment, heralds the end of the dominance of such organizations as the BBC and the IBA. The latest commentator here is Mr Peter Jay (economist, ambassador, breakfast tv mogul) who has just discovered in optical fibres the technology that will liberate us from the restrictions of the r.f. spectrum with its need for regulation. Every man could be his own programme producer, according to Mr Jay. Speaking at the Edinburgh International Television Festival, he declared "We are well and truly in sight of a world in which electronic publishing can both legally and practically take place without coming within the purview of the broadcasting regulations."

There is no question that optical fibres and other new technical developments are going to alter the overall pattern of electronic entertainment, but Mr Jay underestimates the two great advantages of conventional broadcasting: in organization, the resources it has to mount elaborate, high quality productions (e.g. "The voyage of Charles Darwin"); and in technology, the cleverness of the all-pervading electromagnetic wave in unobtrusively getting to your receiver aerial wherever it may be. And it is through the broadcasting organizations that we have the best means of raising programme standards, because of their accountability to the public.

But whatever happens in the development and exploitation of the new technology, responsible engineers will want to feel proud of the results of their work. It may be naive to expect better technology to bring higher standards, but it is worse – a cop-out – not to expect it.

High-resolution weather satellite pictures

Receiver design

by M. L. Christieson

TIROS-N series satellites send high-resolution weather pictures in real time and it is possible for the enthusiastic amateur – as well as the professional – to receive, display and store image transmissions direct from the spacecraft. The author presents the design philosophy and some practical details of a station for receiving and demodulating these digital transmissions. Data processing and storage by computer are outlined in the article but interfacing is left to the constructor due to the large variations in computer systems. This part of the article discusses transmission characteristics, antennas and receiver design.

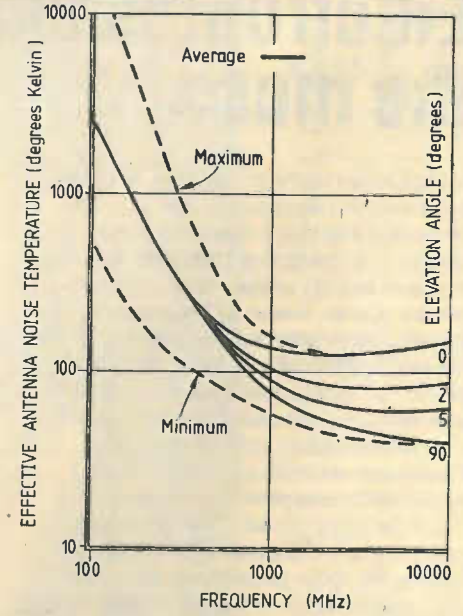

Fig.2. Graph of effective antenna noise temperature against frequency.

Facsimile weather pictures sent in analogue form by a variety of scanning radiometer satellites are familiar to many people from either television weather bulletins or direct reception by enthusiastic amateurs. Some pictures come in real time from satellites in polar orbit such as TIROS and METEOR, while some are preprocessed and retransmitted from geostationary platforms such as GOES, Meteosat, and GMS. Although the image scanning parameters differ, they are all sent as an amplitude modulated signal on a 2400Hz f.m. subcarrier, and can therefore be described as 'analogue' transmissions. They all come under the generic term of 'automatic picture transmissions', or a.p.t.

Previous spacecraft have also sent pictures with higher spatial resolution on S band (1700MHz) at the same time as the a.p.t. on v.h.f. (137MHz) in analogue form, using the same system but at a higher line rate. With the launch of TIROS-N, the first in a new series of NOAA weather satellites, and Meteosat-1, a new breed of pictures became available in Europe. These are sent in digital form, consisting of a stream of ones and zeros containing numerical information about the radiance value of the ground below. This type of transmission, known as p.d.u.s. (primary data user station) from Meteosat and h.r.p.t. (high resolution picture transmission) from the TIROS series, provides the highest resolution weather pictures to date. Unfortunately Meteosat-1 is no longer operational, but succeeding satellites in the TIROS series are providing good images throughout the world, and they will be replaced as a matter of routine.

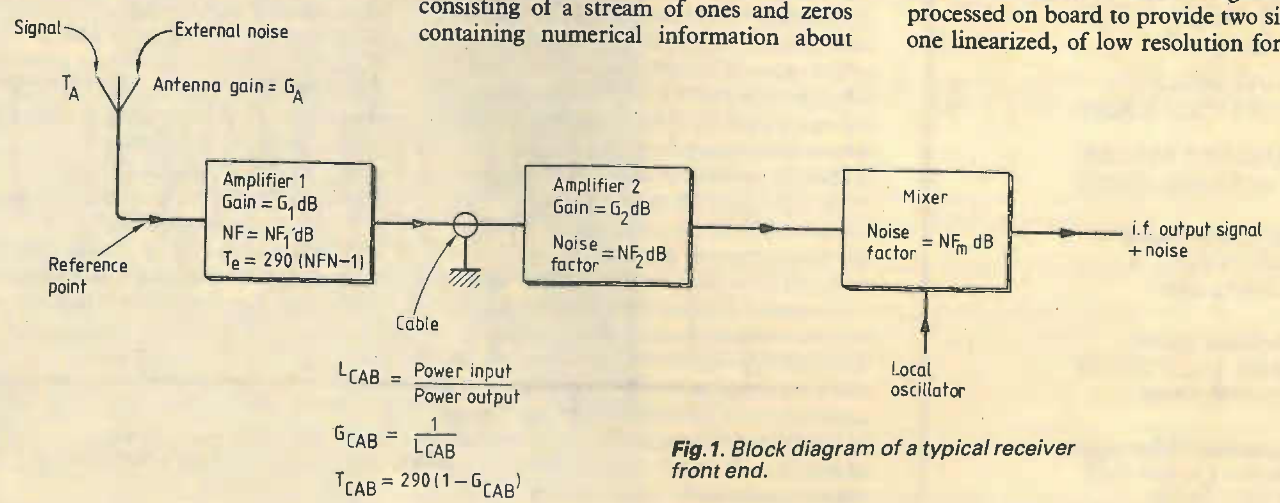

Fig.1. Block diagram of a typical receiver front end.

The equipment to be described is for use with h.r.p.t., and was developed using the signal from NOAA-6.

A.v.h.r.r. transmission characteristics

The advanced very-high resolution radiometer has a rotating mirror like many of its predecessors and scans successive lines as the spacecraft passes over the ground below at a rate of 360 lines per minute. The incoming radiation is split into five spectral bands, each having its own detector.

The five bands are:

Channel 1	0.58	- 0.68μm
Channel 2	0.725	- 1.10μm
Channel 3	3.55	- 3.93μm
Channel 4	10.3	-11.3μm
Channel 5	11.5	-12.5μm

A full description of the radiometer is beyond the scope of this article but has been published[1]. The spacecraft also carries several other instruments used for atmospheric measurements. These generate low data rate t.o.v.s. (TIROS operational vertical sounder) data, the content of which is described elsewhere[2]. The outputs from the radiometer detectors are digitized and processed on board to provide two signals, one linearized, of low resolution for analogue transmission with limited telemetry on v.h.f. at 120 lines per minute, and the other 'raw' at 360 lines per minute on S band. The t.o.v.s. instruments data is also transmitted on v.h.f. but in digital form.

All spacecraft data, a.v.h.r.r. t.o.v.s., and telemetry are combined into one multiplexed transmission and sent as the main signal on S band forming the h.r.p.t. The characteristics of the h.r.p.t. signal are summarized below:

Transmission frequencies	1698.0MHz } either may 1707.0MHz } be used
Back-up	1702.5MHz
Antenna polarization	right-hand, circular (1702.5MHz is l.h. circular)
Transmitter power	5.25 watts
E.i.r.p. (at 63° from nadir)	40.4dBm (nominal)
Modulation type	digital split-phase-L
Modulation index	±67.3°
Bit-rate	0.6654 M-bit/s
Bandwidth	5.7MHz
Bits/word	10
Words/frame	11090
Frame rate	6 per second
Frame sync.	first 6 words of frame
Scan lines/frame	1
Image samples of each channel in one frame	2048

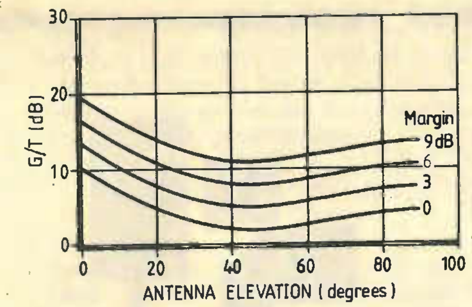

Fig.3. Graph of required G/T (antenna gain minus system noise temperature) against antenna elevation for an error rate of 1 in 10^6.

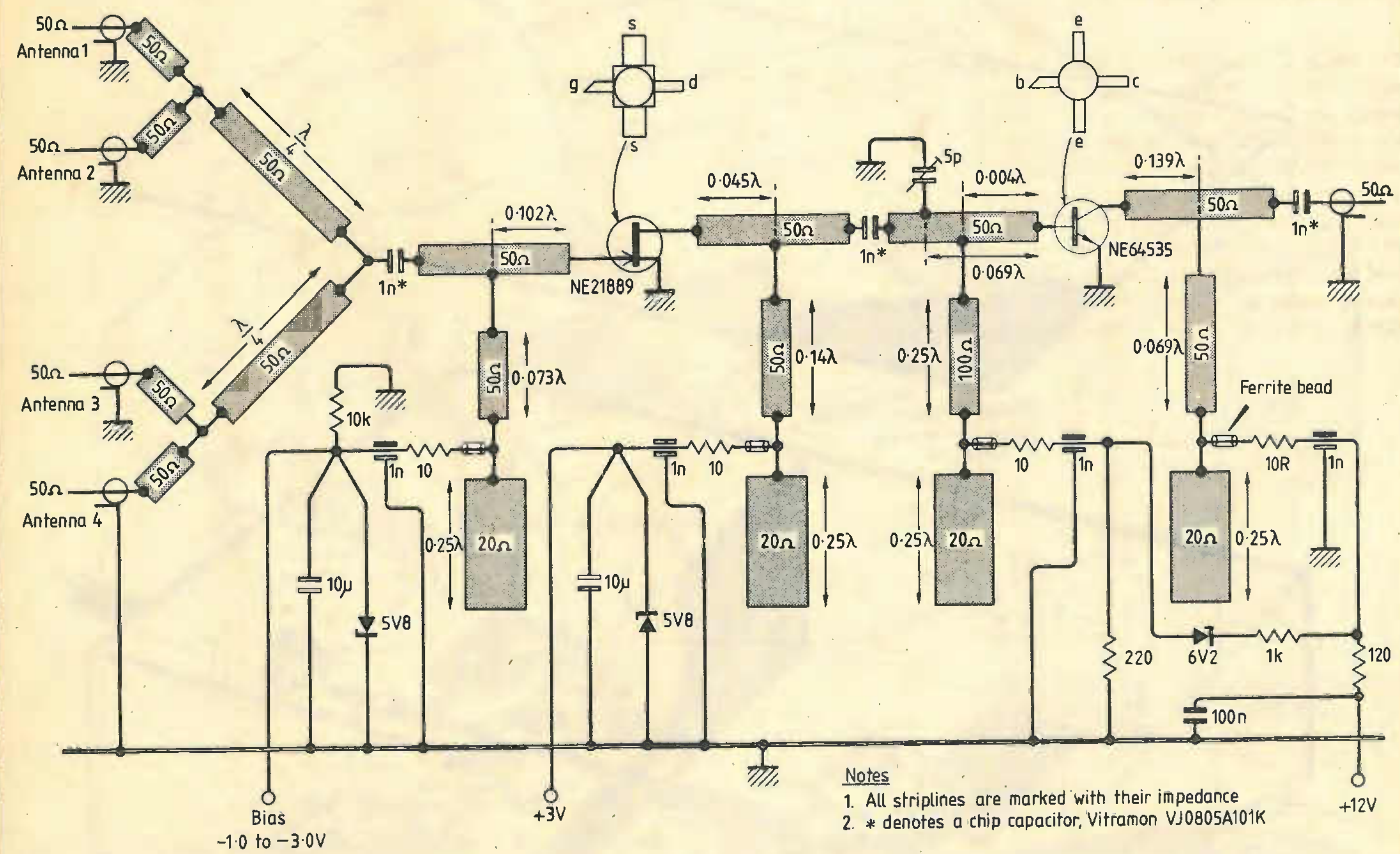

Fig.4. Combiner and signal amplifier circuits. In order to obtain a low noise figure, a gallium-arsenide f.e.t. is used in the first signal amplifier.

S-band receiver

The first step towards receiving the data is to make a combination of antenna, front end and mixer capable of down-converting the signal to a suitable intermediate frequency with a sufficiently high signal-to-noise ratio. This could be achieved by using a very large antenna together with a high performance front end, but at a cost far exceeding most users' budgets. A compromise must therefore be reached between cost and performance. The overall receiver parameters depend to a great extent on the antenna, front end and mixer, so it is there that the first design decision must be made.

Referring to the transmission characteristics, it is the use of 1700MHz that determines several factors. The first intermediate frequency should be in the region of 100-200MHz because this enables the use of standard v.h.f. techniques but is high enough to reject most of the image noise with simple filters. As the transmitted power is quite low, and the bandwidth quite high, good performance at this stage is essential for any degree of success; so at least one stage of signal frequency amplification must be used. At this high frequency high antenna gains may be realized with modest size, but clearly the better the front end, the smaller the antenna can be, and with the necessity to track the satellite this is an important factor. Most of these variables can be related to a single 'station performance' factor called *G/T*, and a full understanding of the use of this is the key to successful design.

G/T is antenna gain minus system-noise temperature, and is normally measured in dB/K. Antenna gain is a familiar concept but system-noise temperature may need some explanation. Figure 1 shows a typical receiving front end. The output signal-to-noise ratio is directly proportional to antenna gain because the latter does not affect the contribution of noise by the amplifiers. Also, an increase of gain reduces the beam width which maintains constant the contribution due to external noise which is normally omnidirectional. An increase in noise of any type will decrease the output signal-to-noise ratio, therefore the output signal-to-noise ratio is directly proportional to *G/T*. The main sources of noise in the system are:

– Receiver generated noise: this is noise produced by the amplifiers themselves and is determined by the noise figure of the amplifiers. Above 2000MHz this type of noise is usually the most important.

– External noise caused by galactic noise and ground noise: ground noise is generated by charge movement in everything around the antenna, such as electrons shuffling about in the bushes nearby, and is produced by everything above absolute zero in temperature. Other sources of

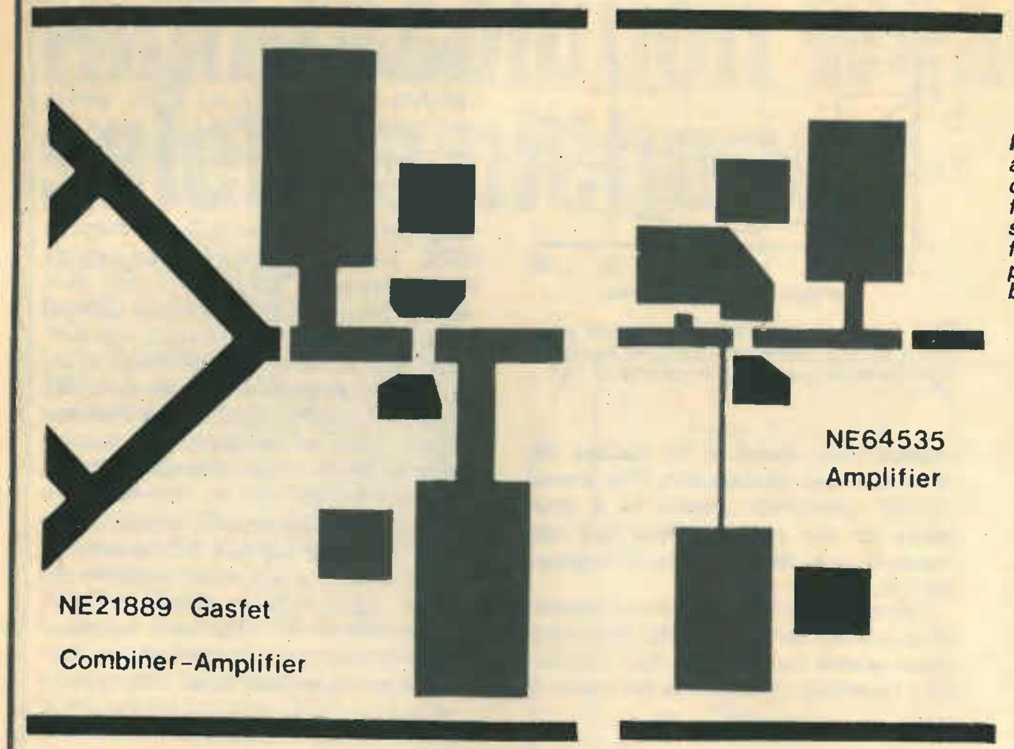

Fig.5. One-to-one drawings of the front-end amplifier circuit boards (see text). The combiner/first amplifier board is made from p.t.f.e. microwave substrate and the second amplifier board from 1/16in glass-fibre p.c.b. with 1oz copper. The ground-plane is retained on the reverse side of both boards.

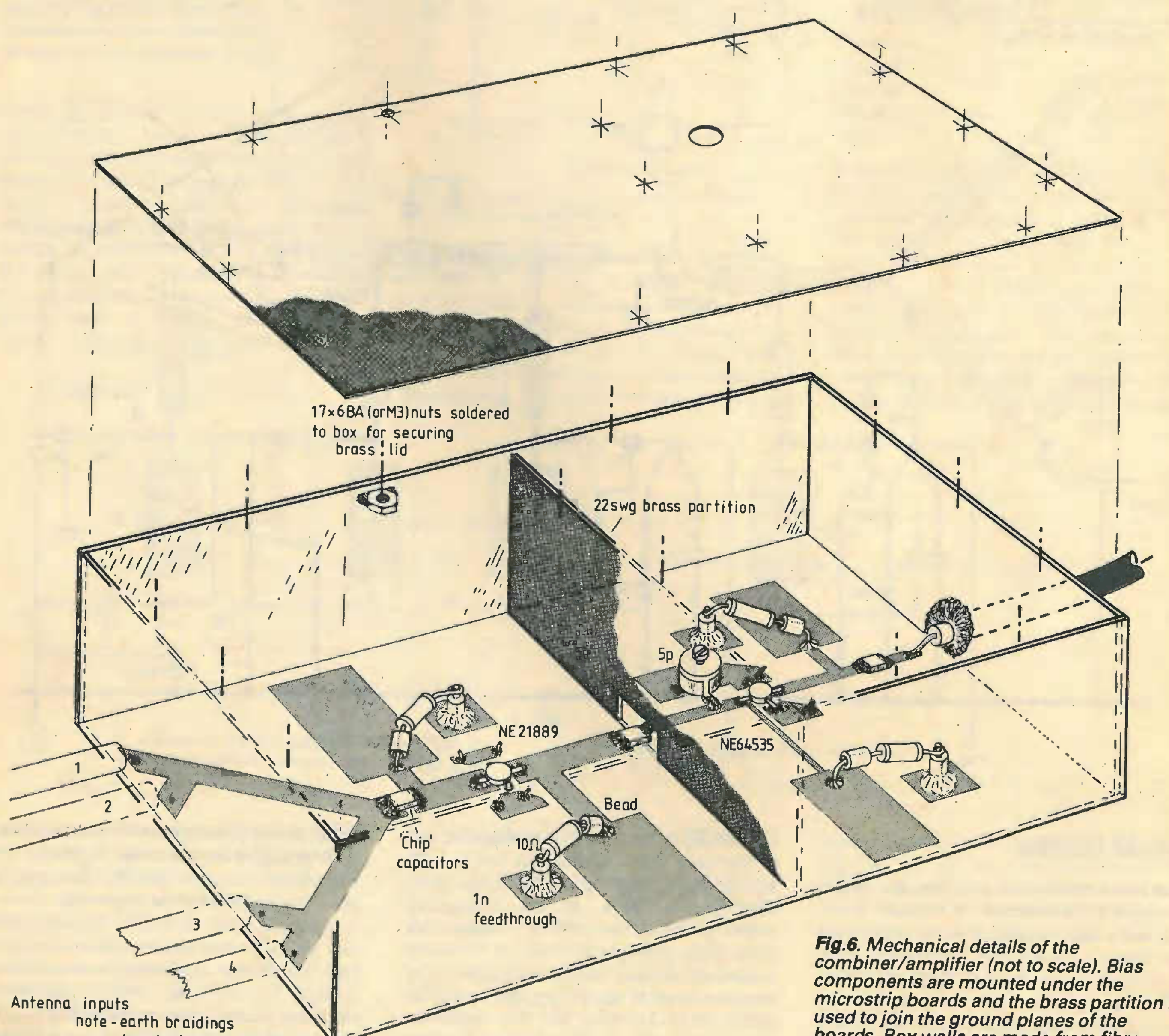

Fig.6. Mechanical details of the combiner/amplifier (not to scale). Bias components are mounted under the microstrip boards and the brass partition is used to join the ground planes of the boards. Box walls are made from fibre glass p.c.b. and all joints are seamed with solder.

external noise include unwanted signals and electrical interference. These two become more important below 1000MHz.

In order to calculate G/T, the way in which each part of the system contributes to the total noise output must be quantified, starting with the amplifier noise and how it is related to noise figure. The familiar definition of a noise figure is the amount by which the signal-to-noise ratio is degraded by passing it through an amplifier. This is, however, only true for one value of noise input. It is possible to state the input noise power in terms of that produced by a hot resistor. For a resistor at TK, noise power$=TkB$, where $B=$bandwidth, k=Boltzmann's Constant and K=temperature in Kelvins.

Using this relationship the noise input power can be expressed alternatively as the 'noise temperature' of the source, and for standard noise figure measurements it is 290K. Clearly, the output-noise power is the amplified version of the source plus that generated in the amplifier. This additional noise could be represented by an apparent increase in the source temperature which would give the same noise output if the amplifier were noiseless. This is called the 'effective' noise temperature of the amplifier and is related to noise figure, NF, by

$$T_e=290(NFN-1)$$

where $NFN=$the numerical noise figure (antilog $NF/10$). This represents the additional noise power and is no longer dependent on input level. If a further amplifier is added on at the end, its noise contribution may be included in the source temperature of the first amplifier input which is now called the reference point. The contribution is less because it is not subject to the gain of the first amplifier. The total system noise is simply;

$$T_{sys}=T_{AMP1}+\frac{T_{AMP2}}{GN_{AMP1}}$$

where GN_{AMP} is the numerical gain. There are many possible reference points that could be used, but the only one that can be used here is the antenna input terminals (it is interesting to work out why). A further factor which takes account of external noise, the equivalent antenna temperature, is simply added directly at the reference point. Lossy cables have an equivalent noise temperature and negative gain, thus completing the picture. For the system shown in Fig. 1;

$$T_{sys}=T_A+T_1+\frac{T_{CAB}}{GN_1}+\frac{T_2}{GN_1\,.\,G_{CAB}}+\frac{T_M}{GN_1\,.\,G_{CAB}\,.\,GN_2}$$

None of these is, of course, a physical temperature.

Using this type of analysis it is easy to prove that if T_A is less than 290K (as well may be the case), the signal-to-noise ratio improvement resulting from a reduction in first amplifier noise figure is greater than the noise figure reduction itself. The converse is also true.

All the amplifier noise figures may be estimated from the device data sheets, but T_A, which has a large effect on T_{sys}, is unfortunately difficult to define for individual stations[15]. A general guide is given by Fig. 2 as a function of frequency. Examination of this plot shows how quickly T_A decreases with frequency. Working through the equation for T_{sys} for various frequencies shows how little benefit is realized by very low noise amplifiers below 200MHz. This type of analysis may also be used in ground based calculation; for example to find how much benefit might be realized by reducing feeder loss on a 144MHz amateur station receiver.

The requirement for h.r.p.t. reception with an error rate better than 1 in 10^6 is shown in Fig. 3. Note that due to the gain profile on the spacecraft the signal reaches a maximum at an elevation of 50°. Thus the minimum G/T possible in order to copy overhead passes with zero margins is 4.5dB/K.

Assuming a value for T_A of 70K and the best possible amplifier combination yielding about $NF=1.5$dB, inserting these into the equation for T_{sys} gives

$$T_{sys}=70+119=190\text{K}$$

This must now be converted to dB in order to conform with the units of G_A

$$T_{dB}=10\log(T_{sys})=22.8\text{dB}$$

This is fairly meaningless in itself but it allows G/T to be calculated;

$$G/T=G_A-T_{dB}$$

rearranging:

$$G_A=G/T+T_{dB}$$

The exact value of G/T is of course equally meaningless but it is used for system comparisons. Using the values calculated, the

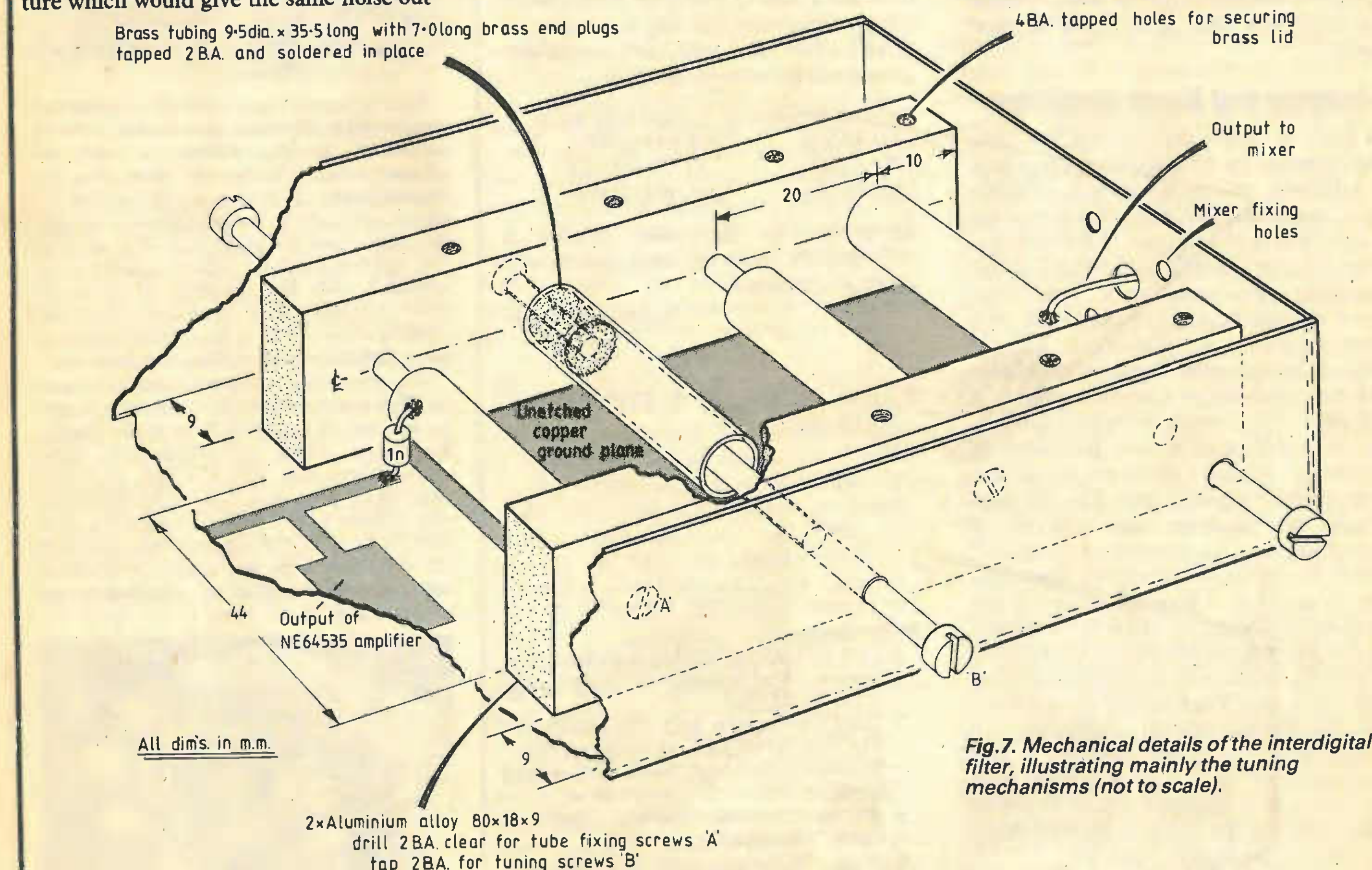

Fig.7. Mechanical details of the interdigital filter, illustrating mainly the tuning mechanisms (not to scale).

required antenna gives

$$G_A=4.5+22.8dB=27.3dB$$

This could be achieved using a parabolic dish several metres in diameter (4 metres is recommended commercially), but together with the difficulty of tracking accurately with such a massive object, it would be very expensive to buy or to build. In order to reduce the antenna equipment some sacrifice must be made in error rate.

Practical antennas

The prototype antenna is a set of four 28 element loop yagis phased for right-hand circular polarization. This type of antenna has been developed by amateur-radio operators interested in light-weight equipment for 1296MHz. They have been described in several articles[3,4] and work admirably. The dimensions were scaled from the design for 1296MHz and mounted, as shown on the front cover, in a square with sides of 51 centimetres. The two mounted on their sides are set 4.5cm in front of the other two to give r.h.c. polarization when fed through identical length feeders to an in-phase combiner. The antennas are attached to wooden supports which detune the array less than an all metal arrangement.

Combiner and signal amplifiers

In order to obtain the required low-noise performance, the first signal amplifer uses a relatively expensive gallium arsenide f.e.t., the NEC NE21889. This device has a noise figure of less than 1dB and represents the best available performance at this frequency. The amplifier is constructed using microstrip, as is the combiner that feeds the input-matching circuit. The antenna is located some 6 metres away from the main receiver, so a second amplifier is included. This uses a bi-polar transistor, the NE64535, and is also fabricated in microstrip. Figure 4 shows the circuit diagram of the completed unit. The part containing the combiner and NE21889 is etched on p.t.f.e. microwave substrate* which has better characteristics than ordinary glass fibre. The physical size of the lines is dependent on dielectric constant and so depends on the type of board used. Figure 5† is a full-size microstrip layout of both parts, and Fig 6 shows the mechanical construction. Special components are indicated on the circuit diagram. A full description of the design techniques used for this type of amplifier would be out of place here and the reader is recommended to consult references 6, 7 and 8.

Care must be taken when designing a power supply, to remove any possibility of an over-voltage spike reaching the GaAs-f.e.t. as they are rather delicate. Some method should be provided for the adjustment of the bias in order to set the drain current to about 10mA.

The amplifier at the antenna is connected to the down-converter inside by a length of UR67 coaxial cable.

Mixer/local-oscillator

This is based on a previous design used for the reception of Meteosat[9]. However, some improvements were made to satisfy the more stringent performance requirements. The original design comprised a local-oscillator chain feeding one port of a microstrip balanced mixer using Schottky-barrier diodes. The other mixer port was connected directly to the output of a further signal-frequency amplifier using an NE64535. The main change is the insertion of an interdigital filter between this amplifier and the mixer input. The amplifier design remains similar but the microstrip dimensions were changed to be identical with those in the NE64535 section of the antenna amplifier. The glass-fibre board is extended to include the filter. Figure 7 shows the mechanical details together with the tuning screws. This type of filter has a high Q and it has been used in microwave converters for a number of years[10]. The local oscillator crystal frequencies to use are as follows:

Receiver frequency	Crystal frequency
1698.0MHz	86.69444MHz
1707.0MHz	87.19444MHz
1702.5MHz	86.94444MHz

These are for use with an i.f. of 137.500MHz which was used to fit in with existing equipment.

To be continued

*The p.t.f.e. board used was type GX-0600-55 from the 3M Company.

†Every effort has been made to ensure that the dimensions of Fig.5 are as near life size as possible but due to the printing process, the accuracy required for reproduction of such boards cannot be guaranteed. We are looking into the feasibility of providing photographic negatives for these boards and will inform readers of price and availability if and when possible.

References

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2 Data Extraction and Calibration of TIROS-N/NOAA Radiometers, NOAA technical memorandum NESS 107.
3 *Radio Communication*, January 1975, 'Microwaves'.
4 *Radio Communication*, January 1978, 'Microwaves'.
5 F.e.t. Application Note, Plessey Optoelectronic and Microwave.
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7 Low-noise GaAs f.e.t. amplifiers, NEC technical note TN77902.
8 Cu-tips 2, 3M Electronic Products Division.
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10 Interdigital Converters, J. Dahms, *VHF Communications*, Autumn 1978.

Personal hi-fi

It all started with the Sony Stowaway (rapidly re-named the Walkman). This was a cassette player which was easily portable and had no loudspeakers. It played pre-recorded stereo musicassettes through headphones. This meant that power amplifiers were not needed and the whole unit was very compact. One of the advantages was the very lightweight headphones which used cobalt-samarium magnets, giving high-quality sound with very low power.

Of course it was inevitable that many other companies, especially the Japanese, would jump on the band-waggon, and there was a proliferation of personal hi-fi systems, some incorporating stereo f.m. tuners, some with the ability to record as well as play back.

Some of the next generation of 'personal' entertainment products are now available. One of the first is the Sony Walkman 2 which was released almost exactly one year after the original model. It is even smaller so that the player unit is about the same size as a cassette tape plastic case and only about twice as thick. Our experience with the set is that it need not be considered only for pop music or for out-of-doors activities. One can escape from the confines of the 'listening room' and continue to enjoy the music while moving about the house.

The provision of the two output sockets on the Walkman 2 gave us the opportunity to give an A/B test to a pair of Koss Sound Partner headphones. These are subminiature, lightweight headphones with a 3.5mm plug (and adaptors for a standard jack, or for equipment with a mono 3.5mm socket). Comparing these with the Sony MDR4, which are supplied with the Walkman, both sets gave a very similar response, with the Koss set extending a little further into the bass.

The Koss Sound Partner stereo headphone has hinges so that it may be folded into the neat carrying bag provided with it. It is sold with the Koss Music Box Radio and may also be bought separately.

At the Harrogate Hi-Fi Show, Koss were also displaying a shirt-pocket sized am/fm radio for use with headphones only. Like the Walkman, this also has provision for two sets of headphones. There are separate right and left slider volume controls which dispense with the need for a balance control.

World of Amateur Radio

No Class B on 70MHz

Class B licence holders (phone operation on 144MHz and above) are disappointed at the Home Office decision not to allow them to operate on the 70MHz band when the new Radio Regulations come into force next year. They appreciate that 70MHz is not an international amateur band but was instituted in the UK to help bridge the very wide gap between 28MHz and 144MHz bands. Such a gap does not exist in Regions 2 and 3 where the band 50 to 54MHz is used by amateurs. At WARC 1979, the Radio Regulations relating to amateur operation were changed to allow administrations to issue licences without a Morse test for frequencies above 30MHz (instead of above 144MHz) and it was widely assumed that the Home Office would amend the Class B licences to include the 70MHz band.

Even those of us who are keenest to encourage Class B amateurs to learn Morse, and so qualify for the Class A licence, feel uneasy at the way in which the Class B conditions have helped to concentrate so much operation in the UK into 144-146MHz, leaving 70MHz and (in sunspot minimum years) 28MHz relatively under-populated. So while the Home Office is clearly acting within its rights, it seems a puzzling decision.

Similarly one wonders why Class B operators should be forbidden to learn Morse by using it from their own station, although permitted to use it "under supervision" of a Class A licence holder – a restriction that has also been proposed should the Home Office ever get round to issuing any form of "novice" licence in the UK. It all seems in direct contrast to the encouragement given to newcomers in many countries. In Japan, the international "rules" are bent the other way: low-power operation is permitted without a Morse test even on bands below 30MHz on the grounds that the signals are unlikely to cause interference outside Japan.

Guide to repeaters

The UK FM Group (London) has recently published a revised and extended edition of "A newcomer's guide to FM simplex and repeater operation on two metres" by Antony Askew, G4BPC with a foreword by Douglas Davis, G3PAQ. This points out that whereas in the early days of repeaters most amateurs had experience of two-way working without their aid, nowadays quite a few newcomers owe their first introduction to amateur operating by using a low-power handheld or mobile transceiver in conjunction with a 144MHz repeater. The 16-page booklet contains a lot of good advice, although unfortunately no information on price or address. (Membership secretary, Pat Spenceley, 67 Downs Wood, Tattenham Corner, Epsom Downs, Epsom, Surrey KT18 5UJ, may by able to help.) It can be recommended to those unfamiliar with current operating techniques.

Unhappily repeater operation, particularly in the London area, is not without its special problems and the booklet has a section on "jamming." This advises operators never to acknowledge or be provoked by any deliberate jamming or abuse of the repeater by what the booklet calls "a motley collection of hooligans who, if they are ignored, will eventually give up and go away".

Unfortunately it is taking a very long time for this to happen.

It also seems that deliberate jamming is increasing on h.f. bands, with various "dx nets" an especial target. Part of the problem, although certainly no excuse for jamming, is the tendency for some net operators to lay claim to exclusive use of certain specific frequencies, even when not actually transmitting. On c.w. there is still a friendlier atmosphere of co-existence: it is still unusual to come across deliberately bad-mannered operators except in "dx pile-ups", which is one reason why some of us tend to steer clear of them.

Here and there

Transatlantic working on 1.8MHz should be easier this winter with the Loran-A marine radionavigation system already largely phased out although not due to end in some countries until late 1982. In America, the FCC has already lifted the transmitter power restrictions on the band (1800 to 2000kHz) although retaining a number of geographic restrictions and warning the Americans that it may be unwise to invest in new equipment for the band until the new International Frequency Table has been fully sorted out. WARC 1979 restored 1810 to 1850 kHz as an exclusive amateur band but in the UK and North America amateurs are hoping to retain use of the full 200kHz on a shared basis (through presumably UK amateurs will be permitted to use 150 watts in the 1810 to 1850 kHz section).

According to *Electronics Australia* a Parliamentary report suggests that about half of all the c.b. equipment in use in Australia is unlicensed and the chances of illegal operators being caught are "fairly remote" since several large Australian states have only a single officer charged with tracking down offenders, equipped only with "outmoded, inefficient and inadequate" detection equipment. The Australian Federal Government, after considering the matter for five years, has finally turned down a proposal of the Wireless Institute of Australia that old age pensioners should pay a reduced amateur radio licence fee. Reason given is that this would give rise to similar requests in respect of other types of radio equipment including c.b.

CQ-TV reports the setting up of another amateur television repeater in South Australia, located north of Adelaide and powered by means of a wind generator. The Adelaide group are seeking permission to link the new repeater with the VK5RTV tv repeater in Adelaide, to give a range for amateur television transmissions of over 100 miles. The considerable interest in amateur tv in the UK is underlined by sales of the BATC handbook exceeding 1500 in just a few months. BATC, however, has expressed some concern at the IARU Region 1 proposal that tv should gradually move out of the 432MHz band. AMSAT-UK, however, clearly feel that it is possible for satellites and amateur tv to co-exist in the band and seem to feel that some tv enthusiasts are raising a storm in a teacup.

It is now being assumed that the loss of transmissions from OSCAR 7, since early June, due apparently to battery failure, is likely to prove permanent. Since its launch in November 1974 several million amateur radio contacts have been made through this very successful spacecraft.

Investigation of auroral propagation, which has long attracted keen amateur interest, should be improved by the opening of the EISCAT 234MHz and 933MHz £13-million radar facility with transmitter/receiver at Tromso, Norway, and receiving sites at Kiruna and Sodankyla, Finland, after several years of delay. It is only the second incoherent radar facility to be set up in auroral latitudes.

Successful reception of reformed slow-scan television pictures from Voyager Two by Jeremy Royle, G3NOX was followed by his appearance on ITN's "News at Ten". During the late-August approach of the interplanetary spacecraft to Saturn, the Jet Propulsion Laboratory amateur radio station W6VIO reformed and retransmitted images of Saturn's rings and satellites as the pictures came in from Voyager Two on the large JPL dish aerial. The s.s. tv pictures were transmitted in the 14, 21 and 28MHz bands, together with s.s.b. and c.w. on all bands from 3.5 to 28MHz.

The Guernsey Amateur Radio Society won the RSGB's 1981 National Field Day. The Bristol Trophy goes to the Great Western Contest Group; the Gravesend Trophy to the Gravesend society; the Frank Hoosen Memorial Trophy to Southgate Radio Club; and the Scottish NFD Trophy to Glenrothes and District Amateur Radio Club.

PAT HAWKER, G3VA

Funkausstellung 33

tv goes stereo

International audio and video fair, Berlin

by Geoffrey Shorter

Internationale Funkausstellung Berlin 4.-13.9.1981

Massive support from broadcast organisations, the Bundespost and almost the entire entertainment electronics industry, combine to make this the biggest show of its kind.

As if by way of commemorating Clément Ader's 30 August two-channel sound demonstrations in Paris a hundred years ago – almost to the day – the Zweiten Deutsches Fernsehen tv authority commenced regular stereo tv broadcasting at the Berlin show. Not only does transmission of a second sound channel give a stereo sound option for discussions and sporting events as well as the usual musical programmes (to say nothing of trials using a dummy head planned by WDR), but it also provides a second language option for foreign films and Eurovision programmes etc. Transmission standards were fixed jointly with industry, the Bundespost and the two broadcast organisations last year, when ZDF commissioned the Bundespost to equip the second tv network for stereo sound (transmitters built after 1974 are convertible to stereo operation).

The other broadcasting organization, Arbeitsgemeinschaft der öffentlich-rechtlichen Rundfunkanstalten der Bundesrepublik Deutschland to give it its full name, is not in a position to up-date its older equipment until revenue from an increase in licence fee becomes available. (A star distribution point at Frankfurt, for instance, is not stereo-equipped.) This will mean a difference of a few years in providing two-channel sound (even though the present ZDF coverage is only 29 transmitters out of a total of 89, it represents a population coverage of 60%) a "thoroughly regrettable" state of affairs, according to Dipl. Ing. Müller-Römer, who is technical director of Bayerischer Rundfunk, one of the 12 ARD stations. As he is also chairperson of the joint ARD/ZDF technical commission, one wonders why the scheme is going ahead at this time.

The reason is tied up with the state of the television receiver industry in Germany. With the tv set production curve falling off as market saturation is approached, many companies in the red and many suffering from the effects of competition from abroad, the industry likes to have technical innovation to spur the public into buying its products. Even though the start of stereo tv will be gradual it is estimated that sales of stereo sets will be as much as 45% of the whole by 1983, in spite of the added price of 13 to 18%.

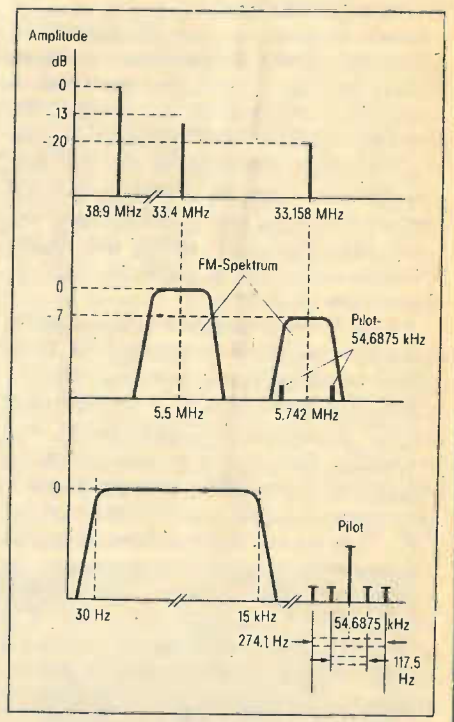
But it is with the gradual expiry of the tv industry's PAL patent portfolio, which has been its main protection against competition from the Far East in the large screen business, that the industry is seeking patentable innovations whose licensing they can control. Patents have been assigned to the industry patent-holding group, and they do not intend giving licenses to overseas makers until 1983 at least. This was borne out by Finnish set maker Salora who were cautioned about their new "three channel" stereo tv sets, not having been granted a licence. (They don't mean three channels of course, they mean three speakers, one with a sum signal feed for the front and antiphase difference signals for the sides, an idea which goes back more than a decade ago to David Hafler and Duane Cooper, arguably even to Blumlein.)

And it isn't only tv sets that won't be licensed: Japanese video recorders with tuners will have to receive mono sound, while the Philips/Grundig 2000 recorders will receive stereo.

Japanese studies started as far back as the early sixties and led to NHK's adoption of a frequency-division multiplex system whose sound channel uses an f.m. subcarrier for the stereo difference signal of 31.5kHz, twice the line frequency. Comparison with the alternative technique of using twin carriers for sound has shown that both methods offer adequate crosstalk and noise performance under normal conditions, but that in mountainous regions a two-carrier method shows least degradation.

The German idea, which also originated in the sixties from the ARD/ZDF Institut für Rundfunktechnik in München, is to use two separate sound carriers, one for a compatible signal at 5.5MHz from the vision carrier (standard in CCIR systems B & G) and the other separated by 242.1875kHz, which is an odd multiple of half the horizontal scan frequency f_H to minimise Moiré interference. Both carriers are frequency modulated to a deviation of 30kHz, but the second carrier is additionally modulated with a 54.6875kHz pilot sub-carrier ($3\frac{1}{2} \times f_H$) up to 2.5kHz deviation for signal identification. For mono transmissions it is unmodulated, for stereo signals it is 50% amplitude modulated at 117.5Hz ($f_H \div 133$), and for dual channel use at 274Hz ($f_H \div 57$). As the second channel carries an R signal, simple matrixing retrieves an L signal from the compatible $(L+R)/2$ signal. Demodulated identification signals when converted into a two-bit binary code activate audio route switches and panel indicators, which also take account of the viewer's selection for mono, stereo, language 1 or language 2.

The cheapest way of using the new transmissions would be to build in a second intercarrier-type demodulator using the standard TBA120S. Using a mono output stage and a new i.c. that provides matrixing and identification decoding, selection of either channel is possible as well as mono sound; but we didn't see such a simple scheme. The least i.c.-count way to do the job is with a quasi-split



Modulation scheme for two television sound channels prevents foreign competitors from selling stereo tv sets in Germany.

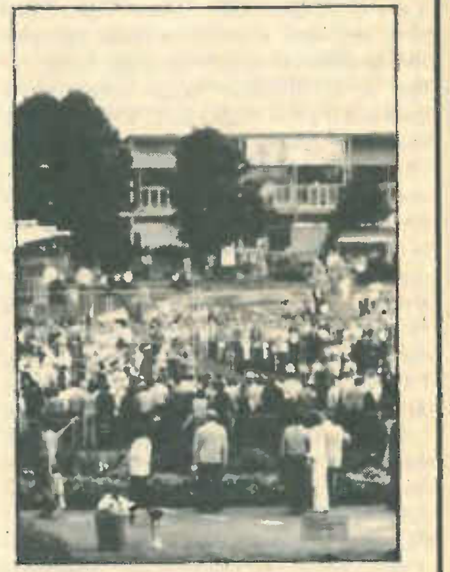
sound system that claims better signal-to-noise ratio, where the vision signal is separately processed and the sound section retains a video component to allow intercarrier demodulation. Two new i.cs are needed for this, TDA2546 dual i.f. amplifier and demodulator and TDA3800 containing a second demodulator together with matrix and identification decoder. But the posh way to do the job is with i.cs that allow separation of a.f. and i.f. sections for the modular-chassis approach (TDA2545, 2 × TBA120S, plus matrix

and decoder i.c.)

Some months ago, before the new i.cs were available, Philips suggested a way of using available components. Starting with the two audio-frequency signals, the basic idea was to dematrix with an op-amp and emitter followers, then to pass de-emphasized signals through the routing switches TDA1029 controlled by standard t.t.l. circuits. These took their feed from a TDA2795 identification decoder which envelope-demodulated the 54kHz carrier, filtered the 117 or 274Hz tones if present with second-order active filters and then processed them to produce logic controls, to decide whether two speakers will have the same or different feeds. As Loewe Opta were first on the market with two-channel tv sets back in March, this may well be the way they did it.

Metz, who this year take the prize for the largest tv display with a wall of 200 sets doing silly things, have fitted a novel quasi-stereo circuit for mono programmes.

Compatible multilevel teletext, first shown in Europe at the Berlin Show, includes high definition graphics (level 3), specific graphics (level 4), and "photographic-quality" colour pictures (level 5). Picture below, taken at show, was stored on floppy disc and built up gradually for teletext display.



Their circuit, due to RCA Labs, feeds high and low frequencies preferentially to one speaker and middle tones to the other. But at two carefully chosen frequencies of 320 and 1700Hz, said to be the dominant ones in speech, both speakers have equal feeds intended to give a central image. The idea seemed to work for the voice chosen. Metz appear to be the only tv maker with a separate tv stereo decoder to offer. Most others say that plug-in decoders are available for sets up to two years old. Blaupunkt, who this year claim to have increased their tv market share by between one and two per cent to nearly 10%, say decoders won't be available from them for pre-1980 sets, which presumably goes for Siemens tv sets as they are made by Blaupunkt.

Considering that direct broadcasting from satellites will not start on a trial basis before 1985 in Germany, and that permanent broadcasts are unlikely before the end of the 80's, there was a surprising amount of involvement in evidence. Not only from organisations directly involved such as the Bundespost, the Aerospace Research Establishment (DFVLR), ARD and West German commercial interests (Siemens, AEG-Telefunken, TE KA DE and others), but also from Finland's Salora company, who aim to sell individual receivers, and Japan's Sony. Since the last Funkausstellung Sony has added sound radio to its satellite receiver for home use. This time their prototype receives the full WARC agreement five tv channels, one of which can be converted to 12 p.c.m. stereo channels. In the demonstration, in which the four-phase p.s.k. transmitter was also Sony-built, 12GHz signals were reflected back within the confines of the stand and converted to 113MHz p.c.m. using a microwave i.c. The digital audio processor was actually sampling at a 32kHz rate but Etsumi Fujita of Sony's Tokyo audio technology centre says this will be changed to the more common 44.1kHz, and at the same time quantization increased from 14 to 16 bits (linear) with a new low-cost 16-bit d/a converter that Sony will shortly sell. The error correction code applied is one in which b.c.h. and parity are combined to yield what is claimed to be an extremely low error rate allowing receiver operation down to carrier to noise level of 7dB. They give word error probability as 10^{-9} word/s for a bit error rate of 1 in 10^{-3}, which at 4-bits a word for each stereo channel of 12 doesn't seem to agree with their claim of a correction of only "once in several hours".

The major display of capability, if one was needed at all, was put on by the Bundespost, DFVLR and ARD, to give direct reception from the ESA's orbital test satellite (OTS). On-site television programmes produced by Saarländischer Rundfunk were relayed to the DFVLR satellite transmitter near München so that they could be received on prototypical equipment at the exhibition (except for the antenna, which needed to be 3.3m in diameter because of the low power of OTS). As before-and-after pictures were displayed next to each other, visitors could assess picture quality, including the effect of the quarter-second transmission delay! Bayerischer Rundfunk did a similar thing over OTS with radio transmissions but digitally so that the very wide dynamic range of their digital tape recordings was preserved up to the stage of conversion, just before the headphones.

Since France and Germany opted out of ESA's cooperative satellite effort – the resulting "Euro-satellite" consortium aims to sell satellites or perhaps rent tv channels – two national launchings have been authorized, France's TDF-1 in 1985 and Germany's TV-Sat at the end of 1984, at a cost of over DM 500 million.

There is some uncertainty about the use of TV-Sat. Five tv channels have been allocated to Germany and with the high cost of satellite launching one expected five to be provided from the start. But the Federal Government's announcement about this refers only to three channels in "preoperational service" and the satellite is being called "experimental" by the Government.

Moreover, in the two year test phase the third channel is being ear-marked for test purposes and only the two tv programmes may be transmitted in unaltered form. The broadcasters want to transmit non-regional programmes by satellite, one tv channel for digital radio, and ultimately to use terrestrial transmitters for an improved regional service.

The Bundespost has also told the broadcasters that a five-channel satellite should not be used before the 1990s, if at all.

A situation that obviously has some bearing on this is the effect of programmes from other countries. Satellite signals will be picked up well outside the national ellipses laid down at the WARC in 1977, if only because of technical development. It is estimated that 12-17 tv and 30 to 50 sound programmes will become available in Germany, assuming the frequencies are not interfered with. Whether such large-scale competition from outside is seen as a threat to "cultural heritage" remains to be seen. But one thing is clear: the Bundespost has reserved the satellite band, 11.7 to 12.5GHz, for "radio direction finding". And that means, in less euphemistic terms, that they will have the ability to jam broadcasts they regard as undesirable, politically or commercially.

And then there is a problem of deciding who should use the additional channels of a five-channel satellite. National satellite services need the approval of the Länder: "it is hard to imagine an agreement," Herr Müller-Römer suggested, "in views of the current differences in views between Länder ruled by the SDP and those ruled by the CDU."

To coincide with the tv industry's introduction of two-channel sound, both Grundig and Philips have stereo Video 2000 recorders with a dynamic noise suppressor, apparently based on High Com i.cs but as a different noise spectrum is involved it's not High Com. With the slow linear tape speeds involved, the addition of stereo sound is bound to heighten awareness of relatively poor quality; h.f. response is down 8dB at 10kHz and a signal-to-noise ratio of 50dB is about the limit that can be achieved presently. After about a year and a half on the market a share of 25% is claimed in Europe (Video 2000 is not yet sold in USA) with Grundig selling 100,000 in the last year, expecting to sell double that figure this year and 600,000 in 1984. By that time Grundig forecasters expect the present level of video recorder penetration of 5% to have increased to 30%, following a similar trend to colour television but with a decreasing time lag.

Meanwhile the phenomenal growth of Japanese video continues, Matsushita figures just released for the first half of 1981 show an increase of 42% in video sales over last year; overall, Japanese exports have more than doubled. To increase production of VHS recorders, the Berlin factory of the Telefunken-Thorn-JVC consortium* will be in operation early next year with a production of 400,000 recorders p.a. whether or not the French government sanction Thomson's involvement. And by the time this gets read, talks between Matsushita and Blaupunkt over local VHS production should have been completed.

Any sales advantage conferred to V2000 by non-licensing of Japanese recorders for stereo reception will last, it appears, only until 1983. Then, another scheme to fuel video recorder sales may come into play. The much-discussed addition of coding data to radio broadcasts for programme identification is likely to be extended to tv broadcasts, especially as neither additional bandwidth or legislation is required. Later, additional air time could lead to out-of-viewing-hours recording. But what is not yet clear is whether agreement on such a coding would be sought internationally, as with sound radio. If it turns out that aspects of this are patentable, the Germans could go it alone again and delay giving licences to Japanese manufacturers.

★ Telefunken Video GmbH was founded in July with a capital of DM1.5 million.

Multipurpose optical fibre networks will make 5MHz colour videophones commonplace. Prototype equipment installed over the next few years for field trials in Berlin, Düsseldorf, Hamburg, Hanover, München, Nurnberg and Stuttgart provides both telecommunication services (viewdata, speech, data, text, graphics) and broadcast services (two to four television programmes, 24 radio programmes). The DM150 million project is part of a general increase in telecom r & d spending in Germany in a drive to increase competitiveness. The networks are in addition to coaxial cable pilot projects already under way in Ludwigshafen and Dortmund, with München, Berlin and seven other cities to follow. Original area-wide plans were scrapped about two years ago and work is now limited to "islands of partial networks". With national coverage estimated to cost DM20 to 30 billion and optical systems at several times as much, the Bundespost is hoping for large price reductions with volume in the near future.

A catalogue of 100 titles is the aim of Thorn-EMI for the UK launch of the grooveless capacitance video disc, VHD, in June with a build-up to 160 by the year end. At the JVC Berlin demonstration, a Thorn-EMI executive stressed their commitment to VHD, as the prime software supplier: Thorn and EMI had merged "precisely to take advantage of the home video market", he said. The latest players were designed to show compatibility when the colour systems of player and disc do not correspond. A PAL disc, first played on a PAL player was next played on SECAM and NTSC players. Then an NTSC record was shown to play back on a PAL player, apparently without significant detriment.

Automatic circuitry in the players switches the appropriate motor speed, of course, 750 or 900 rev/min; that bit's easy. But proper synchronization due to differing vertical frequencies is only possible with modified frame scanning circuitry, as included in the monitors used. No doubt Thorn tv sets will in future contain circuitry with a wide enough pull-in range to accept 60Hz discs, but not presumably automatic circuitry to alter vertical deflection as was done in the demonstration! Normally playing an NTSC disc on a PAL player would show a black bar for the missing lines. And the other way around there would be picture loss; but only about 10% point out JVC rather than the 16% that would be the case if tv sets didn't overscan.

The VHD players feature a chapter search facility through a code recorded onto the disc and an automatic search mode based on a time code. Variable-speed search up to 65 times normal speed allows a disc to be scanned in under a minute. Various play modes are provided including a choice of speeds, repeat modes and frame by frame advance. For the interactive kind of programme appropriate parts of the mastering tape would be doubled-up so that playing time could be reduced by up to a half (Type 2 disc).

Dynamic expansion is said to give a 60dB signal-to-noise ratio for the two stereo or bilingual channels. With the addition of a p.c.m. converter three audio channels (one centre to avoid the phantom image) and a fourth for still pictures become available in the AHD version.

VHD players were to be seen elsewhere but not, after the first day, on the almost-nationalized-Thomson stand from which a player was removed at the suggestion of a French government official. Which puts a question mark by the commitment of Nordmende and more recently Saba who are also part of the same group to market VHD players – and what of VHS?

Anyone with ideas for keeping conventional record presses in business that bit longer gets listened to at the moment. Which of course is part of the appeal of VHD and CED. What Telefunken is now offering is a digital sound record, developed from their earlier ideas of a hill and dale television disc but with a stiff disc rather than the earlier foil record rotating at 250rev/min. The new Mini Disc records are made by conventional processes but use less p.v.c. record material – diameter is 135mm offering a one hour playing time per side.

The data format used allows starting points of individual sections to be instantly located as with other digital systems, additional audio channels to be provided, and coded text to be added for display, Telefunken suggest, of the words of a song or any other information for that matter, on a television set. And for popular music a 10minute Micro Disc would be 74mm diameter.

Another response to the coming transformation in the record business has been that of coding a conventional record so that it will appear as noiseless as its digital rival. This is the way dbx is currently promoting itself. But there's a snag, even before thinking about dynamic ones: dbx encoded discs need a decoder. If you can devise a technique that matches the noise level of digital tape recordings, with little or no audible pumping, good transient response, intolerant of level mismatches, and that is *compatible*, i.e. acceptable without a decoder, then one might have something. Such is the CBS scheme, called CX, currently being demonstrated to manufacturers.

It is a wideband compander with a 2:1 law from 0dB reference level to −40dB, below which it is linear. In operation, control signals are derived by taking the largest full-wave rectified value of left and right inputs. If this then controlled variable-gain stages in the signal paths directly, with a 1ms attack and 10ms deray time, noise level pumping would be unacceptable and distortion would occur. Four parallel filter paths are designed to overcome this and allow it to operate with signals that are "difficult for other systems", according to Louis Abbagnaro of CBS Technology Center, who claims the benefits are "without any distortion or pumping".

One filter path is optimized for low-level steady-state signals to ensure "minimum" audible noise and signal modulation but not for rapidly changing signals. Another filter path allows the circuit to track a rapid decay for 200ms; after that noise pumping becomes obvious, CBS say, and control is passed over to the previously-mentioned filter path which keeps the noise level steady (2s time constant). Fast attacks are passed by a third filter with a 30ms time constant. The effect of ripple can't be heard, according to CBS tests, in this time. If the signal lasts longer, a high-pass filter comes into play to remove the ripple from the signal. So these last two filter paths respond with a 1ms attack time and no ripple after 30ms. (The four filter outputs are summed to control the two variable-gain circuits.) Mr Abbagnaro told us that within a year, output from RCA Records, WEA, Teldec and CBS would be CX-encoded. In addition, RCA, MCA and Universal-Pioneer will be using it for their video discs and players. Decoder licensing dues are 15 cents a unit with nine brand names so far behind CX including Telefunken, Marantz, Phase Linear, Sound Concepts, MXR and Audionics, with a Japanese brand name to be added.

High Com now has 40 licensees, plus 10 partners buying from Japan; this year 30 of the hi-fi cassette recorders on sale in Germany will have High Com fitted. But what is its future now with the emergence of Dolby C? It offers typically 73-75dB as against 68dB signal-to-noise ratio, and there are situations where as much as 83dB can be obtained in commercial equipment by careful design. This is largely because Dolby C gives 20dB improvement only between about 2 and 8kHz; in terms of the IEC A-weighted r.m.s. curve, points out Hans-Joachim Thuy, Special Products Manager at Telefunken, this amounts to 15dB as against 20dB over the audio band. So it still has something to offer. The two main signal sources used with noise reduction systems – records and stereo broadcasts – both offer signal-to-noise ratios of around 60dB. A noise reduction system that provides, say, 65dB s/n ratio, will degrade that figure to 57dB, whereas a 75dB system would degrade the source to only 59.5dB. High Com's advantage, 2.5dB in this example, is likely to be greater the better the source signal. Hence Telefunken's interest in improving signal-to-noise ratio of records with CX.

To try to improve radio channel signal-to-noise ratio a compatible circuit was designed to provide 9dB improvement. Broadcast tests earlier this year by IRT showed this to be undetected. Unfortunately aiming for 15dB proved a little too greedy but further tests are planned round a 12dB circuit.

Some quick work on decoders for the new internationally-agreed standard for viewdata (Bildschirmtext) resulted in some fine displays of graphics from almost-completed "prototype" decoders on the Siemens and Bundespost stands. The new CEPT standard includes more characters (320), improved characters and graphics, a private character set possibility, smooth graphics (lines, curves), dynamically redefinable characters with 10×12 matrix format, double height and width facility, two-speed blinking, and half brightness colours.

Extensive high resolution capability, such as that also given by Teledon and demonstrated on the Canadian government stand, requires expensive memory and isn't needed for most purposes, according to Eric Danke, Postdirektor for Bildschirmtext. High resolution would probably only be required in 100,000 to 150,000 decoders, out of a forecast million users. For this minority of users a decoder with full alpha-geometric capability might cost as much as DM1000 (£250), Herr Danke estimated, whereas a bare-essentials decoder could cost as little as DM200 in volume, DM500 initially. A whole range of decoders is likely to be available for the start of the service in 1983, when the current trials end. The field trials started last year and have been deliberately limited to around 6,000 users (2,000 private and 1,000 business users in Berlin and Düsseldorf) with introduction of a new standard in mind.

With the main impetus for development in television receivers coming from manufacturers aiming for lower production costs rather than broadcasters looking for enhanced performance the current route to lower cost is still through greater integration, to take advantage of v.l.s.i. densities of up to 50,000 gate-equivalents. To do this for more functions than just channel selection and remote control, ITT have digitized those processes with a frequency low enough to make digital conversion economic. In practice this means the stages after the video demodulator: while eight-bit a-to-d converters can digitize up to 40MHz, they're still not cheap enough. The digitized sections comprise keyboard, audio stages, matrixing, delay line, luminance and chrominance filters, sync pulse separation, and both horizontal and vertical amplifiers working in class D. But equally important is the facility to enter alignment data by programmable memory, governed from a central control unit. Not only does this cut down factory time by avoiding the customary "tweaking" processes but it also provides the means for making adjustments in sound and picture processing to compensate for ageing. ITT say a design will be available next year using just five integrated circuits, later to be reduced to three, ultimately one. Besides cost benefits, the potential improvements in picture performance are substantial – pictures noise-free, echoes cancelled, flicker eliminated by increasing frame rate, freeze-frame presentation, easy pictures within pictures, greatly eased interfacing.

Such local improvements to picture quality will undoubtedly highlight relative inadequacies in the transmitted signal. Already direct RGB input to receivers from computers and digital video equipment in general can lead to higher resolution displays than the h.f. section of current receivers allows. The idea of improving picture quality by digital coding and by separation of chrominance and luminance information may become a feasible proposition with the availability of satellite channels. For direct reception the problem is one of decoder cost; but when plans for wide-band optical fibre networks are realised nationally the market for such decoders would be increased to an economic size, assuming digital standards were congruent.

Given these wider channels and a general desire for better pictures, especially for projection to large audiences, some countries will surely be looking at high-definition tv pictures in the not-too-distant future. Japanese broadcasters have been studying the possibilities for at least 15 years now and two or three years ago experimented with an f.m. system over Japan's 12GHz satellite. Though no high definition equipment was on display at the exhibition it is known that prototype digital apparatus is under construction in Japan. Recently, US broadcast companies have been active in this area and now Germany has made a proposal they hope others will adopt.

A new television standard, the Germans say, should have between 1150 and 1250 lines arranged in such a way that following programme production two signals are available, one high definition and the other containing alternate lines to provide a compatible 625-line signal for terrestrial distribution. But picture improvement could come through other avenues. Work is under way that may demonstrate feasibility of using "offset dot raster" scanning, a scheme which subjectively improves vertical and horizontal resolution and that would be compatible with existing standards.

Digital storage and analysis of speech

4 – Fourier transforms and estimating formant position

by Ian H. Witten, M.A.,M.Sc., Ph.D., M.I.E.E., University of Calgary

Dr Witten continues his discussion of spectral analysis with an explanation of the discrete Fourier and fast Fourier transforms, and shows how to estimate the positions of formants.

Discrete Fourier transform

Let us return from the brief digression into techniques of digital signal analysis to the problem of determining the frequency spectrum of speech. Although a bank of bandpass filters such as is used in the channel vocoder is perhaps the most straightforward way to obtain a frequency spectrum, there are other techniques which are in fact more commonly used in digital speech processing.

It is possible to define the Fourier transform of a discrete sequence of points. To motivate the definition, consider first the ordinary Fourier transform (FT), which is

$$g(t)=\int_{-\infty}^{\infty} G(f)e^{+j2\pi ft}df$$

$$G(f)=\int_{-\infty}^{\infty} g(t)e^{-j2\pi ft}dt,$$

This takes a continuous time domain into a continuous frequency domain. Sometimes you see a normalizing factor $1/2\pi$ multiplying the integral in either the forward or the reverse transform. This is only needed when the frequency variable is expressed in radians/s, and we will find it more convenient to express frequencies in Hz.

The Fourier series (FS), which should also be familiar to you, operates on a periodic time waveform (or, equivalently, one that only exists for a finite period of time, which is notionally extended periodically). If a period lies in the time ranges $[0,b)$, then the transform is

$$g(t)=\sum_{r=-\infty}^{\infty} G(r)e^{+j2\pi rt/b}$$

$$G(r)=\frac{1}{b}\int_0^b g(t)e^{-j2\pi rt/b}\,dt.$$

The Fourier series takes a periodic time-domain function into a discrete frequency-domain one. Because of the basic duality between the time and frequency domains in the Fourier transforms, it is not surprising that another version of the transform can be defined which takes a periodic frequency domain function into a discrete time-domain one.

Fourier transforms can only deal with a finite stretch of a time signal by assuming that the signal is periodic, for if $g(t)$ is evaluated from its transform $G(r)$ according to the formula above, and t is chosen outside the interval $[0,b)$, then a periodic extension of the function $g(t)$ is obtained automatically. Furthermore, periodicity in one domain implies discreteness in the other. Hence if we transform a finite stretch of a discrete time waveform, we get a frequency-domain representation which is also finite (or, equivalently, periodic), and discrete. This is the discrete Fourier transform (DFT), and takes a discrete periodic time-domain function into a discrete periodic frequency-domain one, as illustrated in Fig. 14. It is defined by

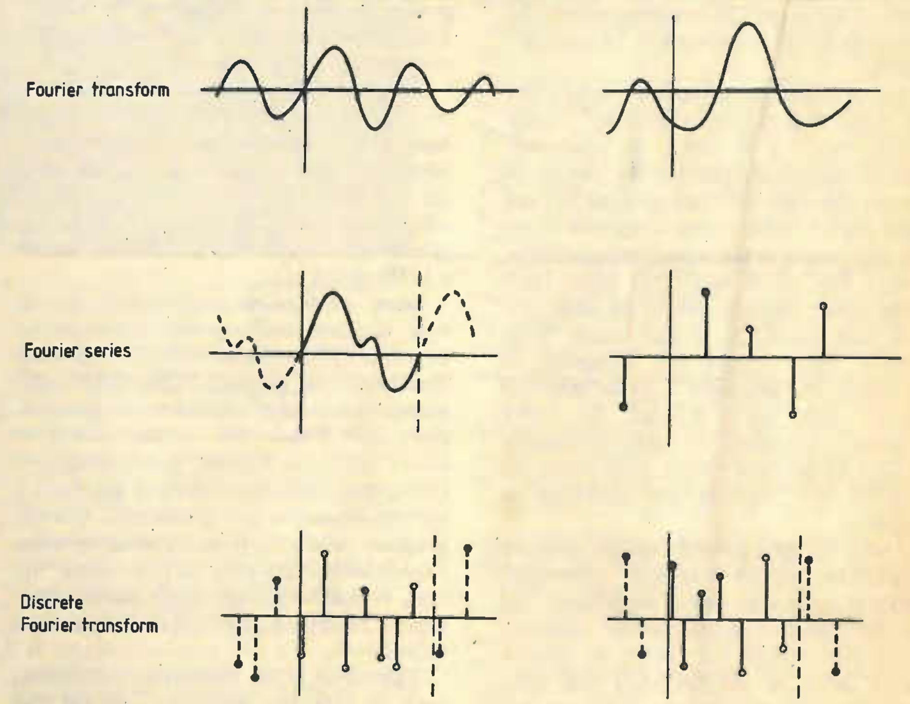


Fig. 14. Fourier transform, Fourier series and discrete FT.

$$g(n)=\frac{1}{N}\sum_{r=0}^{N-1} G(r)e^{j2\pi rn/N}$$

$$G(r)=\sum_{n=0}^{N-1} g(n)e^{-j2\pi rn/N},$$

or, writing $W=e^{-j2\pi/N}$,

$$g(n)=\frac{1}{N}\sum_{r=0}^{N-1} G(r)W^{-rn}$$

$$G(r)=\sum_{n=0}^{N-1} g(n)W^{rn}.$$

The $1/N$ in the first equation is the same normalizing factor as the $1/b$ in the Fourier series, for the finite time domain is $[0,N)$ in the discrete case and $[0,b)$ in the Fourier series case. It does not matter whether it is written into the forward or the reverse transform, but it is usually placed as shown above as a matter of convention.

As illustrated by Fig. 15, discrete Fourier transforms take an input of N real values, representing equally spaced time samples in the interval $[0,b)$, and produce as output N complex values, representing equally spaced frequency samples in the interval $[0,N/b)$. Note that the end-point of this frequency interval is the sampling frequency. It seems odd that the input is real and the output is the same number of *complex* quantities: we seem to be getting some numbers for nothing! However, this isn't so, for it is easy to show that if the input sequence is real, the output frequency spectrum has a symmetry about its mid-point (half the sampling frequency). This can be expressed as

DFT symmetry: $G(\frac{N}{2}+r)=G(\frac{N}{2}-r)^*$

if g is real-valued, where * denotes the conjugate of a complex quantity (that is, $(a+jb)^*=(a-jb)$).

It was argued above that the frequency spectrum in the DFT is periodic, with the spectrum from 0 to the sampling fre-

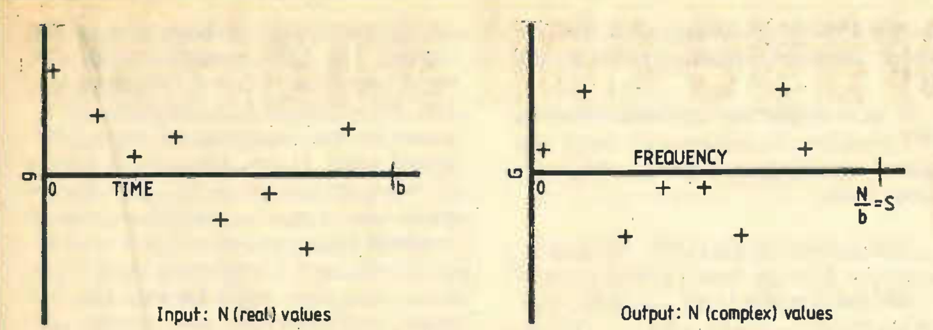


Fig. 15. Time and frequency domains for discrete Fourier transform (DFT).

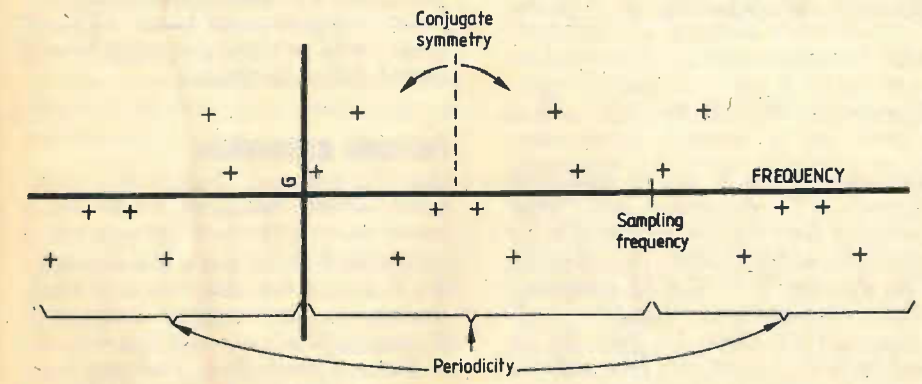


Fig. 16. Symmetry and periodicity in DFT.

quency being repeated regularly up and down the frequency axis. It can easily be seen from the DFT equation that this is so. It can be written

DFT periodicity: $G(N+r) = G(r)$ always.

Figure 16 illustrates the properties of symmetry and periodicity.

Estimating the frequency spectrum of speech using the DFT

Speech signals are not exactly periodic. Although the waveform in a particular period will usually resemble those in the preceding and following pitch periods, it will certainly not be identical to them. As the articulation of the speech changes, the formant positions will alter. Furthermore, the pitch itself is certainly not constant, because the intonation of speech varies continually. Hence the fundamental assumption of the DFT, that the waveform is periodic, is not really justified. However, the signal is quasi-periodic, for changes from period to period will not usually be very great. One way of computing the short-term frequency spectrum of speech is to use pitch-synchronous Fourier transformation, where signal pitch periods are isolated from the waveform and processed with the DFT. This gives a rather accurate estimate of the spectrum. Unfortunately, it is difficult to determine the beginning and end of each pitch cycle, as we shall see later in this article when discussing pitch extraction techniques.

If a finite stretch of a speech waveform is isolated and Fourier transformed, without regard to pitch of the speech, then the periodicity assumption will be grossly violated. Figure 17 illustrates that the effect is the same as multiplying the signal by a rectangular window function, which is 0 except during the period to be analysed, where it is 1. The windowed sequence will almost certainly have discontinuities at its edges, and these will effect the resulting spectrum. The effect can be analysed quite easily, but we will not do so here. It is enough to say that the high frequencies associated with the edges of the window cause considerable distortion of the spectrum. The effect can be alleviated by using a smoother window than a rectangular one, and several have been investigated extensively. The commonly-used windows of Bartlett, Blackman, and Hamming are illustrated in Fig. 18.

Because the DFT produces the same number of frequency samples, equally spaced, as there were points in the time waveform, there is a tradeoff between frequency resolution and time resolution (for a given sampling rate). For example, a 256-point transform with sampling rate of 8 kHz gives the 256 equally-spaced frequency components between 0 and 8 kHz that are shown in Table 4. The top half of the frequency spectrum is of no interest, because it contains the complex conjugates of the bottom half (in reverse order), corresponding to frequencies greater than half the sampling frequency. Thus for a 30 Hz resolution in the frequency domain, 256 time samples, or a 32 ms stretch of speech, needs to be transformed. A common technique is to take overlapping periods in the time domain to give a new frequency spectrum every 16 ms. From the acoustic point of view this is a reasonable rate to recompute the spectrum, for as noted above when discussing channel vocoders the rate of change in the spectrum is limited by the speed that the speaker can move his vocal organs, and anything between 10 and 25 ms is a reasonable figure for transmitting or storing the spectrum.

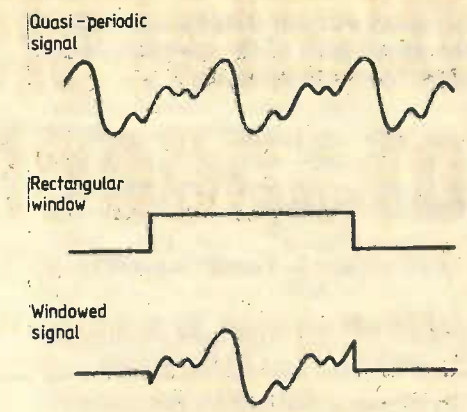


Fig. 17. Isolating part of waveform for analysis – windowing.

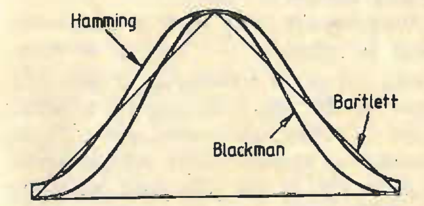


Fig. 18. Three window shapes to reduce effects of discontinuities at beginning and end of window period.

time domain sample number	time	frequency domain sample number	frequency
0	0 μsec	0	0 Hz
1	125	1	31
2	250	2	62
3	375	3	94
4	500	4	125
...	...	...	...
...	...	...	...
...	...	...	...
254	31750	254	7938
255	31875	255	7969

Table 4 Time domain and frequency domain samples for a 256-point DFT with 8 kHz sampling figure for transmitting or storing the spectrum.

The DFT is a complex transform, and speech is a real signal. It is possible to do two DFTs at once by putting one time waveform into the real parts of the input and another into the imaginary parts. This destroys the DFT symmetry property, for it only holds for real inputs. But given the DFT of a complex sequence formed in this way, it is easy to separate out the DFTs of the two real time sequences. If the two time sequences are $x(n)$ and $y(n)$, then the transform of the complex sequence

$$g(n) = x(n) + jy(n)$$

is $G(r)=\sum_{n=0}^{N-1} [x(n)W^{rn}+y(n)W^{rn}]$.

It follows that the complex conjugate of the aliased parts of the spectrum, in the upper frequency region, are

$$G(N-r)^{\star}=\sum_{n=0}^{N-1}[x(n)W^{-(N-r)n}-y(n)W^{-(N-r)n}],$$

and this is the same as

$$G(N-r)^{\star}=\sum_{n=0}^{N-1}[x(n)W^{rn}-y(n)W^{rn}],$$

because W^N is 1 (recall the definition of W), and so W^{-Nn} is 1 for any n. Thus

$$X(r)=\frac{G(r)+G(N-r)^{\star}}{2}$$

$$Y(r)=\frac{G(r)-G(N-r)^{\star}}{2}$$

extracts the transforms $X(r)$ and $Y(r)$ of the original sequences x and y.

With speech, this trick is frequently used to calculate two spectra at once. Using 256-point transforms, a new estimate of the spectrum can be obtained every 16 ms by taking overlapping 32 ms stretches of speech, with a computational requirement of one 256-point transform every 32 ms.

The fast Fourier transform

Straightforward calculation of the DFT, expressed as

$$G(r)=\sum_{n=0}^{N-1}g(n)W^{rn},$$

for $r = 0, 1, 2, \ldots, N-1$, takes N^2 operation, where each operation is a complex multiply and add (for W is, of course, a complex number). There is a better way, invented in the early sixties, which reduces this to $N\log_2 N$ operations – a very considerable improvement. Dubbed the "fast Fourier transform" (FFT) for historical reasons, it would actually be better called the "Fourier transform", with the straightforward method above known as the "slow Fourier transform"! There is no reason nowadays to use the slow method, except for tiny transforms. It is worth describing the basic principle of the FFT, for it is surprisingly simple.

It is important to realize that the FFT involves no approximation. It is an *exact* calculation of the values that would be obtained by the slow method. Problems of aliasing and windowing occur in all discrete Fourier transforms, and they are neither alleviated nor exacerbated by the FFT.

To gain insight into the working of the FFT, imagine the sequence $g(n)$ split into halves, containing the even and odd points respectively.

even half $e(n)$ is $g(0)\, g(2) \ldots g(N\text{-}2)$

odd half $o(n)$ is $g(1)\, g(3) \ldots g(N\text{-}1)$.

Then is is easy to show that if G is the transform of g, E the transform of e, and O that of o, then

$$G(r)=E(r)+W^rO(r) \text{ for } r=0, 1, \ldots, \frac{N}{2}-1,$$

and

$$G(\frac{N}{2}+r)=E(r)+W^{\frac{N}{2}+r}O(r) \text{ for } 0, 1, \ldots, \frac{N}{2}-1.$$

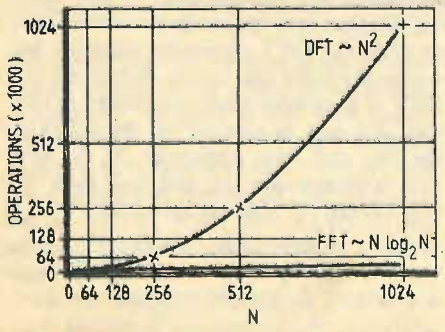
Calculation of the E and O transforms involves $(N/2)^2$ operations each, while combining them together according to the above relationship occupies N operations. Thus the total is $N + N^2/2$ operations, which is considerably less than N^2.

But don't stop there! The even half can itself be broken down into even and odd parts to expedite its calculation, and the same with the odd half. The only constraint is that the number of elements in the sequences splits exactly into two at each stage. Providing N is a power of 2, then, we are left at the end with some 1-point transforms to do. But transforming a single point leaves it unaffected! (Check the definition of the DFT.) A quick calculation shows that the number of operations needed is not $N + N^2/2$, but $N\log_2 N$. Figure 19 compares this with N^2, the number of operations for straightforward DFT calculation, and it can be seen that the FFT is very much faster.

The only restriction on the use of the FFT is that N must be a power of two. If it is not, alternative, more complicated, algorithms can be used which give comparable computational advantages. However, for speech processing the number of samples that are transformed is usually arranged to be a power of two. If a pitch synchronous analysis is undertaken, the time stretch that is to be transformed is dictated by the length of the pitch period, and will vary from time to time. Then, it is usual to pad out the time waveform with zeros to bring the number of samples up to a power of two; otherwise, if different-length time stretches were transformed the scale of the resulting frequency components would vary too.

The FFT provides very worthwhile cost savings over the use of a bank of bandpass filters for spectral analysis. Take the example of a 256-point transform with 8 kHz sampling, giving 128 frequency components spaced by 31.25 Hz from 0 up to almost 4 kHz. This can be computed on overlapping 32 ms stretches of the time waveform, giving a new spectrum every 16 ms, by a single FFT calculation every 32 ms (putting successive pairs of time stretches in the real and imaginary parts of the complex input sequence, as described earlier). The FFT algorithm requires $N\log_2 N$ operations, which is 2048 when N = 256. An additional 512 operations are required for the windowing calculation. Repeated every 32 ms, this gives a rate of 80,000 operations per second. To achieve a much lower frequency resolution with 20 bandpass filters, each of which are fourth-order, will need a great many more operations. Each filter needs between four and eight multiplications per sample, depending on its exact digital implementation. But new samples appear every 125 *micro*seconds, and so somewhere around a million operations are required every second. If we increased the frequency resolution to that obtained by the FFT, 128 filters would be needed, requiring between 4 and 8 million operations!

Fig. 19. Fast Fourier transform (FFT) requires many fewer operations than DFT. Size of transform plotted horizontally.



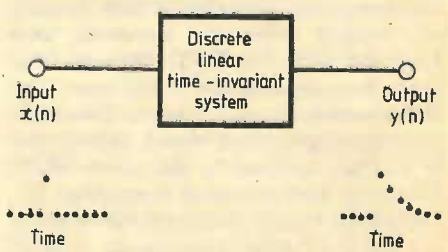
Formant estimation

Once the frequency spectrum of a speech signal has been calculated, it may seem a simple matter to estimate the positions of the formants. But it is not! One reason for this is that, unless the analysis is pitch-synchronous, the frequency spectrum of the excitation source is mixed in with that of the vocal tract filter. There are other reasons, which will be discussed later in this section. But first, let us consider how to extract the vocal tract filter characteristics from the combined spectrum of source and filter. To do so we must begin to explore the theory of linear systems.

Discrete linear systems. Figure 20 shows an input signal exciting a filter to produce an output signal. For present purposes, imagine the input to be a glottal waveform, the filter a vocal tract one, and the output a speech signal (which is then subjected to high-frequency de-emphasis by radiation from the lips). We will consider here discrete systems, so that the input $x(n)$ and output $y(n)$ are sampled signals, defined only when n is integral. The theory is quite similar for continuous systems.

Assume that the system is linear; that is, if input $x_1(n)$ produces output $y_1(n)$ and input $x_2(n)$ produces output $y_2(n)$, then the sum of $x_1(n)$ and $x_2(n)$ will produce the sum of $y_1(n)$ and $y_2(n)$. It is easy to show from this that, for any constant multiplier a, the input $ax(n)$ will produce output $ay(n)$ – it is pretty obvious when a=2, or indeed any positive integer; for then $ax(n)$ can be written as $x(n)+x(n)+\ldots$ Assume further that the system is time-invariant; that is, if input $x(n)$ produces output $y(n)$ then a time-shifted version of x, say

Fig. 20. Linear system with input and output, with impulsive input and corresponding output.



$x(n+n_0)$ for some constant n_0, will produce the same output, only time-shifted; namely $y(n+n_0)$.

Now consider the discrete delta function $\delta(n)$, which is 0 except at n=0 when it is 1. If this single impulse is presented as input to the system, the output is called the impulse response, and will be denoted by $h(n)$. The fact that the system is time-invariant guarantees that the response does not depend upon the particular time at which the impulse occurred, so that, for example, the impulsive input $\delta(n+n_0)$ will produce output $h(n+n_0)$. A delta-function input and corresponding impulse response are shown in Fig. 20.

The impulse response of a linear, time-invariant system is an extremely useful thing to know, for it can be used to calculate the output of the system for any input at all! Specifically, an input signal $x(n)$ can be written

$$x(n)=\sum_{k=-\infty}^{\infty}x(k)\delta(n-k),$$

because $\delta(n\text{-}k)$ is non-zero only when k=n, and so for any particular value of n, the summation contains only one non-zero term – $x(n)$. The action of the system on each term of the sum is to produce an output $x(k)h(n\text{-}k)$, because $x(k)$ is just a constant, and the system is linear. Furthermore, the complete input $x(n)$ is just the sum of such terms, and since the system is linear, the output is the sum of $x(k)h(n\text{-}k)$. Hence the response of the system to an arbitrary input is

$$y(n)=\sum_{k=-\infty}^{\infty}x(k)h(n-k).$$

This is called a *convolution sum*, and is sometimes written

$$y(n)=x(n)\star h(n).$$

Let's write this in terms of z-transforms. The (two-sided) z-transform of $y(n)$ is

$$Y(z)=\sum_{n=-\infty}^{\infty}y(n)z^{-n}=\sum_n\sum_k x(k)h(n-k)z^{-n}.$$

Writing z^{-n} as $z^{-(n-k)}z^{-k}$, and interchanging the order of summation, this becomes

$$Y(z)=\sum_k[\sum_n h(n-k)z^{-(n-k)}]x(k)z^{-k}$$

$$=\sum_k H(z)z^{-k}=H(z)\sum_k x(k)z^{-k}=H(z)X(z).$$

Thus convolution in the time domain is the same as multiplication in the z-transform domain; a very important result. Applied to the linear system of Fig. 20, this means that the output z-transform is the input z-transform multiplied by the z-transform of the system's impulse response.

What we really want to do is to relate the frequency spectrum of the output to the response of the system and the spectrum of the input. In fact, frequency spectra are very closely connected with z-transforms. A periodic signal $x(n)$ which repeats every N samples has DFT

$$\sum_{n=0}^{N-1}x(n)e^{-j2\pi rn/N},$$

and its z-transform is

$$\sum_{n=-\infty}^{\infty}x(n)z^{-n}.$$

Hence the DFT is the same as the z-transform of a single cycle of the signal, evaluated at the points $z=e^{j2\pi r/N}$ for r=0,1, . . . ,N-1. In other words, the frequency components are samples of the z-transform at N equally-spaced points around the unit circle. Hence the frequency spectrum at the output of a linear system is the product of the input spectrum and the frequency response of the system itself (i.e., the transform of its impulse-response function). It should be admitted that this statement is somewhat questionable, because to get from z-transforms to DFTs we have assumed that a single cycle only is transformed – and the impulse response function of a system is not necessarily periodic. The real action of the system is to multiply z-transforms, not DFTs. However, it is useful in imagining the behaviour of the system to think in terms of products of DFTs; and in practice it is always these rather than z-transforms which are computed because of the existence of the FFT algorithm.

The DFT frequency spectrum of a typical voiced speech signal shows humps at the formant positions. However, superimposed on this is an "oscillation" (in the frequency domain!) at the pitch frequency. This occurs because the transform of the vocal tract filter has been multiplied by that of the pitch pulse, the latter having components at harmonics of the pitch frequency. The oscillation must be suppressed before the formants can be estimated to any degree of accuracy.

One way of eliminating the oscillation is to perform pitch-synchronous analysis. This removes the influence of pitch from the frequency domain by dealing with it in the time domain! The snag is, of that it is not easy to estimate the pitch frequency: some techniques for doing so are discussed in the next main section. Another method is to remove the pitch ripple from the frequency spectrum directly. This will be discussed next, in an intuitive rather than a theoretical way.

Cepstral processing of speech. Suppose the rippled frequency spectrum were actually a time waveform. To remove the high-frequency pitch ripple is easy: just filter it out! However, filtering removes additive ripples, whereas this is a multiplicative ripple. To turn multiplication into addition, take logarithms. Then the procedure would be

– compute the DFT of the speech waveform (windowed, overlapped);
– take the logarithm of the transform;
– filter out the high-frequency part, corresponding to pitch ripple.

Filtering is often best done using the DFT. If the rippled waveform is transformed, a strong component could be expected at the ripple frequency, with weaker ones at its harmonics. These components can be simply removed by setting them to zero, and inverse-transforming the result to give a smoothed version of the original frequency spectrum. A spectrum of the logarithm of a frequency spectrum is often called a cepstrum – a sort of backwards spectrum. The horizontal axis of the cepstrum, having the dimension of time, is called "quefrency"! Note that high-frequency signals have low quefrencies and vice versa. In practice, because the pitch ripple is usually well above the quefrency of interest for formants, the upper end of the cepstrum is often simply cut off from a fixed quefrency which corresponds to the maximum pitch expected. However, identifying the pitch peaks of the cepstrum has the useful byproduct of giving the pitch period of the original speech.

To summarize, then, the procedure for spectral smoothing by the cepstral method is

– compute the DFT of the speech waveform (windowed, overlapped);
– take the logarithm of the transform;
– take the DFT of this log-transform, calling it the cepstrum;
– identify the lowest-quefrency peak in the spectrum as the pitch, confirming it by examining its harmonics, which should be equally spaced at the pitch quefrency;
– remove pitch effects from the cepstrum by cutting off its high-quefrency part above either the pitch frequency or some constant representing the maximum expected pitch (i.e. minimum expected pitch frequency);
– inverse DFT the resulting cepstrum to give a smoothed spectrum.

Estimating formants from smoothed spectra. The difficulties of formant extraction are not over even when a smooth frequency spectrum has been obtained. A simple peak-picking algorithm which identifies a peak at the k'th frequency component whenever

$$X(k-1)<X(k) \text{ and } X(k)<X(k+1)$$

will quite often identify formants incorrectly. It helps to specify in advance minimum and maximum formant frequencies – say 100 Hz and 3 kHz for three-formant identification, and ignore peaks lying outside these limits. It helps to estimate the bandwidth of the peaks and reject those with bandwidths greater than 500 Hz – for real formants are never this wide. However, if two formants are very close, then they may appear as a single, wide, peak and be rejected by this criterion. It is usual to take account of formant positions identified in previous frames under these conditions.

There are several estimation algorithms. The simplest uses the number of peaks identified in the raw spectrum (under 3 kHz, and with bandwidths greater than 500 Hz), to determine what to do. If exactly three peaks are found, they are used as the formant positions It is claimed that this happens about 85% to 90% of the time. If only one peak is found, the present frame is ignored and the previously-identified formant positions are used (this happens less than 1% of the time). The remaining cases are two peaks – corresponding to omission of one formant – and four peaks – corresponding to an extra formant being included. (More than four peaks do not normally occur.) Under these conditions, a nearest-neighbour measure can be used for identification. A suitable measure is

$$v_{ij}=|F^*_i(k)-F_j(k-1)|,$$

where $F_j(k-1)$ is the j'th formant frequency defined in the previous frame $k-1$ and $F^*_i(k)$ is the i'th raw data frequency estimate for frame k. If two peaks only are found, this measure is used to identify the closest peaks in the previous frame; and then the third peak of that frame is taken to be the missing formant position. If four peaks are found, the measure is used to determine which of them is furthest from the previous formant values, and this one is discarded.

This procedure works forwards, using the previous frame to distinguish peaks given in the current one. More sophisticated algorithms work backwards as well, identifying anchor points in the data which have clearly defined formant positions, and moving in both directions from these to identify neighbouring frames of data. Finally, absolute limits can be imposed upon the magnitude of formant movements between frames to give an overall smoothing to the formant tracks.

Very often, people will refine the result of such automatic formant estimation procedures by hand, looking at the tracks, knowing what was said, and making adjustments in the light of their experience of how formants move in speech. Unfortunately, it is difficult to obtain high-quality formant tracks by completely automatic means.

One of the most difficult cases in formant estimation is where two formants are so close together that the individual peaks cannot be resolved. One simple solution to this problem is to employ "analysis-by-synthesis", whereby once a formant is identified, a standard formant shape at this position is synthesized and subtracted from the logarithmic spectrum. Then, even if two formants are right on top of each other, the second is not missed because it remains after the first one has been subtracted.

Unfortunately, however, the single peak which appears when two formants are close together usually does not correspond exactly with the position of either one. There is one rather advanced signal-processing technique that can help in this case. The frequency spectrum of speech is determined by *poles* which lie in the complex *z*-plane inside the unit circle. (They must be inside the unit circle if the sytem is stable. Those familiar with Laplace analysis of analogue systems may like to note that the left half of the *s*-plane corresponds with the inside of the unit circle in the *z*-plane.) As shown earlier, computing a DFT is tantamount to evaluating the z-transform at equally-spaced points around the unit circle. However, better resolution is obtained by evaluating around a circle which lies inside the unit circle, but outside the outermost pole position. Such a circle is sketched in Fig. 21.

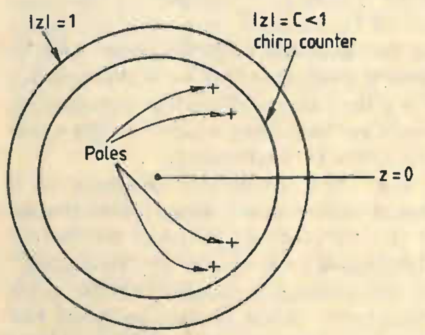


Fig. 21. Evaluating Z-transform outside outer pole but inside unit circle.

Recall that the FFT is a fast way of calculating the DFT of a sequence. Is there a similarly fast way of evaluating the z-transform inside the unit circle? The answer is yes, and the technique is known as the "chirp z-transform", because it involves considering a signal whose frequency increases linearly – just like a radar chirp signal. The chirp method allows the z-transform to be computed quickly at equally-spaced points along spirally-shaped contours around the origin of the *z*-plane – corresponding to signals of linearly incresing complex frequency. The spiral nature of these curves is not of particular interest in speech processing. What is of interest, though, is that the spiral can begin at any point on the *z*=0 axis, and its pitch can be set arbitrarily. If we begin spiralling at *z*=0.9, say, and set the pitch to zero, the contour becomes a circle inside the unit one, with radius 0.9. Such a circle is exactly what is needed to refine formant resolution.

To be continued

Literature Received

Catalogue of passive and active electronic components, hardware and tools, which includes a greater number of optoelectronic devices than usual, can be obtained by writing to HB Electronics, Norfolk House, Wellesley Road, Croydon CR0 0YF on company notepaper. WW401

A variety of noise sources, from basic diodes to programmable generators is produced by Micronetics, who offer a catalogue through distributors March Microwave Ltd, 112 South Street, Braintree, Essex. WW401

Crow of Reading's capabilities in the design and construction of broadcast television equipment, from single instruments to large stations, is briefly described in a colour brochure which can be obtained from Crow of Reading Ltd, PO Box 36, Reading, Berks. WW402

A range of seven microterminals made by Burr-Brown are illustrated and shortly specified in a brochure, available from Burr-Brown International Ltd, Cassiobury House, 11-19 Station Road, Watford, Hertfordshire WD1 1EA. WW403

Catalogue of small tools and a selection of hardware is produced by Electroware, who describe their range in a new catalogue, which is obtainable from Dutton Lane, Eastleigh SO5 4SL. WW404

Voltage regulator i.cs to provide current up to 8A positive and 1.5A negative, and a range of switching power supplies for up to 50A are made by Lambda. Brochures can be had on application to Lambda Electronics Co., Abbey Barn Road, High Wycombe, Bucks. WW405

Production equipment for the electronics industry (cutting, stripping, bending and cleaning) is described in a leaflet produced by Eraser International Ltd, Unit M, Portway Industrial Estate, Andover SP10 3LU. WW406

P.r.o.ms and programmable logic devices from many makers are detailed in a new wall-chart from Microsystem Services, Duke Street, High Wycombe, Bucks. HP13 6EE. WW407

Booklet from the Electric Cable Makers' Confederation lists the member companies by name and by product, and includes a short resumé of each company's activities. The confederation's address is 56 Palace Road, East Molesey, Surrey KT8 9DW. WW408

Catalogue of general electronic components and tools, including a wide range of semiconductors and the well-known audio modules, can be obtained from Bi-Pak, the Maltings, 63a High Street, Ware, Herts. SG12 9AD. WW409

Link Electronics have produced a guide to their closed-circuit television equipment and systems, including cameras, studio equipment, complete studios and mobile units. It is available from Link Electronics Ltd, North Way, Andover SP10 5AJ. WW410

The Acron 505 Sync. pulse generator, for PAL, NTSC and PAL-M is described in a colour leaflet from Acron Video, Unit 3, Lovelace Road, Bracknell RG12 4YT. WW411

Communications, logic and memory devices in ISO-CMOS technology, which confers high speed at low power, will shortly be introduced by GTE, who have sent us a short description of the new devices. Copies can be obtained from GTE Microcircuits, 2000 W. 14th Street, Tempe, Ariz., 85281. WW412

Zilog's newsletter Z-Bits is now in its second issue, the latest one including details of the Z-Lab development system for sixteen users, new peripheral devices, Z8003 and 8004 c.p.us, a cross-assembler for Intel dev. systems and a new 4K by 8-bit quasi-static r.a.m. Copies can be had from Zilog (UK) Ltd, Babbage House, King Street, Maidenhead, Berks. SL6 1DU. WW413

A vast range of test and measuring instruments is fully described in the 1981/82 catalogue of instruments from Electroplan Ltd, PO Box 19, Orchard Road, Royston, Herts. SG8 5HH.

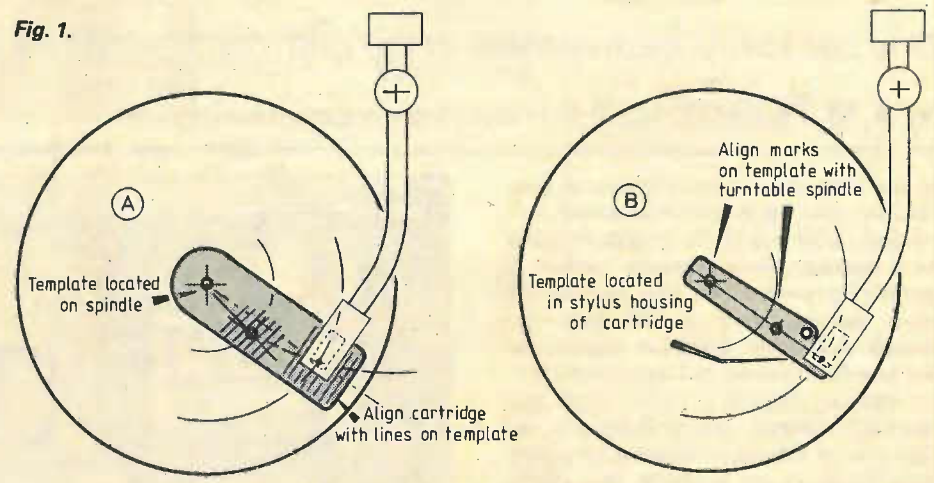
Cartridge alignment gauge

Simple device offers accuracy with convenience

by R. J. Gilson, M.I.Mech.E.

As anyone who has attempted to position a pick-up cartridge accurately on a headshell will realise, the so-called "protractor" method customarily recommended is not by any means as positive in use as its advocates claim. There are two major difficulties; first, the fact that the cartridge is usually well hidden under the headshell; and second, the fact that zero angle at the two protractor radii cannot be achieved unless the overhang is correct. It seems not to be generally realised that the stipulation of zero angle error at any two radii on the record necessitates a specific overhang value. The relationship between these factors was given in "The Cartridge Alignment Problem" in *Wireless World*, October 1981 (see later): $h=\sqrt{C^2+Rr}-C$, where h is the overhang, C is the centre distance from the arm pivot to the turntable axis and R and r are the radii for zero angle-error. In practice it is not easy to measure the overhang with any accuracy, nor is it easy to line up the cartridge with the guide lines marked on the protractor. Many cartridges are only about 12 mm or so long, and an error of 1 mm in this length could easily occur, giving an angular error of some 5°.

Fig. 1.

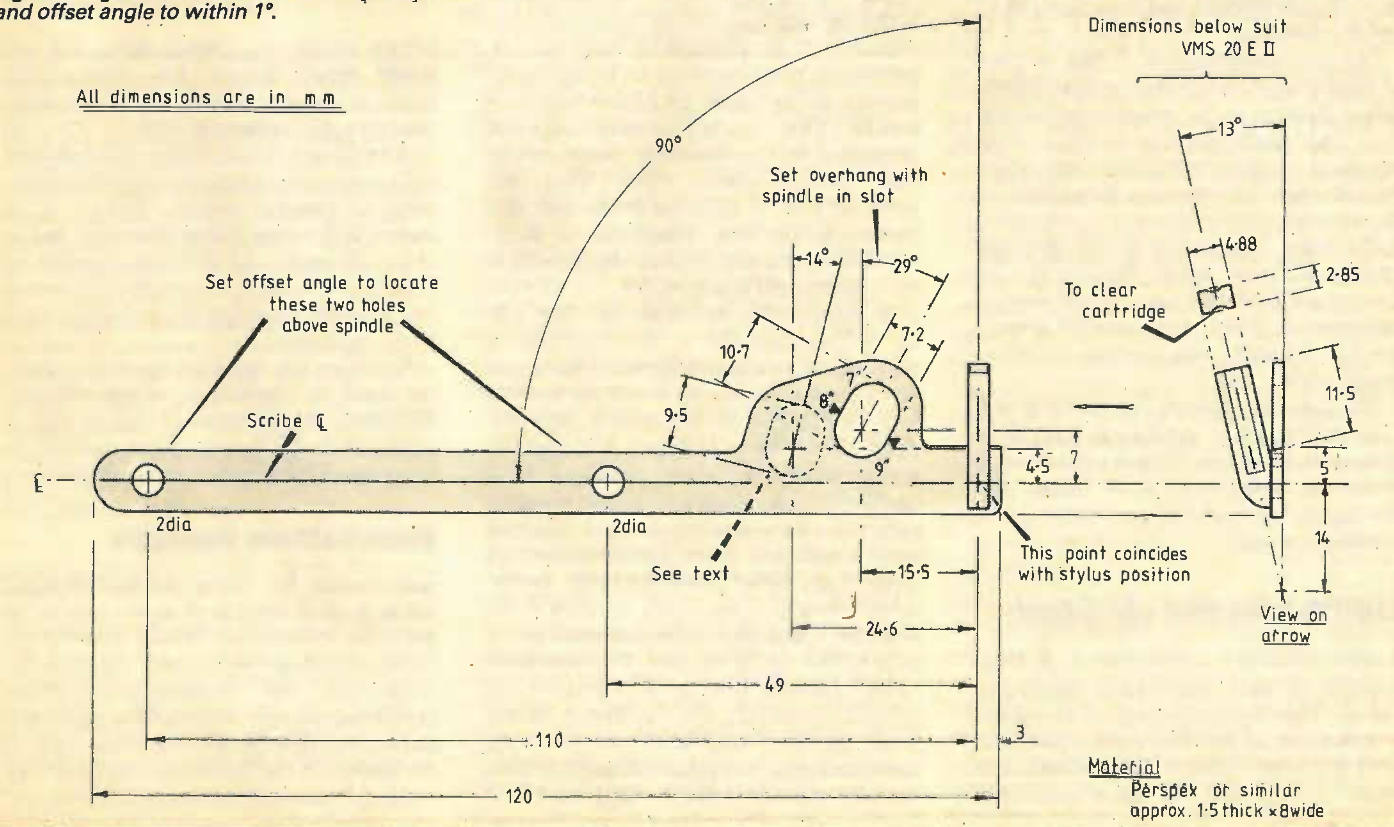


Both these problems are avoided with this improved setting gauge. Figure 1 shows at A the customary "protractor" method, and at B the new method, in which the replaceable stylus unit is removed from the cartridge body, and the setting gauge inserted in its place. Fig. 2 gives the detailed design of a gauge suitable for the VMS 20 EII cartridge. For other cartridges the tongue portion which engages with the cartridge body would, of course, be modified to suit. The essential features are that the tongue is a snug fit in the cartridge without lateral play, and that it lies at exactly 90° to the setting line running along the horizontal limb; it is necessary also that this setting line passes through the stylus point position.

The overhang is first set by aligning the turntable spindle with the slot near the cartridge which is elongated to accommodate a range of arm lengths of around 7-9 in. The correct end to use is indicated by the 7 and 9 figures marked near the slot. Intermediate figures can of course be judged, bearing in mind that the half-way figure of 8 will be a little nearer the 9 end, as suggested by the marks on the slot edges. Ideally, the overhang-setting slot should be located in line with the cartridge axis, but this would make it too inaccessible, and the position shown is more convenient. For those arms which have insufficient inwards movement for the slot to reach the turntable spindle, an alternative slot position is indicated in dotted lines, but the nearer position is preferable.

continued on page 80

Fig. 2. Gauge reduces error of cartridge position and offset angle to within 1°.



Subscription television experimental station

One company's equipment in the pilot cable schemes just starting

by A. M. Peverett, M.I.E.E., Rediffusion Engineering Ltd

In the early 'sixties Rediffusion, in conjunction with the Rank Organisation, developed a coin box pay-tv system designed for a payment-per-programme service. A monitoring system was also included to assess the popularity of each item. Although this cable television experiment was scheduled to start in Leicester in 1965, for various reasons it never went into operation. Indeed, British Relay was the only one of several companies preparing experiments to put a system into public service, successfully operating one programme in London and Sheffield for a year or so. The experiment was ended when the then government refused permission for it to be expanded to an economic size.

Rediffusion is now making a contribution to the new pilot cable subscription television schemes in the UK, this company being one of several licensed to take part in the experiment. Called Starview, this service will operate in Burnley, Pontypridd, Tunbridge Wells, Reading and parts of Hull, showing recent films – that is, about a year old – well before they appear on broadcast television. About fifteen movies are to be shown in any one month, in a schedule comprising two transmissions each evening with a late night film on Fridays and Saturdays, and a Sunday matinee.

The first screening is at 7.00 p.m., and no films with X certificates are transmitted before 10.00 p.m. by government regulation. This basic schedule is likely to be expanded as the experiment gets under way. During the morning and afternoon the networks will become a "community notice board" which may include messages from the Citizens' Advice Bureau, the Job Centre, the Samaritans etc., some form of Exchange & Mart, and possibly even a weather forecast, accompanied by background music.

The economic charge for the channel is £12 a month, but in some areas this will be reduced to £8 or £10. This is in addition to the normal cable service input charge. The movies can be viewed as many times as the subscriber wishes.

Experimental pilot equipment

A typical Starview control room (at Hull) is shown in Fig. 1 and its block diagram in Fig. 2. The bay on the left of the photo houses most of the electronic equipment apart from the standby video cassette recorder (v.c.r.) and the items associated

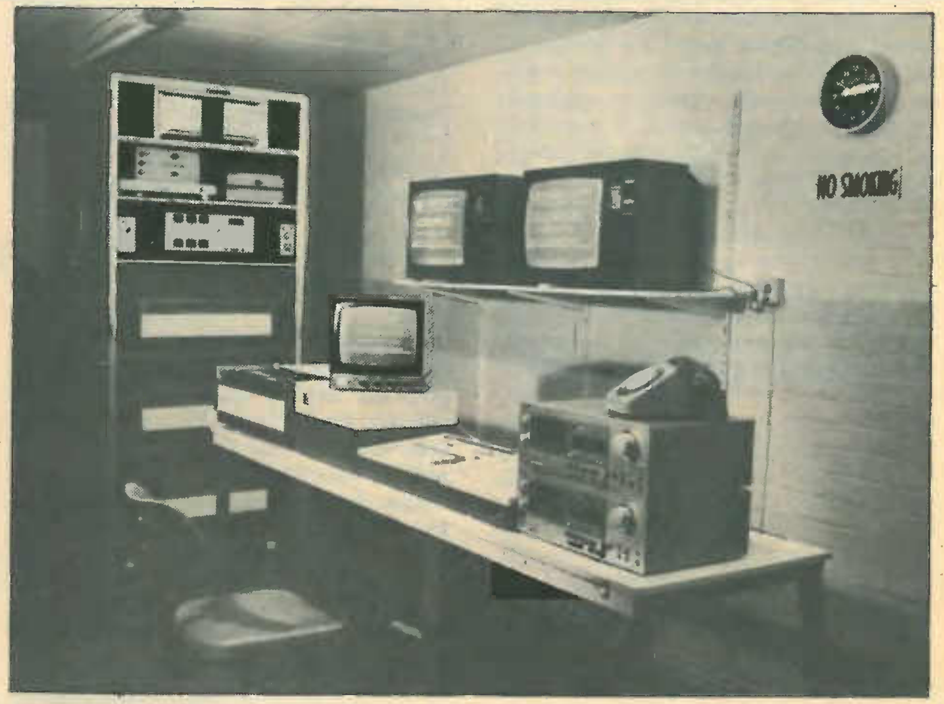


Fig. 1 Control room of the station at Hull. The major part of the electronic equipment is in the bay on the left, but the stand-by v.c.r. is on the desk.

with the caption generator, which can be seen on the desk.

Three editing U-Matic v.c.rs are housed at the bottom of the bay. The maximum U-Matic cassette playing time currently available is 80 minutes so that movies, previously transferred on to U-Matic cassettes, can be made to run for up to 4 hours. The v.c.rs are automatically controlled by a programmer, which can be seen directly above them. This also switches over to captions at the end of a movie or in the event of a v.c.r. breakdown. (A much fuller description of the programmer is given later.)

As Rediffusion networks also carry off-air tv programmes, it is important to minimize interference between them and the Starview system by ensuring that the last-mentioned is transmitted on an appropriate carrier frequency, and that synchronizing waveforms are to broadcast standards. For this reason a broadcast standard sync pulse generator is provided, together with a timebase corrector/encoder – all these items being above the programmer. After correction the signal is taken to an 8.9MHz vision modulator mounted in the rack at the top of the bay. The associated sound channel goes to a 2.9MHz f.m. sound modulator, also mounted in the rack, the two modulator outputs being combined prior to being transmitted down the network. As older Rediffusion tv receivers require an audio signal for the sound rather than an f.m. carrier, this must also be transmitted, a suitable audio amplifier also being provided.

A standby v.c.r. is also supplied, loaded with a duplicate tape, to deal with equipment or cassette failure. This v.c.r. is locked to the sync pulse generator, but in order to bypass as much equipment as possible its output is not routed through the timebase corrector but straight to the vision modulator.

Provision has also been made for a camera with an associated sound channel. However, the purpose of the service is primarily to show new films and not to compete with the broadcasting authorities.

Video cassette recorders

The reason for using editing U-Matic v.c.rs is that they have speed control of both the video drum (which contains the video scanning heads) and the capstan. This allows the scanning heads to be synchronized with the recorded signal and at the same time permits the video signal to be locked to the broadcast standard sync pulse generator. However, a timebase corrector is also required to adjust any frequency variations that occur between the tape drive system and the tape itself.

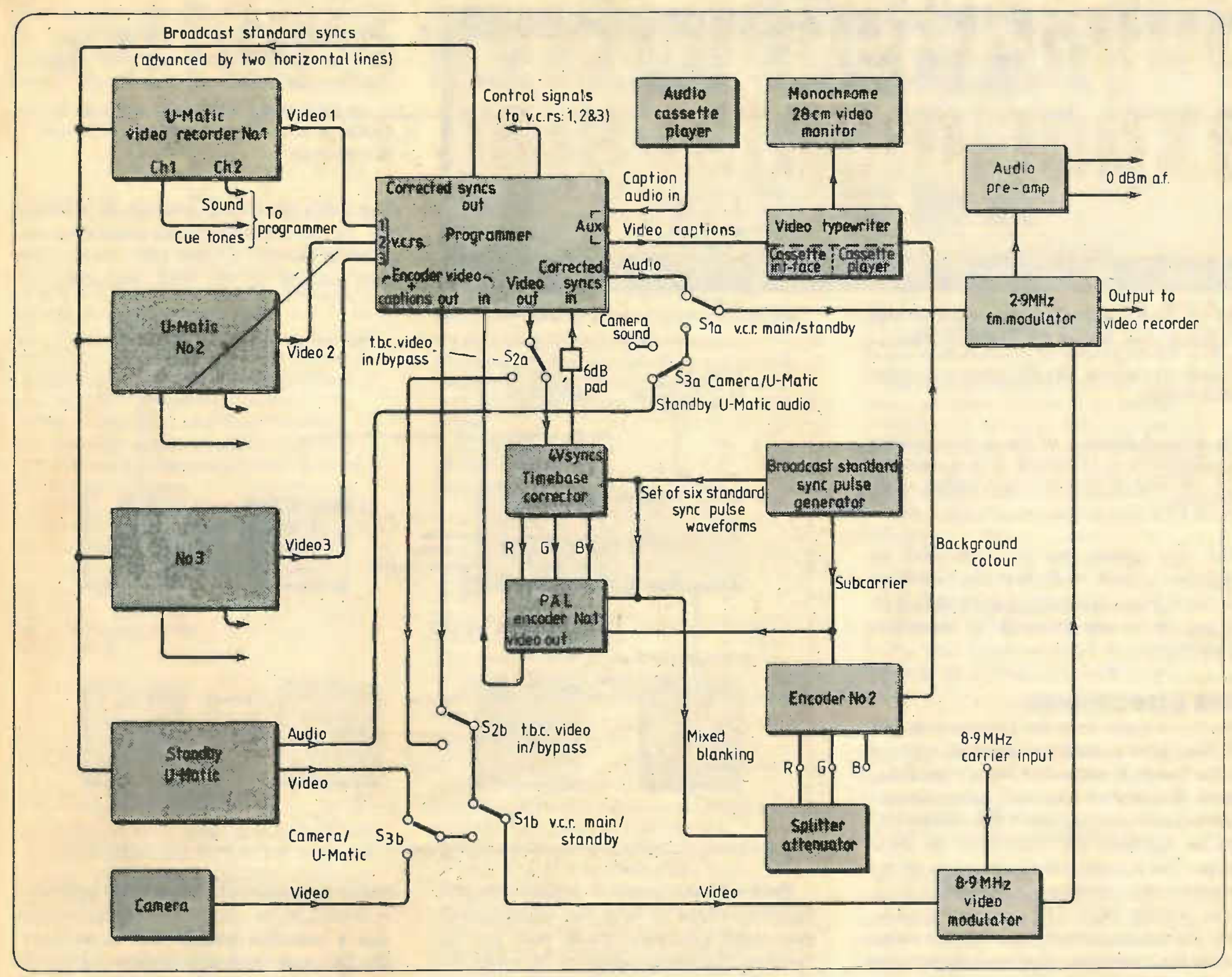


Fig. 2 Block diagram of the equipment shown in Fig. 1, with the U-Matic video recorders on the left. The three switches, S_1, S_2 and S_3 are coaxial types.

In order to feed the programmer with the correct v.c.r. start and changeover information, audio cue tones are recorded on channel 1 audio sound track of the video tape, channel 2 being used for the film sound track. The "start" tone consists of a 300Hz signal correctly positioned at the "start" point of each tape. The "changeover" or "finish" tone is a 450Hz signal, each one lasting for approximately 10 seconds. These tones "cue" the programmer, which in turn sends back the necessary "start", "stop" or "rewind" signals to the remote control sockets of the v.c.rs, as described below.

Programmer

The programmer serves four basic functions:

- To start the v.c.rs at pre-selected times.
- To change over from one v.c.r. sound and vision signal to the next (when more than one v.c.r. is in use), by means of cue tones.
- To stop the last v.c.r. at the end of the film programme and change back to captions. (It will also do this if the v.c.r video output disappears due to a fault.)
- To transmit a 6-minute tone at the end of the last programme warning viewers to switch off their tv sets. (This is in accordance with broadcast practice and will probably be accompanied by a suitably worded caption.)

Fig. 3 shows the programmer's front panel. The starting times for each programme are set up on thumbwheels, the programmes in use per day being controlled by switches below them – apart from the sixth thumbwheel which has no switch and controls the last (or only) programme, at the end of which the warning tone sounds.

To load the v.c.rs, the programmer "load" button is pressed, removing the automatic control of the programme which otherwise overrides the v.c.r. controls. The number of v.c.rs to be used for the first programme is now selected (e.g. "all v.c.rs") which puts them back to the automatic control of the programmer. It will first rewind the tapes and then play them forward until the 300Hz "start" tones are reached on each v.c.r., at which point they will stop. The status light next to the pushbuttons, which flashes during setting up, will now stay on permanently, indicating that the v.c.rs are ready to start the first programme. When that time comes the programmer will start up v.c.r. 1 and, after a few seconds, switch the video over from captions to the movie, continuing until the 450Hz "changeover" tone is reached, at which point v.c.r. 2 will start up. The changeover actually takes place a few seconds later when v.c.r. 2 has reached its correct running speed, so ensuring a smooth change. V.c.r. 1 will now rewind, setting itself back to its original starting point, as will v.c.rs 2 and 3 when they reach the cue tones on their cassettes.

When the movie has finished (and during loading and setting up) the programmer will automatically switch back to caption announcements. This will also happen if there is a v.c.r. failure, an apology caption having been pre-selected on the caption generator. However, just before the end of the last programme this caption would be changed to one announcing the end of the day's viewing, and possibly also advertising the next day's films.

If more than six programmes a day are required, it is possible to operate v.c.r. 1 manually be means of the manual button on the programmer. This allows a short item, such as a cartoon, to be shown between automatic programmes, although sufficient time must be allowed in the automatic schedule to fit it in.

In addition to these facilities, the programmer contains a sync pulse distribution amplifier, which feeds the broadcast stan-

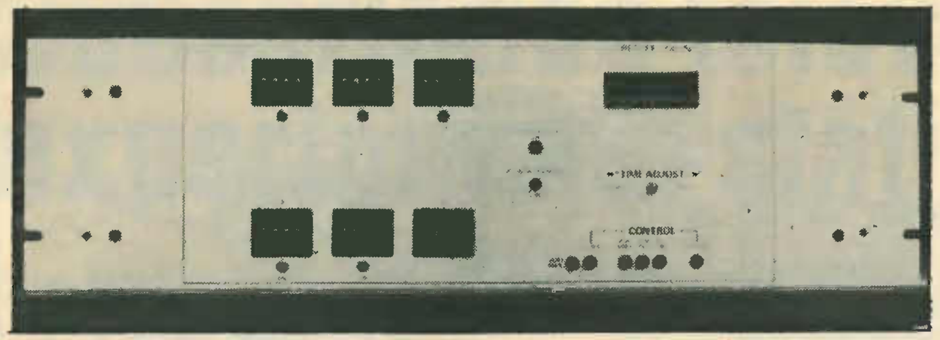
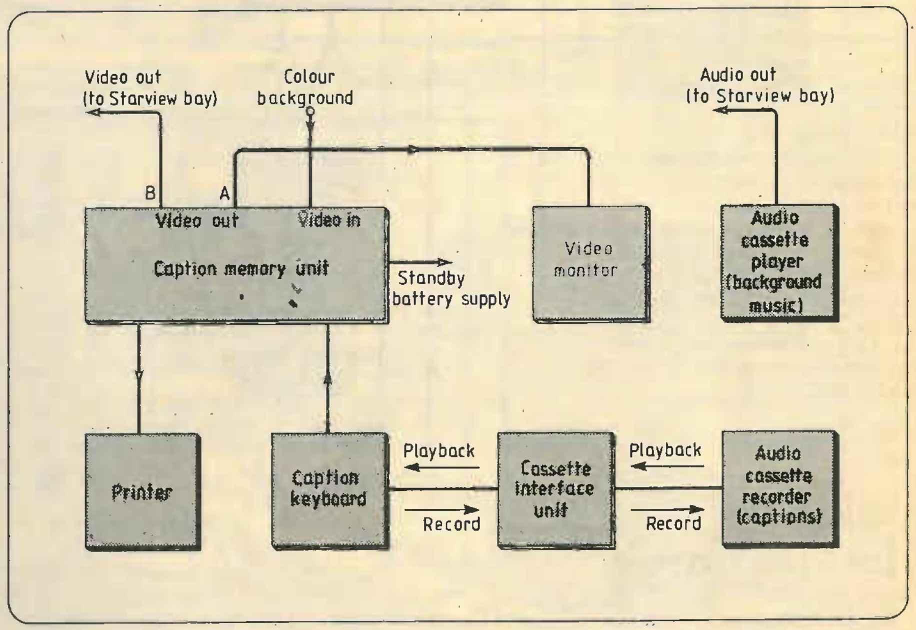


Fig. 3 Front panel of the programmer shown in Fig. 2. The six thumbwheels for setting starting times of programmes are in a bank on the left. On the right is a digital clock display.

Fig. 4 Block diagram of the caption generator, basically a keyboard and a memory unit capable of storing eight pages of information.



dard sync pulse to the v.c.rs, and an electronic circuit to bypass the timebase corrector when the caption generator is in use, as this is not required for non-v.c.r. equipment.

Time base corrector

The v.c.r. video from the programmer and the broadcast standard sync pulses both go to the timebase corrector, where the video signal is decoded into its luminance and chrominance components. Any timing difference between the video and the sync pulses, due to speed variations between the tape and the tape drive, is converted to an error voltage inside the unit and used to alter the value of the charge coupled variable delay lines until the two signals are synchronized. The unit is capable of dealing with errors of up to two horizontal lines.

As the output signal is in an RGB format, a PAL encoder is used to convert it back to its previous (PAL encoded) form. The decoding-recording process also reduces the chroma noise.

Emergency switching

The three (coaxial) switches shown in Fig. 2 perform the following emergency functions:

S1 changes from the main v.c.rs to the standby equipment in case of a v.c.r. (or cassette) breakdown.

S2 bypasses the timebase corrector, the encoder and the sync pulse generator in case any of these fail, all three being interdependent.

S3 switches between the standby v.c.r. and the camera, should the latter be used.

The audio signal selected by the programmer (or by switch S1A under standby conditions) is taken to the 2.9MHz f.m. sound modulator and them combined with the 8.9MHz vision signal prior to transmission down the network. As mentioned above, an audio signal is also transmitted for earlier Rediffusion cable receivers.

Standard 'off air' receivers are connected to the network via a frequency inverter which converts the h.f. vision and intercarrier sound signals to u.h.f.

Back-up battery power supplies are provided in order to keep the programmer, sync pulse generator crystal oven and the two modulators operating in the event of a power failure. This ensures that as soon as the mains supply returns (or a standby mains supply is switched in) the programme will continue from the point at which it stopped.

Caption generator

A block diagram of the caption generator equipment is shown in Fig. 4. The basic caption generator comprises a keyboard and a memory unit which is capable of storing eight pages of information, each of which can be previewed on the video monitor. However, by using a cassette memory interface together with an audio cassette recorder, it is possible to store approximately 150 different captions on a C90 cassette. In addition, by using a cassette recorder which has an auto reverse facility when it reaches the end of the cassette, with a total of five complete cycles, 10 hours' playing time can be achieved.

Each taped caption appears on the monitor as a "print-out", the page being completed in approximately 15 seconds. It is then held for a further 15 seconds or so before the next page begins. The caption will be accompanied by background music, utilizing an identical cassette recorder/player.

One of the eight pages of the basic memory unit has to be kept free for the taped captions, the remaining seven pages being used to store apology captions, forthcoming movie programmes, announcements, etc. In addition, any of these seven pages can easily be updated when required.

To maintain a permanent record of the captions actually transmitted, a printer is also provided.

Caption colour background. By feeding the mixed blanking signal from the sync pulse generator to the Red, Green and Blue sockets of the PAL encoder, two things are achieved: the caption generator is locked to the broadcast standard syncs; and a coloured background is obtained, the hue and saturation depending on the signal levels fed to the RGB sockets of the encoder.

In fact, orange has been found to be quite a restful colour when using white lettering, and is obtained by using the red and green inputs only, the splitter/attenuator unit controlling the exact colour and saturation. However, for purity reasons, orange is not always so desirable for a colour tv set!

Start of programmes

The new service has just begun (September 1981) and the experiments are scheduled to run for two years. The pilot schemes will enable all the participants to gain valuable first-hand experiences of and information on the future potential for this new service. A successful outcome to the experiments, coupled with government approval for full subscription tv services, would almost certainly lead to the introduction of subscription tv in other areas, although a full extended service would not necessarily use the same equipment configuration described above for the pilot schemes.

Finally, I would like to thank Les Brown, the assistant chief engineer of the Yorkshire region of Rediffusion, for use of his photograph of the Starview control room at Hull, and the directors of Rediffusion Engineering Ltd. for permission to publish this article.

Letters to the Editor

News on teletext

I was delighted to read about teletext in "Ariel's" September columns. I feel, however, I must point out one slight misconception about the lack of change in the news between early morning and midday.

As "Ariel" says, one of the prime advantages of Ceefax is the instant transmission of news as it is made. The essential point is that we are concerned with the transmission and not the making of news. If anyone shoots a prince, prime minister, pope, or president between early morning and lunchtime, then clearly we can report it.

On second thoughts, though, with computer systems becoming more complex and software more sophisticated, perhaps we should be getting into the news creation business.

Graham Clayton
Duty Editor, Ceefax
BBC Television Centre
London W12

Making ploughshares

I would like to congratulate Mr Adrien Belcourt for his letter in the August issue. I do not think I have ever heard a more eloquent, or a more elegant exposition of the 'double standard' argument anywhere before.

I confess that my own opinion is rather different, but perhaps that reflects my environment. For example, my son is one of those (the doctors say because of some accident at birth of unknown nature) classified as e.s.n. This means that he lives in a very much simplified world, with many of the inhibitions and taboos used by the rest of us diluted or absent. It is therefore sometimes possible to grasp his motivation without having to push aside the mass of curtains that most of us surround ourselves with.

A couple of years ago, he developed a fascination for toy guns. With other children, this could have been reaction against parents, but I am convinced that this was not. What seemed to be happening was that he was standing behind the toy gun, in order to obtain the extra boost for his personal status which he felt that otherwise he was lacking.

When it comes to making ploughshares, I might point out that at least some of us have had the guts to try. Those of us who have tried (and I have been involved in the founding of two companies, both of which are beginning to find their feet) will tell you that making military electronics is strictly for the boys of this world. Agricultural electronics, which I am more and more convinced must be classified as a discipline in its own right, has been described as mil. spec. equipment at automobile prices, and that makes it an order of magnitude more difficult. It also makes it one order of magnitude more satisfying in its achievement, and yet another because it is constructive.

Finally, I would like to ask why anyone thinks of things like Trident as anything other than an invitation to the military in Moscow, unless it is a lovely excuse to extend their own personal empires – especially as the CO_2 laser has clearly made such things irrelevant by the time they go into service. On the other hand, think what effect, say, satellite beamed tv channels carrying televised reports from the Western parliaments would have on the Poles for a start. We may think the Commons is corny, but the sight of genuine elected groups trying to come to terms with everyday problems, and being voted out by the mass of the people, would surely be more effective than the whole of the Western (or Eastern?) military might.

H. M. Butterworth
Whitchurch
Reading

Television subtitling

Your recent review of the IBA guidelines for subtitling television programmes (News, September) might give the impression that the BBC2 subtitling of the Royal Wedding is the norm for "the current art of subtitling".

We at Oracle and our colleagues at Ceefax would be very unhappy if this were so. Subtitling of recorded programmes using a teletext system provides a much more sophisticated version of subtitling than that which appeared for portions of the Royal Wedding on BBC2. The latter was utilising a phonetic system in an attempt to subtitle live events. At the same time Oracle was also subtitling live using normal English with a fast typist and front end software to ensure rapid formatting and insertion.

Any teletext owner can judge for himself the present state of the art by watching "Coronation Street" any Monday or Wednesday in conjunction with page 199 of Oracle.

Guy Rowston
Deputy Editor, Oracle
Independent Television
London SE1

Electrical and mechanical units

May I draw your attention to an erroneous statement in the article by Professor D. A. Bell in the July issue "Electrical and Mechanical Units – are they the same?" He states "**H** is the property of a current which is independent of the surrounding medium". From this and the following comments it is clear that Professor Bell is suggesting that there are two separate contributions to **B**: $\mu_0\mathbf{H}$ due to free currents and $\mu_0\mathbf{M}$ due to magnetisation of any materials. In fact **H** in general consists of two components: one due to the free currents, and the other arising from any magnetized body in the vicinity. One need only consider the case of a permanent magnet to realize that an **H** field can exist even though there are no free currents in the region.

If one wishes to separate the **B** field into the component arising from free currents, and other components arising from any magnetization which occurs, then the equation $\mathbf{B} = \mu_0(\mathbf{H} + \mathbf{M})$ must be rewritten in the form

$$\mathbf{B} = \mu_0(\mathbf{H}_0 + \mathbf{M})$$

where $\mathbf{H} = \mathbf{H}_0 + \mathbf{H}_m$. It is $\mathbf{H}_0$ which describes the spatial distribution of the free currents, not **H**. $\mathbf{H}_m$ arises from any magnetized bodies that may be in the vicinity, and is usually referred to as the demagnetizing field. Only in the case of a uniformly wound toroid does $\mathbf{H}_m = 0$, and $\mathbf{H}_0 = \mathbf{H}$.

The fallacious statement that **H** depends only on the spatial distribution of the applied currents, with the implication that **H** can be calculated from the free current only, seems to be widely believed. The misunderstanding seems to arise from the facts that in the equation $\nabla \times \mathbf{H} = \mathbf{J}$ the $\mathbf{H}_m$ component of **H** has zero curl, i.e.

$$\nabla \times \mathbf{H} = \nabla \times (\mathbf{H}_0 + \mathbf{H}_m) = \mathbf{J};$$
but $\nabla \times \mathbf{H}_m = 0$, so that $\nabla \times \mathbf{H} = \nabla \times \mathbf{H}_0$.

Since the $\mathbf{H}_0$ component is solenoidal everywhere, $\nabla . \mathbf{H}_0 = 0$. However, in general $\nabla . \mathbf{H}_m$ is not zero everywhere, hence $\nabla . \mathbf{H} = 0$. Similar remarks apply to the **D** vector:

$$\nabla . \mathbf{D} = \rho,$$

where $\mathbf{D} = \mathbf{D}_0 + \mathbf{D}_p$ and $\nabla . \mathbf{D}_p = 0$ but $\nabla \times \mathbf{D}_p \neq 0$, and therefore $\nabla \times \mathbf{D} \neq 0$.

W. James
Department of Physics
University of Aston in Birmingham

The author replies:

I don't agree with the analysis proposed by W. James, but let us start with what I take to be agreed propositions: (1) Curl H equals J. (2) Complete specification of any vector, such as H, requires a statement of both its curl and its divergence.

The distinction between "free" currents and magnetization effects is surely spurious, since current belief in physics is that magnetic effects in materials are due to currents in the form of orbital motion of electrons (diamagnetism) or electron spin (paramagnetism, ferromagnetism, antiferromagnetism). Given this, I do not see how magnetization of materials can produce a divergence of H any more than "free" currents can. Moreover the existence of a divergence would imply the existence of a "magnetic charge" which I can only interpret as a free magnetic pole. This follows from the relation div X = ρ where X is any vector and ρ a corresponding charge density. This is commonly applied in electrostatics, where free charge is obviously available, but it is a mathematical theorem which is independent of the physical nature of the quantities involved, provided only that ρ is the density of some "charge" which acts as a "source" of X. I therefore maintain that div H ≡ 0 and that curl H = J is a sufficient definition of H.

D. A. Bell

Multipath distortion

I have read the correspondence concerning multipath distortion with avid interest, having been involved in the design of f.m. car radios for many years.

When I joined a particular company I was asked to investigate complaints of noise and distortion on an f.m. car radio which was currently in production. These complaints originated in the Johannesburg/Pretoria area, and since the terrain is hilly and there are many tall buildings the possibilities for multipath distortion were seemingly endless.

An investigation of the problem was started on my part with a preconceived idea that the problem was indeed a multipath distortion problem aggravated by the horizontal polarization/vertical car aerial combination, and that little would be able to be done on my part to effect any improvement. A car was fitted with various car radios available at the time and a switching console was used to switch the aerial, speaker and power supply to each radio such that a comparison could be made.

The trouble was evident in various locations, apparently as a fluttering signal combined with sharp increases in distortion and noise as the vehicle was in motion. The relative performance of the sets was difficult to quantify because of the transient nature of the distortion and driving over the same stretch of road evinced different degrees of the effect on the same car radio. All the radios tested showed some degree of the effect. Surprisingly, though, some showed that they were less susceptible than others. At first differences in sensitivity and a.m. suppression were suspected, though no correlation could be determined when these parameters were checked on the bench.

I then realized that Pretoria and Johannesburg had about six strong transmissions each and, being in close proximity, the areas of transmissions overlap. Therefore in many areas between the two cities twelve stations of reasonable strength could be received across the 88 to 108MHz band.

The possibility of intermodulation products of some of the transmissions falling on other stations was therefore investigated and, surprisingly, on all stations it was possible to receive intermodulation products of perhaps two or three other pairs of transmissions (frequency planners please note).

I then set about modifying the front end of our set. Firstly, looking at the r.f. stage output with a spectrum analyser and feeding in two 100mV signals, the intermodulation products could clearly be seen at about 45dB down on the incoming signals. I changed the r.f. transistor to a BF324 and increased the current in the stage from about 1.5mA to 5mA. The intermodulation products fell to 70dB down.

The listening tests were repeated with disappointing results.

The circuit configuration of the tuner was implemented with a permeability tuner having one tuned circuit prior to the r.f. stage and one tuned circuit in the collector circuit, each with a unloaded Q of 70. However, when a swept measurement of the r.f. stage was made it was found that the effective total Q of the r.f. stage was 7! As far as could be determined this was due to feedback effects around the r.f. stage and spurious coupling between the rather close and large coils in the permeability tuner. The mixer stage was therefore receiving high level unwanted signals. The circuit was again modified to a broad band input to the r.f. stage (which now had good dynamic range) and the two available tuned circuits were inserted as a critically coupled bandpass pair between the r.f. stage and the mixer.

The listening test was repeated and the results were a revelation. The newly modified receiver out-performed all the others to a remarkable degree. No distortion effects were discerned and the signal remained clear from the centre of town to the fringe areas.

A reliable test for cross modulation is to feed in two signal generators via a splitter. Firstly tune one signal generator to 98MHz, 25kHz deviation and adjust to −3dB limiting level. Note the a.f. output level of the set, leaving it tuned to 98MHz, tune the signal generator to 100MHz modulated to 12.5kHz deviation and set the second signal generator to 102MHz unmodulated. (Modulating the 100MHz signal with 12.5kHz deviation results in 25kHz deviation at the intermodulation product.) Increase the level of the two signal generators in unison until the previous level of a.f. is restored. The difference in level between the 98MHz limiting sensitively and the level of one of the signal generators can be taken as the intermodulation ratio at that input level.

In conclusion one wonders if multipath distortion is such a serious problem, and is not cross modulation often mistaken for multipath distortion, for it is very difficult to make meaningful measurements of these effects in the field. I certainly have gained the impression that true multipath distortion is not encountered nearly so often as would be expected and that a car radio with a vertically polarized aerial on a horizontally polarized f.m. environment can perform satisfactorily if care is taken with the design.

J. D. K. West
Montclair
South Africa

Callsign coyness

Over the past year or so I have observed in the technical press, including your own magazine, articles written by radio amateurs, often professional engineers, relating to the subject of citizens' band. The authors of these articles, on receiver converters, frequency synthesis systems etc. invariably do not give their allocated callsigns.

Is this, I wonder, because they do not wish their fellow amateurs to know that they have some technical or financial interest in c.b., or is it that they do not wish the c.b. fraternity to know that they are licensed radio amateurs? At this point I should say that I have no particular axe to grind relating to c.b. I am just curious to find out why these people are apparently so reluctant to divulge their callsigns on these articles, but not on others.

A. E. Green, G8NRB
Dunstable
Beds

Training medical technicians

I read the news item "Medical technicians get a new deal" in your May issue with grave concern. There are already in existence for MPPM technicians, the majority of whom are employed in the NHS, nationally recognised examinations. These are O TEC and HNC/TEC, which are recognised as established links in the gradings and career structure of the technicians concerned.

I fear that there are many pitfalls not apparent to your reporter: not only does it require many hours of hard work to establish an examination, but once the qualification is gained this must be acceptable to the employer. I would suggest that it should first be established whether the employer, in this case the NHS, requires further examinations.

For a number of years the Federated Associations of Medical Technology have been working in close liaison with the Technician Education Council and the DHSS for a Diploma Course at O TEC level and this is now in the final stage of preparation. Technicians are also represented in discussion with TEC at HNC/TEC through the Federated Associations of Medical Technology.

As to the statement "The Interest Group hopes to keep open good channels of communication with other institutes and bodies relevant to the MPPMs" — as far as I am aware as Secretary of the Federated Associations of Medical Technology and Executive Member of the Association of Respiratory Technicians and Physiologists, no approach has been made to either organisation with reference to the education requirements of the technicians they represent.

S. E. Gough
Federated Associations of Medical Technology
Papworth Hospital
Cambridge

Concepts in physics

Although I work in the field of electronics, I am by both training and inclination a physicist, and it is in this field that I have earned my living for the past thirty years. It is in this context, therefore, that I have watched with growing dismay and dissatisfaction the trend of theoretical and academic physics towards progressively more weird and seemingly irrational concepts.

As a physicist, one could look back with an amused tolerance at the absurd notions of phlogiston and caloric and essential spirits having negative weight, summoned up by our brothers in the field of chemistry at the end of the eighteenth century, in their struggles to explain the phenomena of combustive oxidation. However, there is a growing feeling among physicists that we, ourselves, may be climbing up an equally absurd gum tree in our attempts to reconcile ourselves to the apparent constancy of the speed of light.

Unfortunately, one of the consequences of the acceptance by the academic establishment in the early 1920s of the general concepts expressed by Einstein in his special and general theories of relatively, has been that there is an effective academic censorship of any ideas which have tended to cast doubt on the validity of these theories.

This censorship has been effective throughout my own professional career, and its effect has been such that any public expression of doubts on the Fitzgerald-Lorentz-Poincaré-Einstein sequence of theories has resulted in a minor avalanche of privately published papers, from authors who have found no way of expressing their views apart from this.

I have therefore noted with very great approval the opportunity provided by *Wireless World*, as a respected journal on the fringes of physics, to authors such as Essen[1], Catt[2], Dingle[3] and Wellard[4,5], and your other contributors Aspden[6], Francksen[7], Diamond[8], Theocharis[9,10], and Morris[11], to express alternative views which would certainly not have been permitted publication in any of those journals more specifically dedicated to theoretical physics.

In particular, I think that the stress laid upon the conservation of energy, by Wellard[5], is one which should be taken seriously, along with the implications of Maxwell's equations, as discussed by him — chief among which is the need for some medium in which electromagnetic waves may be propagated. Even Einstein, who was not noted for doffing his cap to his predecessors, in his own book admitted that the concept of a completely empty

space was incomprehensible to him.

If, therefore, we assume that there *is* some medium for e.m. propagation, and that, in order to satisfy the findings of the Michelson-Morley experiment it was, at least locally, geocentric, it would seem strange that we had not observed it.

Any good detective story writer would allow his readers to discover, in due course, that the thing for which they sought had been under their noses all the time, but that they had not recognised it for what it was. May I suggest that this function can be filled, in the case of e.m. propagation, by the gravitational field within which we all must work. Surely it is too weak to carry any but the most feeble modulation as a symmetrical excursion in its value, but perhaps it is capable of being modulated, upwards, in an unsymmetrical manner.

This would account for the otherwise inexplicable duality of continuous wave vs. photon propagation, would give the results found by Michelson and Morley, as well as that found by Fizeau, which people now conveniently ignore. Moreover, it would satisfy the requirement for the conservation of energy, since e.m. radiation could not go where it would be lost.

If I may attempt a similar debunking of the concept of 'black holes', to that offered by Morris[11] in the case of the twins paradox, I would argue that if a 'black hole' can form at all, the conditions necessary for it most certainly existed at the centre of the universe at the time of the 'big bang', in which case we are all inside one right now.

Incidentally, if anyone, not a physicist, would like to read a lucid and analytical account of the revolution of the relativity theories, I would recommend that by Cullwick in the *Journal of the IEE* (March 1979, pp. 172-178).

J. L. Linsley Hood
Taunton
Somerset

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2. Catt, I. March 1980, pp. 77-78.
3. Dingle, H. Oct. 1980, pp. 54-56.
4. Wellard, M. G. March 1981, pp. 83-86.
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6. Aspden, H. July 1981, p.51.
7. Francksen, C. B. July 1981, p.51.
8. Diamond, R. J. June 1979, p.81.
9. Theocharis, T. Oct. 1979, p.72.
10. idem May. 1981, p.58.
11. Morris, W. T. Nov. 1979, p.79.

Amateur radio licences

Pat Hawker (World of Amateur Radio, September) makes a valid comment on the lack of activity on the 28MHz band and the danger of intrusion by other users. However, I find it difficult to understand how class B licencees are making it difficult for class A licencees to use 28MHz for mobile and local working. Surely, the opposite question should be posed; why not allow class B licencees onto the 10 metre band? The answer is usually given as 'international agreements' i.e. WARC, which require that operators on frequencies below 100MHz (30MHz from 1.1.82) must pass a statutory Morse test. The test standard is set by the individual country. In the case of the UK the requirement is 12 words per minute, transmitted and received, with no uncorrected errors. The cost of the test is high (£12) and if one lives some distance from the very few available test centres the cost per attempt can easily exceed £25. How do other countries interpret these regulations? In Spain, no Morse test. In the USSR and W. Germany, no test for 10 metres. In the USA, incentive licensing, starting at 5 w.p.m., with more power and frequencies available to more qualified people; but Morse tests are receiving, 'comprehension' tests only — far easier than a full, transmit and receive, no-errors test.

A large pool of active and experienced radio amateurs is therefore readily available to take up the 10 metre band; surely a more desirable solution than the complete loss of a valuable and interesting part of the spectrum to other users. If operation just below 28MHz is to be allowed on production of a licence fee to c.b.ers, why not the use of 28MHz-29.7MHz to qualified radio amateurs, who are unable or unwilling to learn Morse?

Taking this discussion a stage further, why not a fully integrated incentive licensing scheme for the UK? In recent years the Radio Amateurs Examination has been criticised for the easiness of questions; it has even been suggested that random chance may be quite an effective response solution technique. Why not introduce levels of difficulty, with at least the lower levels administered voluntarily by qualified amateurs, on the lines of the US incentive licensing scheme?

As another refinement, award 'points' for technical exam passes interchangeably with Morse test difficulty levels, thus affording two parallel, but linked, routes to class A type licences. A secondary, but important, advantage of this scheme would be a very significant improvement in the technical knowledge of the 'average amateur', i.e. a fulfilment of the self-training clause of the licensing conditions.

Peter H. Saul, G8EUX
Towcester
Northants

The death of electric current

Mr Catt attempts to argue in his reply to my letter in the August issue that the conventional theory of the electron current cannot cope with transient conditions, to which I cannot agree. He instances a voltage-current step advancing along a transmission line at the velocity of light. This fact, however, does not in the least require that the drift velocity of the electrons needs to be equal to the velocity of light as Mr Catt argues for in his para. 3. Indeed, as Mr Catt agrees, and as we can calculate quite simply, the drift velocity of the electrons along a conductor, is very slow indeed (in fact, of the order of 9mm/s for a 10-ampere current in a copper wire of 1mm diameter).

The point is, surely, that a conducting wire contains a very large number of free electrons (e.g. for copper, 8.5×10^{28}/cu. metre) physically close to each other from end to end. Hence, firstly the electrons transmitting the wavefront do not have to come from anywhere, since they are already present everywhere along the wires. Secondly, a voltage-current step can therefore be transmitted at a very much higher velocity than the electron drift velocity (in fact, at the velocity of light for the dielectric) for the reason that each individual electron needs only to move quite slowly for a very short distance, in order that the voltage-current step can be transmitted very rapidly over a much larger distance. A cause travelling much slower than the speed of light thus creates an effect travelling at the speed of light.

A simple analogy often given in explanation is that of the transmission of a forward movement along a line of trucks, each in contact with the next, along a railway line. If a push is applied, each truck moves quite slowly and only a short distance, but the 'step' of movement, or push, is very rapidly transmitted from one end of the line to the other.

I am therefore still somewhat at a loss to understand what discovery Mr Catt has made, or what experiments support his ideas; I continue to find the 'billiard-ball electron' a valid and useful concept in dealing with everyday electronics or telecommunications, and I would even suggest that the refined theory of the standing wave electron is of little use, and therefore meaning, in solving normal electronic problems. Even in waveguide transmission, the movement of electrons needs to be invoked, e.g. to explain the attenuation of the voltage vector of a TEM wave in a padding attenuator.

Peter G. M. Dawe
Botley
Oxford

Frequency hopping radio

I read with interest in your July issue of the Racal frequency hopping transceiver and the claim that this is the first such radio in production.

The attached data sheet shows that the Securecom SC-16, which has been available for some twelve months or more from my company, utilises the same technique of operation.

T. B. Stockton
Stockton Partners
Grimsby
South Humberside

Mr Stockton also provided the following description: "The Securecom SC-16 is a frequency hopping v.h.f. radio operating in the 145-165MHz band. A frequency synthesised transceiver, in the 'secure' mode the SC-16 hops through 16 user programmable frequency channels from a total 24 channels capability. In the 'clear' mode the SC-16 utilises its 24 channels in a normal manner. Tactical level security with a 50 billion plus codes capability, user changeable frequencies and code sequences for companion or group working allow total flexibility. Selective calling, 128 channel with interchangeable linear or pseudo random series modules, voice, fax, data or phone applications are available options. R.f. outputs of 50-100 watts are available." — Ed.

Engineering education

There is one point which your recent correspondence on engineering education has not encompassed. Until about ten years ago a considerable portion of "professional" engineers was recruited, not from university graduates, but from apprentices taken on as school leavers and trained at night-school and on day release. The less able apprentices developed to be (technician) engineers in production, test, installation, etc; the more able took the positions of junior engineers in design/development, with similar prospects of promotion to the graduates recruited to fill "professional engineer" positions at a similar age.

For reasons which should be obvious (a partial list is given below*) the ex-apprentices were of more value in the design laboratories

than the graduates; and it is perhaps unfortunate that the increased availability of university education and the decision of the learned societies to restrict membership to graduates has deprived us of this source of engineers.
D. Noble
Canvey Island
Essex

* Familiarity with company procedures.
Familiarity with technical concepts peculiar to the company's area of interest. (Example: how many graduates can explain dB, dBm, dBm0, dBm0p?)
Familiarity with circuit techniques and components common to company's product range. (Example: graduates who do not know what a quasi-complementary class-B output stage is: who confuse "protected" and "buffered" in c.m.o.s. terminology despite having used c.m.o.s. in a university project.)
Experience in trouble-shooting. (Example: how often have we seen graduates sitting in front of a 1 transistor audio amplifier, input turned up to 10 V r.m.s., oscilloscope on output set to 20 mV/cm a.c. "I really can't see what's wrong with it!")
The properly paranoid attitude required for "design for production".

Comment from Prof. D. A. Bell
The bright graduate will very quickly pick up the technical concepts peculiar to his employer's area of interest, if he is not already familiar with them. The problem is with the not-so-bright graduate and the question is whether he would have been more use as a not-so-bright apprentice. This raises three questions, all of which are very wide:
1. What should be the criteria for admission to a university course?
2. Can, should and do universities provide vocational training for technician engineers?
3. Is the value of a university course limited to its vocational content?

But in any case I do not think Mr Noble's complaints apply to *all* university graduates: much depends on the individual and the university from which he or she graduated.
D. A. Bell

NiCad batteries

Further to articles you have published on recharging/reactivating dry batteries and also NiCad rechargeables, the increases in battery prices have been exacerbated by the wider range of goods requiring them and also by stereo cassette portable radios of up to 30W output. (Nobody seems to know whether their 1/3-cubic-foot speaker enclosures are adequate for "a good sound" or whether we should all be building 15-foot horns, but I want to short-circuit that topic by suggesting that fundamental in the low bass region is a rare phenomenon.)

I want to make two suggestions about the desirable state where we all end up running a variety of stuff from NiCads. One is that we can pay for a few interchangeable NiCad packs by running an electric razor off them and thus avoiding the expense of a shaver point in the bathroom. (I note in passing that older houses may well have washbasins in bedrooms with wall sockets adjacent which it would now be illegal to fit since they expose the user of a defective shaver to electrocution through the the availability of a wet earth connection in the basin.) And the other is that manufacturers should facilitate swapping clip-on battery packs between different devices.

The risk of explosion is also threatened with rapid charging of NiCads and I heard of one person wrecking a large radio-controlled car with the heating effect of rapid charging, probably carried past the end point. However, this means of charging in 20 minutes from flat condition is obviously here to stay at model rallies and I merely suggest that cells should not be boxed in and also relay a rumour that new cells should be cycled twice before rapid charging is carried out.

NiCad packs accidentally shorted can make the shorting wire very hot indeed and hence constitute a fire risk, and I suggest interchangeable packs or battery boxes should be developed with contacts below the pack surface, as for instance in the socket used on cassettes etc. for 6V power input; thus eliminating the fire risk. Finally it is hard at the moment to get chargers for 2 or 3 small cells and I hope large, versatile chargers will be produced.
Bernard Jones
London

Gag on authors

I think I can help Mixer. In the August issue he wondered why *Wireless World* does not get more contributions from Russia. Part of the answer may lie in the following extract from a book by John Barron:

"Science is controlled more closely than religion (in Russia). The party needs and fears scientists. It must allow them to engage in objective scientific enquiry if the nation is to progress, yet it dare not let them apply scientific enquiry to political, economic, and social subjects. It must grant access to Western research data while shielding them from Western ideas. It must grant enough freedom and status and incentive to do creative work but not enough to cause them to speak out publicly, as Sakharov has done. The KGB regulates this dilemma."

("KGB", 1974, p.102.)
S. Frost
Edinburgh

Electronic organ sound

Mr F. E. Norrington asks in May Letters why so many electronic organ stops sound unrealistic in spite of the presence of many of the upper harmonics in the sawtooth waveform applied to the stop filters. One important factor in this matter must be the presence of out-of-tune harmonics in the output of a large number of styles of organ pipe as mentioned in "The Organ" by W. L. Sumner (Macdonald and Jane's, London, 1973) and in "Dictionary of Pipe Organ Stops" by Stevens Irwin (Schirmer Books, New York, 1965). Specifically, many of the flue pipes are tuned by rolling down strips of metal between cuts at the top of the pipe and many reed pipes are regulated in a similar manner (although with reeds the main tuning is performed by adjusting the reed). The effect of such slots is to make the pipe appear to be a different length to different frequencies, which will cause the harmonics to be out of tune (sharper in this case) relative to the fundamental. In fact certain of the string stops have a slot cut at the top quite deliberately, apart from any tuning function, in order to give a distinctive sound by this means. In addition narrow pipes, as used in string-toned stops, will produce out-of-tune harmonics even if they are completely cylindrical, due to effects involving the viscosity of air.

The effect of such harmonics is to form beats between themselves and the fundamental, giving the resultant sound a subtlety and life which is hard to imitate electronically. Additional effects must also contribute, including the addition of noise of various kinds.

The brilliant effect of a full chorus on the pipe organ arises from the slight clashing of pipes which are inevitably slightly out of tune, in addition to any effect of the harmonics of individual pipes. This is termed the "chorus effect".

Most electronic organs use the expedient method of forming sawtooth waves and using some form of octave division to generate the entire range of octaves needed. This prevents the occurrence of chorus effects as all the unisons of a note are generated together and any octaves are phase locked to this. In addition, many electronic organs generate the mutation stops (sounding intervals such as fifths with the unison) by taking them from the appropriate generator (e.g. using the G generator to produce a fifth with C). This sounds wrong because the intervals of the scale are tempered whereas mutations on the pipe organ are tuned to true intervals.

The lack of chorus effect with many designs of electronic organ can be improved if more oscillators are used in generating the tones, and particularly if mutations are generated by their own oscillators. Imitation of the out-of-tune harmonics is more difficult but may be produced by some form of frequency shifting or ring-modulation of the tone. This has the difficulty that different stops may require different degrees of modification in this way, and there would also be changes necessary within a rank. It would be difficult to do this type of modification cheaply.

The difference between a sound which is merely harmonically rich and one which is "brassy" is the presence of some kind of resonance in the latter. The most effective imitations of pipe organ reeds that I have heard use some form of electronic resonator (inductive or gyrator) with a fairly high Q to produce a strong exaggeration of some part of the frequency spectrum. This is not the same as a harmonically rich sound such as a sawtooth where the intensity of harmonics decreases with increasing frequency from the fundamental.

I would also take issue over Mr Norrington's suggestion that an electronic organ need not imitate a pipe organ. This may well be true for pop organs with rhythm synthesizers and the like, but organs for the serious performer of the classical organ repertoire, or for ecclesiastical use, justify attempts to approach the sound of the pipe organ.
Peter Stockwell
Dunedin, New Zealand

The Nuvistor

The threat of damage to semiconductors by EMP (electromagnetic pulse) could stimulate a revival for valves, particularly in military equipment (News, September). I expected this when the Nuvistor was introduced by RCA. Whatever became of this device? The only equipment in which I have seen them is oscilloscopes. One would have thought television receiver designers could have made good use of Nuvistors.
K. J. Treeby
Plymouth

Circuit Ideas

Regulating l.e.d. outputs

Using a simple compensation circuit based on an opto-coupler, the power output of l.e.ds in series can be maintained to within ±5% of the value at 25deg. C over their full operating temperature range. Compensation is required to overcome the negative temperature coefficient of near-infrared l.e.ds which decreases the power output by 0.9% per deg. C increase. Fig. 1 maintains the output power by varying the forward current I_f through the l.e.d. string. The l.e.d. in the opto-coupler is used as a reference device and the collector-base photodiode is used as an output monitor. A CA3140 op-amp regulates I_f by maintaining a steady current through the sensor. In addition, the l.e.d. output power can be controlled by the potentiometer. The supply must provide adequate voltage for the l.e.ds, i.e. 2.4V + 1.4 times the number of l.e.ds in the string. Temperature performance will be improved if the l.e.ds are matched. Resistor R_L limits the current through the string and is determined by calculating the maximum current required and the value of Vcc above the minimum value required.

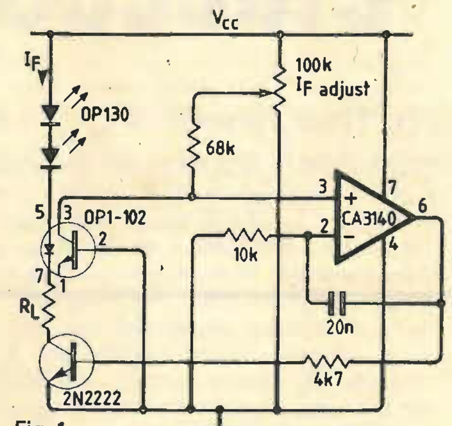


Fig. 1

If, due to a low Vcc, the l.e.ds cannot be used in a single string, several groups can be controlled as shown in Fig. 2. The transistors should be matched to provide equal I_f regulation in each string.
Norbain Electro-Optics
Reading
Berks.

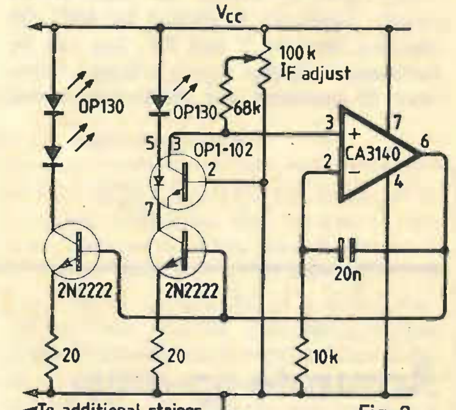
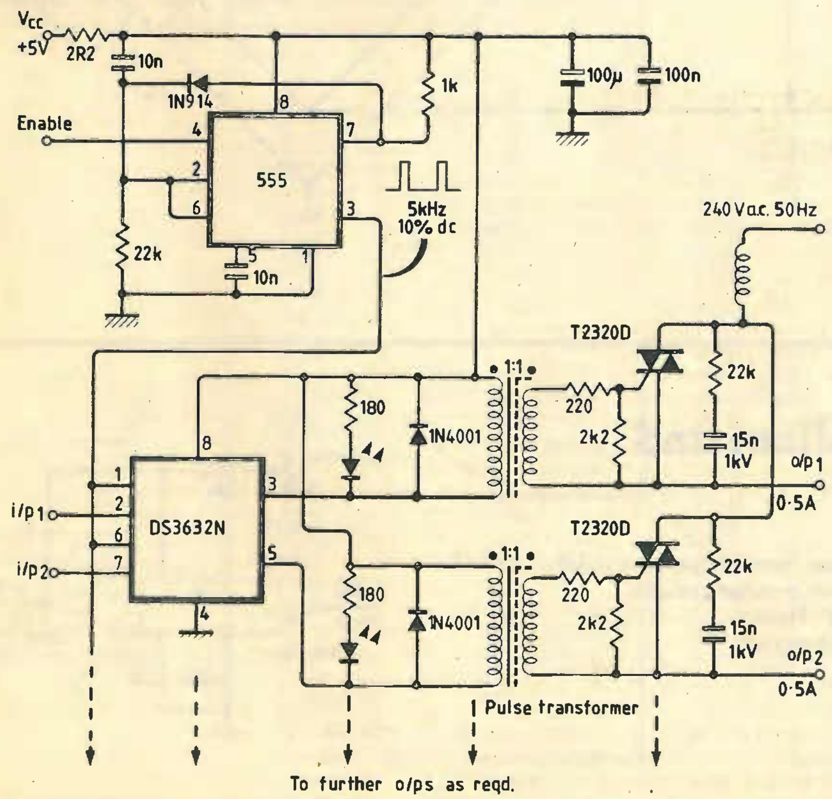


Fig. 2

C.m.o.s. to mains interface

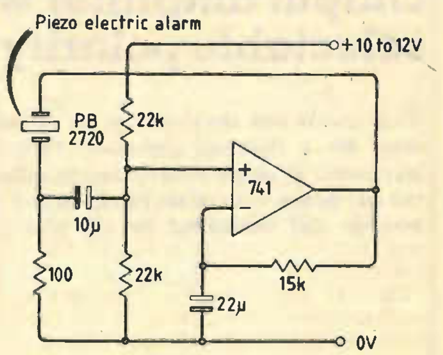
Mains control by c.m.o.s. logic can be safely achieved using this isolation circuit. Almost 360° conduction is assured for all a.c. voltages, and higher currents can be switched by using larger triacs.

The 555 oscillator provides a master enable input and can drive extra switching stages as shown.
L. Hurst
Auckland
N. Zealand



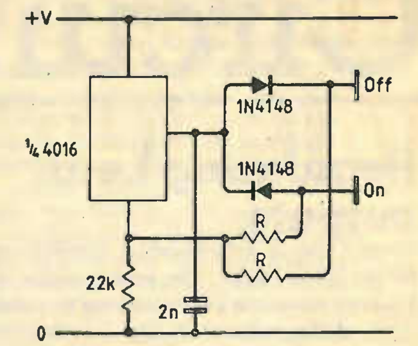
Piezoelectric-crystal driver

Because piezoelectric sounders are most efficient at their reasonant frequency, drive circuits should be adjusted to suit individual crystals. This oscillator drives a crystal and does not need to be adjusted with a pre-set control. The circuit is a non-inverting a.c. amplifier whose gain approaches the open-loop gain of the op-amp, and has positive feedback applied via the piezoelectric device. The ceramic element acts as a stable mechanical vibrator which determines the frequency of oscillation so the circuit automatically oscillates at the sounder's resonant frequency. The circuit shown requires about 3.5mA with a 10V supply.
M. L. Ford
Worcester



Simple c.m.o.s. switch

A single c.m.o.s. transmission gate can be used as a touch switch which requires practically no current when off. The gate is wired as a bistable and two diodes steer a 50Hz signal to change the state of the switch. Resistors R should be 4M7 for supplies between 5 and 8V, but can be increased for higher supply voltages. Capacitor C smoothes the 50Hz signal and prevents the transmission gate from turning on when the power is applied.
P. Record
Glasgow

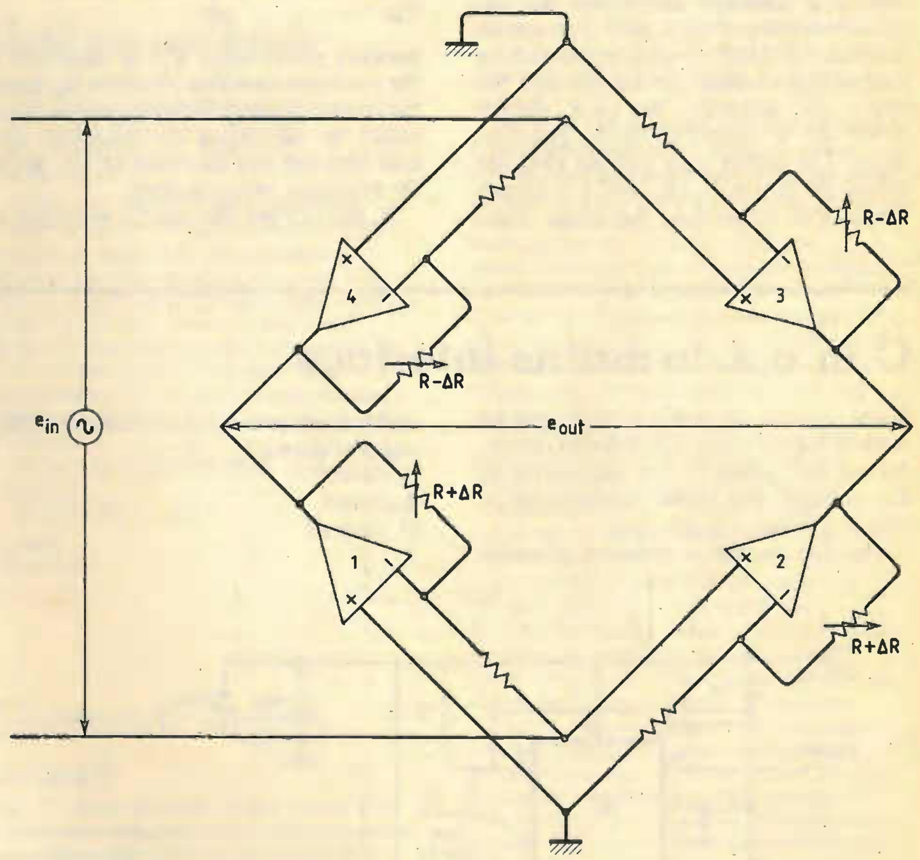


Accurate op-amp bridge

When measurements are made using resistive transducers, the sensors are often included in the arms of a balanced bridge. An improved circuit can be achieved by using an op-amp in each arm of the bridge and positive going transducers (+ΔR) in arms 1 and 2 or negative going types in arms 3 and 4. The bridge can be built around a single quad op-amp such as the LM324, and four matched sensors, and can be powered by d.c. or floating a.c. Output voltage is

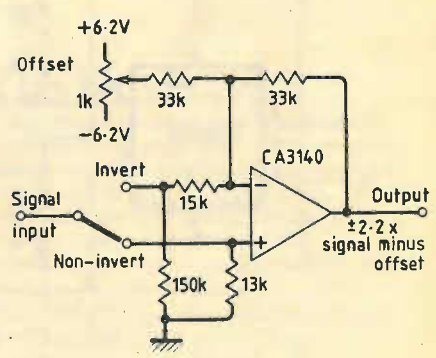
$$e_{out}=\frac{4e_{in}\Delta R}{R}$$

This shows that the output is linear over a wide range and has a four-fold sensitivity compared with a single op-amp bridge. The circuit can also provide high output voltage, low output impedance and high noise immunity.
N. Balakrishnan
Bangalore
India



Output amplifier with offset and selectable polarity

This circuit was developed as an output stage for a function generator. Output waveforms of either polarity can be selected and added to an offset voltage which is variable and unaffected by the polarity switch. Input impedance is 13kΩ with the switch in either position.
M. P. Hadley
Southampton



Interfacing microprocessors

Input and output functions

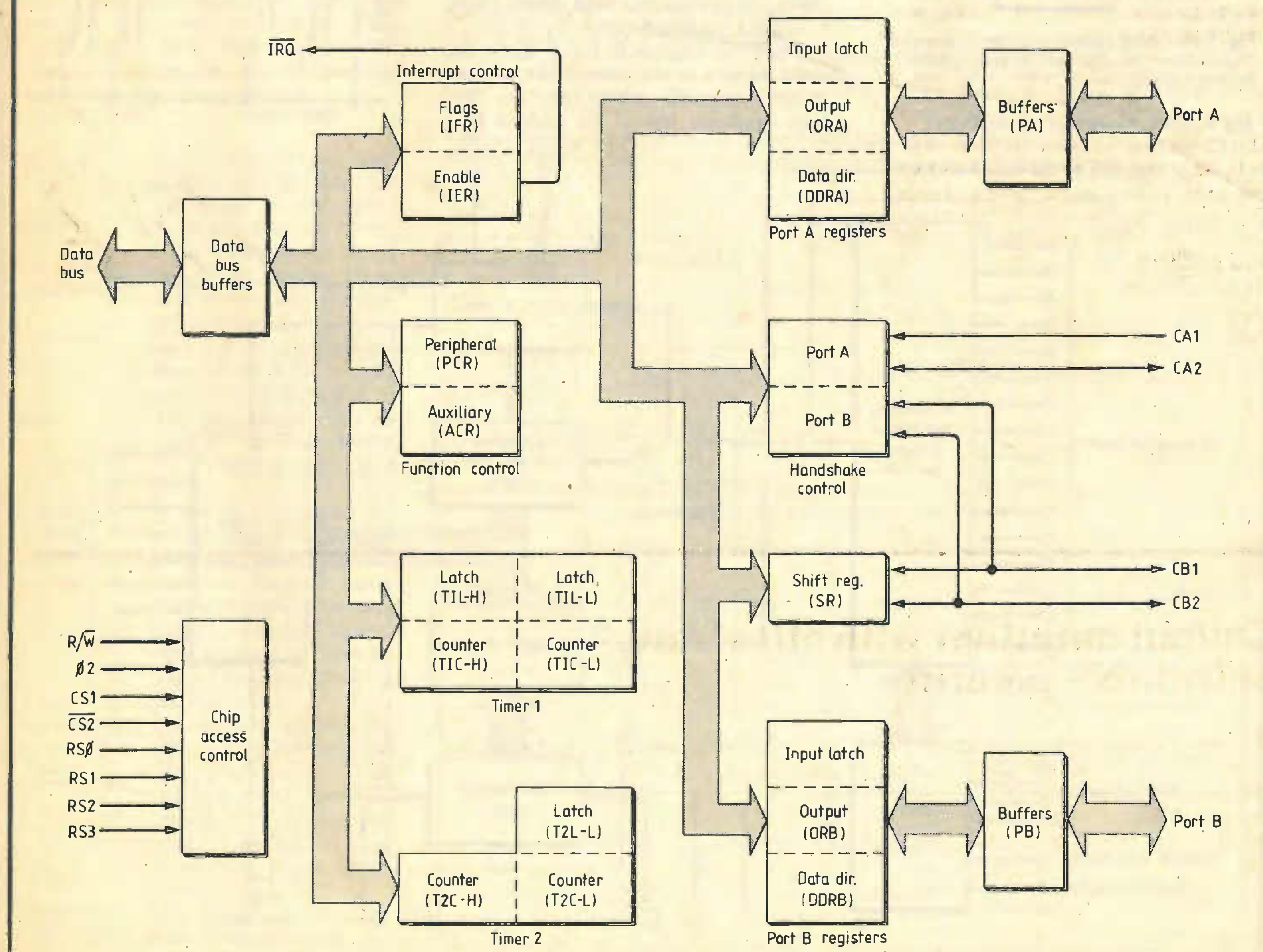
by J. D. Ferguson, B.Sc., M.Sc., M.Inst.P., **J. Stewart, and P. Williams,** B.Sc., Ph.D., M.Inst.P.
Microelectronics Educational Development Centre, Paisley College of Technology

Part one of this series outlined a universal interface for 6502 microprocessor boards and microcomputers. Part two describes the operation and functions of the main i.cs and gives simple examples of driving the devices using machine code or Basic.

The 6522 v.i.a. is a very powerful device which can perform several functions simultaneously. It consists of several independent sections controlled by 16 8-bit registers which occupy 16 sequential locations in memory, the base address being selected by decoding on the microprocessor board. Some registers are directly accessible via the pins of the i.c., while others are set and monitored by the data bus. Each register is selected by the four least-significant address bits, A0 to A3, with the i.c. activated by chip-select pins. Data enters and leaves the 6522 in 8-bit bytes and two registers, called ports A and B, are reserved for this purpose. In a hardware oriented system the designer would specify one port as an input and the other as an output, but this would take no account of a common requirement for unequal numbers of pins. For example, if a dozen sensors are scanned and two or three warning indicators are driven, it would be costly to design a range of boards to cope with the large number of possible variations. An alternative scheme has a controlling register associated with each port called the data-direction register. For every bit set to 1 in the d.d.r., the corresponding pin of the port behaves as an output, while a 0 sets the pin to behave as an input. Changing the contents of the d.d.r. can, in one step, alter the status of any or all eight pins of the corresponding port. Similar control can be achieved over the functions, and Fig. 1 shows the format of the auxiliary control register. This is the eleventh register out of sixteen on the chip, and is itself selected by the address decoding at A000 to A00F. Therefore, the address of this register is A00B. Bits 0 and 1 determine whether the latches associated with the ports are latched, allowing data to be held during sections of a program.

Bits 2 to 4 control the shift register, determining whether it is used for serial to parallel or parallel to serial conversion, and also the source of the timing pulses. One of the two internal timers can be used to generate single time delays in a so-called

Fig. 2. *Block diagram of the 6522.*



monostable mode or to count the number of transitions on a particular pin of a port. The last facility is useful for event counting or as the basis of a frequency meter, while the monostable mode has wide applications in controlled time delays. The timer has an internal 16-bit register which can be reset to a prescribed value under program control, with interrupts being automatically generated at time-out. The second timer has a monostable mode under the control of bits 6 and 7, but can also be used as a free-running generator or astable to repetitively switch an output pin from 0 to 1, with each half-cycle set by the value latched into the corresponding register. This allows the value of a given half-cycle to be continually modified until the end of the previous half-cycle is reached because the timers run independently of the microprocessor once a sequence has commenced. However, the microprocessor can always interrupt and control the sequence.

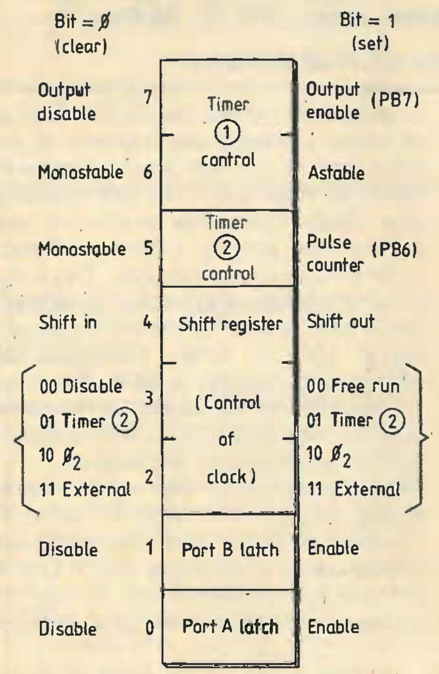


Fig. 1. *Auxiliary control register of the 6522. This is the eleventh register and has the address A00B.*

The complete range of functions is large and a summary is shown in Table 1, which should be considered in conjunction with Fig. 2. Selected functions will be covered in future articles but full details are available in references 1 and 2.

A-to-d converter

Most a-to-d converters take a single analogue input signal and produce a binary-coded output after an interval of typically tens or hundreds of microseconds. In engineering systems it is more often necessary to rapidly scan a series of inputs and collect the data for further processing. This is possible by combining an a-to-d converter with suitable analogue switching, and a suitable circuit is now available in a single low-cost i.c. The ADC 0817 covers 16-channels automatically with an expansion capability for larger systems and, although the problem of signal conditioning remains, for applications with signals above 0.5V a self-contained system is possible.

The block diagram in Fig. 3 shows the main features of the system. An address decoder, normally driven from the four least-significant bits of the address bus, selects the analogue channel in use. The decoder can be enabled and the conversion started by the rising and falling edges of a single pulse. The appropriate analogue signal is switched through, with an intervening common stage of signal processing or filtering if required, and a chain of resistors across a reference voltage is scanned with a successive approximation register until a match is found between its output and the signal being measured. The most-significant bit is tested first and accepted or rejected after comparison with the unknown. Each further bit of the eight is similarly tested so that the cumulation voltage becomes closer and closer to the unknown voltage. Each conversion takes exactly eight test cycles regardless of the value of the unknown, which provides fast and precise timing relationships suitable for multi-channel systems.

On completion of the conversion, a pulse is generated which can be used by the microprocessor to activate tri-state controls and give the a-to-d latched outputs access to the data bus. When data for one channel is collected and stored, the processor is ready to provide the address of the following channel.

Some simplification is possible with Basic programs which run sufficiently slowly for the conversion process to finish naturally before the start of the next instruction.

Fig. 3. *Block diagram of the ADC 0817.*

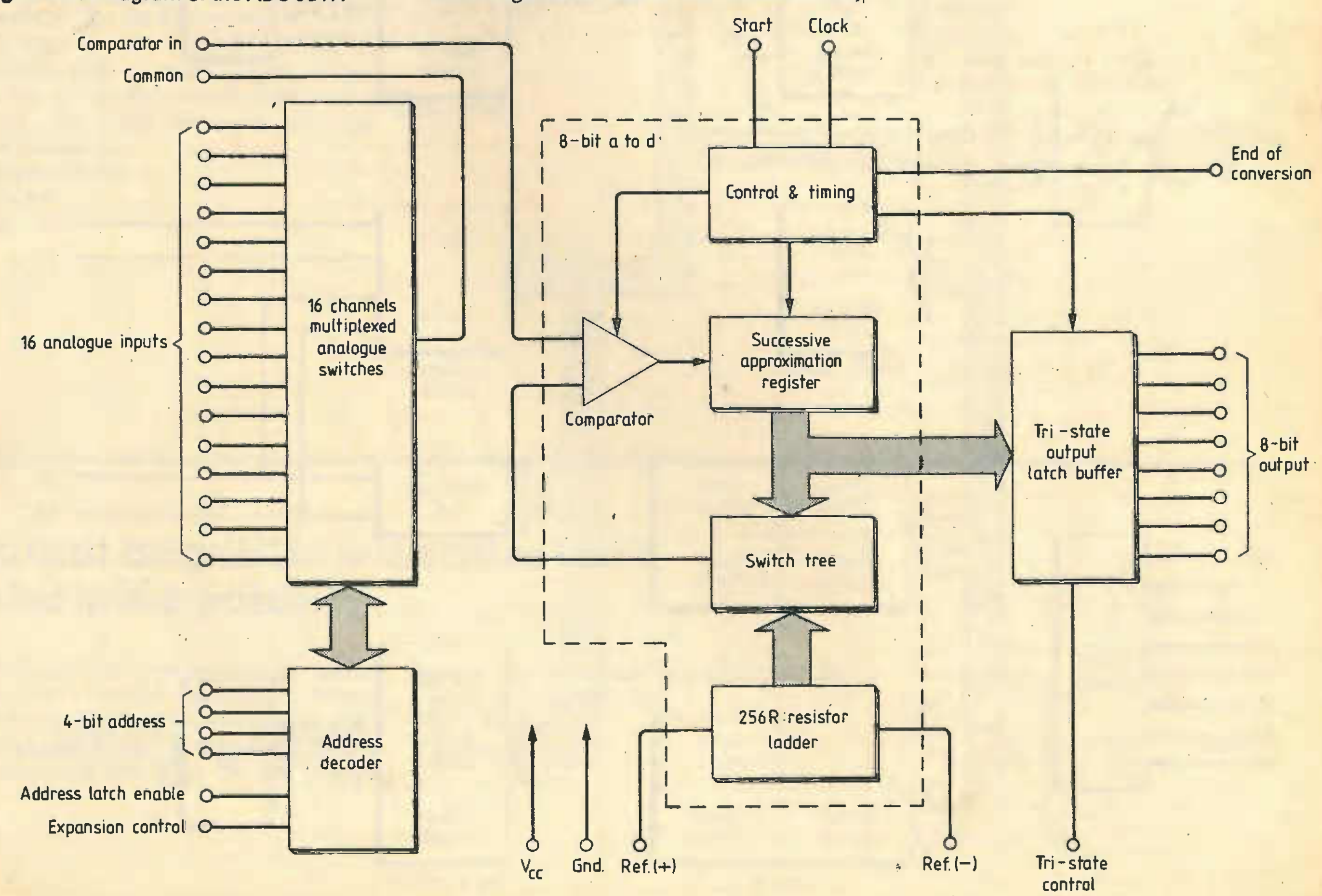
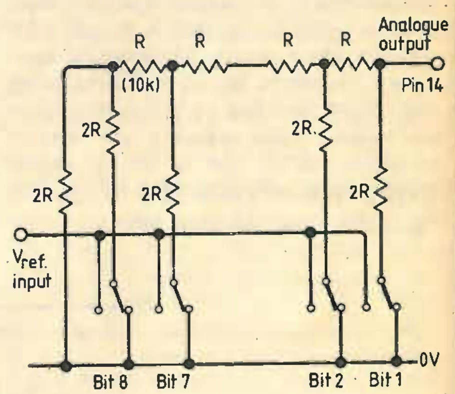


Fig. 4. *Internal ladder network of a ZN425E. The ladder can be powered by an internal or external reference.*



D-to-a converter

The ZN425 is a well established device which lacks the sophistication of some more recent devices, but is still worth using in general applications. Additional gating and latching is required for use with a microprocessor and at present only the d-to-a capability is used. The data bus is latched to the converter and an internal R-2R ladder network provides a proportional output as shown in Fig. 4. An internal or external reference may be used to drive the ladder, but the internal counter provided for a-to-d applications is not used. The reference may be a variable voltage if required, normally in the 0 to 5V range, and a small negative reference voltage (<0.5V) may be used although this is not covered by the specification. Further details of the ZN425 can be found in reference 4.

Processor interface

The 6522 was designed to interface directly with the 6500 series of microprocessors and therefore presents no difficulties when used with the systems mentioned in part one. Fig. 5 shows the lines used by the v.i.a., namely;

Data bus — Eight bidirectional wires used to transfer data between the v.i.a. and c.p.u.

R/W — A control line used by the c.p.u. to define the direction of data transfer. If the R/$\overline{W}$ is low, data is transferred from the c.p.u. to the v.i.a., i.e. a write operation. If the R/$\overline{W}$ is high, data is read by the c.p.u.

Reset — The reset signal clears all internal registers except T1, T2 and the shift register.

0_2 clock — 0_2 acts as a time base for the various timers, shift registers etc. in the i.cs.

Register select — The four Register select lines are normally connected to the four least-significant address-bus lines to give the processor access to the 16 registers.

Chip select — The selected register can only be accessed when the chip select pin, $\overline{CS2}$, is held low. This signal is usually derived from the address decode circuit which places the i.c. in the memory map.

Interrupt request (IRQ) — This output can be used to interrupt the c.p.u.

Table 1. V.i.a. registers and functions. L=0.4V, H=2.2V

Register select					Addressed register	R/$\overline{W}$=L	R/$\overline{W}$=H	Notes
RS3	RS2	RS1	RS0	Address				
L	L	L	L	0	IRB/ORB	Write ORB clear CB2 and CB1 interrupt flags (IFR3 and IFR4)	Read IRB clear CB2 and CB1 interrupt flags (IFR3 and IFR4)	1=high, 0=low
L	L	L	H	1	IRA/ORA	Write ORA clear CA2 and CA1 interrupt flags (IFR0 and IFR1)	Read IRA clear CA2 and CA1 interrupt flags (IFR0 and IFR1)	1=high, 0=low Controls CA2 handshake
L	L	H	L	2	DDRB	Write DDRB	Read DDRB	0=input, 1=output
L	L	H	H	3	DDRA	Write DDRA	Read DDRA	0=input, 1=output
L	H	L	L	4	T1	Write T1L-L	Read T1C-L clear T1 interrupt flag (IFR6)	
L	H	L	H	5	T1	Write T1L-H & T1C-H transfer T1L-L to T1C-L clear T1 interrupt flag (IFR6) initiate T1 counting	Read T1C-H	
L	H	H	L	6	T1	Write T1L-L	Read T1L-L	
L	H	H	H	7	T1	Write T1L-H clear T1 interrupt flag (IFR6)	Read T1L-H	
H	L	L	L	8	T2	Write T2L-L	Read T2C-L clear T2 interrupt flag (IFR5)	
H	L	L	H	9	T2	Write T2C-H transfer T2L-L to T2C-L clear T2 interrupt flag (IFR5) initiate T2 counting	Read T2C-H	
H	L	H	L	A	SR	Write SR clear SR interrupt flag (IFR2)	Read SR clear SR interrupt flag (IFR2)	
H	L	H	H	B	ACR	Write ACR	Read ACR	
H	H	L	L	C	PCR	Write PCR	Read PCR	
H	H	L	H	D	IFR	Write IFR	Read IFR	1=detected, 0=not detected
H	H	H	L	E	IER	Write IER	Read IER	1=enable, 0=disable
H	H	H	H	F	IRA/ORA	Write ORA clear CA2 and CA1 interrupt flags (IFR0 and IFR1)	Read IRA clear CA2 and CA1 interrupt flags (IFR0 and IFR1)	1=high, 0=low no effect on CA2 handshake

Table 2. Driving the interface i.cs in machine code and Basic. In these examples the address decode circuit has been adjusted so that each i.c. occupies the location shown.

V.i.a 6522	ADC 0817	ZN425E
4000H → 400FH	4010H → 401FH	4020H
16384 → 16399	16400 → 16415	16416

(a) To output byte AA H on port B of the 6522

	Assembler	Acorn Basic	Aim/Apple Basic	Comment
Make port B an output	LDA #FF H STA 4002 H	10 ?#4002 = #FF	10 POKE 16386,255	Write FF # to data-direction register for port B
Output AA H to port B	LDA # AA H STA 4000 H	20 ?#4000 = #AA	20 POKE 16384,170	Data sent to port B

(b) To input, in digital form, an analogue signal on channel 4 of ADC 0817

	Assembler	Acorn Basic	Aim/Apple Basic
Select input channel Initiate conversion	STA 4014 H	10 ?#4014 = 0	10 POKE 16404,0
Wait 100μs	JSR DELAY		
Read data from a to d	LDA 4014H	20 A = ?#4014	20 A = PEEK(16404)

See note (2)

See note (4)

Comment:

(1) A Write operation selects the input channel and initiates the conversion – the last digit of the hex address defines the input channel.

(2) The contents of the accumulator or the number POKED is not important – it is the Write operation that selects the channel and initiates conversion.

(3) Basic is so slow that a delay routine is not required.

(4) A Read operation to any address between 4010 and 401F will give the result of the last conversion.

(c) To output, in analogue form, a digital signal using the ZN 425E

Assembler	Acorn Basic	Aim/Apple Basic	Comment
LDA # AA H STA 4020 H	? # 4020 = # AA	POKE 16416,170	Analogue equivalent of AA H is sent to output of ZN425E

Table 2(a) illustrates how the v.i.a. can be used to output a byte in parallel form on port B. The v.i.a. registers are treated as memory locations by the programmer and can be read or written to in assembly language using LDA or STA instructions, or in Basic using Peek and Poke instructions.

The ADC 0817 has been designed to be compatible with a wide range of microprocessors and Fig. 6 shows that most of the signals used by the converter can be taken directly from the 6502.

Data bus

0_2

Channel select The four least-significant address lines can be used to select each of the sixteen input channels.

The R/$\overline{W}$ line is not used directly but is gated with the 0_2 clock to produce the Not Read Data Strobe, NRDS, and the Not Write Data Strobe, NWDS. NRDS and NWDS only go to zero during the positive part of 0_2 in a Read or Write cycle respectively as shown in Fig. 7. Fig. 6 shows how a Write operation to the i.c. activates the NWDS and creates the necessary transitions on the address-latch enable pin and initiate-conversion pin to perform the following tasks. Select the input channel from the address currently on the four least-significant address lines. Initiate an analogue-to-digital conversion. After a 100µs delay, a Read operation activates the NRDS, enabling the tri-state output and placing the digital signal on the data bus. Table 2(b) shows the programming instructions used to drive the i.c. A Write instruction, STA or Poke, is used to define the input channel and initiate the conversion. After a delay a Read instruction, LDA or Peek, obtains the digital information.

The ZN425E is not directly compatible with a microprocessor and must be used with the 74LS373 which latches transient data from the processor and provides the 425E converter with a continuous digital input. The latch is memory mapped and enabled by a chip-select signal from the address decode circuit, see Fig. 8. This ensures that the latch captures stable data on the bus during the positive part of the 0_2 clock. Table 2(c) shows how the 425E is used in Basic and assembly language.

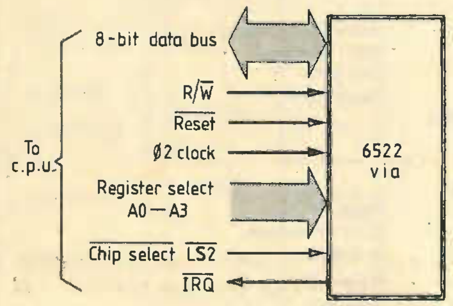


Fig. 5. V.i.a. connections to the 6502.

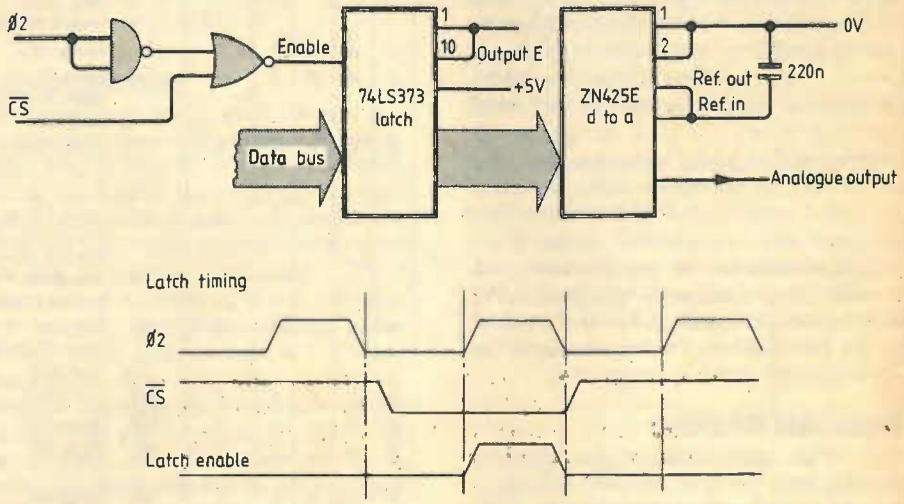


Fig. 8. Enable signal and latch timing for the d-to-a converter.

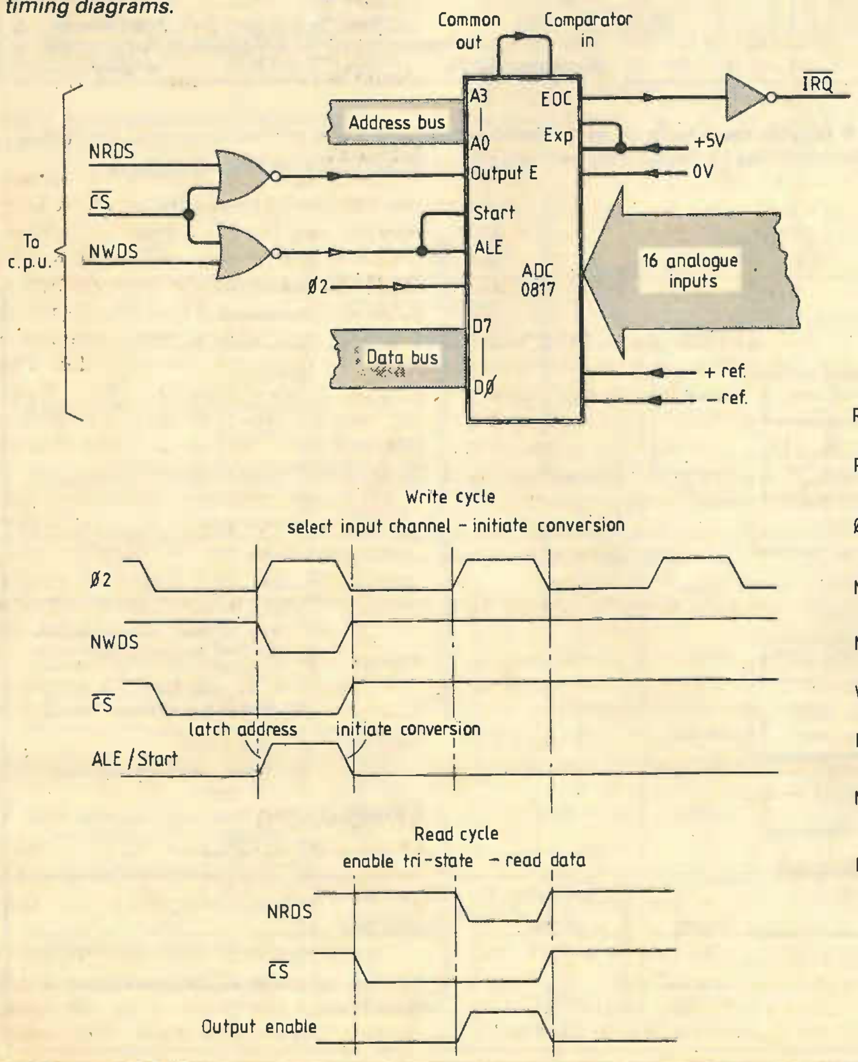


Fig. 6. A-to-d input/output connections and timing diagrams.

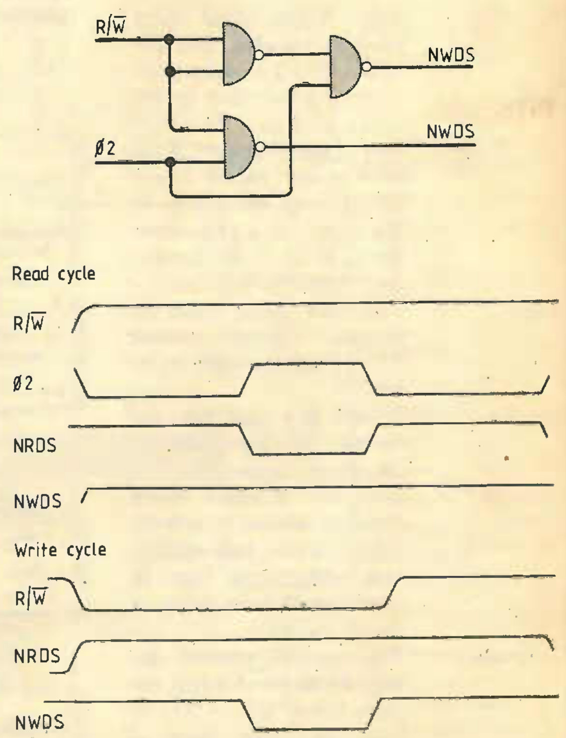


Fig. 7. Generating NWDS and NRDS signals for the ADC 0817.

References

1. Rockwell data sheet, no. 29000D47.
2. Rockwell, R6500 hardware manual, no. 29650 N. 31, p. 6-1.
3. National Semiconductor data book.
4. Ferranti data converters, application report no. 13.

Accurate sine-waves

Analogue implementation of the Darwood accurate sine-wave oscillator algorithm

by D. H. Follett

In response to Mr Darwood's 'Accurate sine-wave oscillator' article in the June'81 issue of *Wireless World*, the author shows here that the digital implementation used to generate accurate sine and cosine functions can be replaced by simple analogue circuits. A prototype circuit operated over three decades with ±1dB amplitude variation, less than 1° error between the quadrature outputs and around 1% or less distortion. The circuit requires only four quad-i.cs.

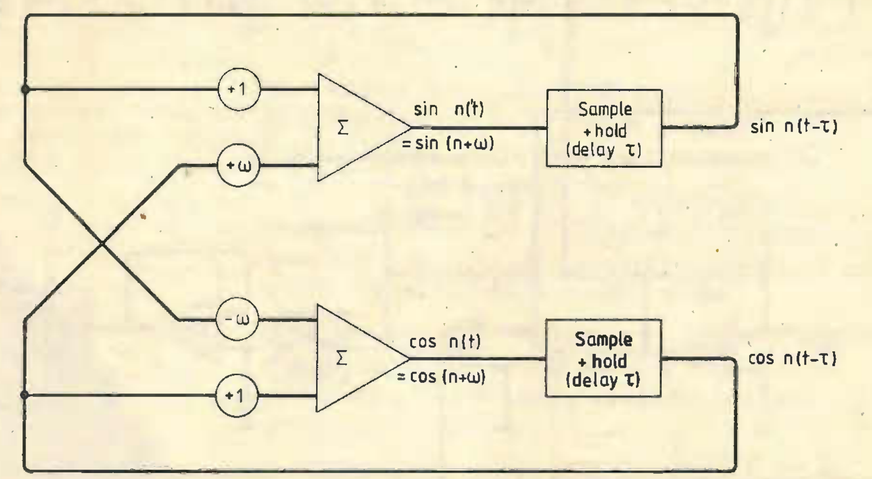


Fig. 1. Block diagram illustrating application of the equations for values of sin n(t) and cos n(t).

The algorithm recently described by N. Darwood[1] for generating sine and cosine functions with digital implementation may also be produced by analogue means, as will be shown. The circuit is really a form of recursive digital filter but I am unrepentant in calling it an analogue implementation since no digitization in the proper sense occurs.

The prototype operated over three decades of frequency with amplitude variations of ±1dB, distortion about 1% or less, and phase error between outputs less than 1°. Only four cheap quad i.cs are required, although Fig. 2 shows six i.cs, since the four dual op-amps can be replaced by two quad op-amps such as the LF347.

Principle

Referring to the original article for fuller explanation, each new value of sin$n$ is computed from the previous value by adding a fraction ω of cos$n$;

$$\sin(n+\omega)=\sin n+\omega\cos n$$

Note that ω does not have its usual significance. If we write $\sin(n+\omega)$ as $\sin n(t)$, the value of sin$n$ at time t, and sin$n$ as sin$n$ $(t-\tau)$, the value at time τ earlier, then

$$\sin n(t)=\sin n(t-\tau)+\omega\cos n(t-\tau)$$

Similarly,

$$\cos n(t)=\cos n(t-\tau)-\omega\sin n(t-\tau)$$

These equations are applied as shown in the block diagram, Fig.1. The value of sin$n$ is sampled and held so that the output of the sample and hold circuit is effectively delayed by the sampling interval τ and represents the value of $\sin n(t-\tau)$. To this is added the fraction ω of the cos function to generate the new value of the sine function, $\sin(n)t$. A similar process is used for cos$n$.

Referring again to Mr Darwood's article, the sine and cosine outputs are synthesized with $2\pi/\omega$ steps per cycle so that the output frequency is $2\pi/\omega$ times less than the sample clock frequency.

Implementation

The circuit was designed to operate in the audio-frequency range with values as shown in Fig.2. During the first half of each clock cycle (Q high) the values of sin and cos are transferred to the first pair of hold capacitors while the previous values are held on the second pair. In the second half cycle the values are transferred to the second pair of capacitors. This avoids having to use very short sample times and ensures that loops are never closed while settling. The 100kΩ resistors determine the fraction ω; the optimum fraction seems to be about one-tenth, giving about 60 steps per cycle. Although the circuit will run with 400 steps per cycle, distortion occurs because circuit errors become comparable with the step size. More accurate sample-and-hold i.cs and higher accuracy resistors will decrease circuit errors.

The diode-resistor networks around A_2 and A_6 provide a small degree of non-linearity sufficient to stabilize the oscillation amplitude. If only one output is required and exact phase quadrature thus unimportant, one network and the associated preset can be omitted, leaving only the 10kΩ feedback resistor.

Setting up

Initially, the 1kΩ presets should be set to zero to prevent oscillation and the null offsets adjusted. The presets should then be advanced until oscillation occurs and then adjusted for phase quadrature. The output amplitudes should be about 4 to 5V peak-to-peak. Finally, the null offsets may need readjusting. The output frequency is not critical during the adjustments, but should be between 50 and 5,000Hz.

Results

Figure 3 shows oscillograms for frequencies between 5Hz and 16kHz obtained by varying only the clock frequency. Single time-base sweeps were used for all but the 16kHz frequency as the steps are not, in general, synchronized with the output. In Fig. 4(a), the 500Hz signal is expanded to show the steps more clearly, while Figs 4(b) and (c) show Lissajous figures resulting from x-y display of the two outputs to illustrate the quadrature accuracy obtainable between 5Hz (b) and 5kHz (c).

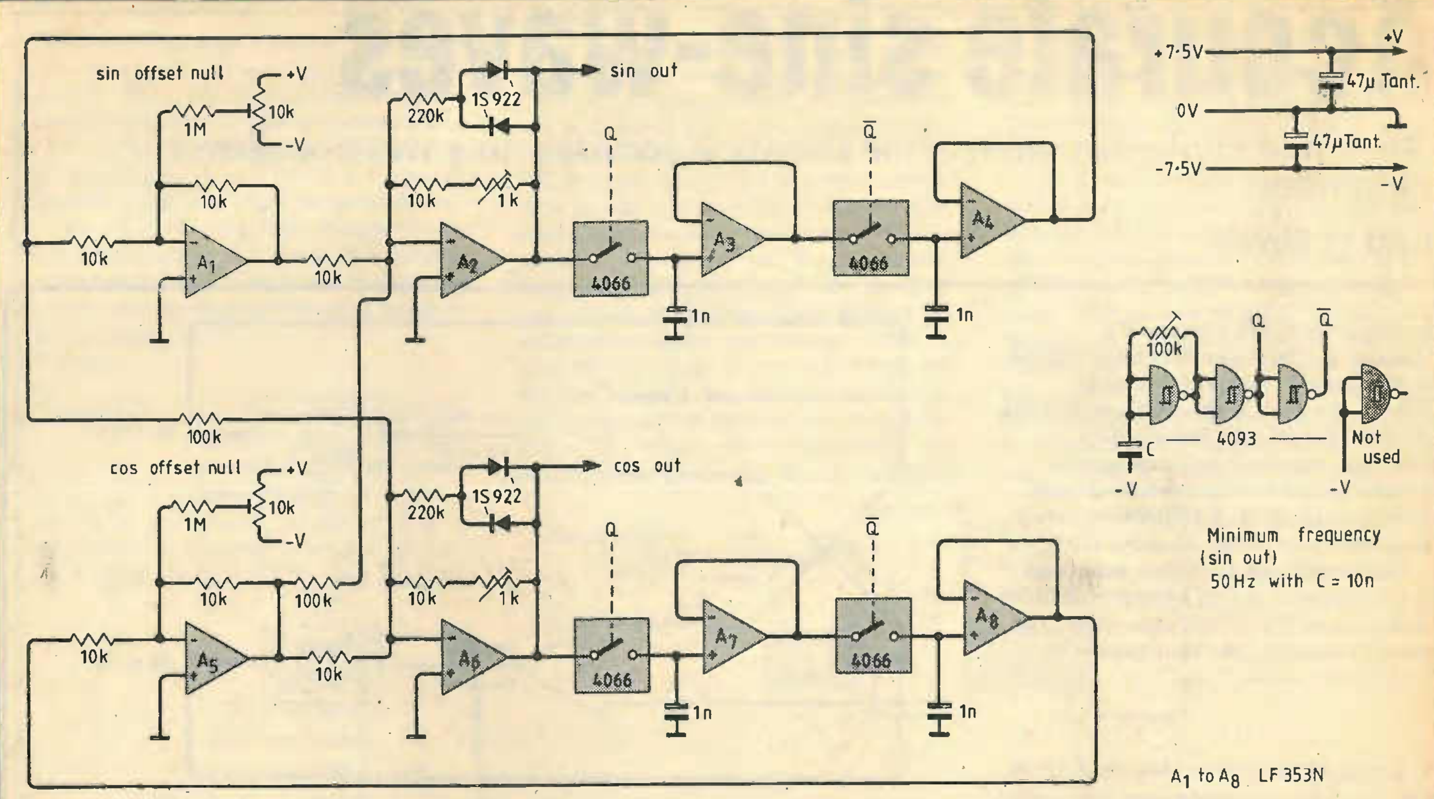
The upper frequency for constant amplitude is about 16kHz but frequencies lower than 5Hz can be obtained by increasing the 1nF hold capacitors proportionally. These capacitors must of course be polystyrene types, or similar, to minimize dielectric soaking effects.

If the clock is replaced by a voltage controlled oscillator the circuit can also be used as a sweep oscillator.

Comparisons

Out of interest, two other oscillators based on recursive filters were compared to the circuit described here using the same building blocks.

The first used direct implementation of the second-order differential for a series-tuned circuit (equivalent to the state-variable filter in band-pass mode). This circuit



used two op-amps fewer but was limited to about 30 steps per cycle, as second order terms make circuit errors more critical.

Phase-shift oscillators using three or four cascaded single-pole filters were also tried. These oscillators were more docile than those previously described, but four sections were required to obtain quadrature outputs and almost twice the component count of the circuit described here gave an inferior performance. D.c. stability was, however, better as feedback at d.c. is negative and thus reduces offsets.

The circuit described here is sensitive to offsets because of positive feedback at d.c., so offset null adjustment is included.

Reference

1 N. Darwood, 'Accurate sine-wave oscillator', *Wireless World*, June 1981, pp 69-78.

Fig.2. Circuit diagram of the oscillator and clock. Op-amps A_1 to A_8 were four LF353N i.cs in the prototype but they can be replaced by, say, two LF347 quad i.cs if required. These op-amps have j.f.e.t. inputs.

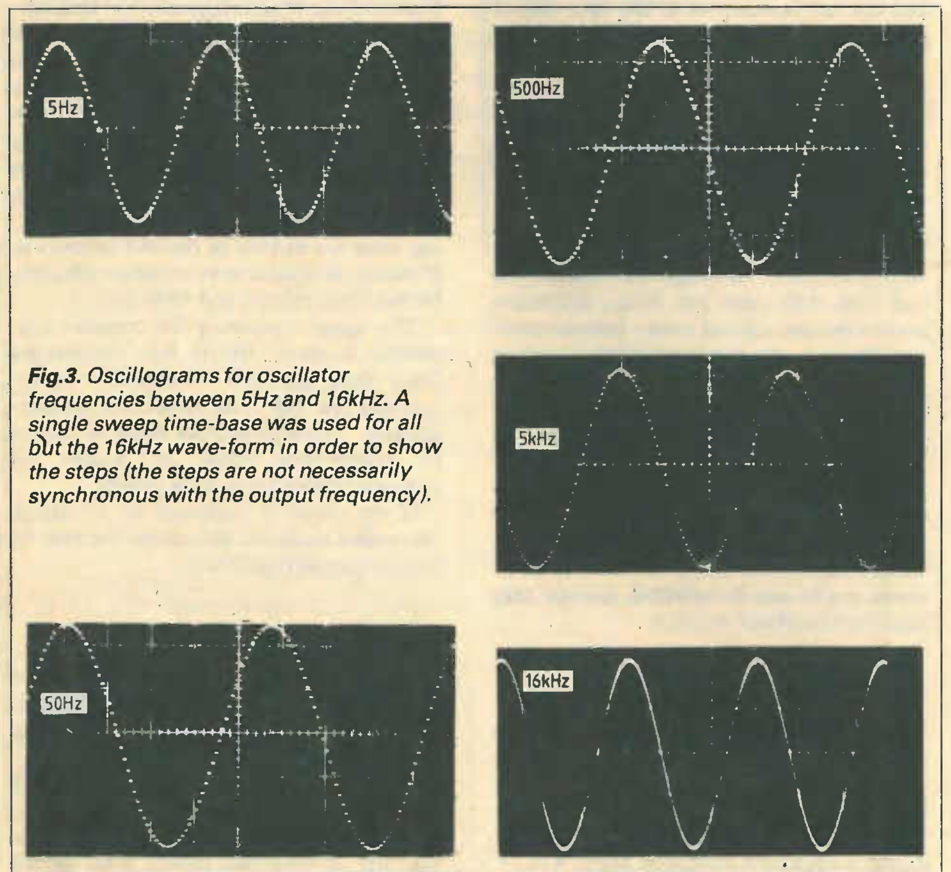


Fig.3. Oscillograms for oscillator frequencies between 5Hz and 16kHz. A single sweep time-base was used for all but the 16kHz wave-form in order to show the steps (the steps are not necessarily synchronous with the output frequency).

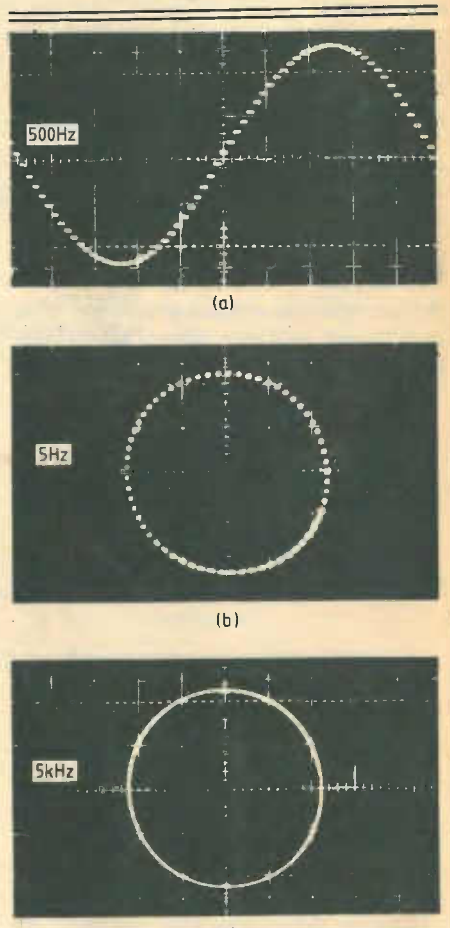


Fig.4. (a) is the 500Hz sweep expanded to show the steps more clearly. (b) shows a Lissajous figure resulting from the two oscillator outputs at 5Hz, and (c) is as (b), but at a frequency of 5kHz.

News of the Month

Subscription tv by cable

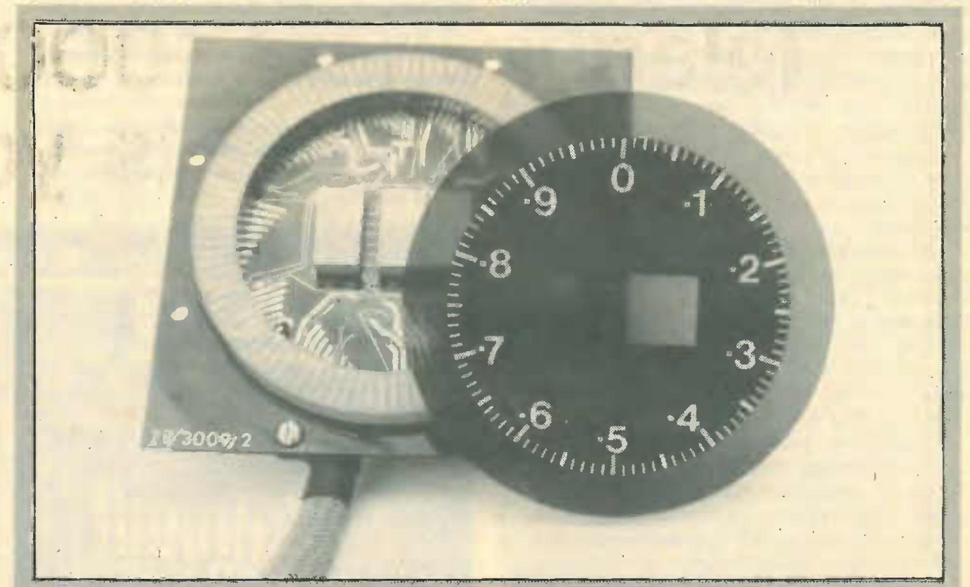
Cables were first used for broadcast distribution in the 1920's and were extended and updated to include television, two and then three channel tv. The cables could get the broadcasts to areas where the reception was poor or non-existent. Since then, improvements and additions to the broadcasting network have made the need for cable distribution redundant and the subscribers to the cable services were reducing in numbers. However the cable networks exist, and Rediffusion, amongst others, have been pressing the Government to be allowed to institute subscription television services. *Wireless World* reported the granting of licences by the Home Office to a number of pilot schemes in the May issue, and the first to commence transmission, on Wednesday the 9th September, was the Rediffusion 'Starview'. Starview is being transmitted in five areas; Burnley, Hull, Pontypridd, Reading and Tunbridge Wells.

At the time of the launch, there were some 3,000 subscribers to Starview in the selected areas. Another 19,000 were subscribers to the public broadcast network and there was a potential audience of 56,000 houses which could be easily connected to the cables.

Rediffusion research has indicated that what the public really wanted was recent feature films. Sixteen films had been selected for broadcasting in September, with a further ten for October. Two films are shown each evening with an extra late-night film on Friday and Saturday and an afternoon 'matinee' performance on Sunday.

Rediffusion were surprised by the high distribution fees demanded by the Motion Picture Exporter Association of America. To break even, it is estimated that a subscription fee could be as much as £12 each month. Rediffusion have decided to charge the full rate, £11.95, only in Reading; in Burnley and Hull they are charging only £7.95.

Technical details of the Starview service are described elsewhere in this issue.



When Racal-Decca bought some digital displays from Hewlett-Packard for use in radar equipment, the dials incorporated in the displays were manufactured by Chequers (UK) Ltd in London, some 15 miles away from the Racal-Decca Marine Radar plant in New Malden, Surrey. To cover those 15 miles they had in fact travelled 10,000 miles across the Atlantic and back. The dials have an outer ring of 100 l.e.ds to give an analogue readout with three seven-segment l.e.d. digits in the centre. Because the printed dial has to match up with the l.e.ds, the diodes are positioned and the printing registered to within 0.003in.

S.s.b. mobile radio still promising

The claim made two years ago by Pye Telecommunications Ltd that, to create more channels for land mobile radio, single-sideband operation at v.h.f. is the most promising technique (June 1979 issue p. 95) has now been given qualified support by some recent Home Office trials. The narrow-band system actually tested, in comparison with others, was s.s.b. with a channel spacing of only 5kHz. The testing was a subjective evaluation of the quality of calls and it was done by operators of a typical user of private mobile redio, Bell Fruit (UK) Ltd. The other two systems compared with the 5kHz s.s.b. were 25kHz and 12.5kHz channel spacing using f.m. It was intended to use 12.5kHz a.m. for comparison as well, but this in fact will be done later.

According to D. M. Barnes of the Home Office's Directorate of Radio Technology: "The results have shown that from a user's assessment 5kHz s.s.b. equipment could be used to provide a land mobile radio system without any loss in quality or intelligibility when compared with 12.5kHz f.m. equipment. Furthermore, in many situations the quality of the s.s.b. equipment would be better than that of existing 12.5kHz f.m. equipment. However, it has also been shown that in general 25kHz f.m. equipment would provide a higher quality service. The use of 5kHz s.s.b. could theoretically provide an acceptable service with 5 times or 2.5 times as many channels in a given block of spectrum than 25 or 12.5kHz f.m. equipment respectively. However, further work is required on the frequency re-use characteristics of the different systems before a final conclusion can be reached".

This report comes from a paper delivered by Mr Barnes at the IERE's Clerk Maxwell Commemorative Conference on "Radio Receivers and Associated Systems" at Leeds in July. The tests were conducted over a six-week period on 21 mobiles – seven of each type – with a base station of three transmitters in Central London. Peak envelope powers of the three different systems were made equal: 10 watts p.e.p. for the mobiles and 25 watts e.r.p. for the transmitters. Frequencies were in the region of 160MHz for the mobiles and 165MHz for the transmitters. The f.m. transceivers were standard commercial land mobile radio equipments. The s.s.b. sets, produced by Pye Telecommunications, were of the single-sideband plus pilot carrier type (see June 1979 issue). The pilot carrier level was set at -12dB with respect to the peak envelope power. Details of these sets were presented by R. Wells of Pye in a companion paper at the above IERE conference.

Results were recorded for both stationary and moving vehicles and also using three areas of different field strengths between about 3μV/m and 100μV/m. Altogether nearly 3000 results were obtained, divided more or less equally between the three systems. Subjective rating of call quality by the operators was given in terms of a CCIR five-point scale ranging from 5 (excellent) down to 1 (unusable). In the results the 25kHz f.m. equipment achieved a higher percentage of grade 5 ratings than the other two systems, but the s.s.b. equipment obtained a higher percentage of grade 5 ratings than the 12.5kHz f.m. equipment. However, when grade 4 and grade 5 ratings were combined the s.s.b. and 12.5kHz f.m. had the same percentage ratings. The paper comments: "This tends to imply that on an overall basis 25kHz f.m. would provide the best quality service but s.s.b. equipment would provide a similar or better quality than 12.5kHz f.m." Results obtained for stationary and moving vehicles in a given area were similar.

When the results were considered on an area basis "in the high field strength area the s.s.b. equipment achieved a greater percentage of grade 5 ratings than either of the two f.m. systems. However, in the medium and low field strength areas the 25kHz f.m. achieved the highest percentage of grade 5 results with the s.s.b. achieving more than the 12.5kHz f.m."

Further work, according to the paper, will aim to discover the distance at which a given s.s.b. channel frequency could be re-used without causing interference. There will also be tests to establish the adjacent channel performance of the different types of equipment.

● Pye Telecommunications have experimented with adapting one of their v.h.f/a.m. hand portable (walkie-talkie) sets, the P5001, for s.s.b. operation with a 5kHz channel spacing. For this a temperature-compensated crystal oscillator and i.f. crystal filters had to be specially made. According to a further paper by R. W. Wells at the IERE conference, the results did not fully meet operational requirements but they did show that "v.h.f. s.s.b. is indeed feasible with hand-portable equipment". There was a large cost penalty with the circuits used and this indicated a need for much more work before such a hand portable is a saleable reality.

BBC graphics

Viewers will have noticed the change to the titles for BBC news. What they won't realise is that the striped patterns and figures are generated electronically. ANT (animated news titles) came into service on the 7th September, only one month after it had been suggested that it may be possible. Priority was given to the graphic design for the main 9 o'clock news. BBC engineers were able to demonstrate this sequence within a week of starting the project. After the details of the other sequences had been produced it took a further three weeks to implement them.

The hardware for the system was based on that used for the BBC2 electronic clock and the animated Open University logo. The equipment needed modification to cater for multiple captions, the generation of 'key' signals so that pictures may be incorporated into the sequences, and for the definition of certain areas in the displays.

The software, which controls the commands and the sequences of the animations, uses only 1kbyte of memory for the programme. It requires another 6kbytes for the data. The data is stored in tables for each step of animation with a look-up table to arrange the actual sequence. Each data table defines only those parts which need to be changed, assuming a current state. This avoids the need to define the whole screen for each step. The microprocessor control is triggered 25 times a second by the display controller and the whole sequence can be started automatically

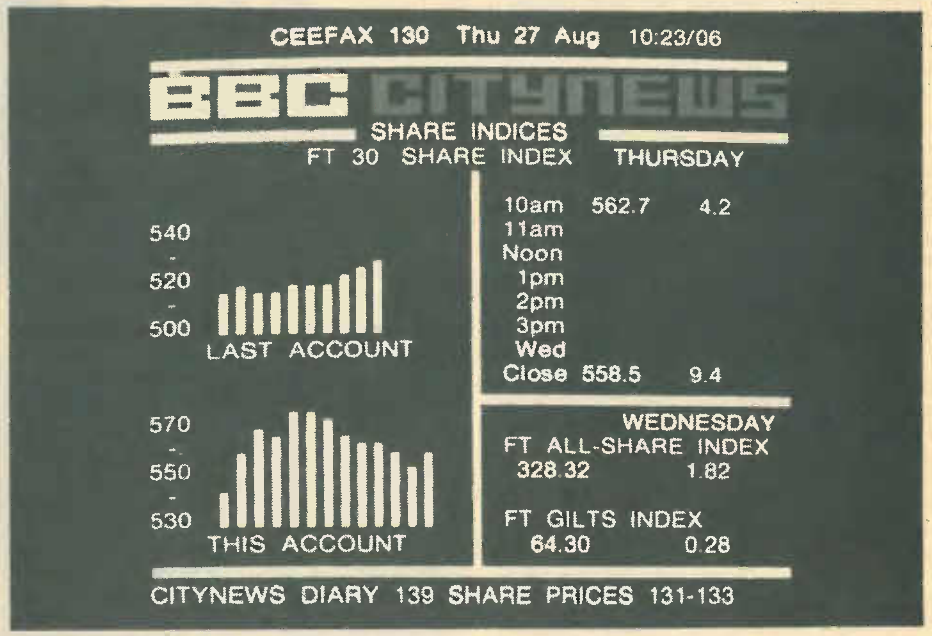
● In a programme of work, supported by the Department of Industry, BBC research department has produced equipment to be used to study enhancements to the British teletext system.

One of the early uses of the equipment has been to produce a teletext decoder capable of displaying the normal pages as they are broadcast now, but with a better quality of character generation than is found at present. When the teletext specification was written, five years ago, the shape and style of characters were deliberately left undefined. This was so that as equipment improved, manufacturers could offer a choice of type style.

Spare signalling capacity to control a change of character set was also provided. When new character generators came into use, the decoders would still be compatible with existing transmissions, and existing decoders will continue to function normally.

The BBC equipment is being used to investigate coding methods for high-quality teletext graphics, using the techniques known as 'redefinable characters', 'alphageometric' and 'alphaphotographic' coding. It has already been used to display high quality still pictures at the IEEE Chicago Conference, and at the Berlin Radio Show.

A photograph of a transmitted Ceefax page using the decoding equipment developed by the BBC Research department to study enhancements to teletext.



Computers may Dial to each other

The British Standards Institution has published the first Part of DD 75 *The structure and representation of data for interchange at the application level (DIAL)*, a major Draft for Development describing a new system of data interchange that could lead to massive economies for users in industrial, commercial and public sectors. Entitled Part 1 *Recommendations for syntax and basic principles*, the Draft is designed to achieve direct camputer-to-computer intercommunication and provides the basis for the first 'language' in the world for *general* applications, regardless of differences in the equipment used.

At present, communications such as invoices and purchase orders start off on one computer and certainly end up on another in a different organization. It's the bit in between that causes problems. Take, for example, a company which uses a computer to control stocks and order their replenishment. Normally, the order is printed out, put into an envelope and mailed (via a postal service now much more expensive and slower than in pre-computer days), sorted in the recipient's mail room, part processed clerically and then, ultimately, keyed into the organization's computer system.

Note the need for clerical pre-processing and key-entry operations! These happen to be two of the most expensive and error-prone tasks associated with computer systems. And at every stage of this drawn-out programme of events, the order sits waiting for attention. In the circumstances it is hardly surprising that a processing period of three days is considered to be remarkably fast, three weeks is probably typical and three months not unknown. In other words, a slow, tedious and remarkably inefficient process which stems largely from the lack of the necessary standards that would permit more effective communication.

The major obstacle to direct inter-computer links has always been the absence of a common data language and, hence, incompatibility in the software used by the sender and the receiver, not to mention anomalies in the equipment (eg flexible discs at one end of the line – magnetic tape at the other). Where only one partner is involved, of course, it is not difficult to write programmes that will effect the necessary conversion. But there can be few suppliers with only one customer, or buyers with a single supplier. Nor is it feasible to accommodate additional organizations by writing suites of individual programmes. Quite apart from the prohibitive cost, there are just not enough analysts and programmers available to cope with interchange on this basis.

Obviously, the long-term solution is to adopt standard messages using standard software. Some industries with particularly urgent needs have, in fact, already developed their own standards, notably those now employed in banking and airline computer systems. Currently, some 16 per cent of all clearing bank transactions and probably well over 90 per cent of airline communications are dealt with in this way. Not every group of interests, however, has the necessary expertise to devise independent standards, especially where messages are required to cross sector boundaries.

BSI's new DIAL system aims to provide a common facility to all branches of industry, commerce and administration having access to computer services. Part 1 of the Draft describes a general-purpose language for the interchange of machine-readable data with a minimum of negotiation or agreement. It contains:

(1) A basic grammar, suitably precise for computer processing, with extensions to meet specific applications.
(2) General recommendations for the representation of frequently-occurring categories of data.
(3) Administrative arrangements for data interchange.

DIAL is intended for use with any interchange medium including:

(a) Telecommunication networks providing simultaneous transmission
(b) Telecommunications networks using a store-and-forward service
(c) The transfer of physical media such as magnetic tape

The language is independent of the applications and equipment used and has a structure that permits the necessary degree of manual processing to ensure operational integrity and flexibility. In the interests of compatibility it uses a set of characters (letter, digits and symbols) which are restricted to those available on virtually every computer, so that messages can be sent to anyone regardless of the type and make of the equipment at the receiving end.

Another important asset is that DIAL is compatible (most of it identical) with the standards produced for international trade procedures by SITPRO (the Board for the Simplification of International Trade Procedures) which are approved by the United Nations. Thus, although DIAL will become a British Standard for internal UK use it is compatible with international equivalents – an important consideration for organizations operating both at home and overseas.

Broadcasting "radio data"

Details of the BBC's experimental broadcasting of digital signals for programme labelling, called "radio data"(News, September issue), were revealed by Dr S. R. Ely, BBC Research Department, at a recent IERE conference on "Radio receivers and associated systems" at Leeds. (And further information became available in a BBC Research Department report, RD 1981/4 "V.h.f. radio-data: experimental BBC transmissions" June 1981.) The system, developed jointly by the BBC and Televerket of Sweden, has been used on three BBC v.h.f. sound transmitters in the London area, Radio 2, Radio 4 and Radio London, in experiments running since April this year.

The digital data is conveyed on a 57kHz subcarrier which is phase-locked to the third harmonic of the 19kHz pilot tone of the stereo transmission. Frequency tolerance of this subcarrier during stereo broadcasts is ±6Hz. It is added to the stereo multiplex signal (or a monophonic signal) at the input to the v.h.f./f.m. transmitter. Peak deviation of the main carrier due to the 57kHz subcarrier is about ±2.25kHz.

This subcarrier is double-sideband suppressed-carrier, amplitude modulated by the digital data, which has the form of a bi-phase data signal with a bit rate of 1187.5 bit/s. (The method of modulation may be considered as a form of two-phase p.s.k. with a phase deviation of ±90°.) The bit rate is in fact, derived by dividing the transmitted subcarrier frequency by 48. But this division ratio may occasionally be altered to 50 or 46, to facilitate phasing of the transmitted code words, in such a way as to insert or delete one 57kHz cycle in each half of the bi-phase symbol corresponding to a data bit. Data is arranged in 114-bit blocks, giving 625 blocks per minute.

About 35% of the available data channel capacity is being used at present to transmit the most likely types of message required, including the network name (e.g. BBC R4 – see September News picture) in ASCII code for display purposes. The remaining 65% of the capacity is packed with dummy data from a pseudo-random binary sequence generator.

Currently these radio data transmissions are being received by special BBC v.h.f. receivers containing circuitry for demodulating the 57kHz d.s.b.s.c. a.m. signal and decoding the bi-phase digital symbols. The first operation is to recover the 57kHz subcarrier from the suppressed carrier d.s.b. radio data signal. This is then used locally in a synchronous demodulator to recover the digital modulation at 1187.5 bit/s. Before the synchronous demodulator, though, a 57kHz bandpass filter is inserted to attenuate the comparatively large amplitude sound signal components in the multiplex signal.

The stream of bi-phase digital data is then recovered by a symbol decoder described as an integrate and dump decoder*. For decoding purposes the 1187.5 bit/s rate must be available locally as a clocksignal. This is obtained by dividing down the recovered 57kHz subcarrier by the 48 divisor mentioned above and correctly phasing the resulting 1187.5 bit/s clock relative to the zero-crossings of the recovered bi-phase coded data stream.

Last year this BBC/Televerket system, together with three other similar ones, from France, Holland and Finland, were field tested in the Bern region of Switzerlsnd, using a Swiss PTT broadcast transmitter in the mountains. In these conditions, all four systems were found to suffer from a high mean bit-error-rate of 10 to 20%. The principal source of errors was thought to be multipath propagation causing programme signals to intrude into the data channels. However, with two of the systems using a high frequency subcarrier (BBC/Televerket on 57kHz and TDF (France) on 58.3314kHz), 70% of data blocks were received without error, as against two systems using lower subcarriers (NOS (Holland) on 16.625kHz and YLE (Finland) on 19.6kHz) which gave only 10% and 27% respectively of data blocks received error-free.

A firm specification for a Western European standardized radio data system will eventually be decided by the EBU.

* French,R.C. "Error performance of p.s.k. and f.f.s.k. subcarrier data demodulators," *The Radio and Electronic Engineer* 46, 11, pp. 543-548, 1976. Also Norton, J.J. "Drop your costs but not your bits with a Manchester-data decoder", *Electronic Design*, 27, 15, pp. 110-116, 1979.

C.b. legalized

November 2 is the date set by the Home Office for the start of legal c.b. operation in the UK, on the 27MHz and 934MHz bands, using frequency modulation. Licences costing £10 will allow operators to use up to three sets.

The relevant specifications are set out in Home Office publications MPT1320 (27MHz) and MPT1321 (934MHz), obtainable from HMSO at £1.95.

Within a day of the Home Office announcement, *Wireless World* has already received a protest from the Citizens' Band Association, pointing out that the choice of frequencies means that the UK and European systems are incompatible, and claiming that the new standard will render aircraft more vulnerable to interference than the illegal system.

Engineers study social implications of technology

Electrical and electronics engineers in the USA are to investigate "the impact of technology on society, including both positive and negative effects, the impact of society on the engineering profession, the history of the societal aspects of electro-technology, and professional, social and economic responsibility in the practice of engineering and its related technology".

These are the stated interests of a new group, the Society on the Social Implications of Technology, now being set up by the IEEE in New York. It will publish a journal, the IEEE *Technology and Society Magazine*, the first issue of which will appear in early 1982. The Society's administrative committee will consist of representatives from each of the IEEE's seven technical divisions together with its own officers and elected representatives. Although it will be interested in ethics and will publish articles on the subject, the new society will not have sole responsibility for developing ethical standards within the IEEE. Further information can be obtained from Robert J. Bogumil, 530 W. 112th St., New York, N.Y. 10025, USA.

Two UK organizations recently set up to study this field are the Technical Change Centre (News, April issue) and the New Technology Research Group at Southampton University (May issue, p.53).

Two-way wrist radio by year 2000

A two-way wrist radio will become a reality by the year 2000 as a result of communications satellite developments, according to the Lockheed Missiles & Space Company.

Lockheed engineers in California are developing a 180-foot demonstration version of a communications satellite antenna suitable for transport on the Space Shuttle. Once in space, such an antenna would be unfurled and look much like a huge umbrella. It would act as a highly sensitive receiver of low-power signals from Earth which it would re-broadcast at high levels to designated areas. Thus, a small, low-power radio – even worn on the wrist – using a simple antenna, could transmit voice using the satellite as a signal booster and switchboard that would beam transmissions to selected parts of the earth, such as remote areas without telephone lines.

Other potential uses for the advanced antenna are radiometry – the measuring of temperatures, snowpack, moisture content on Earth – observations of great value to agriculture; radio astronomy, and radio telescope applications.

The antenna with its communication satellite could be launched by the Space Shuttle into a geosynchronous orbit 22,300 miles above the Earth's equator. On site, the antenna would be deployed automatically.

Present communications satellites used in commercial communications, including television, require elaborate antenna systems on Earth. The antenna/satellite system envisaged by Lockheed – because of its great sensitivity and beam-aiming ability – would enable users to communicate nationwide using simple transmitter-receiver units.

Simulator aids reactor safety

An Advanced Gas-cooled Reactor (AGR) training simulator has been ordered from Marconi Space and Defence Systems (MSDS) to assist in training operators at Hunterston 'B' nuclear power station in Scotland.

The order, which comes from the South of Scotland Electricity Board, is valued at approximately £3 million and results from feasibility studies carried out by MSDS since 1973 for both the SSEB and the Central Electricity Generating Board.

The simulator, which will be the first in the world to provide total realism in terms of accuracy and speed in a nuclear power station control room, is to be installed at the Hunterston 'B' site by mid-1983.

The principles used in the design of the AGR simulator can be used equally for a pressurized water reactor (PWR). The PWR is based on American technology and is similar to that involved in the accident at the Three Mile Island power station, Harrisburg, Pennsylvania two years ago. Marconi hopes to gain significant export orders as well as further orders from the UK in support of the universal drive to maintain high training standards for operators in nuclear power plants.

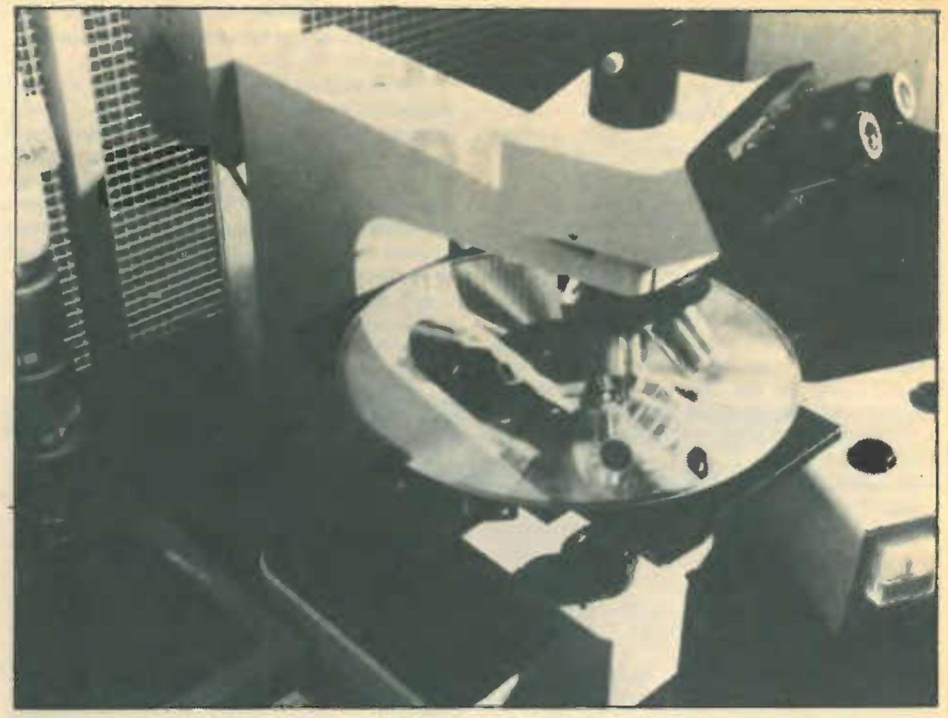
LaserVision delayed

When video disc systems were first introduced into the United States, the suppliers were swamped with demands for more and more discs and could not produce them quickly enough. This led to disappointments and disillusion amongst the customers. This is the principal reason why Philips have decided to delay the launch of their LaserVision system in the UK. Originally planned for Autumn 1981, Philips now say that they will "launch in the UK when we have sufficient numbers of discs to support our initial catalogue of titles".

Jimmy Dunkley, the divisional director of LaserVision, admitted that they had some production difficulties at their Blackburn disc pressing plant which he described, rather coyly, as "progressing up the learning curve". In order to meet the higher level of demand for discs which predictions indicate, additional plant is being installed to increase the pressing capacity. Player production has commenced in two factories in Europe to supply the needs of the UK launch.

Philips have also revealed some of their plans for uses of the disc system. Of course it is highly suitable for feature films, but it may also be used, for example to store the contents of a reference book. A large illustrated encyclopaedia can be stored on the 54,000 frames available on each side of a disc and any particular frame can be found and then displayed on the tv screen. Philips are directing their attention to users of instructional, educational and business communication programmes.

Technical details of LaserVision and other disc systems were published in our September issue.



A LaserVision disc at a visual inspection station at the Blackburn disc-pressing plant. Discs are produced under 'clean room' conditions like those needed for integrated circuit production.

Microcomputers in schools – free

An enterprising businessman in Berkshire, Mr Len Lewis of Audio Systems Components Ltd, in Theale, has come to an arrangement with the local school whereby he will provide ten Commodore Pet microcomputers for the free use of the school. He gets in exchange the classroom space to hold evening classes for courses in computing for adults.

Mr Lewis told us that his project was not entirely philanthropic since he hoped to break even on the basis of well-attended classes, "but I like to think that any profit will be all the better for knowing that the school children are benefiting too". He plans to plough back some of the profits from the evening classes by purchasing peripherals, to finance a users' group and to organise a project team to develop educational software. He also told us that he thought of the scheme after reading our report of the Government's Microcomputers in Schools scheme in the June 1981 issue of *Wireless World*.

Engineering Council chairman

Electronics engineers will note the fact that the chairman of the new Engineering Council is to be Sir Kenneth Corfield, for, although Sir Kenneth is by training a mechanical engineer, he is of course chairman and chief executive of Standard Telephones and Cables Ltd, the ITT subsidiary. The Engineering Council, which at the time of writing is about to receive a Royal Charter, is the Government's response to the proposals of the much debated Finniston report on the engineering profession. It is widely seen as a watered-down, and cheaper, version of what Finniston wanted (for example, the chairman will be unpaid and part-time) with little real power to make much needed changes. Finniston called for an Engineering Authority that would be a statutory body, funded by the government and with members appointed by the Secretary of State for Industry; it would have been accountable to the government for the use of its statutory powers and for money voted to it by Parliament.

The objects of the new Council will be "to advance education in, and to promote the science and practice of, engineering . . . . for the public benefit and thereby to promote industry and commerce" in the UK. Apart from this and other similarly vaguely stated duties, the Council will have the more specific task of forming a register of professional engineers, technician engineers and engineering technicians. Since the existing Engineers' Registration Board is run by the Council of Engineering Institutions, it would appear that the CEI will have to hand over this register – and also its power to award the title "Chartered Engineer" – to the new body. But these transfers will depend on the agreement of the CEI, in the form of a two-thirds majority at an extraordinary general meeting.

High street battle of personal computers

Two items of news which affect the microcomputer came out at about the same time. One was that the mainframe computer manufacturer, IBM, is to market a micro. There have been many analyses of the impact this will have. The Venture Development Corporation in America, who produce many market analyses, have published a study which indicates that by "placing its seal of approval on low end computers, IBM will spark growth in the market for both personal and small business computers. It will be some time, though, before IBM captures a significant share of the personal computer market. IBM will have to strengthen its position with regard to distribution channels and applications software before Radio Shack [Tandy] and Apple will have anything to worry about". VDC also points out that the [American] home user thinks that games are of the first importance and that users would not buy a home computer that didn't have Space Invaders. IBM are selling their computer through the Sears Roebuck mail order catalogue and through the US Computerland chain of retail stores.

Another analysis from Gnostics Concept gives a different answer. They suggest that the basic version of the IBM personal computer has a higher specification and a lower price than the Apple II and the full system is also better and cheaper than the Apple III. So the battle has started but at present IBM have no plans to market outside North America.

The UK domestic market is also hotting up, however, with the news that the Sinclair ZX81 is to be sold in selected High Street branches of W. H. Smith & Son. Boots, Argos and Rumbelows are all planning to test-market the Texas Instruments' TI 99/4. Boots and Smiths are also planning to sell the Commodore VIC 20 computer, but at present there are enough to go round and Commodore will be selling only through computer shops. The VIC 20 has been beset by delays in production and by a lack of software packages to go with it. It is thought that the machine will be launched towards the end of the year.

Another 'dark horse' waiting on the sidelines is the BBC microcomputer which has not been released at the time of writing but offers a high specification at a low price. The BBC plans are to sell through mail order only, but the proliferation of high street outlets might get them to change their minds.

Display aid for microprocessors

Oscilloscope interface for alphanumeric information

by Dr K. Padmanabhan, Ph.D., M.I.E.E., **and A. P. Senthilnathan**

When developing, testing or repairing complex digital circuits, particularly microprocessor based systems, a means of displaying information is helpful and often essential. A convenient method of displaying data is on an oscilloscope, and this interface enables up to four lines of information to be displayed simultaneously.

The circuit is connected to the address and data lines of a microprocessor system and provides X and Y inputs suitable for a 5MHz oscilloscope. The design is based on a simple ASCII character generator which uses a dot matrix display. A surplus MK2002 is shown in Fig. 1, but any character generator which gives column outputs can be used. The display comprises four rows of 16 characters, each formed from a 5×7 dot matrix. Three dot spaces are used between characters and three line spaces between rows. The display does not use Z-modulation to produce the characters, instead character information is achieved by switching the Y-axis for each dot on a line. This by the simulated display produces a positive and negative image as shown in Fig. 2, and either or both can be viewed by adjusting the Y-shift control.

The circuit uses a 555 clock running at 100kHz for the dot timing, and a 4011 time-base generator operating at around 600Hz for the X-axis line generation. The character generator is provided with ASCII data from a 128×8 static r.a.m. and, as the MK2002 is a m.o.s. device, a t.t.l. to m.o.s. interface is provided by two 7426 high-voltage NAND gate i.cs and a 74141 one-of-ten decoder-driver.

Clock pulses are gated to a 4024 7-stage column counter which drives the column decoder through eight steps and changes the column selected for each character. At the end of every 8th count, the r.a.m. address is incremented by the address selector to present the next character on the same row. After accessing and displaying 16 characters on the first line of the first row, the clock gate is disabled by a flip-flop which detects the 128th count from the 4024.

On the next line the clock gate is enabled by the rising edge of the time-base signal and the row counter advances by one. In this way the 4158 advances for ten successive lines, out of which seven provide the display and three provide line spacing. After line 10, the remaining three rows (10 lines each) follow in the same manner except that the memory address count continues from 16 to 64 because address lines A4 and A5 are connected to the second stage of the 4518. This stage counts up to five because only four rows of characters are used.

Column output information from the MK 2002 is selected during each of the seven lines by a 74151 1-out-of-8 switch which is addressed by the 4518. The lines are shifted below each other by adding weighted outputs from the 4518 and driving the Y-amplifier of the oscilloscope. Video shift information from the 74151 output is also combined by the CA3130.

Data from a microprocessor is fed to the memory by a 74365 unidirectional buffer. Six data lines are used as only six lines are needed for the capital letters in ASCII code. The 64 characters stored in r.a.m. are continuously displayed on the c.r.t. until the data is changed by switching the r.a.m. address to the microprocessor via the 74157 address selector, and enabling the 74365 with the latch output. For storing data, the 7475 is loaded with a 1 and software instructions load the r.a.m. Software then resets the latch by loading a 0 into it which also switches the r.a.m. addresses back to the counters.

The address decoder selects the display r.a.m., which here is given the addresses 0800 to 087F. However, in many microprocessor systems full address decoding is not necessary. Fig. 3 gives an example of the software necessary for displaying data and a legend on four lines in locations 0180 to 01C0 using an 8085 processor.

Part two describes hardware modifications for 8-line operation and programming details for a 2716 character generator.

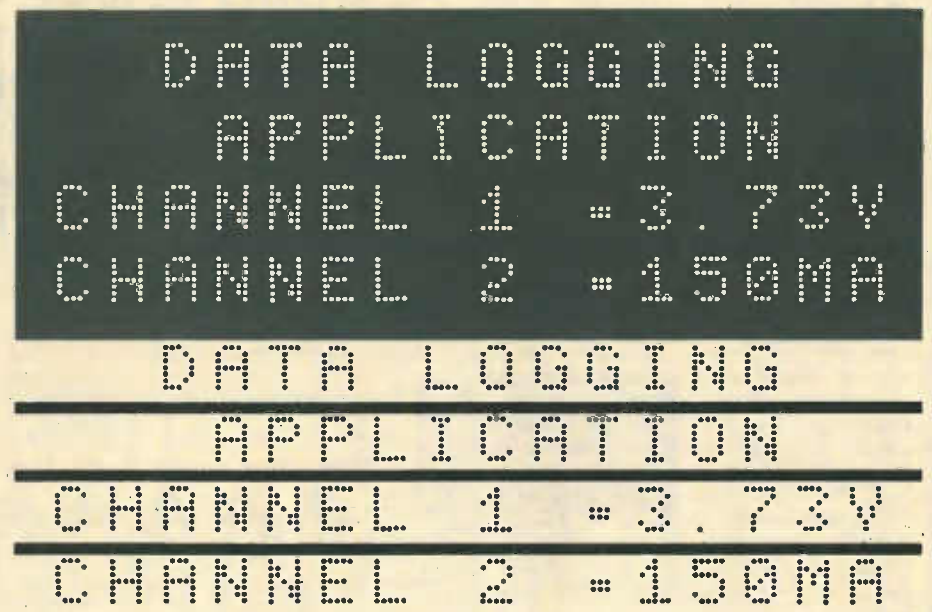


Fig. 2. Dot matrix display format. Because the Y-axis is switched to produce dots on a line, positive and negative displays are shown simultaneously.

Fig. 3. Software example for an 8085 processor.

```
PUSH  D
PUSH  B
PUSH  H
SUB   A
INC   A              Make Accumulator = 1
LXI   H 00 18        Point to latch address
MOV   M,A            Sets selecting latch
LXI   D 00 08        Point to display r.a.m.
MVI   B 40
LXI   H 80 01
MOV   A,M            Store the character in
                     r.a.m. address
STAX  D
INX   D
INX   H              Increment memory
                     address
DCR   B              Count for 64
JNZ         LOOP
SUB   A
LXI   H 00 18
MOV   M,A            Resets the selecting
                     latch for counter access
                     to r.a.m.
POP   H
POP   B
POP   D
HLT
```

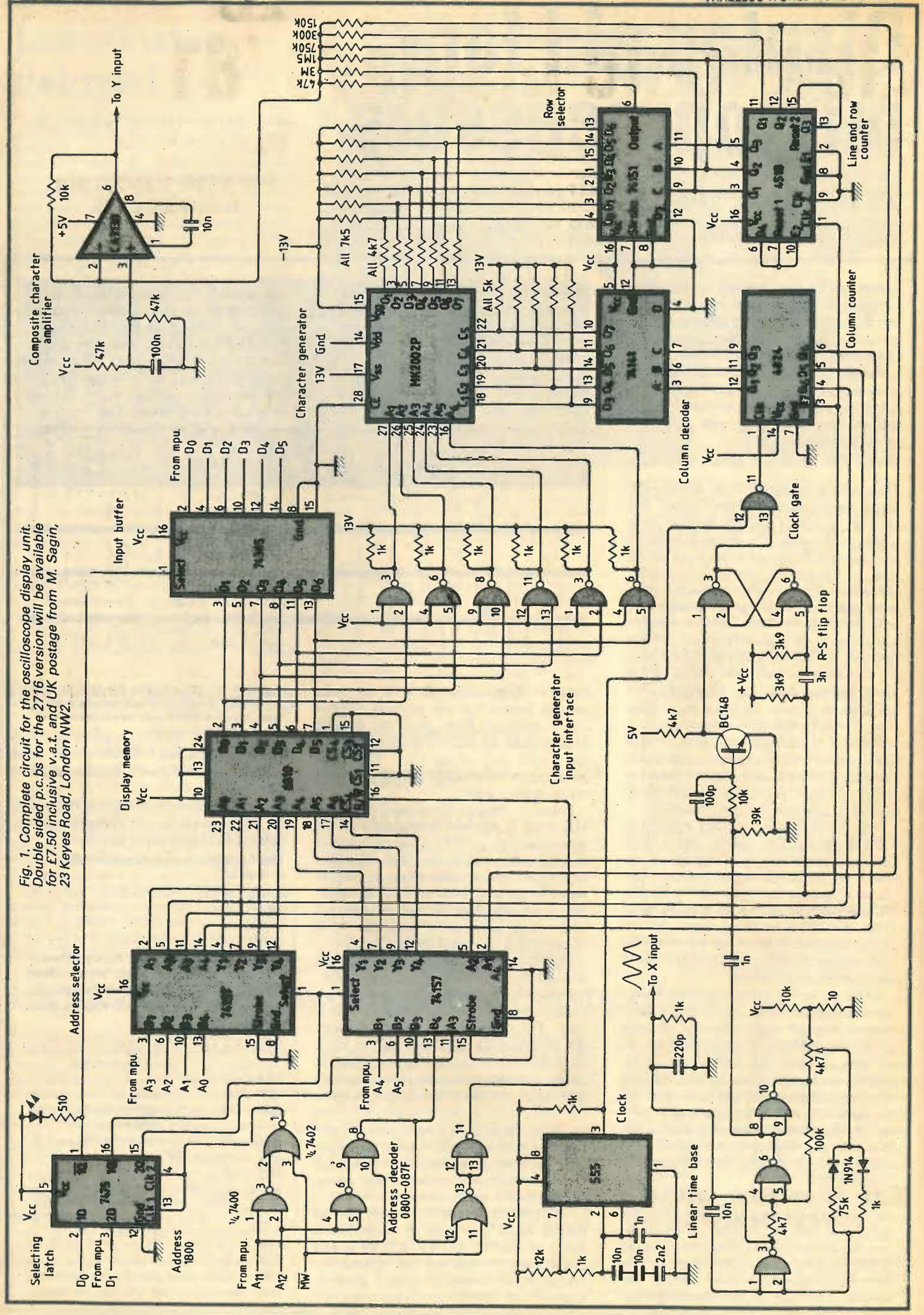


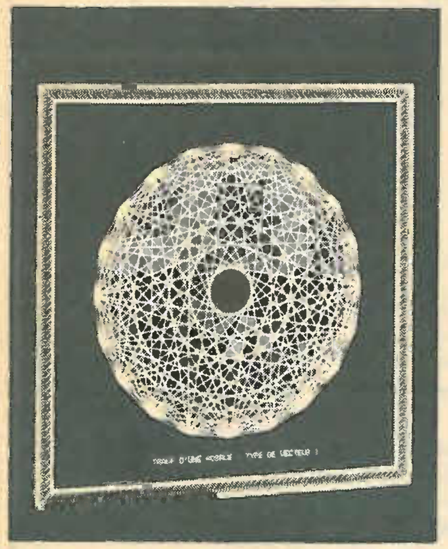
Fig. 1. Complete circuit for the oscilloscope display unit. Double sided p.c.bs for the 2716 version will be available for £7.50 inclusive v.a.t. and UK postage from M. Sagin, 23 Keyes Road, London NW2.

Electronic Displays '81

With the continued success of Electronic Displays, this year's show was held in the more spacious Kensington Exhibition Centre, and attracted 55 exhibitors. Unlike some other areas of electronics, the display market does not seem to be seriously affected by the economic troubles. Several exhibitors were showing new products which had just been "unpacked" and they could not yet give prices or delivery.

L.c.ds – the fastest growing technology

Because the traditional weaknesses of liquid crystal displays are steadily being overcome, they are now receiving a great deal of attention from many equipment makers. This trend was reflected by the large number of exhibitors, nearly a third, who were offering custom or ready-made displays. Most development effort at present is aimed at increasing the step-response and temperature range of the fluids, and increasing the size of displays which is limited by the sealing process on the glass plates.



A 235mm square plasma panel from Thomson-CSF which offers a resolution of 512 lines x 512 points.

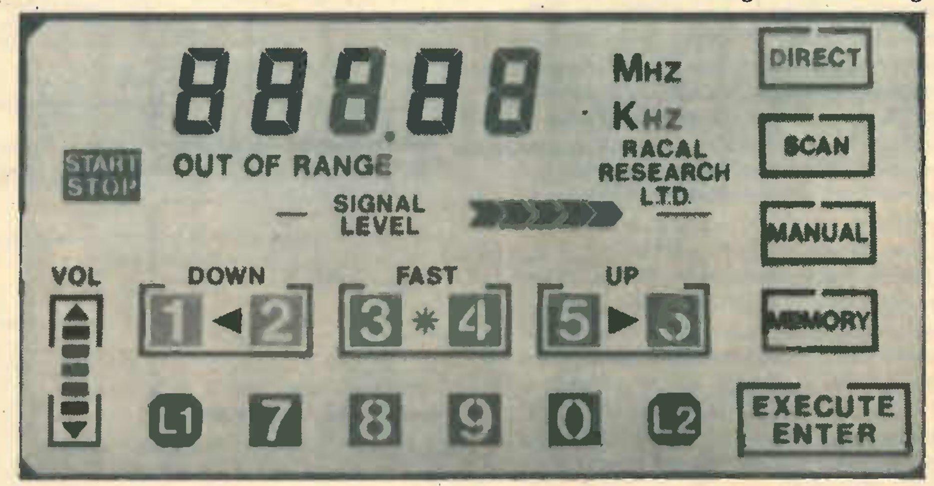
Most manufacturers are improving their hermetic sealing technique and consequently are offering much larger display sizes. Several exhibitors were demonstrating 7-segment and dot-matrix displays with character heights above 80mm. Lucid displays announced a new range of devices with an extended temperature range of −30 to +85 deg. C.

More distributors want a piece of the action

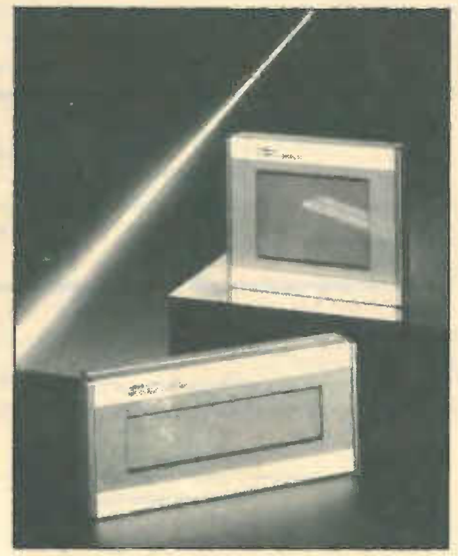
New names in the l.c.d. business include Bulgin, ITT and Racal. Bulgin are now marketing the Data Images (a splinter company from LXD) range of displays which includes two and four-inch character sizes. These displays are supported with electroluminescent backlights and Bulgin's own range of bezel assemblies.

ITT Meridian have recently signed an agreement with the Japanese manufacturer Epson who claim to have produced the first range of long-life l.c.ds. These devices offer an expected lifetime of 100,000 hrs instead of the usual 50,000 hrs. Racal's stand generated a lot of interest following their announcement of a new l.c.d. division which can offer a custom design and manufacturing service for colour and large area displays.

Two innovations from this division are a display electronic module (d.e.m.) and a reconfiguring display/keyboard. D.e.m. combines a l.c.d. and thick-film technology to produce a single display driver module. The l.c.d. backplane forms a thick-film substrate which carries the necessary circuits to produce, for example, a complete frequency counter and display module. This system allows the display to be used in the transmissive mode without the obstruction of a p.c.b. Racal's reconfiguring display/keyboard combines a l.c.d. with a touch-sensitive switch, when pressed, reconfigures the display to show a new set of prompts in a similar way to the "menu" on a computer v.d.u.



▲ An example of Racal's reconfigurable keyboard/display.



Flat screen electroluminescent displays from Sharp. ▼

Flat-panel displays are replacing c.r.ts

Flat-panel displays using liquid crystal, electroluminescent and plasma technology were all demonstrated as alternatives to the conventional bulky c.r.t. display. Hitachi, a newcomer to the show, claim to manufacture over 50% of the world l.c.d. output, including flat-panel types. One disappointment, however, was the "non-arrival" of Hitachi's prototype l.c.d. colour television. Exhibits which did arrive included a new range of colour 7-segment displays and a 64×200 dot-matrix display for larger characters. To support their range of displays, Hitachi have also developed a 4-bit c.m.o.s. microprocessor which will directly drive l.c.ds.

G.E.C. have produced an 80-character d.c. electroluminescent display panel which only requires 8 and ±60V supplies. Each of the 80 characters is formed by a 5×7 dot matrix and they are arranged in four rows. The display panel is supplied with two circuit boards which provide supply regulation, data organization, character generation and display drive. A 128-character set is standard, but special character sets can be provided.

A 235mm square a.c. plasma panel from Thomson-CSF comprises 512 lines of 512 points. This panel can be used for displaying graphics where each point is individually addressed. Alternatively, for alphanumeric operation, 64 lines of 85 5×7 characters or 32 lines of 64 7×9 characters can be produced.

The three-day exhibition was supported by a conference which presented 24 papers covering display device technology, teletext, display systems, and display applications. Reprints from these sessions and those presented at the 78, 79 and 80 exhibitions are available from Network, Printers Mews, Market Hill, Buckingham, Bucks.

C.b. frequency synthesis

Generating 40 channels for 27MHz

by E. F. da Silva, M.Sc., Ph.D.

This article reviews the digital frequency synthesizer systems which can be used to generate the crystal-controlled frequencies required for 40-channel British citizens' band operating at 27 MHz. A practical design is also described which provides 40 channel operation.

The lower and upper frequency limits of c.b. are 27.601250 and 27.991250MHz, with a channel spacing of 10kHz and a frequency tolerance of 1.5kHz per channel. The carrier is frequency modulated with voice transmission and the maximum frequency deviation is 2.5kHz. In addition to the frequencies shown in Table 1, another set of forty frequencies (transmit frequencies and receiver intermediate frequency) must be supplied for the local oscillation in the superheterodyne receiver. In view of the requirements for frequency stability, manually controlled variable-tuning oscillators are not practical and, if direct crystal-controlled oscillators are used, frequency multiplication and/or mixing will generally be necessary to produce the required frequency deviation. Unfortunately, frequency multiplication and mixing produce harmonics and increase the cost, so a cheaper and more practical method is desirable. The availability of high-frequency low-power c.m.o.s. i.cs now makes frequency synthesis a practical alternative. An ideal synthesizer for c.b. would comprise one or two i.cs but, as there are no dedicated devices available at present, standard components must be used.

The basic frequency synthesizer as shown in Fig. 1. comprises a voltage-controlled oscillator operating at frequency f_0. This frequency is divided by a programmable divider-counter N, to produce a frequency f_n which is compared with a reference frequency f_r. The difference between these two frequencies is translated into a d.c. voltage which controls the v.c.o. so that $f_n = f_r$. Because $f_0 = Nf_n = Nf_r$, f_0 is locked to the reference frequency by the programmable divider. In practice f_r is normally chosen to be the frequency channel step or spacing, i.e. 10kHz for 27MHz c.b., or a sub-multiple of the channel spacing so that integer changes in N will step the output frequency to the required operating frequency.

Direct synthesis for c.b.

The block diagram of a direct synthesis system, shown in Fig. 2., is similar to Fig. 1. except that a prescaler, K, is connected between the programmable divider and v.c.o. The prescaler is necessary because c.m.o.s. programmable counters are not readily available for direct operation at 27MHz. Also, crystal oscillators operating at a reference frequency of 10kHz are generally bulky and expensive, so it is more convenient to use a higher crystal frequency and divide it for the reference frequency.

As mentioned earlier, the channel spacing is 10kHz, the lowest transmit frequency is 27.601250MHz and the highest transmit frequency is 27.991250MHz. The factors of these frequencies are 2 × 5 × 5 × 5 × 5 × 22081Hz, and 2 × 5 × 5 × 5 × 5 × 2239Hz respectively. With c.m.o.s. programmable counters restricted to around 10MHz at 5V, a ÷10 prescaler would give programmable-counter ratios of 22081-22393 to cover the band of transmitting frequencies, and the reference frequency would then be 125Hz. However, this low reference frequency will limit the capture range of the phase comparator, present difficulty in low-pass filtering and also cause a large change in N because $N = (f_{channel} \div K \div f_r)$. Therefore, eight steps in N will be required for each channel change. A similar system has been described by RCA for American citizens' band transceivers.

Table 1. Allocated frequencies for the 27MHz citizens' band

27.601250	27.701250	27.801250	27.901250
27.611250	27.711250	27.811250	27.911250
27.621250	27.721250	27.821250	27.921250
27.631250	27.731250	27.831250	27.931250
27.641250	27.741250	27.841250	27.941250
27.651250	27.751250	27.851250	27.951250
27.661250	27.761250	27.861250	27.961250
27.671250	27.771250	27.871250	27.971250
27.681250	27.781250	27.881250	27.981250
27.691250	27.791250	27.891250	27.991250

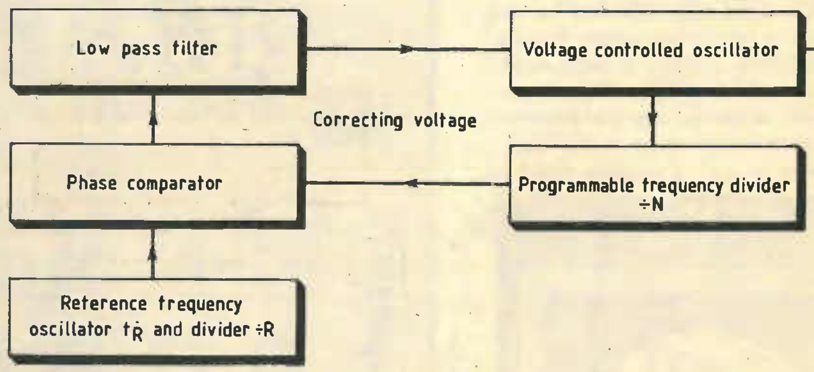


Fig. 1. Basic frequency synthesizer system.

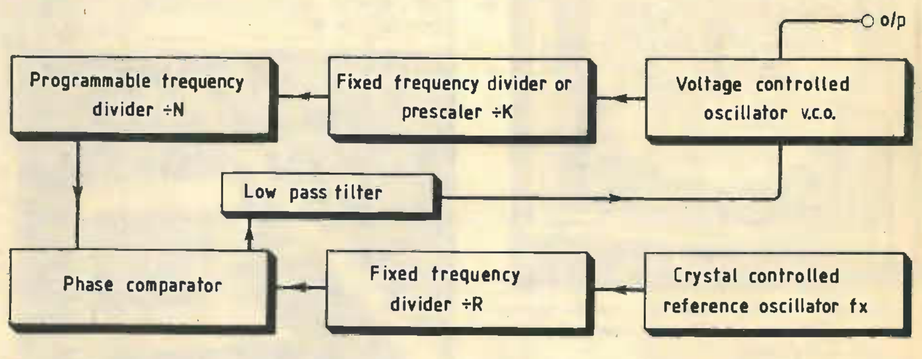
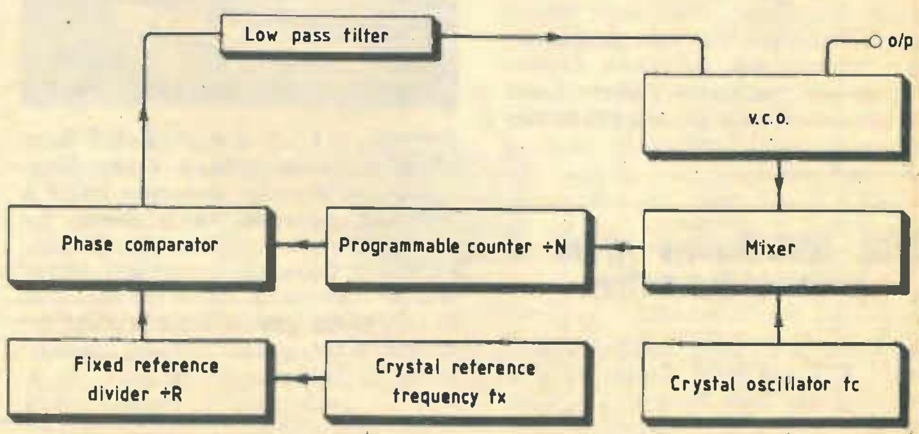


Fig. 2. Direct frequency synthesizer which uses a prescaler between the programmable divider and v.c.o.

Fig. 3. Mixing type of frequency synthesizer. The output frequency is mixed with a crystal oscillator signal to produce an intermediate frequency.



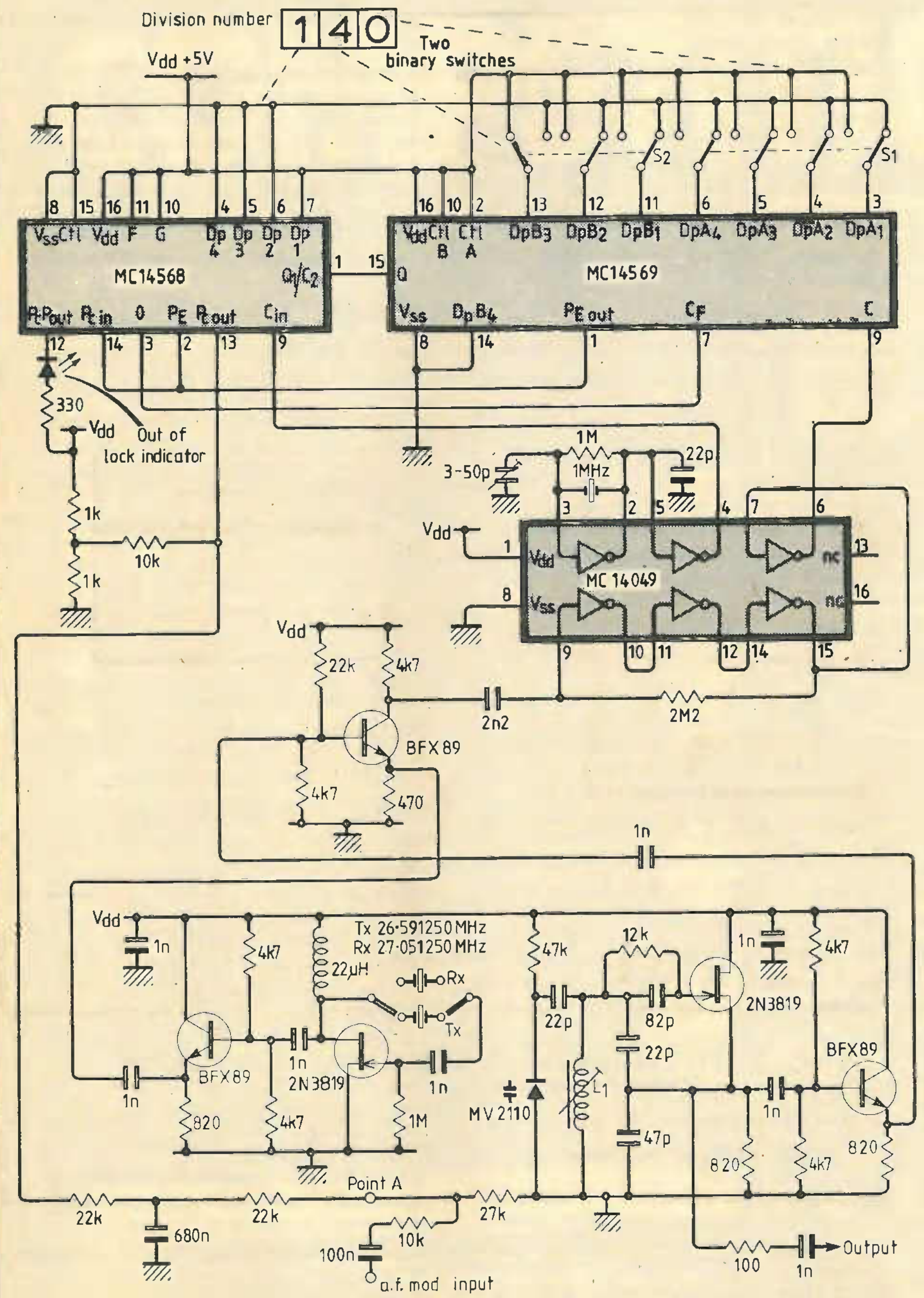


Fig. 4. Practical design for a mixing synthesizer. L_1 is 13 turns of 0.25mm wire on a Neosid A7 assembly.

Synthesizer mixing methods

A block diagram of a frequency synthesizer using mixing is shown in Fig.3. The output frequency f_0 high, 27.991250MHz, is mixed with a 26.591250MHz crystal oscillator, f_c, to produce an i.f. of 1.4MHz which can be fed directly to the programmable divider-counter. The advantages of such a system are, the reference frequency can be made equal to the channel spacing, a prescaler need not be used for c.m.o.s. programmable counters, the total division factor is greatly reduced which increases the loop bandwidth, more easily divisible frequencies can be chosen and the frequencies are lower, which eases production techniques. A disadvantage is the additional cost of a mixer and crystal oscillator. However, this cost is greatly offset by the saving in logic circuits which would normally be needed to generate the local oscillator signal.

Local oscillator frequencies

The set of forty local-oscillator frequencies for the transceiver when receiving can be obtained in several ways. The programmable counter can be made to perform an additional count when the transceiver is operating in the receive mode. For example, with f_0 at 27.991250MHz, f_r at 10kHz, a division ratio of 140, and a receiver i.f. of 460kHz, the local-oscillator frequency must be 27.991250 + 0.460, i.e. 28.451250MHz.

This frequency can be generated by letting N count initially to 140 (the figure set by the operator), inhibiting its output and then setting N to count an additional 46 steps (460kHz ÷ 10kHz), i.e. a total of 140 + 46. At the end of this count an output pulse is fed to the phase comparator. The additional 46 steps can be produced automatically by using multiplexing devices such as the 4019. This system produces local-oscillator frequencies greater than the transmit frequency by the chosen i.f., but it can be more costly with the additional i.cs.

An alternative scheme uses early zero detection where, instead of letting the programmable counter reach its full count of 140, the count is stopped at 140 -46, i.e. the 94th step. Therefore, the frequency f_n will initially be greater than the reference frequency and it will cause the phase comparator to decreases the v.c.o. frequency until it is 460kHz below its initial frequency of 27.991250MHz.

A third scheme, only applicable to frequency mixing systems, is simply to switch in an alternative crystal which is offset from the transmit frequency by the receiver i.f. This method permits either high or low injection of the receiver local oscillator and is relatively easy to implement.

Practical circuit

A frequency synthesizer using the mixing method described above is shown in Fig. 4. The crystal reference-oscillator frequency f_x is produced by a 1MHz crystal. No tuning controls are needed, and the frequency divider chain ÷ R is incorporated within the 14568 phase comparator i.c.

The division ratio has been programmed to 100 and the reference frequency is therefore 10kHz. The programmable divider-counter divides over the range 101 to 140. The units and tenth part of the division ratio is incorporated in the 14569 and is controlled externally by binary switches connected to the DpA and DpB inputs respectively. The hundredth part of the progammable counter in incorporated in the 14568 in conjunction with the phase comparator. This part of the counter is hard-wired to divide by 1, so no switch is necessary. The local oscillator frequencies are obtained by switching in the 27.051250 MHz crystal in place of the 26.591250MHz transmit crystal.

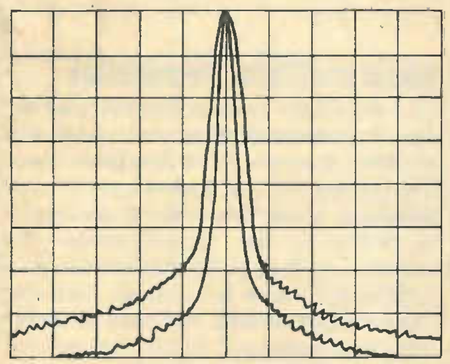


Fig. 5. Typical spectrum around the carrier for the circuit in Fig. 4.

To adjust the synthesizer, set the thumbwheel switches to 20, i.e. a frequency-division ratio of 120, and check that the transmit crystal is being used. Adjust L_1 in the v.c.o. until the l.e.d. turns off and then set the voltage at point A to 2.6V. If a counter is available, check that the output frequency is 27.791250MHz. Set the programmable counter switches through positions 1 to 40 and check that the frequencies agree with Table 1. Switch in the receive crystal, step the programmable counter switches from 1 to 40 and check that the output frequencies are 460kHz above the corresponding values in Table 1. The synthesizer is now adjusted and should produce a spectrum similar to that shown in Fig. 5.

Further reading

1. Home Office Publications, "Open Channel Radio", citizens' band radio, HMSO, July, 1981.

2. Dance, B., "Digital Tuning Systems", *Electronic Industry*, p.41-46, June, 1981.

3. RCA application note ICAN 6374, "Applications of the COS/MOS CD4059 programmable divide by N counter", Digital frequency synthesis for FM tuners and CB transceivers.

4. RCA application note ICAN 6716, "Low Power Digital Frequency Synthesizer utilizing COS/MOS ICs".

Books

Semiconductor Data Book,

compiler A. M. Ball
184 pp., paperback
Newnes Technical Books, £5.50

Those familiar with the Radio Valve and Semiconductor Data Book, last published in 1975, will be pleased to know that a new edition – the eleventh – is now published. Valves have finally taken their leave and left the field open for a full range of discrete semiconductor devices.

In format, the book is very similar to its predecessors, giving a number of the most important characteristics against each type number, the main listing being followed by a section on pinout details and list of devices comparable to each type – though this is not cross-indexed.

Electric Circuit Theory,

by R. Yorke
331pp., hard and paper backs
Pergamon Press Ltd, £13.00 (£6.50)

Dr Yorke's intention was to provide first-year university students with a course of reading on circuit theory "of modest complexity and length". The mathematics needed for an appreciation of the text do not, therefore, extend beyond A-level.

Chapters on a.c. and d.c. circuits by the steady-state and transient analysis of linear circuits in the time and frequency domains by means of exponential and Laplace transforms. Chapters on network analysis include introductions to Kirchhoff, Thevenin and Norton, topology, the superposition theorem and the frequency response of networks with attention to poles and zeros and the Bode plot. The final chapter deals with the transmission of power in polyphase lines.

Throughout the book, the author is careful to include a large number of problems (answers given) and a short bibliography is provided.

Radio and Television Servicing,

Ed: R. N. Wainwright.
815pp., hardback
Macdonald, £17.50

This is the latest in a long series of books well known to those engaged in repairing domestic receivers. It consists of manufacturers' servicing information – circuit diagrams and alignment details at least and, in some cases, a more detailed description – of several hundred 1980/81 models of radio and television receiver, clocks, tape recorders and music centres from most of the manufacturers, with a supplement containing information which has appeared since the data sheets were published.

Computer Consciousness,

by H. D. Covvey and N. H. McAlister
212 pp., paperback
Addison-Wesley, $4.95

Computers are complicated devices; and people are jealous of status. The two together have established a new social class of computer pundit, in whose interest it is to baffle the public with computerspeak. In turn, this has led to the appearance of a great number of books which set out to dispel the fog and explain computers in simple terms. This is one such book.

Unfortunately, since computers are indeed complicated, it is barely possible to explain them simply. No amount of weird cartoons or whimsical headings will make the subject easier to understand. This is a tentative book: in common with far too many of its kind, it spends much of its time looking at computers from a distance without ever coming into contact with them, and gives the feeling of listening to an endless overture when one would really like the opera to begin.

Faced with a computer, most lay people (to whom this book is directly addressed) will ask "What will it do?" They will not find the answer here – there is much vague generalization and background, but not much to help a businessman decide whether a computer would assist him or not. There is a need for a text which will debunk the subject in a helpful and concrete manner. This is not it.

Linear Integrated Circuits

by Sol D. Prensky and Arthur H. Seidman. 336 pp., hardback
Prentice/Hall International, £14.95

This is a practical book on the applications of linear i.cs for the engineer or technician written at about the same level as *Wireless World*. It covers op-amps, including testing and breadboard work, power amplifiers, consumer and communications circuits, regulators, digital interfacing, phase-locked loops, and a-d and d-a conversion. An appendix lists commercial devices by type number and gives one-line descriptions and cross-references with the text. Much of the material appears to have been obtained from manufacturers' application notes. Seidman is a professor of electrical engineering and the book is an expansion of an earlier manual by Prensky, now deceased.

Analog I/O Design

by Patrick H. Garrett. 272 pp., hardback
Prentice/Hall International, £16.45

With the increasing use of digital computers to process information in electronic systems, there is a new field of technology growing up concerned with making analogue devices and circuits work in conjunction with them. This book is on the design of analogue systems primarily for computer input and output applications. It is written to provide both a one-term course on analogue application and computer interfacing for students and a reference work on detailed design for practising engineers. Most chapters end with a set of problems. The book covers instrumentation amplifiers, active filter design, transducers, analogue signal processing, data conversion devices including a-d and d-a, and reconstructing the original signals from digital outputs. Three experiments are given in appendices.

High-frequency Application of Semiconductor Devices

by Ferenc Kovacs. 391 pp., hardback
Elsevier, 78 US dollars

Written by a Hungarian author from a research institute in Budapest, this expensive book is a fairly deep and rather academic treatment of the operation of discrete and integrated semiconductor devices at high frequencies. Basic design principles of many practical circuits are discussed in the 24 chapters. The bulk of the space is given to amplification, and the remainder to oscillators, frequency convertors, multipliers etc. The book is well illustrated and has numerous tables and mathematical analysis. It has an extensive, 15-page list of references.

Diode function generation

Simple strategy for choosing break-points

by Muhammad Taher Abuelma'atti, B.Sc., Ph.D., University of Riyadh

This strategy for picking the necessary break-points in designing a diode-resistor networks avoids negative resistance values in the result which saves computational time. This simplifies diode-resistor network design and makes it more systematic than previously.

Resistor-diode networks are often designed to meet a given non-linear input-output specification. While modelling diodes with the diode equation gives a solution which is both accurate and general[1,2], the choice of break-points becomes a problem where the input is limited[1] ($V_{in} \leq 10V$), especially for highly non-linear functions. Contrary to the ideal diode model[3] where any two points on a curve such as Fig. 1 can be connected by a straight line, it becomes obvious using the diode equation that if two points are chosen too close together they cannot be realised. If two points are realised close together this sets up a condition whereby the next points cannot be realised[1]. This is mainly due to the need for negative resistance values which are not practically feasible. To avoid this difficulty a simple strategy for picking the break-points is needed.

Convex non-linearities

The non-linear input-output characteristic of Fig. 1(a) can be met by the diode-resistor network shown in Fig. 2(a). Design equations, rewritten from Bello[1], are

$$R_{2i}=R_{1i}\left[\frac{V_{DC}}{V_{2i}}-1\right],\ i=1\rightarrow N \quad (1)$$

$$I_{Di}=I_o[\exp(V_{Di}/\eta V_T)-1],\ i=1\rightarrow N$$

$$\frac{V_{1i+1}-V_{2i+1}}{R_A}=\sum_{j=1}^{i} I_{Dj}+\frac{V_{2i+1}}{R_B},\quad i=1\rightarrow N$$

$$\frac{V_{2i+1}-V_{DC}-V_{Dj}}{R_{2j}}+\frac{V_{2i+1}-V_{Dj}}{R_{1j}}=I_{Dj}$$
$$j=1\rightarrow i,\ i=1\rightarrow N. \quad (2)$$

For the ith diode initial conditions in equation are taken from the $(i-1)$th calculation ($i>2$). Combining equation (2) written for $j=1$ and with equation (1) solving for R_{1i} in terms of known quantities gives

$$R_{1i}=\frac{V_{DC}}{I_{Di}}\ \frac{V_{2i+1}-V_{2i}-V_{Di}}{V_{DC}-V_{2i}},\ i=1\rightarrow N. \quad (3)$$

For R_{1i} and R_{2i} to be positive, equations (1) and (3) show that the following two conditions must be satisfied:

$$V_{DC}>V_{2i} \text{ and } V_{2i+1}-V_{2i}>V_{Di},\ i=1\rightarrow N.$$

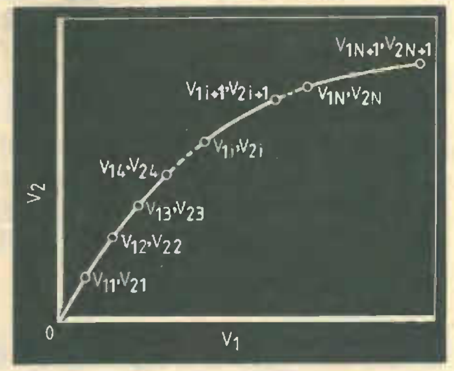
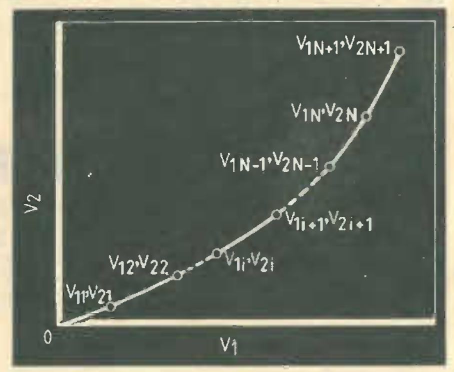


Fig. 1. Monotonically increasing non-linear characterisitcs, with N+1 break-points, synthesized by diode-resistor networks.



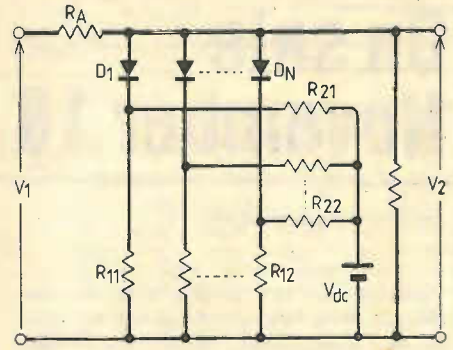
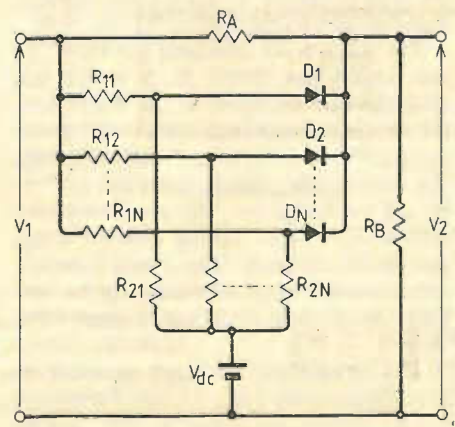


Fig. 2(a) Diode-resistor network for realising monotonically increasing convex characteristic of the type shown in Fig. 1(a). (b) Diode-resistor network for realising monotonically increasing concave characteristic of the type shown in Fig. 1(b).



This means that the supply voltage must be greater than the maximum output voltage. Also the break points must be chosen so that the difference between output voltages at two successive break-points will be greater than the voltage drop across the conducting diode (about 0.2V for Ge and 0.6V for Si diodes).

This strategy was extensively used to design diode-resistor networks to meet given monotonically increasing convex characteristics. Fig. 3(a) shows a typical example for meeting the non-linear function

$$V_o=V_i-0.04V_i^3+0.001V_i^5$$

with maximum input voltage of 4V.

Concave non-linearities

The non-linear input-output characteristic of Fig. 1(b) can be met by the diode-resistor network of Fig. 2(b). Design equations, rewritten in a generalized form from Abuelma'atti[2], are

$$R_{2i}=R_{1i}\frac{V_{2i}+V_{DC}}{V_{1i}-V_{2i}},\quad i=1\rightarrow N \quad (4)$$

$$\frac{V_{2i+1}}{R_B}=\frac{V_{1i+1}-V_{2i+1}}{R_A}+\sum_{j=1}^{i} I_{Dj},\ i=1\rightarrow N$$

$$I_{Di}=I_o[\exp(V_{Di}/\eta V_T)-1],\ \ i=1\rightarrow N$$

$$=\frac{V_{1i+1}-V_{2i+1}-V_{Dj}}{R_{1j}},$$

$$j=1\rightarrow i,\ i=1\rightarrow N. \quad (5)$$

$$\frac{V_{2i+1}+V_{Dj}+V_{DC}}{R_{2j}}+I_{Dj}$$

For the ith diode, initial conditions in equation (5) are taken from the $(i-1)$th calculation. Combining equation (5) written for $j=i$ with equation (4) for R_{1i} in terms of known quantities gives

$$R_{1i}I_{Di}=V_{1i+1}-V_{2i+1}-V_{Di}-\frac{(V_{2i+1}+V_{Di}+V_{DC})(V_{1i}-V_{2i})}{V_{2i}+V_{DC}}$$

If the supply voltage V_{DC} is chosen so that

$$V_{DC}\gg V_{2i+1}+V_{Di} \quad (6)$$

then

$$R_{1i}I_{Di}\approx V_{1i+1}-V_{2i+1}-V_{Di}-V_{1i}+V_{2i}. \quad (7)$$

For R_{1i} and R_{2i} to be positive equations (4), (6) and (7) show that the supply voltage must be sufficiently larger than the maximum output voltage, and the break-points must be so chosen that the difference between input voltages of two successive points is greater than the difference

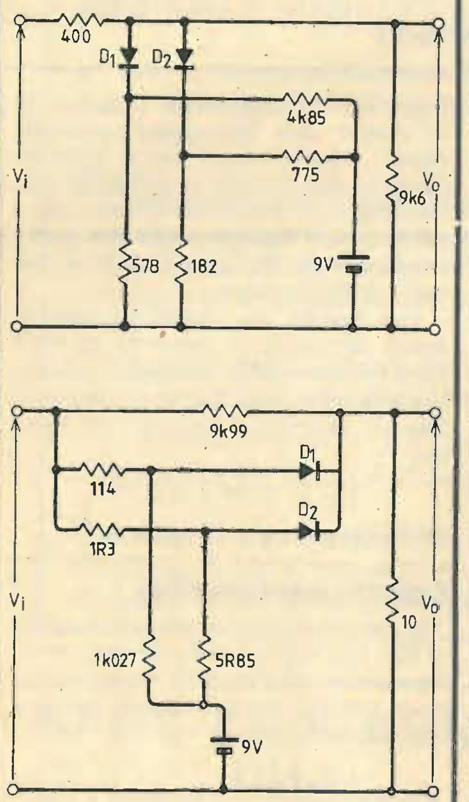


Fig. 3(a) Diode-resistor network for realising function with maximum input voltage of 4V. (b) Diode-resistor network for realising the function $V_o=V_i-0.04V_i^3+0.001\,V_i^5$ with maximum input 3.5V. Diodes are type 1N5404.

between the corresponding output voltages by an amount at least equal to the voltage drop across the conducting diode.

This strategy was extensively used to design diode-resistor networks to meet given monotonically increasing concave characteristics. Fig. 3(b) shows a typical example where the non-linear characteristic was expressed by

$$V_o=0.001V_i^5$$

with maximum input voltage of 3.5V.

The means of selecting break points for diode-resistor networks presented here is intended to simplify the design of function generators. Networks for monotonically increasing concave and convex functions illustrate the validity of the selection procedure.

References

1. V. G. Bello, Design of a diode function generator using the diode equation and interation, *IEEE Transactions on Circuit Theory*, vol. CT-19, March 1972, pp. 213/4.
2. M. T. Abuelma'atti, Synthesis of a concave monotonically increasing function using the diode equation model, *International Journal of Electronics*, In press.
3. A. E. Crump, Diode function generators, *Wireless World*, vol. 73, December 1967, pp. 594-8.

IN OUR NEXT ISSUE

Millimetre-wave lens aerials. An easier way of constructing metal plate refractor aerials, which hitherto have not been popular because of manufacturing difficulties. Dr Ken Smith gives design and construction details for aerials in the 20-30GHz region.

Understanding light units. Electronics engineers are having to use optical devices and techniques more and more but have difficulty in understanding the various units for measuring light. This interpretive guide is written specially to help them.

Direct digital frequency synthesizer generates sine waves in numerical steps, a 1MHz output, for example, being produced by stepping through the sine table at a rate of 45° every 125ns and feeding the result into a d-a converter. Range: 0-3MHz.

On sale November 18

continued from page 49

Having first set the overhang, the cartridge is then twisted round slightly until the two sighting holes at 110 and 49 mm radii both align with the centre of the turntable spindle as the arm is swung inwards. Due to the offset of the overhang-setting slot, this twisting round of the cartridge may slightly alter the overhang, but the appropriate correction is easily made in a second shot if necessary.

The amount of overhang provided by the dimensions shown is in accordance with the rule proposed in the above article: $h=2600/C$ where C is from arm pivot to turntable axis, in mm. Needless to say, the basic design can be used for any required overhang rule, the position of the slotted hole and setting marks being changed accordingly. The 2 mm holes are only intended to act as setting marks, and could be omitted in favour of short cross lines.

The author has made up a gauge in accordance with Fig. 2, and finds it a major improvement. He can now be certain, for the first time, that the required cartridge position and offset angle are correct to something within 1° of error, whereas previously an error of several degrees would have been possible.

● **Cartridge alignment problem.** A misunderstanding over whether author's corrections had been incorporated into proofs led to errors which must have made understanding R. J. Gilson's October article difficult. Figure numbers were omitted and although the diagrams were in the right order some of the text references were incorrect. On page 60 column 1, read Fig. 2 in line 5 for Fig. 1, Fig. 2 for Fig. 3, and in column 3, Fig. 2 for the lower reference to Fig. 3. Take the multiplication signs for addition signs in the Appendix on page 61, formulae 4 a, b and c, and also prior to 2 & 2.5° on page 60, column 1. Also in the Appendix, for the upper formula 1, read $(L^2+R^2-C^2)/2LR$, whilst in formula 4c β_{in} should have been β_i. Just below the Appendix in column 3, insert a stop after 13mm to end that sentence. Apologies to Mr Gilson for this marring of his constructive review of the tracking problem.

Multichannel digital tape recorder

Design requirements of the digital circuitry

by A. J. Ewins, B.Tech., Research Laboratories, London Transport

In the first part of this article, the author described the aims and design concept of this economical instrumentation recorder, which employs a modified audio cassette deck with added digital electronics. In this second part, the additional circuitry is outlined.

Having determined the number of channels per track of the tape-recorder, the number of bits per data word, the length of the sync. word, and the data and tape-clock frequencies, the digital circuitry could now be designed. Figure 2 shows the main body of the recording circuitry in block form, the heart of which is the block marked 'control circuitry'. Starting with a crystal–controlled oscillator of 3.2768 MHz, this circuitry generates the two clock frequencies, DC and TC, which are divided down and operated on by various logic elements to generate the numerous pulse trains that control the flow and direction of the serial data. The inverse clocks outputs, $\overline{DC}$ and $\overline{TC}$, clock the serial data through the various shift registers. In this way, all gates and switches are opened or closed on negative transitions of $\overline{DC}$ or $\overline{TC}$, whilst the serial data advances on positive transitions. A reset pulse is generated every 72 cycles of DC (or 80 cycles of TC) and serves to synchronize the various logic elements of the control circuitry.

An example of some of the pulse sequences produced by the control circuitry is shown in Fig 3. This illustrates the control of the clock pulses as seen by the two 72-stage temporary buffers (store 1 and store 2) and the sync. word buffer. Store 1 is shown being filled with serial data under the control of $\overline{DC}$, up to the moment of reset, and then being emptied under the control of $\overline{TC}$. Store 2 is shown being emptied under the control of $\overline{TC}$ up to the moment of the 72nd pulse. Having emptied store 2, the remaining eight pulses of $\overline{TC}$, up to the moment of reset, are used to empty the sync. word buffer. After reset, store 2 is then filled with data under the control of $\overline{DC}$. In this way, the sync. word is inserted into the data stream every 72 bits or six data words. A frame of data thus consists of one sync. word followed by six data words, one for each channel sampled. The eight bits of the sync. word are permanently present at the parallel inputs of the 8 bit shift register, and the control circuitry controls the re-entry of these 8 bits into the register once the sync. word has been serially inserted into the data stream.

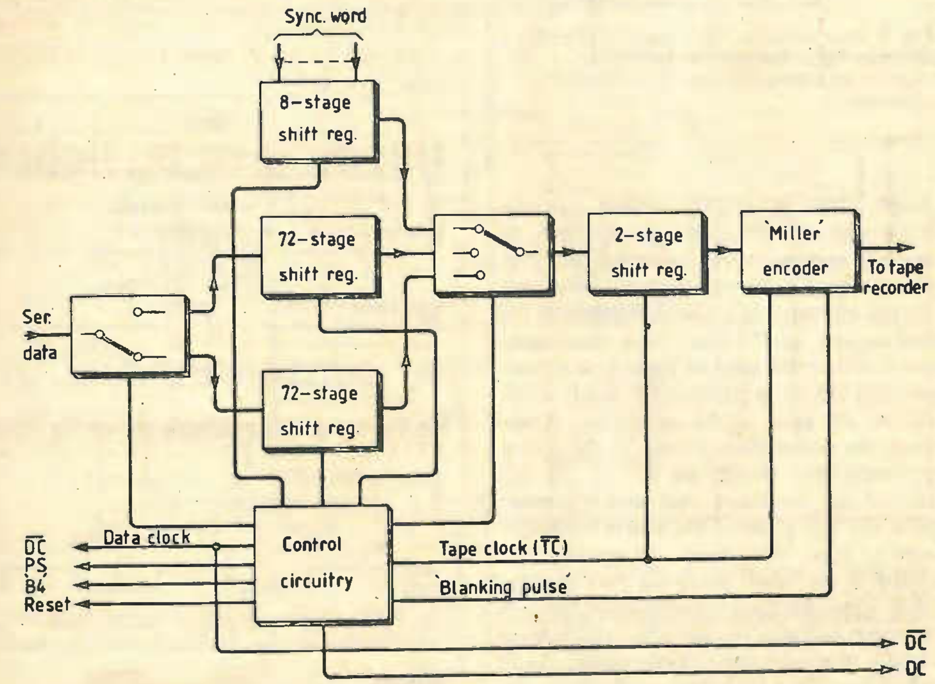


Fig. 2. *Main part of recording circuitry, which controls data flow to recorder.*

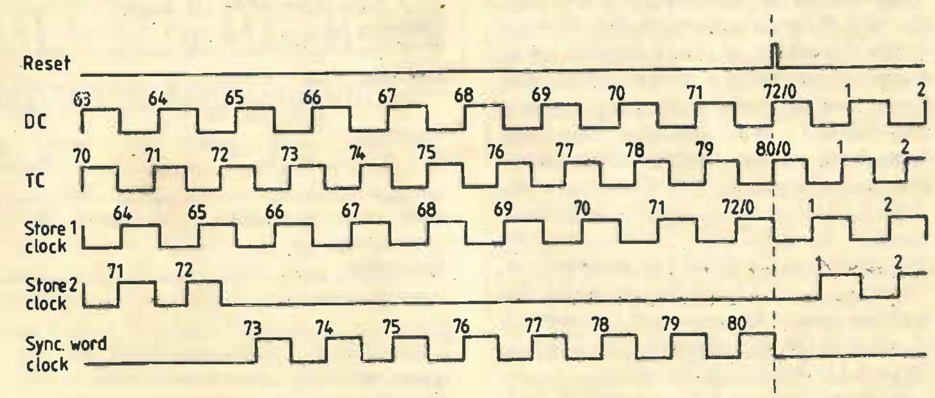


Fig. 3. *Pulse trains generated by system in Fig. 2, showing sync. word being inserted into data after 72 bits in store 2.*

The control circuitry also generates four sequences of logic pulses, $\overline{DC}$, PS, 'B4' and RESET, which go to the preceding stage (Fig 4) to control the multiplexing of the six analogue channels, the digitization of the selected channel and its conversion from parallel to serial form. Figure 5 shows the logical sequence of control pulses, RESET, PS, 'B4' and $\overline{DC}$, together with the DATA READY pulse, $\overline{DR}$, generated by the analogue-to-digital converter. The RESET pulse is the same as that referred to earlier and occurs every six data words. Having initially synchronized the analogue multiplexer, its continuing presence checks that the multiplexer is always in its original state at the start of each data frame. PS is the parallel/serial control pulse to the 12 bit shift register. When at the logic 1 level, a positive transition at the clock input transfers the data present on the parallel inputs into the re-

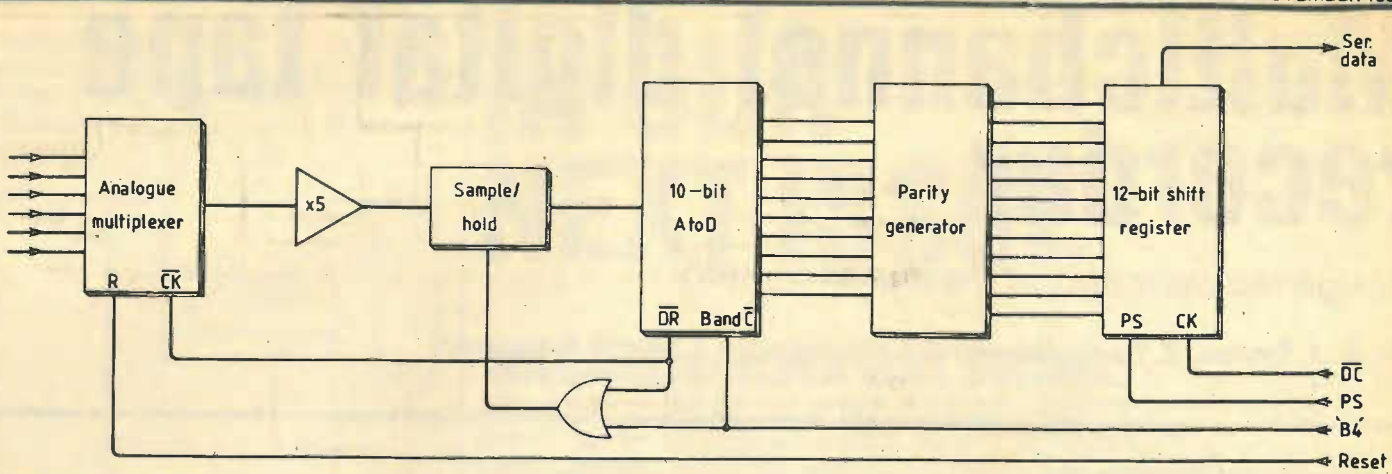


Fig. 4. *Four outputs from 'control circuitry' block in Fig. 2 are used to multiplex, digitize and serialize data in six input channels.*

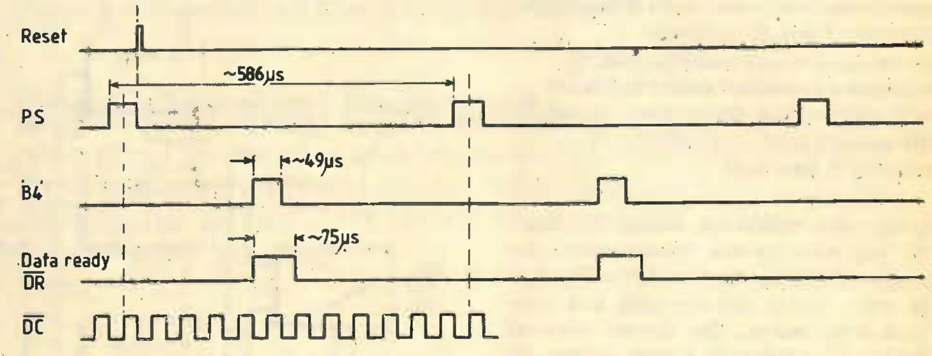


Fig. 5. *Timing of control pulses from Fig. 2 system, used to control circuit in Fig. 4.*

gister. When at the logic 0 level, positive transitions of $\overline{DC}$ transfer the data serially through and out of the shift register. The control pulse B4 is derived from the control circuitry in a similar fashion to PS and occurs, as PS does, once every data word. When B4 goes to logic 1, the sample/hold circuit is put into its 'hold' mode via the OR gate. At the same time, it initiates the conversion process of the a-to-d converter and blanks its output. At the start of the conversion and until it is complete the $\overline{DR}$ pulse of the a-to-d converter goes to logic '1' to keep the sample/hold circuit in the 'hold' mode via the OR gate. Only when the data is ready and $\overline{DR}$ goes negative to logic '0' does the sample/hold circuit revert to the sample mode. As it does so, the analogue multiplexer is clocked to sample the next analogue channel.

Because of the sequencing of the RESET and PS pulses, the data that is being serially shifted out of the 12 bit shift register immediately after a RESET pulse (and during the conversion of the analogue data from channel 1) is the last data word, from channel six, of the previous data frame. The resulting sequence of data words between RESET pulses is thus in the order of channels 6,1,2,3,4 and 5. This may be resequenced to the desired arrangement of channels 1,2,3,4,5 and 6 by connecting the analogue output from channel 1 to input 6 of the multiplexer, channel 2 to input 1, channel 3 to input 2, and so on.

Referring back to Fig 2, it will be seen that a small 2-stage shift register is placed immediately after the switch gating the output from the two storage buffers and the sync. word buffer. This register is included to remove the undesirable changes in logic level that might otherwise occur as the outputs from these buffers are switched. Remember, the serial data is clocked out of the buffers on the positive transitions of $\overline{TC}$ and therefore changes in the logic level should only occur at these instances. The switch selects the appropriate buffer on the negative transition of $\overline{TC}$, producing possible logic level changes at the wrong moment. Without the 2-stage shift register in between the gate and the

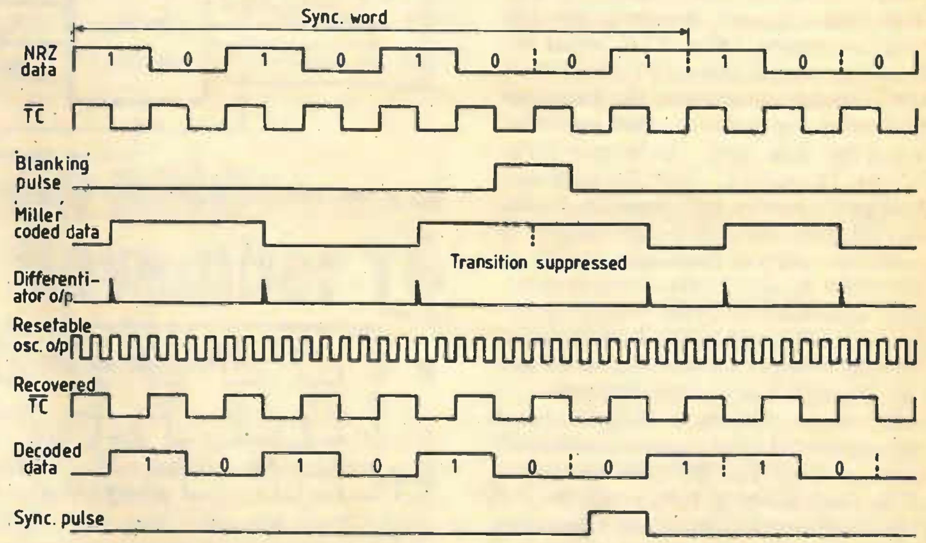


Fig. 6. *Sequence 1001 must be used in sync. word to generate sync. pulse on replay. Blanking pulse suppresses a transition, causing a 'gap' which is used to generate pulse. Rest of waveforms are used by Miller decoder, which produces recovered data, recovered tape clock and a sync. pulse at its output.*

Miller encoder, the Miller encoder would incorrectly interpret these logic level changes.

As mentioned earlier, it was decided that the sync. word should be 8 bits long and include the sequence 1,0,1. In order that the sync. word may be recognized on playback and decoding of the serial stream (it is quite possible for the sync. word sequence to occur within the normal data stream) it is also essential that it includes the sequence 1,0,0,1. The need for the 1,0,1 and 1,0,0,1 sequences could be satisfied by a six-bit sync. word consisting of 1,0,1,0,0,1. However, since it was necessary for it to be 8 bits long it was chosen to be 1,0,1,0,1,0,0,1.

The need for the sequence 1,0,0,1 can be best explained by examination of the various pulse trains shown in Fig. 6. These are generated during the encoding and decoding of the NRZ serial data and are shown in their correct time sequence. The first row is an example of the NRZ serial data that emerges from the 2-stage shift register of Fig. 2 immediately before encoding. The third row shows a blanking pulse that is generated once every complete data frame (i.e. 80 cycles of TC) and

coincides with the centre of the 1,0,0,1 sequence in the sync. word. The blanking pulse is fed to the Miller encoder and suppresses the transition that would normally take place at the centre of the two zero bit cells of the 1,0,0,1 sequence. The suppression of this transition creates a unique gap in the Miller coded transitions, as shown in row four, and is used on replay to generate a synchronizing pulse. This sync. pulse is shown in correct relation to the decoded data stream in the last row of Fig. 6.

The remaining pulse trains of Fig. 6 are associated with the block-circuit diagram of Fig. 7, which shows the tape-recorder interface circuit (the peak detector), a differentiator, resettable oscillator and Miller decoder. During recording, the Miller-coded data stream is presented to the recording electronics of the tape-recorder without any attempt at reshaping. However, upon replay the Miller-coded data looks like a series of positive and negative peaks (associated with the original positive and negative transitions) due to the frequency-response characteristics of the tape-recorder circuits. The peak detector detects these peaks and reconstructs the data to look exactly like the original Miller-coded data. The recovered Miller-coded data is then differentiated to produce a series of short-duration, positive pulses, associated with every positive or negative transition (see row 5, Fig. 6). These pulses synchronize a resettable oscillator running at four times the frequency of the recovered tape clock. The outputs from both the differentiator and the resettable oscillator are fed to the Miller decoder. Apart from the decoded serial data, the outputs from the Miller decoder are the recovered tape clock, RTC, and a sync. pulse.

The three pulse trains, shown in the last three rows of Fig. 6, together with the crystal-controlled data clock, DC and DC from the recording stages, are fed to the circuit shown in Fig. 8, which is the block diagram of the four temporary storage buffers (72-stage shift registers), an 8-stage shift register and the associated control circuitry. As directed by the control circuitry, the temporary storage buffers receive the serial data under the control of the recovered tape clock. Both the serial data and RTC contain wow and flutter from the tape recorder, but will remain in sync. with each other provided the wow and flutter content does not rise above about 6%. The serial data first passes through the 8-stage shift register, which has parallel outputs so that as the 8 bit sync. word passes through it may be recognised by the control circuitry. Providing this recognition coincides with the recovered sync. pulse produced by the Miller decoder, an overall sync. pulse is produced that aligns the logic elements of the control circuitry in their correct sequence of operation.

The four temporary storage buffers are filled with data in sequence. Eighty RTC clock pulses clock a complete data frame into a buffer, and as each buffer is only 72 bits long, the leading sync. word passes all

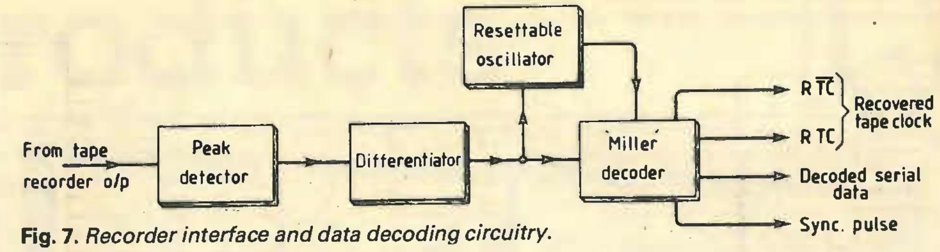
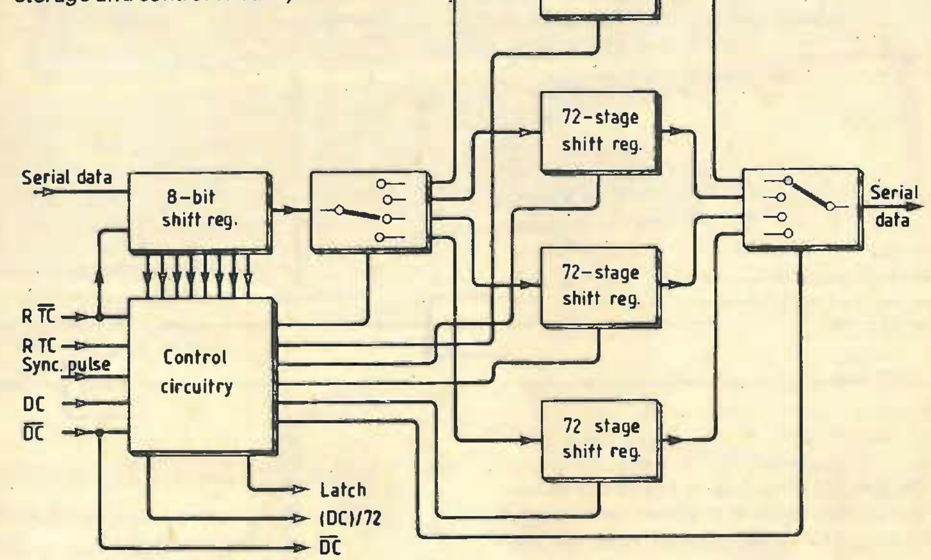


Fig. 7. *Recorder interface and data decoding circuitry.*

Fig. 8. *Sync. pulse recognition (eight-bit shift register and control), temporary storage and control circuitry.*



the way through and out and is thus removed. When the first two storage buffers are full of data, the control circuitry allows the first buffer to be emptied under the control of DC. A time difference of (2×72)/20,480, or about 7ms, is thus created between the filling and emptying of the buffers. This time gap has proved to be more than sufficient to absorb the small timing errors produced by the wow and flutter of the tape cassette deck.

Three control pulses, $\overline{DC}$, LATCH and (DC)/72, are passed from the control circuitry of Fig. 8 to the succeeding circuit of Fig. 9, which controls the reconversion of the serial data stream into the 12 bit data words, their conversion from digital to analogue form and their final demultiplexing via sample/hold circuits. The serial data first passes through a 12 bit serial-in, parallel-out shift register. At the correct moment, the 12 bits present at the parallel outputs are clocked across to a 12 bit latch. A 10 bit parity checker recalculates the two parity bits, compares them with the two recorded parity bits and passes the two resultant GO/NO-GO answers to the DEMUX control circuitry. At the same time, the 10 bit data word is converted to an analogue output via the digital-to-analogue converter, which is presented to the inputs of the six sample/hold circuits.

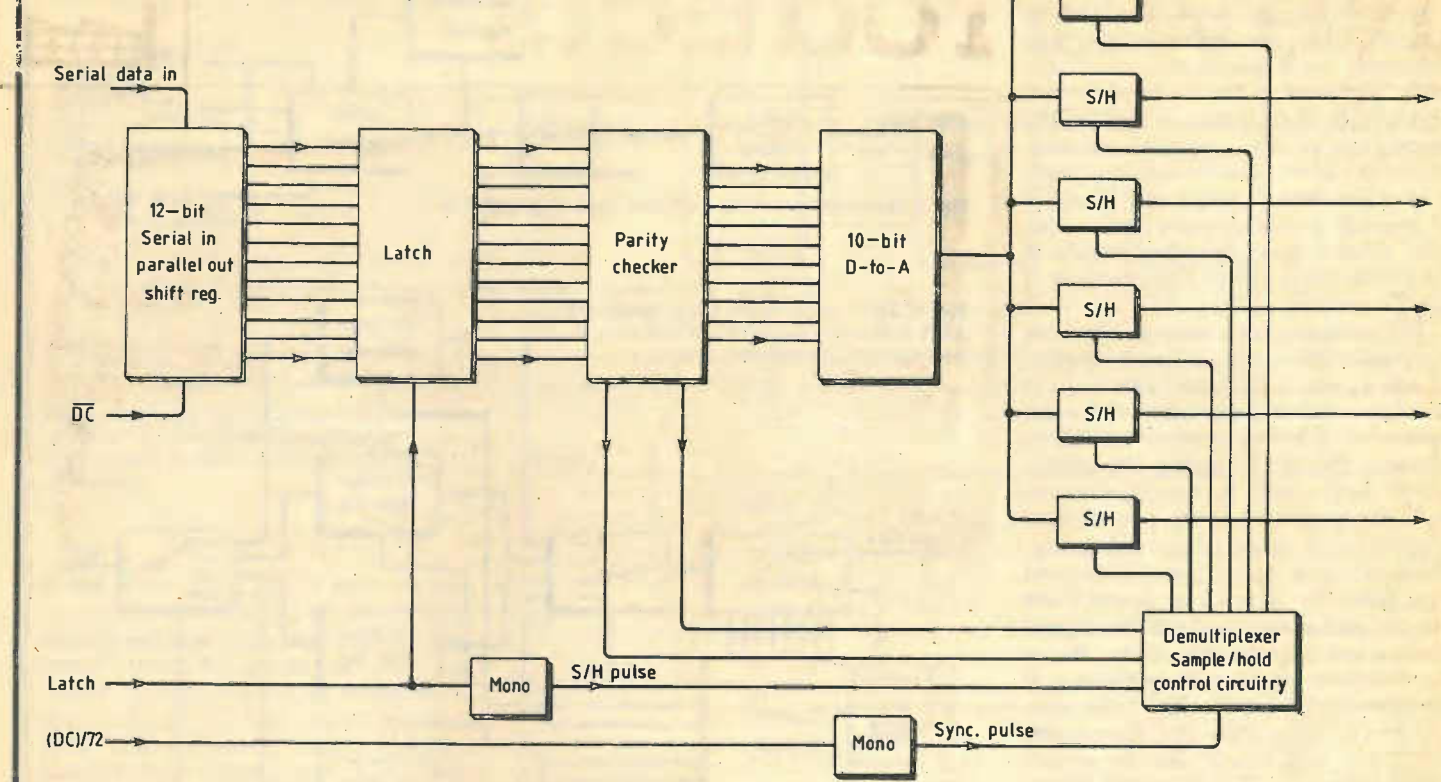
Synchronized by the (DC)/72 pulse and clocked by the LATCH pulse, the DEMUX control circuit switches the correct sample/hold circuit into its sample mode. If, however, the parity checker gives a NO-GO answer on one of its two outputs, the sample/hold circuit is inhibited and remains in its hold mode. Figure 10 shows the sequence of a number of pulse trains controlling the operation of the circuit of Fig. 9. The synchronizing pulse is produced by a monostable triggered by the positive transition of the (DC)/72 pulse. Sample/hold pulse, SH, is produced by another monostable triggered by the negative transition of the LATCH pulse. Both monostables have pulse lengths of approximately five DC pulses.

Because the 12 bit serial-in/parallel-out shift register introduces a delay of exactly one data word with respect to the synchronizing pulse, the data from channel six appears at the expected output of channel 1; channel 1 appears at the expected output of channel 2; channel 2 appears at the expected output of channel 3; and so on. This is of no consequence whatsoever and it is a simple matter to re-label the output channels accordingly.

Speed control circuitry

The principle of operation of the speed-control circuitry is shown in the block diagram of Fig. 11. Ignoring, for the moment, the input to the reference frequency selector from the record/playback electronics of the digital circuitry, it will be seen that accurate speed control is achieved by means of a phase-locked loop. The frequency produced by the tachogenerator is compared with a reference frequency from the voltage-controlled oscillator (v.c.o.) of a p.l.l. integrated circuit, using the phase-sensitive detector (p.s.d.) in the i.c. The

Fig. 9. *Serial-to-parallel conversion, digital-to-analogue conversion and demultiplexer.*



output from the p.s.d. is fed to the motor drive circuit where it is filtered and amplified to provide the required drive for the motor.

The purpose of the frequency selector circuit was to enable the cassette tape-recorder to stand alone whilst at the same time providing an input for an external reference.

Very conveniently, the frequency produced by the tachogenerator when the recorder is running at a tape speed of 1⅞in/s is around 456Hz, which is very close to the 455.1Hz produced by dividing the tape clock of 22,755.5Hz by 50. During the recording process this crystal-derived frequency of 455Hz is therefore used as the reference frequency for the motor speed control. To obtain perfect long-term speed stability on playback, it is necessary to lock the recovered tape clock, from the recorded data, to the crystal-controlled tape clock. It might be thought that all that is necessary to achieve this is to substitute the output from the tachogenerator with that of the recovered tape clock divided by 50. However, this proved not to be the case: due to an increased amount of wow and flutter in the actual transport of the tape, with a slightly different frequency content, a satisfactory lock of the p.l.l. could not be obtained, except by altering its natural frequency (i.e. by changing the filter components). Even when this was tried, the p.l.l. was not as stable as that in the recording process.

A very satisfactory solution was found, even if it was a little unorthodox, by creating a second p.l.l. with a very much lower natural frequency. In this second p.l.l., the crystal-controlled tape clock is compared with the recovered tape clock, after dividing both clocks by 50, via a

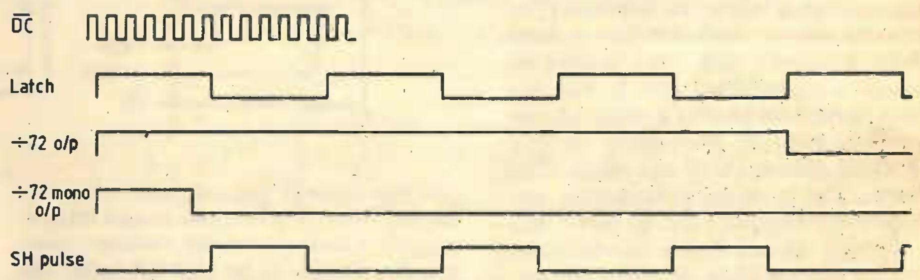


Fig. 10. *Pulse train in Fig. 9.*

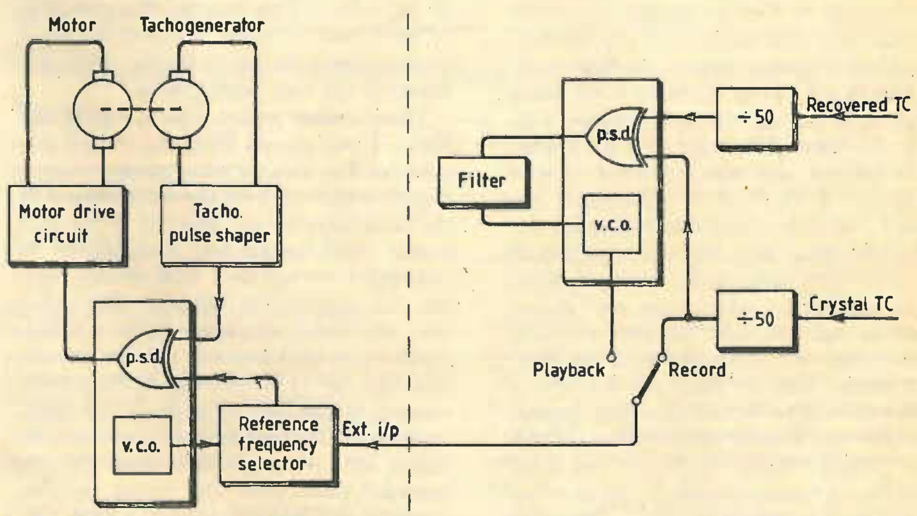


Fig. 11. *Speed control circuitry.*

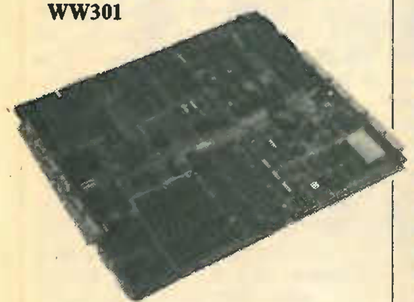
p.s.d. The output from the p.s.d. is filtered (determining the loop's natural frequency) and used to control a v.c.o., the frequency output from which is used to provide the required reference for the motor speed control circuit. The lower natural frequency of the second p.l.l. completely removes the influence of wow and flutter from the recovered tape clock, whilst the higher natural frequency of the first p.l.l. allows the motor speed control circuit to operate under optimum conditions. Visual and audible signals are provided by both p.l.ls to inform the operator that they are 'in-lock'.

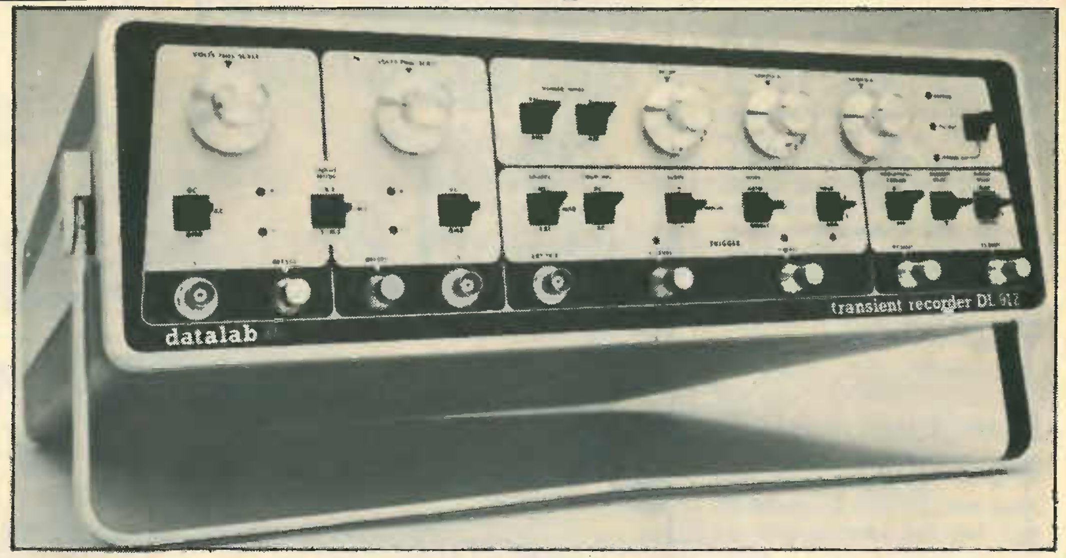
To be continued

New Products

Single-board computer

Not so long ago, electronics engineers strove to design systems with numerous readily replacable printed-circuit boards to speed up repairs. But according to Dicoll Electronics there has been a trend towards single-board computers and they have responded by producing the DE530SBC 16-bit computer board, using Western Digital's WD9000 i.c. set. The board, costing around £2,600, includes colour graphics, analogue and parallel/serial i/o, disc controller and p.r.o.m. programming facility, and runs Pascal 'P' code. Up to 128K-bytes of memory can be accommodated (64K r.a.m. and 64K r.o.m.) and a 24-row×80-column display produced using up to eight colours. Power supply requirements are 5V, ±15V and 25V. Dicoll claim that a system incorporating their board would run 10 times faster than a DEC LSI-11/2. Dicoll Electronics Ltd, Bond Close, Kingsland Estate, Basingstoke, Hants RG24 0QB.
WW301





Two-channel waveform store

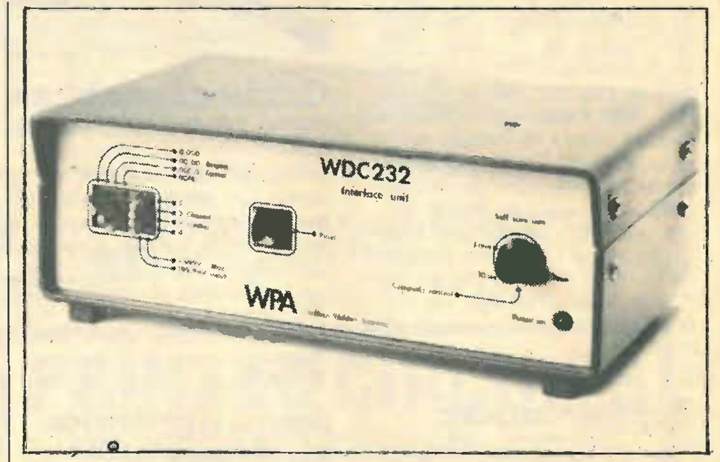
An addition to Datalab's 900 series, the DL912, has two channels and a 20MHz sampling rate a-to-d converter for recording signal frequencies up to 5MHz. Each channel has a 4096-word×8-bit memory providing a resolution of 1 in 250 vertical and 1 in 4000 horizontal. Both channels can be loaded simultaneously with waveforms from separate sources through two input amplifiers and stored information can then be displayed on an oscilloscope or chart recorder. Stored waveforms can be presented alternately with d.c. offset, so only a single-channel oscilloscope is required. The two memories can be combined for long waveforms or divided for short waveforms and the time-base frequency may be altered at a predetermined point on the sweep. Delay and pre-trigger recording are among other facilities of this unit. A digital interface is standard but may be replaced by options including RS232 and IEEE488 (GPIB) compatible types. Data Laboratories Ltd, 28 Wates Way, Mitcham, Surrey CR4 4HR.
WW302

Computer interface

Up to four analogue signals in the range 0 to ±2V can be accommodated by WPA's WDC232 laboratory instrument interface. Data is transferred to the computer through an RS232 link in 7-bit ASCII form from a 3½-digit b.c.d. a-to-d converted with a resolution of one part in 4000. Data from the converter is collated and formatted by a microprocessor which also controls input-channel selection. Up to four of these units can be used together for processing sixteen analogue inputs. Serial data to the computer is automatically adjusted to any rate within 1200 baud. When the WDC232 is fed directly into a printer the transmit rate is fixed at 110 baud. Walden Precision Apparatus Ltd, Shire Hill, Saffron Walden, Essex CB11 3BD.
WW303

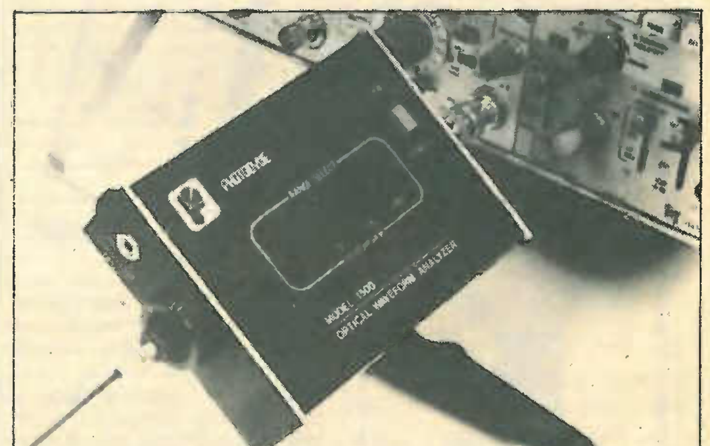
U.h.f. transistors

Transistors for u.h.f. applications, namely the HXTR-3101 with a 1.8dB noise figure and maximum gain of 19.5dB at 1GHz, and the HXTR-3102 with a 1dB compressed gain of 11.5dB at 21dBm output power and 1GHz, are available from Hewlett-Packard at around £3.88 and £4.85 respectively in one-off quantities. Both n-p-n devices are supplied in HPAC-100X metal-ceramic packages. Application notes are also available. Enquiries Section, Hewlett-Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.
WW304



Optical/electrical signal converter

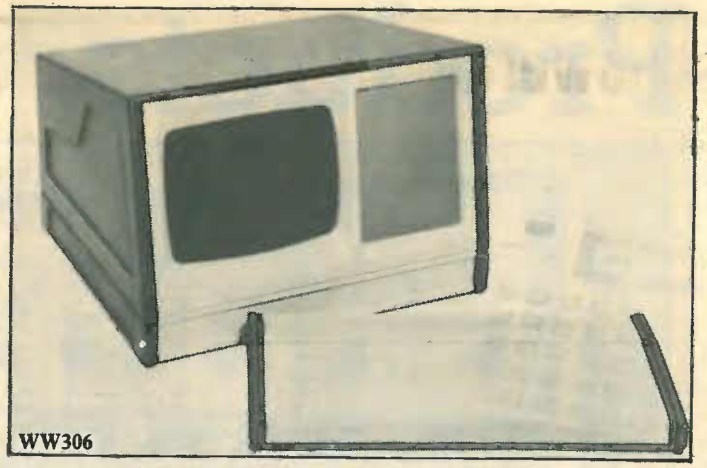
A unit for converting signals from fibre-optic cables, l.e.ds or lasers into electrical signals for displaying on an oscilloscope, spectrum analyser, etc. is manufactured by Photodyne Inc. and distributed in the UK by Lambda Photometrics Ltd. The 1500XP has a frequency response of 0 to 200MHz with 2ns rise and fall time, and is calibrated in millivolts-out per microwatt-in over four push-button-selectable ranges of 1, 10, 100 and 1000mV/μW. Applications include waveform and loss analyses in optical fibres, and l.e.d. output rise and fall-time measurement. The distributors also announce availability of a calibrated optical attenuator (0 to 90dB) with flat response in the range 800nm to 1300nm from the same manufacturer. Lambda Photometrics Ltd, Lambda House, Batford Mill, Harpenden, Herts AL5 5BZ.
WW305



WW303

Housings for terminals

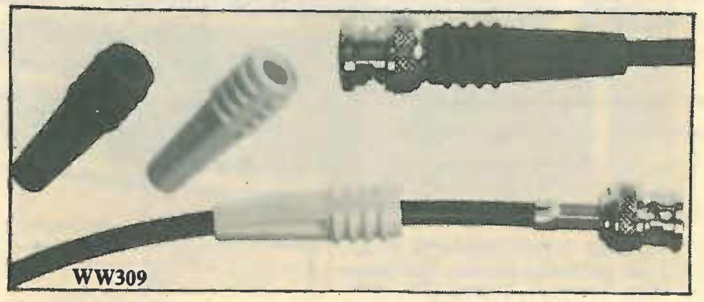
Injection-moulded keyboard and v.d.u. housings with panels for mounting disc-drives can be obtained from West Hyde Developments Ltd. The distributors of these German manufactured foam-plastic enclosures have options available for mounting 12in c.r.ts with panels for floppy-disc drives and with plain front mouldings for hard-discs, power supplies, etc. Keyboard enclosures have the same widths and styling as the terminal housings. West Hyde Developments Ltd, Unit 9, Park Street Industrial Estate, Aylesbury, Bucks HP20 1ET.
WW306



WW306

Disc-data separator

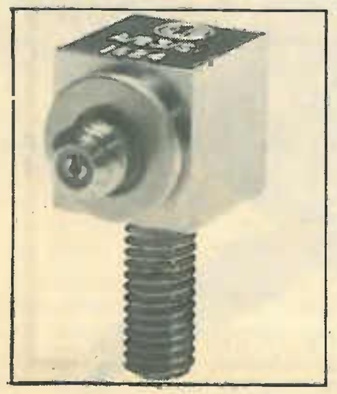
Pulses from a floppy-disc consist of clock and data information which must be separated before it enters the controller. Thame Components now market an i.c. from SMC which carries out this function and replaces they say, up to 10 t.t.l. i.cs. The 8-pin d.i.l. FDC9216 operates from a 5V supply and is t.t.l.-compatible and programmable for use with either 8in or 5¼in drives with single or double density. An 8MHz crystal clock is required by the i.c.Thame Components Ltd, Thame Park Rd, Thame, Oxon OX9 3XD.
WW307



WW309

Accelerometer

The A-23SI accelerometer from D. J. Birchall Ltd is a case-isolated version of the A-23 series of transducers originally designed for use on aircraft engines. Low base-strain/cross-axial sensitivities and long-term repeatability are claimed to be inherent features of the patented Konic element used in the device and specifications include 7pC/g charge sensitivity, 4.5g weight, 50kHz resonant frequency and −55 to +300°C temperature range. The stainless-steel housing is welded and stud-mounting (10-32 UNF stud), and the price is £190. D. J. Birchall Ltd, 102 Bath Rd, Cheltenham, Gloucestershire GL53 7JX.
WW308

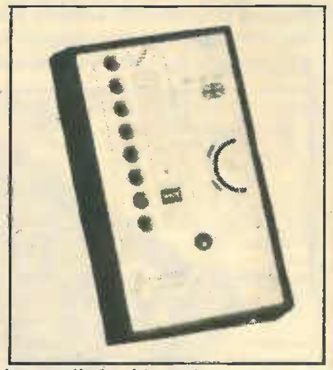


Cable assemblies

Various lengths of cable with U.H.F. or B.N.C. connector terminations and colour-coded strain relievers (10 colours) are available from Greenpar Connectors Ltd in 50 and 70 ohm versions. All components used to make up these cables are also available as separate items. Greenpar Connectors Ltd, P.O. Box 15, Harlow, Essex CM20 2ER.
WW309

Small generator for colour tv

A pattern generator for servicing PAL-system colour sets is available through House of Instruments. The Sadelta MC101 generates colour-bar, grey-scale, red-raster, white-raster, cross-hatch, dot, central-cross, central-spot and vertical-line patterns on any carrier between channels 21 and 41. Each generator measures around 131×81×23mm, weighs 250g and



is supplied with rechargeable battery, charger, connecting lead and carrying case for £149.50 inclusive of packaging and delivery, but excluding v.a.t. (quantity discounts are available). House of Instruments, 34/36 High St, Saffron Walden, Essex CB10 1EP.
WW310

Encoder discs

Rotation-encoding discs from the electro-forming and photo-etching company Veco are now available 'off-the-shelf' for prototypes, etc. Four versions – one of 30mm diameter with 120 slots and three of 60mm diameter with 120, 240 or 360 slots – are immediately available and the range is to be extended. Some specifications of the 0.8 to 0.9mm-thick discs are ±20µm on the 10mm centre hole, 1:1 mark/space ratio, ±7µm on the slot width and ±20 seconds angular tolerance on the slots. Veco Electroforming/photo-etching Ltd, 36 Essendene Rd, Caterham, Surrey CR3 5PA.
WW311

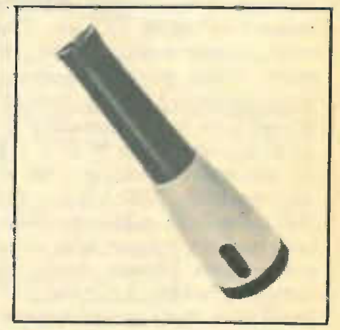
High-speed Schottky t.t.l.

A further six 74F series devices have been added to Fairchild's Advanced Schottky t.t.l. range available from Celdis. Among the six are the F109 dual flip-flop for up to 125MHz operation and the F189 64-bit r.a.m. with 20ns access time. The others are the F182, F243, F258 and F399. These devices are claimed to have on average around 75% better frequency response and 25% lower power consumption than standard Schottky types. An evaluation kit for F74 series containing 68 parts, 14 types (not those mentioned above), is available for £30. Celdis, 37 Loverock Rd, Reading, Berkshire RG3 1ED.
WW312

P.c.b. measuring aids

Folding lens/graticule assemblies for measuring p.c.b. track dimensions, hole diameters, etc, can be obtained from Opsec Ltd. Versions for ×5, ×8 and ×10 magnification and either Imperial or metric graticule scales are available. These units, with glass lenses, cost under £10. Opsec Ltd, Holywell Hill, St Albans, Herts AL1 1BR.
WW313

A magnifier for examining the insides of plated-through holes (see photo) is manufactured by Graticules Ltd. The Borescope gives a complete picture of the inside of the hole with adjustable magnification from ×40 to ×80. Hunter Equipment Ltd, High St. Bordon, Hants GU35 0AY.
WW314



Frequency-measurement module

An l.c.d. frequency meter module is available from Thurlby for £19.95 excluding v.a.t. The FM77T, with five, 9mm-high digits, can be used to measure frequencies up to 3999.9kHz directly: external pre-scalers can be used to extend the range. A crystal timebase is used and drift is said to be less than ±1 digit from 10° to30°C. Decimal point position, kHz/MHz legends and 23 pre-programmed i.f. offset frequencies (for use in radio-receiver applications) are selectable. Supply requirements are 4.5 to 7V, 1mA and overall dimensions, 70 by 38 by 11mm. Thurlby Electronics Ltd, Office suite 1, Coach Mews, The Broadway, St Ives, Huntingdon, Cambs PE17 4BN.
WW315

In the July issue we published details of a range of German-made power supplies that were then available through a distributor called 'Big Ears'. If you tried to contact said outlet you probably think we were pulling your leg. This is not so; EA Produktion power supplies are now available through E.A. Electronics, St Albans House, 577-579 Harehills Lane, Leeds LS9 6NQ.

Who ever heard of card frames in plastic?

There's always a first time for everything, and West Hyde are now supplying the brand new Type 02 range of plastic cases by AKA. These versatile enclosures can be used either on their own or together with a purpose-designed card frame and their ultra-smart appearance has to be seen to be believed. The card frames will accept either Eurocards or 112mm cards and all standard edge connectors. All models are designed with clip-in plain or ventilated sections at the front or back, have the option of prop-up feet (some models can be supplied with handles), and are finished in an attractive brown and beige colour.

WEST HYDE

West Hyde Developments Limited
Unit 9, Park Street Industrial Estate, Aylesbury, Bucks.
Telephone: (0296) 20441. Telex: 83570 W HYDE G.

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4116 250ns	.90	.80	.70
2114 200ns Low power	1.30	1.20	1.10
2114 450ns Low power	1.25	1.15	1.05
4118 250ns	3.50	3.15	2.95
6116 150ns CMOS	6.95	6.45	5.95
2708 450ns	1.95	1.75	1.65
2716 450ns 5 volt	2.25	2.05	1.95
2716 450ns three rail	7.40	7.00	6.75
2732 450ns Intel type	4.50	4.15	3.95
2532 450ns Texas type	4.95	4.60	4.40

Z80A-CPU £5.25 Z80A-PIO £4.75 Z80A-CTC £4.75

Low profile IC sockets:

Pins	8	14	16	18	20	22	24	28	40
Pence	9	10	11	14	15	18	19	25	33

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5-inch SSDD £17 5-inch DSDD £21
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Gladestry, Kington
Herefordshire HR5 3NY
Tel: (054-422) 618 or 628

WW – 021 FOR FURTHER DETAILS

SOUND INVESTMENT

Replacement tape heads from Monolith could mean a big improvement in sound quality from your tape recorder. A full catalogue is available, price 50p, which features a wide range of heads for cassette and reel to reel machines, as well as replacement motors, tape transports, etc.

Universal cassette heads to EIAJ standard, hole centres 17mm apart, 12mm from head face:

B12-02	Mono record/playback	£ 4.62
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B24-02	Stereo r/p	£ 7.66
B24-07	Stereo r/p for Dolby systems	£ 9.05
C42RPH20	Stereo r/p sendust head, suitable for chrome & metal tapes	£10.67
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C42RPS18	Stereo twin gap r/p long life head for record monitoring	£28.99
C21ES18	Mono/Stereo erase head	£ 2.13
C44RPH03	Four channel/track r/p	£15.15
C22ES04	Twin half track erase	£ 5.43

Ex stock deliveries, all prices include VAT. Post and packing 40p.

MONOLITH electronic products

The Monolith Electronics Co. Ltd., 5/7 Church Street, Crewkerne, Somerset TA18 7HR. Tel: 0460 74321. Telex: 46306 MONLTH G.

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AMPLIFIER WITH HEAT SINK

BIPOLAR Standard, with heatsinks — Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	DISTORTION T.H.D. Typ at 1kHz	DISTORTION I.M.D. 60HZ/7kHz 4:1	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HY30	15w 4-8Ω	0.015%	<0.006%	±18±20	76x68x40	240	£7.29	£1.09					
HY60	30w 4-8Ω	0.015%	<0.006%	±25±30	76x68x40	240	£8.33	£1.25					
HY120	60w 4-8Ω	0.01%	<0.006%	±35±40	120x78x40	410	£17.48	£2.62	HY120P	120x26x40	215	£15.50	£2.33
HY200	120w 4-8Ω	0.01%	<0.006%	±45±50	120x78x50	515	£21.21	£3.18	HY200P	120x26x40	215	£18.46	£2.77
HY400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£31.83	£4.77	HY400P	120x26x70	375	£28.33	£4.25

Protection: Load line, momentary short circuit (typically 10 sec) *Slew rate:* 15V/μs *Rise time:* 5μs
S/N ratio: 100db *Frequency response (– 3dB):* 15Hz – 50kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω/100Hz)>400

HEAVY DUTY with heatsinks — Without heatsinks

MODEL NUMBER	OUTPUT POWER	T.H.D.	I.M.D.	SUPPLY VOLTAGE	SIZE	WT	PRICE	VAT	MODEL NUMBER	SIZE	WT	PRICE	VAT
HD120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x50	515	£22.48	£3.37	HD120P	120x26x50	265	£19.84	£2.98
HD200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x60	620	£27.38	£4.11	HD200P	120x26x50	265	£23.63	£3.54
HD400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£38.63	£5.79	HD400P	120x26x70	375	£34.28	£5.14

Protection: load line, PERMANENT SHORT CIRCUIT (ideal for disco/group use should evidence of short circuit not be immediately apparent).
The Heavy Duty range can claim additional output power devices and complementary protection circuitry with performance specs. as for standard types.

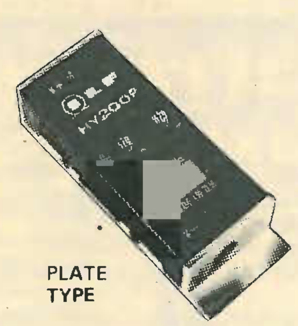

PLATE TYPE

MOSFET Ultra-Fi, with heatsinks — Without heatsinks

MODEL NUMBER	OUTPUT POWER	T.H.D.	I.M.D.	SUPPLY VOLTAGE	SIZE	WT	PRICE	VAT	MODEL NUMBER	SIZE	WT	PRICE	VAT
MOS120	60w/4-8Ω	<0.005%	<0.006%	±45±50	120x78x40	420	£25.88	£3.88	MOS120P	120x26x40	215	£23.32	£3.50
MOS200	120w/4-8Ω	<0.005%	<0.006%	±55±60	120x78x80	850	£33.46	£5.02	MOS200P	120x26x80	420	£28.53	£4.28
MOS400	240w/4Ω	<0.005%	<0.006%	±55±60	120x78x100	1025	£45.39	£6.81	MOS400P	120x26x100	525	£38.91	£5.84

Protection: Able to cope with complex loads, without the need for very special protection circuitry (fuses will suffice).
Ultra-fi specifications:
Slew rate: 20V/μs *Rise time:* 3μs *S/N ratio:* 100db *Frequency response (– 3dB):* 15Hz – 100kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω/100Hz)>400

POWER SUPPLY UNITS

MODEL NO.	FOR USE WITH	PRICE	VAT
PSU30	± 15V combinations of HY6/66 series to a maximum of 100mA or *one* HY67	£4.50	£0.68
	The following will also drive the HY6/66 series except HY67 which requires the PSU30.		
PSU36	1 or 2 HY30	£8.10	£1.22
PSU50	1 or 2 HY60	£10.94	£1.64
PSU60	1 x HY120/HY120P/HD120/HD120P	£13.04	£1.96
PSU65	1 x MOS120/1 x MOS120P	£13.32	£2.00
PSU70	1 or 2 HY120/HY120P/HD120/HD120P	£15.92	£2.39
PSU75	1 or 2 MOS120/MOS120P	£16.20	£2.43
PSU90	1 x HY200/HY200P/HD200/HD200P	£16.20	£2.43
PSU95	1 x MOS200/MOS200P	£16.32	£2.45
PSU180	2 x HY200/HY200P/HD200/HD200P or 1 x HY400/1 x HY400P/HD400/HD400P	£21.34	£3.20
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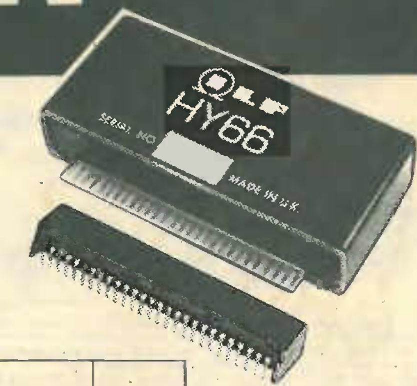

Which modules?

In launching eighteen different units all within amazingly compact cases to help make complete audio systems using I.L.P. power amplifiers, we bring the most exciting, the most versatile modular assembly scheme ever for constructors of all ages and experience. Study the list – see how these modules will combine to almost any audio project you fancy – and remember *all I.L.P. modules are compatible with each other*, they connect easily. Modules HY6 to HY13 measure 45 x 20 x 40mm. HY66 to HY77 measure 90 x 20 x 40mm. They are so reliable that all I.L.P. modules carry a 5 year no quibble guarantee.

MODEL NO.	MODULE	DESCRIPTION/FACILITIES	CURRENT REQUIRED	PRICE	VAT
HY6	MONO PRE AMP	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Volume/Bass/Treble	10mA	£6.44	£0.97
HY7	MONO MIXER	To mix eight signals into one	10mA	£5.15	£0.77
HY8	STEREO MIXER	Two channels, each mixing five signals into one	10mA	£6.25	£0.94
HY9	STEREO PRE AMP	Two channels mag. Cartridge/ Mic + Volume	10mA	£6.70	£1.01
HY11	MONO MIXER	To mix five signals into one + Bass/Treble controls	10mA	£7.05	£1.06
*HY12	MONO PRE AMP	To mix four signals into one + Bass/Mid-range/Treble	10mA	£6.70	£1.01
*HY13	MONO VU METER	Programmable gain/LED overload driver	10mA	£5.95	£0.89
HY66	STEREO PRE AMP	Mic/Mag. Cartridge/Tape/Tuner/Aux + Volume/Bass/Treble/Balance	20mA	£12.19	£1.83
HY67	STEREO HEADPHONE	Will drive headphones in the range of 4Ω – 2KΩ	80mA	£12.35	£1.85
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HY69	MONO PRE AMP	Two input channels of mag. Cartridge/ Mic + Mixing/Volume/Treble/Bass	20mA	£10.45	£1.57
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†HY75	STEREO PRE AMP	Two channels, each mixing four signals into one + Bass/Mid-range/Treble	20mA	£10.75	£1.61
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* Ready August – may be ordered now
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All the above modules operate from ±15V minimum to ±30V maximum higher voltages being accommodated by use of dropper resistors. HY67 can only be used with the PSU 30 power supply unit.

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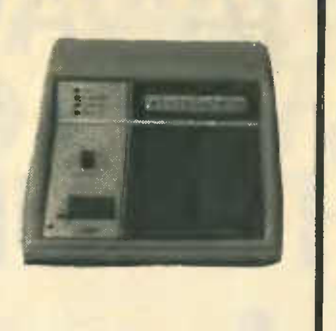

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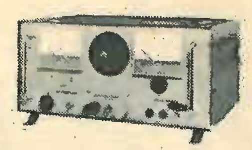

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AC187	0.32
AC188	0.32
ACY17	1.50
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AF115	0.86
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ASZ15	1.38
ASZ16	1.27
ASZ17	1.15
ASZ20	2.64
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BA154	0.12
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BA156	0.12
BAW62	0.06
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BC108	0.18
BC109	0.18
BC113	0.17
BC114	0.17
BC115	0.17
BC116	0.22
BC117	0.26
BC118	0.21
BC125	0.21
BC126	0.21
BC135	0.17
BC136	0.22
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BC303	0.39
BC307	0.13
BC308	0.13
BC327	0.14
BC328	0.14
BC337	0.14
BC338	0.14
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BCY39	3.91
BCY40	3.22
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BCY43	0.35
BCY58	0.22
BCY70	0.20
BCY71	0.21
BCY72	0.20
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BD124	2.30

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BD137	0.46
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BF154	0.20
BF159	0.20
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BF173	0.35
BF177	0.40
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BF180	0.32
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BF194	0.16
BF195	0.14
BF196	0.15
BF197	0.16
BF200	0.46
BF224	0.29
BF244	0.32

BF257	0.31
BF258	0.31
BF259	0.32
BF336	0.32
BF337	0.38
BF338	0.41
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BFS61	0.23
BFS98	0.23
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BFW11	1.10
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BFX87	0.35
BFX88	0.35
BFY50	0.29
BFY51	0.29
BFY52	0.29
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BT106	1.38
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MJE520	0.54
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NKT404	2.53
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OA81	0.20
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OA90	0.09
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OA211	1.73
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OC203	3.45
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OC206	2.88
OC207	2.88
OCP71	2.30
ORP12	1.15
R2008B	2.30
R2009	2.59
R2010B	2.30
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TIC226D	1.38
TIL209	0.18
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TIP30A	0.52
TIP31A	0.38
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TIP33A	0.62
TIP34A	0.77
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TIP2955	0.81
TIP3055	0.64
TIS43	0.49
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1N4006	0.13
1N4007	0.14
1N4009	0.08
1N4148	0.05
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1N5401	0.15
1S44	0.05
1S920	0.09
1S921	0.10
2G301	1.15
2G302	1.15
2G306	1.15
2N404	1.50
2N696	0.37
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2N698	0.37
2N705	1.44
2N706	0.29
2N708	0.29
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2N1131	0.35
2N1132	0.35
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2N1303	0.92
2N1304	1.38
2N1305	1.15
2N1306	1.73
2N1307	1.27
2N1308	2.01

2N1309	1.38
2N1613	0.37
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2N1893	0.37
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2N3771	1.61
2N3772	1.84
2N3773	2.07
2N3819	0.35
2N3820	0.45
2N3823	0.69
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2N5458	0.37
2N5459	0.37
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DL92	1.26
DL94	1.38
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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
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ECF80	1.24
ECF82	1.38
ECF86	1.73
ECH35	2.30
ECH42	1.32
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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
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EF41	2.30
EF42	2.30
EF50	1.73
EF54	5.75
EF55	2.88
EF80	0.92
EF83	4.03
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	12.65
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	4.03
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	11.96
EL822	12.55
EM34	5.75
EM80	1.26
EM81	1.15
EM84	1.15
EM85	1.44
EM87	1.73
EN32	13.66
EN91	2.94
EN92	5.23
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	5.50
M8099	5.98
M8100	9.49
M8136	9.98
M8137	9.73
M8140	5.17
M8141	5.52
M8142	7.77
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	62.10
MX151	17.25
MX152	143.75
MX161	166.75
MX163	23.11
MX164	27.95
MX166	161.00
MX168	48.30
N78	20.13
OA2	2.30
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	16.17
QQV03-20A	20.13
QQV06-40A	47.15
QQV07-50	60.66
QQZ03-20A	59.80
QQZ06-40A	63.37
QU37	14.38
QV03-12	5.62
QV04-7	2.88
QV08-100	137.08
QY3-65	57.06
QY3-125	62.40
QY4-250	77.05
QY4-400	80.44
QY5-500	168.83

QY5-3000A	356.66
QZ06-20	34.16
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	63.94
RG4-1250	43.13
RG4-3000	90.36
RR3-250	53.54
RR3-1250	94.83
S11E12	55.20
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	16.98
TT22	16.98
TT100	59.51
TY2-125	69.01
TW4-400	74.07
TY4-500	105.97
TY5-500	187.45
TY6-800	193.20
TY6-5000A	356.50
TY6-5000B	264.50
TY6-5000W	316.25
TY7-6000A	368.80
TY7-6000W	322.00
TZ40	28.75
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	58.02
XG2-6400	113.50
XG5-500	28.23
XG2-6400	155.42
XR1-1600A	58.88
XR1-3200	87.15
XR1-3200A	93.15
XR1-6400	108.30
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	17.86
2J42	109.25
2J55	239.97
2J70A	442.75
2J70B	418.34
2K25	40.25
3-400Z	57.50
3-500Z	63.25
3A5	2.70
3B24	9.20
3B28	16.50
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	26.83
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	74.75
4CX250B	51.75
4CX350A	80.50
4X150A	24.41
4X150D	28.75
5B254M	23.12
5B255M	23.12
5C22	74.75
5J180E	1380.00
5R4GY	4.03
5U4G	3.86
5U4GB	2.90
5V4G	1.75
5Y3GT	0.98
5Z3	1.73
5Z4G	1.75
5Z4GT	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	11.96
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	34.50
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	55.20
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
30PL1	2.88
30PL14	1.93
30PL15	2.07
35W4	0.69
50C5	0.81
75B1	5.38
75C1	2.70
85A1	8.63
85A2	2.75
90AG	14.90
90AV	14.90
90C1	2.81
90CG	16.72
90CV	17.50
92AG	14.90
92AV	14.90
95A1	7.48
150B2	3.47
150B3	6.39
150C2	2.21
150C4	2.75
211	21.85
723AB	40.25
803	11.50
805	23.00
807	4.31
811A	21.08
812A	21.08
813	91.15
833A	153.57
866A	17.56
872A	24.69
922	5.01
931A	18.15
1624	2.59
1625	1.96
2050	8.00
4212E	304.75
4212H	304.75
5544	62.10
5545	67.85
5551A	123.51
5552A	166.98
5553A	259.10
5642	6.45
5654	3.93
5651	4.66

5670	5.18
5675	21.47
5687	6.31
5696	4.35
5718	7.87
5725	5.62
5726	3.62
5727	6.47
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	12.08
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
6097AxBxC	166.75
6146A	12.24
6146B	9.34
6159B	19.91
6189	10.03
6201	10.92
6442	17.25
6883B	14.64
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	86.40
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	0.25
B7G skirted	0.35
B9A unskirted	0.25
B9A skirted	0.35
Int Octal	0.40
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	28.75
DG7-5	72.82
DG7-31	66.78
DG7-32	66.78
DH3-91	67.65
DH7-11	130.09
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	0.20
7402	0.20
7403	0.20
7404	0.21
7405	0.21
7406	0.49
7407	0.49
7408	0.23
7409	0.23
7410	0.20
7412	0.33
7413	0.37
7416	0.37
7417	0.37
7420	0.21
7422	0.23

7423	0.38
7425	0.35
7427	0.35
7428	0.50
7430	0.20
7432	0.35
7433	0.46
7437	0.37
7438	0.37
7440	0.37
7441	1.04
7442	0.83
7447AN	1.35
7450	0.21
7451	0.21
7453	0.21
7454	0.21

7460	0.21
7470	0.44
7472	0.38
7473	0.44
7474	0.44
7475	0.62
7476	0.48
7480	0.64
7482	0.86
7483	1.15
7484	1.21
7486	0.45
7490	0.69
7491	0.94
7492	0.69
7493	0.69
7494	0.94

7495	0.84
7496	0.94
7497	3.62
74100	1.77
74107	0.52
74109	0.84
74110	0.59
74111	0.82
74116	2.13
74118	1.15
74119	1.77
74120	0.95
74121	0.49
74122	0.71
74123	1.36
74125	0.67
74126	0.67
74128	0.72
74132	0.83

74136	0.59
74141	1.02
74142	2.64
74143	2.99
74144	2.99
74145	1.15
74147	2.30
74148	2.02
74150	2.07
74151	1.08
74154	2.07
74155	1.04
74156	1.04
74157	0.86
74159	2.53
74170	2.76
74172	5.06
74173	1.63
74174	1.84

74175	1.17
74176	1.33
74178	1.56
74179	1.56
74180	1.38
74190	2.19
74191	2.19
74192	2.19
74193	2.19
74194	1.44
74195	1.38
74196	1.55
74197	1.55
74198	3.11
74199	2.64
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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VOLTAGE REGULATORS

78XX1A TO-220 pos	0.58
79XX1A TO-220 neg	0.60
78G 1A TO-220 adj pos	1.10
78G 1A TO-3 adj pos	3.95
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78H5A TO-3 12v pos	5.45
78HG5A TO-3 adj pos	7.45
79HG5A TO-3 adj neg	7.45
LM317.5A adj pos	1.30
LM337.5A adj neg	1.75
78S401.5A adj pos sw reg	1.20

DISCRETES

BC237	8p	BC556	12p		
BC238	8p	BC550	12p	2SK168	35p
ZTX238	9p	BC560	12p	J310	69p
BC239	8p	BC639	22p	J176	65p
BC307	8p	BC640	23p	40823	65p
BC308	8p	2SC1775A	22p	3SK45	49p
BC309	8p	2SA872A	18p	3SK51	54p
BC413	10p	2SD666A	30p	3SK60	58p
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Amps/AC Volts: ±3% of full scale
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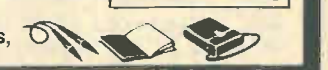

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151	200	12.28	1.72
152	250	14.61	2.04
153	350	18.07	2.12
154	500	22.52	2.20
155	750	32.03	OA
156	1000	40.92	OA
157	1500	56.52	OA
158	2000	67.99	OA
159	3000	95.33	OA
161	6000	203.65	OA

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Separate 12V windings Pri 220-240V

Ref.	12v Amps	24v	£	P&P
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213	1.0	0.5	2.90	1.00
71	2.0	1.0	3.86	1.00
18	4.0	2.0	4.46	1.20
85	5.0	2.5	6.16	1.20
70	6.0	3.0	6.99	1.20
108	8.0	4.0	8.16	1.44
72	10.0	5.0	8.93	1.60
116	12.0	6.0	9.89	1.60
17	16.0	8.0	11.79	1.72
115	20.0	10.0	15.87	1.84
187	30.0	15.0	19.72	2.04
226	60.0	30.0	40.41	OA

50 VOLT RANGE
Pri 220-240V. Volt available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40 or 20V-0-20V or 25V-0-25V

Ref.	Amps 50v	25v	£	P&P
102	.5	1	3.75	1.20
103	1	2	4.57	1.20
104	2	4	7.88	1.44
105	3	6	9.42	1.60
106	4	8	12.82	1.72
107	6	12	16.37	1.84
118	8	16	22.29	2.20
119	10	20	27.48	OA
109	12	24	32.89	OA

30 VOLT RANGE (Split Sec)
Pri 220-240V. Volt available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V or 15V-0-15V

Ref.	Amps 30v	15v	£	P&P
112	0.5	1	2.90	1.00
79	1	2	3.93	1.00
3	2	4	6.35	1.20
20	3	6	7.39	1.44
21	4	8	8.79	1.60
51	5	10	10.86	1.60
117	6	12	12.29	1.72
88	8	16	16.45	1.96
89	10	20	18.98	1.84
90	12	24	21.09	OA
91	15	30	24.18	OA
92	20	40	32.40	OA

60 VOLT RANGE
Pri 220-240V (Split Sec)
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Ref.	Amps 60v	30v	£	P&P
124	.5	1	4.27	1.20
126	1	2	6.50	1.20
127	2	4	8.36	1.60
125	3	6	12.10	1.72
123	4	8	13.77	1.96
40	5	10	17.42	1.84
120	6	12	19.87	2.04
121	8	16	27.92	OA
122	10	20	32.51	OA
189	12	24	37.47	OA

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Ref.	mA	Sec Volts	£	P&P
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212	1A, 1A	0-6, 0-6	3.14	1.00
13	100	9-0-9	2.35	.50
235	330, 330	0-9, 0-9	2.19	.60
207	500, 500	0-8-9, 0-8-9	3.05	.95
208	1A, 1A	0-8-9, 0-8-9	3.88	1.20
236	200,200	0-15, 0-15	2.19	.60
239	50MA	12-0-12	2.88	.50
214	300, 300	0-20, 0-20	3.08	1.00
221	700 (DC)	20-12-0-12-20	3.75	1.00
206	1A, 1A	0-15-20, 0-15-20	5.09	1.20
203	500, 500	0-15-27, 0-15-27	4.39	1.20
204	1A, 1A	0-15-27, 0-15-27	6.64	1.20

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500	248	22.52	OA
1000	250	45.94	OA
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3000	253	95.32	OA
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4	150	0-10-115-200-220-240V	5.89	1.20
67	500	0-10-115-200-220-240V	12.09	1.84
84	1000	0-10-115-200-220-240V	20.64	2.20
93	1500	0-10-115-200-220-240V	25.61	OA
95	2000	0-10-115-200-220-240V	38.31	OA
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200	£12.02	1.44	65W
250	£13.38	1.44	69W
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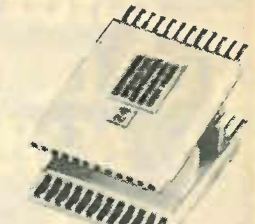

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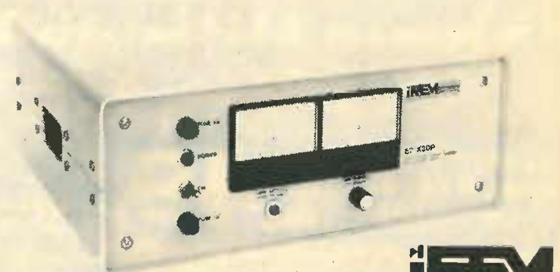

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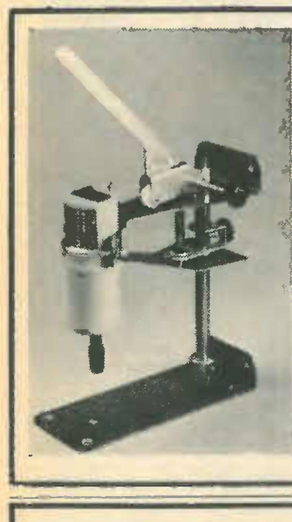

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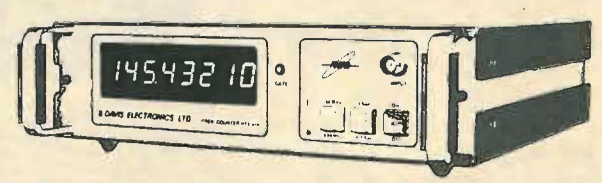

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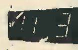

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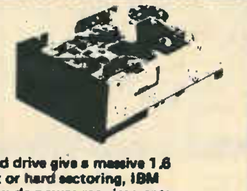

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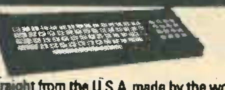

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04	16p	90	40p	06	48p	20	54p	42	52p	47	38p
05	16p	109	32p	07	18p	21	54p	46	80p	51	19p
08	16p	123	40p	08	52p	22	54p	49	28p	70	17p
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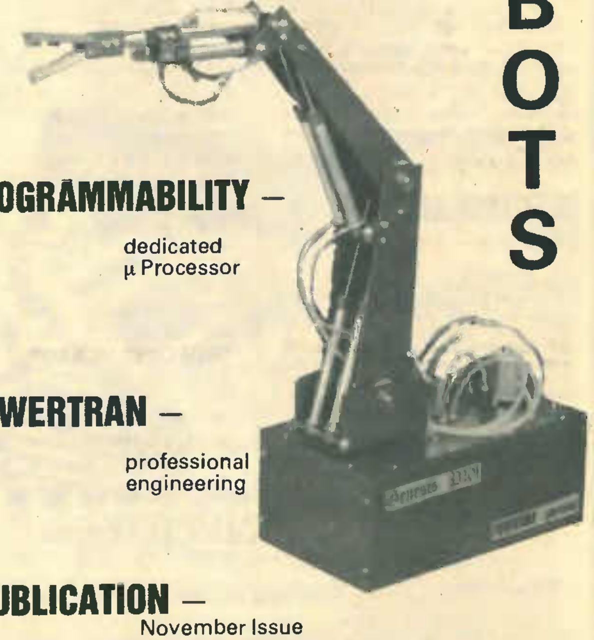

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(1371)

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Although the work is primarily concerned with CAD techniques, applicants should have some familiarity with digital or analogue circuit design. The work will involve developing and supporting new interactive software (including interactive graphics programs), maintaining established programs and assisting research workers in their use and establishing a device, material and process library for use with the software.

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Application forms can be obtained from **Lorna Bird in the Personnel Group on Abingdon (0235) 2190, ext. 510. Alternatively, write to her quoting reference VN 916R, Rutherford Appleton Laboratory, Chilton, Didcot, Oxon OX11 0QX.** More technical information can be obtained via Nesta Jones (ext. 6660).

Closing date of application is 29th October, 1981

(1375)

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£6501-£7371
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Assistance will be given with removal/legal expenses in accordance with the Council's scheme.

Requests for application forms should be addressed to the Director of Manpower Services, Regional Buildings, Inverness, quoting the above post number. Closing date 4th November 1981.

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(1366)

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