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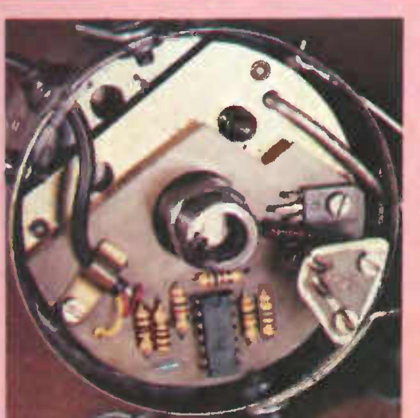
APRIL 1981 60p

70 years of publication

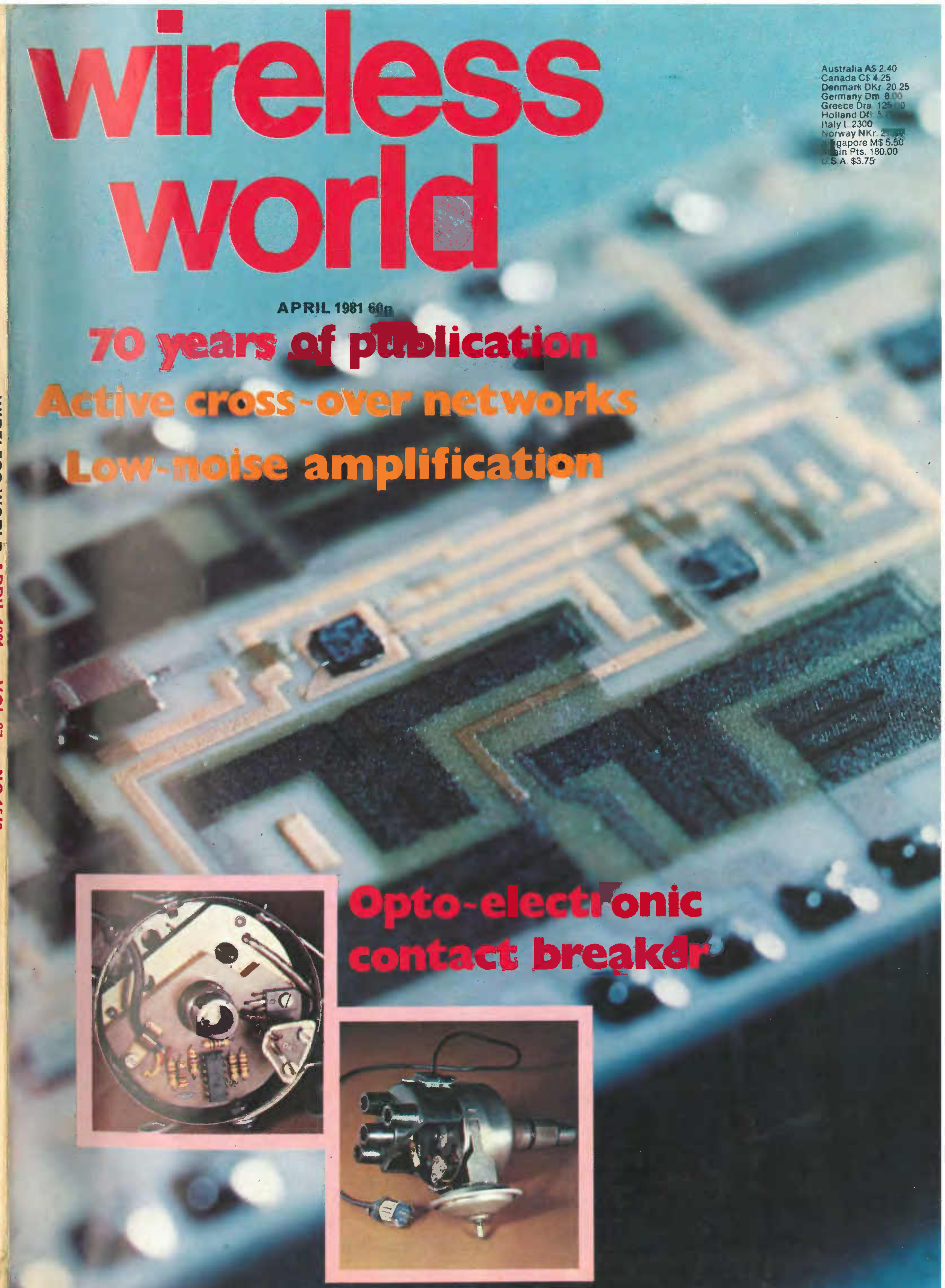
Active cross-over networks

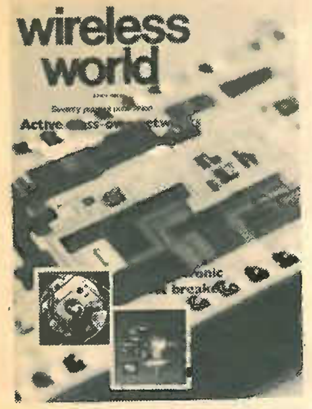
Low-noise amplification

Opto-electronic contact breaker



WIRELESS WORLD APRIL 1981 VOL 87 NO 1543





Front cover shows (inset) details of the opto-electronic contact breaker described in this issue on the background of a Marconi Space and Defence Systems hybrid microelectronic circuit.

IN OUR NEXT ISSUE

Digital capacitance meter **uses the timed charge-injection method of measurement, with an input protection circuit, optimized to reduce errors.**

Wien oscillator **is a new design by Linsley Hood, using a different connexion of the standard Wien bridge to give a total harmonic distortion of 0.001%.**

Active television deflector **receives tv signal, amplifies and re-transmits it to viewers in no-signal reception areas.**

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ELECTRONICS / TELEVISION / RADIO / AUDIO

APRIL 1981 Vol 87 No 1543

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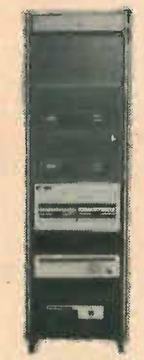
April 1981 Latest Computer Equipment

PDP11 SYSTEMS



DEC

PDP11/34A System complete with 256KB MOS memory DL11W Asynchronous Interface / Line Clock, KY11-LB Programmers Panel, VT100 Terminal, 2 x RL01 5-meg Disk Drives, DZ11A 8-Line multiplexer, FP11A Floating Point, H960 Cabinet....... **£17,500.00**

PDP11/34A System complete with 256KB MOS memory, 2 x RK07 28-meg Disk Drives, TMB11 magnetic tape station, DZ11 16-line multiplexer, Data system cabinet and expander box, LA36 console terminal.... **£27,750.00**

PDP11/60 System with 2 RK07 Disk Drives, choice of console **P.O.A.**

PDP11/03 System (desk-mounted) 20KW MOS, RX11 dual floppy disk drive and control, 3 serial interfaces, LA180 Printer, VT100 Console terminal......... **P.O.A.**

PDP11 C.P.U.s

DEC.

PDP11/03-SD Processor in 3½" chassis complete with 16KW MOS memory and E1S option.
BRAND NEW — ONLY **£1495.00**

PDP11/04 Processor in 10½" chassis complete with 16KW MOS memory and DL11W Interface.
BRAND NEW (can be enhanced to 28KW) **£4500.00**

PDP11/34 in 10½" chassis complete with 64KB MOS memory **£5500.00**

PDP11/34 Processor (non-A) in 10½" chassis complete with 128KB MOS memory, DL11W Interface and programmers front panel **£5900.00**

PDP11 MEMORY

DEC.

MF11L 8KW core memory c/w 9-slot system unit **£975.00**
MM11L 8KW core memory **£795.00**
MM11LP 8KW parity core memory **£750.00**
MM11DP 16KW core (ex DEC-maintained 11/34 systems).
BARGAIN OFFER — ONLY **£395.00**
MM11UP 16KW Parity core memory complete with 9-slot system unit **£1500.00**
MM11UP 16KW parity core memory (pre-requisite MF11UP) **£1250.00**
MS11JP 16KW MOS memory **£675.00**
MSV11C 16KW MOS memory (LSI11) **£495.00**
MJ11-BE 64KW 11/70 memory **£4500.00**
MK11-BE 64KW MOS memory for 11/70 .... **£3950.00**
MS11-MB 256KB ECC MOS memory for 11/44 (NEW) ... **£3942.00**

DISKS

DEC.

RK05J add-on disk drive 2½ meg. Exchangeable cartridge type.
From **£1850.00**
RK06 Add-on disk drive 14 meg. Free standing. From **£3250.00**
RK07-ED Add-on Disk drive 28 meg. .... **P.O.A.**
RL01-AK Add-on Disk drive 5 meg. **£1975.00**
RP02 20 meg add-on disk drive **£1250.00**
RP04 add-on 88 meg disk drive **£8000.00**
RP06 add-on 176 meg disk drive **£15,950.00**
RX11-BD Dual floppy disk drive and control **£1800.00**
Controllers usually available for above drives.

MAGNETIC TAPE

DEC.

Available from time to time — TU10, TU45, TE16 TS03 etc.

PDP11 OPTIONS

DEC.

AA11D VT01 Controller with 4-slot System Unit **£125.00**
DD11A 4-slot System Unit **£125.00**
DD11B 4-slot System Unit **£150.00**
DD11-DK 9-slot backplane **£465.00**
DL11 Serial Interface **£250.00**
DL11WA/B Serial Interface/Line Clock **£395.00**
DR11C General Purpose Interface **£250.00**
DRV11B 16-bit Parallel Interface **£225.00**
DZ11A 8-line E1A MUX **£1395.00**
FP11A Floating Point **£1750.00**
KL11 TTY Interface **£150.00**
KW11L Real Time Clock **£150.00**
KW11P Programmable Clock **£345.00**
M105 Device Selector **£30.00**
M792 ROM Diode Matrix **£195.00**
M920 Unibus Connector **£12.00**
M9301-YB Bootstrap **£325.00**

POWER SUPPLIES

DEC.

H720 Power supply for BA11 Expander Box, BRAND NEW SURPLUS **£175.00**

PDP8A C.P.U.

DEC.

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

PDP8A MEMORY

DEC.

MM8AA 8KW Core **£750.00**
MM8AB 16KW Core **£995.00**

PDP8E CPU, MEMORY, OPTIONS

DEC.

DP8EB Communications Adaptor **£395.00**
KA8E Positive 1/0 Bus **£95.00**
KD8E Databreak **£145.00**
KL8E Asynchronous Interface **£250.00**
KP8E Power fail/auto restart **£95.00**
MM8E 4KW Core memory stack **£350.00**
TA8E Dual Cassette Drive and Controller **£525.00**
VT8E Set graphics Control Modules **£250.00**

TERMINALS

DEC.

LA34 DECwriter 1V 30cps desk-top terminal, 132 columns, upper/lower case ASCII **£495.00**

LA36 DECwriter 11 Keyboard Printer Terminal. The Terminal that has become an industry standard, with 132 column upper/lower case printing and switch-selectable speeds of 10, 15 & 30cps. Available with either 20mA or RS232 interface. NOW ONLY **£595.00**

VT 52 SPECIAL PURCHASE of this outstanding Video Display Terminal featuring full upper/lower case ASCII character set, 24 × 80 display, auxiliary keypad, direct cursor addressing and tabulation, scroll or hold screen mode with X-off facility, 9 switch-selectable baud rates (75-9600 baud) choice of 20mA or RS232 interface. BRAND NEW SURPLUS.
ONLY **£450.00**

VT100 — Also available from time to time, DEC's latest 132 column display terminal. Please enquire for latest price and delivery. **£750.00**

PRINTERS

Centronics 101.

Heavy Duty Matrix printer with 64 ASCII upper case character set. 165 cps operation. 132 print positions with adjustable tractor feed. Parallel input. ONLY. **£495.00**

GP80 Graphics.

NEW

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 .... £240.35)

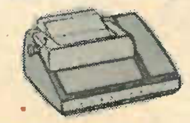
GE Terminet 1200.
RO printer, 80 columns, tractor feed, upper/lower case, ASCII, 20mA Interface **£325.00**

Hazeltine.
Thermal printer, 80 columns, 30 cps silent RO with parallel TTL input **£395.00**

Tally 1602.
Matrix printer, parallel input, upper/lower case, tractor feed, as new **£995.00**

Teletype.
ASR 33 input/output terminal incorporating paper tape punch and reader. 64 ASCII upper case character set. 110 baud operation, even parity keyboard choice of RS232 or 20mA interface.
NOW ONLY **£595.00**

Options.
ICL-type keyboard **£50.00**
8th level marking **£25.00**
Remote reader control **£50.00**
Reader step **£20.00**
Auto reader **£25.00**
Pedestal **£30.00**



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**

Termiprinter 7075.
Impact printer, upper/lower case, pin feed, RS232 .... **£325.00**

Texas.
733 ASR terminal utilising high performance twin cassette drive for fast time-saving transmission and off-line storage.

- ★ Silent operation
- ★ Switch-selectable transmission speeds 10, 15, & 30 cps
- ★ Full tape editing capability
- ★ High-speed duplication and rewind
- ★ Standard RS232 interface **£1375.00**

745 Portable Data Terminal including keyboard, printer, integral acoustic coupler and carrying case. Total weight only 13 lbs **£750.00**

April 1981........ Latest Computer Equipment

PAPER TAPE PUNCHES

Digitronics.
P120 paper tape punch. Solenoid-actuated unit capable of punching 5 to 8 channel tapes at speeds up to 35 cps.
Pulse amplitude 27 VDC. Compact table-top unit **£95.00**

Facit 4070.
The top quality punch that has become an industry standard. Asynchronous 75cps operation. Adjustable for punching 5, 6, 7 or 8 level tape. Self-contained desk-top unit incorporating supply and take-up spools, chad box, and TTL-compatible control logic ... **£650.00**

KEYBOARDS

George Risk.
New ASCII Keyboards
New Low Prices

NEW

KB771 Superb 71-station ASCII keyboard incorporating separate numeric/Cursor control pad and installed in custom-built steel enclosure with textured blue enamel finish. Ideal for the VDU builder. Case dimensions: 17¼" × 7½" × 3⅜".
Total weight 4kg. PRICE..... **£85.00**
Mail Order Total £103.50

KB756 56-station ASCII keyboard mounted on P.C.B. **£39.50**
Mail Order Total £47.15
KB756MF as above, fitted with metal mounting frame for extra rigidity **£45.00**
Mail Order Total £53.48
KB710 10-key numeric pad, supplied with connecting cable.... **£8.00**
Mail Order Total £9.78
KB701 Plastic enclosure for KB756 or KB756MF **£12.50**
Mail Order Total £15.24
KB702 Steel enclosure for KB756 or KB756MF **£18.00**
Mail Order Total £23.00
KB2376 Spare ROM encoder **£12.50**
Mail Order Total £15.24
KB15P Edge connector for KB756 or KB756MF **£3.25**
Mail Order Total £4.31
DC-512 DC convertor to allow operation at 5V only (plugs in to P.C.B.) **£7.50**
Mail Order Total £9.20
DB25S Mating connector for KB771 .... **£4.25**
Mail Order Total £5.46
PERK 56-station ASCII keyboard for PET complete with PET interface, built-in power supply and steel enclosure **£95.00**
Mail Order Total £115.00

Discounts available for quantities.

PROGRAMMABLE CALCULATORS

Hewlett Packard.
9830A with 8K Memory, Extended I/O ROM, String Variables ROM, 1 Serial and 3 parallel interfaces **£1695.00**

MODEMS

Racal Milgo.
Modem 26 lsi 1200/2400 baud, 2 or 4 wire, full/half duplex .... **P.O.A.**

GENERATORS

Mawdsley.
45KVA Generator system comprising AC Induction Motor, AC Generator, AC Exciter and Emreg Regualator.
The alternator comprises of a screen-protected rotating field, complete with built in over-hung exciter of the brushless pattern. It is wound for 415V, 3 phase, 50Hz, 4 wire and developing 45KVA at 018 P.F. when running at a speed of 1500 rpm.
The alternator and exciter are used in conjunction with the automatic transistorised voltage regulator, incorporating 3-phase sensing. The regulator is so designed that when the alternator is on balanced 3-phase load and with one phase switched off or disconnected, the phase voltage will not vary more than ‡ 6% under any conditions **£1250.00**

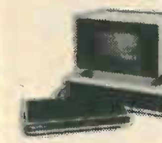
VDUs

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 x 80 display upper case ASCII, RS232 interface, choice of baud rates SUPER VALUE **£199.00**

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

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



Modular One. Now with upper/lower case, XY cursor addressing, 24 x 80 line display, dual intensity detachable keyboard, choice of 8 transmission rates up to 9600 baud **£399.00**

MONITORS

Ball Miratel TTL15.
15in. diagonal green phosphor tube, integral power supply. Requires separate horizontal and vertical video input. BRAND NEW SURPLUS **£75.00**

FLOPPY DISK DRIVES

NEW

Shugart SA400.
5¼" MINI-FLOPPY

- ★ Capacity (unformatted): 110Kb (single density) 220Kb (double density)
- ★ Transfer rate: 125/250 kilobits/sec.
- ★ Average access time: 463ms.
- ★ Read/Write and Write Protect electronics
- ★ Power requirements + 5VDC + 12VDC Dimensions 5¾" x 3¼" x 8", weight 3lbs

Supplied complete with technical manual.
Application notes are available on interfacing the SA400 to Intel 8080A, Motorola etc. **£195.00**

Shugart SA450.
Double-sided, double density minifloppy providing 440KB unformatted storage capacity, yet the same compact size and weight as the SA400 .... **£299.00**

Shugart SA801.
8" FLOPPY (NEW)

- ★ Capacity (unformatted): 400Kb (single density) 800Kb (double density)
- ★ Transfer rate: 250/500 kilobits/sec.
- ★ Average access time: 211ms
- ★ Read/Write and Write Protect electronics
- ★ Power requirements +24VDC +5VDC −5VDC Dimensions 4⅝" × 9½" × 14¼"

Supplied complete with technical manual **£395.00**

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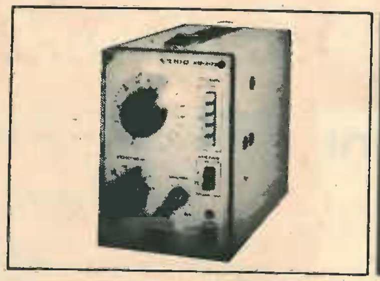
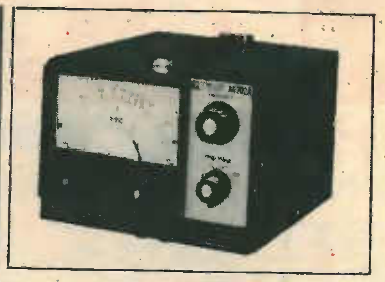


AG 203 LOW DISTORTION OSCILLATOR £110

AG 202A SINE-SQUARE OSCILLATOR £60



AG203 Low Distortion Oscillator — 10Hz to 1MHz in 5 ranges — < 0.1% distortion — very flat O/P to 7V r.m.s. sinewave from 600 ohms, squarewave 10V pp — Ext. Sync. — > 60dB's of variable output attenuation.

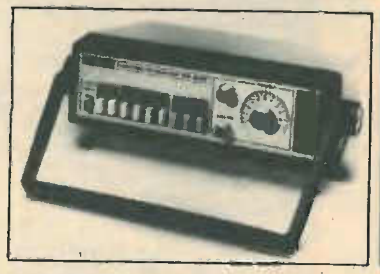
AG202A 200KHz R.C. Oscillator — 20Hz to 200KHz in 4 ranges — Sine and Squarewave — Flat O/P to 10V r.m.s. from 600 ohms — < 0.5% distortion — > 60dB of variable O/P atten — Ext. Sync. — Large easy to read single dial with smooth precise tuning control — Instant stable signals — Solid State.

SG 402 30 MHz A.M. SIG. GEN. £59

CO 1303D 5 MHz OSCILLOSCOPE £100

SG402 A.M. Signal Generator — 100KHz to 30MHz in 6 bands — 100mV of O/P with variable attenuator — Int. and Ex. A.M. — Solid State — Lightweight and portable — Large clear easy to read frequency dial.

CO1303D, DC to 5MHz Oscilloscope — 10mV/div sensitivity with variable atten. — Int. variable sweep frequency in 4 ranges from 10Hz to 100KHz — Int. and Ext. sync. — Direct deflection terminals can monitor R.F. up to 450MHz. CO1303G as above, plus 1:8 to 54MHz monitor freq. range from 1 to 500W direct coupling — Two Tone gen. 1KHz and 1.575KHz — ideal for SSB, A.M. C.W. etc.



FG 270 FUNCTION GEN. £146

CS 1562A 10 MHz DUAL TRACE £224

FG270, Function Generator — 0.1Hz to 1MHz in 6 ranges — sine, square and triangle — 20V p-p open circuit output — < 1% distortion — D.C. offset — TTL O/P — Ext. VCO for sweep tests. FG271 as above plus 0.02Hz to 2MHz in 7 ranges — Int. sweep — Pulse, Tone Burst and A.M.

CS1562A Dual Trace 10MHz Oscilloscope — 10mV to 20V/div sensitivity in 1-2-5 sequence with fine control — 1µs to 0.5 s/div sweep time plus X5 Mag. — Auto, Manual and T.V. triggering — Z mod and X-Y operation. A single trace version CS1559A is available at even lower cost.

Plus many other Trio Products such as high sensitivity electronic voltmeters, Wow and Flutter meters, DIP meters and of course the main range of Trio scopes up to 100MHz — JUST ASK FOR THE CATALOGUE

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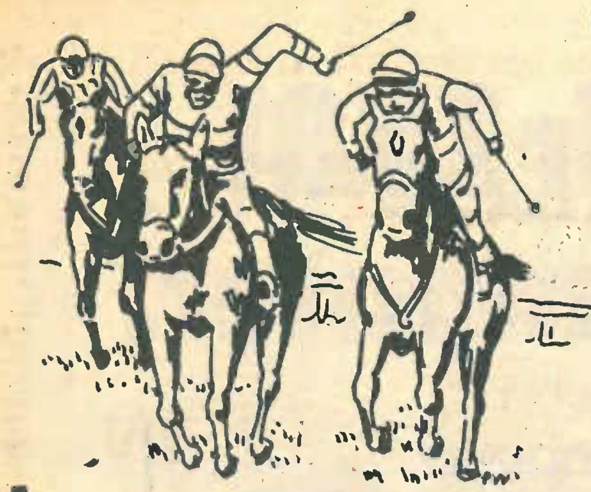
WW – 022 FOR FURTHER DETAILS

DAL 9622



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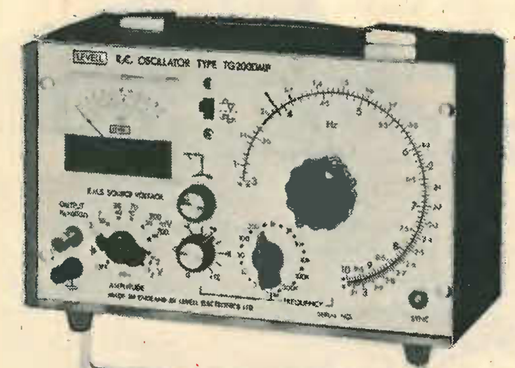
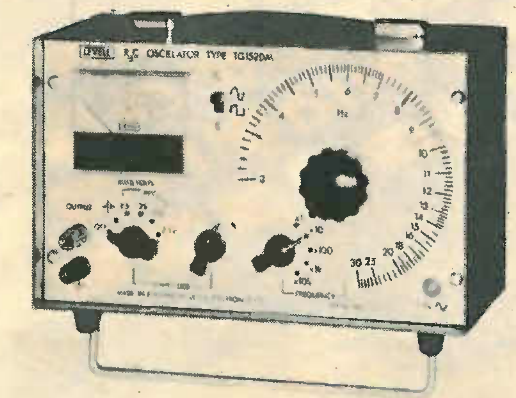


FREQUENCY	1Hz to 1MHz in 12 ranges. 0 to 1% fine control on TG200DMP
ACCURACY	± 1.5% ± 0.01Hz up to 100kHz. ± 2% up to 1MHz.
SINE OUTPUT	7V r.m.s. down to < 200µV with Rs = 600Ω.
DISTORTION	< 0.05% from 50Hz to 15kHz, < 0.1% from 10Hz to 50kHz, < 0.2% from 5Hz to 150kHz, < 1% at 1Hz and 1MHz.
SQUARE OUTPUT	TG200D, DM & DMP only, 7V peak down to < 200µV. Rise time < 150nS.
SYNC OUTPUT	< IV r.m.s. sine in phase with output
SYNC INPUT	± 1% freq. lock range per volt r.m.s.
METER SCALES	TG200M, DM & DMP only. 0/2V/ 0/7V & −14/+6dBm.
SIZE & WEIGHT	260 × 130 × 180mm. 4.3kg with batteries.

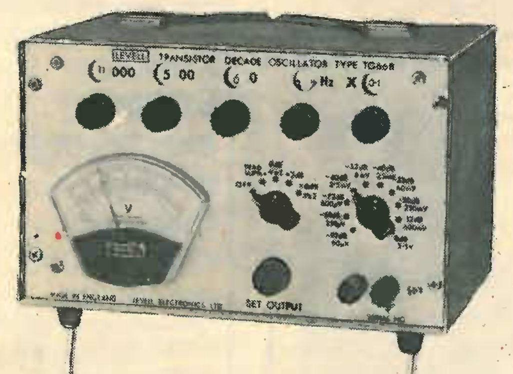
TG200	TG200D	TG200M	TG200DM	TG200DMP
£99	£108	£125	£130	£135



FREQUENCY	3Hz to 300kHz in 5 decade ranges.
ACCURACY	± 2% ± 0.1Hz to 100kHz. Increasing to ± 3% at 300kHz.
SINE OUTPUT	2.5V r.m.s. down to < 200µV
DISTORTION	< 0.2% from 50Hz to 50kHz. < 1% from 10Hz to 200kHz.
SQUARE OUTPUT	2.5V peak down to < 200µV.
SYNC. OUTPUT	2.5V r.m.s. sine.
METER SCALES	0/2.5V & −10/+10dB on TG152DM.
SIZE & WEIGHT	260 × 130 × 180mm. 3.4kg with batteries.

TG152D Without meter **£80**

TG152DM With meter **£99**



FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	± 0.02Hz below 6Hz. ± 0.3% from 6Hz to 100kHz. ± 1% from 100kHz to 300kHz. ± 3% above, 300kHz.
SINE OUTPUT	5V r.m.s. down to 30µV with Rs = 600Ω.
DISTORTION	< 0.15% from 15Hz to 15kHz. < 0.5% at 1.5Hz and 150kHz.
METER SCALES	2 Expanded voltage and −2/+4dBm
SIZE & WEIGHT	260 × 180 × 180mm. 5.4kg.

TG66B Battery model **£265**

TG66A Mains & battery model **£280**

Prices are ex works with batteries. Carriage, packing and VAT extra.
Optional extras are leather cases and mains power units.
Send for data covering our range of portable instruments.

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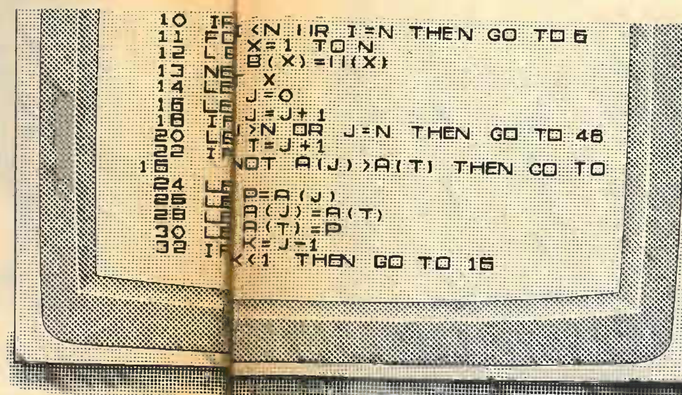
WW – 017 FOR FURTHER DETAILS

New! Sinclair ZX81 Personal Computer.

Kit: £49.95 complete



Built: £69.95 complete

Reach advanced computer comprehension in a few absorbing hours

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. At £99.95, the ZX80 offered a specification unchallenged at the price.

Over 50,000 were sold, and the ZX80 won virtually universal praise from computer professionals.

Now the Sinclair lead is increased: for just £69.95, the new Sinclair ZX81 offers even more advanced computer facilities at an even lower price. And the ZX81 kit means an even bigger saving. At £49.95 it costs almost 40% less than the ZX80 kit!

Lower price: higher capability
With the ZX81, it's just as 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, or to select a program off a cassette through the keyboard.

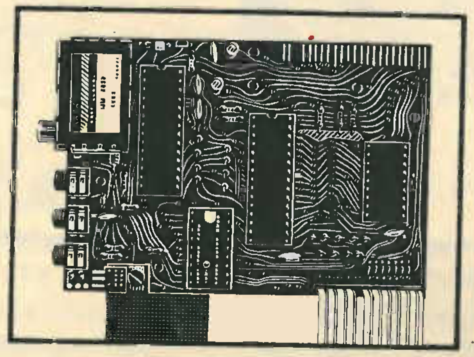
Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

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!

Kit or built – it's up to you!

The picture shows dramatically 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.



Proven micro-processor, new 8K BASIC ROM, RAM – and unique new master chip.

New Sinclair teach-yourself BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs. You need no prior knowledge – children from 12 upwards soon become familiar with computer operation.

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 (not available yet – but coming soon!)
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

sinclair ZX81

Sinclair Research Ltd,
6 Kings Parade, Cambridge, Cambs., CB2 1SN. Tel: 0276 66104.
Reg. no: 214 4630 00

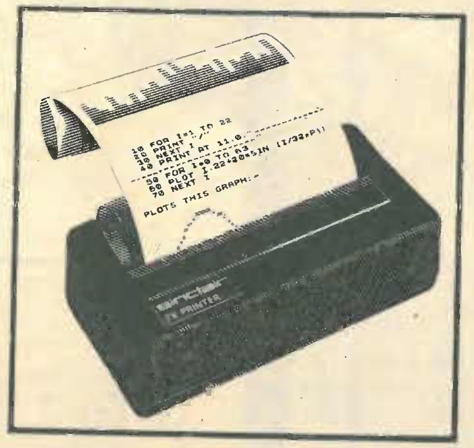
If you own a Sinclair ZX80...

The new 8K BASIC ROM used in the Sinclair ZX81 is available to ZX80 owners as a drop-in replacement chip. (Complete with new keyboard template and operating manual.)

With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 – including the ability to drive the Sinclair ZX Printer.

Coming soon – the ZX Printer.

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics across 32 columns, and highly sophisticated graphics. Special features include COPY, which prints out exactly what is on the whole TV screen without the need for further instructions. The ZX Printer will be available in Summer 1981, at around £50 – watch this space!



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.

How to order your ZX81
BY PHONE – Access or Barclaycard 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 or Barclaycard.
EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST 7, Cambridge, CB2 1YY. **Order**

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	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(s).	18	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

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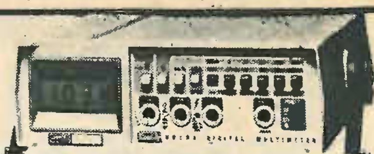

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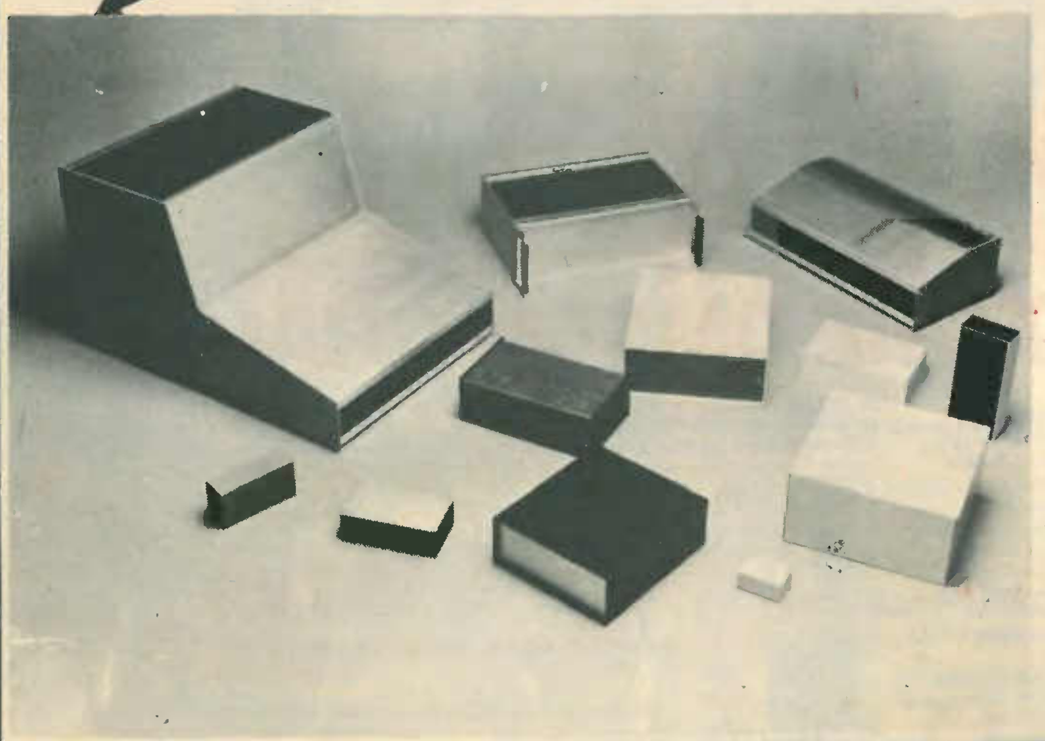

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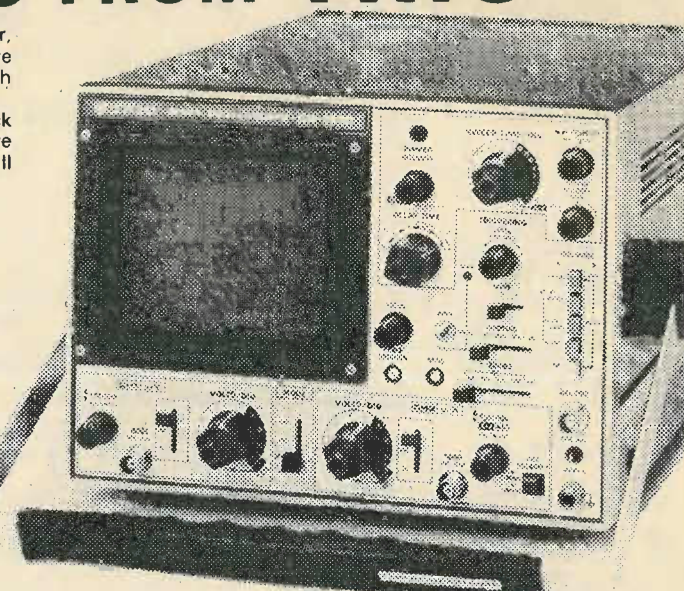

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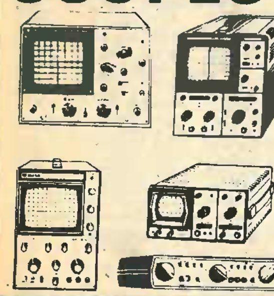

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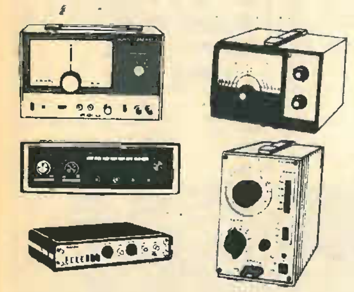

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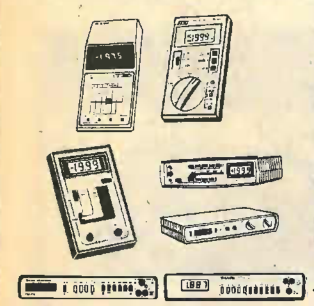

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DM450 4½ Digit LED 34 ranges AC/DC 10 amp **£113.85**
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TR303TR 20K/volt plus 12A DC plus hfe test **£15.95**
AT20 20K/Volt 21 range de luxe plus 10A DC and 5KV DC **£21.95**
AT205 50K/Volt 21 range de luxe plus 10A DC **£24.95**
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AT2050 50K/Volt 18 range de luxe plus hfe test **£28.50**
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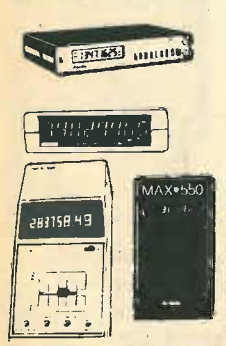

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HEWLETT PACKARD	
4342A 'Q' Meter QLC complete	1250
MARCONI	
TF868A Universal Bridge	250
TF1313A Universal LCR Bridge 0.1%	375
WAYNE KERR	
B224 Wide range LCR Bridge	475
B500 Log LCR Bridge	225
B601 RF LCR Bridge (Detector and Oscillator not incl).	125
B641. Measures L/C/R/G Accuracy of 0.1%	450
Q801. Y parameter test set. Plus transistor adaptor unit	230

Cable Test Equipment

	Prices from £
MARCONI	
TF2333 Transmission Test set	575
HEWLETT PACKARD	
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NEC	
TTS-37B. Noise, level and VU measurement. Sensitivity -80dBm up to +20dBm	275
STC	
74216A Noise Generator CCITT	240
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TEKTRONIX	
1502 Portable TDR Cable Tester	2,725
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5308A 0-75 MHz. Universal Module. 50mV sens. 1MΩ	100
5267A Time Interval Plug-in 10ns	120
5345 DC-500 MHz Time Int. Ave. Burst Total Ratio	1225
10590A Adaptor converts 5245 Plug-ins to 5345	225
RACAL	
9024 10 Hz-600 MHz 7+1 digits	250
9835 6 Digit DC-20 MHz 10mV	100
9837 DC-80 MHz 6 digits	130
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6053 9 Digit 20 Hz-3 GHz BCD O/P	850
6054A/04 11 Digit 20 kHz-18 GHz BCD O/P	2800

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DL905 Digital Storage Unit DC-3 MHz 10mV	1055
DRANETZ	
606-3 Disturbance Analyser Avg, Sag/Surge	2625
GAY	
LDM Records +ve/−ve transients of 50ns on AC or DC Lines	1250

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MARCONI	
TF2300A 1-1000 MHz. AM/FM	450

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3300B Dual Trace DC-50 MHz 5mV/div. Dual Timebase	600
GOULD ADVANCE	
OS1000B DC-20 MHz Dual Trace X-Y TV Sync	250
HEWLETT PACKARD	
1703A Storage 1000Div/ms. DC-35 MHz. Dual trace Mains/Ext DC	1200
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182C DC-100 MHz Mainframe, large screen	525
MEDELEC	
M-scope 4 channel DC-100 kHz U/V Chart	1650
PHILIPS	
PM 3211 DC-15 MHz Dual Trace 2mV	425
PM3233 Dual Beam DC-10 MHz 2mV/div.	400
TEKTRONIX	
475 Dual Trace DC-200 MHz 2mV	1125
485 Dual Trace DC-350 MHz 50Ω 1 MΩ 250 MHz	2100
545B/1A1. DC-30 MHz. dual trace. Delayed timebase	325
585A/82. DC-80 MHz. dual trace 10 mV sensitivity	525
547/1A1. DC-50 MHz. dual trace DTB	525
547/1A4. DC-50 MHz. four trace DTB	625
7403N DC-60 MHz 3 Plug-in Mainframe	450
7704A DC-200 MHz. CRT Readout. Mainframe for 4 Plug-in	1200
TELEQUIPMENT	
D34 Dual Trace DC-15 MHz 2mV Mains/Batt	525
D75 Dual Trace DC-50 MHz Dual Timebase	600
D83 DC-50 MHz. Dual trace. Large 6½" CRT. Dual Time Base	650

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1804A DC-50 MHz Four channel 20 mV-10V/div.	575
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1805A Dual Trace DC-100 MHz 5mV. 1MΩ/50Ω	550
TEKTRONIX	
Type R. Transistor R.T. tester. Pulse rate 120 pulses/sec. R.T. Less than 5 mμs	100
Type G. Differential amplifier. 100:1 CMR DC-20 MHz. 50 mV sensitivity	50
Plug-ins for 500 series	
1A1 dual trace Plug-in DC-50 MHz	225
1A2 dual trace Plug-in DC-50 MHz	180
1A4 four trace Plug-in DC-50 MHz	375
1A5 Differential Plug-in	175
Z Differential Plug-in	140
81 Adaptor Plug-in 1A Series to 580 Series	75
7A12 Dual Trace DC-105 MHz 5mV/div.	410
7A22 High gain diff. amp. 0.1 Hz-1 MHz 10μV	450
7A26 Dual Trace DC-150 MHz 5mV-5V/div.	525
7B53A Dual Timebase 5ns-5s/div.	550

Oscilloscopes (storage)

	Prices from £
TEKTRONIX	
549/1A1. DC-30 MHz. 5mV sensitivity. Dual trace. Storage scope. Writing speed: 5cm/μs with enhancement. Includes trolley	675
564B/3A6/2B67. DC-10 MHz. Dual trace 10mV sensitivity, split screen storage oscilloscope	750
466 Storage 1350 cm/μs Variable Persist DC-100 MHz	2225
7313 Split screen 4.9 cm/μs. DC-25 MHz (M/F for 3 Plug-ins)	1650

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DRANETZ	
301A 5 Hz-500 kHz. Z in 100kΩ. Accuracy ±1° to ±2°. Analogue O/P	400

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	Prices from £
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HEWLETT PACKARD	
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435A 0.3μW to 100mW 5 MHz-18GHz	475
8481A Power Sensor for 435A	200
MARCONI SANDERS	
6460 10 MHz-40 GHz (Depending on Head)	300
6420 10 MHz-12.4 GHz 10mw	110
MARCONI	
TF2512 DC-500 MHz 0.5-30w 50Ω	130
TF 893A 10 Hz-20 kHz. 20μW-10W.	120

Power Supplies

	Prices from £
BRANDENBURG	
475R 10-2100V 5mA DC Stab.	150
FARNELL	
L30B 0-30V 1A DC Stab.	55
FLUKE	
415B 0±3100V 30mA 0.005% reg. Protected	350
ITT	
Power Lab. up to 30V Dual Supply	90
MARCONI	
TF2154/1 0-30V 1A. 0±15V 2A 0±7.5V 4A	60
SMITHS	
4701 5-7V o/p Power Pack	32
SORENSEN	
DCR 300-2.5 0-300V 2.5A DC Stab.	375

Pulse Generators

	Prices from £
DB ELECTRONICS	
150. I.C. pulse generator	50
EH RESEARCH	
122. 1 KHz-200 MHz 5V/50Ω RT 12ns	220
139(L). 10Hz-50 MHz 10V/50Ω RT 5ns	175
1221. Timing Unit 6 Channel 0-10 MHz 5V/50Ω RT 8ns	50
HEWLETT PACKARD	
214A 100V/50Ω. Double pulse O/P. W50ns-10ms. 10 Hz-1 MHz. 15ns RT	350
MARCONI	
TF2025 0.2 Hz-25 MHz ±10V/50V RT 7ns	350

Recorders and Signal Conditioning Equipment

	Prices from £
AMPEX	
PR2200 Instrumentation Recorder up to 16 channels. FM/DR. Record replay all speeds. 1" tape FM/DR I.R.I.G. DC-40 kHz FM. 100 Hz-300 kHz DR	6500
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ME102C. Wow and flutter meter	90

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BS314 4 channel 1mV-10V 16 speeds	1650
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7046A Two pen A3 0.25mV-5V/cm	995
KUDELSKI	
Nagra 4.2 LSP Professional Audio Recorder (Batt optd)	1215
PHILIPS	
PM 8251 Single pen 10in chart 10mV-50V FS	450
RACAL	
Store 4. Uses D/4 inch magnetic tape. Will record 4 F.M. channels. Operates at 7 different speeds.	1675
S E LABORATORIES	
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994 6 Channel Pre-Amp ± 1% ± 1V o/p	450
6008 25 Channel μV 8 in 4m/sec to 25mm/min	895
SMITHS INDUSTRIES	
RE541.20 Single Pen. 0.5mV-100V FSD. 3-60cm/min and hour	350
YOKOGAWA	
3046. 10 inch Chart Single Pen. 0.5 mV-100 VI/P2.60cm/min and/hr	350
3047. 2 Pen Version of 3046	425

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	Prices from £
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DYMAR	
1525 100 kHz-184 MHz Int/Ext AM/FM Batt/Mains	525
GENERAL RADIO	
1362 UHF, 220-920 MHz	450
GOULD ADVANCE	
SG70 5 Hz-125 kHz 600Ω 4w	85
HEWLETT PACKARD	
204D 5 Hz-1.2 MHz. 600Ω. 80dB att. O/P 5V RMS	150
620B 7-11 GHz 50Ω FM/PM 1mw	1100
8614A 800 MHz-2.4 GHz + 10dBm to −127 dBm 50Ω AM/FM	1950
8616A 1.8-4.5 GHz Ext AM/FM/PM 10 mw	925
MARCONI	
TF144 H/4S HF Generator 10 kHz-72 MHz AM	550
TF791. FM Deviation Meter 4-1024 MHz	95
TF801/D1. 10-470 MHz AM. FM.	255
TF995A/2. 1.5-220 MHz AM. FM.	350
TF2171 Digital Synchroniser for TF2015	525
TF2002/AS 10 kHz-72 MHz FM/AM 0.1-1V o/p	625
TF2012 UHF, FM 400-520 MHz, 0.03μV. Counter o/p	650
TF 2012 UHF, 400-520 MHz. FM	550
RACAL	
9081 5-520 MHz LED Display O/P − 130dBm AM/FM	1875
SCHAFFNER	
NSG330 Ignition Interference Attachment	150
NSG200B Mains Interference Simulator (Mainframe)	250
STC	
74216 Noise Generator 20 Hz-4 kHz Flat/CCITT Wtg	315

Spectrum Analysers

	Prices from £
HEWLETT PACKARD	
8443A Tracking Gene/counter 100 kHz-110 MHz	850
8445A Automatic pre-selector 10 MHz-18 GHz	1300
8555A RF Plug-in 10 MHz-18 GHz 1 kHz Res	3000
851B/8551B Display & RF Section	1,350
NELSON ROSS	
011. DC-20 kHz. 80dB dynamic range. Dispersion: 100 Hz-6 kHz	350
022. DC-100 kHz. Dynamic range 60dB fits into various 500 series CRO's	350
TEKTRONIX	
3L5. Plug-in unit fits into various 500B series CRO's. 50 Hz-1 MHz. Greater than 60dB dynamic range	475

Sweep Generators

	Prices from £
HEWLETT PACKARD	
8690B Mainframe. Int/Ext AM. Ext FM	600
8693B/100 3.7-8.3 GHz.5mW. PIN levelled 'N' connectors	600
8699B/100 0.1-4 GHz.6mW. (20mW to 2 GHz). PIN levelled. 'N' connectors	1200
TEXSCAN	
9900 Sweep Generator 10-30 MHz CRT Display	525
VS60 Sweep Generator 5-100 MHz Rate 60 Hz	950
TV Markers set of 5: 31.5, 32.5, 35, 39.5 & 41.5 MHz	195
LN40A Log Amplifier	105

Temperature Measuring Equipment (NB Thermocouples not incl.)

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COMARK	
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1604BLS −60°C to +170°C Type K Thermocouples	82
1625BLS −100°C to +300°C Type T Thermocouples	90
1642BLS −120°C to +800°C Type J Thermocouples	75

Voltmeters-Analogue

	Prices from £
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8 Mk IV AC/DC V.AC/DC Amps. Ω	70
BOONTON	
92AD/01/09 10 kHz-1.2 GHz 1999 FSD 10μV Res	525
92C 10 kHz-1.2 GHz 500μV-3V. 1% of FS	350
HEWLETT PACKARD	
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427A. AC/DC/Ω multimeter	275
3406A. 10 kHz-1.2 GHz	345
3400A 10 Hz-10 MHz 1mV-300V True RMS	350
KEITHLEY	
610C Electrometer DC 1mV-100V, Amps 10^{-14} Recorder o/p	350
LEVELL	
TM3B 5μV-500VAC 1 Hz-3 MHz + 50 to 100 dB	80
MARCONI	
TF2603. AC voltmeter to 1.5 GHz	300
PHILIPS	
PM2454B 1mV-300V 10 Hz 12 MHz Z in 19MΩ. DC O/P	300
RACAL	
9301 RMS Millivoltmeter 10 kHz-1.5 GHz with carry case	475

Voltmeters-Digital

	Prices from £
ADVANCE	
DMM 7A/01 1999 FSD AC/DC/Ω/Current	115
FLUKE	
8000A 1999 FSD. AC/DC/OHMS/Current	115
HEWLETT PACKARD	
34740A/34702A 9999 FSD.AC/DC/OHMS	180
SOLARTRON	
LM1420.2. 2300 FSD DC only 0.05%	75
LM1420.2BA. 2300 FSD AC True RMS/DC	110
A200.19999 FSD DC only	160
A203.19999 FSD AC/DC/Ω. Sensitivity: (1μV DC. 10μV AC, 100mΩ resistance)	300
A205.19999 FSD AC/DC/Ω	300
A243. 119999 FSD AC/DC/Ω. Sensitivity: (1μV DC. 10μV AC, 10mΩ resistance)	325
7050.99999 Auto AC/DC/Ω	350

Voltmeters Vector/Phase

	Prices from £
DRANETZ	
305B 9999 FSD Mainframe for PA 3001 module	575
HEWLETT PACKARD	
3490A 100000 FSD 1μV-1000V DC 0.01% 10μV-1000V AC & Ω	625

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HEWLETT PACKARD	
8640B Precision AM-FM Signal-Generator	£3550
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8552B Spectrum Analyzer — IF Section	£2200
8553B Spectrum Analyzer — RF Section	£1650
8555A Spectrum Analyzer — RF Section	£4400
8556A Spectrum Analyzer — LF Section	£1650
8558B Spectrum Analyser (for 180 Mainframe)	£2500
1600A 16 Channel Display Logic Analyzer	£2150
PHILIPS	
PM 3212 Dual Trace 25 MHz 2mV/Div Oscilloscope	£525
PM 3214 Dual Timebase Dual Trace DC-25 MHz Oscilloscope	£625
RACAL	
9081 5-520 MHz Generator 130 dBm AM/FM	£1975
TEKTRONIX	
485 Dual Trace 350 MHz Oscilloscope	£2995
T912 Dual Trace Storage Oscilloscope DC-10 MHz 250 cm/ms writing speed	£699
7313 Storage Oscilloscope Mainframe 4.9 cm/μs writing speed DC-25 MHz	£1900
7A22 Differential Plug-in. As new DC-1 MHz 10μV-10V/Div (12 month guarantee)	£670
7A26 Dual Trace Plug-in. DC-150 MHz 5mV-5V/Div.	£780
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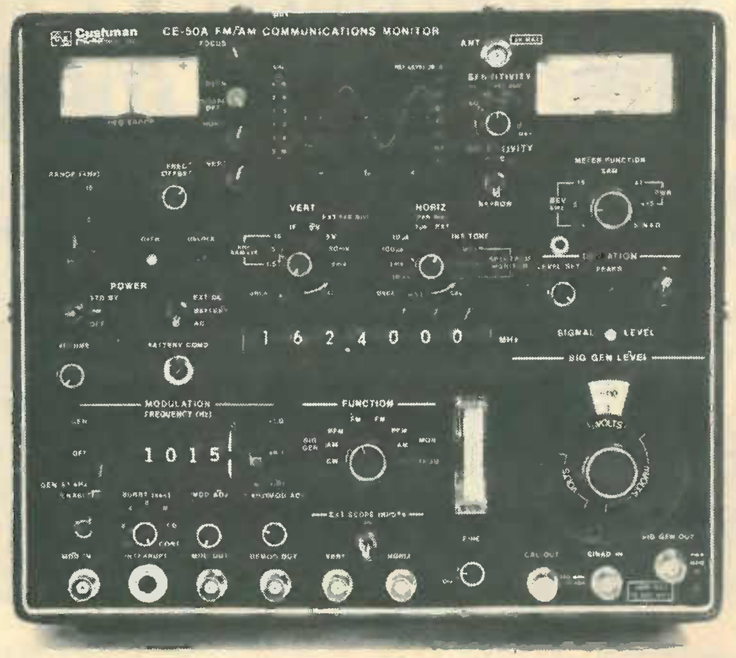

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SEC: 0 12V 0V 12V

TYPE	AMPS 12v 24v	PRICE £	P/P £
242	0.3 0.15	1.70	0.40
213	10.50	2.32	0.70
71	2 1	2.51	0.90
18	4 2	3.24	1.43
68	3 1.5	3.15	1.43
85	5 2.5	5.52	1.43
70	6 3	6.26	1.43
108	8 4	7.36	1.73
72	10 5	8.05	1.65
116	12 6	8.57	1.90
17	16 8	10.53	2.05
115	20.10	13.69	2.05
187	30.15	17.72	2.45
232	40 20	25.16	3.50
226	60 30	35.35	4.00

48/96V RANGE PRI 120/220/240V
SEC: 0V 36V 48V 0V 36V 48V
VOLTS 12 ⟹ 48 — 0 — 48

TYPE	AMPS 48v 96v	PRICE £	P/P £
430	1 0.5	4.14	1.43
431	2 1	7.22	1.73
432	4 2	11.87	2.05
433	6 3	14.47	2.20
434	8 4	18.43	2.45
435	10 5	26.16	2.65
436	12 6	32.75	4.00
437	16 8	35.77	4.60

15/30V RANGE PRI 220/240V
SEC: 0V 12V 15V 0V 5V 9V 15V
VOLTS AVAILABLE 3 ⟹ 15 — 0 — 15

TYPE	AMPS 15v 30v	PRICE £	P/P £
112	1 0.50	2.47	0.95
79	2 1.0	3.16	0.95
3	4 2	5.64	1.43
20	6 3	6.59	1.73
21	8 4	7.80	1.73
51	10 5	9.68	1.90
117	12 6	10.97	2.05
88	16 8	14.65	2.20
89	20 10	16.93	2.35
90	24 12	18.84	2.55
91	30 15	21.56	2.65
92	40 20	30.08	3.50

AUTOTRANSFORMERS 240/220—115V 65VA — 10KVA
0V 115V 220V 240V

TYPE	VA	PRICE	P/P
25	65	3.82	1.10
64	80	4.40	1.10
4	150	5.64	1.43
69	250	7.13	1.73
53	350	8.97	1.90
67	500	11.09	2.20
83	750	12.42	2.20
84	1000	16.88	2.65
95	2KVA	31.26	4.00
73	3	61.27	4.75
57	5	87.42	6.60
101	10	159.45	13.00

25/50V RANGE PRI 120/220/240V
SEC: 0V 20V 25V 0V 8V 15V 25V
VOLTS OUT 5 ⟹ 25 — 0 — 25

TYPE	AMPS 25v 50v	PRICE £	P/P £
102	1.0.50	2.88	1.43
103	2 1.0	3.60	1.43
104	4 2	7.04	1.73
105	6 3	8.33	1.90
106	8 4	11.18	1.90
107	12 6	14.79	2.20
118	16 8	20.49	2.55
119	20 10	24.52	2.55
109	24 12	29.39	3.50

CASED AUTOTRANSFORMERS
240V LEAD IN: 115V 2PIN SOCKET OUT

TYPE	VA	PRICE £	P/P £
56W	20	5.52	0.58
64W	80	7.63	1.43
4W	150	9.63	1.73
69W	250	11.98	1.90
67W	500	18.67	2.20
84W	1000	26.90	2.65
95W	2000	48.45	7.00
73W	3000	69.18	8.00

30/60V RANGE PRI 120/220/240V
SEC: 0V 24V 30V 0V 10V 18V 30V
VOLTS 6 ⟹ 30 — 0 — 30

TYPE	AMPS 30v 60v	PRICE £	P/P £
124	1 0.5	2.92	1.43
126	2 1	5.78	1.43
127	4 2	7.13	1.73
125	6 3	10.73	1.90
123	8 4	12.28	2.20
40	10.5	15.55	2.20
120	12 6	17.72	2.35
121	16 8	25.09	2.65
122	20 10	29.07	4.00
189	24 12	33.51	4.60

LINE ADJUSTMENT AUTOTRANSFORMERS
0 200 210 220 230 240 250

TYPE	VA	PRICE £	P/P £
415C	50	2.13	0.58
416C	100	3.13	1.10
417C	200	3.65	1.43
418F	350	5.63	1.43
419F	500	6.13	1.73
420E	750	7.60	1.90
421F	1000	10.55	2.05

MAINS ISOLATORS (SAFETY SCREEN)
PRI 120/220/240V SEC 60V 55V 0V 55V 60V 60V 55V 0V 55V 60V

TYPE	VA	PRICE £	P/P £
149F	60	7.35	1.73
105F	100	8.61	1.73
151F	200	12.15	2.05
152F	250	14.75	2.20
153F	350	18.22	2.55
154F	500	22.70	2.65
155F	750	32.08	7.00
156F	1000	41.26	7.00

MAINS ISOLATORS (SAFETY SCREEN)
PRI 380/415/460V SEC 60V 55V 0V 55V 60V 60V 55V 0V 55V 60V

TYPE	VA	PRICE £	P/P £
243F	60	7.35	1.43
244F	100	8.61	1.73
245F	200	12.15	2.05
246F	250	14.75	2.20
247F	350	18.22	2.55
248F	500	27.70	2.65
249F	750	32.08	7.00
250F	1000	41.26	8.00

TYPE	VA	PRICE £	P/P £
277PI	750	[illegible]	[illegible]
279PI	1500	50.60	7.00
280PI	2250	68.26	7.00

MAINS ADAPTORS
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TYPE	VA	mA	PRICE	P/P
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101	6-7.5-9v	300	4.70	0.58

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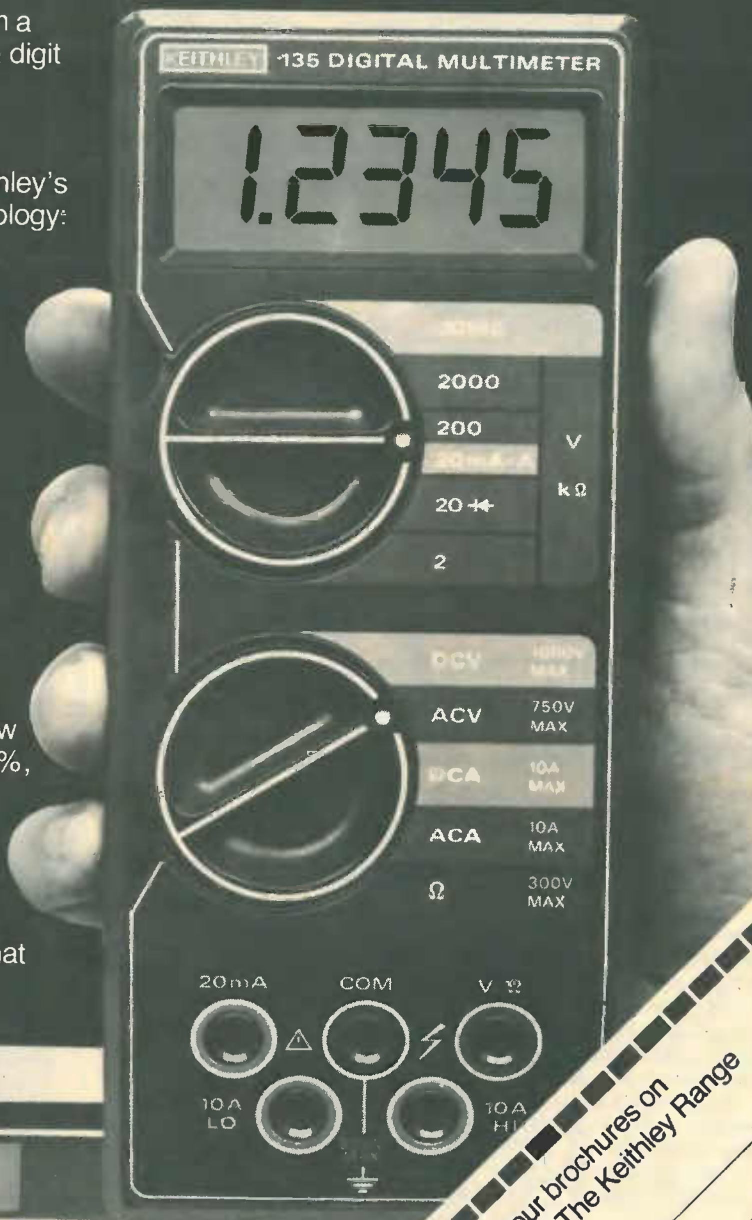

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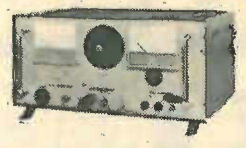

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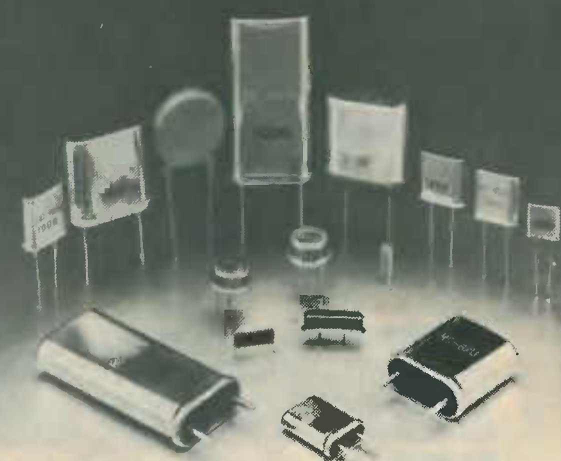

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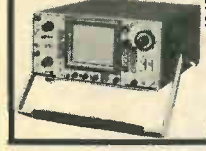

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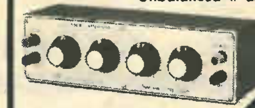

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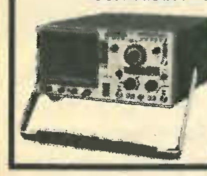

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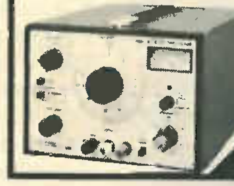

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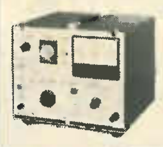

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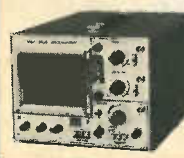

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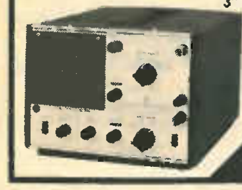

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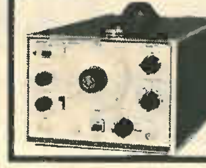
457A 0.01Hz to 100kHz, Sine, triangular and square output. V.C.G. mode (FM) 1000:1 V.C.A. mode (AM).



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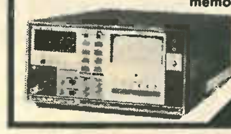

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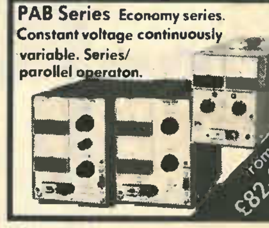

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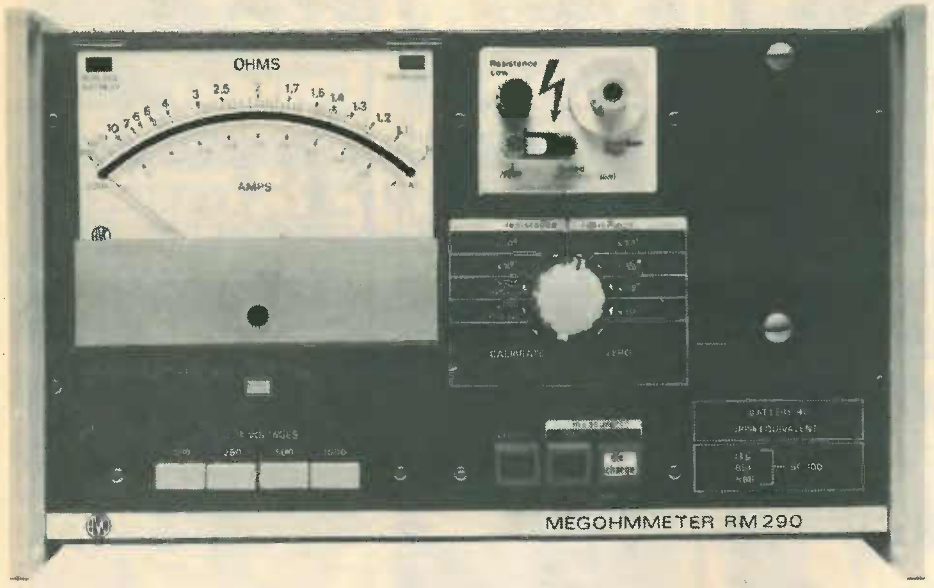

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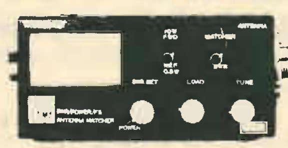

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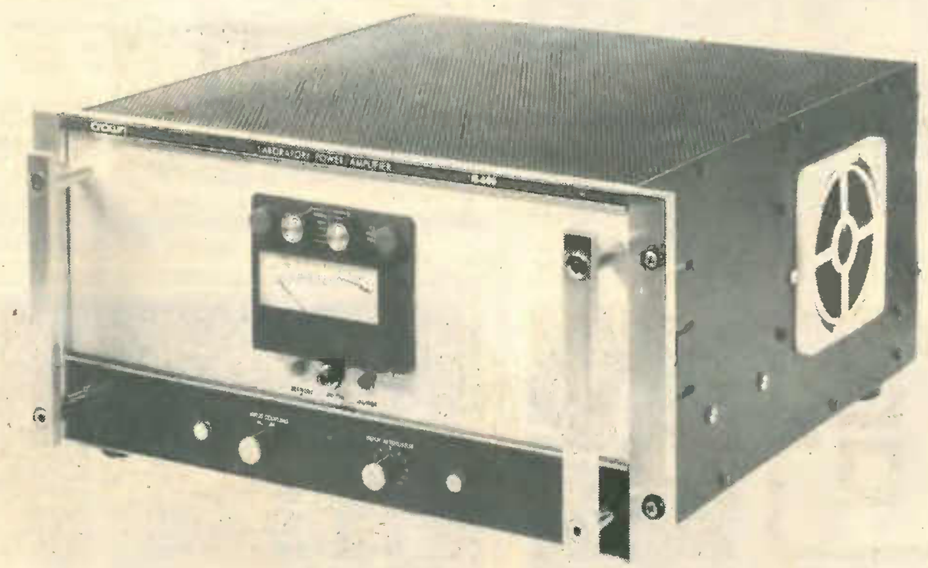

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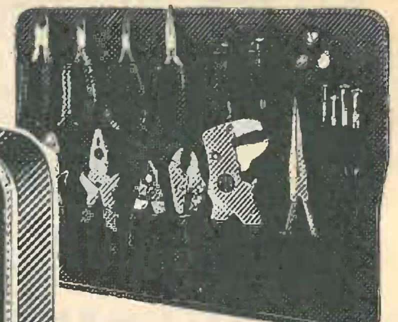

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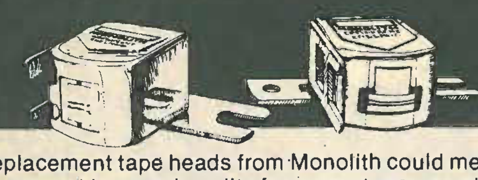

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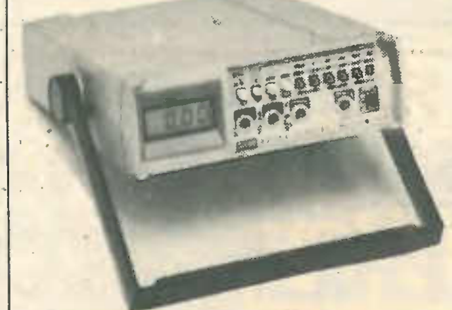

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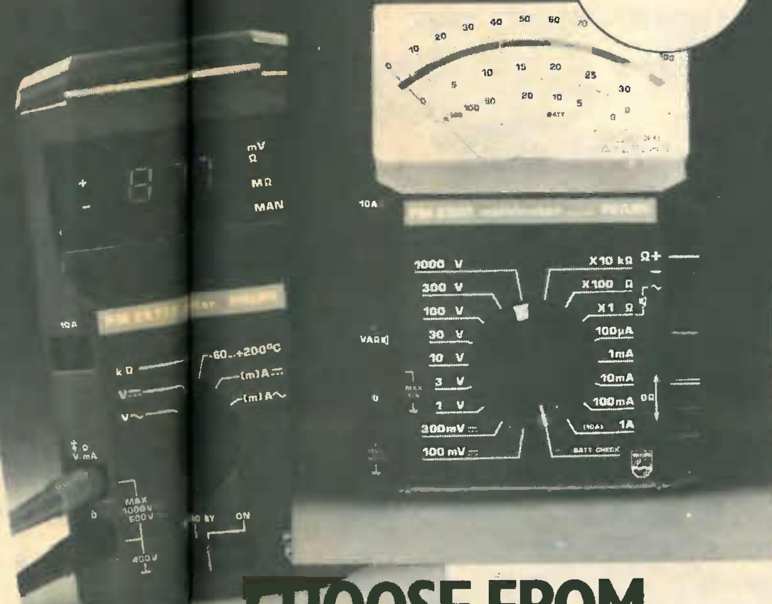

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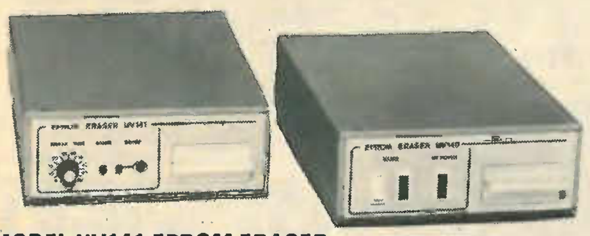

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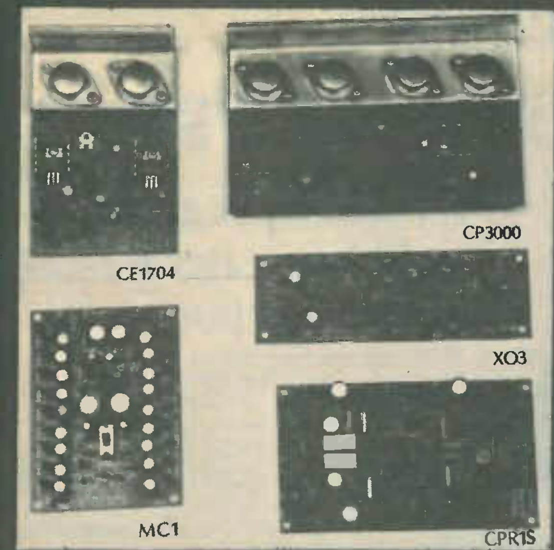

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SPECIFICATIONS

Type	O/P8ohms*	O/P4ohms*	PSU	H/Sinks	Slew	S/N	Sensitivity	T.H.D. (typ)	F.R.	Size
CE 608	38		CPS1	50mm	30V/uS	110dB	775mV	0.0035%	1.5Hz 50Khz (3dB)	80 · 120 · 25
CE1004	44	70	CPS3	100mm	30V/uS	110dB	775mV	0.0035%	1.5Hz 50Khz (3dB)	80 · 120 · 25
CE1008	65		CPS3	100mm	30V/uS	110dB	775mV	0.0035%	1.5Hz 50Khz (3db)	80 · 120 · 25
CE1704	85	121	CPS6	150mm/FM1	30V/uS	110dB	775mV	0.0035%	1.5Hz 50Khz (3dB)	80 · 120 · 25
CE1708	125		CPS6	150mm/FM1	30V/uS	110dB	775mV	0.0035%	1.5Hz 50Khz (3dB)	80 · 120 · 25
CP3000		250	CPS6	FM2	30V/uS	110dB	775mV	0.0035%	1.5Hz 50Khz (3dB)	161 · 102 · 35
CPR1(S)	Output	775mV	REG1		3V/uS	70dB	2.8mV/RMS	0.008%	20Hz 20Khz	138 · 80 · 35
MC1(S)	Output	2mV	REG1			65dB	70uV/150	0.008%	20Hz 20Khz	80 · 120 · 35
XO2 XO3	Output	775-2500mV	REG1		9V uS	90dB	775mV	0.01%	X over points	150 · 50 · 20

*Power output is quoted WRMS and is given for two modules run off the same power supply. Higher powers are obtainable if using one module per P.S.U. or if using a stabilised P.S.U.

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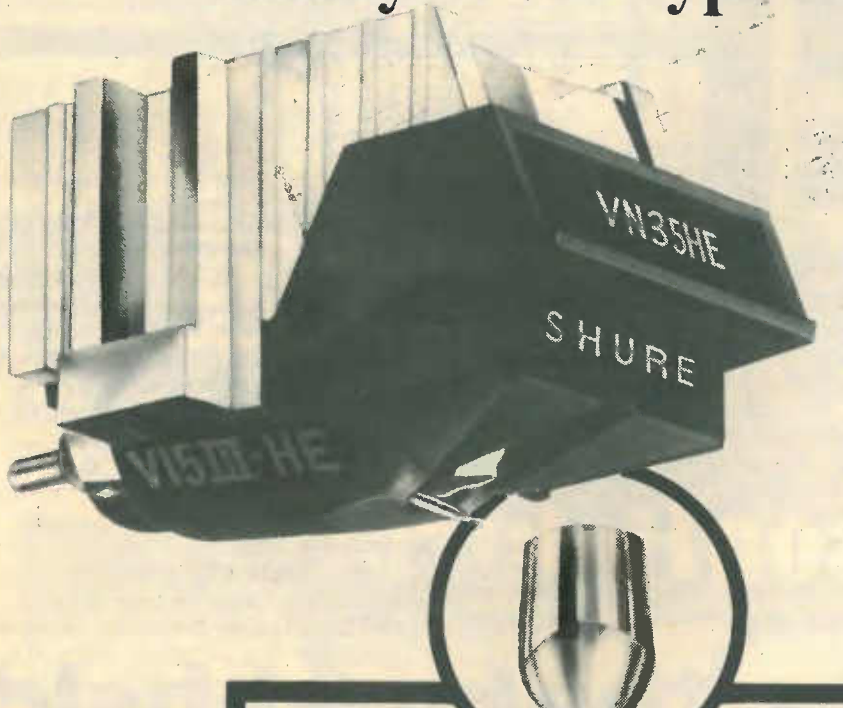

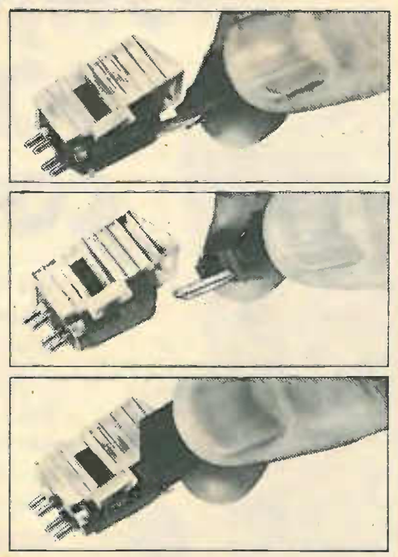

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The next seventy years

The artist Pablo Picasso once said: "Age only matters when one is ageing. Now that I have arrived at a great age, I might just as well be twenty." *Wireless World* feels much the same. Being the oldest radio journal in the world and having reached this month the Biblical age of three score years and ten, we can justly consider ourselves – in terms of electronics journalism – to have arrived at a great age. And we might just as well be twenty because it is in the nature of a periodical publication to renew itself with each issue. It doesn't matter whether one has produced 1,500 or only 15 previous issues, the next edition is always a completely new book – a new product belonging uniquely to its own moment in history and reflecting its own world at that moment. We did our reminiscing about the past on our 50th and 60th birthdays. Now, already 15 years into the era of the integrated circuit, we are as curious about the future and what it holds for us as any young person just starting to look at electronics as a possible career.

If we survive the next 70 years, what could we be looking back on in 2051 AD? Here a little humility is called for. If the periodical survives (and not necessarily on paper) it may well be a very different animal from what it is now. Electronics may no longer exist as a definable area of technology and industry. Just as radio spawned electronics, which then proceeded to absorb its parent, the same thing may happen again – several times over. On this principle one might look at other branches of science and technology with which electronics is already conjoined and speculate if they are capable of such absorption. Optics, perhaps, chemistry, biology . . . ? Or one might even consider the complete fragmentation of electronics into a variety of other technologies and interdisciplinary activities, some of which don't yet exist.

Extrapolation from present trends does take us a little way – greater complexity and higher performance in electronic products, more devices on a silicon chip, changes in microprocessor architecture and so on. This is the gadgeteering approach which envisages a world increasingly full of clever robots, wrist-watch radios, flat tv screens and information centres in the home. But it doesn't allow for the possibility that a completely new, seminal device will be invented that will transform the technology – just as the valve transformed radio communication and the transistor opened the way to integrated circuits. Several laboratories are now exploring the possible use of biological structures as transducers and energy converters. Could this lead perhaps to a stochastic, rather than deterministic, principle of information processing and transmission, analogous to that in the animal central nervous system?

But it is unrealistic to consider a technology in isolation from the society which produces it. You can say with truth that scientists and engineers discover and invent things which change our lives. These individuals, however, are part of society and subject to its pressures. You can say with equal truth that the technology we have is a symptom of the kind of society we are: it develops in particular directions in response to our material, emotional and spiritual needs. Broadcasting, hi-fi and other electronic diversions are technological responses to the needs of the "nuclear family" for entertainment and even "company" in homes that are becoming socially isolated from communities. As in the past, technology will continue to be both cause and effect.

1911, in which we were founded, was the fateful year when Rutherford did the historic experiments that led him to postulate the atomic nucleus and the picture of the atom we have now. Since then our physicists have been discovering ever more fundamental particles and our view of matter and energy has been greatly elaborated. During the next 70 years there could be a discovery or insight that would unify our observations and even depart from the traditional line of thinking started by Democritus. Such an event would not immediately alter the practice of electronic engineering but would certainly affect profoundly the work of the applied scientists who research into physical processes to create new devices.

Opto-electronic contact breaker

Compact and maintenance free switching for electronic ignition systems

by J. R. Watkinson, B.Sc., M.Sc.

The conventional automotive contact breaker is still widely used in modern petrol engines despite its shortcomings. Superior alternatives have been available for several years, but car manufacturers have been slow to remove the weak link in the ignition system. This design is simple, cheap, reasonably easy to install, and provides a maintenance free unit which will drive almost all electronic ignition systems which operate with mechanical contacts.

Although many electronic ignition units are available, and several well designed constructional circuits have appeared, most of them are triggered by the existing contacts and use either inductive or capacitive discharge to improve the spark and extend contact life. Some designs claim to eliminate the effect of contact bounce, but the effects of contact heel wear and timing scatter still remain.

The circuit in Fig. 1 provides an output which, for low currents, simulates the contact breaker and can trigger an electronic ignition unit without modification. The existing centrifugal and vacuum advance mechanisms are retained, and the only mechanical part which must be constructed with any precision is a chopper disc.

The light source is an infra-red l.e.d. with a lens to give a well defined beam, which is received by a spectrally and physically matched phototransistor. Light passing between the two devices is interrupted by a chopper disc which produces a rough square wave. This waveform is cleaned up before it is used for timing because electronic ignition circuits generally require a sharp edge to trigger an s.c.r. A conventional two transistor Schmitt-trigger was not used because the regenerative

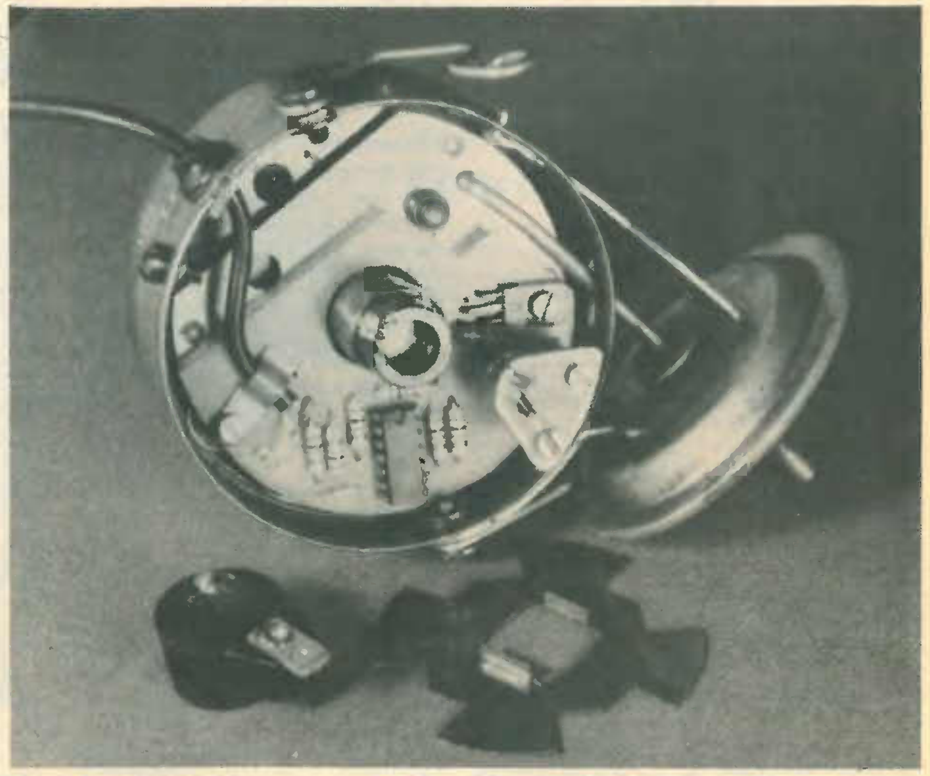


Fig. 2. Printed circuit board mounted on the action plate of a distributor. In the prototype Tr_1 was mounted underneath the board.

action only occurs if the input has a low source impedance and, in this design, the phototransistor is a current source. Instead, an open collector t.t.l. i.c. with two gates connected as a set – reset bistable is used. The inputs are driven in a complementary mode by using a third gate as an inverter, and the remaining gate is used as a buffer. The regenerative action of this circuit gives fast switching, and a conservatively rated series regulator provides reliable operation.

The complete circuit can be built on a glassfibre p.c.b. and mounted inside the distributor as shown in Fig. 2. The prototype fits a Delco distributor as fitted to many G.M. vehicles, but the layout can be modified to fit most other types. Some foreign vehicles use very small distributors, and for these it is best to house the circuit in a small metal box beside the distributor. Installation is much easier if a replacement distributor is used. Also, the second unit is useful to carry as a spare.

The phototransistor is mounted directly on the p.c.b. and the l.e.d. is mounted about 2.5mm away on a small board supported by 3mm tapped pillars which also carry the l.e.d. current. The main p.c.b. is mounted with spacers on the action plate in the distributor with 3mm screws which must have holes drilled and tapped. As the action plate is rotated by the vacuum advance mechanism, it must not be ob-

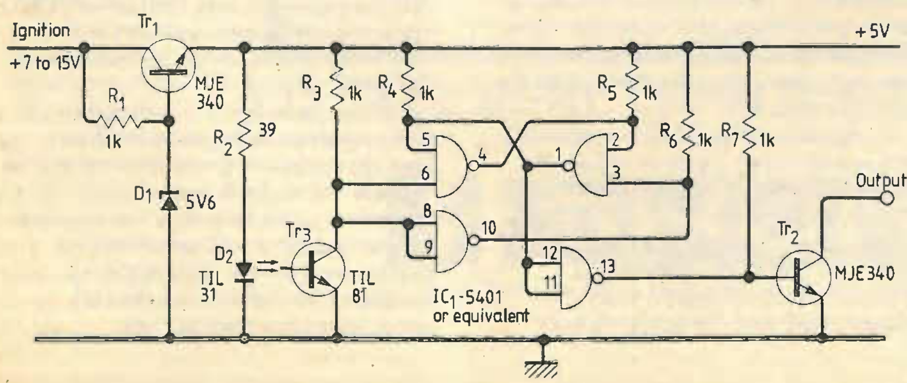
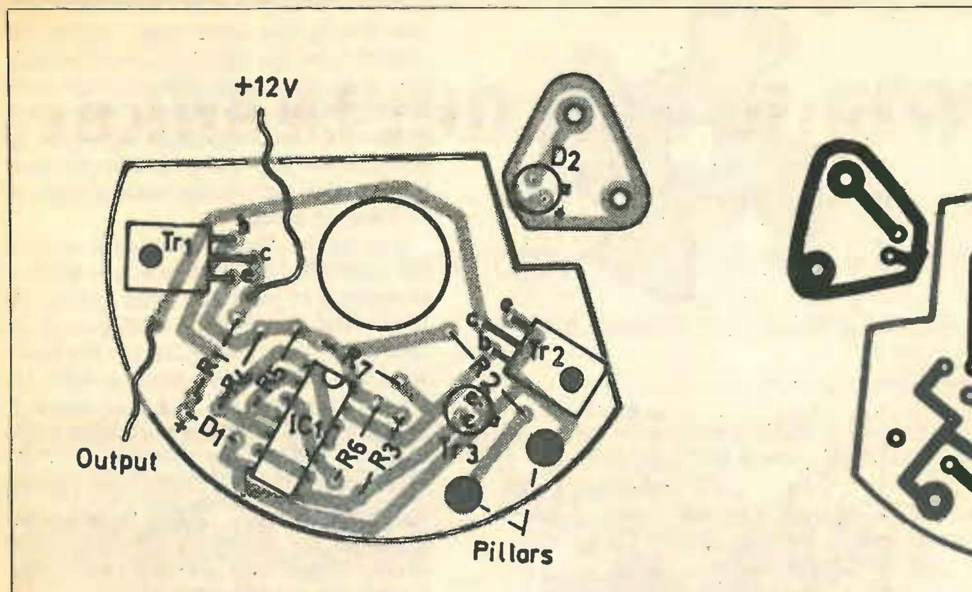


Fig. 1. Switching circuit and regulator. Tr_1 and Tr_2 do not require heatsinks, but should be secured with the screws that hold the p.c.b. in place. Note that IC_1 must be a ceramic type to ensure reliable operation during large temperature changes.



A set of shaped p.c.bs based on these layouts will be available for £4.00 inclusive from M. R. Sagin, 23 Keyes Road, London N.W.2.

Fig. 3. Printed circuit boards and component locations for a Delco distributor.

Fig. 4. Phototransistor and l.e.d. mounting. The two pillars must be metal types to carry the l.e.d. current.

Why replace the contact breaker?

A conventional contact breaker consists of a cam, rotated by the engine, which opens and closes a moving contact held in place by a stiff spring. As the contacts are forced open by the cam and closed by the spring, the cam has an alternating torque acting upon it. The cam is turned about the mainshaft by centrifugally operated weights which reach equilibrium with restoring springs to give different spark advance angles for different speeds. Therefore, there are two mass compliance systems which cause a wide distribution of timing. This problem is made worse by manufacturing tolerances in the cam and general wear in the contact breakers. Although a new distributor with correctly adjusted contacts operates fairly well, this peak performance rarely lasts for more than 2000 miles, and most petrol engines spend a significant proportion of their working life with a sub-standard ignition system.

The two most common replacements for the contact breaker are a magnetic pickup, where a lobed rotor varies the flux through a coil, and an optical system, where a light beam is interrupted by a chopper disc. The magnetic system is attractive to a mass producer because magnetic components and coils are familiar, but the optical system is more attractive for conversion of an existing unit because fewer mechanical parts are required.

Both types use the existing centrifugal and vacuum advance systems and, as the amount of energe extracted from the shaft is small in either case, the torsional excitation of the advance mechanism is negligible. Both systems do, however, exhibit a slight hysteresis between acceleration and deceleration as the rotor advances to take up any backlash when the engine slows. This is a small penalty and is normally of little consequence.

structed by the board or swarf, and the manufacturer's recommended lubricant should be restored. If the existing contact pivots on a pillar rivetted to the action plate, the pillar must be removed before the p.c.b. can be installed. Care must be taken to ensure that the small board does not foul the rotor arm or the inside of the distributor cap. When installed, the p.c.b. is connected to the ignition unit by a length of good quality miniature three core stranded cable. The cable should be supported by a small P clip fixed by one of the mounting screws, and by the existing grommet in the distributor body. Remember to leave enough cable loose so that the action plate can revolve.

The circuit can be tested by connecting +12V to the supply lead, and a low power bulb from +12V to the output lead. The lamp should remain on until the light beam is interrupted. Note that the specified device does not emit visible light. If the circuit switches the lamp correctly, connect it to the electronic ignition unit and take the h.t. lead from the coil directly to one spark plug. This will avoid coil breakdown if the rotor arm is not pointing at a segment of the distributor cap. Check that a spark is generated every time the light beam is interrupted and not when it is re-established.

When the circuit has been tested, a chopper disc should be constructed to suit the distributor. The accuracy of this disc affects the overall performance of the system, and the most important parameter is the angle between the leading edge of the blade and the line joining the mainshaft axis with the centre of the rotor arm sector. It is imperative that this angle causes the leading edge of a blade to just obscure the l.e.d., i.e. the point of firing, when the end of the rotor arm is directly opposite a segment inside the distributor cap, with the vacuum advance at mid-travel. If this condition is not achieved the engine may not run. Another important requirement is that the chopper blades are evenly spaced to avoid scatter. The angle between the blades is found by dividing 360° by the number of cylinders. Although this unit is suitable for any number of cylinders, the greatest improvement will be noticed on engines with six cylinders and above, where multi-lobed cams cause more timing scatter.

The disc does not need great strength, and the prototype was cut from tinplate. The centre hole has tabs which are alternately bent up and down to grip the cam as shown in Fig. 5. To construct the disc make a centre punch mark and scribe a straight line through the centre mark. Using a large transparent circular protractor with 0 and 180° marks on the line, mark the position of the blade edges and scribe lines to the centre. If an inductive discharge system is used, the angle between the chopper blades becomes the dwell angle, the angle through which the points remain closed, and must be the same for all cylinders. With a conventional contact breaker the dwell angle has to be short so that the points can open a reasonable distance. Unfortunately, a short dwell angle limits the time available for primary

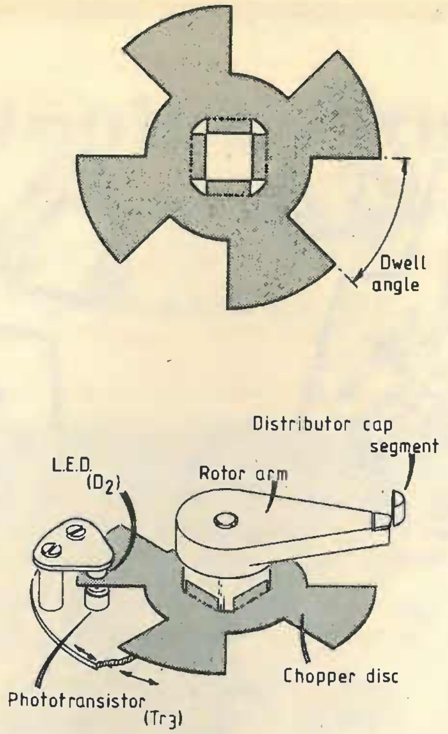


Fig. 5. Typical shape and mounting for the chopper disc. It is imperative that, when the disc just interrupts the light beam, the rotor arm is directly opposite a distributor segment with the vacuum pushrod at mid travel.

current build-up at high revolutions. With this design, the dwell angle can be increased from the manufacturers specification to increase spark energy at high revolutions. If the unit is used with a c.d. ignition system, the angle between the blades is not important because the spark is controlled only by the leading edges of the chopper blades.

Cutting the disc shape is made easier if the tinplate is clamped to a thin sheet of aluminium or plywood. After drilling the centre hole and filing it to shape, cut the disc to the correct diameter, cut the blades to shape and finish with a fine file. Finally, bend the tabs for a good central fit on the cam. The disc is then fixed to the cam with epoxy resin after checking that all the parameters are correct and that the disc revolves freely. When installation is complete, the distributor can be mounted in the engine and adjusted for correct timing with a strobe light.

Although this unit will not produce a dramatic increase in performance from a correctly tuned engine, the firing at high revolutions should be smoother and tick-over should be very steady even when cold, which permits sparing use of the choke. However, the main benefit is a maintenance free ignition system. The prototype has now been in use for five years and the distributor cap is only removed to show disbelievers.

BOOKS

Beginner's Guide to Digital Electronics,
by Ian R. Sinclair.
146pp., paperback.
Newnes Technical Books, £3.25.

Only a limited knowledge of electronics is assumed here. The author's intention is to explain the basics of digital technique to those who have no training in electronics, but who may have accumulated information on the active and passive components used in and around integrated circuits. He deals briefly with digital elements from switching devices, through small-scale systems such as counters, to microprocessors, though the chapter on micros, which occupies only fifteen pages, is rather too cursory to be of much practical value.

A complete beginner may find the lack of information on application a little worrying: elements are well described, but with little explanation of what their role in a system might be. A microprocessor, for example, is presented as a device whose program is capable of carrying out the action of a truth table as an alternative to a set of gates and registers, with no explanation of the advantages gained thereby.

The Prestel Business,
by Roger Nicholson and Guy Consterdine.
104pp., hardback.
Northwood Books, £4.95.

This is not a technical approach to Prestel, but an explanation, primarily for business people, of what a viewdata system is, how information is provided and used, some costings and some of the background. This would be a good introduction to the service for those who know little more than the name and who suspect that it could be of assistance in their work. There is no technical description whatever.

More on active crossover networks

Using electrostatic loudspeakers with a common bass unit

by D. C. Read, B.Sc.Hons (Elec. Eng.)

Modifications to David Read's 1974 active filter crossover design provide for Quad electrostatic loudspeakers or Isophon tweeters, with appropriate alterations in crossover frequencies.

An article in the November 1974 issue of *Wireless World* showed how some economies could be achieved in a stereo system using active cross-over networks. One such economy was to have a mixed mono/stereo arrangement using a single bass unit working in that part of the audio band where sounds are non-directional. Sounds in the mid and upper ranges were, in the system suggested, produced by smaller speakers fed via the amplifier/active-filter crossover units as described earlier (*Wireless World*, December 1973). This economy arrangement worked well, with the added flexibility of the active filters enabling best use to be made of the five conventional cone units – one bass, two mid-range, two upper-frequency speakers – variously selected for best operation in the chosen ranges.

Given greater financial freedom in the choice of the output units, it seemed an attractive idea to apply such a mixed mono/stereo arrangement to a three-speaker system, using a single cone bass unit working between a pair of Quad electrostatic radiators. An obvious benefit of band-sharing in this way was that the use of the single bass speaker relieved the electrostatic units of having to produce possibly loud sounds in that part of the audio spectrum where they are at their lowest efficiency and where, especially at

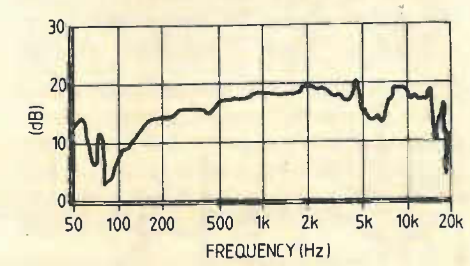


Fig. 1. Basis of modified design is this on-axis speaker response curve.

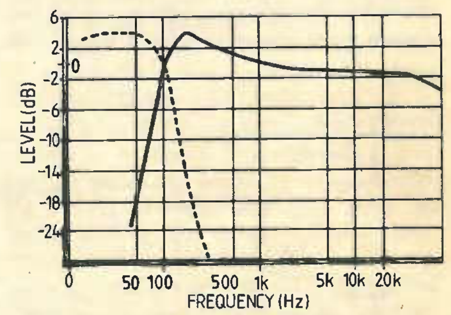


Fig. 2. New crossover frequency of 100Hz is chosen for dual electrostatic + common bass combination.

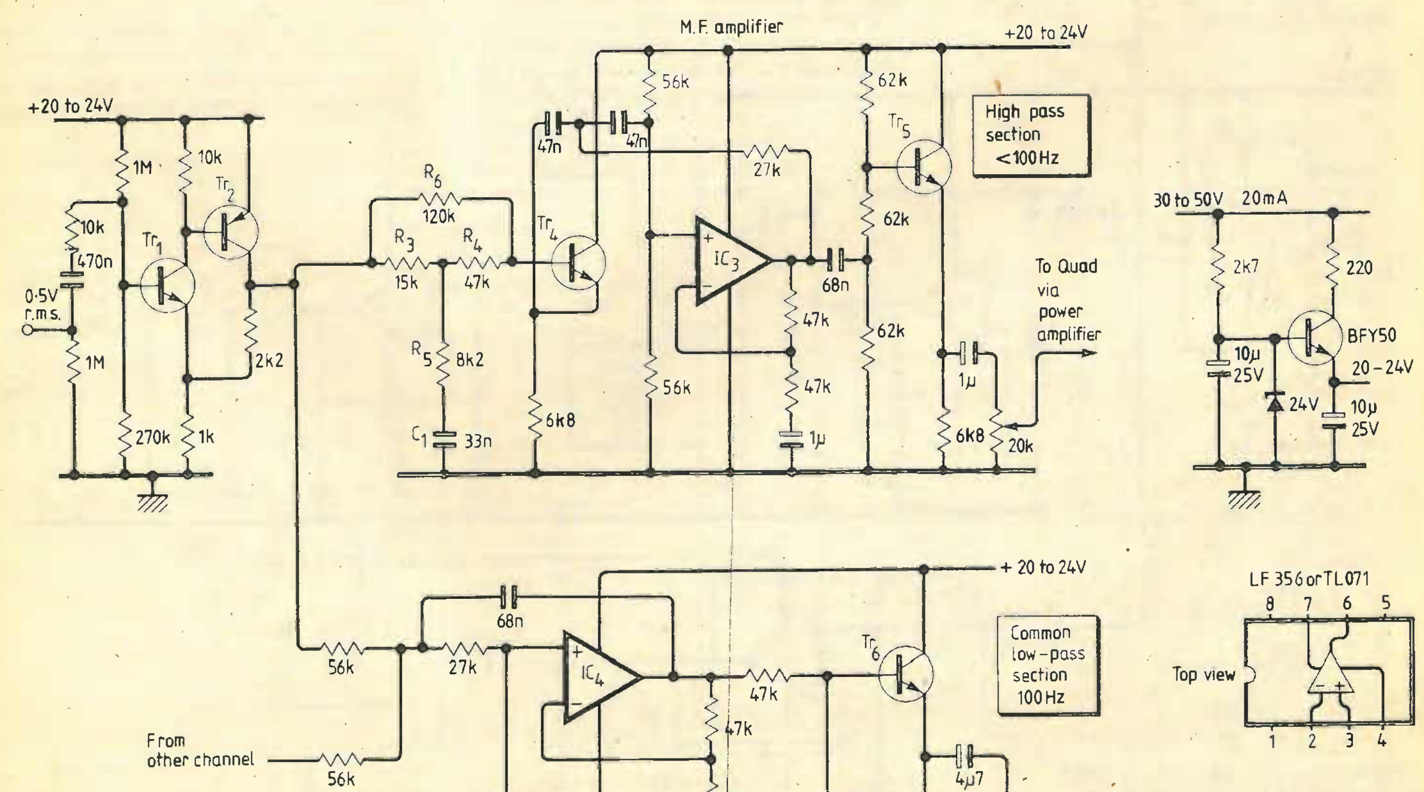


Fig. 3. Cut-down and modified version of circuit, originally published in the November 1974 issue, for use with Quad electrostatic loudspeaker. IC_4 and associated components are required only once.

the very lowest end of the range, they can generate considerable distortion.

I therefore set about making the necessary modifications to the active filter circuit, given as Fig. 2 in the November 1974 article, page 444 or, December 1977, page 575. The basis for the modified arrangement is the on-axis response (sine-wave input) published on page 157 of the 1979 Hi-Fi Choice, repeated here for reference as Fig. 1.

The part of the audio band of particular interest is that between 80 Hz and about 850 Hz. This range of frequencies can be divided into two regions: 80-170 Hz and 170-850 Hz. Considering the lower region first, the Quad electrostatic speaker response curve here shows a fall in output which has an average slope of about 7dB per octave. It has been suggested that the optimum rate of change of loudspeaker response in a crossover region is 18 to 20 dB/octave. I therefore decided that a designed filter slope of about 15 dB/octave would be required so that, over this part of the band, the combined effect of filter and speaker responses would be a fall-off rate on the high side of optimum, because l.f. energy below 150Hz produces high second and third harmonic distortion in a Quad electrostatic speaker.

The upper part of the response curve section being considered, from 170 Hz up to 850 Hz in Fig. 1, shows a slope in the same sense as before but at a more gentle rate of about 2 dB/octave. This slope does not contribute usefully to the desired effect as in the previous instance and has to be compensated by an opposing active filter characteristic to maintain the loudspeaker output reasonably constant down to the cut-off point of 170 Hz.

These two considerations suggest the general form of the required filter response curve. In addition, I decided to move the stereo/mono change-over point further down the band, to 100 Hz instead of 160 Hz in the original system, which used twin KEF B110 cone units for the mid-range with a single B139 bass speaker. The reason for the change is that in larger living rooms having floor dimensions in excess of six metres square the stereo effect is extended to lower frequencies. As the electrostatic speakers not only gave good output to this lower point in the band but have a response shape which helps in the crossover arrangement, it seemed reasonable to make the change.

The filter response achieved to satisfy the three requirements detailed above is the full-line curve in Fig. 2. This shows the variation of voltage with frequency of the output labelled m.f. amp in the filter circuit diagram of Fig. 3. This output provides the feed for one Quad electrostatic speaker: an identical circuit serves the other channel. The mono bass speaker – a KEF B139 is suggested but any comparable unit with suitable power-handling capacity would do – is fed via a power amplifier from the channel combining and filter circuit drawn at the bottom of Fig. 3. The response of the output from this circuit is shown as the broken curve in Fig. 2 which intersects with the high-pass filter curve at the new mono/stereo change-over point of 100 Hz.

The active filter itself is a cut-down and modified version of the circuit as originally published in the 1974 article and needs

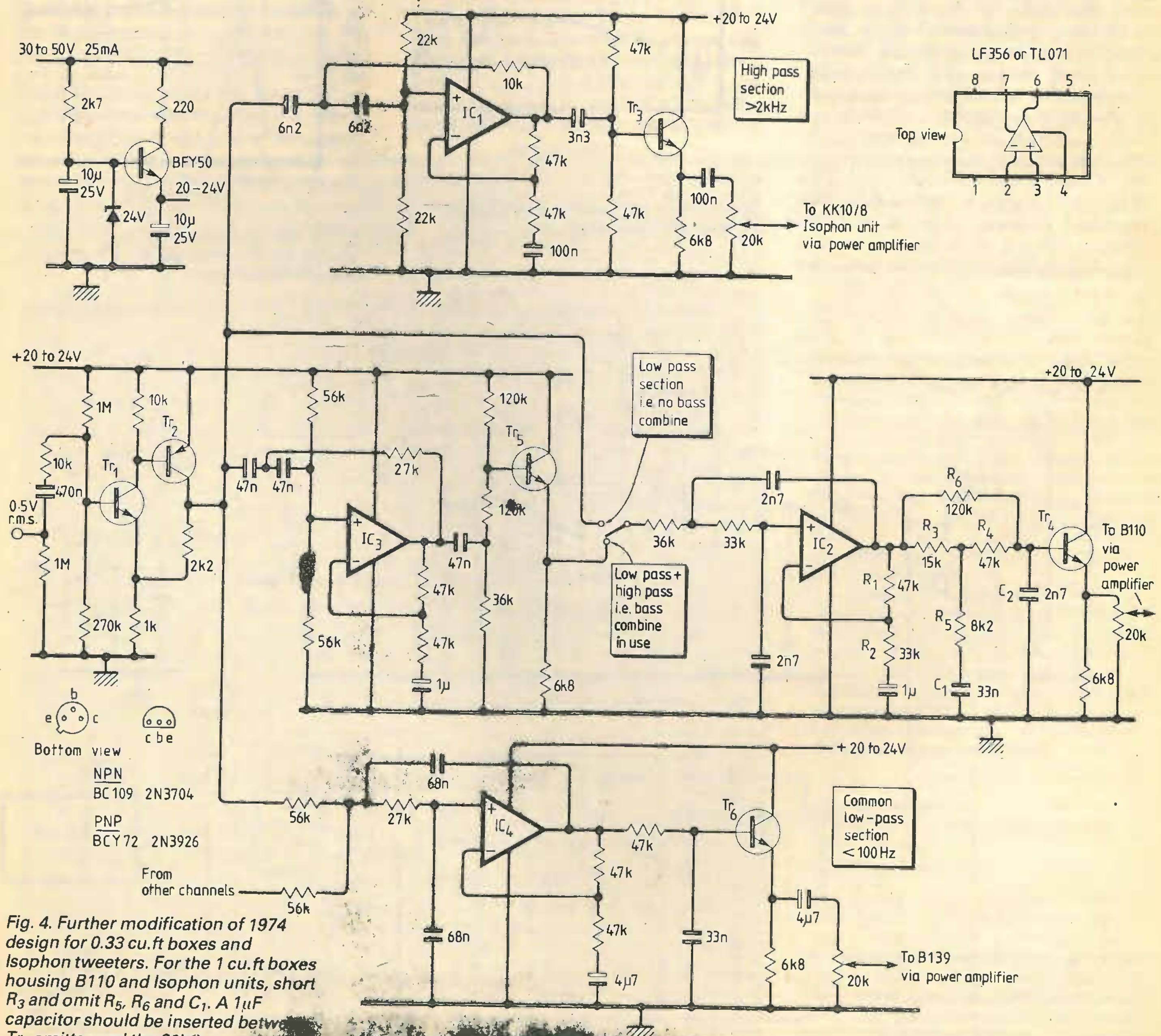


Fig. 4. Further modification of 1974 design for 0.33 cu.ft boxes and Isophon tweeters. For the 1 cu.ft boxes housing B110 and Isophon units, short R_3 and omit R_5, R_6 and C_1. A 1µF capacitor should be inserted between Tr_4 emitter and the 20kΩ potentiometer.

little further description. Op-amp IC_3 provides the high-pass output with the bridged-T section between Tr_2 and Tr_4 giving the 2dB/octave compensating tip-up between 1kHz and 100Hz (with slope controlled by the choice of value for R_6. Op-amp IC_4 provides a mixing point and a suitable low-pass response for feeding the common bass unit.

For people with the room space and the pocket money to suit, an improvement in their arrangement could be obtained by having four such units stacked in pairs. Frames specially designed for this purpose are now available* The resulting increased radiation "frontage" and power-handling capability should gladden the ears of any enthusiast. But you might need to make peace with the neighbours first!

At the other end of the scale, with cost an important factor, the Quad units could be replaced, using the original 0.33 or cu. ft boxes plus the original B110s with a pair of Isophon KK10/8 tweeters, instead of T27s. For those interested in such a variation in the arrangement, the circuit of Fig. 4 gives the alternative component values (bracketed) which would produce a slightly different filter response curve, as shown in Fig. 5, suitable for feeding the Isophon units. The applied volts curve for the KK10/8 and cross-over point to the B110 was adjusted to obtain the flat overall response similar to the curve the 1974 article.

Listening to the various systems with pink noise (i.e. constant energy per octave) and sweeping through the audio spectrum I have become aware that room acoustics significantly colour the results. Having used an anechoic chamber during the speaker development I realised that a wedge shape filled with sound absorbent material would be available to me by undertaking an attic conversion. The sloping roof to the now-boarded floor provided the wedge behind my electrostatic speakers. This wedge is now filled with sacks of old clothes from a once-too-full wardrobe (all the family have been equally deprived). I have now achieved an excellent listening room where I can pull the ladder up after me.

* From Audio-T, West End Lane, London NW6

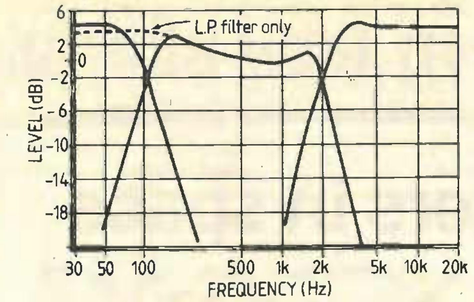


Fig. 5. Applies voltage curve for 0.33 cu.ft box and Isophon tweeters. Broken line shows response with low-pass filter only.

The power amplifiers, Fig. 6, use the Hitachi complementary pair 2SK133, 2SJ48 and I obtained a kit from Ambit International the details of which are in their second catalogue. The kit for each power amp. is £16.10 supplied with drilled board, data sheet and component location (heat sink £6.32). After many tests on this amplifier, and accepting the no secondary breakdown and self-limiting with negative thermal coefficient properties, the only criticism was that the quiescent current fell markedly after a long period at maximum power out and distortion measured a few per cent. I considered adding positive temperature coefficient thermistors at the variable resistor position but as these appear to be highly non-linear devices I felt the best solution was to use large heat sinks on the m.o.s.f.e.ts to minimize the temperature rise. A word of warning – lath and plaster ceiling and loose tiles don't get along with large bass speakers driven by 100W m.o.s.f.e.t amplifiers.

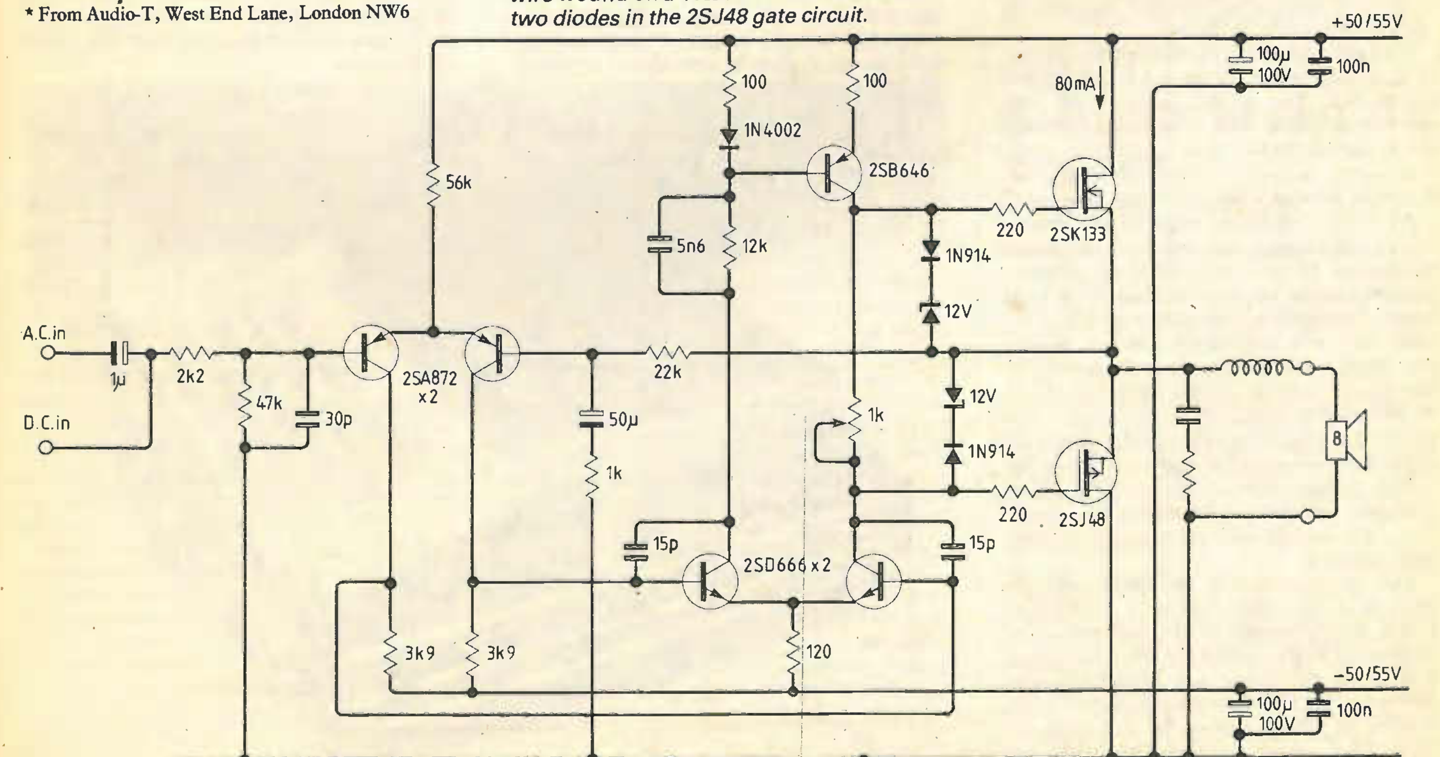
A final point on overload margins. The power amps approaching clipping at 80V pk-pk out, approximately 4V pk-pk in. The worst-case active filter networks is 13V pk-pk clipping in the bandpass or high pass, mid-frequency section, so to obtain similar headroom in each the active filter output pots are at about a third up from the earth end, this being correct for the m.o.s.f.e.t. power amplifiers.

Having listened to Quad pairs and stacked pairs it does seem that the slope between 200Hz and 1kHz should be lessened, so I suggest halving the 120kΩ resistor at Tr_4 base. It would seem that as you go down the audio spectrum phase coherence increased and this gives an apparent lift in low end of the m.f. band. This is undoubtedly related to the large radiating area from stacked Quads and the large sound absorbing area of an attic conversion.

If you are aware of sound level peaks in your listening room then some pre-fab-

Continued on page 54

Fig. 6. In recommending this power amplifier circuit, David Read points out that power m.o.s.f.e.ts can suffer from h.f. instability between 100 and 1000MHz, which won't be visible on a scope but which will heat the resistor in the RC network across the load (10nF, 10Ω). He suggests keeping to the Ambit-proven layout, with f.e.ts mounted on the board. (Further details in Ambit catalogue, no. 3 page 61/2, no. 4 page 87/6, available from 200 North Service Road, Brentwood, Essex.) Inductor is 12 turns at 12 gauge wire wound on a 10Ω resistor. Reverse the two diodes in the 2SJ48 gate circuit.



NEWS OF THE MONTH

Microcomputers in space

British Aerospace. Space and Communications Division is developing a spacecraft microcomputer module (SMM) as a standard unit suitable for general application in satellite systems. In addition to the hardware, the Division is also developing the necessary computer programs which includes all the basic executive routines needed to control an SMM system.

Eash SMM is a totally self-contained microcomputer. One of the design aspects of particular note is that of flexibility in choice of microprocessor used. The SMM development system at the Space and Communications Division currently comprises a Ferranti F100-L, three Texas Instrument 9900's and a DEC PDP11/34 mini computer, all running with compatible software and common hardware interfaces.

The F100-L which has been selected for use with SMM in the immediate future, is a bipolar microprocessor with low-power dissipation, manufactured by Ferranti as an LSI circuit on a single chip encapsulated in a 40-pin dual-in-line package. Military standard F100-L microprocessors are subjected to additional special testing and screening before being nominated for service in space.

A method of interconnecting up to 64 SMMs has been developed such that not only can their processing capabilities be shared for complex computations, but tasks may be transferred to other units should faults arise in individual devices. Input/output functions are performed by non-intelligent modules which are linked in an SMM system by a two-wire serial data bus designed by the Space and Communications Division.

An addressable serial bus interface circuit (ASBIC) is used as the standard interface for connecting a module to the bus.

Data and control instructions are transferred as 32-bit long words via the bus at 500 kilobits per second. The ASBIC performs all data synchronisation, module address detection and the serial-to-parallel and parallel-to-serial conversions necessary when transferring information between a module and the bus.

An ASBIC comprises a single 40-pin ceramic dual-in-line package. It is an LSI circuit manufactured by Ferranti using collector diffusion isolation and the uncommitted logic array technology developed by that company. It is TTL compatible, and importantly, operates at very low power levels from a single 5v source, an advance over similar circuits using hybrid and discrete technologies. It contains a 16-bit parallel data highway ideally suited to microprocessor applications and is manufactured to full military specifications. Utilising ASBIC, non-intelligent terminals can be adapted for connection to the data bus with the minimum of additional circuitry.

The configuration of the SMM and the selection of the military version of the Ferranti F100L microprocessor is the outcome of an engineering study carried out over the last 18 months by the Space and Communications Division to assess the operational characteristics required of microprocessors for prolonged service in space, aboard satellites. The F100-L was selected because its bipolar technology renders it inherently more resistant to radiation damage, with the added merit that it is the only 16-bit microprocessor wholly designed, developed and manufactured within Europe. Throughout the study, liaison was maintained with the European Space Agency (ESA) to ensure the technical solutions proposed were compatible with data handling requirements for satellites specified by ESA.

Before the study began, British Aerospace Dynamics Group had already acquired considerable knowledge of the factors likely to influence computer operations in space as a result of previous privately-funded technical evaluations. The Group is continuing to invest money in the current research and development work, the cost of which is being shared by the Department of Industry as part of the UK Space Technology Programme.

The Space and Communications Division will be incorporating SMMs in the next generation of satellite systems they build and have begun evaluating the device with its supporting components to qualify it for use in the space environment. In addition to space, it is envisaged that SMMs will be eminently suited for a wide variety of data handling applications.

China standardizes in Industry

From a previous policy of self-reliance, China has embarked on a comprehensive programme of modernisation including a number of product standards and a building and civil engineering code. Details are included in a report, *Exporting to China*, prepared by the Standards Association of New Zealand and available from the British Standards Institute's Technical Help to Exporters service.

Chinese standards are divided into three grades – national, ministerial and enterprise – and the policy for each grade is explained. Details are given of the types of products covered by the mandatory National Standards. There are two Chinese standards covering labelling requirements for shipped goods and the labels are clearly illustrated. The report includes full addresses of all relevant organisations, corporations and embassies.

As if to underline that such trade is not necessarily one-way, Hitachi have announced the signing of a contract for the establishment of a joint venture company in Fujian Province, China for the production of television sets. Intended for domestic sales and for export, the company expects to be producing 200,000 colour and 180,000 black-and-white tv sets per year.

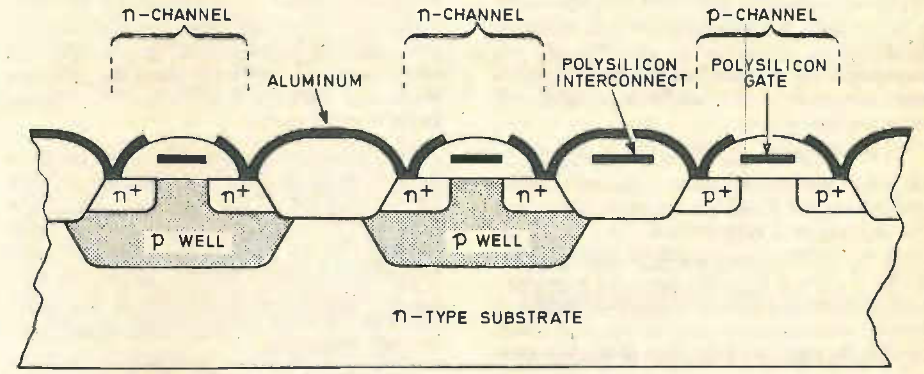
Computer in case

Intended for the 'globe trotting' reporter, salesman, engineer, programmer, auditor etc, model 8400 computer is fitted into a briefcase.

Produced by Microdata Computers Ltd, in Hayes, Middlesex, the computer incorporates many features to make it not only portable but also of practical use: it may be connected to a wide range of power supplies' voltages and frequencies and so may be used almost anywhere in the world; it incorporates a real time clock which can display GMT and local time; it includes acoustic couplers for transmission and reception of programmes or data through the telephone network. There is a full ASCII keyboard, a fold-away dot matrix gas plasma screen with a capacity of 480 characters; there is full text processing capability and the magnetic bubble memory does not lose data when the power is removed.

An early prototype of the Microdata model 8400 briefcase computer, now going into production.

Integrated circuits to your own design



This cross section illustrates the basic principle of ISO-CMOS

Isolated oxide CMOS, or ISO-CMOS, can be used to produce integrated circuit devices of higher speed, lower power consumption, lower propagation delays, higher densities and lower cost per function, according to the new GEC company, Marconi Electronic Devices Ltd which has been set up to combine ISO-CMOS with the established Cellmos computer-aided integrated circuit design service, the combined service to be known as ISO-Cellmos. By the addition of bigger and better computers and improvements in software, the service can now take a logic design, feed it into the computer which can analyse the circuit and can demonstrate the output response to any given input waveform. It can then select the appropriate gates from its own library and place them automatically in relation to each other to produce an optimal layout. The interconnect tracking is also laid out automatically. The layout is then analysed with capacitance measurements and checking for the effects of possible transients. It is also checked against the design rule book.

All this has taken place within seconds of entering the original design into the computer. Two plots are produced; one of the proposed layout with pad positions etc. The other is a diagram of the chip in logic diagram form, allowing the customer to check it against his original circuit. At this stage, changes to the circuit may be made to correct any errors or to add modifications.

Once the layouts are accepted by the customer, they can be simply translated into magnetic tape format for the automatic preparation of production masks. At the same time test tapes are generated for the automatic testing of the finished integrated circuits.

A simpler and even more rapid approach is suitable for those circuits which can be adapted to the ISO-CMOS uncommitted logic array. The Cellmos system can generate a layout for the interconnection pattern which can be added to ULAs available from stock. As these have fixed connection pad positions a testing faciliy is instantly available.

Thus the Cellmos system can design and layout a circuit in seconds – a job that would take a competent design engineer at least three months.

The new company, Marconi Electronic Devices Ltd, as well as providing the Iso-Cellmos service, has also taken under its wing the microwave, power and hybrid component divisions of the GEC/Marconi group.

Keyboard research

It has long been known that the 'qwerty' keyboard is not the most efficient way of arranging the letters. In fact it was originally designed to slow down the typist so that the primitive mechanics of early typwriters could cope with the task and not suffer from entanglements. The European Commission is inviting tenders for a unified keyboard layout suitable for the many languages based on the Latin alphabet. The keyboard layout will be used within the Commission and other European or international organisations who need to deal with many languages. Whether the reseach will lead to a major re-design of keyboard layout or just a tidy-up exercise of the comparatively minor differences in the various nationality keyboards remains to be seen.

Authors recognise technical writers

The Society of Authors (a professional society representing over 3000 writers) has under consideration a plan to form a Technical Writers' Group within the Society, to cater for the needs of technical and scientific authors. Those who write about technology are themselves much affected by the introduction of new technology in publishing and printing, and by rapid changes occurring in this field of writing.

The formation of a special Group would provide technical writers, in addition to the normal services of the Society, with the benefit of a core of expertise in this expanding area of writing and the opportunity to discuss problems common to technical and scientific writers.

These matters were discussed by Stanley Lyons in a special article in *The Author* recently. Copies of this – and further details about the Society – may be obtained gratis from the Society.

Centre to study effects of technology on society

The interaction of electronic systems such as computers and data processing equipment with society at large may well be one of the subjects to be studied by a new research centre now being set up in the UK. Called the Technical Change Centre, it is mainly concerned with the relationship of technology to economic well-being in the UK: it will develop "a major programme of research on the choice, management and acceptability of technical change relevant to the advancement of the national economy" in the words of its official statement. But it will also study changes in society and the economy which act as pressures influencing the course of technical innovation. A related area of research will be "trade-offs" between economic advance and social loss (in such matters as pollution and conservation) and the way technical change could be planned so as to reduce the inevitable disruption it causes in people's social and occupational lives.

The economics bias of the TUC is reflected in the choice of its director, who is an economist, Professor Sir Bruce Williams. Among many other appointments he was economic adviser to the Minister of Technology in 1967. Electronics interests are represented by the organizing committee having as one of its members Philip Hughes, who is managing director of Logica, the well-known software and electronics company. Funding comes from the Leverhulme Trust, which will contribute £1.5m over the first five years, and from the Science Research Council and the Social Science Research Council, each of which will provide £525,000 over the same period. Eventually the Centre is expected to have an annual budget of £750,000, with some of its revenue coming from commissioned research.

To some extent the TCC resembles the Office of Technology Assessment (OTA) which was established in the USA in 1972 – but by law. It is intended to be of practical help to those technocrats in government, industry and elsewhere who have the task of shaping public policies to respond to technological development and the changing position of the UK in the world economy.

Gallium arsenide invades Silicon Valley

The Harris Corporation is moving ahead on its first semiconductor operation in San Franciso's famed 'Silicon Valley' area by approving construction of a $4 million facility in Milpitas, near San José.

The company is making the investment on behalf of an 80-per-cent-owned new company, Harris Microwave Semiconductor, Inc. The firm was established last June by Harris and a group of local semiconductor executive, specialising in the new field of gallium arsenide technology.

Gallium arsenide is a compound of two elements, gallium and arsenic. As a base material for integrated circuits, it offers significant advantages over silicon in applications requiring very good speed, high frequencies and extreme miniaturisation. Harris will use this technology to produce gallium arsenide transistors, microwave components and integrated circuits to support their communications and information processing equipment now under development.

Flat c.r.t from Sinclair

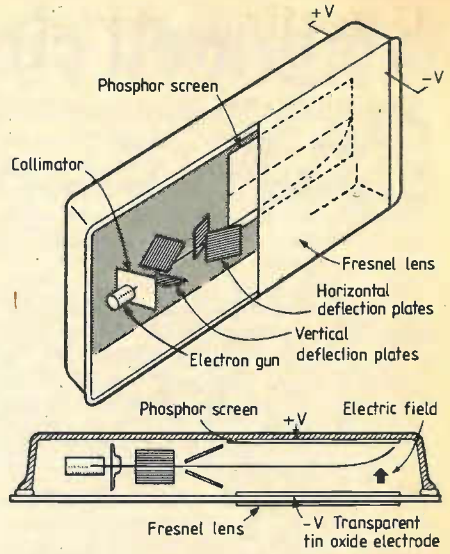
Clive Sinclair of Sinclair Research Ltd has recently announced the successful development of a flat cathode ray tube which will be incorporated into a miniature t.v. set. The set will include v.h.f./f.m. radio and may be switched to most international t.v. standards, making it of universal use.

The Sinclair tube measures about 4 × 2 × ¾ in. and is three times brighter, requires between one quarter and a tenth of the power and is half the volume of a conventional c.r.t. with the same size screen. It is assembled from just two sheets of glass, a flat front plate and a vacuum-formed backing plate. The phosphor screen is coated on the inside of the backing plate and is viewed through the front face from the same side that the electrons strike. This gives a brightness of more than double that of a conventional c.r.t. with the same beam energy. In addition to the horizontal and vertical deflection plates there is a third set between the phosphor screen and the front face to bend the electron beam on to the screen.

To correct for distortion the screen height is reduced by as much as half while the width is kept constant. This narrows the angle subtended by the electron beam and the picture height is restored optically by using a horizontal Fresnel lens to give an effective picture size with a 3 in. diagonal. Other distortion is eliminated by careful attention to the modulation applied to the deflection plates.

The tube has been produced in Sinclair's pilot production plant at St Ives, Cambridge but it has just been announced that a full production plant is to be commissioned in Dundee by the Timex Corporation. Timex were awarded the contract by Sinclair because of their expertise in automatic production. It is expected that at the end of the first phase the capacity will exist to produce the tubes at the rate of a million a year.

The Microvision t.v. set which will incorporate the tube is also to be produced by Timex and should be on the market by mid-1982. Although the exterior design of the set has not been completed, some design models have been produced to show that the set will be about 6 × 4 × 1 in. or about the size of a paperback book. It will retail for about £50.



Further developments for the tube depend upon the extremely high brightness which may be achieved. This leads to its suitability for use in projection systems. A monitor for the Sinclair personal computer is high on the applications list, as is a colour projection t.v. which would incorporate three of the tubes and the associated electronics in a projector about the size of a shoe box to produce a picture on a wall screen with a 50 in. diagonal.

Electronics bosses disagree on industry's priorities

Opposing views on the future of the British electronics industry were expressed recently by two of its prominent figures, Mr Ernest Harrison, chairman and chief executive of Racal, and Mr Frank Chorley, deputy chairman and managing director of Plessey Electronic Systems. Mr Harrison believes that rationalisation will be necessary in the UK industry to meet foreign competition effectively. In a speech to stockbrokers, industrialists and financial journalists he said: "If we are to survive as a nation in professional electronics, or indeed in any of the electronics industries, we have got to do something about our resources and getting together. We are going to face in the 'eighties the might of Japan and America and these two countries are determined to dominate the world. They spend huge sums on research and development the like of which we cannot imagine. . . . The competition is going to be intense and it cannot be avoided". Referring to the rationalisation that had already taken place – Racal taking over Decca and Thorn taking over EMI – Mr Harrison claimed that "many more people now agree with what I have been saying for a long time".

One exception, however, is Frank Chorley. "I certainly don't agree with Ernie on that," he said, in reply to a question at a press lunch. "It's a good idea to scrap it out, because it makes us all more efficient." Companies in the UK industry were well able to look after themselves. Racal, Marconi and Plessey were all highly successful, though they were perhaps not good in all areas. There was no benefit to be gained by bringing them together.

A further difference of attitude emerged on the two companies' involvement in military electronics. Despite the fact that a large proportion of Racal's business has always been in this field (about 38% recently), and is likely to continue so with the acquisition of Decca, Mr Harrison declared: "We are too much in Defence. This is much too large a proportion of our total business. What about the many applications for electronics in the old manufacturing industries in the UK? Who's going to do them?" He gave one example of a civil application which was fairly new to Racal – electronic funds transfer. A new company was doing a lot of development in this area and it had a good product but things were moving slowly because "the banks cannot make their minds up".

Mr Chorley's attitude about his own company, however, was that "The Defence industry is very successful in the UK. From time to time Socialist MPs have complained to me that we ought to make calculators and other such products, but we have got to do what we are good at. We have got to exploit the market that already exists for us. The UK has a significant lead in this field – so why not exploit it?"

One matter on which both men were agreed was that the UK electronics industry should be supported by the government. Referring to the billions of pounds that the present administration is now pouring into steel and motor cars, Mr Harrison commented enviously "Just imagine what you could do in this business if you were given a billion pounds to invest in electronic projects".

Fourth TV channel signal monitoring

The quality of the transmitted signal of the new fourth television network due to go into service in the autumn of 1982 (News, January issue) will be monitored by automatic equipment. Instruments will be provided for the complete network of main stations. Each of these is under the supervision of a station controller which in turn is linked back to a computer at a regional operations centre. The automatic monitoring equipment, based on a Marconi Instruments insertion signal analyser, operates under software control. All parameters important in the maintenance of picture quality can be monitored and the results compared with limits stored in the equipment. Warnings can then be given and executive action taken if any parameter falls outside its defined limits.

The monitoring equipment is being provided for the IBA by Marconi Instruments under a contract worth over £500,000.

Alternatives for society

Appropriate technology, community communications, alternatives to nuclear energy and self-regulating education are among the alternatives to existing centralized institutions to be discussed in 30 small forums at the First Assembly of the Fourth World, London, July 29-31. According to its convener, John Papworth, "Human survival now depends on the swiftness with which our political, social and economic institutions can be made small enough for them to be manageable and more adequately responsive to human control." The education forum will be guided by Dr K. L. Smith of the Electronics Laboratories, University of Kent at Canterbury. Details from Fourth World, 24 Abercorn Place, London NW8 (tel: 01-286 4366).

More news from Sinclair

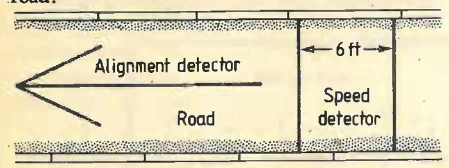
To be launched at the Microsystems '81 exhibition is a new Sinclair personal computer. It will incorporate a new, British, custom-built master chip, have a 'significantly higher specification' than the successful ZX80 and yet will be marketed at a 'substantially reduced price'. Details are also to be announced of a low cost printer and supporting software libraries.

Detecting drivers' behaviour

An electronic indicator which can be laid simply and quickly on a road surface to spot faulty driving has been developed by engineers and psychologists working in the School of Automotive Studies at the Cranfield Institute of Technology.

Although its most obvious use is to alert police to drivers who are drink-impaired, the Speed and Alignment Indicator can also be used to monitor speed alone. It could play a part in studies of driver behaviour too – a field in which there are many opinions, much speculation, but few certain ways of finding out precisely how drivers drive their cars.

When laid on the road the indicator looks like the rubber tubing used to count passing vehicles. Two tubes are laid parallel to one another across the carriageway and six feet apart. Beyond them is another set of tubes arranged like an arrowhead pointing in the same direction as the traffic flow. Each tube has a transducer which converts the pressure of vehicle wheels passing over them into an electronic signal to a micro-computer by the roadside. The micro converts the signals into the speed of the vehicle and its alignment on the road.



Vehicle speed is computed from the interval in time between the wheels passing over each of the two parallel tubes. Alignment is computed by the driver first of all driving along a straight line laid up the centre of the carriageway. This line ends at the arrow's tip, from which two rubber arms slope away – the shape of an arrowhead. If the driver has aligned the two arms of the arrowhead simultaneously. If one wheel strikes its arm ahead of the other, the vehicle must be off the centre line.

The micro-computer is both 'Intelligent' and versatile, making a decision in milliseconds on whether a driver has passed or failed each of the two tests set by the operator. He/she can pre-programme the device with the speed limit of the road and can also decide on the margin of error allowed to a driver on the alignment test. British or metric units can be chosen and the indicator will give separate decisions on speed and alignment. The micro's decisions are flashed on a screen in front of the operator as 'pass' or 'fail' together with the figures for speed and the number of inches or centimetres by which the car is veering from the centre line. The decisions are also printed out, and a warning buzzer sounds when the error limits are exceeded. The indicator can be set to record every vehicle passing, or it can print out for failures only – whichever mode the operator chooses.

The equipment is compact and easy to use. It can be carried round in the smallest of cars. The Speed and Alignment Indicator is a prototype only at the moment, but it can be made and marketed easily if there is a demand for it. If police forces were interested in using it, the indicator could be set up on a road with a warning sign telling motorists that they were about to be tested. Drivers would then align with the guide line to the arrowhead and drive along it: if the indicator showed a driver to be out of alignment he could be stopped further down the road and asked to take a breath test.

At the moment police can stop a motorist and test him if they have 'reason to believe' he might have drunk too much alcohol, but there is no objective test of this and motorists have always opposed random testing.

The indicator could also be used to study driver behaviour by being set up to show, for example, how people take corners, road position, etc. There is no objective, accurate and easy way of obtaining this information at the moment.

C.b. to become legal with f.m.

Mr William Whitelaw, the Home Secretary, has announced that Citizen's Band, officially still known as Open Channel, radio is likely to become legal in the autumn of 1981. Two wavebands are to be allocated, 27MHz and 930MHz both to be frequency modulated. Amplitude modulation is to remain illegal and f.m. operators will require a licence. No details are available as to the maximum permissible signal strength or the number of channels but a draft specification will be issued to potential manufacturers.

The European Communities Commission is attempting to produce a harmonised set of technical regulations covering c.b. sets and are studying French proposals for a 27MHz service with a maximum strength of two watts and fewer than 22 channels.

Wireless World will be publishing a series of constructional articles for those wishing to build a c.b. set.

Approval and dis-approval for telephones

Although, under the policies of the present Government, British Telecom is to lose its monopoly of providing telephones and other attachments for use on telephone lines, it is very much concerned that there will not be a free-for-all. At present the only equipment permitted is that certified by British Telecom as suitable for use as an attachment. This ensures that the equipment is technically compatible with the British network; it presents a minimal risk of injuring people or damaging the system; it does not interfere with other customers' use of the network; and it is correctly connected, to help in diagnosing faults. Even when British Telecom lose the monopoly, they will still be the sole supplier of the first telephone connected to the exchange line entering a person's home or office, under new arrangements proposed by the Government. Certification of the suitability of attachments will continue but will be no longer carried out by British Telecom but by an independent Government approved body which will establish and publish standards for privately supplied attachments and then test and certify that the attachments conform to the standards.

British Telecom warns that most telephone equipment now on sale in shops and department stores is not specially designed or modified for use on the British network, despite various claims that it 'meets British Post Office standards'. It is nearly all made and designed for use abroad. If connected to the British network, it may not work properly. Phones designed for overseas use are frequently insufficiently sensitive for satisfactory operation on all lines in the U.K. Mains-powered equipment can be electrically unsafe. Not only do the owners of such equipment suffer, but also the callers whose calls are made inneffective if the apparatus does not respond correctly, or gives poor quality reception. British Telecom are threatening, regretfully, to disconnect the telephone lines of customers who persist in using uncertified equipment.

To counter the sales of such lillicit phones, British Telecom are continuing their programme of offering a wider range of telephones to be supplied direct to the customer. Two additions to the range are illustrated. On the left is Dawn. Intended for the boudoir, it has a low, sculptured profile on a circular base and is available in pale yellow, avocado green and white. The one-piece Eiger telephone, with a press-button keypad, includes a memory to store the last number called. It can call again automatically, if required to. The colours are more business-like; red, stone or two-tone brown.

CIRCUIT IDEAS

Divide by (2n−1)

Fig. 1(a) shows a divide-by-(2n−1) circuit which generates an equal mark-to-space ratio output if a divide-by-2 circuit is used in the final stage as shown in Fig. 1(b). With this arrangement, a divide-by-(n−½) output is available from the divide-by-n counter, but not with an equal mark-to-space ratio. Fig. 2 shows a divide-by-3 circuit, based on Fig. 1, where the divide-by-4 counter is clocked by a positive edge of the input waveform and then by a negative edge. During one complete output cycle the divide-by-4 counter receives four clocking pulses for three cycles of the input waveform. A divide-by-(n−½), i.e. divide-by-1½, output is available from Q_A.

With the basic circuit of Fig. 1(a) it is easy to build other odd value counters by inserting the desired divide-by-2n circuit. Also, by combining divide-by-(2n−1) and divide-by-2n circuits, a counter can be designed to divide by any value of (2n−1). Some examples are shown in Fig. 3. Note that inputs and outputs between the various exclusive-OR gates must be separated by a counter.

A. J. Ewins
Harrow
Middx

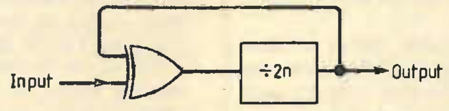


Fig 1 (a) Divide-by-(2n−1)

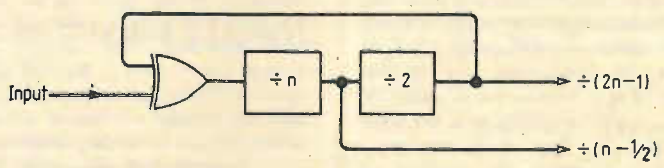


Fig 1 (b) Divide-by-(2n−1) with ÷(n−½) output

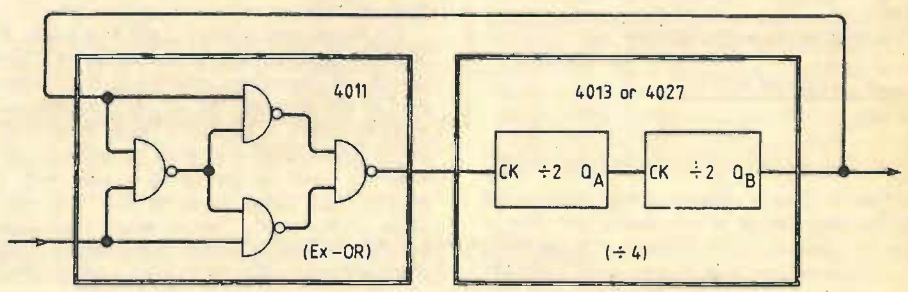


Fig 2 (a) divide-by-3 circuit

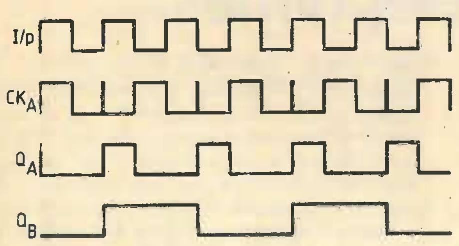
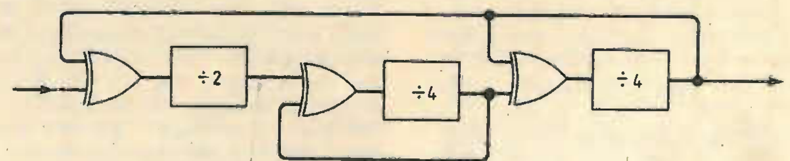
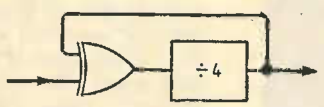


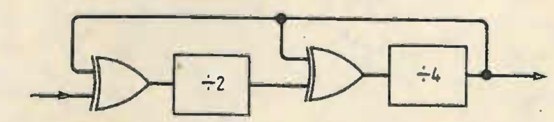
Fig 2 (b) Waveforms of divide-by-3 circuit



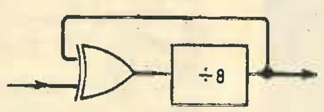
Divide-by-17



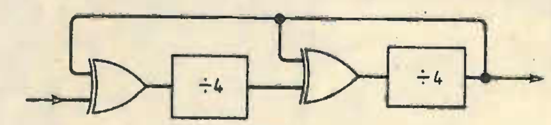
Divide-by-3



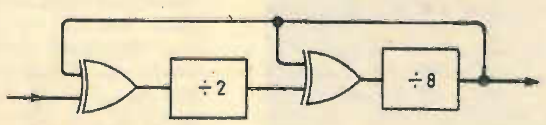
Divide-by-5



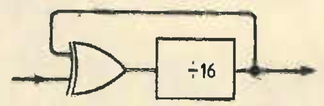
Divide-by-7



Divide-by-11



Divide-by-13

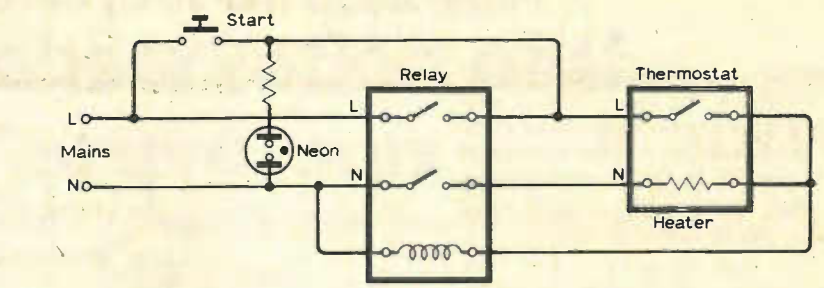


Divide-by-15

Pre-amp with multisection tone control

The input stage of this preamp, which originates from a studio mixer, will handle signal levels from 500μV to 5V r.m.s. For optimum performance the preset control should feed 5mV to Tr_2 which, with A_1, amplifies the signal to 3V r.m.s. The filters around gyrators A_3 to A_7 provide low-impedance paths to ground for five frequency bands, and attenuation or gain for these bands is achieved by controlling the low-impedance paths towards the voltage dividers around A_2. Balancing the filter potentiometers gives unity gain at A_2 because the input and feedback voltage-dividing networks cancel each other. The open-loop gain of the op-amps determines the maximum number of gyrators that can be used. At 15kHz the paralleled gyrator series resistors, 180Ω and 330Ω, which are boot strapped by the open-loop gain, should still be greater than the divider source impedances, 2k7, and prevent unexpected dips or peaks at high frequencies.

H. Riegstra
Amsterdam
Holland

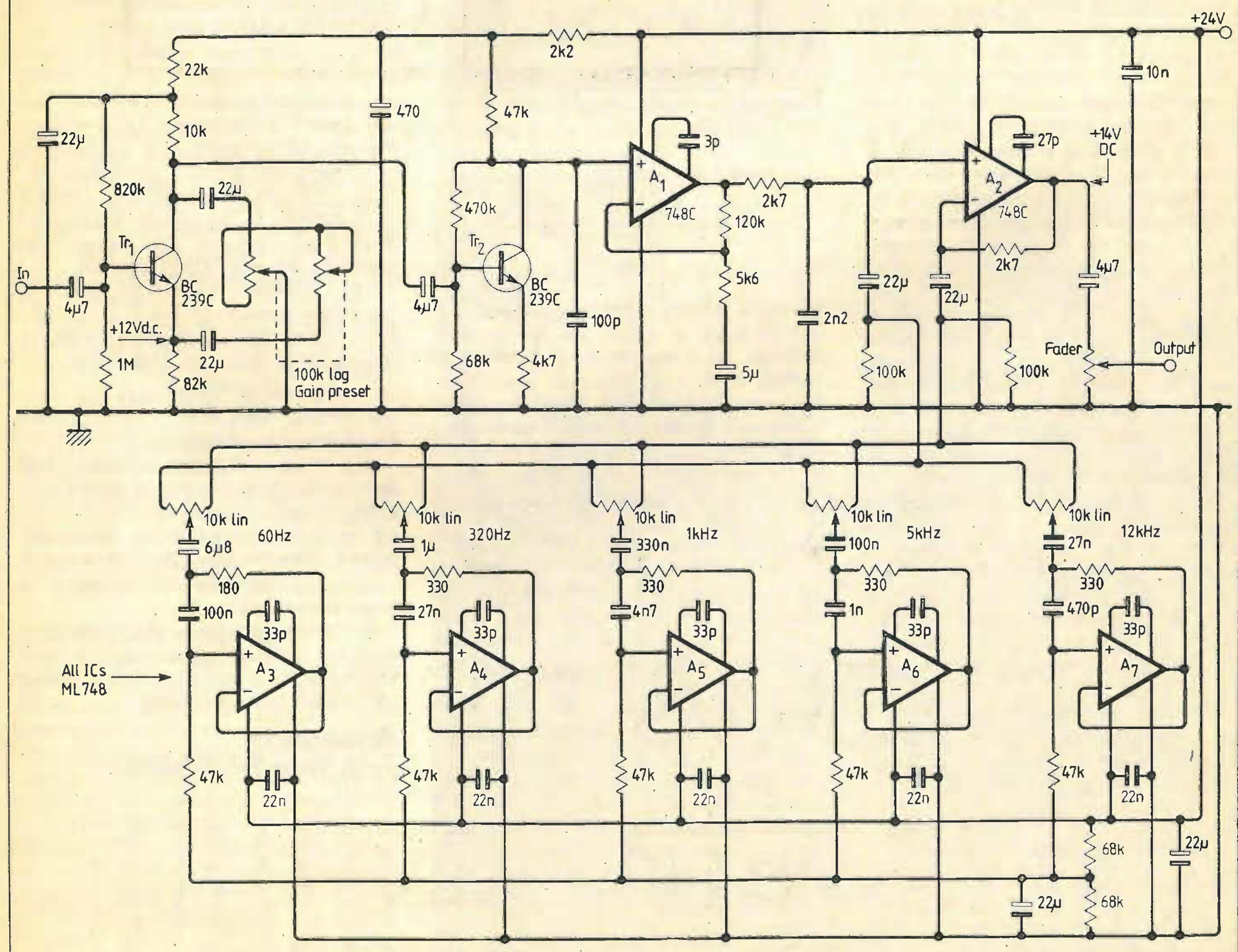


One-shot control of immersion heaters

A conventional immersion heater requires two operations, switching on and later switching off. Although simple, the second step is inconvenient and costly if forgotten. This simple circuit is easy to install and obviates the need to manually switch off the heater. A relay forms a one-shot monostable which is thermally rather than electrically controlled. A trigger is provided by the start button which energizes the relay coil, and the heater is powered until the thermostat cuts out and de-energizes the coil. Water temperature, and therefore the duration of the on period, can be adjusted via the thermostat setting. Apart from the relay connections, only one extra low-current wire is required between the start button and the thermostat.

This circuit can also be used to isolate equipment from the mains after a power failure.

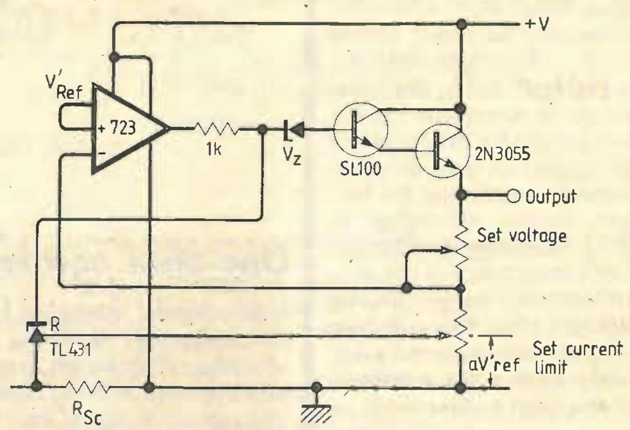
S. Ho and
D. Wibberley
Manchester



Power supply with stable current limit

One problem with power supply current limits, which use the V_{BE} drop of a transistor, is their drift with temperature variation. A simple solution is to use a programmable Zener diode for current sensing, which offers less than 50 p.p.m./°C variation in V_{ref}. In the circuit shown

$$I_{limit} = \frac{V_{ref} - aV_{ref}}{R_{Sc}}$$



When the voltage at the R terminal of TL431 switches it on, base drive for the output transistors is removed and the output current is limited. However, if the output terminals are shorted, the TL431 is turned on but the voltage across it is 2.5V. Therefore, to take the output voltage to zero, V_z is required which can be any low voltage Zener diode above 2V.

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India

"Test your knowledge"

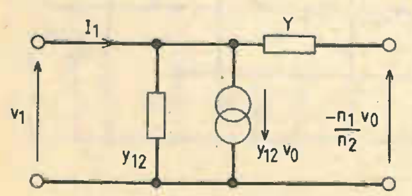
Answers to the December issue multiple-choice quiz

None of the entries received for Test Your Knowledge was completely correct, and the best entries had at least three of the answers wrong. That was one result of the quiz compiled by R. W. Ellingham and B. L. Hart and published in last December's issue. The stiff test was based on 40 questions, each with multiple answers, given to electronics students at the North East London Polytechnic. We offered prizes of Circuit Designs 3 or a subscription to *Wireless World* for ten correct entries opened after 5 January for UK readers and 2 March for overseas.

The answers provided by the authors are given in the panel. As almost all entrants gave the incorrect answers to questions 3, 24 and 34 (no-one got this last right), here are their solutions.

Question 3. The assertion is not true. A bipolar junction transistor comprises two p-n junctions both of which are forward biased when the device is saturated. By suitable biasing it is possible to arrange for the two junction drops to be equal in magnitude.

The reason is a true statement. Operation of the b.j.t. depends on the existence of both electrons and holes. Therefore (d) is the correct answer. Most thought (b).



Question 24. See diagram. For neutralization $I_1 = 0$ when $v_1 = 0$.

$$\therefore y_{12}v_0 = -\frac{n_1}{n_2} v_0 Y$$

$$Y = -\frac{n_2}{n_1} \cdot y_{12}$$

$$= -2(-j0.2) = j0.4\text{mS} \quad \text{(d)}$$

Question 34. Upper trip level corresponds to the level at which the comparator switches for a positive-going input. Assuming $V_0 = -12$V, the p.d. across the 8kΩ resistor keeps the + input of the comparator below +4V, hence the output stays at −12V, until i_g increases to $i_g = (+4-(-8))$V/8kΩ which is 1.5mA, so (b) is correct, but everyone gave (c).

About half the entrants gave incorrect choices for questions 8, 9, 18, 36 and 37. In Q8, I_c is $((I_c/I_b)+1)I_b$ = 110mA and in Q9 zener current varies between 1mA (I_b = 9mA) and 10mA so the mean dissipation is 5V×5.5mA. In Q18, the solution is found by equating the increase and decrease in charge first across the input C, to give $v = -E/3$ then across the output C to give $E_o = Mv/3$. Those who got Q36 wrong gave (e) as the answer but the correct frequency is 50kHz. The period is obtained from $2\times(C\Delta V/I)$, due to current mirror action, giving 50kHz. Most entrants realised that the 150kHz printed for (d) was intended to read 50kHz. The minimum frequency, Q37, is one tenth of that.

Other answers were less frequently wrong, but more consistently so. In the answers to question 11, emitter current was invariably given where collector current wasn't. For question 23, it appears that the transformation ratio was taken to be the square of Xc_1/Xc_2 rather than $(Xc_1 + Xc_2)/Xc_2$. As the amplifier of question 27 is matched to the source, actual noise power is twice the ideal noise power. That makes the noise figure 3dB, not 0dB.

The Thévenin equivalent circuit is needed for question 33. For V_o to be high, the + input at the comparator must be more positive than −1V. This means

$$\frac{R_2((10/3)+2)}{R_2 + (R_1/3)} > 1,$$

from which the answer follows.

Only a few got question 22 wrong, but one that did, Jeffrey Borish of Santa Clara, California, wrote to correct his answer saying the question could be a "deliciously wicked trick," depending on whether c.m.r.r. was taken for the differential or single-ended output.

At the time of going to press the cut-off date for overseas readers hadn't been reached but prizes for the best UK entries have already been despatched. □

Answers to Test Your Knowledge

1	C	11	D	21	B	31	B
2	B	12	E	22	B	32	D
3	D	13	A	23	B	33	B
4	B	14	B	24	D	34	B
5	B	15	D	25	C	35	B
6	C	16	E	26	B	36	D(50kHz)
7	C	17	D	27	D	37	A
8	C	18	B	28	A	38	C
9	C	19	E	29	B	39	C
10	E	20	A	30	C	40	D

Radio observation of the 'active' sun

Solar effects on propagation recorded on home-made apparatus

by R. A. Ham

Since 1968 the author has used a simple radio telescope constantly to monitor the effects of solar activity on radio frequencies. This article is a brief history of sunspotters followed by a chronicle of solar events and outlines of the equipment used to make the recordings.

Until the advent of radio it was not realized that the sun, and indeed other stars, emitted radio waves. However, suspicions were aroused very early in radio's history as Sir Oliver Lodge tried to detect radio waves from the sun using a receiver with a coherer detector, and the editor of the *Scientific American* called upon radio enthusiasts to listen carefully during the total eclipse of the sun on 24 January 1925 and report any strange happenings to radio signals.

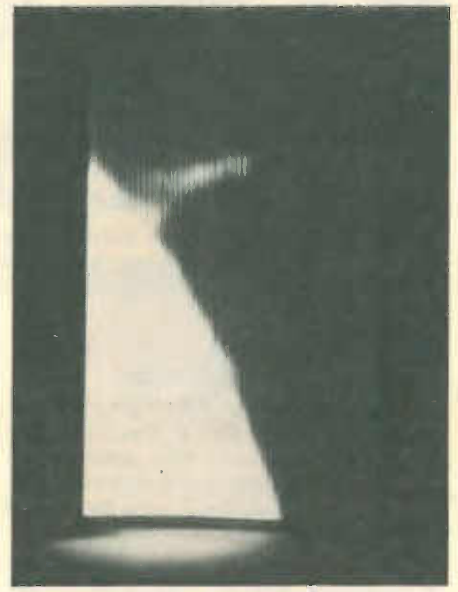


Fig. 1. Solar prominence photographed from the 'spectroheliograph' by Cmdr Hatfield on 10 February 1976.

Short-wave bands

Throughout the pioneering days of the short-wave bands for broadcasting both amateurs and professionals were trying to explain why the propagation of radio signals varied between day and night and was often subject to echoing, fading and sudden blackouts.

Scientists such as Oliver Heaviside, Arthur Kennelly and Professor (later Sir) Edward Appleton had shown how the existence and structure of the ionosphere reflected short-wave signals around the world. But as more evidence was gathered by astronomers, physicists and radio engineers it was soon realized that streams of particles from a solar event, Fig. 1, could disrupt the prevailing state of the ionosphere and consequently upset the normal paths of terrestrial radio signals.

Solar radio astronomy

Signs of radio being used as an astronomer's tool date back at least to 1935 when Karl Jansky first detected radio waves coming from the suns in the Milky Way. Later in the same year Denis Heightman heard a hissing noise in the 10m band which was later confirmed as being caused by radio waves coming from a solar event. Between 1936 and 1939 this same noise was reported by no less than 24 amateurs using the same frequency, and by Miss Barbara Dunn while using a frequency of 56MHz.

Early in 1942 British wartime operators using similar frequencies recorded an extraordinarily high level of noise which was also found to be the result of a large sunspot group and soon after the war research into solar radio waves and their effects on radio was stepped up.

Simple radio telescope

Having heard the effects of solar noise, the author decided to build a simple radio telescope*, to find out more about the 'active' sun and its effects on terrestrial radio communications. The radio waves from the sun at 143MHz are collected by four 4-element yagis mounted on a wire mesh reflector, Fig. 2, which has a head amplifier mounted on its frame. The amplified signal passes along a coaxial cable to a 2m converter, where the observational frequency, having being changed to 27MHz, is tuned on an FRG-7 communications receiver which in turn drives a

* The author's radio telescope was featured in 'Tomorrow's World' by the BBC and in a scientific film made by Yorkshire Television and networked by the IBA.

Fig. 2. Four 4-element yagis used to collect radio waves from the sun.

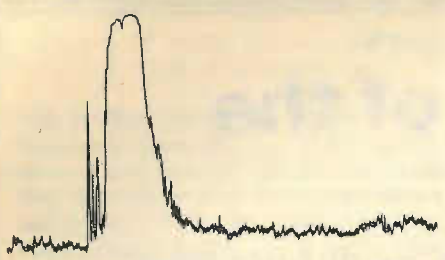


Fig. 3. Chart recording of a typical short duration solar flare.

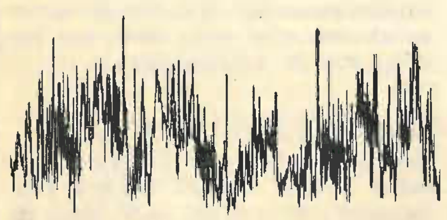


Fig. 4. A ten minute recording of a solar noise storm which occurred on 30 October 1973 at 136MHz.

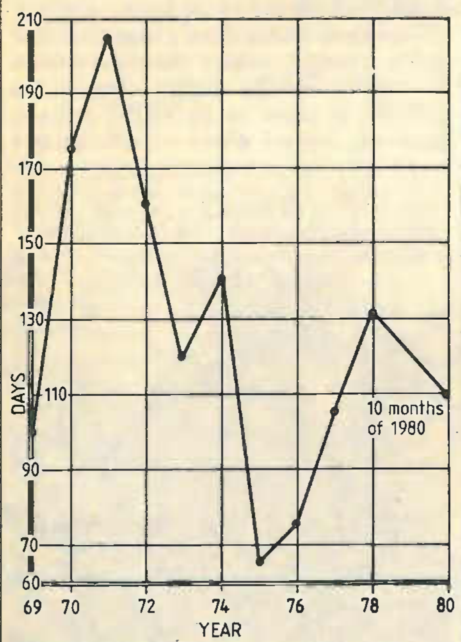


Fig. 5. Solar activity as recorded by the author originally at 136MHz and later at 143MH (see text). Note that the peak in '71, the low in '75/'76 and the rise thereafter correspond with the recognized cycles.

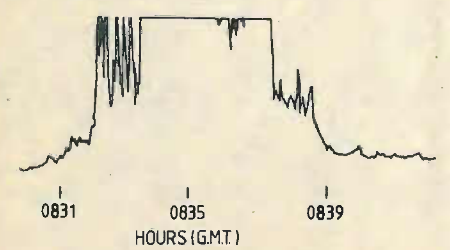


Fig. 6. One of the more memorable solar bursts from 3 July 1974 in which the recorder pen was sent off the scale.

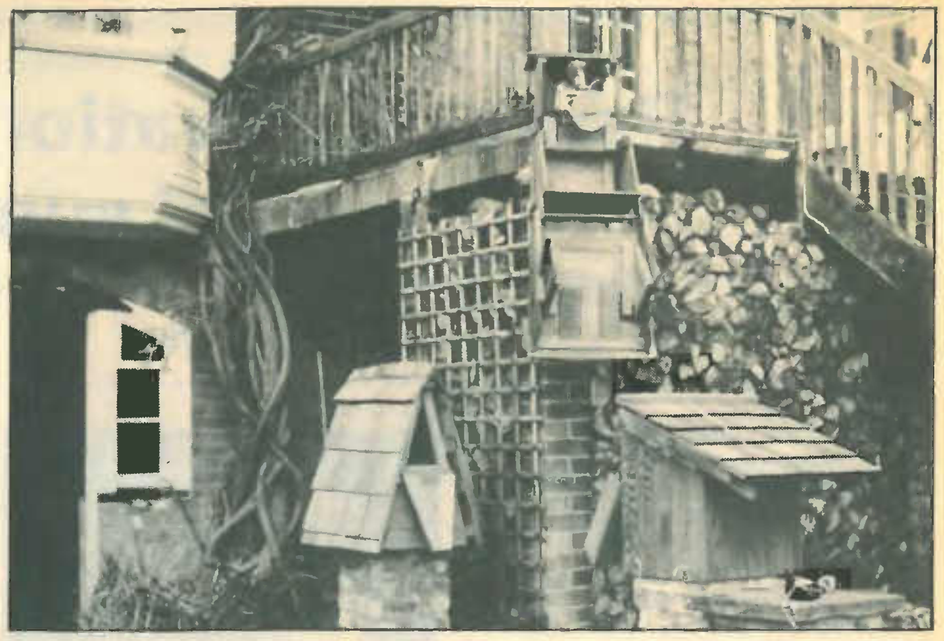


Fig. 7. The spectrohelioscope. A mirror (top centre) follows the sun and reflects light towards the second unit (bottom right) which in turn passes through the garden room door off to the left via the lens housing (bottom left).

d.c. amplifier and pen recorder.

This instrument, although originally using a slightly different frequency and receiver, was brought into operation in 1968 and has operated for three hours daily ever since. Using a chart recording speed of 7cm/h, short-lived solar bursts are easily identifiable.

Sunspots – briefly

When a long-life sunspot, or group of sunspots, appears on the east-limb of the sun it can be visible for about 13 days before leaving on the western limb. The sunspots themselves are stationary but, because the sun revolves once every 27 days, they appear to move across the surface.

Constant observations have shown that when sunspots are present there are two main features of the associated solar r.f. noise, the individual burst, Fig. 3, which may last for several minutes, and the continuous noise storm which may last for days, Fig. 4. These radio waves are often generated by solar flares or prominences, Fig. 1, but the nuclear waste ejected by the event can take up to 50 hours before it reaches the earth and causes some form of atmospheric disturbance.

Sunspot cycle No. 20

The author's observations began on the rising side of sunspot cycle No. 20 (1965 to 1976 approx.) in June 1968. After a quiet start, a large burst of activity from a group of sunspots on 13 August and a noise storm from the 18th to 21st were recorded. Another period of quiet ended on 17 October with a 5-minute burst from a period of solar activity which lasted until 4 November. The main feature of this event was a noise storm which began on the 29th and ended on 1 November: shortly after its termination an aurora borealis manifested and deflected v.h.f. signals from amateur radio stations in northern England, Northern Ireland and Scotland towards the south of England, proving to the author the connection between the 'active' sun and terrestrial radio disturbance.

The number of days on which solar noise was recorded increased towards a peak in 1971 and then decreased until the new cycle began, Fig. 5. One of the largest noise storms recorded began on 11 November 1970 and raged until the 22nd, during which time the solar-noise level was apparently constant as the output from the fixed azimuth aerial increased daily as a large sunspot group approached central meridian and gradually decreased thereafter.

This was an example of following the rotation of the sun using radio. The telescope's recording pen was at full scale throughout the observations on the 15th and 16th, which was not surprising because the *Daily Telegraph* newspaper reported on 17 November that there were four separate sunspot groups at the time and the biggest passed through the central meridian on the 16th. This solar event upset h.f. communications and one unusual feature was the high atmospheric noise level that was heard on the h.f. bands after sunset. Another major storm, associated with a large sunspot group between 3 and 13 March 1972 was the subject of a special report to the British Astronomical Association (BAAJ June '72) with a special emphasis on the flares which were recorded by radio on the 5th.

Of the many individual bursts recorded during the past decade, a large solar burst at around 08.35hr on 3 July 1974 was the most memorable. The telescope had been recording the radio waves from a severe noise storm on the two previous days so the author decided to check the rising sun by using a 2m beam and some auxiliary equipment. Suddenly the noise increased at 136MHz and other receivers in use at the time emitted noise at 70.5 and 30MHz.

At this point a communications receiver and a long-wire aerial were used to follow the noise and for six minutes it overpowered all terrestrial signals down to 8MHz before it slowly faded away back to 136MHz, Fig.6. Solar noise was also heard at 28.5 and 70MHz on 3, 6 and 28 July.

At 07.45hr on 22 August 1976 strong bursts of solar noise were heard at 28MHz and later at 11.58hr while the author was using a low-band mobile radiotelephone another big burst occurred and blotted out the channel for 16 minutes. This burst was also recorded by the author's radio-telescope at 136MHz.

The sun often produces the unexpected and having been quiet, apart from two tiny bursts, for 18 days it suddenly emitted a 28 minute burst which covered 50MHz of the v.h.f. spectrum at 13.16hr on 29 July 1973. Another notable burst began on 1 August at 11.46hr and for eight minutes the solar noise was strong enough to overpower static from a local thunderstorm.

Auroral observations

Briefly, an aurora manifests when a stream of particles from the sun collides with the gases of the earth's polar atmosphere causing a temporary ionisation which affects terrestrial radio signals. An auroral reflected signal can be identified by the following characteristics: an s.s.b. transmission sounds like a ghostly whisper, a c.w. signal becomes a low-pitched rasp and the main image on a television screen is accompanied by many distorted images, all frequently changing as the aurora ebbs and flows. Throughout the past decade Mr C. Newton, Auroral Co-ordinator for the RSGB, has organized a large network of radio amateurs who monitor the effects of signals bouncing off aurora.

Following a period of large solar bursts an aurora manifested in two phases on 8 March 1970. During the first phase, 16.00 to 16.47hr, auroral signals were heard in southern England from amateur stations located in parts of Ireland, Scotland, Wales and Holland in the 2m band. The second phase, 18.15hr to 23.30hr, was more intense and auroral signals from many east-European broadcast stations operating between 65 and 73 MHz were received in addition to the amateur stations heard during the first phase.

A large sunspot group was responsible for the noise storm which began on 2 August 1972 and became very intense on the 3rd. At sunrise on the 4th the solar noise was heard at several radio frequencies and by mid-day it had reached large proportions. It was not surprising that from midnight on the 4th until about 03.00hr on the 5th a spectacular aurora manifested which not only had an umbrella effect on v.h.f. radio signals, but its full glory was visible from southern-Eng-

Fig. 8. The yagi used in conjunction with the spectrohelioscope.

Recorded noise storms of 1971

7 to 14 and 19 to 23 Jan.
28 Jan. to 3 Feb.
10 to 17 Apr.
9 to 12 May.
14 to 19 and 24 to 28 Jul.
18 to 26 Aug.
16 to 19 Nov.
4 to 9 Dec.

Fig. 9. Sunspots photographed at 14.50hr on 11 February 1978.

Fig 10. Clouds of gas from an active region of the sun.

Fig. 11. Solar activity near sunspots recorded on 3 May 1978.

Fig. 12. Sunspots and solar activity from 25 May 1978.

land. Although less intense, the prevailing solar storm continued through the 5th, 6th and 7th. At 15.00hr on the 5th another aurora manifested but this time it could only be 'seen' by radio. Without radio both these events may have gone by unrecorded, the first could have been screened by cloudy skies and the second was obscured by daylight.

A special watch was kept on the 4m band during the solar activity from 28 March to 2 April 1973. At 16.00hr on the 1st observers in southern England were rewarded with auroral reflected signals from the Polish broadcast station at Gdansk, 70.31 MHz, and during the following hour auroral signals from 14 European broadcast stations were heard between 49 and 71 MHz.

The auroral events on 15 September and 13 October 1974 were expected because of the prevailing solar activity around these two dates. The September event lasted most of the afternoon and evening and although the October aurora was much shorter, 14.00hr to 17.15hr, the first warning came earlier as signals from the OSCAR-6 satellite crossing the north-pole were affected by the aurora.

At 08.41hr on 23 March 1976 a large solar burst was also recorded by the radio-telescope which Cmdr Henry Hatfield uses at his home in Kent in conjunction with a spectrohelioscope. At noon, Cmdr Hatfield noted that one of the legs of an arched prominence on the east-limb of the sun was very bright, indicating the presence of a new sunspot. This spot later proved to be very active because from 24 March to 1 April a solar noise storm was recorded and auroral propagation was reported during the afternoons of 26 March, 1 and 3 April.

The spectrohelioscope

By the beginning of sunspot cycle 21 Cmdr Hatfield, with his spectrohelioscope†, had introduced another tool for the study of solar activity. This instrument consists of two wave collectors, one a mirror, Fig. 7, and the other a 4-element yagi aerial, Fig. 8, which both follow the path of the sun. The sunlight is passed through a series of mirrors and lenses to an observatory in the garden room below the house. At the same time radio waves collected by the yagi are fed to a radio telescope in the same room.

The output stage of the radio telescope amplifier is used to drive an alarm bell when solar bursts are detected.

Sunspot cycle No. 21

It is understood that cycle 21 began in 1976 when sunspots of the new cycle were seen along the tail enders of cycle 20. From the author's observation cycle 21 got off to a slow start because solar radio noise was only recorded on 47 days out of 304 between 1 November 1976 and 31 August 1977. A marked increase in the daily rate of noise began in September 1977 and was still high at the end of July 1978. Out of the 212 days from 1 January to 31 July solar noise was recorded on 108 days compared with 34 for the same period in 1977, 35 days in 1976, 34 days in 1975 and around 124 days for the same period in the peak year, 1971. From present records 1978 appears to be the peak year, Fig. 5, of cycle 21 therefore it is worth taking a more detailed look at some of the special events which took place.

On 11 February 1978 the first clear sky for several days enabled Cmdr Hatfield to use his spectrohelioscope and in view of the high level of radio noise which had been coming from the sun on previous days he was not surprised to see some large sunspots. At 14.25hr he watched an explosion take place near the upper sunspot in Fig. 9 and soon after recorded a massive six minute long burst of radio noise at 136MHz. On 6 March at 12.31hr Cmdr Hatfield managed to photograph the solar activity, Fig. 10, responsible for the noise storm which was in progress using the spectrohelioscope.

Around 12.00hr on 9 April a burst of radio noise lasting six minutes was heard sweeping across the spectrum from 1.8 on 144MHz and during the severe noise storm from the 14th to the 17th, solar bursts were frequently heard at 28.5 and 136MHz. The sun was relatively quiet from the 19th to 27th when suddenly at 13.29hr on the 28th an enormous burst of noise lasting 32 minutes occurred which almost instantaneously blacked out the h.f. bands for a couple of hours. Some 50 hours later during the afternoon of the 30th an aurora took place which, with the help of another noise storm on 1 May, rolled around until the early hours of the 4th, Fig. 11. On 25 May Cmdr Hatfield again photographed solar activity around a group of sunspots, Fig. 12, which was causing a radio noise storm and it is possible that these spots were responsible for the solar flare at 10.45hr on 31 May and the sudden ionospheric disturbance that went with it.

Records show that aurora and/or ionospheric disturbance occurred during solar noise storms which manifested on six days in September, 10 in October, eight in December 1977, seven in January, 19 in February, six in March, five in April, six in May, five in June, six in July 1978, two in April, five in August 1979 and nine in April 1980. After 12 years of consistent observation the author has come to the conclusion that the 'active' sun is very unpredictable. □

† Cmdr. Hatfield's spectrohelioscope was the subject of the BBC television programme 'The Sky at Night'.

Literature received

Mallory alkaline and mercury **batteries**, and Multiplex NiCad rechargeable types are described in a leaflet from Intel Electronic Components Ltd, Henlow Trading Estate, Henlow, Beds. WW401

Brochure on Controlox, a multi-plane, plugboard **programming system** can be obtained from Oxley Developments Company Ltd, Priory Park, Ulverston, Cumbria LA12 9QG. Controlox is individually designed to undertake multi-programme circuit switching or sequencing. WW402

Data recorders SR-30 and SR-50 by TEAC are sold and serviced in the UK by International Recorders Ltd, 92 High Street, Berkhamsted, Herts. HP4 2BL, who can provide a brochure on these 7- and 14-channel instruments. WW403

Toroidal transformers in the OT series are based on stock core sizes to reduce manufacturing time and reduce costs. These custom-built units are described in a leaflet by Avel-Lindberg Ltd, South Ockenden, Essex RM15 5TD. WW404

The use of the input l.e.ds of an **optical isolator** to protect the inputs of an operational amplifier is described in a design note from Norbain Electro-Optics Ltd, Norbain House, Arkwright Road, Reading, Berks. RG2 0LT. WW405

Ancom's range of **temperature measuring** sensors and assemblies are illustrated and characterized in a leaflet, which can be obtained from Ancom Ltd, Devonshire Street, Cheltenham GL50 3LT. WW406

Unilab, makers of **science teaching equipment**, produce a set of booklets on the use of their equipment which can also be used in their own right as experimenter's guides. A variety of subjects in physics is covered; microwaves, microelectronics, geophysics, for example, the booklets costing, on the average, around £1.50. A list of 'Notes for Use' can be had from Unilab Ltd, Clarendon Road, Blackburn BB1 9TA. WW407

More on active cross-over networks

continued from page 43

ricated absorber boxes may provide an improvement. These involve membranes of bituminous roofing felt with mineral wool in hardboard panels 15 cm deep, the sound entering through perforated fronts with 4 mm holes on a 4 cm grid, and approximately 1 m square for the overall panel. The panels, of which several could be needed, are normally mounted on battens attached to the wall and ceiling. This is however a specialized subject involving reverberation time measurements and is a separate topic, discussed for example in BBC engineering division report RD1958/28, available in most university libraries or from the BBC for £1.50. □

Transient intermodulation distortion

We are sorry that the tutorial article on transient intermodulation distortion intended for this issue (see note in March issue p. 1) has had to be postponed. We hope to be able to go ahead with it later this year.

LETTERS TO THE EDITOR

ARTIFICIAL INTELLIGENCE

In your January issue Malcolm Peltu presents a spirited and cogent defence of artificial intelligence as an important area of study. His already-strong case can be strengthened even further by the observation that a great deal of what is now presented as computer science has its origins in work carried out under the banner of artificial intelligence.

The contribution of AI to computer science is perhaps most readily illustrated by reference to early work. The programming language LISP was devised by McCarthy and his group to aid their work in AI, and this has had a profound influence on computer science. The value of recursion in programming was clearly shown by McCarthy's work as well as by that of Newell, Shaw and Simon on their General Problem Solver. The LISP language is also a paradigm for all the other languages (including PASCAL and ALGOL 68) which allow the construction of trees and other special data structures. Chomsky's pioneering work on the formal representation of syntax was undoubtedly stimulated by the attempts to make computer programs which would manipulate natural language, whether for mechanical translation or question-answering systems.

In more recent times, interest in distributed array processors has stemmed, at least in part, from the development of pattern recognition techniques and their potential application to specific tasks such as the automatic analysis of bubble-chamber photographs. The special programming languages developed at MIT and referred to as "LISP extensions" certainly embody features which will find their way into future data-base schemes with applications in science and commerce.

I am surprised that there now seems to be a tendency for computer scientists to dissociate themselves from AI. This is surely short-sighted in view of the fact that part of today's AI becomes tomorrow's computer science.

A. M. Andrew
Department of Cybernetics
University of Reading

MULTIPLEX KEYING FOR ORGANS

With reference to the article "Multiplex keying system for organs" by A. W. Critchley in the January and February issues, may I draw your attention to the fact that this company has marketed a multiplexing system for pipe organs for nearly four years.

The system is applicable to organs of any size, transmitting all the organ facilities over a single coaxial pair between console and organ. The system includes the necessary correlation between stops, keyboards and pipes of all ranks at any pitch and between keyboards and couplers at any pitch, thus avoiding the need for multi-contact relays and playing keys or the equivalent multiple gates. The customers' requirements are programmed into r.o.m., which controls the standardised modules. A solid-state piston capture system is also available.

We also have a solid-state recording system which records some ten minutes or more of unrestricted organ playing in 32Kbytes of r.a.m. – a full performance of the well-known Widor Toccata uses just over the capacity. Tape back-up allows permanent retention of an unlimited library, with a C60 cassette holding several hours' playing time.

The transmission system has been installed on many organs, large and small, throughout this country and has been exported to the USA and South Africa.

L. W. Ellen
Christie Music Transmission Systems Ltd
Colchester
Essex

THE DEATH OF ELECTRIC CURRENT

My thanks to Ivor Catt for giving me a good laugh at myself for nearly being duped. I read his article "The death of electric current" (December 1980 issue) carefully, and then came to the analogies. Memorable things analogies (witness that damned mutual impedance somewhere in the hot water system), but so dangerous.

The theory C analogy succeeded in giving me a vivid picture of Catt's travelling wave packets going out into the world along what I used to think were insulators, but which I now see are the very opposite. But just a minute, isn't that the philosophical point from which I started: something travelling along the easiest path? It's just back to the wave-particle duality. They're in different places, that's all. I honestly don't know which to call correct and I should like to hear if Catt will swear that nothing that exists is a particle. The trouble with theoreticians is that they can begin to speak as if their self-consistent mathematics were the fact. OK Catt, your maths may be right, and I don't doubt that it is more helpful in your field of practical endeavour, but for me the AVO meter theory of electrical current has more deductive and predictive power. My money goes on Sprague, but when I need you, Catt, I'll gladly acknowledge it. In the meantime please don't put me down as a fool because I tend to live my life close to one side of the duality only. (I never got a shock from an insulator yet.)

The reference to the phlogiston theory was a red herring; *that* was proved by experiment to be untenable.

J. H. J. Dawson
Amsterdam
Netherlands

The author replies:

The duality (Theories N and H) inherent in classical electromagnetism is not the same thing as wave-particle duality. (See for instance D. A. Bell, *Wireless World* Sept. 1980, page 50, first para.) As to "They're in different places, that's all," my reply is that the location of a thing is one of its most important characteristics. As to ". . . . . nothing that exists is a particle," it depends what you mean by 'particle'. I have no sympathy for the billiard ball idea, and no sympathy for the notion of wave-particle duality. The idea of wave-particle duality could probably only have been concocted by people who did not know Heaviside's concept of a slab of energy current, now called the Heaviside signal (see *Wireless World*, July 1979). In these particular matters my view coincides with Einstein's;

". . . . . We all of us have some idea of what the basic axioms in physics will turn out to be. The quantum or the particle will surely not be amongst them; the field, in Faraday's and Maxwell's sense, could possibly be, but it is not certain."

"Quantum Mechanics and Reality. In what follows I shall explain briefly and in an elementary way why I consider the methods of quantum mechanics fundamentally unsatisfactory."

(Max Born, "The Born-Einstein letters", pub. Macmillan 1971, pp. 164, 168.)

The most prominent feature of the maths of "OK Catt" is its virtual non-existence. E-m theory was buried in nonsensical, complex maths a long time ago, and I am extricating it. (See "Maxwell's equations revisited", *Wireless World*, March 1980, pp 77-78.)

(I would get a real shock if I got a shock from a conductor.)

Ivor Catt
St Albans

COMMERCIAL BROADCASTING

It is silly to speak of freedom of choice where the main criterion of choice is advertising revenue. It is equally silly to pretend that the best of anything is that which is desired by the majority, who clearly desire pools, dirt as represented by the *News of the World* etc, and pop-tune after pop-tune regardless of quality; good, bad or indifferent. This morning's paper says that peak viewing is soap-opera. And presumably the finest wartime musical work was "Roll out the Barrel" if popularity is the criterion.

It was as long ago as Hume or J. S. Mill that it was first pointed out that rigid democracy led as surely as any other system to suppression of minority interests. Certainly if longer hours mean more dreary episodes of Coronation Street and the like, more samey westerns and American cop-and-robber sagas and long-since-dated films, then they can have my licence back.

And what is it all for? To try to dupe more people into buying, at ridiculously inflated prices, cosmetics, cancer-sticks, and beer which tastes, as Lawrence Durrell so admirably put it, like a urine sample from a mule. To make matters worse you would think from their attitudes that the advertisers were transmitting the word of God. In fact we would all be much better off if they were all strangled.

F. V. Bale
Maidenhead, Berks

With reference to your leader of the December 1980 issue I feel that I must pass comment on a number of salient points.

First, you state that the BBC has already started a course of competing for large audiences on terms set by the commercial broadcasting networks. It is not – it is competing on the same terms as always, but using material which is supposedly more suited to the changing tastes and opinions of the present day. That some find this material displeasing is a consequence of the more depressed financial state of the country as a whole, not just of the BBC itself. There may not exist a desirable level of funds in the Corporation for new developments and the expansion of the network, but on a national level in a period of depressed outlook the discontent with most public services tends to increase anyway.

Secondly, you voice the opinion that, "British life will be impoverished without a good, strong-voiced public service broadcaster, independent of the state, creative and risk-taking . . . ". Certainly I agree with most of your underlying sentiments, but I would venture to propound that, with respect to the BBC, the commercial networks have been just as strong-voiced on some important national issues and have demonstrated equal amounts of creativity and willingness to take risks. I would also say it is tenable fact that today they are generally as praiseworthy as the BBC, and state categorically that by definition (and in their *modus operandi*) they are much more independent of the state.

This brings me to my third point, being your statement that commercial broadcasting "is not independent at all . . . " and does not "sell programmes directly to the public, in the manner of theatres or book publishers . . . ". Frankly, I do not follow this line of argument at all, especially as you carry on to say that "It is in the game for profit, and the service which it provides is incidental . . . ". Theatres and book publishers produce plays and sell books that in some cases make a significant contribution to our culture, but they are still mainly 'in the game' for the primary purpose of taking money from our pockets.

Perhaps your leader writer might not have noticed that plays which are box-office disasters (=financial loss) do not tend to stay too long on the stage. Maybe, as a writer, he only has the slightest suspicion that authors receive a warmer welcome at the publisher's office if it is thought that their books may become best-sellers (=financial gain).

The commercial broadcast networks do indeed produce programmes that they calculate will receive the highest audience figures, and they appear to do so quite successfully so that their calculations cannot be too far awry. Therefore the public is paying, albeit indirectly through advertising revenue, mostly for what it wants to receive from these networks: if it were not, advertising revenue would plummet, the networks would go out of business, and the BBC would achieve higher audience ratings. (Somehow, though, I think that previously-advertised products would not be reduced in price; and maybe then the BBC would start to complain about competition from theatres and cinemas?).

The service that the commercial networks provide is anything but incidental; it is their very bread and butter, for if it did not meet the majority of the viewing and listening public's demands it would not receive the revenue income it needs to survive.

Finally, lest I be branded a 'public-sector-basher' or a 'capital extremist'', let me wish for the BBC, and our country, better times: let me also ask that we remember that in our time of depression the horns must be drawn in, and that no solution exists in discrediting a service simply because it is *not* public-sector.

F.C.T. Gale, G8FH
Hengelo
Netherlands

Congratulations on your editorial "Save our public service broadcasting". One has only to view the American broadcasting situation to realise what would happen here if commercial broadcasting got the upper hand. The only reason why it produces good programmes now is because it must compete with the BBC. Had ITV-ILR arrived first, there would have been no BBC and our programmes would have been at the American level.

The BBC operates two television services and an extensive sound broadcasting service at a lower cost than ITV-ILR operates one television service and a skeleton sound broadcasting service. But the greatest danger facing the public in the event of the demise of the BBC lies in the field of news broadcasts. It is generally believed that most people obtain their news via tv. Those of us who are old enough to remember the so-called "news-reels" of pre-war and just post-war days shudder to think of the type of "news" that would be presented to us by a commercial news-handling monopoly.

Roy C. Whitehead
Sutton
Surrey

MAIL ORDER BUSINESS

For many years people have bought magazines like *Wireless World* as a source of up to date information on component prices and availability. In any technical magazine the advertising is as much a service to the reader as is the editorial content. Increasingly, however, the material advertised for mail order is not available. Mail order firms are increasingly banking cheques and delaying months before sending goods either because they are grossly undermanned or because they get interest on the banked money. Alone of your advertisers, Sinclair are honest in admitting that goods will not be supplied from stock. It has been a long tradition in the electronics industry that small orders of components came by return of post. Unless this tradition is restored, I, for one, will no longer order by post. Those firms operating from the West Country are particularly remiss.

I am beginning to wonder if the people Roger Cook pursues have decided to move into the fraudulent component supply racket. Thus far I have not heard of any fraud in the area of electronic supply but the field is wide open. Advertise cheap memory and you could expect at least a thousand cheques for between twenty and thirty pounds. That is a lot of money. Electronics has traditionally been a field where people trusted each other, firms rarely bothering to wait for cheques to clear before sending goods. If criminals are going to move into this area, either by selling kits and data that won't make up into working devices, by sending for goods with bouncing cheques or advertising non-existent goods, a multi-million pound industry could just vanish.

Fred Allen
Cambridge

ELECTRONICS AND UNEMPLOYMENT

Though your magazine is not the place for an essay in economics, some comment on the January editorial may be in order.

First consider the overall effect of 'automation', a term which I use as short-hand for any procedure which uses sophisticated capital equipment – whether electronic or mechanical – to reduce the labour content of manufacture. One of the objectives of automation is to reduce manufacturing cost. A large part of the cost of robots, computers etc. is the cost of highly skilled labour employed in their design and manufacture (and marketing). Since there is an overall reduction in cost there must be an overall reduction in labour employed. This is on the basis of constant volume of output; and there are arguments on grounds of limitation of material resources and 'quality of life' against the older idea of continual expansion of volume of output. Equally important as the reduction in total employment is the upgrading and change in type of skills required.

A reduction in working hours is often demanded. Over the course of history, working hours have been reduced from all the hours of daylight in six days to 60, 50, 40 per week and some further reduction would not be out of line. At constant hourly productivity and constant total output this would require more employees and so reduce umeployment; but in these terms it would be a form of work-sharing and require a reduction in weekly wage – probably not acceptable.

There are many detailed ifs and buts to be added. For example, *if* morale is improved by shortening the working week, production per man will not be reduced pro rata with hours. Volume of production may be limited by natural resources, *but* what about the sophistication factor? Automation may reduce cost of manufacture, *but* this is not the only motive for its introduction. One cannot just say whether or not "chips" will cause unemployment of millions: one must examine each sector of industry in detail and then the interactions between sectors. The one thing which does seem clear, however, is that training in appropriate skills is going to be of supreme importance.

D. A. Bell
Beverley
North Humberside

MICROCHIPS AND MEGADEATHS

Your editorial of last November, 'Microchips and megadeaths', and some of the letters in reply, remind me almost irresistibly of the words of 'Shooty' in the 'Hitch-hikers' guide to the galaxy': "I don't go round gratuitously shooting people and then bragging about it in seedy space-ranchers' bars. I go around gratuitously shooting people and then agonising about it afterwards to my girlfriend."

May I suggest that any electronics engineer who really agrees with your editorial should resign his job and live on the dole. Thus not only would he avoid the risk of inventing anything that might have a military application, but he would use up funds which could otherwise be spent on arms.

J. S. Linfoot
Oxford

By profession I am an artist; my hobby, since the early 1950s has been electronics. *Wireless World* has always been of great interest to me, keeping me up to date. Your articles and projects have always been on the highest level. I have built many projects – from Dinsdale, Linsley-Hood, Nelson-Jones, Baxandall etc. – and have received much pleasure from them, although I think the designers would be shocked with the look of some of my efforts. I bend wires instead of using p.b.cs, though, believe it or not, most work extremely well.

The other side of the electronics profession disturbs me very much and, like you, I wonder how highly intelligent, highly skilled electronics engineers can be so blind as to continue to invent and to use their ingenuity with modern circuitry, not to give pleasure and ease the burdens of life alone, but to destroy everything they and every creative person has ever worked for on this planet – including themselves and us!

Your excellent leading article and some letters from engineers in the industry in the November 1980 issue prompts me to write and congratulate you on your courage and foresight in printing these. Having travelled broadly, I know your magazine is read in many countries, so I hope engineers in the industry will take inspiration from you and stop supporting the industrial and political maniacs around the globe in their blind drive to destroy so much of the work of the Creator.

Please carry on the good work.

Ken Evans
Shaftesbury
Dorset

ELECTRONIC COMBINATION LOCK

I have read with interest the article describing an electronic combination lock (January issue), but what I feel Jan Hruska *ought* to have developed is a lock that opens to a pre-determined rhythmic operation of a conventional door bell press button. This would save any need for a keypad, and would be of use in situations already equipped with an electric striker, such as buildings with controlled access by "entry-phone" type systems, for example blocks of flats.

H. T. Wynne
Glasgow

The author replies:
I would like to make the following points in favour of my original design:
1. The hexadecimal code used in my design is equivalent to a combination of 16 dots and dashes, which would be a considerably greater burden of information for a non-user of Morse to learn.
2. Input of code in this form would take longer.

However, I had already considered constructing such an alternative device and have built a battery operated prototype using an Intel stand-alone microcomputer.

Jan Hruska
University of Oxford

PICKABACK SPARKS

John T. Lloyd, writing in November 1980 letters, mentions the phenomenon where a third electrode at high voltage initiates a discharge in air between two electrodes connected to a charged capacitor. I can confirm his observation and would add that a high frequency Tesla coil source may not be necessary.

I first observed the effect as a child, when I built an electronic flash gun. Having no xenon tube at the time, I decided to attempt an air discharge. The capacitor was about $200\mu F$ charged to 350 volts, and a miniature ignition coil was used (from a model aircraft). At first I was only able to obtain the weak high voltage spark, but by moving the electrodes progressively closer, I was rewarded by the bang and blue flash which discharged the capacitor. I found that a bare copper wire, freshly cut on a diagonal gave the best result.

Much later in life, I suggested the idea of a third electrode to Unilever Research in connection with an explosibility test apparatus. Originally two pointed electrodes were connected to a bank of capacitors which were gradually charged. The gap was sized to fire at a predetermined voltage. Unfortunately, the voltage at which breakdown occurred was not accurately reproducible. Some of the reasons will be apparent from "Sparks gaps" by J Dearden in your November 1980 issue.

Using a third electrode allowed "ignition" of the discharge which then almost completely emptied the main capacitor bank. The significance of this method is that although a *high voltage* spark is used to ignite the discharge, the *energy* in the high voltage spark can be *minute* by comparison with that in the capacitor bank. This discharge starts at a very predictable voltage (that of the capacitor bank itself) and a negligible disturbance is caused by the third electrode.

This idea worked very well in practice. I do not know whether Unilever has used this work or published it since I left. However, I would certainly like to lay claim to the invention; although I would be very surprised if no-one realised that this effect could happen before I discovered it for myself as a child.

A. R. Churchley
Sara Ltd
Warrington
Lancs

OPPORTUNITY LOST?

While in course of conducting research in the technological history of disc sound recording I browsed through a volume of the defunct German scientific journal *Akustische Zeitschrift*. On the last page of the July 1941 issue there is a review of a demonstration that took place in Berlin on June 10, 1941. The object in question was the "new Magnetophon" which boasted noiseless playback. The paragraph which is of the greatest interest, historically, is the following (translated by me into English):

"In recent research H. J. von Braunmuhl and W. Weber (RRG) succeeded in improving the quality considerably, particularly the dynamic range, because they used high frequency magnetization in the recording head instead of d.c. magnetization. Thereby practically all noises originating from the tape disappear."

Now what does this prove? It proves to me that a fact which was not discovered by the Allied powers until 1945 and which explained certain feats of radio transmission during the 1939-45 war, was in fact publicly disclosed in Germany as early as 1941. The technical description was adequate, i.e. a person skilled in the art would have been able to fathom the advantages, had he read that particular review. The war was a great obstacle, but surely there was at least a trickling distribution of scientific journals in the Allied countries (possibly through the neutral states Sweden or Switzerland). It seems rather a case of too few readers with sufficient fluency in reading German, because none of the standard accounts of the history of magnetic recording mentions this very early publication (e.g. Basil Lane's extremely thorough "75 years of magnetic recording" in *Wireless World* in 1975). It also proves that research into the history of technology (as any other historical discipline) cannot do without access to every page of an original publication and cannot be done by means of abstracting services or the like.

I hope to be corrected by any of your readers who may know about previous publication of the above reference.

George Brock-Nannestad
Gentofte
Denmark

DESIGNING WITH MICROPROCESSORS

R. M. O'Connor, writing in October 1980 letters, raises a number of important matters which deserve further discussion.

Firstly, there is no one "best" way of learning about microprocessors and their application. A method aimed at recent graduates with a formal training in logic design may be completely inappropriate for a practising designer with many years of experience, and now faced with using this new device. Similarly, a programmer with a background in mini-computers is likely to need a quite different approach. I hope that *Wireless World* will cover these aspects too in due course.

O'Connor makes the point that what the designer needs to know is what micros can do. It is equally important that he also knows those things that micros can't do *economically*. There has been far too much talk about the wonders of the mighty micro, and far too little about the cold, hard facts of the hidden costs of using them.

On the question of machine independence, neither O'Connor nor Zissos and Valan have said whether they are talking about a single chip controller, a small industrial controller, or a system such as a TRS-80 or an Apple with a large capacity hard disc, line printer, etc. Perhaps it is best summed up by J. L. Alty in his introduction to Professor Zissos's "System Design with Microprocessors" in which he says:

"It is important to realize that the new technology will permeate society in two ways – the high volume/low cost and low volume/high cost categories. The former type will be produced in millions and will be very cheap indeed. They will often be single chips dedicated to one application and, as such, will not even be recognisable as computers.

Computer systems do not however consist of hardware alone. The software required to operate the new technology will also be provided in the same two categories – high volume/low cost and low volume/high cost, and each category will tend to run on the equivalent category of hardware. The software in the single purpose chips for example will also be single purpose, relatively fault free, and very cheap if only because of the large volume of sales. It will be unalterable by the user, and will not be maintained. It will simply have to work."

In the high volume applications, the cost of the hardware is likely to be the deciding factor. A $1.00 microprocessor is going to face stiff competition from another costing 99c, no matter which language each uses. For these applications it won't make much difference which language is used – so long as the final code will fit in the memory space available, will do what has to be done in the time available, and is highly reliable.

The major part of the cost of software for microprocessor applications is in preparing the detailed specifications, then deciding the program logic and verifying the flow charts. The cost of coding these flow charts is then fairly small, so that if it is necessary to use a different microprocessor at some stage, the conversion cost could well be fairly small – particularly if the original programs have been kept free of sneaky tricks designed to save the odd byte of code by using a special feature of the original microprocessor.

At the other end of the scale, in the one-off and specials, the lowest total system cost will usually be obtained by using "off-the-shelf" standard hardware and software, with the absolute minimum of additions. In these cases, it often pays to modify the requirements to suit what is available to keep the costs down. Although the system may well turn out to be much more powerful than really necessary, does this matter if the costs are reduced?

For small production runs, it is probably better to design the system around a range of "off-the-shelf" modules. In this case, the particular microprocessor used is not as important as the range of modules available, and whether the hardware modules each have any necessary driver software supplied with them. Each module should be supplied with its own service manual, so that the system documentation can be prepared by assembling the manual for each module, and adding a section on the complete system.

O'Connor raises the question of the disappearing micro. Now although it is true that many microprocessors have appeared, then disappeared just as rapidly, there are three families that have been with us for many years, and look like being around for a long time to come. These are the 6502, the 6800/6809 and the 8080/8085. Not only have the manufacturers taken care to see that it is a simple matter to change the software for new members of each family, but there is considerable support in the form of hardware and software, both from the semiconductor manufacturer and also from a large number of independent suppliers. I have deliberately left out the Z80 for two reasons – there is little software available specifically for the Z80 and in most applications they run 8080 code and so do not make use of all the extra facilities, and their future is likely to depend very much on how fast the Z8000 is accepted. The Z80 might simply be phased out and replaced by the 40-pin version of the Z8000.

The moral from this would seem to be – if you are going to make your product in millions then do what you would do for any other product, i.e. specify an interface that is independent of the type of microprocessor used, place an order for the cheapest components from one or two reliable suppliers, and make sure you buy enough for future spares. If the product sells so well that you have to make another 10 million, then it won't matter if new software is needed. After all, a black box is a black box is a black box is a black box to misquote Stein, and if you can't get inside it to repair or change it, does it matter whether it is a microprocessor, a state machine or random logic? What is important is the original unit cost, the reliability, and the replacement unit cost.

On the other hand, if you are only going to produce small quantities you had better stick to one of the above three families, and design around the one which has the best overall hardware and software support available to you locally, and which has a range of readily available modules which meet your needs. Although these modules look expensive at first they turn out to be far cheaper than rolling your own. You have to make a large quantity to recover the development and proving costs, even if you follow the recommended practices and get it right the first time. Designing a unit which works correctly is straightforward – designing a unit which works correctly and *can be produced economically* requires considerable extra skill and experience.

This leads me to comment on the design steps used by Zissos and Valan in part 5 (October, 1980). They advocate designing the hardware first then the software, then repeating these steps until a satisfactory design is obtained. In each of the failed designs that I have investigated the designers have followed this approach. I cannot stress too strongly that these two steps must be carried out concurrently, and in fact that there are four separate but strongly interwoven areas that must be considered in parallel. These are: 1. Hardware design. 2. Software design. 3. Design for testing. 4. Design for production.

The last two areas are often left till the prototype is completed, and then it's back to the drawing board for some very expensive changes. We should follow the Smallpiece philosophy of "Get it right the first time." Test points, both for production testing and field servicing *must* be built into the hardware and software during the original design. There is a lot to be said for making a commitment to including signature analysis in every product. Similarly, what is the point of designing a system that can't be produced economically without redesign and the consequent delays in getting your product into the market place? After all, one of the big incentives to using microprocessors is that their use can substantially reduce the development time for the product.

As O'Connor said "Microprocessors are only cheap if they are cheap to use; if the way in which they are used brings crippling costs, they are extraordinarily expensive."

Alan M. Fowler
North Balwyn
Victoria, Australia

DESIGNING WITH MICROPROCESSORS

I would like to thank D. M. Vaidya for his letter in the March issue (p.62) pointing out the error in our Table 3 (p.73) of Part 6 of our series "Designing with microprocessors" in the December 1980 issue. We understand that the editor hopes to publish a corrected version in the next available issue.

Regarding the second point, we must disagree on this. We have written numerous programs using different microprocessors which show the generality of the approach that can be achieved with these different devices. This will be demonstrated in detail in an article which will follow later in our current series. Meanwhile, any readers who would like to have this information in advance are welcome to write to us at the address below.

D. Zissos and L. Valan
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Calgary, Alberta T2N 1N4
Canada

THE TWINS PARADOX OF RELATIVITY

Alex Jones's letter (January) contains a fundamental flaw which I feel should be corrected.

The relative ageing in the Twins Paradox is not dependent on the accelerations at the start and finish of the journey, because the theory has it that, with the same accelerations, doubling the spatial distance of the trip doubles the age difference at the end (with short acceleration durations compared to total journey duration).

This is certainly the impression Einstein wished to impose on the world, and it is backed up by the whole series of text-books since. The effect is quite clearly one of Special Relativity, not of General Relativity.

If, as he suggests, the results of SRT are only "apparent", but the Twins Paradox experimentally resolves in Einstein's favour, as numerous text-book writers would have us believe, then Jones's "coincidence" is not only remarkable, but miraculous.

L. J. Higgins
Swindon Wilts

WIRELESS WORLD'S 70th ANNIVERSARY

If I give a brief record of my association with *Wireless World* it will explain how much pleasure it has given me to be invited by the present editor to say a few words on the 70th anniversary.

Looking for a career in journalism I answered an advertisement by the Marconi Company for an editorial assistant which stated "some knowledge of wireless would be an advantage". As I already had a Post Office Experimental Licence and had read all I could on the subject I had no difficulty in securing the job. I found myself on the editorial staff of the *Wireless World* with the launching of the first number. With a commission in the Royal Engineers, the 1914-18 war took me to Mesopotamia and Persia engaged on interception and direction finding. The Marconi Company kindly kept open the editorship of *Wireless World* for me on my return after demobilisation and I continued with the journal as editor and then as director and managing editor until my retirement in 1962.

With a career which has been so intimately wrapped up with the story of the *Wireless World* I welcome with enthusiasm its achievement of 70 years and, under the control of our present editor, we can look forward with every confidence to the future. I am proud to have been associated with a staff which has created *Wireless World* over the years.

Congratulations and every good wish for the future.

Hugh Pocock
London NW3

Hugh Pocock, writer of the above letter (centre), with two later editors of Wireless World, H. F. Smith (right) and F. L. Devereux (left), on the occasion of the journal's 50th anniversary.

Dividing by fractions

Digital frequency synthesis using non-integral frequency division

by **Gilbert Pearson,** Australian Broadcasting Commission

This circuit allows a direct division from PAL/625 sub-carrier frequency to twice-line frequency, or a direct multiplication from twice-line to sub-carrier frequency. This is achieved in both cases using only digital counters and a single, phase-locked loop. Present methods require additions or subtractions in the frequency domain, which in turn require linear stages.

The unit to generate sub-carrier frequency from line frequency has been built and found to work satisfactorily. The greatest use for the circuit may well be found in synchronizing pulse generators, where its low cost and reliability should prove an advantage. But the principles described are applicable to any frequency synthesis problems where fractional divisions or multiplications are required.

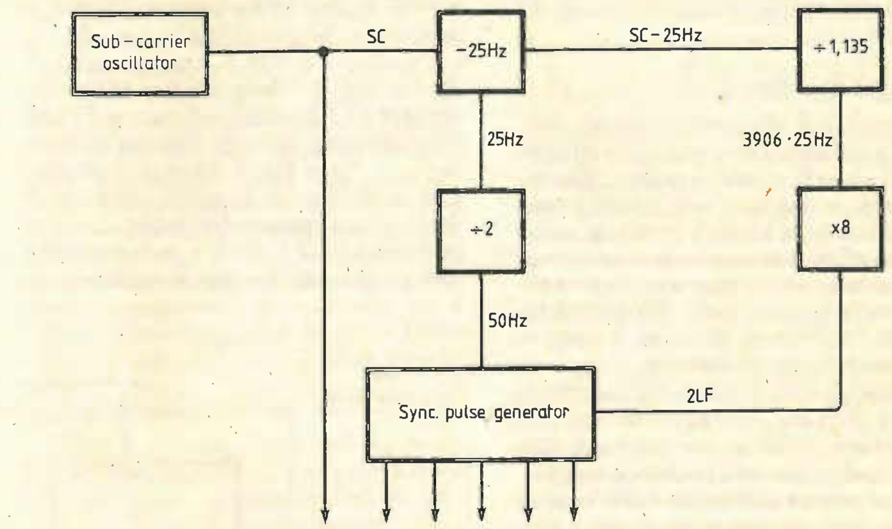


Fig. 1. Typical synthesizing technique.

The colour sub-carrier frequency as used in the 625/PAL colour television system is 4,433,618.75Hz. It is derived from the relationship –

$283\frac{3}{4}\times$line frequency$+25$Hz
i.e. $283\frac{3}{4}\times 15{,}625+25$Hz

The addition of the 25Hz makes synthesis of one frequency from the other difficult. While straight divisions or multiplications can be done simply, with integrated-circuit dividers and phase-locked loops, the addition or subtraction of frequencies, such as 25Hz, requires precision phase shifters and tuned stages.

A common technique used in the generation of twice line frequency (2LF) from sub-carrier (SC) in a sync. pulse generator is shown in Fig. 1.

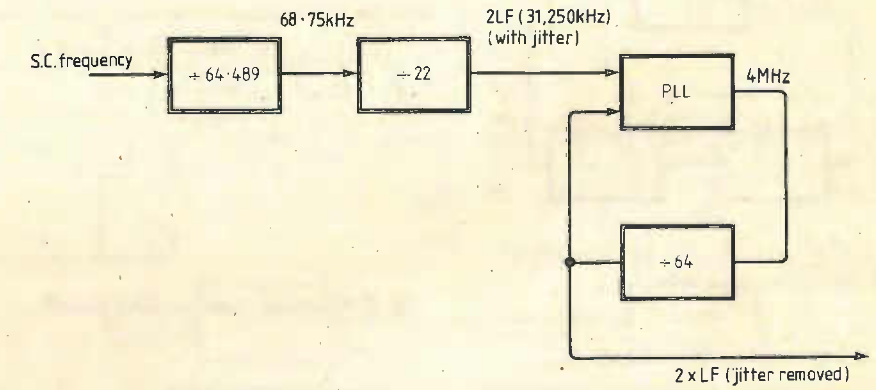


Fig. 2. Twice-line frequency (2LF) derived from sub-carrier frequency.

New method

The two frequencies can be broken into lower multiples, as shown below.

$$SC=4{,}433{,}618.75\text{Hz}$$
$$=11\times 25\times 25\times 644.89\text{Hz}$$
$$2LF=31{,}250\text{Hz}=2\times 25\times 25\times 25\text{Hz}$$

Thus, $$\frac{SC}{11\times 25\times 25\times 644.89}$$

$$=\frac{2LF}{2\times 25\times 25\times 25}=1\text{Hz}$$

i.e. $$2LF=SC\frac{25\times 2}{11\times 644.89}$$

$$=SC\,\frac{5}{11}\times\frac{1000}{64{,}489}$$

It must be pointed out at this stage that 64,489 is prime number and thus cannot be broken up further. From the above, it would seem that we could divide by 64,489, multiply by 1,000, divide by 11, multiply by 5 to generate twice line frequency. The problem with this, however, is that SC divided 64,489 gives 68.75 Hz and it is extremely difficult to stabilize a phase-locked loop (p.l.l. hereafter) with an input frequency which is so low. An ideal solution would be a divider which somehow achieved a fractional division.

i.e. $$2LF=\frac{SC}{2.2\times 64.489}$$

A reasonable first reaction is that this is impossible, and strictly this is correct. However it is possible, using programmable counters, to achieve on average a fractional division by dividing by two or more numbers in an appropriate ratio. For example a division of 4.5 could be performed by dividing alternately by 4 and 5. A division of 4.333 could be performed by dividing by 4 and 5 in the ratio of 2:1 respectively. Of course, the problem with such an arrangement is that the output exhibits a large amount of jitter. This can, for our requirements, be eliminated by a phase-locked loop and will be dealt with later.

If we assume for the moment that both 64.489 and 2.2 dividers are possible, arrangements as shown in Fig. 2 and 3 can be used to generate 2LF from SC and vice-versa. In the schematic in Fig. 2, 2LF is derived directly from the two dividers in cascade. However, this output has large amounts of jitter, so the p.l.l. and divide-by-64 is included to remove this. This circuit would seem particularly useful in a sync. pulse generator where a suitable p.l.l. is often included anyway for the purpose of genlocking.

In Fig. 3, the p.l.l. serves two functions. Firstly, in conjunction with digital circuitry, it provides the means of multiplication. Secondly, by selecting the time constants of the p.l.l., it serves to prevent the jitter of the dividers being reflected on the SC output.

64.489 divider

As described in the previous section, fractional divisions are obtained by dividing by two numbers in a suitable ratio. In the case of 64.489, a solution is to divide by 64 and 65 in the ratio of 511:489. There are many ways in which such a ratio can be achieved, but the best one is that which gives the least low frequency jitter. To do this the divisions by 64 and 65 must as near as possible be evenly distributed.

Before moving to a detailed description of the divider, background on the programmable counters is necessary. The 9310 is such a counter, in which it is possible to arrange a division of any number from 1-10 by programming on pins 3 to 6. It is further possible to cascade the counters and so arrange a division of any number. For our particular purpose a division of 64 and 65 can be achieved as shown on Fig. 4. The programming for each division is shown at the bottom as well as the logic required to switch between the two divisions. When point A is high a division of 64 is performed and a division of 65 when low.

If, as in Fig. 4, the output of the divider is divided by 2 and fed to A, the result will be that the principal divider will alternately divide by 64 and 65, giving, on average, a division by 64.5. The output is also shown to be fed back, through a gate, to the PE terminal of the counters, This is a requirement for this particular counter.

The circuit of Fig. 5 is an extension of that in Fig. 4. There are five 9310s designated XI-X5, integrated circuits X1 and X2 performing the same function as those in Fig. 4. As in Fig. 4, when point A goes high a division of 64 occurs. Instead of there being a separate division by 2, this is performed by X3, itself a programmable divider. X3 and X4 are programmed to divide by 90 and 92 and, since both are even numbers, the Q_0 output of X3 will, regardless of which division is performed, always alternate between 0 and 1.

As stated previously a division of 64.5 is performed by the circuit shown in Fig. 4. This is close to the required division of 64.489. If 11 of the divide-by-65s ("÷65s") in 1,000 are changed into "÷64s" the correct ratio of 511:489 is obtained. This occurs in the circuit of Fig. 5. X3 and X4 divide by 90 and 92 in the ratio of 6:5. This means that they divide by 90.9090 . . . or 1,000/11, and point C will thus have eleven pulses for 1,000 occurring at the clock of X3. Furthermore, these pulses derive from the terminal count of X4, and thus at a time when Q_0 of X3 is high and when B would be low, normally giving a ÷ 65 instruction. The 'high' on C thus overrides this through the OR gate and forces a "÷64" instead. The correct ÷90, ÷92 ratio is obtained from X5. A 9310 is not usually used to divide by 11, but it was used in this case to make all the types standard. When X5 is programmed

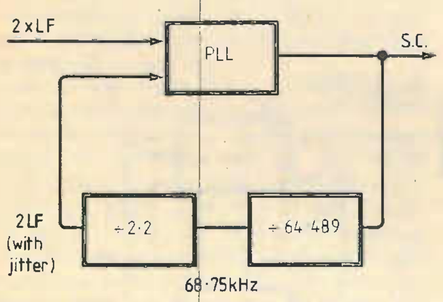


Fig. 3. Sub-carrier frequency (SC) derived from twice line frequency.

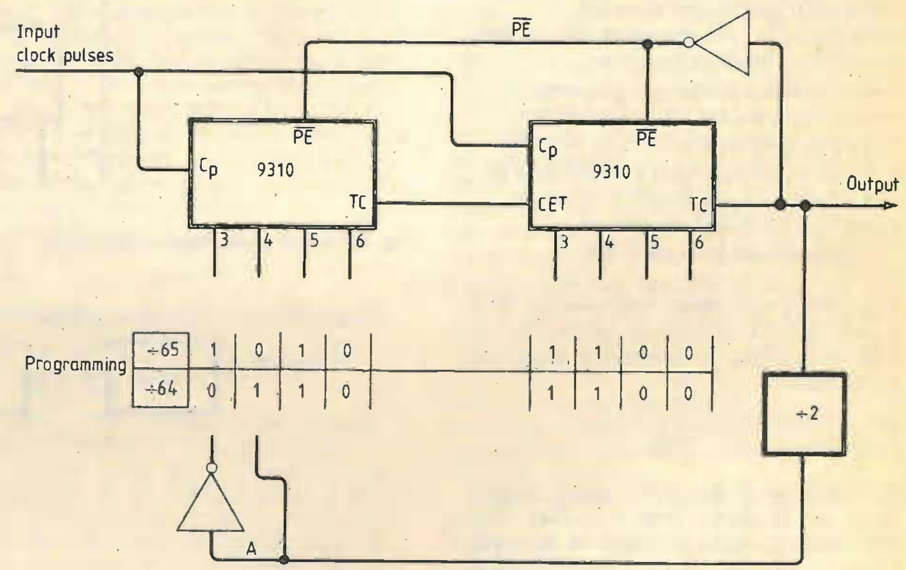
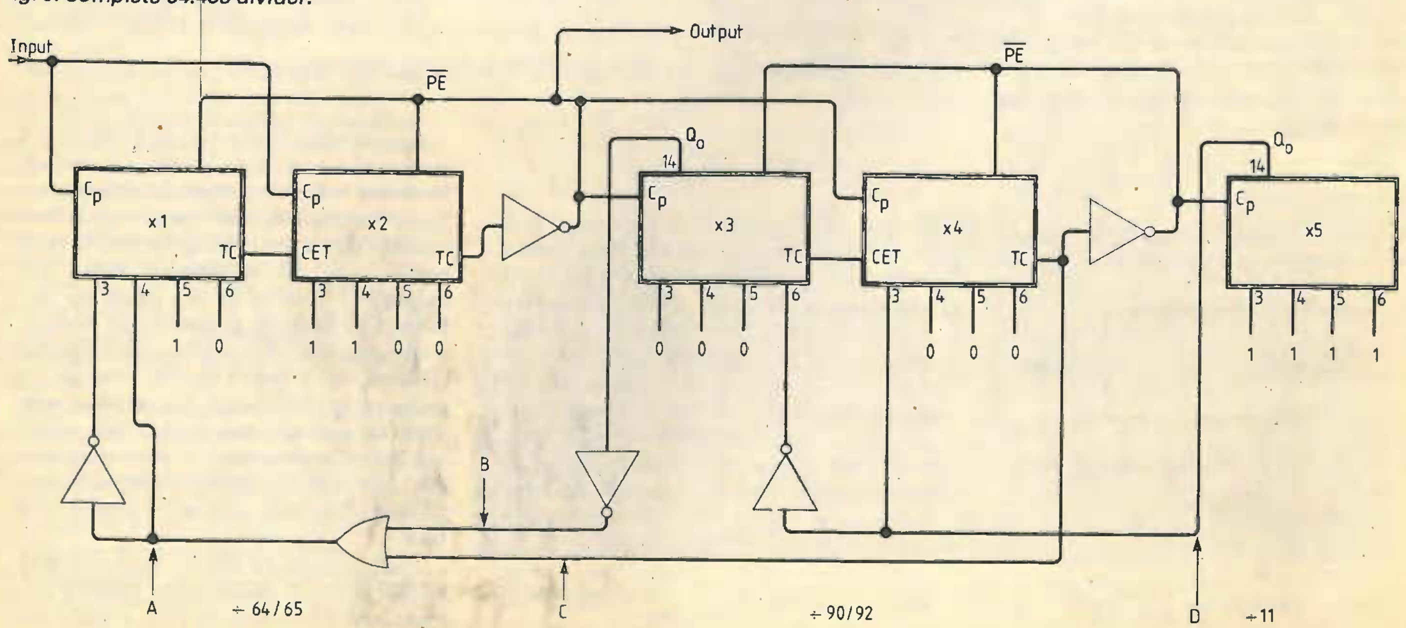


Fig. 4. Alternate divisions of 64 and 65.

Fig. 5. Complete 64.489 divider.



as shown, it will divide by 11 and its Q_0 output will oscillate between 0 and 1, except at the maximum count, when it will give two consecutive 1s. Q_0 will thus be high and low in the ratio of 6:5. It is this point, point D, that is used to command the ÷90/92 counter.

To summarize, X1 and X2 divide by 64 or 65, depending upon the command appearing at point A. This point will go high ("÷64") when either B or C are high. B alternates between low and high and thus, taken in isolation, would alternately command division by 64, 65. Point C goes high for just 11 of 1,000 pulses appearing at the output and it does this when B is low, instructing a "÷65". On these 11 occasions in 1,000 then, a "÷65" is converted to a "÷64" making the ratio of the two divisions 489:511 instead of 500:500 or 1:1.

Jitter. If the divider is given an input of sub-carrier frequency it has the following jitter components:

Frequency	Jitter (ns-pp)
34.375kHz	226
756.25 Hz	111
378 Hz	1.24
68.75 Hz	1.13

The first can be easily understood, since the divider for most of the time divides alternately by 64 and 65, meaning that the output phase oscillates about a true mean with a period of two output cycles. Since with a SC input the output will be 68.75kHz, this first jitter frequency must be half this, 34.375kHz. Its peak to peak excursions are 226ns, one period of the input frequency (T hereafter).

The remaining components are best described with reference to Fig. 6(a). The horizontal axis is calibrated in periods of the output of the divider (1-1,000) and the vertical in its output phase, such that a mean line would be horizontal. The 34.375kHz component has been ignored. Beginning at point A, the divider divides alternately by 64 and 65 and since this is not quite the required division the output phase steadily deviates from the mean as seen by the slope of line A X. Referring to the previous section, instead of the 89 and 90th divisions being 64 and 65 as before, they are both "÷64s" resulting in an abrupt correction in the output phase (X-B). The count sequence from B-C is similar, except that the 91st and 92nd divisions are altered to both be "÷64s". Thus A-B and B-C give slightly different average divisions. The counts from C-D, E-F, G-H, I-J, and K-L are identical with A-B, while the alternate ones, D-E, F-G, H-I and J-K are identical to B-C. It must be noted that there are six of the former sequences and five of the latter, as described in the previous section. After point L, the entire sequence A-L repeats itself. By a quantitive examination of the plot of Fig. 6(a) it is possible to calculate the various jitter components, their waveforms and peak to peak values.

Alternate divisions of 64 and 65 clearly give an average of 64.5. This differs from the final required average by 64.5-64.489. That is 0.011 of an input period (T). This error repeats itself for every pair of divisions and is accumulative. After 88 divisions, or 44 pairs of divisions, from point A, the accumulated error will be 44×.011=484*T* at point X. When the correction is made, (X-B) with a double-division-by-64 a step of 64.0-64.489=−0.489T is made.

It is clear that the sawtooth plot AXBYC . . . represents the next most significant jitter frequency. Eleven cycles of this jitter appear within 1,000 divider output periods; thus, its frequency is

$$\frac{68,750\times 11}{1,000}=756.25\text{Hz}$$

Its peak to peak excursions will be 0.489*T*, i.e., with a SC input − 0.489×226ns≐111ns

An error of +0.484T accumulates to point X and a correction is made (X-B) of −0.484T when a double division by 64 takes place. The correction therefore "overshoots" by an amount of 0.005T. As the counter proceeds from B to Y, an error of 45 × 0.011 = 0.495*T* accumulates. A double division of 64 occurs from Y to C bringing a correction of −0.489T. In this case, the correction is insufficient and "undershoots" by an amount of 0.006T. Since C-D is identical to A-B and D-E is identical with B-C, the process of "overshoot", "undershoot" continues, the jitter waveform of Fig. 6(b) being the result. It is

continued on page 76

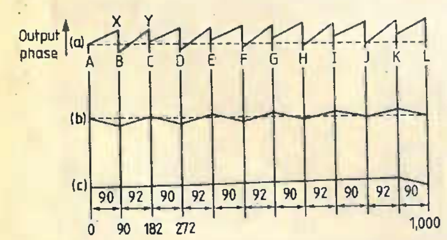


Fig. 6. 756.25 Hz, 378 Hz, and 68.75 Hz jitter components.

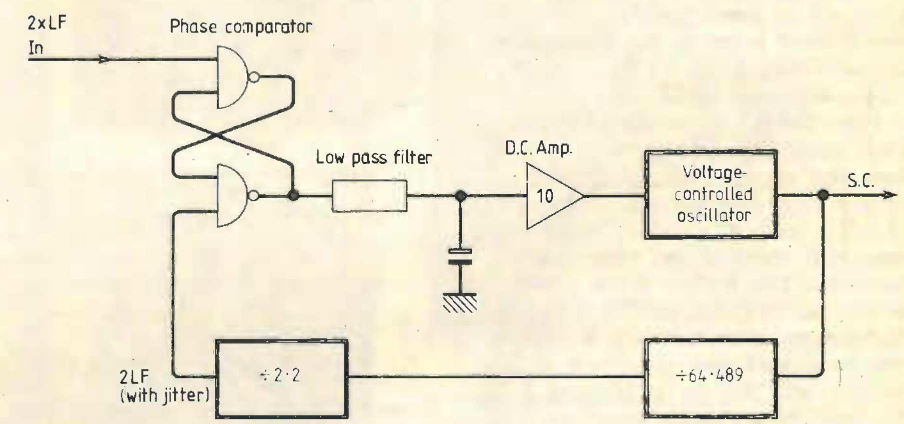


Fig. 7. Phase-locked loop used for synthesis of sub-carrier from twice line frequency.

Fig. 8. Complete 2.2 divider.

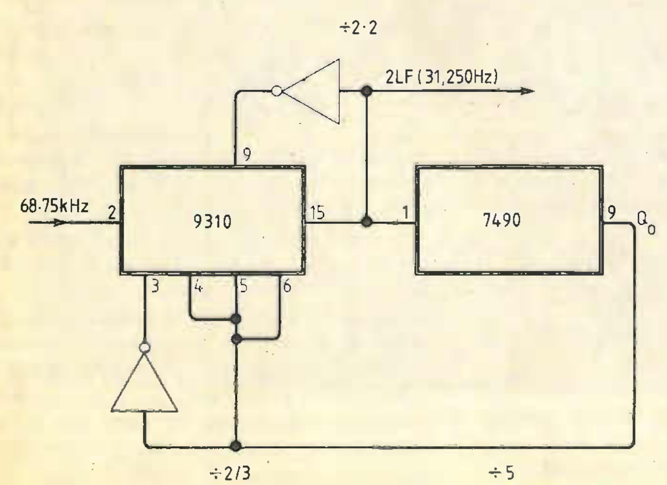
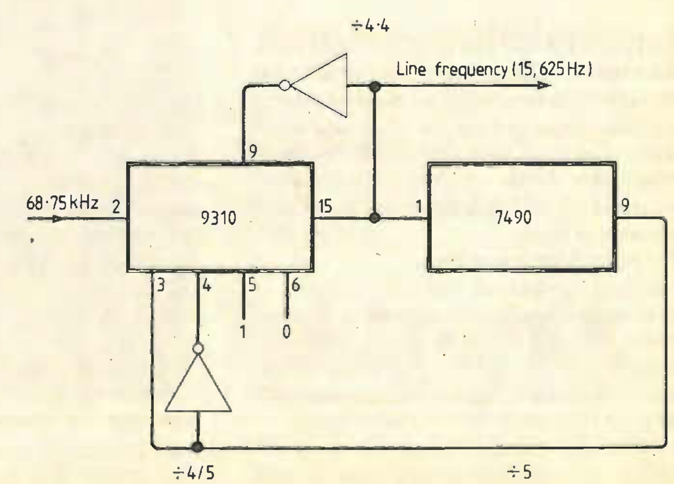


Fig. 9. Complete 4.4 divider.



Phase measurement with an oscilloscope

Avoiding the difficulties of Lissajou figures and time estimation

by I. D. MacArthur

A method of measuring phase angle between two sine waves of the same frequency is described, using a double-beam oscilloscope, which is easy to use up to the full vertical bandwidth of the oscilloscope.

The classical method of measuring phase is by Lissajou figures, as in the example of Fig. 1, a method which suffers from a number of drawbacks. The centre of the ellipse must be accurately aligned with the cross wires of the graticule and then measurements made against the graduations, which are usually on the centre lines themselves. This is tricky and prone to error. Accuracy is poor when the phase angle is near 90° or 270°, and the gain of the horizontal amplifier is usually limited, making it impossible to "open out" the ellipse with small signals. The maximum frequency at which measurements can be made is also restricted by the horizontal amplifier – even a very good modern oscilloscope may be limited to about 200kHz before the relative phase shifts in the vertical and horizontal channels become unacceptable.

It must be stated though, that the Lissajou figure has one big advantage in that it is very useful for checking zero (or 180°) phase shift when the ellipse is closed and any small departures are easily visible.

Another method, shown in Fig. 2, is to measure the times of zero crossing of the waveforms. This method is still probably the best for "a quick look" but has the disadvantages that the two waveforms must be aligned with the centre of the graticule, and that the oscilloscope time base must be accurately triggered. One must also choose between the chopped and alternate modes, which both have disadvantages. On some oscilloscopes it is necessary to provide an external trigger.

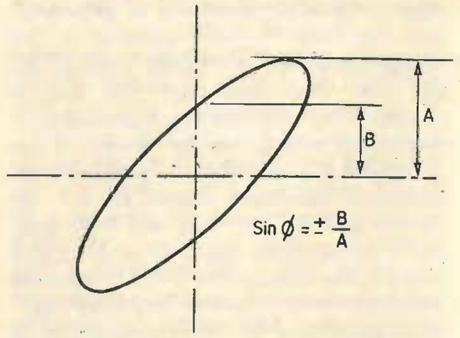


Fig. 1. Phase measurement by the Lissajou figure method. This is difficult, since the graduations on the cursor are usually on the centre line.

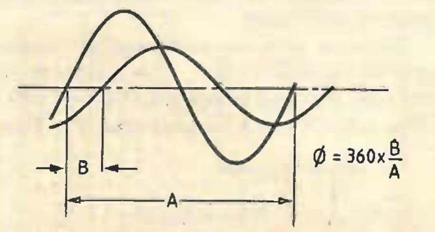


Fig. 2. The zero-crossing method, which can be tricky to set up symmetrically on the screen.

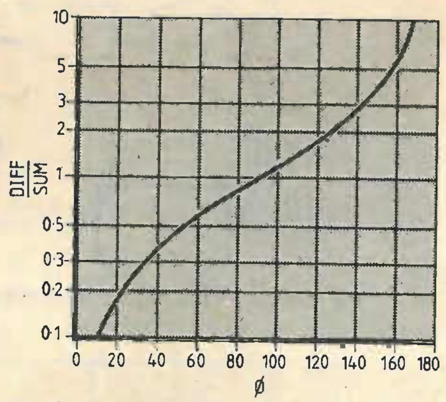
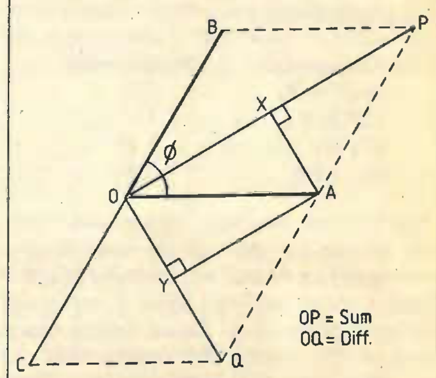


Fig. 3. Graph of diff./sum plotted against phase.

Theory

In the phasor diagram, OA and OB represent the two signals being compared, with a phase difference of Φ between them, shown for convenience in the first quadrant. OC represents the OB signal shifted in phase by 180°, OP is the vector sum of OA and OB, and OQ is their vector difference. OB, OA and OC have been made equal.



AX and AY are perpendiculars from A to OP and OQ and AOP and AOQ are isosceles triangles.

angle AOP=angle APO=Φ/2

and $OX=XP$

Hence $OX=AO\cos\Phi/2$

and $OP=2AO\cos\Phi/2$

Similarly, $OQ=2AO\sin\Phi/2$

Now, $$\frac{2AO\sin\Phi/2}{2AO\cos\Phi} = \frac{\text{difference}}{\text{sum}}$$

$$= \tan\Phi/2$$

Hence $$\Phi = 2\tan^{-1}\frac{\text{diff}}{\text{sum}}$$

Fig. 3 plots this result graphically.

Sum-and-difference method

Here the two signals are displayed as in the zero-crossing time-interval method, but it is unnecessary to have the timebase accurately triggered, or even synchronized in some cases. Measurements can sometimes be made in the presence of significant amounts of noise.

The procedure is as follows:

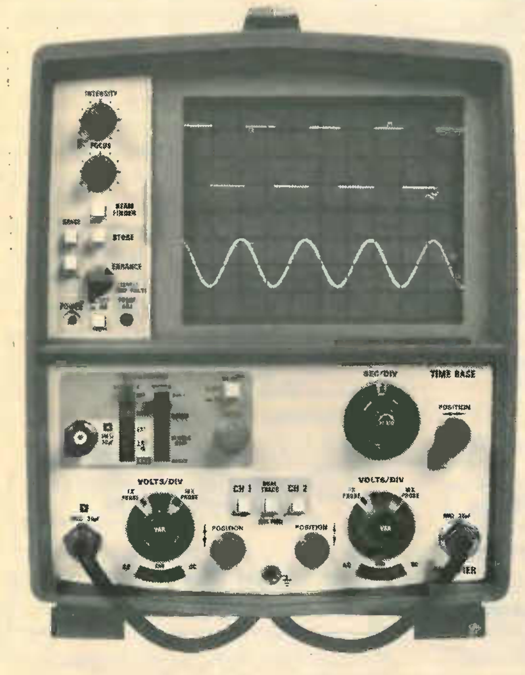
- Adjust the gain of the two channels to give equal-amplitude signals approximately half the screen height (to allow for displaying a 2× signal). The exact amplitude and gain settings are unimportant and the time base need not be synchronized.
- Switch the channel selector to A+B (algebraic add) and record the peak to peak amplitude of the resulting sine wave (the sum voltage).
- Switch the channel selector to A-B (or invert one channel) and record the peak to peak amplitude of the resulting sine wave (the difference voltage).
- Calculate the phase angle from

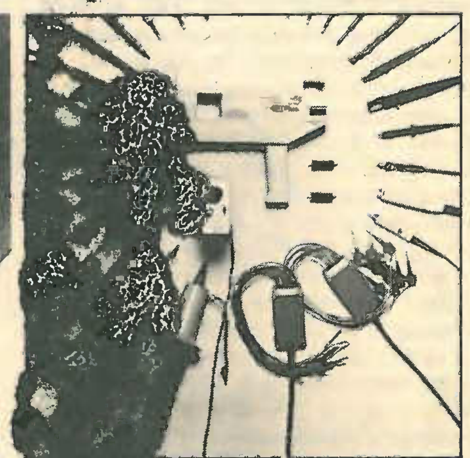
$$\Phi = 2\tan^{-1}\frac{\text{difference}}{\text{sum}}$$

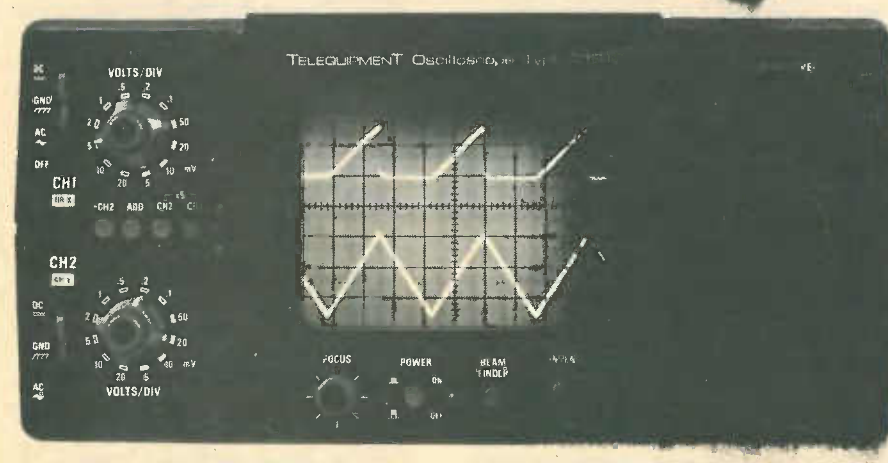
or use the graph in Fig. 3.

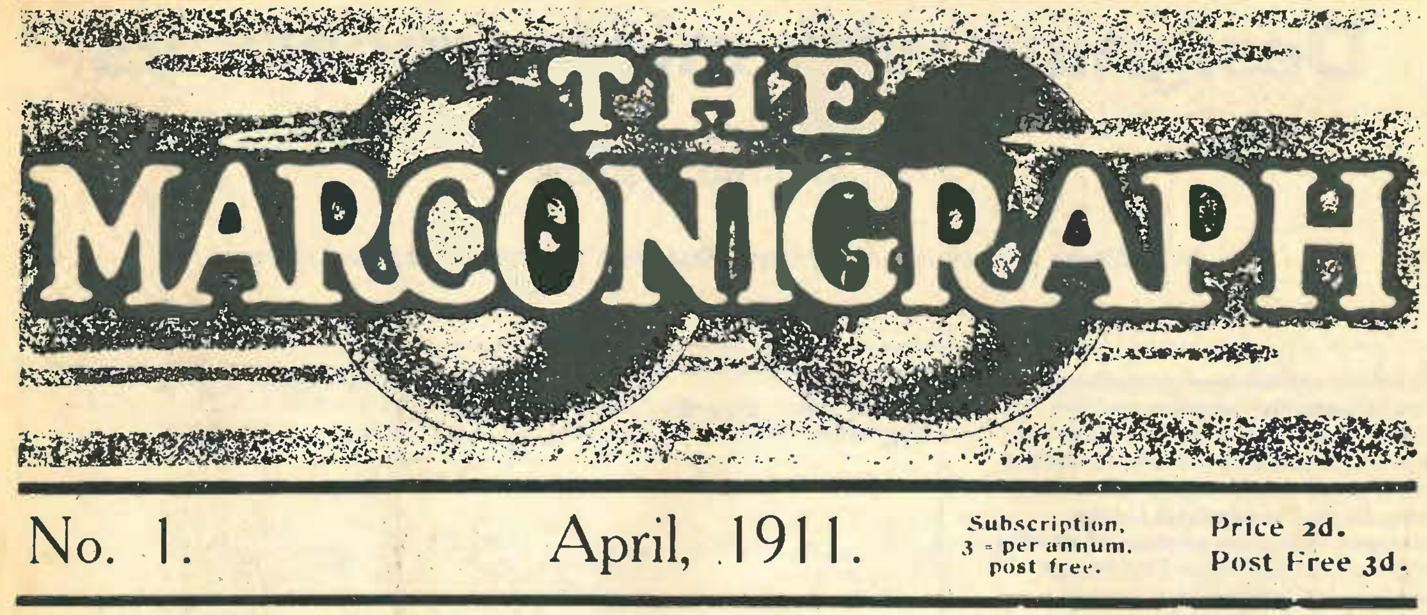
When using this method one must understand its limitations. When making high-frequency measurements it is vital that probes are equally compensated – best done by connecting both probes to one signal and adjusting for equal amplitudes. The accuracy of the method deteriorates as Φ approaches 0° or 180°. If the voltage measurement accuracy is ±5% then accuracy will be about 6.3% at Φ=90°, reducing to about 10.5% at Φ=12° or 168°. Accuracy will also be impaired if significant distortion of either sine wave exists: it is useful to synchronize the time base and check the waveforms.

While the sum-and-difference method of phase measurement will never replace an accurate phase meter or vector voltmeter in the eyes of those who can afford them, it does offer a useful technique which can sometimes out-perform these instruments, particularly when the signals are noisy. I have used the technique on a switching regulator to measure 10mV signals in the presence of 100mV of noise.









Wireless World, 1911-1981

From crystal detectors to microcomputers in 70 years

In 1911, the name of Marconi was almost synonymous with 'wireless': marine wireless operators were, as often as not, referred to as 'Marconi operators'. The growing profession of operating Marconi stations on board ship demanded a magazine, and the Marconi company responded in April 1911 with *The Marconigraph*, which carried news of the company, of operators scattered worldwide and of developments in wireless technique. Two years later, for reasons which have been aired before by writers more directly concerned with the event, *The Marconigraph* became *The Wireless World* and embarked on its declared life's work of being "of use and interest" to a rather wider fraternity than had been the case in its previous existence. Sticklers for detail may, with some justification, point out that *WW* is not 70 this month, but 68. We feel, however, that the two larval years should count towards the total for, while laying no claim to be roseate, we think *WW* quite as sweet as *The Marconigraph*.

While the new science and technology was at first naturally associated with ships' communications, there is a remarkably close parallel to be drawn between the development of radio (and later electronics) and aviation. Both technologies were emergent in 1911 (Bleriot had landed at Dover only two years earlier and Fleming's two-electrode valve was only seven years old), both were to advance rapidly in the two wars and have each, over the years, called for specific development in the other. In the beginning, communication was all, but even in the early days, direction finding and even radio landing aids were seen. The emergence of radar techniques and navigation systems changed the ways in which both civil and military aircraft were operated and even the design of some of them. Looking at it the other way round, the demands imposed on radio and electronics by military aviation in two wars and by an enormous expansion in civil air travel have hastened the development of avionics to a degree where only marginally-stable aircraft become docile, but agile, and where landing aids are capable, in theory at least, of not only landing an aircraft in zero visibility, but getting it to the terminal building as well. Electronics and aviation are now so inextricably interwoven that airliners could hardly be operated without electronic assistance, and military aircraft would be unrecognizably different.

Wireless World has always reflected this use of electronics, beginning with the wireless sets used for gunnery spotting in 1916, reporting Lorenz instrument landing systems in 1935, gathering a whole mass of newly released radar information immediately post-war and continuing to report on air communication and navigation when the information is "of use and interest" to readers.

Our two enduring interests over the years have been radio and television broadcasting and reception, and the high-quality reproduction of sound. A great many of the leading figures in high fidelity have written in *WW*, and continue to do so, on theory and practice – an aspect perhaps best demonstrated by the publication of designs for D. T. N. Williamson's valve amplifier just after World War II, which set a standard to judge the rest by. People still write in to ask for reprints of these articles.

The Williamson standard was and is upheld by writers such as Jack Dinsdale, Arthur Bailey, Laurie Nelson-Jones, John Linsley Hood and many others on the practical side of our content, and contributors of the calibre of Peter Baxandall, Professor David Bell, Thomas Roddam and the immortal Marcus Scroggie (Cathode Ray) have educated thousands of readers in the art of electronics.

Coverage of television began with Baird's first crude experiments, although the tone of some of our reports was a little bemused. It reached peaks in 1947 and 1968 with the publication of one of the first designs for a home-constructed monochrome television receiver (deflection yoke and line-output transformer both being home made) and the colour receiver by Walter Cocking, who made an enormous contribution to the standard of our practical articles over many years. The two receiver designs illustrated some of the reasoning behind *WW* projects, in that they were not necessarily the cheapest way of acquiring the receiver, or whatever was being built. One of the reasons for publishing them was that such a series of articles is undeniably the best way of explaining the operation of equipment. Even if one does not undertake the construction, the text is valuable in its own right.

In those days, of course, there were no integrated circuits. Circuit design was not the cost-effective deployment of the vast range of modules one can now select from, but the basic design that still goes on behind closed doors, its outcome being encapsulated in plastic. Integrated circuits have brought with them enormous opportunities for technical progress, but an unfortunate effect from a journal's point of view is that an article describing a piece of digital equipment often reads a little like a knitting pattern. It is not as easy as it used to be to read such articles in isolation.

Nevertheless, we have no intention of abandoning the ground rules laid down 70 years ago, that *Wireless World* should entertain, educate and be of use to the new generation, as well as their elders. It is doubtful that G. Marconi would recognize his grown-up brainchild, but we do hope he would approve. □

Designing with microprocessors

7 – Wait/go systems

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

Previous articles have described the synchronization problem and the most widely used solution involving software wait loops. In this article the wait/go concept is explained and step-by-step procedures for the design and implementation of wait/go systems are described. The design steps are illustrated by means of a fully worked out example.

The synchronization problem of microprocessors and the most widely used solution involving software wait loops have been described in previous articles. In this article we shall describe a hardware solution which involves keeping the microprocessor in animated suspension while the peripheral is responding. Systems using this solution are easy to design, program, implement and maintain.

The wait/go concept

Let us assume that we have a microprocessor which automatically enters the wait state when an i/o instruction is being executed. Let us further assume that when in the wait state it generates a logic 1 on wait terminal w, and that it exits the wait state when the signal on go terminal is pulled high (g:=1). The block diagram and state diagram of such a microprocessor are shown in Figs. 1 and 2. If we were to activate the peripheral with the 0 to 1 transition of the wait signal w and keep the microprocessor in the wait state until the peripheral had fully responded, we would clearly have no synchronization problems. Furthermore, if the peripheral is an action-/status device[1], the interface reduces to two wires, as we show next.

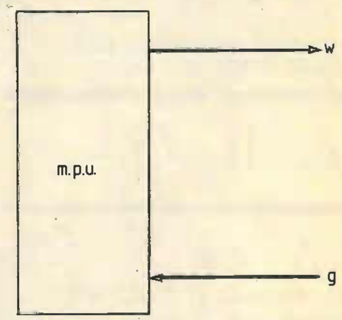


Fig. 1. Block diagram of a wait/go microprocessor.

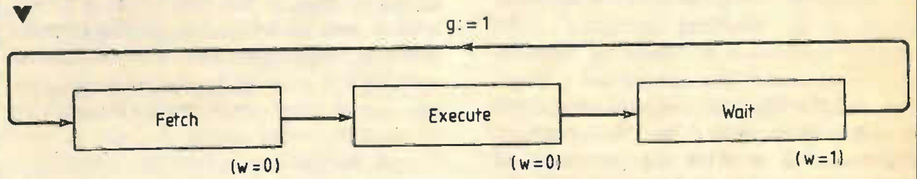


Fig. 2. State diagram of a wait/go cycle.

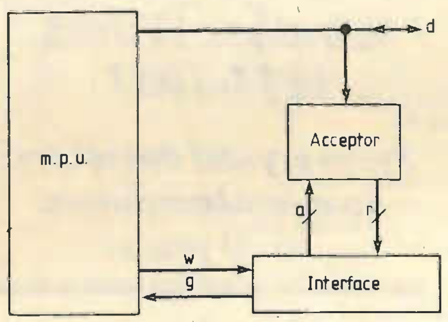


Fig. 3. Block diagram of a wait/go system.

The two-wire interface

Our starting point is the block diagram of a wait/go system shown in Fig. 3. The signals w, g, a and r have the following meaning:

Signal w: A '1' on this terminal (the wait line) indicates that the microprocessor has entered the wait state.

Signal g: A signal transition from 0 to 1 on this terminal (the go line) puts the microprocessor out of the wait state.

Signal a: A signal transition from 0 to 1 on this line triggers the peripheral into action.

Signal r: While the peripheral is responding r=0. When the peripheral has fully responded r changes to 1. No activation is possible when r=0.

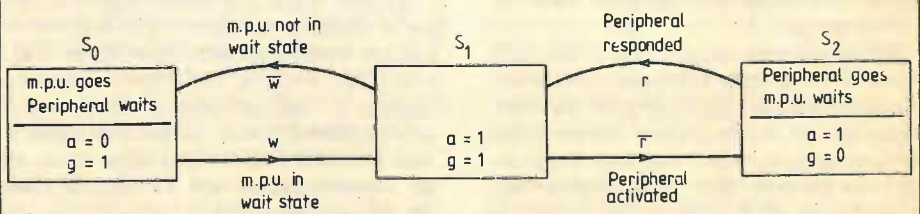


Fig. 4. Internal state diagram of a wait/go interface.

wr	00	01	11	10
S_0		(S_0) a,g = 0,1	S_1 Ø,1	
S_1		S_0 Ø,1	(S_1) 1,1	S_2 1,Ø
S_2			S_1 1,Ø	(S_2) 1,0

(a)

wr	00	01	11	10
S_{012}	[S_{012}] Ø,Ø = 0,0	[S_{012}] a,g = 0,1	[S_{012}] 1,1	[S_{012}] 1,0

(b)

Fig. 5. State tables of the wait/go interface in Fig. 4.

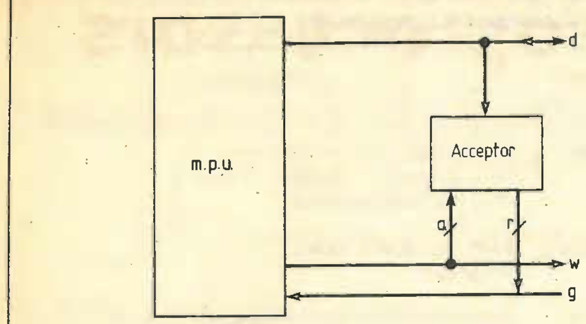


Fig. 6. The two-wire wait/go interface.

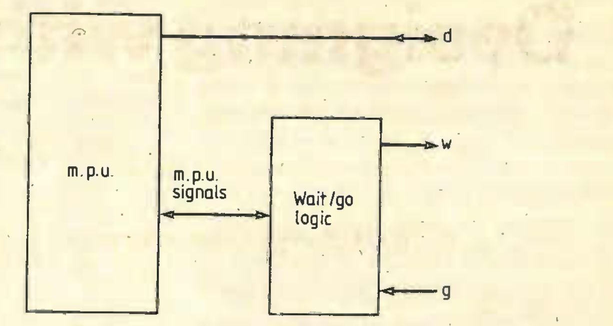


Fig. 7. Block diagram of the wait/go logic.

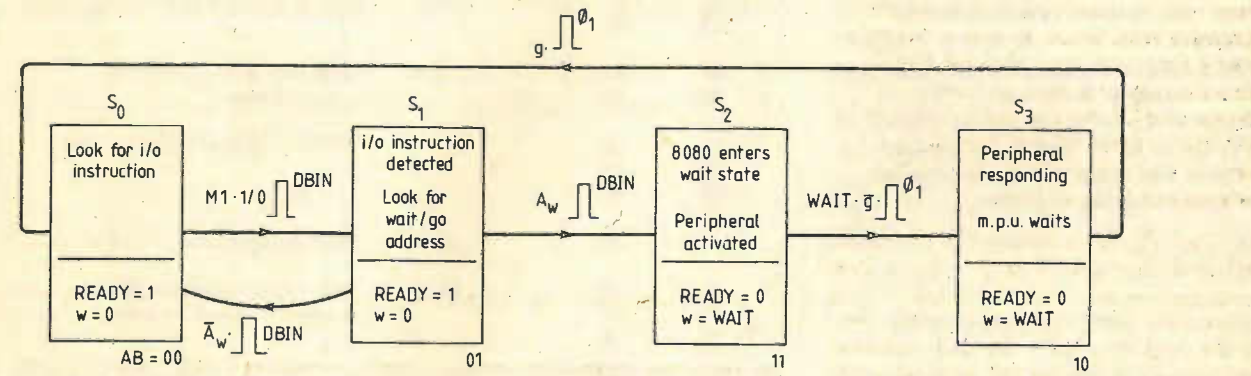


Fig. 8. State diagram of the wait/go logic for the Intel 8080.

A suitable internal-state diagram of a circuit to implement the above interface is shown in Fig. 4. Applying the reduction steps to its equivalent state table in Fig. 5 (a) allows its three rows to merge into one, as shown in Fig. 5 (b).

By direct reference to the reduced state table, we obtain the following equations

$$a=wr+w\bar{r}+(\bar{w}\bar{r})=w$$
$$g=\bar{w}r+wr+(\bar{w}\bar{r})=r$$

The corresponding circuit implementation consisting of two wires is shown in Fig. 6.

Advantages

Wait/go systems are:

Easy to understand. The 'wait' and 'go' are everyday concepts, not requiring specialist knowledge.

Easy to design. The hardware is straightforward and presents no difficulty. Specifically, in the case of action/status devices it consists of two wires.

Easy to implement – because of uncomplicated hardware.

Easy to program. Software overheads are minimal.

Easy to maintain – because of their reliability.

Wait/go logic

Although present-day microprocessors are not designed to operate in the wait/go mode, they can be made to do so by means of a relatively simple logic circuit, the **wait/go logic,** the block diagram of which is shown in Fig. 7. Its function is to look for i/o instructions with wait/go addresses, denoted by A_w, and to put the microprocessor automatically into a wait state when such an instruction is detected. At this point it passes exit control to the go terminal, that is to the outside world.

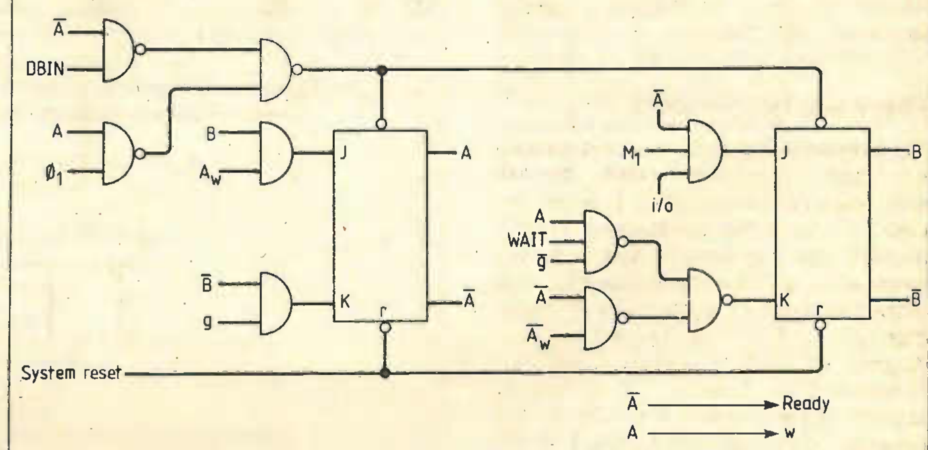


Fig. 9. Circuit implementation of the wait/go logic for the Intel 8080.

The design and implementation of wait/go logic is straightforward, as we demonstrate by means of the following example.

Wait/go logic for the Intel 8080

The m.p.u. signals of the Intel 8080 were described in the first article (May 1980 issue). Reference to these signals shows that the op code and i/o address are loaded into the m.p.u. registers in timeslots M1·DBIN and the following DBIN respectively. It follows that we can identify an i/o instruction by simply determining whether the signals on the data bus in time slot M1·DBIN are 11010011 or not – 11011011 and 1101011 are the op codes for IN and OUT[2]. Similarly, the wait/go addresses are identified by looking at the data bus with the following DBIN signal. A suitable state diagram is shown in Fig. 8.

By direct reference to it, we obtain

$S_A = S1 \cdot A_w$
$= A \cdot B \cdot A_w$ therefore, $J_A = B \cdot A_w$
$R_A = S3 \cdot g$
$= A \cdot \bar{B} \cdot g$ therefore, $K_A = \bar{B} \cdot g$
$S_B = S0 \cdot M1 \cdot I/0$
$= \bar{A} \cdot \bar{B} \cdot M1 \cdot I/0$
therefore, $J_B = \bar{A} \cdot M1 \cdot I/0$
$R_B = S1 \cdot \bar{A}_w + S2 \cdot WAIT \cdot g$
$= A{\cdot}B \cdot \bar{A}_w + A \cdot B \cdot WAIT \cdot g$
therefore, $K_B = \bar{A} \cdot \bar{A}_w + A \cdot WAIT \cdot g$
$Clock = (S0+S1) \cdot DBIN + (S2+S3) \cdot \phi 1$
$= (\bar{A} \cdot \bar{B} + \bar{A} \cdot B) \cdot DBIN + (A \cdot B + A \cdot \bar{B})\phi 1 = \bar{A} \cdot DBIN + A \cdot \phi 1$
$Ready = S0+S1$
$= \bar{A}\bar{B}+\bar{A}B = \bar{A}$
$w = S2+S3$
$= AB+A\bar{B}$
$= A$

The corresponding circuit implementation is shown in Fig. 9.

A design problem: PRINT

The problem is to design and implement a wait/go system that would allow the programmer to produce a hard copy of data, which is stored in consecutive memory locations.

Solution

As explained in the previous article the first three design steps are independent of the microprocessor and therefore common to both solutions.

Step 1: aim of the design. The aim of the design is to expose the reader to wait/go systems.

Step 2: device characteristics. As specified.

Step 3: system design. The block diagram of our solution is shown in Fig. 10. Its step-by-step operation is flowcharted in Fig. 11. As in the case of the test-and-skip solution described in the previous article, we shall use index addressing. Addressing modes were described in Part 3 in the August issue.

Table 1: Hex listing of the PRINT problem when implemented using the wait/go mode and the Motorola 6800.

Hex address	Hex listing	Mnemonics	Comments
0300	CE	LDX	Load index register with line
01	20		40 on page 20 – location of the
02	40		first byte to be printed.
03	86	LDAA	Load acc. A with block
04	n		length (n)
05	97	STAA	Copy acc. A (n) into memory
06	20		location (line 10 on page 20)
07	10		to be used as a counter
M1: 08	27	BEQ	Branch to M2, if n=0 – forward 11
09	0B		
0A	A6	LDAA	Copy into acc. B next byte
0B	00		to be printed
0C	B7	STAA	PRINT – printer address 1000
0D	10		
0E	0D		
0F	08	INX	Point to next byte
10	7A	DEC	Decrement byte count (held)
11	20		in memory location 2010)
12	10		
13	20	BRA	Branch to M1 – back 13
14	F3		
M2: 15	3E	WA1	Stop

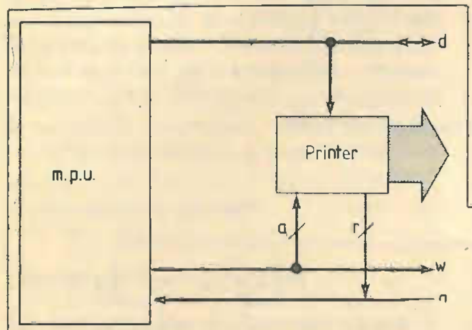


Fig. 10. Block diagram of the PRINT problem.

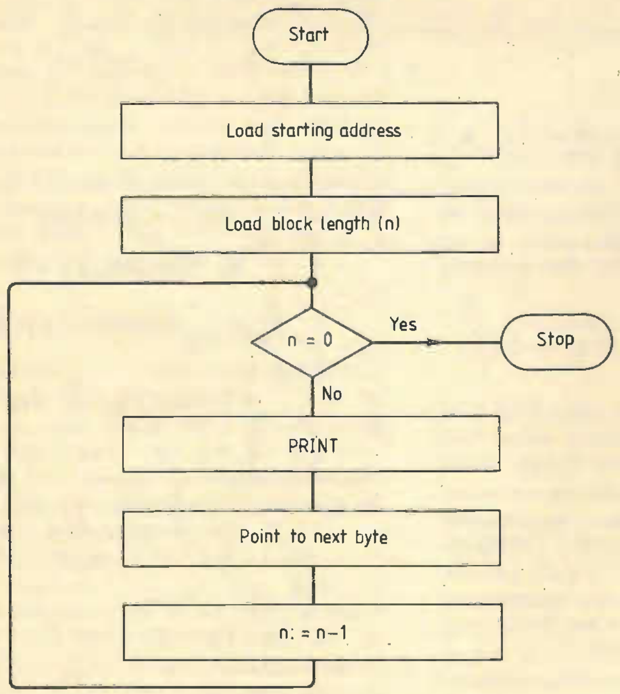


Fig. 11. Step-by-step operation of a wait/go system used to PRINT.

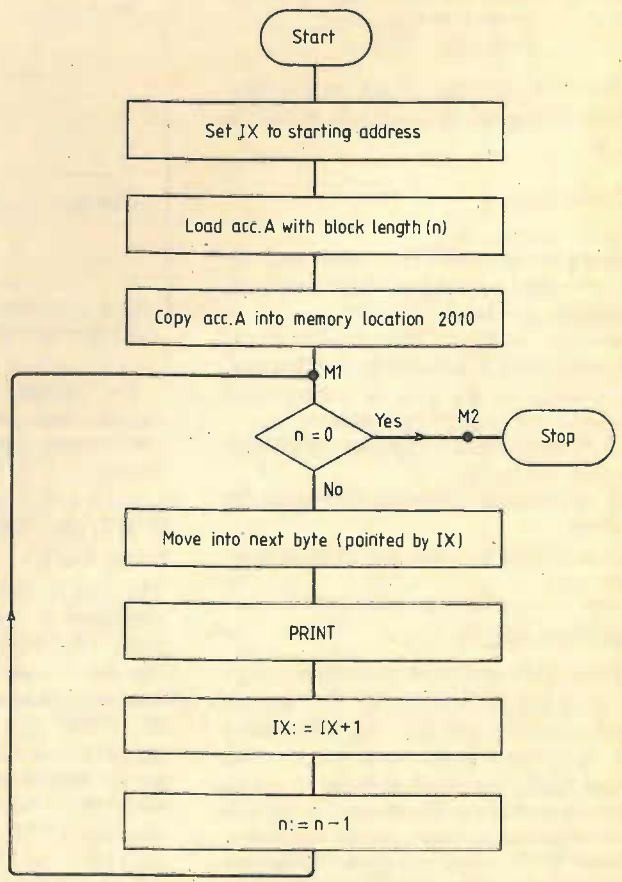


Fig. 13. Programming chart of the PRINT problem using wait/go and the M6800.

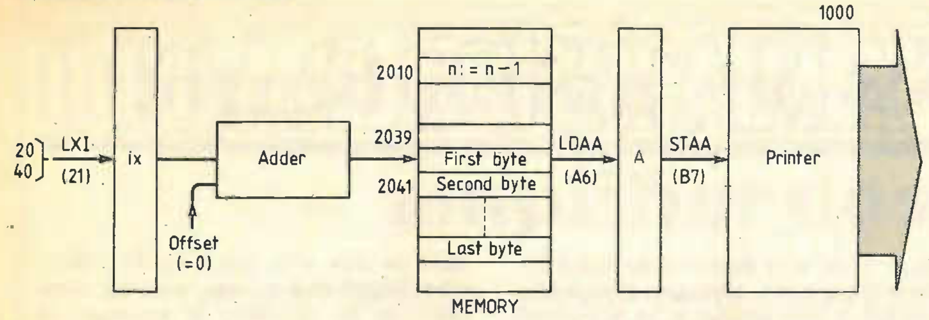


Fig. 12. Programming model for the PRINT problem using the M6800.

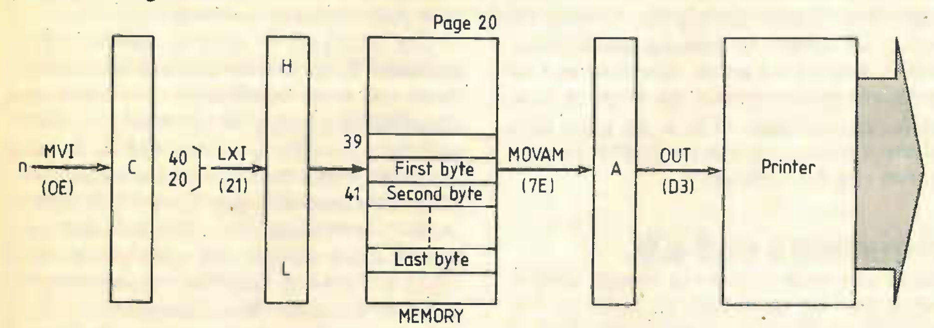


Fig. 14. Programming model for the PRINT problem using the Intel 8080.

Table 2: Hex listing of the PRINT problem when implemented using the wait/go mode and the Intel 8080.

Hex address	Hex listing	Mnemonics	Comments
1000	21	LX1 HL	Set memory pointer to line
01	40		40 on page 20 – location of
02	20		the first byte to be printed
03	0E	MV1 C	Load register C with block
04	n		length (n)
05	0C	INRC	Increment C-sets flags
L2: 06	0D	DCRC	Decrement C
07	CA	JZ	Jump to L1, if n = 0 – that is if the
08	11		zero flag is set
09	10		
0A	7E	MOV A,M	Move into A next byte to be printed
0B	D3	OUT	PRINT
0C	06		
0D	23	INX H	Point to next byte in the block
0E	C3	JMP	Go to L2
0F	06		
10	10		
L1:11	76	HLT	Stop

Demetrius Zissos is Professor of Computer Science and Adjunct Professor of Electrical Engineering at the University of Calgary, Canada. Educated in Britain, he has been associated with industry on both sides of the Atlantic for the past twenty years. He has written five books and numerous articles, including a series (with Brian Holdsworth) on logic design in Wireless World. He is currently writing two further books, one on logic design and the other on distributed systems.

6800 Solution

Step 4: hardware design. No interface hardware is required.

Step 5: software design. Our programming model and programming flowchart are shown in Figs. 12 and 13. Memory location 10 on page 20 is used as a counter and the first byte is stored in line 40 of the same page. Note that the programming model is the same as the one used for test-and-skip systems.

By direct reference to our programming model and to the M6800 instruction set[3], reproduced in Part 4 (September issue), we obtain the hex listing of our wait/go software – see Table 1.

8080 Solution

Step 4: hardware design. As in the case of the 6800, no hardware is required.

Step 5: software design. Our programming model in the case of the Intel 8080 and programming flowchart are shown in Figs. 14 and 15. An m.p.u. register is assumed to be available for use as a counter. The first byte is stored in line 40 of page 20 in memory.

By direct reference to our programming model in Fig. 10 and to the Intel 8080's instruction set reproduced in the previous article, we derive the hex listing of our wait/go software. It is shown in Table 2.

References

1. Zissos, D., "System Design with Microprocessors", Academic Press, 1980.
2. Intel 8080 Microprocessor User's Manual, September 1975.
3. M6800 Microprocessor User's Manual, Motorola, 1976.

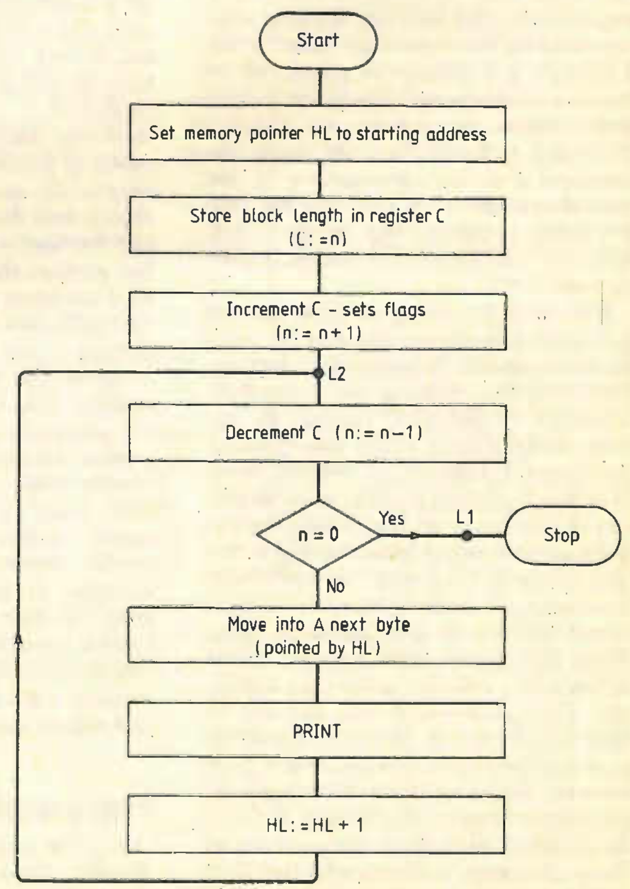


Fig. 15. Programming chart of the PRINT problem using wait/go and the Intel 8080.

WORLD OF AMATEUR RADIO

The earth-less vertical

In one of his series of classic papers on transmitting aerials, Dr George Brown of RCA (*Proc IRE*, June 1937) analysed the efficiency of monopole radiators in terms of their use with 0.4λ buried radials, showing that typically an efficiency of up to 88 per cent can be achieved with 113 radials, reducing to only 12.4 per cent with just two radials. It is on this work that amateur use of the popular "ground plane" and "vertical" aerials has largely been based for over 40 years, while the standard medium-wave broadcast aerial still tends to use 72, 120 or even 144 radials buried a couple of feet below the surface of the earth by means of mole ploughs, resulting in radiation efficiencies of the order of 75 to 90 per cent. More and more, in recent years, amateurs using verticals on 7MHz and below have been persuaded that an extensive earthing system or "mat" is a vital essential. Since such an earthing system cannot be fitted into the average garden, the h.f. monopole is generally accepted as not providing the sort of performance at long-distances of which it should be theoretically capable.

Recently, Leslie Moxon, G6XN, who has built up a considerable reputation for tilting at the many myths that are part of the "aerial lore" of many amateurs (and professionals), has been investigating what one could call the "cult of the radial" to see if effective h.f. directional arrays can be based on quarter-wave radiators at ground level without the use of any physical connection to earth. In doing so he has paralleled a similar investigation by the Australian amateur VK3AM who has been developing compact but efficient h.f. aerials for use in confined spaces, including small boats.

This work is tending to show that, in fact, good efficiency is possible by using the once-popular "counterpoise" arrangement, but that this can be successfully shortened by inductive loading. In one form, G6XN is using with a base-insulated quarter-wave radiator, a 14MHz counterpoise a few inches above ground, consisting of a 7ft length of dural tubing parallel to the ground, with a linear loading inductance of about 11ft of wire. Such monopole (or dipole?) elements can be readily used as driven elements or as reflectors or directors (a two-element array however should be based on a reflector rather than a director). The counterpoise rods can also be used effectively to increase capacitive coupling between the array elements. Such elements can be easily moved to prepared positions to change the direction of fire of the array and taken down when not in use. The performance of an array formed from such elements would appear to be equivalent to those of a similar array using an extensive earth mat, although, as might be expected, a little inferior to an equivalent horizontal array at moderate height. The vertical array, however, has many advantages of cost and convenience since it requires no tower, no rotating mechanisms and is not a permanent structure and so presumably falls outside the scope of local authority planning, while at the same time offering plenty of scope for further investigation and development.

Amateurs and c.b.

More and more it looks as though British amateurs will soon have to learn to live with, even if some of them may find it difficult to love, c.b. or Open Channel on frequencies additional to the proposed 928MHz. Indeed by the time these notes appear the die may well have been cast, although the package is likely to be so wrapped as to absolve the Home Office from any suggestion that they have been forced into making a "U-turn". But it is much to be hoped that amateurs will not allow themselves to be provoked into open hostility. Some of the common complaints made by some amateurs against c.b. could easily be represented as "sour grapes". For example, that amateurs always have to pay for licences, pass examinations, adhere to tight regulations, keep accurate logs etc, etc, so why should so many people have been allowed to "get away" with 27MHz operation? . . . . and that sort of thing. But there are other, more seriously abrasive, causes of friction. Amateurs fear they will have to take the blame for interference and abuses since the media often fail to distinguish between c.b. operators and "hams". But perhaps the most serious problem of all is that many of the thousands of 27MHz c.b. units now being used in the UK will operate – and indeed often are operated – within the internationally "exclusive" amateur band 28 to 29.7MHz. Since most c.b. units are channelised it is possible that some of this intrusion is accidental, though in other cases it appears to be quite deliberate. Since the c.b. operators make no attempt to abide by "band-planning" or similar conventions, amateurs in many countries are seeing a virtual take-over of parts of their band. Unlike the radio control modellers they are not being offered alternative frequencies! C.b. enthusiasts would be well advised to play it cool and not stray above 28MHz.

Here and there

Australian amateurs are now permitted to handle "third party traffic" subject to three main exceptions. International traffic must be only with countries that themselves permit such message handling; there must be no question of payment or material compensation, either tangible or intangible, direct or indirect; and no business traffic must be involved.

The problems of electromagnetic compatibility become ever more complex as more and more interference-producing or interference-susceptible electronics comes into use: interference from and to home computers and microprocessor-based appliances; automobile electronics; switched-mode power units (even the common or garden diode rectifier can emit hash); virtually all forms of electronics for entertainment or business. American amateurs are reporting yet another growing problem: transmitters causing false triggering of "smoke detector" alarms The r.f. can be mains-borne and gets into the detector units unless protected by suitable r.f. bypassing. This requires care if the capacitors are not to interfere with the operation of the units.

An increasing problem for mobile operators, particularly since the public interest in c.b., has been the widespread theft of radio equipment from unattended vehicles. Most weeks, amateurs report the loss of several expensive transceivers (presumably when 27MHz units are stolen the illegal operators are reluctant to report the loss to the police). Recently, the West London 144 MHz repeater equipment of the UK FM Group was stolen and the Group has since taken out insurance on its other repeaters.

In brief

The G-QRP club, founded in 1975 to encourage interest in low-power operation, now has more than 1000 members in 24 countries, including over 200 in the USA the traditional home of the "Californian Kilowatt" . . . . The Radio Amateurs Invalid and Blind Club now has a membership of over 600, including more than 300 licensed amateurs . . . . PY2AA is the callsign of a new 50.055MHz beacon transmitter, with 25 watts power, located at Sao Paulo, Brazil. A South African multi-band beacon, ZS5VHF transmits on 28.2025, 50.005 and 144.925 MHz, the 28 MHz signals have been received well in the U.K. . . . The British Amateur Television Club has just published an all-new "Amateur Television Handbook" with over 100 pages devoted to practical and up-to-date designs of amateur television equipment (Non-members £1.50 plus 35p postage from BATC Publications, 14 Lilac Avenue, Leicester LE5 1FN.).

PAT HAWKER, G3VA

Introduction to low-noise amplifier design

How to optimize collector current and calculate noise figure

by A. Foord

Many constructors still settle for more noise in their amplifiers than necessary because of the complexity of a full mathematical treatment and because manufacturers often fail to specify their transistor parameters in a convenient form. This article shows how to calculate the optimum collector current for a given source resistance and the minimum noise figure at that current, and gives practical circuits for instrumentation use and sound reproduction.

Once the basic design requirement of optimum collector current has been satisfied, the remaining amplifier parameters can be determined from the normal design relationships. For example, as the noise figure is independent of the transistor configuration and overall feedback, the usual feedback pair arrangements are practicable. Therefore the transistor and its operating point can be selected to meet the circuit noise requirements and the configuration or feedback can be determined to meet gain, bandwidth and impedance requirements. This approach allows the noise and other circuit constraints to be optimized independently.

The selection of a suitable input device depends mainly on the source resistance and bandwidth requirements. At the lowest values of source resistance it is necessary to use transformer coupling at the input to match the source resistance to the optimum for the amplifier, Fig. 1. Unfortunately transformers introduce extra losses and degrade the basic noise figure of the amplifier. For example, an amplifier designed for a 5kohm source might have a noise figure of less than 1dB. When matched with a transformer to a 30 ohms dynamic microphone this noise figure could be degraded to 2.7dB.

If integrated circuits are used their parameters are well specified by the manufacturer, but their noise levels are in general about two to five times that of a discrete transistor circuit. This makes them more suitable as second and succeeding stages. Fortunately bipolar transistors can be used for most audio front-end applications and this article is restricted to their use.

There is a slight difference between p-n-p and n-p-n transistors. A p-n-p transistor can have a lower base spreading resistance due to a higher carrier mobility in its base

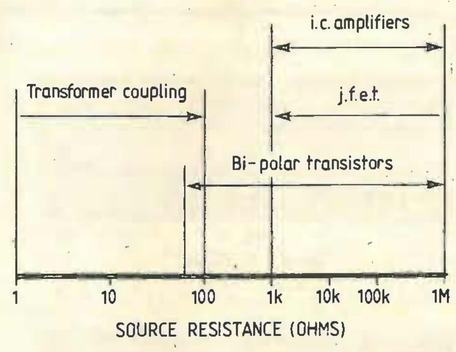


Fig. 1. Choice of input amplifying device depends on source resistance.

region, while an n-p-n transistor often has a slightly larger current gain and bandwidth. This makes the p-n-p type more useful with low source resistances, with the n-p-n transistor useful at the higher end of the resistance range. For this reason, and also for direct coupled circuits, it is desirable to have information on a range of p-n-p and n-p-n devices.

A table of suitable low-noise transistors and their parameters is shown in Table 1. These are measured values and may not agree with those obtained from the manufacturers' specification sheets. Details of some low-noise i.cs are included for comparison.

Some noise mechanisms are process-dependent and result from faults such as surface defects, surface contamination, defective contacts, impurities, dislocations, and irregularities at the base-emitter junction. For this reason transistors with the same type number may vary from maker to maker. This is particularly true for low frequency noise below 1kHz where poor processing techniques become more apparent.

Any source unavoidably generates an amount of thermal noise power which depends on its temperature, Boltzmann's constant, and the system's noise bandwidth. Noise factor, as a ratio, is defined as

$$F = \frac{\text{total available output noise power}}{\text{portion of output power caused by source only}}$$

Noise figure is simply this noise factor expressed in decibels. NF =

$$10 \log \frac{\text{total available output noise power}}{\text{portion of output power caused by source only}}$$

or $NF = 10 \log F$. The noise figure is a measure of the signal-to-noise degradation attributed to the amplifier. For a perfect

Table 1. Measured values of low-noise device parameters may not agree with manufacturers data

		β at I_c of 1mA	100μA	10μA	$r_{bb'}$ (Ω)	Application
2N930	n-p-n	300	200	130	700	High source resistance
2N4124	n-p-n	300	200	110	100	Low source resistance
BC109	n-p-n	350	300	200	400	General purpose
2N3707	n-p-n	350	250	200	200	General purpose
2N4403	p-n-p	200	140	80	40	Low source resistance
2N4125	p-n-p	150	120	90	50	Low source resistance
2N3964	p-n-p	350	310	260	150	Low broadband noise
2N4250	p-n-p	350	310	260	150	Low broadband noise

IC type	V_n (nV/Hz$^{1/2}$)	I_n (pA/Hz$^{1/2}$)	R_s (kΩ)	f (Hz)	NF at R_s (dB)
TDA1034N	9.0	3.0	3.00	10	6.41
	3.5	0.4	8.75	1k	0.70
RM4739	20.0	4.0	5.00	10	10.41
	10.0	0.5	20.00	1k	2.11
LM201A	22.0	0.74	29.73	10	4.82
	16.0	0.20	80.00	1k	1.46
OP10EY	10.3	0.32	32.19	10	1.50
	9.6	0.12	80.00	1k	0.58
AD517	35.0	0.05	700	10	0.86
	20.0	0.03	667	1k	0.31
ZN460	0.8	1.0	0.800	5k	0.41

amplifier, one which adds no extra noise to the thermal noise of the source, the noise factor is unity, and the noise figure zero. Usually there is not a great deal of value in reducing the noise figure much below 3dB. A noise figure of 3dB is equivalent to saying that the amplifier and source are contributing an equal amount of noise to the wanted signal. Even if the amplifier noise could be reduced to 0.1 of the source noise, the total system noise is now about 0.7 of the 3dB condition. However it must be remembered that an amplifier with a noise figure of 0.5dB at 1kHz with a source resistance of 5kΩ will have a higher figure at low frequencies and at source resistances away from the optimum.

The normal procedure is to design the amplifier for a minimum noise figure at the desired source resistance. The optimum collector current for the transistor depends on the driving source resistance R_s and the direct current gain β.

Optimum collector current

$$I_c=\frac{(\beta)^{1/2}}{40R_s}$$

For example, determine the optimum current for a 2N4403 transistor with a source resistance of 400 ohms. Initially β can be taken as 200.

$$I_c=\frac{(200)^{1/2}}{40\times400}=0.88\text{mA}.$$

As shown in Table 1 a β of 200 at 0.88mA is possible. If the formula had given a much lower optimum collector current, say 50μA, then the β would have to be reduced to about 100 and the optimum collector current recalculated. This procedure is repeated if necessary until the β is believable for the calculated collector current.

The procedure is not too critical because of the wide variations in β between one transistor and the next and because the optimum collector current is proportional to the square root of β.

The minimum noise factor F at the optimum collector current can be calculated from the source resistance R_s, the current gain β, and the intrinsic base spreading resistance $r_{bb'}$

$$F=1+\frac{r_{bb'}}{R_s}+\left(\frac{1}{\beta}\right)^{1/2}$$

For the conditions previously discussed for the 2N4403 transistor

$$F=1+\frac{40}{400}+\left(\frac{1}{200}\right)^{1/2}=1.17\text{ times}$$

Then the minimum noise figure is

$$NF=10\log F=10\log 1.17=0.68\text{dB}.$$

Microphone preamplifier example

Many dynamic microphones have impedances of 200 or 600 ohms. The previous examples suggest that a 2N4403 transistor run at a collector current of about 1mA could be used for this application, and a suitable circuit is shown in Fig. 2.

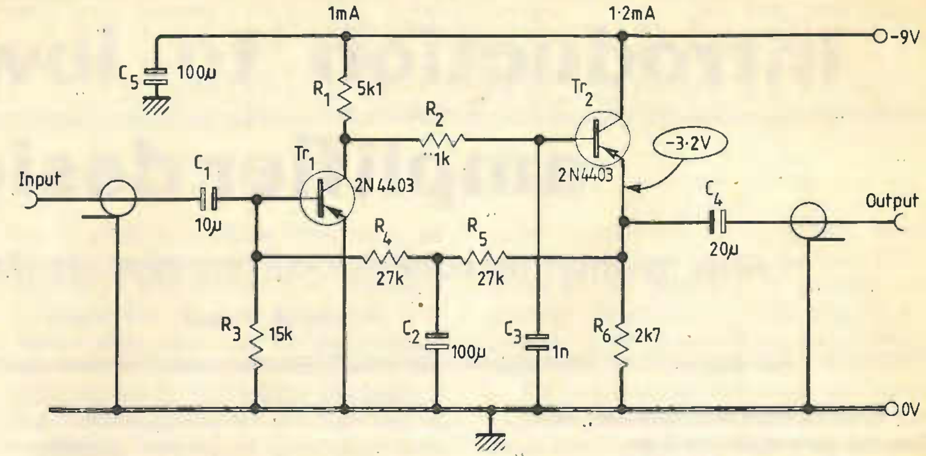


Fig. 2. Instrumentation preamplifier is suitable for microphone use.

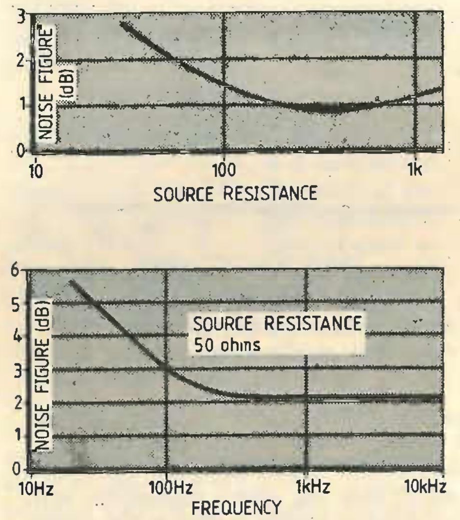


Fig. 3. Noise figure plotted against source resistance for the microphone preamplifier (top), and against frequency (bottom).

A common-emitter amplifier is followed by an emitter follower. The dc conditions are determined by the bias chain from Tr_2 emitter to Tr_1 base, but this does not provide negative feedback at signal frequencies because of C_2. The low frequency response is determined mainly by the input and output coupling capacitors at 10Hz, while the high frequency response is determined by C_3 at 26kHz. If C_3 is not included the high frequency response would extend to 1MHz, which is undesirable.

The first transistor is essentially an unloaded common-emitter stage, and its gain at room temperature is

$$\frac{V_o}{V_i}\approx40R_1I_c=204\text{ times or 46dB.}$$

Measured results on two amplifiers gave gains within 1dB of the calculated value. The input resistance was 2.7k ohms. As

Table 2. Comparison of several transistors for a 6kohm source.

	β	I_c (μA)	$r_{bb'}$ (Ω)	F	NF
2N930	150	51	700	1.198	0.79
2N4124	150	51	100	1.098	0.41
BC109	250	65.9	400	1.130	0.53
2N3707	220	61.8	200	1.101	0.42
2N4403	100	41.7	40	1.107	0.44
2N4125	100	41.7	50	1.108	0.45
2N3964	280	69.7	150	1.085	0.35
2N4250	280	69.7	150	1.085	0.35

Tr_1 has a high gain the noise contribution by Tr_2 is negligible. Fig. 3 shows the noise figure plotted against the source resistance, while Fig. 4 shows the noise figure plotted against frequency for a fixed source resistance; in this case the non-optimum value of 50 ohms.

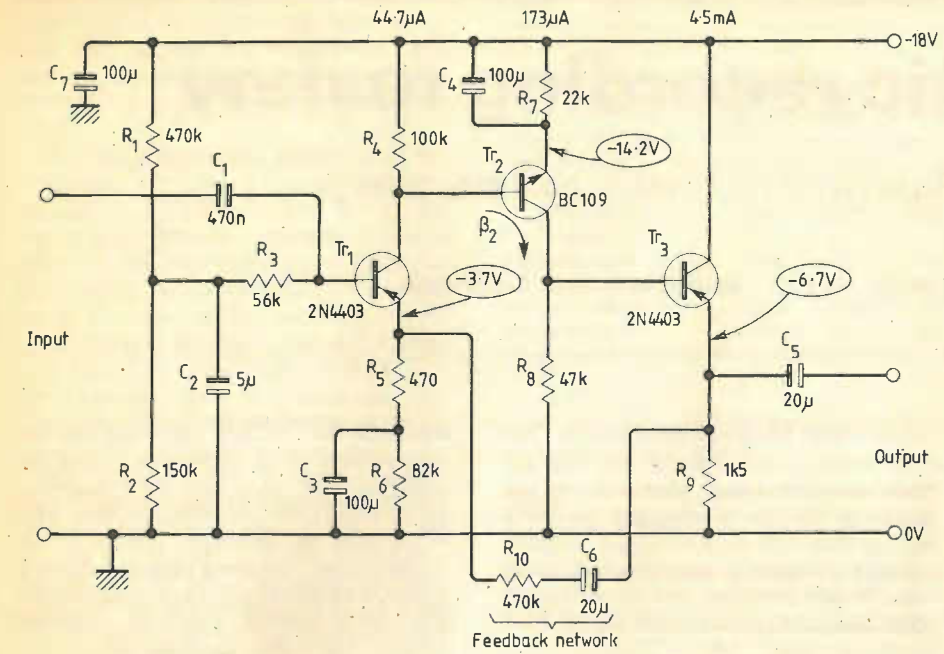
These results confirm the theory, and show that the 2N4403 transistor is particularly suitable for both low source resistances and low frequency applications where noise is important.

Measurements on several 2N4403 transistors suggested that about one quarter of them had excess noise at low frequencies, but mid-frequency results were consistently low. For critical applications the amplifier input should be terminated with a 390-ohm wirewound resistor and Tr_1 selected for a minimum amount of noise. This noise can be measured at the output of the amplifier chain with an oscilloscope or a.c. voltmeter. An oscilloscope is particularly valuable because any low frequency or burst noise can be observed. If the preamp does not dominate the noise generated from succeeding stages (with the gain control at a maximum) then these stages need to be examined!

The full design of a general-purpose audio preamplifier can be quite a problem, and a magnetic pickup may be the most difficult source to match. Its impedance rises with frequency, the amplifier has an equalization curve which gives 20dB boost below 50Hz and 20dB cut at 20kHz, and the basic amplifier noise may be increasing at low frequencies.

The theoretically correct approach is to allow for all these factors and design for the lowest total noise over the complete audio bandwidth. This really demands an exact model for the circuit and a good computer program. In practice a reasonable answer can be obtained by designing for a source impedance of about 6k ohm.

In Table 2 several transistors are compared for this source impedance. All of these transistors appear to be suitable,



apart from the 2N930. The 2N4403 transistor has been chosen for the practical circuit, and the examples.

$$I_c=\frac{(\beta)^{1/2}}{40R_s}=\frac{(100)^{1/2}}{40\times6\times10^3}=41.7\mu\text{A}$$

$$F=1+\frac{40}{6000}+\left(\frac{1}{100}\right)^{1/2}=1.107$$

$$NF=10\log 1.107=0.44\text{dB}$$

One practical circuit might be similar to that shown in Fig. 5, where two common-emitter stages are followed by a common collector stage to drive the feedback network and the next stage. When Tr_1 is biased from a potential divider as shown, the only bias component which contributes noise is R_3. The actual voltage drop across R_3 is small and therefore any excess noise generated by the resistor, due to the current flowing through it, is also small. The amount of thermal noise it generates is attenuated by the source. The value shown will provide the load resistance required for most magnetic cartridges, and can be shunted if necessary for other inputs.

The approximate open-loop gain for this type of circuit is

$$\frac{\beta_2R_8}{R_5+\frac{1}{40I_{c1}}}=\frac{320\times47\times10^3}{470+\frac{1}{40\times44.7\times10^{-6}}}$$

$$=14{,}600\text{ times}=83\text{dB}.$$

A practical measurement of this circuit gave an open-loop gain of 80dB, which is perhaps more realistic.

Unlike the first circuit, where the gain was well defined by the collector current, the gain of this circuit depends on the β of the second transistor. Overall negative feedback is therefore essential to accurately define the closed-loop gain. In Fig. 5 the closed-loop gain is 60dB and the frequency response is 3dB down at 8Hz and 45kHz.

Fig. 4. Preamplifier as shown has flat frequency response; for use with magnetic pick-up replace feedback network with appropriate equalization network. Author recommends metal film or metal oxide resistors, as wirewound ones are bulky and expensive. Tantalum electrolytics are preferred over aluminium because of their lower leakage.

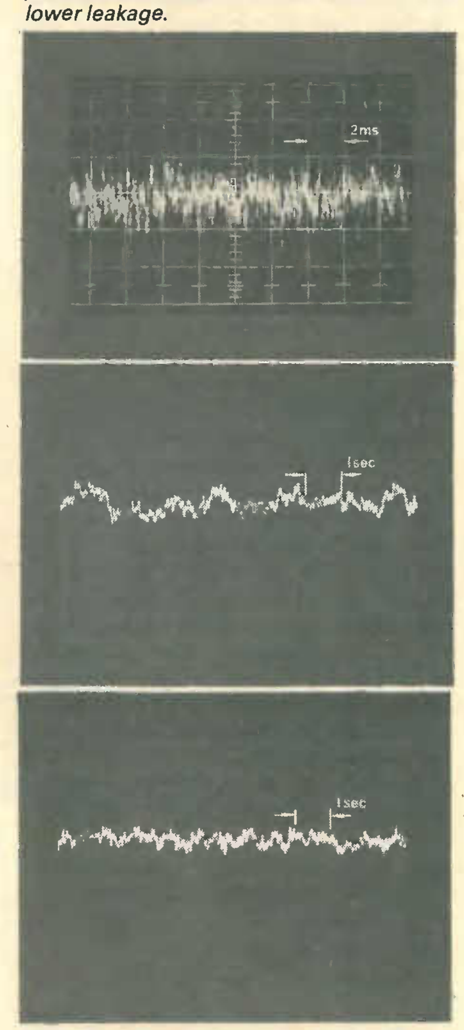


Fig. 6. Broadband noise from a 2N4403 transistor (top), low frequency noise from a poor 2N4403 transistor over 5 to 36Hz (middle), and low frequency noise from a typical 2N4403 transistor over 5 to 36Hz (bottom).

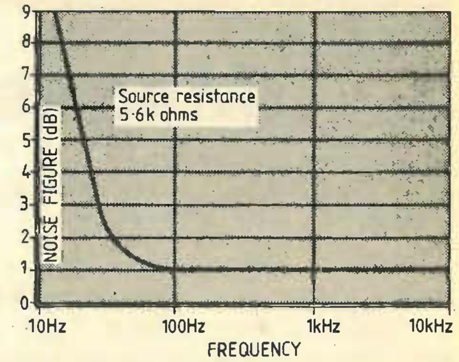


Fig. 5. Noise figure plotted against frequency for the general-purpose preamplifier of Fig. 4.

The closed-loop gain is defined at

$$G=1+\frac{R_{10}}{R_5}\text{ times.}$$

Resistor 5 is required so that the closed-loop gain can be defined by overall negative feedback. It also provides series local feedback for Tr_1 and reduces the open-loop gain by about 7dB. However the open-loop gain of 80dB which was measured is adequate to provide a reasonable amount of feedback at low frequencies even though the equalization curve demands a 20dB gain boost (below 50Hz) above the mid-band gain. The value of R_5 cannot be made too low as this will force a reduction in the feedback impedance, reducing the available output voltage swing at high frequencies where the equalization curve falls at 6dB per octave.

Although negative feedback does not alter the amplifier's noise figure, R_5 is effectively in series with the source and can contribute an amount of thermal noise, the effect of which depends on the source resistance. It should be made much smaller than the source resistance. Noise factor with R_5 is

$$F_r=F+\frac{R_5}{R_s}.$$

In the example

$$F_r=1.107+\frac{470}{6000}=1.185\text{ times}$$

thus $NF_r=10\log 1.185=0.74$dB.

Although this appears to be a significant degradation the resultant noise figure is still less than the 3dB level considered to be a reasonable value. It does indicate why an approach like Fig. 2 is valuable for critical applications, because the gain can be closely determined by the circuit parameters without using emitter degradation.

Further reading

Low-noise Electronic Design, by C. D. Motchenbacher and F. C. Fitchen (Wiley, 1973) gives many practical examples which are fully specified in terms of gain, bandwidth, and noise for up to four different values of passive components.

Magnetic recording review

2 – Performance of modern cassette tapes

by J. Moir, F.I.E.E., James Moir and Associates

Mr Moir continues his survey of magnetic recording technology and materials with an examination of modern cassette tapes. A brief look at possible future developments concludes the article.

Equalization

The limited frequency response of the early ferric coated tapes led to the extensive use of electronic equalization, a shaping of the frequency response of the record and replay amplifiers to improve both the frequency response and the s/n ratio. The correction required to achieve a flat overall record/replay response was divided between the record and replay system in a way that eliminated the need for variable equalization in the user's equipment. Standard replay calibration tapes were produced, having a closely specified response curve, and the recording engineer, having equalized his replay equipment to ensure that these standard tapes played with a flat frequency response, was required to vary the equalization of his recording system until the overall record/replay system response gave the same flat overall response.

However, the performance of tape coatings and our knowledge of record and replay head design has so far improved that the equalization originally specified is not only unnecessary but actually degrades the achieved performance of many of the recent types of tape.

The equalization to be applied to the system was specified indirectly as the relation between the signal voltage at the input of the recording chain and the resultant surface induction (now the short-circuit flux) on the tape. It was defined as the combination of two curves, one being the response of an RC circuit with a time constant of 1590 microseconds, defining the low-frequency performance, and a second RC circuit with a time constant of 120 microseconds defining the performance at frequencies above about 800Hz. The combined frequency response can be read from Fig. 9, using the appropriate curves. The low-frequency signal is boosted and the high-frequency signal attenuated in the recording process to minimize distortion arising from the limited signal handling capacity of magnetic tape at high frequencies. Table 1 provides data on the agreed correction curves for all the current standard tape speeds.

Table 1: Standard time constants

Tape Speeds	Time Constant t_1	t_2
76.2 cm/s (30in/sec) and 38.1 cm/s (15in/sec)	35	Infinity
19.05 cm/s (7½in/sec)	70	Infinity
9.53 cm/s (3¾in/sec)	90	3 180
4.76 cm/s (1⅞in/sec)	120	1 590

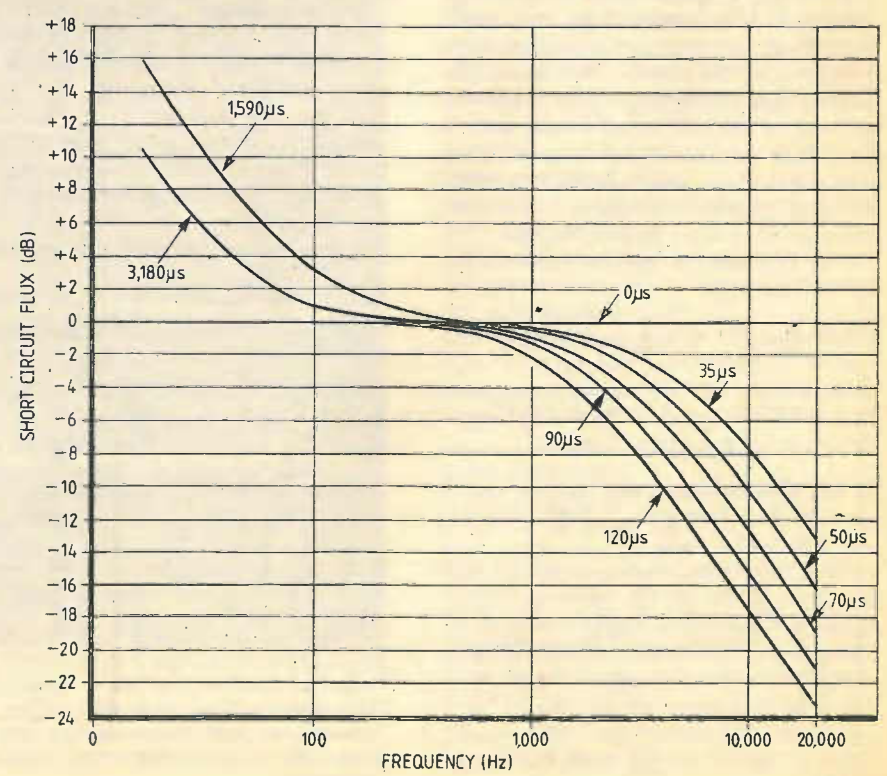
To obtain a flat overall record/replay response, the replay chain must have the inverse response, but to achieve this some additional high-frequency equalization must be included to compensate for the high-frequency losses in the replay head.

The standard replay calibration tapes are recorded with a carefully calibrated, surface short-circuit flux/frequency relation that follows the specified recording curve. When these tapes are used to obtain a flat replay system frequency response the losses in the replay system are automatically corrected and the desired flat response is obtained for the whole record/replay chain.

During the few years following the standardizing of the 120μs equalization, the high-frequency signal-handling capacity of tapes has been greatly improved and designers have taken advantage of this by changing the recommended recording equalization time from 120μs to 70μs. This necessitates an equivalent change in the replay system frequency response, usually achieved by providing two or three alternative switch-selected frequency response curves. The 120μs equalization curve is used for all the ferric tapes and some of the early chromium and cobalt modified tapes, the 70μs equalization curve being employed with the later chromium and pure metal tapes.

Current semi-professional machines and the better domestic units now provide both bias and equalization adjustment, generally using separate controls. Used with understanding, this ensures near-optimum performance with most tapes. Professional and semi-professional machines usually provide a step-less control of bias.

Fig. 9. Recording characteristics (BS1568)



Current tapes

At this point it appears appropriate to change from outlining simple theory to looking at some examples of current practice in tape production. About 100 samples of current cassette tapes from 25 suppliers were examined, using a Nakamichi 582 discrete-head machine, which is a good modern machine, with facilities for bias and equalization adjustment, and which is capable of handling metal tapes without saturating the recording head cores.

The bias settings were chosen using the Nakamichi facilities for equalizing the signal outputs at frequencies of 400Hz and 15kHz and with the equalization set to 120μs for the ferric tapes and 70μs for the ferrichrome, chromium dioxide and metal tapes. The bias settings are quoted in dB with respect to the appropriate DIN reference tape, but since there are as yet no metal reference tapes, the bias setting employed for these tests are quoted with reference to the Nakamichi metal tape.

The data for all the examples of each type of tape coating are averaged and these are the values in Table 2. The limits given in the 'Frequency Response' column should only be taken as being generally indicative of the results, the complete curves being used for any more detailed comparison.

The advantage possessed by the metal-particle tape of high saturation values at high frequencies is not immediately obvious from the data in the Table, being masked by the reduction of the high-frequency replay pre-emphasis from 120μs to 70μs. The higher levels of high-frequency signals that the metal tapes accept allows a reduction in the high-frequency attenuation of the standard recording amplifier and this in turn necessitates a reduction in the replay-amplifier high-frequency boost, with a corresponding improvement in the overall signal/noise ratio.

Typical response curves are provided for each type of tape in Fig. 10. Five separate bias levels are needed to enable optimum performance from every type of tape. However, the person who buys budget and 'special offer' tapes is unlikely to be interested in paying for a wide range of bias adjustment on his machine, so three levels of bias are probably adequate for the majority. Few of the cheap machines provide bias adjustments so the best performance is likely to be secured from the simple ferric tape.

The penalty for buying 'special offer' and 'advertisement-by-postal circular' types of tape is illustrated by the frequency response of Fig. 11. This is measured frequency response of a tape widely advertised under the name of, but having no connexion with, a very well known company. Not all such budget tapes are equally bad, however, and some of the very cheap ferric tapes may well be perfectly satisfactory in a machine bought for a youngster. At an intermediate price level, many own-name tapes from Boots and other well known multiple stores are excellent value for money.

The ferrichrome, two-layer tapes produced an unexpected response curve with a 'step' of about 4dB at frequencies in the region of 2kHz, presumably due to the magnetic discontinuity at the boundary between the chromium dioxide and ferric layers. This step would appear to require a special equalization curve to achieve the optimum performance.

With the bias optimized as described for each type of tape, the metal tapes are seen to have the highest m.o.l. at 330Hz, the highest saturation level at 10kHz, the lowest noise level and currently the highest price, but note the qualification about optimizing the bias. A less well appreciated limitation to the use of metal tapes and even some of the CrO_2 tapes is the inability of many machines to fully modulate the tape at high frequencies, head design and circuit limitations being the apparent cause.

The performance of metal tapes used in machines incapable of providing the optimum bias is generally much worse than that of an intrinsically inferior ferric or ferric-chrome tape.

Some comment about the material employed for the tape base is probably interesting. The original tapes were all pvc-based, but in recent years tensilized poly-

Table 2: Typical performance characteristics of cassette tapes

	Bias level	333Hz MOL	Sensit.	10kHz sat.	Noise (CCIR/ARM)	Print through	Freq. Resp. 10kHz-10dB (n.b. see also Fig. 10)
Budget quality Ferric tape	+0.39	+1.98	−1.38	−5.86	−50.65	−55.1	−1.65dB
Good quality Ferric tape	+1.26	+5.14	+0.03	−4.14	−50.76	−53	−1.34dB
FeCr tapes @ CrO_2*	+3.13	+7.3	−0.7	−6.38	−54.75	−49.5	−3.53dB
pseudo-chromes	+6.33	+5.09	+0.67	−6.12	−54.32	−47.85	−0.83dB
Metal tapes*	+11.3	+6.82	+0.6	−3.56	−54.48	−56.56	−0.2dB

* FeCr, CrO_2 and metal tapes all tested with 70μs equalization. Ferric tapes tested with 120μs equalization.

Notes

1. CrO_2 sensitivity quoted with respect to DIN CrO_2 sensitivity on optimum bias setting (+6dB)
2. FeCr sensitivity quoted with respect to DIN Fe sensitivity.
3. Metal sensitivity quoted with respect to Nakamichi ZX metal tape.
4. @ Equalization problem on Nakamichi with FeCr tapes.
5. All figures quoted with respect to Dolby level unless otherwise stated.
6. From an initial inspection of the Table it would appear that the high-frequency saturation level of metal tapes is little better than that of good-quality ferric tapes. However, the tests carried out on the metal tapes were with 70μs equalization whilst those in the ferric tapes were done using 120μs equalization. In absolute terms, the performance of the metal tape in this respect is at least 4dB better than the ferric tapes but, because the manufacturers have chosen to use a different equalization arrangement, the benefits of improved high-frequency saturation are not realized by the user. As far as the average user is concerned, the main advantage of using a metal tape would be an improvement of 4dB in background noise level.

Fig. 10. Typical frequency response curves

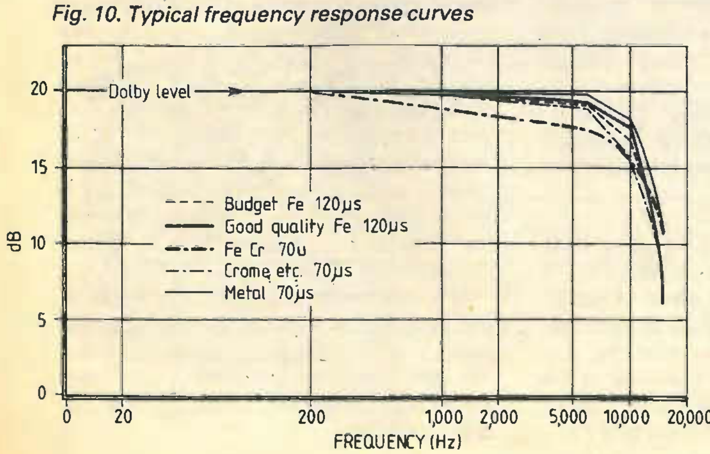
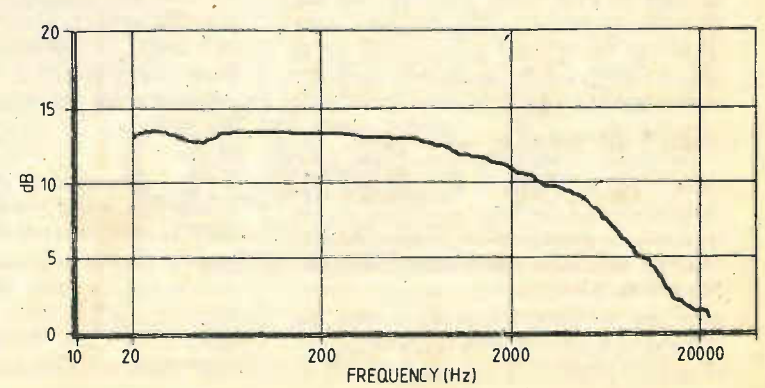


Fig. 11. Cheap tape performance



ester has captured the market because of its superior mechanical properties and its relative freedom from the effects of humidity. Polyester has only a slightly greater tensile strength than pvc tapes, but is some eight times less susceptible to the effects of moisture, a great advantage in ensuring good spooling with a freedom from 'cupping' and variation in the tightness of wind. The pvc base is rather smoother than the polyester base but not significantly so. A smooth base is advantageous in reducing noise modulation effects due to the variation in coating thickness that results from changes in the thickness of the backing tape.

The nominal thickness of the tapes varies somewhat between suppliers but bases about 18µm, 12µm and 6µm thick are usually used for the three common lengths of tape, the C60, C90 and C120 types, the coating thickness being around 6, 4 and 3µm respectively. The C90 size tape is probably the best compromise between playing time and tape strength, the C120 type requiring more care in handling and gentler treatment in machines than is usual.

The use of a thick tape base has the obvious disadvantage of reducing the amount of tape that can be stored in a cassette or on an open spool, but it has advantages in reducing 'print through', the transfer of signals from one layer of tape to adjacent layers. These result in pre and post echoes that are obvious when they occur in the middle of quiet passages. The transfer is accelerated by storage of the tape in a warm environment and by long-term storage without replaying. Some tape coatings are more susceptible to the trouble than others, probably because of their increased temperature dependence.

The future

It is interesting to consider possible further improvements. The cassette format is here to stay, for its convenience clearly outweighs the residual deficiencies in performance. Its mechanical performance is not perfect, but is probably commercially adequate. Tape jamming is rare but still occurs, so the mechanics will be improved in this respect.

Tape saturation at high frequencies produces amplitude compression and harmonic-type distortions that do not occur in reel-to-reel recorders running at higher speeds. There is, therefore, some opportunity for improvement, but in most other respects the performance of the existing coatings is more than adequate for the commercial market. This suggests that achieving the present performance or at least a commercially acceptable performance at half the present tape speed is likely to be the next step.

Development in tape coatings that have contributed so greatly to improvements in performance of the cassette format do not appear to be applicable to 1/4 in tape, or at least do not have the same advantages. Most of the limitations in coating performance are wavelength-dependent and not frequency-dependent effects. An adequate frequency response for all professional requirements can be secured from 1/4 in tape running at the present standard speeds and, in consequence, there appears to be no application for the new coatings in this field.

This situation does not hold for tapes used for tv and data recording, so the half-inch and wider tapes used for these applications are likely to benefit from coating developments that permit lower tape speeds.

Further reading

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Dividing by fractions

continued from page 61

triangular in form, has a frequency of half the last component, that is 378Hz, and a peak-to-peak amplitude of 0.0055 of an input period or, for a s.c. input,

226ns×0.0055=1.24ns

The final component is sketched in Fig. 6(c). The sequence A-B results in a phase error of $-0.005T$ and B-C in an error of $+0.006T$. B-C has thus over-corrected for A-B by an amount of 0.006−0.005=0.001T. The sequence A-C is repeated by C-E, . . . etc and each time an additional error of $0.001T$ accumulates. This is repeated five times to point K, when the accumulated error reaches $0.005T$. Since the sequence K-L is identical to that of A-B, a correction of $-0.005T$ occurs, exactly eliminating the error. The steady accumulation of this error and its final elimination gives the jitter component seen in Fig. 6(c). It is nearly sawtooth in form, has a frequency of 68.75 Hz and a peak to peak amplitude of

226×0.005=1.13ns

It has already been mentioned that removal of these jitter components is done with a phase-locked loop. The count of the divider has been so arranged that the low-frequency components of jitter are smallest in amplitude, as these are the most difficult to remove. If we set a specification of 1ns on the jitter, then both the final two components require little attenuation. The 756.25Hz component is the most difficult as its frequency is relatively low and amplitude high. At this frequency, we require 41dB attenuation, and this can be readily achieved in the phase-locked loop shown in Fig. 7.

The 111ns of jitter in a period of 65µs would give a p-p voltage perturbation of 7mV at the output of the phase comparator. For the moment ignoring any attenuation in the low pass filter, after the d.c. amplifier, 70mV jitter will appear at the input of the v.c.o. It can be shown that for a sawtooth variation at the input of a v.c.o. the output phase variation will be

$$\text{delta } \varnothing = \tfrac{1}{2} V K/f$$

where

delta $\varnothing$=p-p phase deviation at the output
V=p-p voltage deviation at the input
f=frequency of sawtooth waveform
K=sensitivity of the v.c.o. in Hz/volt.

If the sensitivity of the v.c.o. is 100Hz/volt, the output phase jitter will be

$$\text{delta } \varnothing = \tfrac{1}{2}\times 0.07\times 100/756 = 0.0046 \text{ of an output period}$$

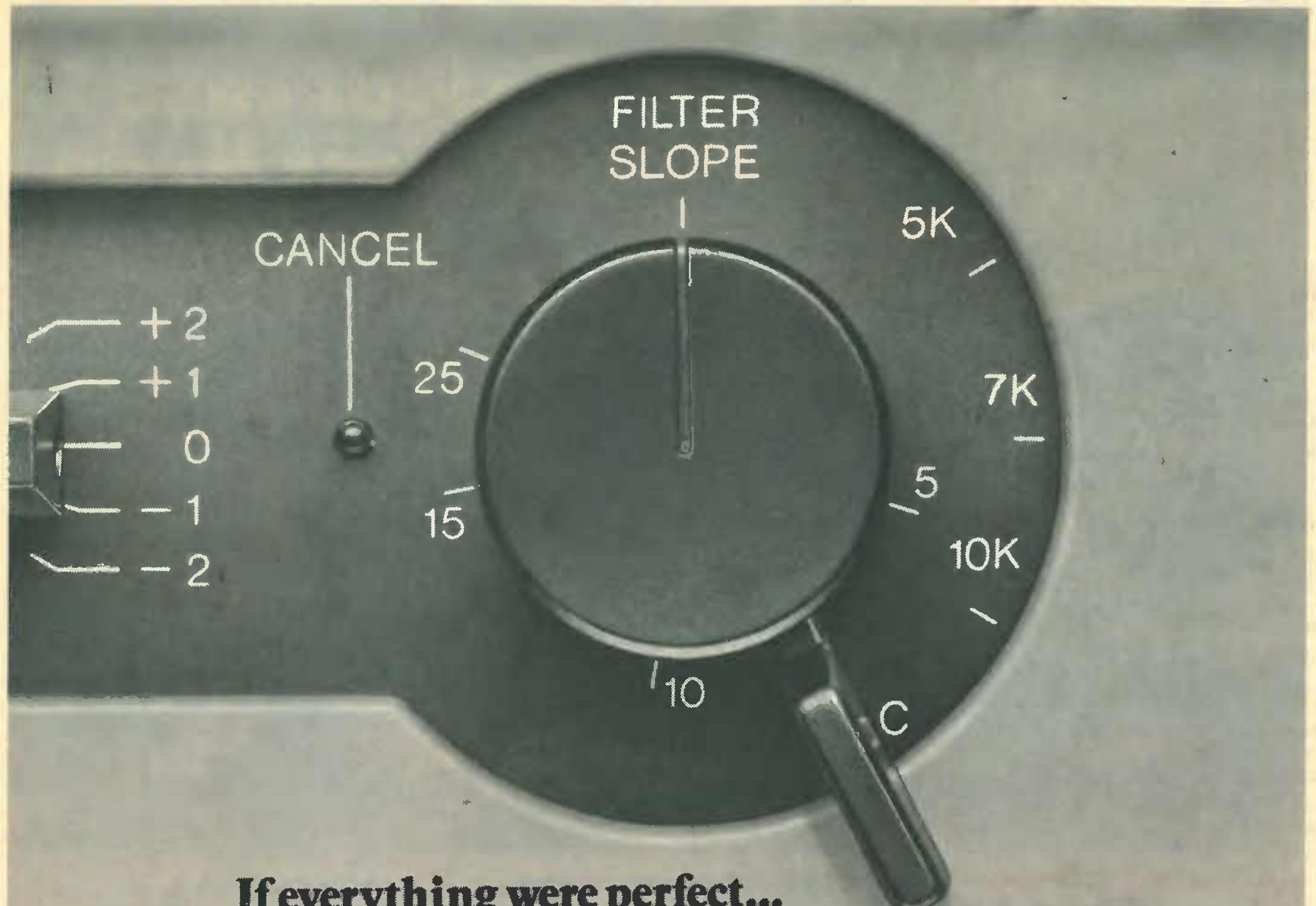
If the input frequency is SC, then the jitter will be 1.05ns. Thus, only a small amount of attenuation need be provided by the low-pass filter to meet specification.

The circuit of Fig. 7 was the one used in the laboratory. If, as in an s.p.g., twice-line or line frequency were being generated from SC (Fig. 2) a phase-locked loop with similar time constants could be used.

2.2 divider

Performing this division is far simpler than that of the previous section. The division is performed by dividing by 2 and 3 in the ratio of 4:1. By taking the output of the last flip-flop within the 7490 as in Fig. 8, we obtain a waveform which is low and high in the ratio of 4:1. This waveform is fed to the programming of the 9310, where it instructs a division of 2 and 3. The output then, as appearing on pin 15, has an average frequency of 2LF, if the input is 68.75kHz. The jitter components present at the output will be 68.75kHz/5, i.e. 13.75kHz. Recalling the jitter analysis done in section 3, it will be clear that this is above that which would cause jitter with the filter and v.c.o. chosen; even though its amplitude is high.

If a division from SC to LF is required, the circuit shown in Fig. 9 would be suitable. This may be preferred, as it avoids the need for an extra flip-flop. The jitter frequencies would be similar to those for the 2.2 divider. □



Surface acoustic wave devices

2 – More on bandpass filters, delay lines and oscillators

by R. J. Murray and P. D. White Philips Research Laboratories

This second part gives fuller information on the specification, operation and performance trade-offs of bandpass filters, delay lines and oscillators.

Bandpass filters

There are two types of s.a.w. bandpass filters. The first is the transversal filter, which consists of two or more interdigital transducers (see "principles") and is a travelling wave structure. These filters are wideband, with bandwidths of 0.2% to 100% of centre frequency. Centre frequencies in the range 10MHz-500MHz are readily achievable with a projected upper limit in excess of 1.5GHz. Design procedures are similar to those used for digital filters. The second type of bandpass filter is the resonator kind, which consists of one or more i.d.t.s in a cavity formed by two surface wave reflectors. This structure supports a standing wave. Bandwidths of 0.01% to 1% of centre frequency are feasible, with centre frequencies currently in the range 50-500MHz and ultimately greater than 1.5GHz. Design procedures are similar to those of conventional LC filters.

Transversal filters. Fig. 7 (a) shows a s.a.w. transversal bandpass filter, which consists of two i.d.ts on a piezoelectric substrate. An electrical signal is fed into one transducer, converted to a surface acoustic wave, reconverted to electrical energy at the other i.d.t. and emerges as a filtered signal. An alternative structure is shown in Fig. 7 (b) which incorporates in the s.a.w. propagation path a multistrip coupler consisting of a series of parallel unconnected metal strips. This acts to transfer the surface wave from one track to another, providing discrimination against unwanted bulk waves which are also launched by i.d.ts.

If two i.d.ts have individual frequency responses $H_1(f)$ and $H_2(f)$, where f is the frequency, then the overall filter transfer function $H(f)$ is given by:

$$H(f)=H_1(f).\,H_2^*(f)e^{-j2\pi\tau} \qquad (1)$$

where $\tau = L/v_0$, L is the geometric centre-to-centre separation of the i.d.ts, v is the s.a.w. velocity and * denotes complex conjugate.

The filter amplitude response $A(f)$ is given by:

$$A(f)=|H_1(f)|\,.\,|H_2(f)| \qquad (2)$$

and the phase $\theta(f)$ by:

$$\theta(f)=-2\pi f\tau+\tan^{-1}\left\{\frac{\mathrm{Im}\{H_1(f)\,.\,H_2^*(f)\}}{\mathrm{Re}\{H_1(f)\,.\,H_2^*(f)\}}\right\} \qquad (3)$$

If $(H_1(f).H_2^*(f))$ is wholly real or wholly imaginary, the phase variation $\theta(f)$ in equation (3) becomes a linear function of frequency. This generally desirable property may be achieved by making each of the i.d.ts symmetrical or antisymmetrical about its geometric centre. S.a.w. transversal filters are usually non-minimum phase filters. This means that the amplitude and phase responses may be designed virtually independently of each other. In particular a very precisely defined amplitude response (e.g. with steep sides, a flat or even equi-ripple passband and good stopband level) can be achieved whilst maintaining a linear phase response i.e. constant group delay, τ. Typical delays are in the range 1 to 5µs.

In general, spurious signals will arrive at the output transducer with a different time delay from that of the main signal. These cause ripples in the amplitude, phase and

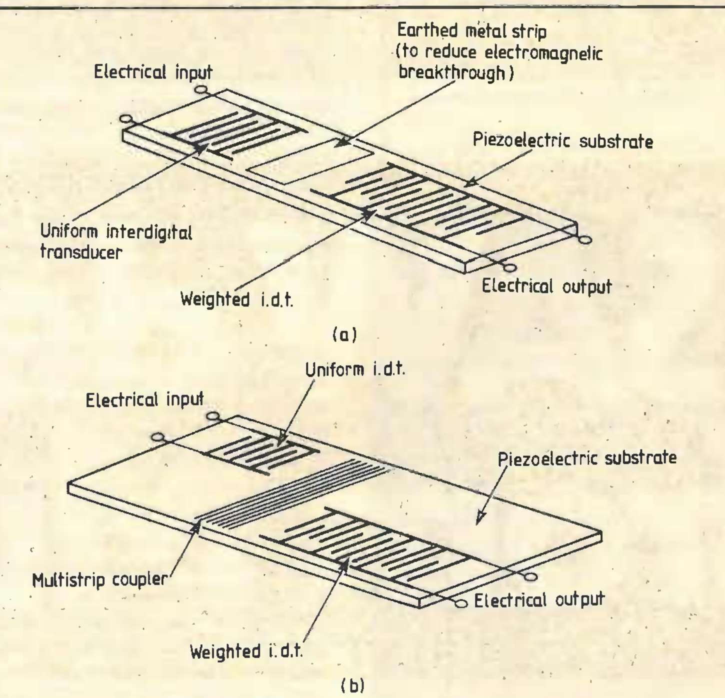


Fig. 7. (a) S.a.w. transversal filter geometry; (b) s.a.w. transversal filter incorporating multistrip coupler to suppress unwanted bulk waves.

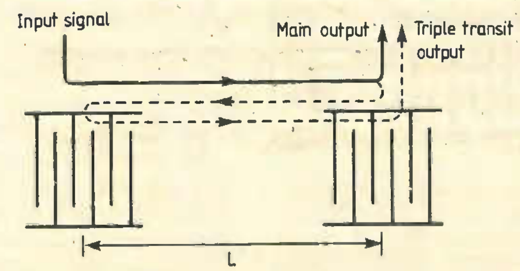


Fig. 8. Triple transit mechanism in s.a.w. devices. The triple transit signal results from successive electrical reflections from the output and input transducers before detection.

group delay responses of the filter. These spurious signals can cause quite large deviations from the ideal response and appropriate steps are usually taken to minimize them.

The most serious unwanted response is usually the triple transit signal which is illustrated in Fig. 8. This is caused by successive reflections from the output and input transducers before detection. If the main signal delay is τ, then the triple transit signal is delayed by 3τ i.e. 2τ more than the main signal. The period of ripples in the frequency response is thus $1/2\tau$.

The major contribution to the reflections which cause the triple transit signal is electrical and is a consequence of the three port structure of the i.d.t. The i.d.t. has two acoustic ports and one electrical port as shown in Fig. 9. When used for launching surface waves an electrical input signal causes acoustic signals to be launched at both of the acoustic ports. If the electrical port is perfectly matched then half of the available power is delivered to each acoustic port. Conversely, if surface waves are incident on one acoustic port with the electrical port perfectly matched then half of the energy is delivered at the electrical port and one quarter is delivered at each acoustic port. This, for a filter consisting of two perfectly matched (electrically) conventional i.d.ts, the minimum theoretical insertion loss is 6dB (never quite achievable in practice) and the triple transit signal is only 12dB below this level, which would result in an amplitude ripple of approximately 4dB peak-to-peak and a phase deviation from linear of approximately 25° peak-to-peak.

For most applications ripples of this magnitude are totally unacceptable. The simplest technique for reducing the triple transit signal, and the most widely used in practice, is to operate the filter with a mismatched source and/or load impedance. This increases the insertion loss but drastically reduces the level of the reflected signals. Using this technique a typical insertion loss is 20dB with peak-to-peak ripples of less than 0.3dB in amplitude and less than 2° from linear in phase. Therefore, when a filter has been designed to operate with mismatched terminations it is important to remember that *any attempt to improve the match and thereby reduce the filter insertion loss will cause increased amplitude and phase ripple*. Other, more complicated, methods of suppressing triple transit responses are available for use in filters with particularly difficult specifications.

There are several other spurious signals in s.a.w. devices which can be substantially reduced by suitable design of the i.d.ts and substrate. Reflections from substrate ends are reduced by bevelling and applying acoustic absorber behind the i.d.ts as shown in Fig. 10. Reflections within i.d.ts are reduced by replacing each single electrode (a quarter of a wavelength wide) by a pair of like polarity 'double' electrodes (each an eighth of a wavelength wide) as in Fig. 11. Spurious bulk wave responses can be attenuated by the use of a track changing multistrip coupler on high coupling materials and/or by treatment of the lower surface of the substrate.

Resonator filters. A surface wave resonator consists of one or more i.d.ts suitably positioned in a cavity between two efficient reflectors of surface waves as shown in Fig. 12. Unlike the more familiar bulk acoustic waves employed in bulk wave resonators, surface waves cannot be efficiently reflected by an abrupt discontinuity (e.g. a substrate edge) because this would cause a significant proportion of the energy to be mode converted into bulk waves. S.a.w. reflectors consist of a large number of small impedance discontinuities in the form of metal strips or grooves spaced by half a wavelength. This results in bandpass reflectors with peak amplitude reflection coefficients of typically 99% or higher. The resonant cavity will generally be capable of supporting several standing waves, and the required mode is selected by careful design of the reflectors and the i.d.t.

The electrical equivalent circuit of a

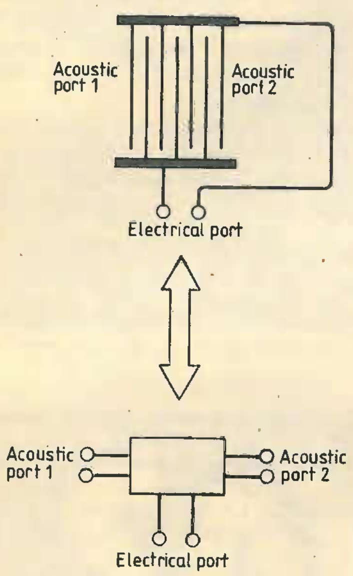


Fig. 9. Three-port nature of the interdigital transducer.

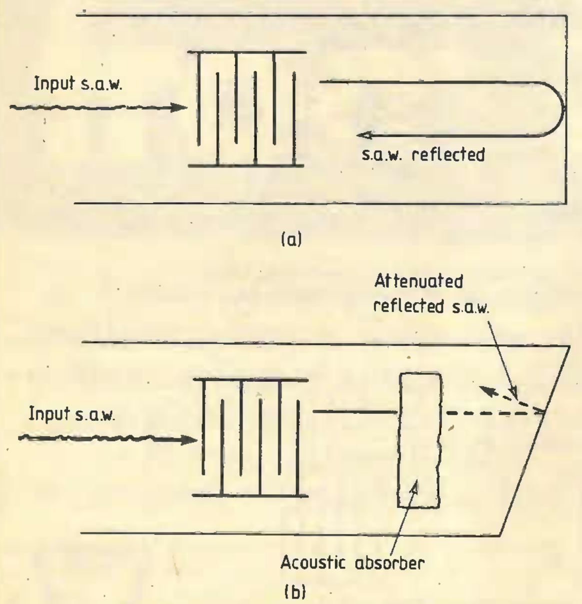


Fig. 10. (a) Spurious s.a.w. reflections from substrate end; (b) suppression of reflections from substrate end. These reflections cause distortion of the filter amplitude and phase responses.

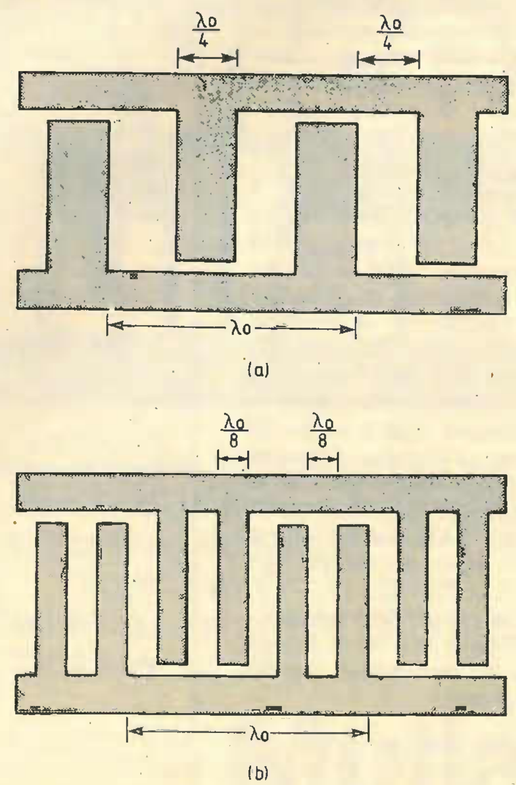


Fig. 11. (a) Conventional 'single electrode' interdigital transducer; (b) equivalent 'double finger' interdigital transducer used to suppress mechanical reflections.

one-port s.a.w. resonator is shown in Fig. 13(a). This is similar to that of the familiar 'quartz crystal' bulk wave resonator, consisting of an LCR resonant section (the cavity) and a shunt capacitance due to the I.d.t. Two or more of these elements may be connected together to produce a coupled resonator. The equivalent circuit of a two port resonator is shown in Fig. 13(b). The capacitor C_c is defined by the coupling transducer and is given by:

$$C_c = 2C_o\frac{N_T}{N_c} \qquad (4)$$

where N_T is the length of the input/output i.d.ts and N_C is the length of the coupling i.d.ts.

Normal coupled resonator behaviour is observed as N_C is changed, as illustrated in Fig. 14. By appropriate choice of structure, including in some cases inductive tuning, various standard filter types may be realised (Butterworth, Chebyshev, etc). In general, any number of resonators may be coupled together to form a multipole filter. A third-order filter is shown in Fig. 15.

S.a.w. resonator filters are low loss narrowband filters and are temperature stable if a quartz substrate is used. In the frequency range of application (50-1500MHz) there are very few suitable alternative filtering techniques and so the s.a.w. resonator allows narrowband filtering to be implemented at frequencies at which it has previously not been feasible. This has many implications in the design of modern systems where the filters may be included at the front end of communication systems and in the high frequency section.

Design procedures for s.a.w. resonator filters are similar to those for LC filters and the filters are minimum phase. Unlike transversal filters, the phase response achieved for a given amplitude response is uniquely defined.

Further details of delay lines

S.a.w. delay lines consist of two i.d.ts suitably placed on a piezo-electric substrate. If each i.d.t. is geometrically symmetric or antisymmetric (about its geometric centre) then the delay line frequency response is band-pass with a linear phase characteristic. Identical uniform transducers are usually used and the amplitude response is, therefore, $(\sin x/x)^2$ (see section on "Principles"). Alternatively, with a suitable asymmetric design of the i.d.ts the delay line can be made to be dispersive (i.e. the delay varying as a controlled function of frequency).

Linear phase delay lines can be made with bandwidths of up to 100% of centre frequency over the frequency range of 10MHz -1.5 GHz. Delays ranging from 400 nanoseconds to 30 microseconds or more can be achieved. Relative delays of less than 400 ns can be achieved directly if electromagnetic breakthrough is not a problem, or as the differential delay between two delay lines. The most attractive feature of s.a.w. delay lines is that relatively large delays can be achieved in a small volume. For an ST-X (temperature compensated) quartz substrate, a delay of 1μs can be obtained with an acoustic path length of 3.2mm.

Applications include radar systems, electronic countermeasure systems and target simulators. S.a.w. delay lines can also be used in discriminator circuits such as that shown in Fig. 16 where a signal is fed to a double balanced mixer via two paths, one direct and the other through a s.a.w. delay line. Provided the delay line has a linear phase response the d.c. voltage output from the mixer is a cosine function of the input frequency and is approximately linear over a reasonable bandwidth. Linearity can be achieved over a wider bandwidth by limiting the signals at the mixer inputs to square waves.

Further details of s.a.w. oscillators

There are two distinct types of low noise, stable s.a.w. oscillators. The delay line oscillator employs a conventional s.a.w. delay line in the feedback loop of an amplifier; the frequency may be linearly modulated by typically 0.1%. The one-port s.a.w. resonator can be used in essentially the same oscillator circuits as conventional bulk wave resonators, or two port resonators can be used in an amplifier feedback loop. Resonator oscillators can only provide very narrowband linear frequency modulation but can provide better noise performance. Both types of oscillator can work at fundamental frequencies in the range 10MHz-1.5GHz without additional multiplying circuitry. The devices are considerably smaller, cheaper and lighter than conventional oscillator techniques.

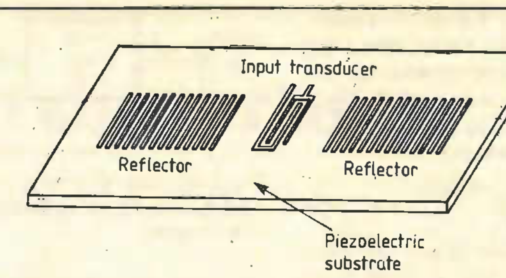


Fig. 12. One-port s.a.w. resonator geometry showing the transducer located between two reflectors.

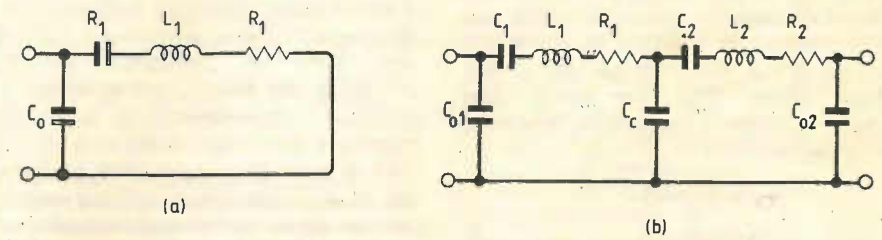


Fig. 13(a) Equivalent circuit of one-port s.a.w. resonator; (b) equivalent circuit of two-port s.a.w. resonator.

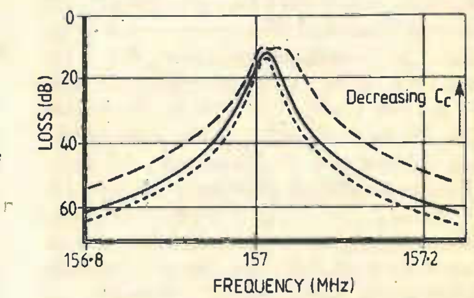


Fig. 14. The effect of varying coupling on s.a.w. resonator response. Note that decreasing the value of the capacitance C_c increases the coupling and results in a broader bandwidth and lower loss as with conventional filters.

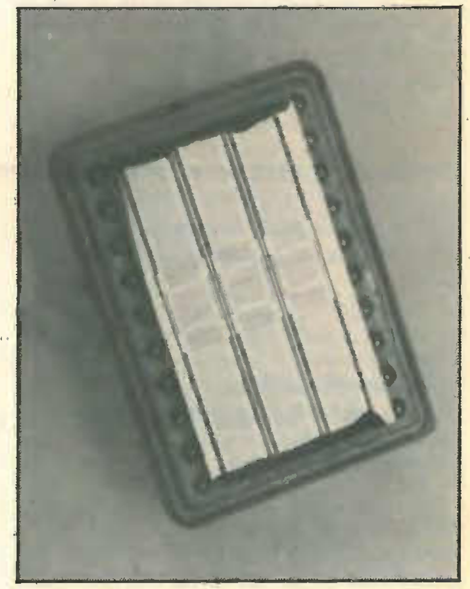


Fig. 15. A third order s.a.w. resonator filter (package size 28mm x 20mm). The central transducers and end absorber are clearly visible.

Delay line oscillators. Fig. 17 is a schematic representation of a s.a.w. delay line oscillator. The delay line consists of two i.d.ts separated by a distance L, with a delay of L/v corresponding to a phase shift at a frequency of ϕ_{DL}, where:

$$\phi_{DL} = \frac{2\pi Lf}{v} \text{ radians}$$

Oscillation will occur when the total phase shift around the loop is equal to an integer (n) multiple of 2π, i.e.

$$\phi_E+\phi_S+2\pi\frac{Lf}{v} = n2\pi$$

where ϕ_E is the electrical phase shift around the loop (excluding delay line and phase shifter but including the amplifier) and ϕ_S is the phase change due to the phase shifter. The loop would thus support a comb of frequencies separated by Δf, where:

$$\Delta f = \frac{v}{L}$$

The required mode (at f_o) is selected by suitable design of the i.d.ts so that frequency f_o is passed but frequencies $f_o \pm nv/L$, where n is a non-zero integer, are located at nulls of the response of the delay line. One simple way to achieve this is for one i.d.t. to be a uniform transducer with N periods where $N = (L/v)f_o$; this makes the centre frequency f_o with traps of the sin x/x response at frequencies $f_o \pm nv/L$. This technique is illustrated in Fig. 18. Transducers with a proportion of electrodes removed (thinned i.d.ts) are often used to increase frequency reproducibility and to reduce internal reflections.

The frequency of the oscillator loop may be modulated by variation of the phase in the phase shift circuit which usually incorporates one or more varicap diodes. The output signal can be taken at any point around the loop (but not usually immediately after the modulator). For maximum power this would normally be immediately after the amplifier; for minimum noise, immediately after the delay line is best.

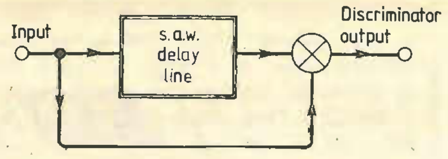


Fig. 16. Delay line discriminator using the good linear phase characteristics of the delay line.

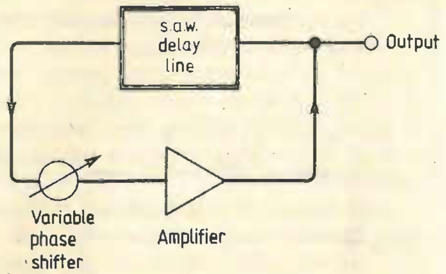


Fig. 17. Delay line oscillator. The circuit will oscillate at a frequency where the total phase shift around the loop is an integral multiple of 2π.

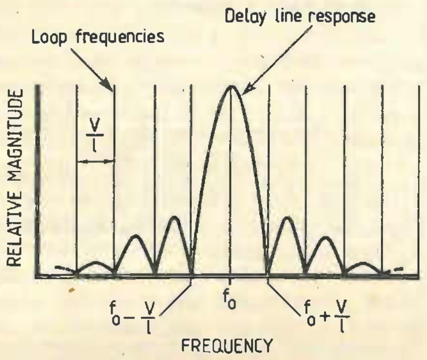


Fig. 18. Loop frequencies and transducer response of s.a.w. delay line oscillator, showing the comb of loop modes, one of which (f_0) is selected by the transducer response.

The gain of the amplifier used must be greater than the loss around the loop and it is common to operate the loop with the amplifier saturated. The delay line loss will typically be 10-20dB, depending on the electrical matching.

Resonator oscillators. S.a.w. resonators (see earlier) are high Q components operating at frequencies of 50MHz and above. Unloaded Qs in excess of 20,000 can be achieved at 250MHz. This makes it possible to use these devices as oscillator control elements to provide stable sources at fundamental frequencies in the range 50MHz to 1.5GHz.

A s.a.w. resonator may be used in an oscillator as either a one-port or two-port device. If a two-port configuration is used then the circuit becomes similar to that used for delay line oscillators, i.e. an amplifier and a s.a.w. device in a feedback loop. The advantage of a resonator over a delay line in this case is that the amplifier need only provide 4 to 5dB of gain since the resonator has a lower insertion loss than the delay line. However, because the frequency response of a resonator is not linear phase, except over a very narrow range (approximately 0.02%), there is less potential for linear frequency modulation.

If the resonator is used as a one-port device then the circuit would be similar to that used for bulk wave crystal oscillators (e.g. Colpitts, Pierce), and because of the higher frequency (at u.h.f.) the construction could be based on a cavity or resonator stabilized microwave oscillator. A single transistor can be used in some cases, giving a very compact oscillator. □

BOOKS

Frequency Synthesizers, Theory and Design, by Vadim Mannasewitsch. 582pp. hardback. John Wiley, £19.25.

This is the second edition of a book, first published in 1976, which thoroughly describes a vast number of techniques, both practical and theoretical, for the generation of highly stable multiple frequencies using one reference – a subject which has only been seriously studied for around twenty years. It is written at a level suitable for graduate engineers.

Chapter 1 prepares the ground for the succeeding sections, covering in outline a large number of techniques and circuit blocks used in frequency generation, and being followed immediately by a chapter on the problems of spurious modulation and frequencies, and phase noise in practical synthesizers. Two 'practical' sections provide advice on screening against electric and magnetic fields and on fault-finding, and the three core chapters are concerned with analogue and digital phase-locked loops and the basic circuits (mixers, amplifiers, dividers, etc.) needed for synthesizer operation. A further two chapters illustrate the techniques described earlier by reference to commercial synthesizers and frequency-reference sources. Important additions for the second edition are descriptions of direct digital synthesis and fractional-N, phase-locked loops.

Mannasewitsch has produced a clearly written treatise on this complex subject, which should be well suited to the needs of a working engineer who needs to acquaint himself quickly with the large number of techniques now in use. It is suggested by the author that the book would serve as a text for a course on the subject.

Handbook for Radio Engineering Managers by J. F. Ross. 947pp., hardback. Butterworth, £35.00

The role of a manager in technical and economic planning, safety engineering, environmental consideration and the operation and maintenance of large and small radio stations is well covered, in all its aspects, in this enormous book. It is organized in six sections, on management and organization, engineering economy, safety practice, fires in radio installations, environmental aspects and specifications and contracts.

While management theory takes up a good deal of the book it is, in the main, a practical text, clearly the fruit of much experience. It is extremely comprehensive, treating not only the larger considerations of economics and planning, but minutiae such as precautions against the depredations of termites. Many photographs and drawings illustrate the text and it is pleasing to see a chapter on the engineer's obligation to the environment. Of particular interest to the British reader (the author is Australian) is an account of the collapse of the Emley Moor television mast in 1969, complete with photographs.

A very valuable work for anyone involved with planning, installing or running a radio station or network, whatever its size.

Multipath distortion

– does polarization matter?

by **Pat Hawker,** Independent Broadcasting Authority

Many broadcasting authorities have introduced, or are planning to introduce, vertical or circular polarisation in the transmitted signal to help reception on vertical aerials in cars or on domestic receivers. However, there is some correlation between polarisation and an increase in distortion caused by receiving the signal from more than one source. Research in Japan and Germany has helped to analyse the problem.

A recent survey article – "How serious is multipath distortion?" (Ref 1) – drew attention to the lack of recognition in the UK that multipath propagation is probably the most serious cause of the degradation of quality when v.h.f/f.m stereo broadcasts are reproduced in the home through good quality equipment, even when reasonably careful regard has been paid to aerial installation.

The article stressed that over 25 years after the start of regular v.h.f/f.m mono broadcasting in the UK (May 2, 1955) and about 15 years after the gradual introduction of pilot-tone stereo, there was still widespread lack of knowledge about the extent, and methods of mitigating multipath effects, induced to some degree by the reluctance of broadcasters, long concerned with the problem of encouraging more listeners to use v.h.f/f.m rather than m.f/a.m, to draw attention, except in the most simplistic terms, to this problem.

Since that article was written, several developments have taken place that deserve serious consideration by those interested in high-quality reproduction of broadcasting.

(1) While the original article drew attention to the work carried out by NHK in Japan, the information then available was limited to a short English-text summary. Full details of this valuable investigation have since been published by Mitsuo Ohara in *IEEE Transactions on Broadcasting* (Ref 2). This paper makes it clear that multipath distortion is "far greater" on stereo than on mono transmissions and also reduces stereo separation (although the early investigations in the US and UK between 1940-1960 were of course confined to mono). Additionally it shows that multipath can be the cause of serious crosstalk into the broadcast programme of information carried on additional sub-carriers, including the SCA (subsidiary authorization channel) system widely used in the USA and, by implication, the ultrasonic tone signalling systems used in the UK, and the experimental 'programme labelling' systems, etc.

(2) Investigations carried out in the Cologne area of West Germany, including 212 site tests carried out from five specially equipped vehicles, and reported in *EBU Review-Technical Part* (Ref 3) indicate that the addition of a vertical component to horizontally polarized transmissions, that is any form of mixed polarization, significantly *increases* rather than decreases the extent of multipath distortion, even for listeners with good, outdoor horizontally polarized aerials. This report emphasises that from both the economic and purely technical points of view, the adoption of circular polarization in West Germany would be undesirable. This report has been published shortly after the BBC announced its intention (Ref 4) of adding a vertical component to the main BBC national v.h.f/f.m networks of Radio 1-4 (with Wrotham to be modified in 1981), on the grounds of providing a better service for listeners using car radios, although the German investigators question even this assumption.

(3) The vulnerability of digital systems (including teletext) to short as well as long term echoes was noted in the earlier article. Since then it has become clear that British Telecom are experiencing more problems than they anticipated in the planning of high-speed digital networks (140 Mbit/s etc) even on strictly line-of-sight microwave links. *The Post Office Research Review 1979* (Ref 5) notes that: "Analogue f.m (link) systems are relatively tolerant of the signal distortions produced by multipath propagation which will cause an increase in intermodulation noise . . . in digital systems, the signal components arriving by alternative paths cause intersymbol interference . . . errors in the phase of the recovered carrier and timing signal which result in a more severe degradation in system performance". To overcome multipath propagation and deteriorations in cross-polar discrimination, both phenomena which in this context vary rapidly with time, British Telecom are considering such remedies as aerial height diversity, adaptive spectrum shape equalization, adaptive decision feedback, etc – all systems of some complexity, particularly when, as appears likely, it was initially expected that the 'ruggedness' of digital transmission would not require these added costs.

It is now clear that even well-planned

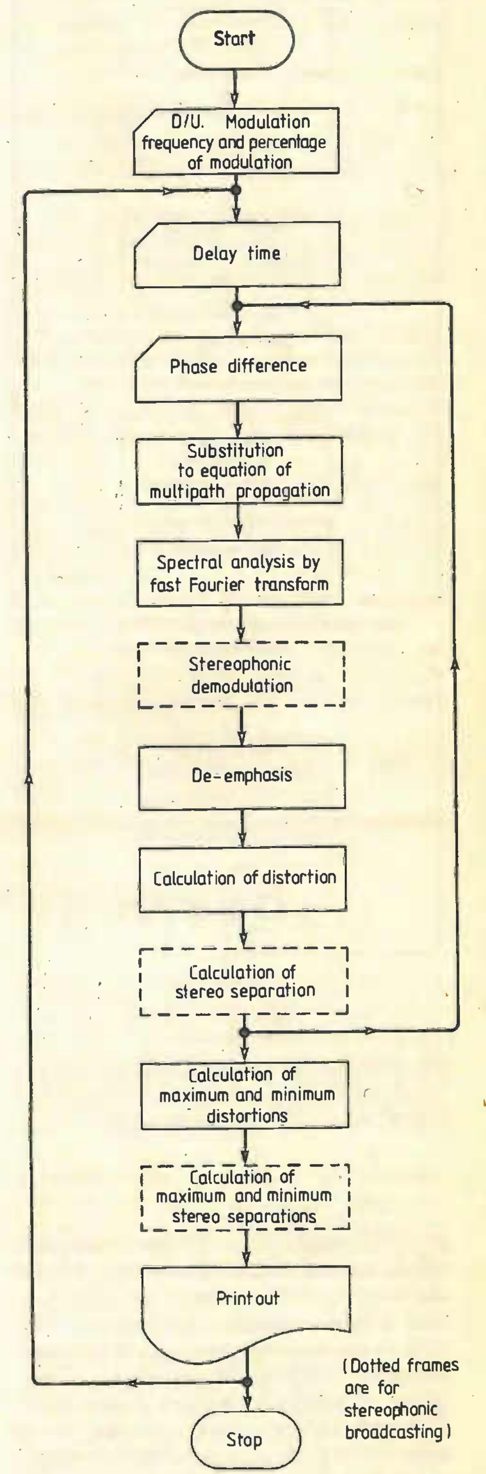


Fig. 1. The procedure used by Mitsuo Ohara (NHK) for computing multipath distortion of monophonic or stereophonic broadcasting.

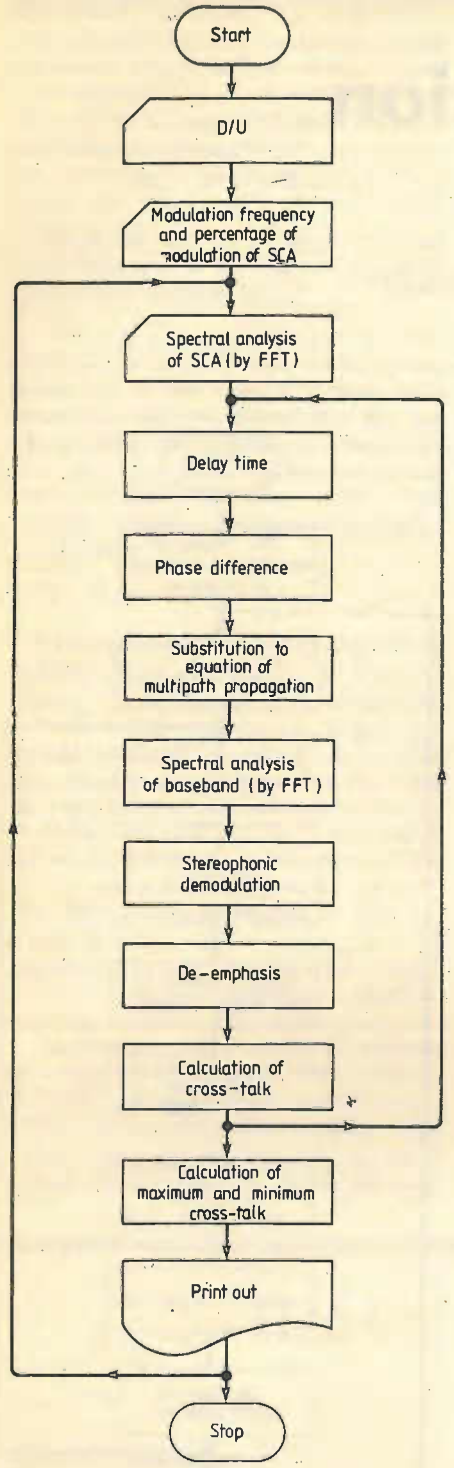


Fig. 2. Procedure for computing crosstalk into a stereo programme channel from 67-kHz (SCA) sub-carrier transmission.

microwave links can suffer from multipath effects causing increased error rate, intense short-duration error bursts or unacceptable adjacent channel interference. The IEE E8 professional group (Radio communications Systems) are planning a *Colloquium on Multipath Problems* in May 1981. Although current thinking tends, for a variety of reasons, to favour digital systems it has to be recognised that there are circumstances where the gradual fall-off in performance of analogue systems is preferable to the 'go/no-go' characteristics of digital.

NHK multipath study

The NHK work on distortion and crosstalk caused by multipath propagation in v.h.f/f.m sound broadcasting constituted the first computer-assisted theoretical analysis of the relationship between multipath distortion and the relevant parameters. It provided a clearer picture of the characteristics of multipath distortion for both mono and stereo transmissions. It also included laboratory tests using a multipath simulator. Subjective listening tests were carried out using the simulator to investigate the relationship between the distortion and the reproduced sound quality under the influence of multipath distortion. It should be appreciated that the Japanese and American pre-emphasis time-constant is 75 microseconds, whereas the European figure is 50 microseconds: this means that multipath distortion effects may be rather different in Europe than elsewhere. Nevertheless too much should not be made of this difference, since with both time-constants the effects of multipath tend to show up intermittently and selectively rather than as continuous distortion. Mitsuo Ohara shows that distortion increases with low percentages of modulation, particularly where there are long delay times on the reflected signals. A few examples of the results of this work are shown in Figs 3-4 and also in (Ref 1).

Crosstalk – 'monkey chatter' from a 67 kHz-subcarrier SCA system is shown to reach peak values for delay times of about 10 microseconds and about 20 microseconds. There is little doubt that a multiplexed SCA channel can result in severe crosstalk to those listening on the main stereo programme channel; this was the experience noted by the BBC when experiments were carried out several years ago. The significance of the NHK work is that this can now be ascribed partly to multipath effects. Similarly it would not be unreasonable to suppose that the type of interference from the experimental programme labelling signals reported by R. Camp in *Wireless World* (Ref 6) could arise either from receiver design *or* from multipath effects, though no indication of this could be gathered from the BBC comments.

Polarization and multipath

The work carried out jointly by the Institut für Rundfunktechnik and Westdeutscher Rundfunk is particularly important in view of the increasing use being made in the UK of mixed polarization. In the form of "slant" polarization this was initially adopted by the BBC for their v.h.f/f.m local radio stations, and virtually all the ILR stations have used circularly polarized serials (although it is recognized that true circularity is not necessarily maintained throughout the service area). The main motivation for this was the 7 dB or so increase of signal strength when the signals are received on vertically polarized car radio aerials (or on portable receivers with telescopic rod aerials used out of doors in circumstances where there is little depolarization of the

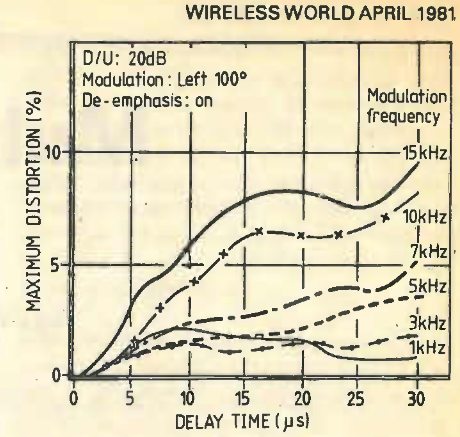


Fig. 3. An example of the relationship between the delay time of an echo and maximum distortion with an aerial direct/unwanted (D/U) ratio of 20 dB for different audio frequencies.

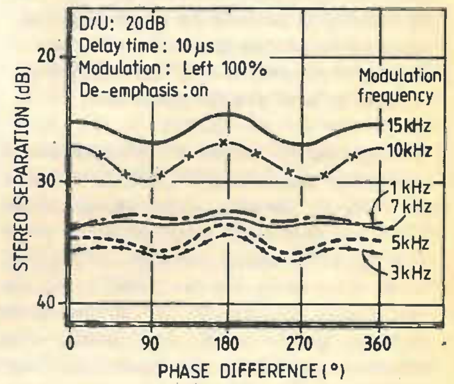


Fig. 4. An example of the relationship between phase difference of an unwanted signal and stereo separation for a D/U ratio of 20dB.

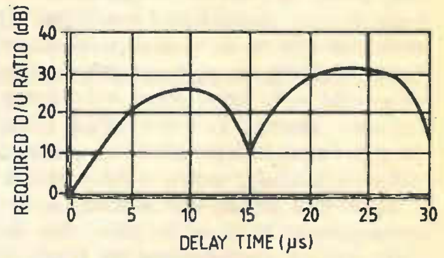


Fig. 5. Relationship between the delay time of an echo and the required D/U ratio if "monkey chatter" crosstalk from an SCA transmission into the main programme is to remain below –55dB (just perceptible). Note that crosstalk into the SCA-programme from the main programme, due to multipath effects, is greater than crosstalk into the main channel.

signals). There have also been some suggestions that cp may provide more homogeneous coverage and possibly some reduction of multipath distortion.

The German work confirms that close to the transmitter cp transmissions result in 4-6 dB more received car-radio aerial voltage, even where the total power of the cp transmissions is unchanged from that of the normally horizontally polarized transmissions. However, it emphasises that vertically polarized v.h.f signals are not

propagated as well as horizontally polarized signals: but in addition it strongly indicates that in normal terrain, there are many more (typically three times as many) long-term 'echoes' with vertically polarized signals than with purely horizontally polarized signals. Unlike most previous studies, the German work was not confined to the sole criterion of received field-strength, but also the quality of reception. The results are a surprisingly vehement rejection of the value of mixed polarization applied to broadcasting.

The tests appear to have been conducted with typical German thoroughness. If one assumes that the methodology contains no hidden flaws, then the results of these trials would seem sufficiently convincing as to suggest that the BBC should reconsider its decision to adopt mixed polarization for its main networks. It is not my purpose, as a member of the 'other' broadcasting organization, to make a partisan point. Indeed if the German work cannot be 'shot down' then there would appear to be every reason why both IBA and the BBC should at least reconsider future policy on local radio, though (as noted later) on lower-power transmissions a more convincing case for cp can be made on behalf of the v.h.f./f.m car radio listeners. For the quality-conscious domestic listener, the key finding in the German experiment is that "it has been seen that the vertical component excites long-range reflections which are so intense as to affect even reception with a horizontally-polarized aerial. It should be noted that this effect is apparent even with a very directional transmitting aerial. If the transmission is omnidirectional the long-range reflections may be even more severe".

The German study also points out that when a vertical component is introduced, there will be problems of compatibility with existing domestic reception. A certain number of new listeners may be gained "at the expense of others who will lose their service". Existing gaps will not be filled to any great extent.

While the German study indicates that a slightly inclined plane of polarization would help listeners with vertically-polarized receiving aerials, it does not even wholeheartedly support such a compromise. But did the German trials 'prove' only what those concerned wished to prove?

IBA engineers commenting in 1975 on the performance of the early ILR circularly polarized transmissions (Ref 7) noted that "the effects of multipath propagation on stereo broadcasts are well-known but often under-estimated. These effects occur far more often than is generally realised. During the off-air loop tests we have found on occasions that the system performance measured at the studio was severely affected by these phenomena. It has been the case that two aerials, on the same building, often very close together, have had very different multipath performance". It was also noted that although multipath distortion is caused by the fundamental mechanisms brought about by the reflected signals, the actual amount of distortion above this figure is likely to vary greatly between different receivers, depending mainly on the amount of limiting applied to the sub-carrier.

Several years ago EBU Working Party K undertook a study of the work done by individual broadcasters on choice of optimum polarization for v.h.f./f.m sound broadcasting. Their report (Ref 8) summarised by F. Wise (formerly IBA) differentiated between: (a) "services intended primarily for high-quality receiving installations, probably with stereo, with no improvement to reception conditions for portable or car sets envisaged"; and (b) "primarily to reach the largest audience, especially those using portable or car sets. Account to be taken of those installations equipped to receive any existing transmissions". For (a) the report came out firmly in favour of retaining horizontal polarization for existing and new services in all types of terrain where existing services use horizontal polarization. For (b) the corresponding choice was 'mixed' polarization for 'flat or rolling terrain', but 'horizontal' for 'rugged' terrain. The report noted that reflections from the side of the direct signal path where the reflecting object may be a man-made structure, trees, hills or mountains will generally be of significantly greater magnitude for vertically-polarized transmissions, and that such transmissions are more likely to be affected by multipath. The evidence for increased reflections from behind the receiving point was then considered less convincing and the EBU Panel considered polarization unimportant, though noting that in Germany some evidence existed that buildings tend to reflect vertically-polarized Band II signals more than those which are horizontally polarized". The decision to convert BBC network transmissions to mixed polarization would appear to run contrary to the 1976 EBU report.

To conclude, it is necessary to stress that these comments are not intended as criticism of the BBC for playing down the multipath issue or even for their decision to add a vertical component to their network transmissions. Rather it is a plea that, as listeners or as broadcasters, we should be more aware of the effects multipath radio propagation and polarization have on the transmission of high-quality analogue or high-speed digital signals. Only if we recognise the problem are we likely to overcome the worst effects, or at least minimise them. We are still all in the learning stage, but it is important for quality-conscious listeners to discover whether the results of the German tests can be accepted as correct.

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1. Pat Hawker, "How serious is multipath distortion?" *Wireless World*, April 1980, pp 46-48.
2. Mitsuo Ohara, "Distortion and crosstalk caused by multipath propagation in frequency-modulation sound broadcasting", *IEEE Transactions on Broadcasting*, Vol BC-26, No 3, September 1980, pp 70-81.
3. T. Bossert and A. Lau, W. Blobel and D. Hoff, "Comparison between horizontal and circular polarization for v.h.f./f.m reception in the home and in motor vehicles" *EBU Review – Technical Part*, No 182, August 1980, pp 175-187.
4. P. E. Lonsdale, Letter to *Electronics & Power*, October 1980, p 795.
5. P. James (Ed), "Microwave Radio Digital Links", *The Post Office Research Review 1979*, pp 42-60.
6. R. Camp, Letter to *Wireless World*, with comments by D. P. Leggatt, October 1980, p49.
7. D. S. Chambers and J. R. Edwards, "The specification and performance of ILR v.h.f. transmitting systems". IBA internal report: SD&C No R3/75, pp8-10.
8. F. Wise, "Choice of polarization for new Band II services" *EBU Review – Technical Part*, No 155, February 1976, pp 21-24.

Literature received

A leaflet on the Japanese Izumi range of **motor-driven timers**, which can switch up to 7A, is available from Appliance Components Ltd, Cordwallis Street, Maidenhead, Berks. SL6 7BQ. WW407

Analog Devices has produced a brochure to explain specifications and applications of a-to-d and d-to-a **convertors**, sample-and-hold amplifiers and v-to-f converters. It can be obtained from AD at Central Avenue, East Molesey, Surrey KT8 0SN. WW408

The FCC 180 series of D-subminiature **connectors** is made by Alpha for use with flat cables. A copy of their leaflet can be had from Alpha Wire, Ltd, Alpha House, Central Way, North Feltham Trading Estate, Feltham, Middx. WW409

Engineering Recommendation G22/1, published by the Electricity Council, is concerned with the use of devices which use the **mains wiring to conduct signals**. A copy can be obtained from the Distribution Engineering Branch, the Electricity Council, 30 Millbank, London SW1P 4RD at a cost of £1.

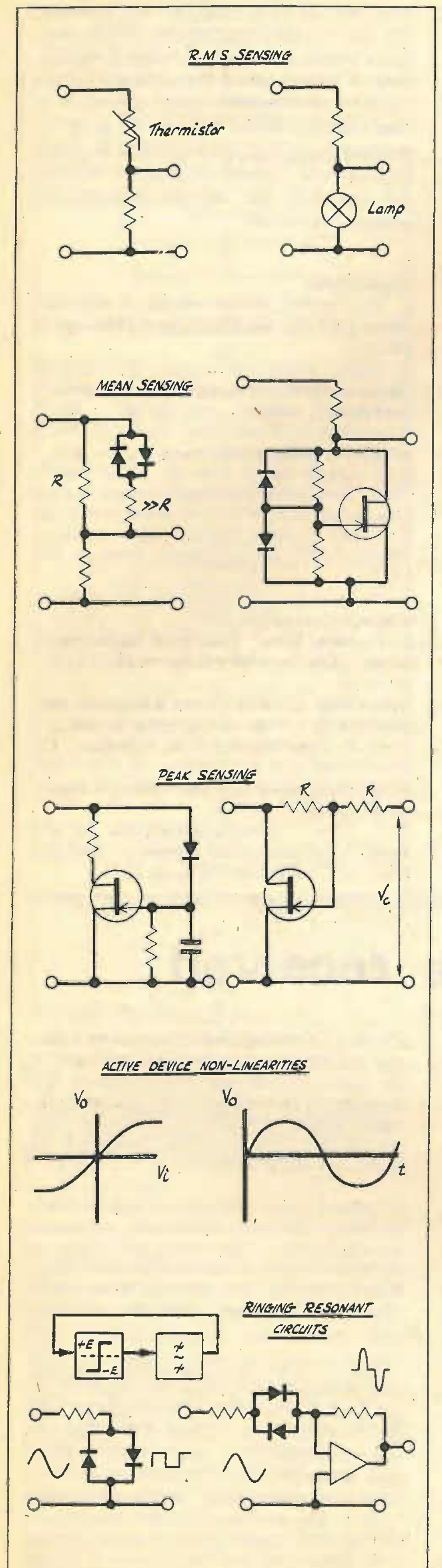
Prolog is a portable, multi-channel data acquisition and replay system, with dual microprocessor control over all operational functions. It is described by Microdata, the manufacturers, in a colour brochure, which can be obtained from the company at Monitor House, Station Road, Radlett, Herts. WD7 8JX. WW410

Verospeed's new **catalogue** is now available, containing 2500 items of hardware, components and instruments. The company will supply one off orders. Copies of the catalogue are available from Verospeed Ltd, Stansted Road, Boyatt Wood, Eastleigh, Hants. SO5 4ZY. WW411

The IEC have issued an international standard to achieve compatibility in the sub-systems and combination of sub-systems used in **satellite earth receiving stations**. The publication sets conditions for the measurement of return loss, input and output levels, amplitude and frequency characteristics, static a.g.c. characteristics, dynamic a.g.c. characteristics, and the group-delay/frequency characteristic. International Electrotechnical Commission, 1 Rue de Varembe, 1211 Geneva 20 Switzerland.

Amplitude sensing and control

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



There are two reasons for controlling the amplitude of a sinusoidal generator.The obvious one is where that amplitude affects the behaviour of some associated circuit or where its value is involved in consequent calculations. Less obviously any increase in amplitude changes the waveform because the output traverses more of the non-linear range of the active devices. The harmonics resulting are returned to the input where intermodulation due to the non-linearities produces new components at the fundamental frequency. These are equivalent to a phase-shift in the fundamental and have the same effect in shifting the frequency of oscillation as would any other phase shift. The amplitude control mechanism is essentially a negative feedback system in which some property of the output amplitude is sensed, used to modify the feedback and hence to set the amplitude to a desired level. The first two networks contain elements whose resistance is temperature- and hence dissipation-sensitive. Their time constant is made long compared with the oscillation frequency. Amplitude then settles to a value at which the heating effect (r.m.s. dependent) brings the element resistance to a level at which the oscillation is self-sustaining.

The r.m.s. methods involve elements that consume power and have of necessity a slow response. When to these factors the relatively high cost and possible temperature dependence are added, alternative solutions become increasingly attractive. The condition for sustained oscillation at constant amplitude is that the loop gain be identically unity. When a non-linear network is included in the feedback loop then the loop gain can exceed the critical value at low amplitude ensuring that oscillation build up. As amplitude increases the signal forces the non-linear elements into regions of their characteristics where the loop gain falls to less than unity. The amplitude stabilizes such that the mean value of the loop gain is at the critical level. Stabilizing action is instantaneous in that there are no time-constants involved other than strays. Disadvantage of the method is that it achieves its affect by deliberately distorting the feedback signal, though the remainder of the circuit may attenuate the harmonics as they pass through the frequency dependent network. The most common technique places a symmetrical pair of diodes (or series connected back-to-back zener diodes) so as to increase the feedback at higher amplitudes. A field-effect transistor having a low dynamic impedance at low voltages and then going into current limit would have the same effect placed in the other limb.

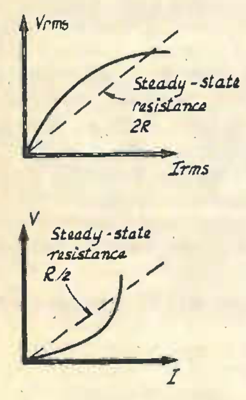
A third method combines some of the advantages of the previous two. It uses only electronic devices, consumes negligible power and can introduce negligible distortion. It has the disadvantage that a deliberate time constant has to be introduced into the sensing action, though this time constant can be varied to suit the oscillation frequency (a property not shared by thermistors of lamps whose thermal time constants must be long compared with the period of the lowest desired oscillation frequency). The output is peak-rectified and the direct voltage is applied to the gate of a field-effect transistor. The on-resistance of the drain-source path is varied and can form part of a potential-divider feedback loop. As shown the positive peaks generate a positive voltage that reverse biases the p-channel f.e.t. The value of r_{on} increases and with it the feedback. Because the f.e.t. characteristic is non-linear it can only be used directly with very small voltage swings – preferably $<V_P/10$ where V_P is the pinch-off voltage. With additional direct feedback across the f.e.t. as shown it is found that the linearity is markedly improved. The resistance across the capacitor is a compromise between speed of response and distortion; increased ripple worsens the second and is caused by attempting to improve the first.

The methods above have the amplitude sensing mechanism in the passive network, the assumption being that the amplifier is perfectly linear. It is equally feasible to incorporate the non-linearities in the forward path i.e. in the amplifier. The disadvantage is that the harmonics are then fully present at the output, the filtering due to the RC network only being effective in reducing the distortion present at the input. In both cases the distortion is minimized by arranging the loop-gain for small signals to be only slightly greater than that required to sustain oscillation. This reduces the non-linear excusions needed to bring the overall gain back to unity and hence reduces the distortion. If the non-linearities are symmetrical about the quiescent point then even harmonics are suppressed.

None of the above examples demand high-Q passive networks as the distortion introduced via the non-linearities or the sensing mechanisms need not be large. These methods are thus acceptable for simple RC oscillators even though the attenuation of harmonics offered by these networks is relatively small. With LC oscillators or certain RC oscillators based on high-Q active filters the constraint is removed. If a high-Q band-pass circuit is driven by a square wave whose fundamental frequency is the filter centre frequency, then the harmonics are so reduced at the output that an almost pure sine-wave results. It is difficult to maintain the drive frequency at the filter centre frequency since each is subject to the usual tolerances. If instead the filter output is passed through a squaring circuit then its input is a square-wave of the appropriate frequency and constant amplitude. Provided the filter gain at the centre-frequency is constant then the constant amplitude square wave ensures an equally stable sinusoidal output. The square wave can be obtained either by a simple diode limiter or with greater accuracy using a comparator with precision clipping. Antiphase feedback with diodes in the forward path of an amplifier are also found.

Amplitude sensing and control

THEORY



● Networks are used as amplitude-controlled negative feedback. At low amplitudes the steady-state resistance is >2R for the thermistor or <R/2 for the lamp. Hence feedback <1/3 and for standard Wien type oscillators the amplitude increases. Conversely at high amplitudes the feedback >1/3 and amplitude decays, stabilizing at the steady state level where the negative feedback just balances the positive feedback.

● These methods are mostly used where only approximate amplitude limiting is required, though they are instantaneous in their action while using little power. The non-linearity makes analysis difficult.

● The f.e.t. drain current $I_B=k[(V_{GS}-V_p)V_{DS}-V_{DS}^2/2]$
For $V_{DS}\to 0$, $I_D\to k(V_{GS}-V_p)V_{DS}$ i.e. conductance

$$\frac{I_D}{V_{DS}}\to k(V_{GS}-V_p)$$

and is a linear function of the gate-source voltage. Hence varying the gate-source bias varies the conductance and hence the feedback.

For the second circuit

$$V_{GS}=\frac{V_{DS}+V_C}{2}$$

Substituting for V_{GS} in the expression for I_D above

$$I_D=k\left[\left(\frac{V_{DS}+V_C}{2}-V_p\right)V_{DS}-\frac{V_{DS}^2}{2}\right]$$

$$=k\left(\frac{V_C}{2}-V_p\right)V_{DS}$$

Hence the conductance

$$\frac{I_D}{V_{DS}}=k\left(\frac{V_C}{2}-V_p\right)$$

and is linear for all values of V_{DS} while being a linear function of the new control voltage V_C. This modification allows control of the feedback without introducing any additional distortion into the system.

● For a second-order transfer function $v_o=k_o+k_1v_i+k_2v_i^2$ and a sinusoidal input $v\sin\omega t$ the output becomes

$$v_o=k_o+k_1v\sin\omega t+k_2v^2\sin^2\omega t$$

$$=k_o+k_1v\sin\omega t+\frac{k_2v^2}{2}(1-\cos 2\omega t)$$

Hence there is a second harmonic term in the output which expressed as a percentage of the fundamental term is proportional to the amplitude of the latter. Similarly higher-order terms result in higher harmonics, the absence of the nth harmonic in the output indicating the absence of the nth order term in the transfer function. Symmetrical transfer functions are preferred in that the even-order harmonic terms are thereby cancelled so that the lowest harmonic is the third harmonic.

EXAMPLES

1. A thermistor has a maximum permitted dissipation of 3mW and sets the output of a Wien bridge oscillator to 1V r.m.s. Choose a suitable value of resistor to complete the bridge.

With 1V r.m.s. total voltage, thermistor has p.d. of ≈2/3V r.m.s. assuming a high gain amplifier.

$$\therefore I=\frac{3.10^{-3}}{2/3}=\frac{9.10^{-3}}{2}=4.5\text{mA r.m.s.}$$

$$\therefore \text{Series resistor } R=\frac{1/3}{4.5\cdot 10}=\frac{10^3}{13.5}=74\Omega$$

A suitable resistor might be 100Ω, to keep the thermistor well below its maximum dissipation.

2. At what output voltage does diode conduction commence in the simple diode amplitude control circuit?

Diode voltage at which current flow commences ~0.5V. But diode voltage is 2/3 of peak output

$$\therefore \text{Output voltage}\sim\frac{3}{2}\times 0.5\text{V}$$

$$\therefore \text{R.m.s. output voltage}=\sqrt{2}\cdot\frac{3}{4}=1.08\text{V r.m.s.}$$

In practice higher values are required since this level corresponds to only slight conduction, barely modifying the amplitude response and requiring critical resistor adjustments.

3. The peak sensing circuit has R=1MΩ. If the frequency of oscillation is 1kHz, and the ripple across the capacitor is not to exceed 2% peak-peak, choose the corresponding capacitance.

For small ripple, then as in simple recifier theory linear discharge is a reasonable assumption

$$\therefore \frac{\Delta V}{\Delta t}=\frac{I}{C} \quad\text{and } I\approx\frac{V}{R}$$

$$\therefore \frac{\Delta V}{V}=0.02=\frac{t}{CR}=\frac{10^3}{G.10^6}$$

$$C=\frac{10^{-9}}{0.02}=50\text{nF}.$$

4. The ringing resonant circuit uses a filter with Q=10 a centre-frequency gain of 20 and an approximate square-wave of 1.2V peak-peak. Determine the % 3rd harmonic at the filter output.

For square-wave of amplitude 1.2V peak-peak, the fundamental and 3rd harmonic amplitudes are

$$\frac{4}{\pi}\times 0.6 \text{ and } \frac{4}{3\pi}\times 0.6$$

$$\therefore \text{Fundamental output } 20\times\frac{4}{\pi}\times 0.6$$

$$T_v=\frac{Hs}{s^2+\frac{\omega_n}{Q}s+\omega_n^2}$$

with Q=10 and $\frac{HQ}{\omega_n}=20$, i.e. $H=20\omega_n$

At $\omega=3\omega_n$

$$T=\frac{2\omega_n\cdot j\cdot 3\omega_n}{-9\omega_n^2+\frac{3j\omega_n^2}{10}+\omega_n^2}$$

$$=\frac{6j}{-8+0.3j}\approx 0.75j$$

$$\left|\frac{T_{\omega=\omega_n}}{T_{\omega=3\omega_n}}\right|=\frac{20}{0.75}\approx 27$$

$$\therefore \%\text{ 3rd harmonic}=\frac{1}{27}\times\frac{1}{3}\times 100\approx 1.2\%$$

NEW PRODUCTS

Cassette deck

Parts subject to wear have been kept to a minimum by eliminating belt drives, pulleys, friction clutches and mechanical brakes in a cassette recorder, designed by Revox, called the B710. These parts are avoided by using four direct-drive motors, two Hall commutated magnetic-disc drive motors with inductive tacho generators for the capstans and two optical tacho-controlled tape-hub motors. Separate p.l.l. circuits with a common, crystal-based reference are used to control the capstan motor speeds. Damped solenoids engage the Sendust/ferrite heads and lock the cassette in position, and the whole drive mechanism is co-ordinated by a microprocessor to afford maximum protection to the tape. A four-digit display doubles as time-clock/timer readout and tape-position indicator, and has provisions for electronic set, cancel and recall of values for both functions. Bar-type l.e.d. indicators display the peak recording level. This recorder is designed for professional use and switching for equalization, changeover, bias, muting and Dolby is electronic to avoid noise. F.W.O. Bauch Ltd, 49 Theobold St, Borehamwood, Herts.

WW301

Data conversion kit

A data conversion evaluation kit for engineers wishing to assess analogue-to-digital and digital-to-analogue converters for a certain application is offered by Celdis. This kit, designed by Ferranti, costs £28 and comprises two 10-bit a-to-ds, six 8-bit d-to-as, two 8-bit a-to-ds and two 8-bit d-to-a/a-to-ds with all the relevant data in folder form. The latter devices require only a comparator and a gate and clock signal to change their operation from d-to-a to a-to-d. Celdis, 37 Loverock Rd, Reading, Berks RG3 1ED.

WW302

Colour printer

Printouts in seven colours can be produced using the CX80 matrix printer from Integrex. Each of these colours, four of which are produced by mixing the three primary colours of the ribbon, is selected by one of seven control codes. In addition to 96 ASCII and 64 graphics characters in r.o.m. there are 15 characters which can be programmed by the user and facilities for producing elongated and reversed characters. Line and form feed are also programmable. Needle addressing allows graphs, logos, teletext and other graphics to be printed in colour. The CX80 uses tractor feed paper up to 10in wide and can produce 80 columns, 60 dots/in and print rates of 150ch/s max. Normal characters have a 5×7 dot matrix and graphics characters a 6×7 matrix. A Centronics interface is standard, but other interfaces are available for the TRS-80, Apple II and for RS-232C, 20mA and IEEE 488. The price is £895 + v.a.t. Integrex Ltd, Church Gresley, Burton on Trent, Staffs DE11 9PT.

WW303

Fibre-optic interfaces

A pair of small fibre-optic interfaces called SEC10-1 can be used to transmit digital data optically over distances in excess of 1km and at data rates of up to 15Mbit/sec. These modules, one a transmitter and one a receiver, are manufactured by Lightdata and measure 30×20×15mm without the fibre-optic connector. The transmitter module operates on a 5V supply, but the receiver can be operated on 4.5 to 12V, to give a t.t.l., d.t.l. or c.m.o.s.-compatible output. Connection is by four wire-wrap pins in d.i.l. formation on the base of each module. Fibre-optic cable can also be supplied by this company to provide a complete data transmission system with a bit error rate of better than 1 in 10^9. Lightdata Fibre Optic Communications, 129 Lindsey St, Epping, Essex CM16 6RE.

WW304

Computer interfacing a-to-d

Analogue input data from sensors is processed to provide digital I/O data, for use with any computer or terminal which has a 20mA or RS-232C port, by the μMAC-4000 measurement and control system from Analog Devices. This system consists of a single 241×330mm board which provides sensor-signal conditioning, analogue multiplexing, analogue-to-digital conversion, digital I/O, serial communications and a p.s.u. Up to four of these boards, each of which accepts 4, 8 or 12 analogue inputs, can be used together to provide 48 channels: expansion boards can be used to allow up to 384 channels. A variety of isolating and non-isolating signal-conditioning modules which plug directly into the p.c.b. are available for voltage and current sensing and for direct connection to thermocouples, r.t.ds (resistance temperature detectors), strain gauges, etc. For control functions, eight t.t.l.-compatible outputs and eight t.t.l. or optically isolated inputs are provided on each board. Conditioned signals are processed by a low-drift, programmable-gain amplifier and 13-bit, integrating a-to-d converter. An 8085 processor with 6K r.o.m. and 1K r.a.m. are used to scale, linearize, convert into engineering units and store the converted input data. The data updating rate can be either 15 or 30 channels per second. A full duplex u.a.r.t. receives and transmits data at the serial i/o port over distances of up to 10,000ft from the host computer, using 20mA loops (for baud rates under 600). Baud rates of up to 9600 and odd or even parity are switch selectable and the 20mA interface is isolated to 300V d.c. The two ASCII-based protocols are compatible with assembly and high-level languages. Analog Devices Ltd, Central Avenue, East Molesey, Surrey KT8 0SN.

WW305

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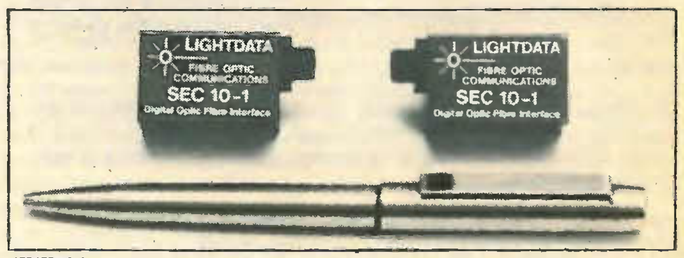

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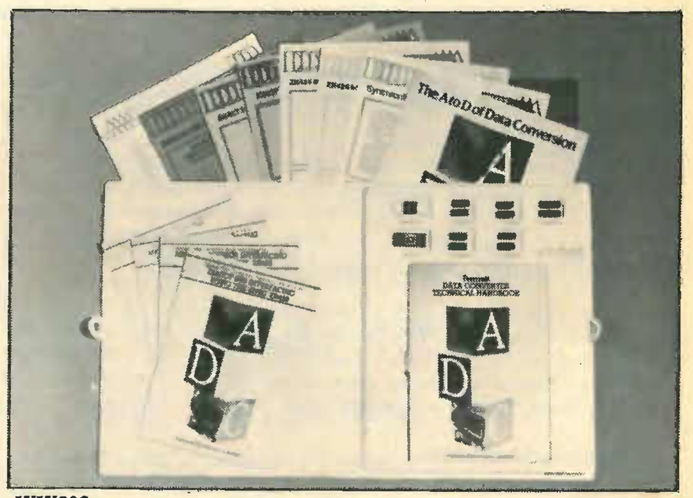

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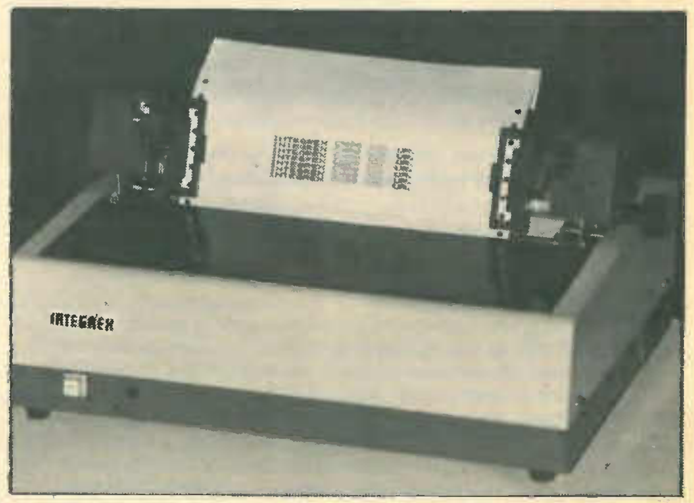


WW303

15in oscilloscope

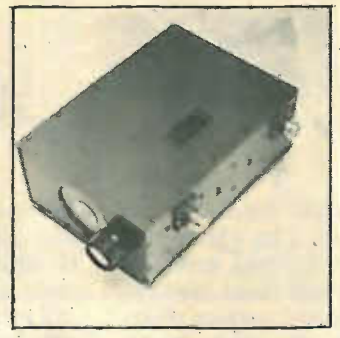
Various face-plates and phosphors are available for the 15in c.r.t. of the 1530 data oscilloscope from Robel Electronics Ltd. This oscilloscope, with its small spot size and high writing speed, can be used in a number of applications, including the monitoring of waveforms from computer-based analysers, radars, sonars and most processing systems, including a.t.e. Slew rates of 0.5μs/cm and one degree phase shift up to 25kHz are quoted for the identical X and Y amplifiers. An internal three-step attenuator, an external continuously variable attenuator, and input impedance selectors are provided for these amplifiers. The Z amplifier, with a rise-time of 30ns, has differential inputs, with voltage ranges from 1 to 10V. A gain/contrast control is also provided. The photo shows the oscilloscope displaying data from an f.f.t. spectrum analyser. Robel Electronics Ltd, Rose Industrial Estate, Cores End Rd, Bourne End, Bucks SL8 5AS.

WW306

Tunable bandpass filters

This series of filters from March Microwave Ltd has octave tuning ranges with direct frequency readout, accurate to ±0.5%. A total frequency range from 30 to 3000MHz is covered by 14 models and a choice of either 2 or 5% relative bandwidth between 3dB points is offered. Insertion loss at any tuned centre frequency is 2.5dB maximum for a 2% unit at 30MHz, and 1dB maximum for a 5% unit at 3000MHz. Attenuation is a minimum of 45dB at two bandwidths away from the centre frequency, and the power-handling capability ranges from 35 to 60W. A single knob with slow-motion gearing is used for tuning and the readout dial is connected directly to the main shaft to avoid backlash. Special models can be constructed with different tuning ranges or steeper attenuation curves if required. March Microwave Ltd, 112 South St, Braintree, Essex.

WW307



Ceramic resonators

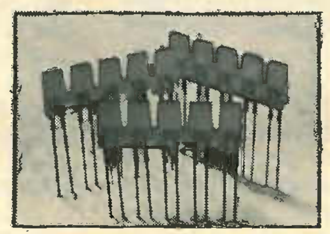
In applications where a timing element is required, cost can often be reduced by using a ceramic resonator instead of a quartz-crystal. Ambit CRM and CFE ceramic resonators are available in the range 200 to 600kHz and drift approximately 0.3% in frequency from −20 to +80°C, with 0.5% drift over 10 years. The CRM type is intended for use as a parallel resonator and the CFE type as a series element for use in bypass and trap applications. Both types are analogous to a quartz-crystal. Prices are 32p each or 19p for 100-up quantities. Ambit International, 200 North Service Rd, Brentwood, Essex CM14 4SG.

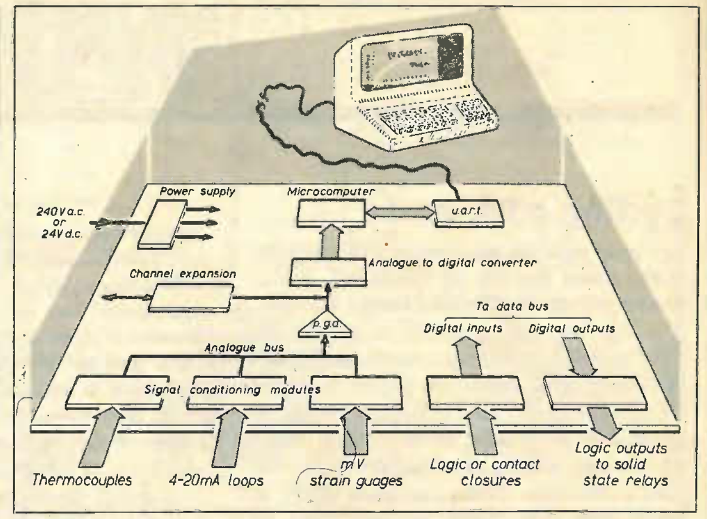
WW308

L.e.d. arrays

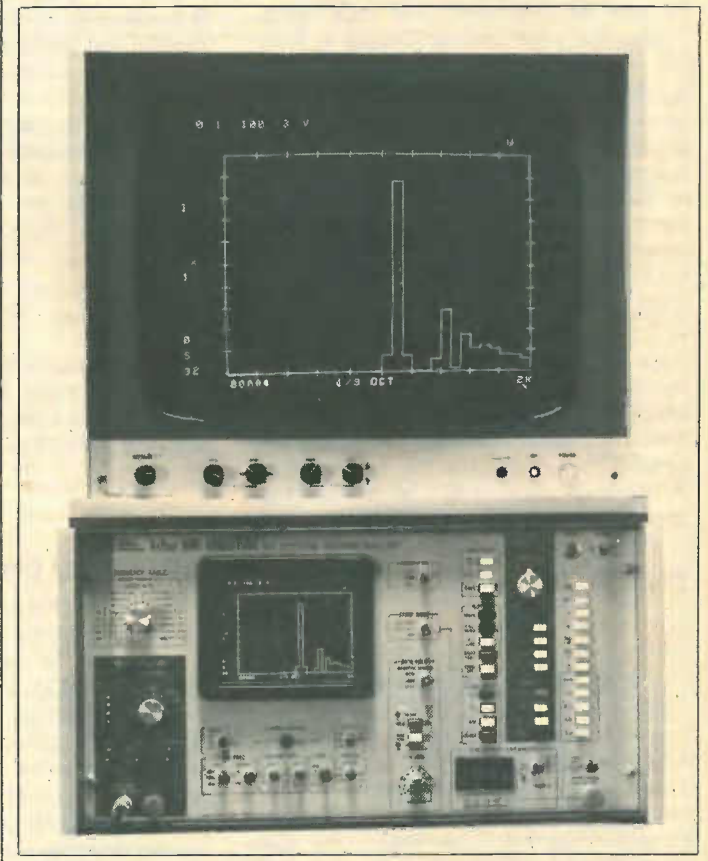
L.e.d. arrays with five or six elements and rectangular faces are manufactured by Impectron Ltd for use as level meter readouts, front panel indicators or simple graphic displays. Each element, measuring 4.5×2mm, is rated at 50mA peak forward current and 2V maximum forward operating voltage, so the GL series arrays can be driven by t.t.l. outputs without buffering. Three one-colour versions, red, yellow or green, and one version with four green and two red elements are available. Luminous intensity varies between 0.2 and 1.7mcd, depending on the colour selected. These l.e.ds are also available in single form. IBR Electronics Group Ltd, Foundry Lane, Horsham, W. Sussex RH13 5PX.

WW309





WW305


WW306

Zero insertion force sockets

Under conditions where occasional field replacement of i.cs is unavoidable the Econo Zip from BFI Electronics can be used. These zero-insertion-force i.c. sockets are designed for production rather than test applications and the usual locking lever is replaced by a screw head. Otherwise, the socket is similar to other such devices on the market but the cost per unit has been kept low. Six versions are available to take 16, 24, 28, 40, 48 or 64 pin i.c.s, and the contacts are gold-plated to 100μm thickness. BFI Electronics Ltd, 516 Walton Rd, West Molesey, Surrey.

WW310

Magnet machining

Permanent magnets from stock or supplied by the customer can be machined by Magnet Developments Ltd. Their factory, they say, is equipped with slitting, slicing and spark-erosion machines, geared to machine and cut permanent magnets accurately for prototypes or short production runs. The range of magnets stocked by the company include sintered and bonded rare-earth types, sintered and flexible ferrites and cast-alnico types. A design advisory service is also available to customers. Magnet Developments Ltd, Unit 7, Headlands Trading Estate, Swindon, Wilts SN2 6JQ.

WW311

SIDEBANDS

By Mixer

Cycling stille hertz

My heart-rending experience with the bike (Feb. issue) did not go unnoticed. Keith Matthews, of the Wessex District Cyclists' Touring Association, writes to tell me not to be so lily-livered and to have another go (although he is much too polite to put in those words). It's all my fault, it seems – something to do with my not being "bike fit" and not having anything better to ride than a Moulton. Well, I'm quite ready to agree with him about my not being in shape for this sort of thing, but I always thought Moultons were nice little bikes. Maybe that's the trouble: I ought to have one of those spidery contraptions with a saddle like an emaciated razor blade and handlebars bent down to somewhere near the front hub.

I am considerably encouraged, however, by Mr Matthews' assertion that most car drivers will give way to a bikie (I am informed that I cannot be a cyclist until I graduate – maybe by riding the three miles without my feet touching the ground or being provoked to personal abuse) because they realise that if they hit you, you will probably bleed all over the paintwork, which will mean a visit to the car wash, a matter of some inconvenience and expense.

The real point of his letter was not, however, all the above, but was contained in the last sentence. He assumes that I shall take up my cycling career again after its disastrous start, and will want to try the bike computer this all started with in the February issue. When I do, he says, I shall discover that it is unreliable *above 30m.p.h.* (my italics). That, I think, adequately demonstrates the gulf that separates us bikies from real cyclists. Thirty miles an hour! Come now, Mr Matthews, I had in mind a rather more sedate progress than that. They used to say that people would suffocate and die at speeds over 20m.p.h., and for all I know, they could be right. No, as long as I go fast enough to avoid the danger of falling off sideways, I reckon that's enough for anyone. I have no ambition to achieve the yellow jersey to go with the plaster and bandages that would be the certain result of my travelling at 30m.p.h.

Thing-um-a-jig

O frabjous day! Calloo! Callay! The dual snubberless Schottky is with us!

I do beg your pardon – I was so overcome by the arrival of a bit of paper announcing the availability of the d.s.S. that I felt a little outgrabing of the old momerath was permissible. But it's all right – I'll stop now, or Ed. will vorpal the page right here.

Isn't it lovely, though? Anyone whose imagination is untouched by a chance to use a dual snubberless Schottky must be a cold fish indeed, I should think. Not just one, mark you, but a dual package of the frumious little beasts. Now that they're here, and not before time, if you ask me, we've got to find something really beamish to do with them, before some dreadful old square writes in to say they're intended as rectifiers, or some such earthbound fate.

It doesn't need much thought to see that a dual snubberless Schottky is not a device you can tie down to anything too specific. It needs a free rein – to be allowed to breathe and develop in an atmosphere of (Oh, look, is there going to be a lot more of this? Ed.)

You have no idea how frustrating this job can be sometimes. I was only going to say that a d.s.S. could be the very thing for one of those electronic games, maybe Hunting the Snark, each player being armed with a paddle-controlled vorpal blade. Every time a v.b. went 'snickers-nack' the d.s.S. would light up, or something.

Well, it's only a thought. You can't give a device a name like dual snubberless Schottky and expect people to use it for anything too serious.

Spoilt by choice

I've been watching the domestic television recording scene for some time now (video, it appears to be called, for some reason) with the kind of feelings I would expect Neanderthal Man to have experienced when confronted by an array of arrow heads down at the stonemonger's. All he wanted was a couple of dozen plain, ordinary arrowheads for the start of the bronto-shooting season and here was this character offering him umpteen models to fit different shaft sizes: all equally well chipped, mind you, but totally incompatible. Manners were fairly elementary then, of course, and for such an act of thoughtlessness, Neanderthal was quite likely to split the stonemonger down the middle and use his skin for trousers, appeals to his better nature notwithstanding. Headstrong, they were, in those times, and direct to the point of rudeness.

Time has had its effect on *Homo sapiens* and I'm not sure that a bit more directness wouldn't be a bad thing, particularly when dealing with all these clever people who keep on inventing video tape recorders and video disc players that do more or less the same job but are just different enough to prevent you using the software from one machine on another. I don't for a moment think that they are deliberately contemptuous of the public's needs and wishes: in fact, I don't even think they give much thought to the public's needs and wishes, apart from the need to 'create' a market and persuade people to buy their wares. If they happen to think that their electronic equivalent to the arrow shaft should be ¼in in diameter, they'll go ahead and make millions of arrows to fit, regardless of the fact that someone else is making them ⅝in in diameter, and has been for years.

It's no good at all saying that it's up to the buyer to make his mind up: how many people who simply want to record the television Shakespeare canon or transfer *Nationwide* to a more convenient time are in a position to make a difficult technical choice between the different v.c.rs? And how many will be able to decide between the three methods of reading a video disc, or realise that you can't play Philips discs on a JVC player, while all the time considering the claims of several firms to have the best disc library?

Quiet, please! It's breakfast time

When I was a bit younger, I used to have a finely tuned timetable in the morning. Everything was worked out to the nearest couple of microseconds, and a few seconds spent in putting a new blade in the razor, or a serious lapse in concentration resulting in the soap getting itself lost in the bathwater could cause havoc. Many's the time I've been ejected from the house without a second cup of coffee.

I've relaxed a bit, now. For one thing, I don't have to drive my wife to school since she gave up teaching and, for another, I've learned more sense. The move to Sutton has helped, too. I now take my mornings very gently, luxuriating over a leisurely bath, savouring a proper breakfast and invariably having a second cup of coffee.

Even so, taking all this gracious living into account and making due allowance for the need to keep abreast of world affairs, I can see no possibility of television getting a look in at that time in the morning. There are many things I want from life, but television with my crispy bacon and scrambled eggs is not one of them. As far as I am concerned, thanks, but no thanks, particularly if there are to be any of those indecently vivacious commercials for orange juice, or Snappaflakes, or whatever. And what of the news itself? Most of it is quite bad enough when printed in a newspaper, but spoken right out loud, just like that, by a television person – well, it's enough to curdle the milk.

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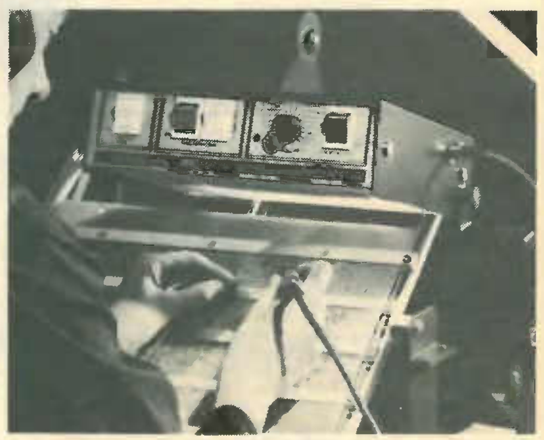

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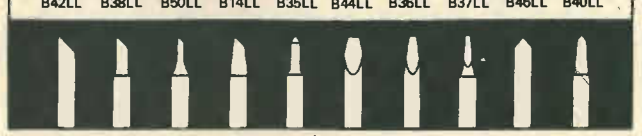

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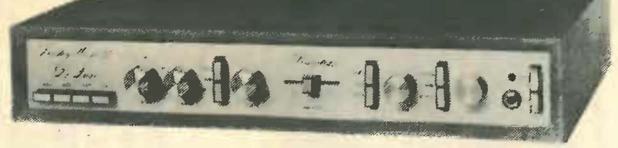


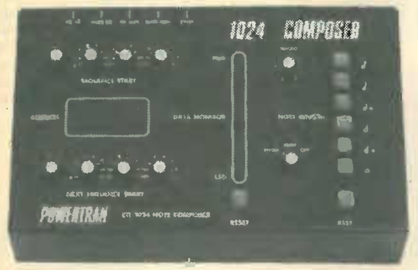
DE LUXE EASY TO BUILD LINSLEY HOOD 75W STEREO AMPLIFIER £85.00 + VAT

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

T20 + 20 20W STEREO AMPLIFIER £33.10 + VAT

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

Above 2 kits are supplied with fully finished metalwork, ready assembled high quality teak veneer cabinet, cable, nuts, bolts, etc. and full instructions — in fact everything!



1024 COMPOSER

COMPLETE KIT ONLY £89.50 + VAT!

READ ALL ABOUT IT! IN ELECTRONICS TODAY INTERNATIONAL

Programmed from a synthesizer, our latest design to be featured in ELECTRONICS TODAY INTERNATIONAL the 1024 COMPOSER controls the synth. with a sequence of up to 1024 notes or a large number of shorter sequences e.g. 64 of 16 notes all with programmable note length. In addition a rest or series of rests can be entered. It is mains powered but an automatically trickle charged Nickel-Cadmium battery supplying the memory, preserves the program after switch off. The kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. — Complete down to the last nut and bolt!

POWERTRAN

BLACK HOLE CHORALIZER

The BLACK HOLE designed by Tim Orr, is a powerful new musical effects device for processing both natural and electronic instruments, offering genuine VIBRATO (pitch modulation) and a CHORUS mode which gives a "spacey" feel to the sound achieved by delaying the input signal and mixing it back with the original. Notches (HOLES), introduced in the frequency response, move up and down as the time delay is modulated by the chorus sweep generator. An optional double chorus mode allows exciting antiphase effect to be added. The device is floor standing with foot switch controls. LED effect selection indicators, has variable sensitivity, has high signal/noise ratio obtained by an audio compander and is mains powered — no batteries to change! Like all our kits everything is provided including a highly superior, rugged steel, beautifully finished enclosure.

COMPLETE KIT ONLY £49.80 + VAT! (single delay line-system)
De Luxe version (dual delay line system) also available for **£59.80**+VAT

Cabinet size 10.0" x 8.5" x 2.5" (rear) 1.8" (front)

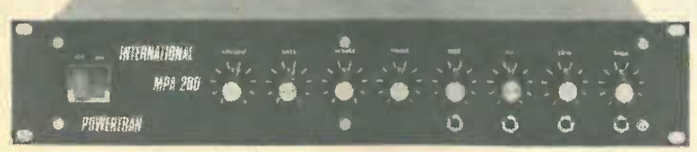
CHROMATHEQUE 5000 5 CHANNEL LIGHTING EFFECTS SYSTEM

This versatile system featured as a constructional article in ELECTRONICS TODAY INTERNATIONAL has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound-to-light or have it strobe all the lights at a speed dependent upon music level or front panel control or use the internal digital circuitry which produces some superb random and sequencing effects. Each channel handles up to 500W and as the kit is a single board design wiring is minimal and construction very straightforward. Kit includes fully finished metalwork, fibreglass PCB controls, wire, etc. — Complete right down to the last nut and bolt!

MPA 200 100 WATT (rms into 8Ω) MIXER/AMPLIFIER

Panel size 19.0"×3.5". Depth 7.3"

Featured as a constructional article in ETI, the MPA 200 is an exceptionally low priced — but professionally finished — general purpose high power amplifier. It features adaptable input mixer which accepts a wider range of sources such as microphone, guitar, etc. There are wide range tone controls and a master volume control. Mechanically the MPA 200 is simplicity itself with minimal wiring needed making construction very straightforward.
The kit includes fully finished metalwork, fibreglass PCBs, controls, wire, etc — complete down to the last nut and bolt.



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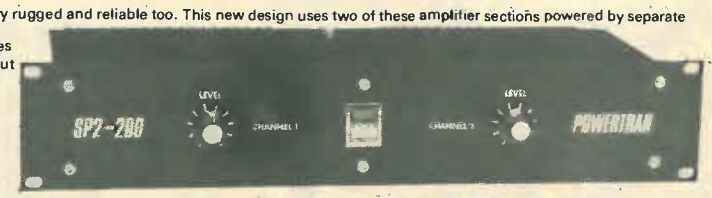
The power amplifier section of the MPA 200 has proved not only very economical but very rugged and reliable too. This new design uses two of these amplifier sections powered by separate power supplies fed from a common toroidal transformer. Input sensitivity is 775mV.
Power output is 100 rms into 8 ohm from both channels simultaneously. The kit includes fully finished metalwork, fibreglass PCBs, controls, wire, etc—complete down to the last nut and bolt!



COMPLETE KIT ONLY £64.90 + VAT!

Panel size 19.0" × 3.5". Depth 7.3"

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HY120


HY60

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Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
MOS120	60W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£25.88 + £3.88
MOS200	120W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£33.46 + £5.02

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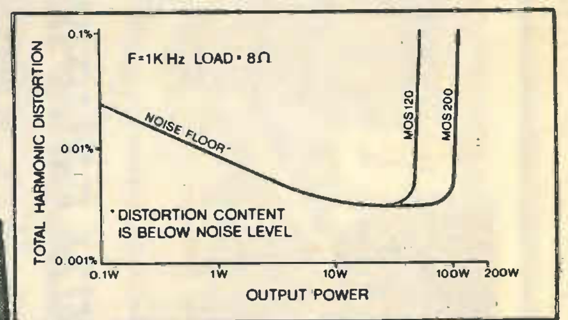

Load impedance both models 4Ω-∞ Input sensitivity both models 500mV
Input impedance both models 100KΩ Frequency response both models 15Hz-100KHz – 3dB

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(Standard O~P Transistors)

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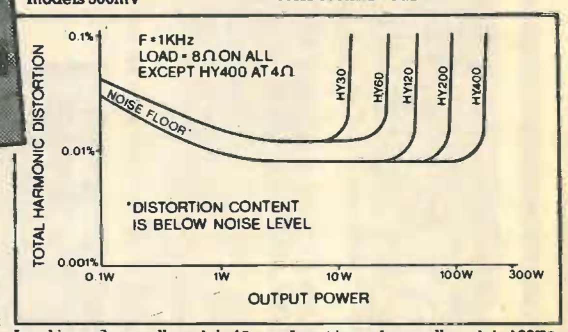
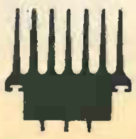
Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
HY30	15W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£7.29 + £1.09
HY60	30W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£8.33 + £1.25
HY120	60W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£17.48 + £2.62
HY200	120W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£21.21 + £3.18
HY400	240W into 4Ω	0.01%	15V/μs	5μs	100dB	£31.83 + £4.77



Load impedance all models 4Ω-∞ Input sensitivity all models 500mV
Input impedance all models 100KΩ Frequency response all models 15Hz-50KHz – 3dB



THE NEW PROFILE EXTRUSIONS
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NEW PRE-AMPS

COMPATIBLE WITH ALL ILP MODULES

HY6 (mono) and **HY66** (stereo) are new to I.L.P's range of advanced audio modules. Their improved characteristics and styling ensure their being compatible with all I.L.P power-amps both MOSFET and BIPOLAR, giving you chance to get the best possible reproduction from your equipment. HY6 and HY66 pre-amps are protected against short circuit and wrong polarity. Full assembly instructions are provided. Mounting boards are available as below.
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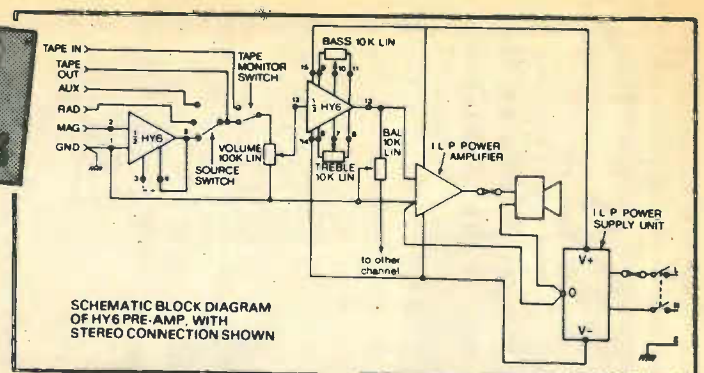
Active Tone Control circuits provide ±12dB cut and boost.
Inputs Sensitivity – Mag. PU. –3mV: Mic – selectable 1-12mV: All others 100mV. **Tape O/P** – 100mV: **Main O/P** – 500mV: **Frequency response** – D.C. to 100KHz – 3dB.

HY6 mono £6.44 + 97p VAT Connectors included
HY66 stereo £12.19 + £1.83 VAT Connectors included

B6 Mounting Board for one HY6 78p + 12p VAT
B66 Mounting Board for one HY66 99p + 15p VAT



SCHEMATIC BLOCK DIAGRAM OF HY6 PRE-AMP, WITH STEREO CONNECTION SHOWN

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PSU30 ± 15V at 100mA to drive up to 12 x HY6 or 6 x HY66 — **£4.50** + 0.68p VAT
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PSU36 for use with 1 or 2 HY30's — **£8.10** + £1.22 VAT
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PSU60 for use with 1 HY120 — **£13.04** + £1.96 VAT
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S-2020TA STEREO TUNER/AMPLIFIER KIT

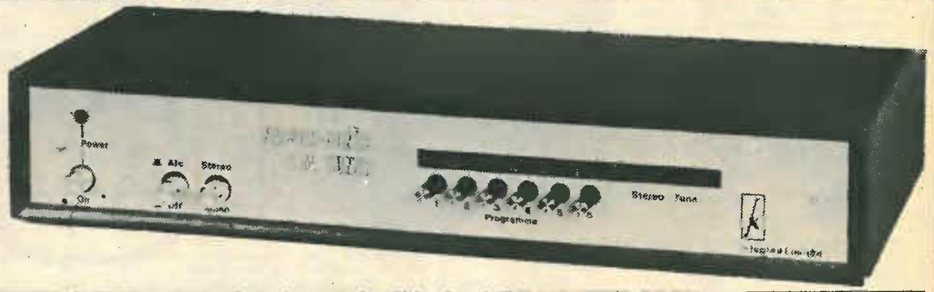
NEW HIGH PERFORMANCE TUNER

A high-quality push-button FM Varicap Stereo Tuner with pilot cancel decoder combined with a 24W r.m.s. per channel Stereo Amplifier, using Bifet op. amps.

Brief Spec. Amplifier Low field Toroidal transformer, Mag. input. Tape In/Out facility (for noise reduction unit, etc.) THD less than 0·1% at 20W into 8 ohms. **High Slew Rate.** Low noise op. amps used throughout. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses UM 1181 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC pilot cancel, stereo decoder, LED tuning and stereo indicators. Tuning range 88-108MHz 30dB mono S/N @ 0.7μV. THD 0.3%.

PRICE: £69.95 + VAT

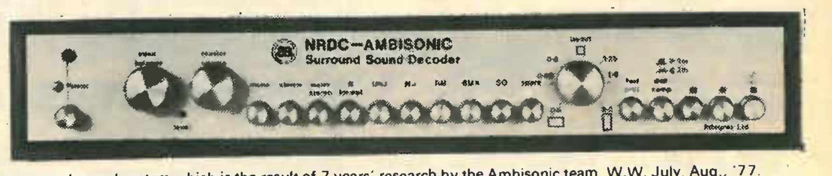
NELSON-JONES Mk. 2 STEREO FM TUNER KIT



A very high performance tuner with dual gate MOSFET RF and Mixer ready built front end, triple gang varicap tuning, linear phase I.F. and 3 state MPX decoder.

PRICE: £74.95 + VAT

NRDC-AMBISONIC UHJ SURROUND SOUND DECODER



The **first ever** kit specially produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug., '77.
The unit is designed to decode not only UHJ but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC HJ. 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit.
Complete with mains power supply, wooden cabinet, panel, knobs, etc.

Complete kit, including licence fee **£57.70** + VAT or ready built and tested **£76.95** + VAT

S5050A STEREO AMP

Very high performance kit

50 watts rms-channel. 0.015% THD. S/N 90 dB. Mags/n 80 dB. Output device rating 360w per channel.
Tone cancel switch. 2 tape monitor switches. Metal case — comprehensive heatsinks.

Complete kit only **£69.95** + VAT

(Also available our 20w/ch BIFET S2020 Amp)

INTRUDER 1 Mk. 2 RADAR ALARM

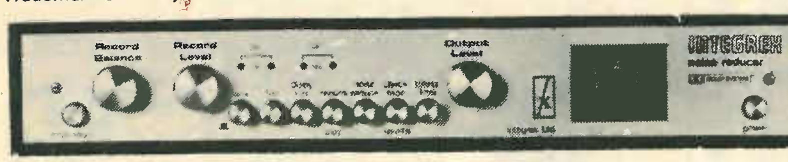
With Home Office Type approval

The original "Wireless World" published Intruder 1 has been re-designed by Integrex to incorporate several new features, along with improved performance. The kit is even easier to build. The internal audible alarm turns off after approximately 40 seconds and the unit re-arms. 240V ac mains or 12V battery operated. Disguised as a hard-backed book. Detection range up to 45 feet. Internal mains rated voltage free contacts for external bells etc.

Complete kit **£52.50** plus VAT, or ready built and tested **£68.50** plus VAT.

Wireless World Dolby noise reducer

Trademark of Dolby Laboratories Inc.



Typical performance
Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)
Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%
Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output
Dynamic range >90dB
30mV sensitivity

Complete Kit **PRICE: £49.95** + VAT (3 head model available)

Also available ready built and tested .... Price £67.60 + VAT
Calibration tapes are available for open-reel use and for cassette (specify which) .... Price £2.75 + VAT
Single channel plug-in Dolby (TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts and all components .... Price £10.50 + VAT

We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?

All kits are carriage free

Please send SAE for complete lists and specifications

INTEGREX LIMITED

Portwood Industrial Estate, Church Gresley, Burton-on-Trent, Staffs DE11 9PT
Burton-on-Trent (0283) 215432 Telex 377106

LANGREX SUPPLIES LTD

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RST Tel: 01-677 2424 Telex: 946708 RST

SEMICONDUCTORS

Type	Price
AA119	0.12
AAY30	0.20
AAY32	0.48
AAZ13	0.17
AAZ15	0.17
AAZ17	0.17
AC107	0.63
AC125	0.29
AC126	0.29
AC127	0.29
AC128	0.35
AC141	0.32
AC141K	0.40
AC142	0.32
AC142K	0.40
AC176	0.35
AC187	0.32
AC188	0.32
ACY17	1.50
ACY18	1.32
ACY19	1.27
ACY20	1.27
ACY21	1.32
ACY39	2.88
AD149	0.86
AD161	0.40
AD162	0.40
AF106	0.40
AF114	0.86
AF115	0.86
AF116	0.86
AF117	0.86
AF139	0.58
AF186	1.15
AF239	0.45
AFZ11	4.00
AFZ12	4.60
ASY26	1.61
ASY27	1.04
ASZ15	1.38
ASZ16	1.27
ASZ17	1.15
ASZ20	2.84
ASZ21	2.88
AU113	2.88
AUY10	3.45
AU110	2.88
BA145	0.15
BA148	0.17
BA154	0.12
BA155	0.13
BA156	0.12
BAW62	0.06
BAX13	0.07
BAX16	0.07
BC107	0.18
BC108	0.18
BC109	0.18
BC113	0.17
BC114	0.17
BC115	0.21
BC116	0.22
BC117	0.26
BC118	0.21
BC125	0.21
BC126	0.31
BC135	0.17
BC136	0.22
BC137	0.22
BC147	0.14
BC148	0.14
BC149	0.15
BC157	0.15
BC158	0.15
BC159	0.15
BC167	0.15
BC170	0.13
BC171	0.12
BC172	0.13
BC173	0.13
BC177	0.32
BC178	0.16
BC179	0.32
BC182	0.35
BC183	0.13
BC184	0.13
BC212	0.13
BC213	0.13
BC214	0.13
BC237	0.13
BC238	0.13
BC301	0.38
BC303	0.39
BC307	0.13
BC308	0.13
BC327	0.14
BC328	0.14
BC337	0.14
BC338	0.14
BCY30	1.44
BCY31	1.73
BCY32	1.73
BCY33	1.27
BCY34	1.15
BCY39	3.01
BCY40	3.22
BCY42	0.35
BCY43	0.35
BCY58	0.22
BCY70	0.20
BCY71	0.21
BCY72	0.20
BCZ11	2.01
BD115	0.48
BD121	1.96
BD123	3.22
BD124	2.30
BD131	0.51
BD132	0.55
BD135	0.46
BD136	0.46
BD137	0.46
BD138	0.55
BD139	0.55
BD140	0.58
BD144	2.30
BD181	1.38
BD182	1.36
BD137	0.62
BD238	0.62
BDX10	1.05
BDX32	2.30
BDY20	1.73
BDY60	3.16
BF115	0.40
BF152	0.18
BF153	0.18
BF154	0.20
BF159	0.20
BF160	0.20
BF167	0.28
BF173	0.35
BF177	0.40
BF178	0.40
BF179	0.40
BF180	0.32
BF181	0.32
BF182	0.35
BF183	0.32
BF184	0.32
BF185	0.35
BF194	0.16
BF195	0.14
BF196	0.15
BF197	0.16
BF200	0.40
BF224	0.29
BF244	0.32
BF257	0.31
BF258	0.31
BF259	0.32
BF336	0.39
BF337	0.38
BF338	0.41
BFS21	4.00
BFS28	2.58
BFS61	0.23
BFS98	0.23
BFW10	1.12
BFW11	1.10
BFX84	0.35
BFX85	0.35
BFX87	0.35
BFX88	0.35
BFY50	0.29
BFY51	0.29
BFY52	0.29
BFY64	0.35
BFY90	1.00
BSX19	0.31
BSX20	0.31
BSX21	0.33
BT106	1.38
BTY79/400R	2.30
BU205	1.50
BU206	1.73
BU208	2.30
BY100	0.46
BY126	0.15
BY127	0.16
BZX61	0.20
Series	
BZY88	0.12
Series	
CRS1/40	0.69
CRS3/06	0.52
CRS3/40	0.86
CRS3/60	1.04
Gex66	1.73
GEX541	5.75
GJ3M	1.73
GM0378A	2.02
KS100A	0.52
MJE340	0.69
MJE370	0.84
MJE371	0.82
MJE520	0.54
MJE521	0.84
MJE2955	1.50
MJE3055	1.27
MPF102	0.40
MPF103	0.40
MPF104	0.40
MPF105	0.40
MPSA06	0.30
MPSA56	0.32
MPSU01	0.81
MPSU06	0.75
MPSU56	0.79
NE555	0.52
NKT401	4.03
NKT403	2.88
NKT404	2.53
OA5	1.38
OA7	0.60
OA10	0.63
OA47	0.14
OA70	0.29
OA79	0.14
OA81	0.20
OA85	0.20
OA90	0.09
OA91	0.09
OA95	0.09
OA200	0.17
OA202	0.17
OA211	1.73
OAZ200	1.73
OAZ201	1.73
OAZ206	1.73
OAZ207	1.73
OC16	2.88
OC20	2.88
OC22	2.88
OC23	4.60
OC24	3.45
OC25	1.15
OC26	1.73
OC28	2.30
OC29	2.30
OC35	1.73
OC36	1.73
OC41	1.04
OC42	1.04
OC43	1.73
OC44	0.98
OC45	0.75
OC71	0.63
OC72	1.15
OC73	1.15
OC74	0.81
OC75	0.75
OC76	1.15
OC77	1.15
OC81	0.75
OC81Z	1.38
OC82	1.04
OC83	0.92
OC84	0.92
OC122	3.16
OC123	2.30
OC139	3.45
OC140	4.00
OC141	4.93
OC170	1.44
OC171	1.44
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OC203	3.45
OC204	3.45
OC205	3.16
OC206	3.16
OC207	2.88
OCP71	2.30
ORP12	1.15
R2008B	2.30
R2009	2.30
R2010B	2.30
TIC44	0.31
TIC226D	1.38
TIL209	0.18
TIP29A	0.49
TIP30A	0.52
TIP31A	0.58
TIP32A	0.41
TIP33A	0.62
TIP34A	0.77
TIP41A	0.51
TIP42A	0.48
TIP2955	0.81
TIP3055	0.64
TIS43	0.40
ZS140	0.29
ZS170	0.24
ZS178	0.62
ZS271	0.20
ZS278	0.65
ZTX107	0.14
ZTX108	0.14
ZTX109	0.14
ZTX300	0.15
ZTX301	0.16
ZTX302	0.21
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ZTX304	0.23
ZTX311	0.15
ZTX314	0.29
ZTX500	0.16
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ZTX502	0.21
ZTX503	0.21
ZTX504	0.24
ZTX531	0.28
ZTX550	0.29
1N914	0.06
1N916	0.10
1N4001	0.07
1N4002	0.07
1N4003	0.07
1N4004	0.08
1N4005	0.10
1N4006	0.13
1N4007	0.14
1N4009	0.08
1N4148	0.05
1N5400	0.15
1N5401	0.15
1S44	0.05
1S920	0.09
1S921	0.30
2G301	1.15
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2G306	1.15
2N404	1.50
2N696	0.37
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2N1306	1.73
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2N1309	1.38
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2N1671	1.73
2N1893	0.37
2N2147	4.60
2N2148	4.31
2N2218	0.37
2N2219	0.37
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2N2221	0.23
2N2222	0.23
2N2484	0.64
2N2368	0.29
2N2369A	0.29
2N2484	0.29
2N2646	0.58
2N2904	0.37
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2N2906	0.24
2N2907	0.24
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2N3440	0.81
2N3441	0.86
2N3442	1.44
2N3614	2.53
2N3702	0.13
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2N3819	0.35
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2N3823	0.69
2N3866	1.15
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2N4061	0.18
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2N4124	0.18
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2N4286	0.17
2N4288	0.21
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2N5457	0.37
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2S017	11.50
2S019	13.80
2S026	28.75
2S103	1.73
2S302	2.30
2S303	1.73
2S322	4.03
2S324	4.03
2S701	2.30
2S745A	1.00
2S746A	1.00

VALVES

Type	Price
A1834	10.35
A2087	13.58
A2134	20.13
A2293	8.62
A2426	17.63
A2521	34.38
A2900	14.43
A3343	25.56
AZ31	1.26
AZ41	1.32
BK448	110.27
BK484	149.09
BS90	52.27
BS810	35.24
BT5	58.13
BT17	106.00
BT19	36.17
BT29	327.00
BT69	335.50
BT75	102.46
BT95	127.02
CBL31	2.30
CL33	2.30
CY31	1.15
C1K	21.30
C3A	11.20
C3JA	23.23
DA41	21.50
DA42	12.30
DA100	112.62
DAF91	0.46
DAF96	1.15
DET22	32.78
DET24	52.90
DF91	0.46
DF96	1.15
DK91	1.21
DK92	1.44
DK96	1.26
DL92	1.26
DL94	1.38
DL96	1.26
DLS10	9.45
DLS15	12.37
DLS16	12.37
DLS19	12.37
DM70	1.44
DM71	1.44
DM160	3.45
DY87	0.74
DY802	0.96
E55L	25.17
E80CC	10.13
E80CF	12.96
E80F	14.19
E80L	11.33
E81CC	6.62
E81L	14.06
E82CC	7.03
E83CC	7.18
E86C	12.48
E88C	7.12
E88CC	3.86
E90CC	9.90
E90F	10.38
E91H	5.34
E92CC	9.40
E99F	10.16
E130L	19.39
E180CC	8.86
E180F	7.86
E182CC	9.90
E186F	12.58
E188CC	6.40
E280F	25.68
E283CC	9.02
E288CC	18.54
EA52	23.00
EA76	2.30
EABC80	1.38
EAC91	0.92
EAF42	1.44
EAF801	2.02
EBC41	1.44
EB91	1.01
EBC33	2.02
EB41	1.44
EBC81	1.26
EBC90	0.97
EBF80	0.58
EBF83	1.44
EBF89	0.97
EBL21	2.88
EBL31	2.30
EC90	1.38
EC91	8.60
EC92	1.44
EC157	310.50
ECC33	4.02
ECC35	4.02
ECC40	2.30
ECC81	1.01
ECC82	0.92
ECC83	1.01
ECC84	1.30
ECC85	1.38
ECC86	2.30
ECC88	2.07
ECC89	1.88
ECC91	10.27
ECC189	1.90
ECC807	2.02
ECC808	2.50
ECF80	1.26
ECF82	1.38
ECF86	1.73
ECH35	2.30
ECH42	1.32
ECH81	1.38
ECH83	1.44
ECH84	1.47
ECL80	1.15
ECL81	1.73
ECL82	1.15
ECL83	1.73
ECL84	1.61
ECL85	1.38
ECL86	1.38
EF37A	4.02
EF39	3.16
EF40	2.72
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
EL34	1.38
EL32	1.73
EL33	4.02
EL34TH	2.53
EL34MUI	3.16
EL36	1.84
EL41	1.44
EL42	2.02
EL81	2.88
EL83	4.03
EL84	1.15
EL86	2.88
EL90	1.10
EL91	8.21
EL95	1.61
EL360	9.77
EL500/504	2.16
EL509	5.63
EL821	11.46
EL822	12.55
EM34	3.75
EM80	1.38
EM81	1.15
EM84	1.15
EM85	1.44
EM87	1.73
EN32	10.28
EN91	2.94
EN92	6.18
EN93	2.02
EY51	2.02
EY81	1.80
EY83	2.02
EY84	10.57
EY86	1.38
EY88	2.02
EY500A	2.23
EY802	0.64
EZ35	0.97
EZ40	1.44
EZ41	1.44
EZ80	0.92
EZ81	0.96
EZ90	1.38
FW4-500	2.88
FW4-800	2.88
G1.371K	41.40
GS31K	12.65
G180.2M	18.42
G240.2D	12.65
G400.1K	18.28
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	9.40
M8081	11.50
M8082	9.87
M8083	8.56
M8091	11.50
M8096	4.31
M8097	4.00
M8098	5.50
M8099	5.98
M8100	8.40
M8136	9.75
M8137	9.73
M8140	5.17
M8141	5.52
M8142	7.77
M8144	4.31
M8149	5.98
M8161	9.11
M8162	10.30
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	2.90
M8248	13.32
MU14	1.73
MX119	58.65
MX125	67.85
MX145	58.65
MX151	17.25
MX152	135.70
MX161	166.75
MX163	23.11
MX164	25.88
MX166	142.00
MX168	48.30
N78	10.35
OA2	2.36
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	1.34
PCL86	1.34
PCL805/85	1.34
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	1.38
PL504/5	1.81
PL508	2.07
PL509	3.73
PL519	3.73
PL801	1.27
PL802	3.40
PY33	1.27
PY81	0.97
PY82	0.97
PY83	0.81
PY88	1.01
PY500A	2.07
PY800	0.97
PY801	0.97
QQV02-6	14.44
QQV03-10	4.14
QQV03-20A	20.13
QQV06-40A	47.15
QQV07-50	60.66
QQZ03-20A	50.60
QQZ06-40A	55.10
QU37	14.38
QV03-12	5.13
QV04-7	2.88
QV08-100	122.26
QY3-65	57.08
QY3-125	91.02
QY4-250	70.16
QY4-400	80.44
QY5-500	168.83
QY5-3000A	333.91
QZ06-20	30.48
R10	5.75
R17	1.80
R18	4.80
R19	1.38
R20	1.06
RG3-250	35.77
RG3-250A	37.49
RG3-1250	36.23
RG4-1250	43.93
RG4-3000	80.94
RR3-250	53.54
RR3-1250	94.83
S11E12	40.25
S130	3.45
S130P	4.03
STV280-40	11.50
STV280-80	24.15
SU41	2.88
SU42	10.35
TD03-10	32.78
TD03-10E	32.78
TD03-29F	33.85
TT15	34.50
TT21	14.16
TT22	18.17
TT100	59.51
TY2-125	60.01
TW4-400	74.07
TY4-500	101.44
TY5-500	178.25
TY6-800	161.00
TY6-800	181.70
TY6-5000A	337.51
TY6-5000B	284.50
TY6-5000W	290.96
TY7-6000A	357.40
TY7-6000W	294.33
TZ40	17.25
U18-20	2.88
U19	15.81
U25	1.33
U26	1.66
U37	10.35
UABC80	1.44
UAF42	1.44
UB41	1.44
UBC41	1.73
UBF89	1.38
UCC84	1.38
UCC85	1.38
UCF80	1.32
UCH42	1.38
UCH81	2.07
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	42.04
XG2-6400	113.50
XG5-500	28.52
XG2-6400	106.15
XR1-1600A	38.53
XR1-3200	83.15
XR1-3200A	93.15
XR1-6400	162.81
XR1-6400A	164.33
YD1120	264.50
YD1240	306.62
Z759	19.32
ZM1000	4.93
ZM1001	6.19
ZM1020	10.83
ZM1021	10.17
ZM1022	10.00
ZM1023	8.81
ZM1040	22.30
ZM1041	19.16
ZM1042	20.44
ZM1051	100.05
1B3GT	2.30
1B24	11.50
1B35A	28.75
1B63	57.50
1R5	1.21
1S5	0.46
1T4	0.46
2AS15	11.50
2C39A	21.85
2C43	20.70
2D21	2.94
2E26	15.34
2J42	99.70
2J55	238.97
2J70A	270.25
2J70B	418.34
2K25	40.25
3-400Z	57.50
3-500Z	63.25
3A5	2.70
3B24	9.30
3B28	8.63
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	18.73
3C45	29.18
3CX100A5	23.00
3E29	29.67
3S4	1.26
3V4	1.38
465A	29.15
4-125A	41.09
4-250A	51.80
4-400A	52.05
4B32	29.16
4C35	74.75
4CX250B	31.63
4CX350A	48.88
4X150A	24.41
4X150D	28.75
5B254M	23.12
5B255M	23.12
5C22	74.75
5J180E	1380.00
5R4GY	2.30
5U4G	3.56
5U4GB	2.90
5V4G	1.73
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	3.73
6AS7G	9.49
6AT6	0.96
6AU5GT	4.97
6AU6	1.61
6AV5GA	4.52
6AV6	0.96
6AX5GT	3.57
6B7	1.73
6B8	2.02
6BA6	1.15
6BA7	5.89
6BA8A	4.51
6BC4	4.27
6BC8	4.14
6BH6	1.75
6BJ6	1.24
6BK4	4.84
6BL6	97.75
6BL7GT	4.44
6BM6	97.75
6BN6	1.80
6BQ7A	4.28
6BR7	4.80
6BR8	1.84
6BS7	4.80
6BW6	4.60
6BW7	1.75
6BX7GT	5.70
6BZ6	2.73
6C4	1.01
6CB6A	2.86
6CD6GA	5.83
6CG7	2.62
6CH6	9.78
6CL6	4.12
6CW4	8.63
6D2	1.01
6DK6	3.00
6DQ6B	4.69
6EA8	3.38
6EB8	2.44
6EW6	1.73
6F6	2.02
6F23	1.84
6F28	1.33
6F33	29.90
6H1	14.38
6H2N	1.21
6H3N	1.21
6H6	1.73
6J4	6.10
6J6	6.21
6J7	5.07
6K4N	1.61
6K6GT	1.50
6K7	1.73
6K8	1.61
6KD6	7.31
6L6G	2.88
6L6GA	1.73
6L6GT	2.24
6L6GC	2.85
6L7	2.30
6N2P	1.21
6N3P	1.21
6N7	1.73
6P25	4.14
6Q7	2.53
6R7	2.07
6SA7	1.87
6SC7	1.73
6SF7	1.84
6SH7	1.73
6SJ7	1.84
6SK7	1.50
6SK7GT	3.06
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	1.15
6X5GT	1.84
7B7	1.96
7C5	3.40
7C6	2.00
7H7	2.30
7R7	1.73
7S7	2.88
7Y4	1.84
7Z4	2.13
11E3	60.52
12AT6	1.38
12AT7	1.01
12AU6	2.97
12AU7	0.93
12AV6	2.55
12AV7	4.00
12AX7	1.01
12AY7	4.00
12B4A	3.62
12BA6	2.52
12BE6	2.79
12BH7	1.29
12BY7	3.11
12E1	19.67
12E1TT	19.26
12E14	34.50
13E1	123.05
19H4	38.75
19H5	40.25
24B9	55.20
30C15	1.84
30C17	1.84
30C18	1.84
30F5	1.84
30FL1/2	1.28
30FL12	2.07
30FL14	1.84
30L1	1.15
30L15	2.07
30L17	2.07
30P4	1.06
30P19	2.30
30PL1	2.86
30PL13	1.93
30PL14	1.93
30PL15	2.07
35W4	0.60
50C5	0.81
75B1	5.38
75C1	2.70
85A1	8.63
85A2	2.73
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	4.68
150C2	2.21
150C4	2.75
211	6.90
723AB	40.25
803	11.50
805	23.00
807	4.31
811A	18.52
812A	15.24
813	85.87
833A	125.80
866A	15.21
872A	21.47
922	5.01
931A	16.97
1625	1.96
2050	8.00
4212E	304.75
4212H	304.75
5544	62.10
5545	67.85
5551A	108.03
5552A	143.35
5559	250.10
5642	6.45
5654	3.93
5651	2.65
5670	5.18
5675	19.91
5687	6.31
5696	4.35
5718	7.87
5725	5.62
5726	3.62
5727	3.42
5749	5.14
5751	4.90
5763	4.06
5814A	4.28
5840	5.06
5842	13.90
5876A	10.53
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	4.80
6061	4.89
6062	4.31
6063	4.20
6064	6.54
6067	4.02
6072	5.90
6080	7.88
6097A×B×C	46.00
6146A	10.30
6146B	8.12
6159B	17.27
6189	10.03
6201	5.28
6442	17.25
6883B	12.77
6973	4.38
7025	2.73
7551	6.45
7586	11.08
7587	20.11
7609	36.57
7868	5.04
7895	13.25
8005	75.03
8056	6.33
8122	60.11
8136	2.48
8417	6.76
18042	6.63
18045	12.06

Tested Ex-Equipment
4CX250B 5.75

BASES

Type	Price
B7G unskirted	0.17
B7G skirted	0.35
B9A unskirted	0.17
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

Type	Price
2AP1	9.78
2BP1	10.35
3BP1	11.50
3DP1	5.75
3EG1	8.05
3FP7	6.90
3GP1	6.90
3JP1	9.20
3JP2	9.20
3JP7	11.50
3KP1	17.25
3RP1	40.25
3WP1	23.00
5ADP1	40.25
5BP1	11.50
5CP1	11.50
5CP1A	46.00
5FP15A	17.25
5UP7	16.10
DG7-5	28.75
DG7-32	41.40
DH3-91	35.65
DH7-11	78.20
VCR97	13.80
VCR138	11.50
VCR138A	14.38
VCR139A	9.20
VCR517A	11.50
VCR517B	11.50
VCR517C	11.50

Tube Bases Prices on application

INTEGRATED CIRCUITS

Type	Price
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	0.84
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	2.89
74144	2.89
74145	1.15
74147	2.30
74148	2.02
74150	2.07
74151	1.08
74154	2.97
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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Regular construction articles have included test equipment, monochrome/colour receivers, monitors and video cameras.

THIS MONTH

Construction

An 'Arrow' Generator

A special joystick control unit for inclusion between camera and monitor ... drawing attention to points on a TV display by use of a moveable arrow.

Servicing

Greatly increased reliability of modern TV sets means intermittent faults are accounting for a much larger proportion of the servicing workload. We offer guidance on tracking down these, often difficult to locate, faults.

Review

THORN TX10 Chassis

We review the latest Thorn chassis probably the equal of any in the world.

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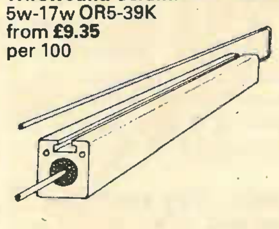

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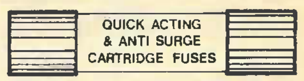

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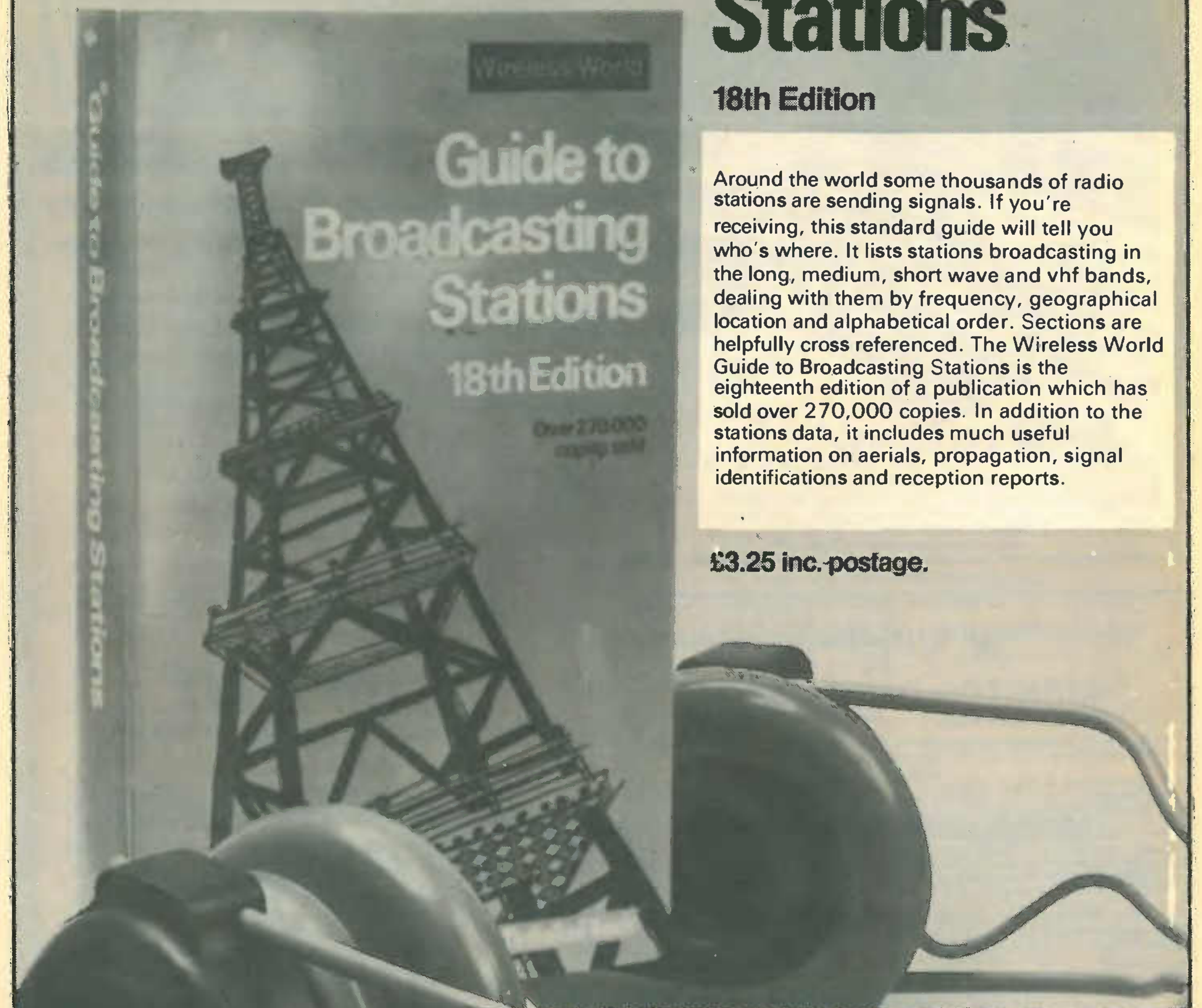
Guide to Broadcasting Stations

18th Edition



Around the world some thousands of radio stations are sending signals. If you're receiving, this standard guide will tell you who's where. It lists stations broadcasting in the long, medium, short wave and vhf bands, dealing with them by frequency, geographical location and alphabetical order. Sections are helpfully cross referenced. The Wireless World Guide to Broadcasting Stations is the eighteenth edition of a publication which has sold over 270,000 copies. In addition to the stations data, it includes much useful information on aerials, propagation, signal identifications and reception reports.

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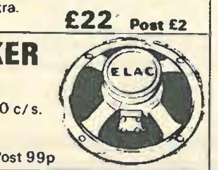

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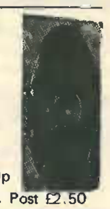

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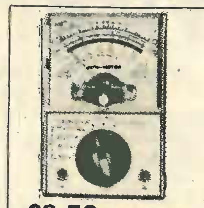

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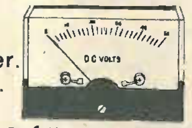

50μa 100μa 500μa, 1ma, 5ma, 50ma, 25 volt, 50 volt, VU Meter. Facia 2⅜ × 1¾ × 1½in. Fixing hole 1½in. dia. Lighting kit 6 or 12v **90p extra.** 1ma (240° scale) 2¼in. sq. **£5** Post 65p

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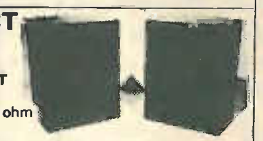

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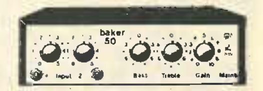
BAKER 50 WATT AMPLIFIER



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AUDAX	TWEETER	3¾in	60	8	£10.50
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BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

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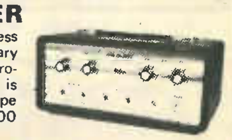

Good quality unit with endless play tape cartridge. Stationary play heads ensure good reproduction and echo variance is achieved by changing tape speed. Input imp: 50k and 600 ohms. Power: 240 volts A.C.
£68. Post £2 Spare tape £5.

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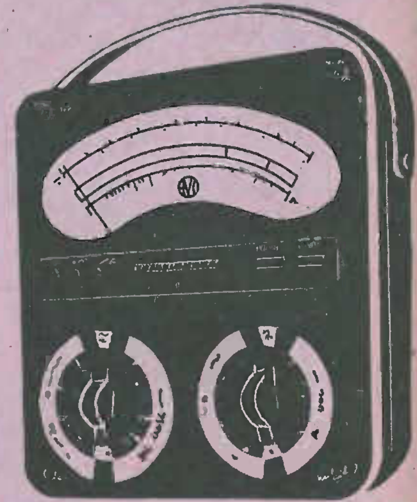

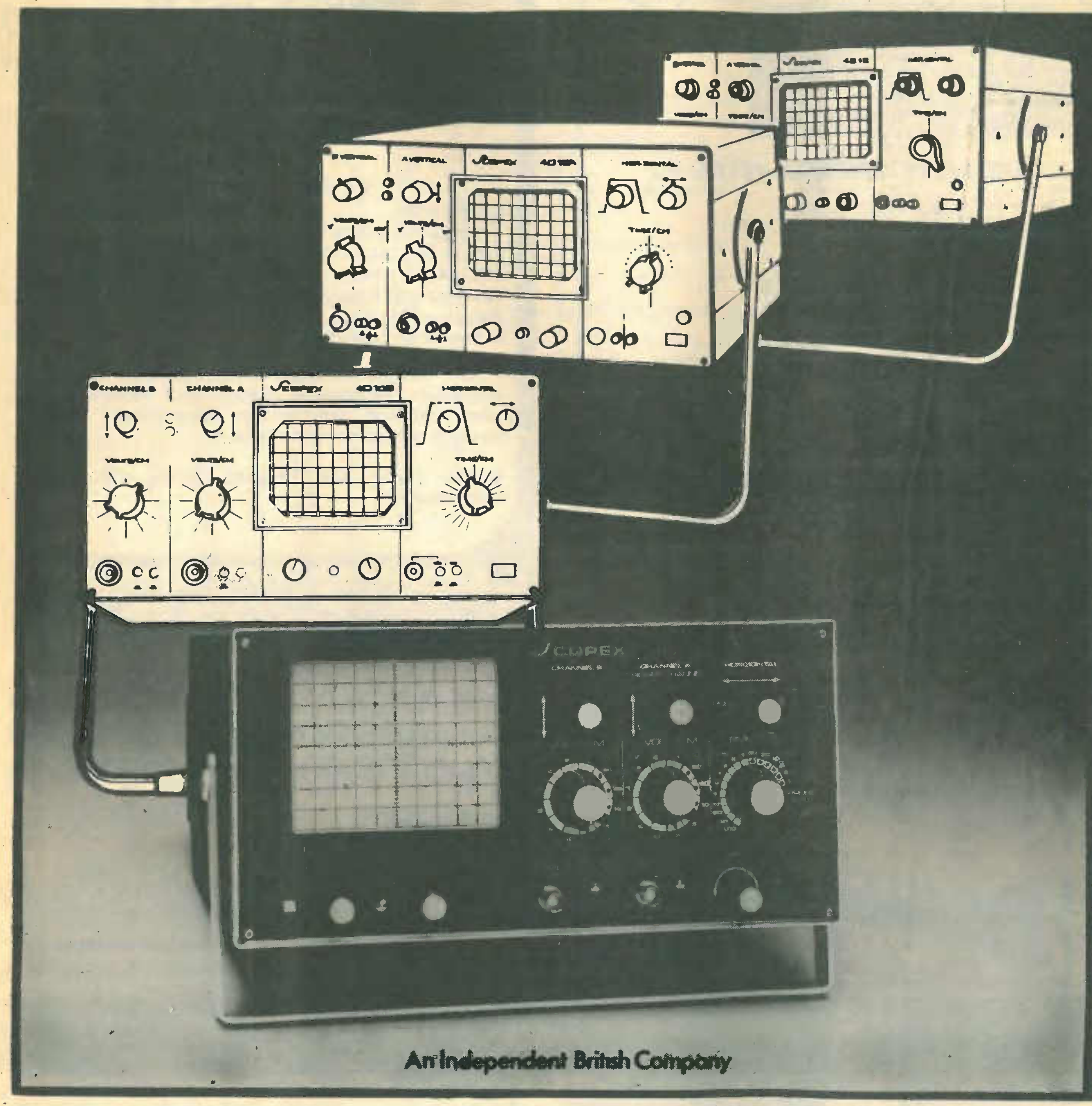

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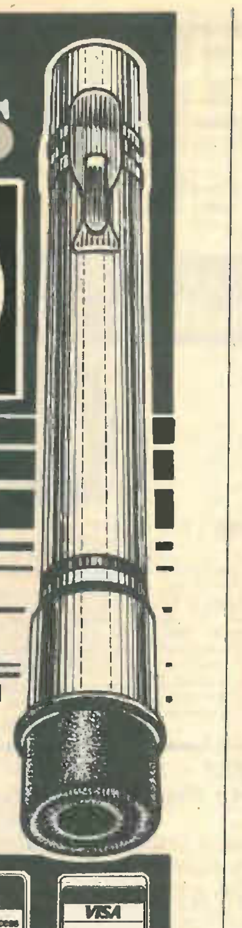

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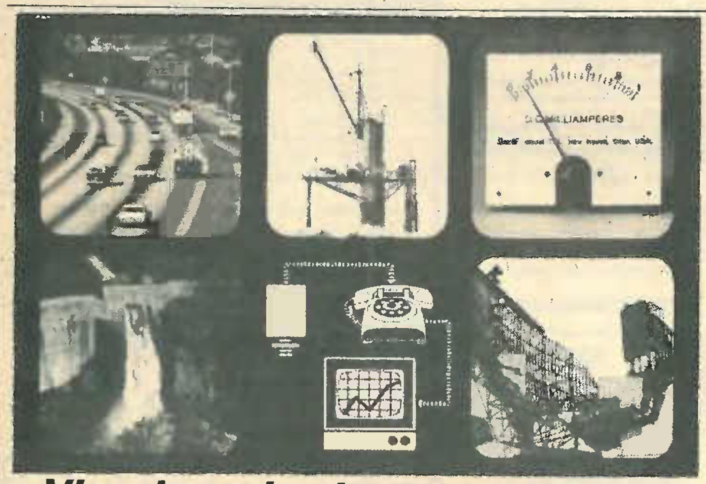

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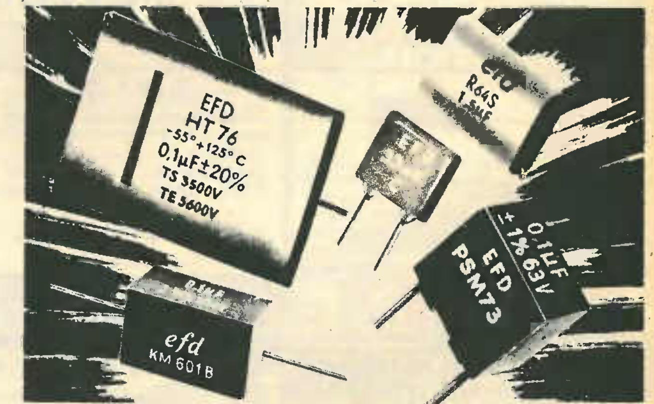

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MINIMUM ORDER £3 VALUE OF GOODS. MINIMUM P&P £1.50 – where P&P not stated please use own discretion – excess refunded. £5 CARRIAGE ON ALL UNITS. P&P or CARRIAGE and VAT at 15% on total MUST BE ADDED TO ALL ORDERS. CALLERS VERY WELCOME STRICTLY BETWEEN 9am-1pm and 2-5pm Monday to Saturday inc. BARCLAYCARD (VISA) and ACCESS taken. Official orders welcome.

CHILTMEAD LTD

NORWOOD ROAD, READING — TELEPHONE NO. READING 669656
(2nd turning left past Reading Technical College in King's Road then first right – look on right for door with "Spoked Wheel")

WW–082 FOR FURTHER DETAILS

Appointments

Advertisements accepted up to 12 noon Monday, 23 March, for May issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £12 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £2 per line, minimum three lines.
BOX NUMBERS: £1 extra. (Replies should be addressed to the Box Number in the advertisement, c/o Quadrant House, The Quadrant, Sutton, Surrey SM2 4AS.)
PHONE: JAYNE PALMER, 01-661 3033
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Company Communications Controller

c.£10,000

As a major name in aviation and communication services for the world, maintaining and upgrading our own lines of communication is vital; customers and suppliers, for instance, are constantly in contact through telex, telephone, data transmissions and post. The task of our Company Communications Controller is to supervise both the technical and human aspects of the existing network and to advise on the introduction of new computer based information handling systems throughout the group.

He or she will work from Southall, liaising with suppliers and with service staff on maintaining equipment. There is also a large amount of advisory and analytical work involved, in order that existing systems may be improved.

Candidates should possess an HNC in telecommunications engineering and should have worked for at least five years with a manufacturer, major telecomm. user, or in Post Office telecommunications. They should understand business communication problems, and ought to be capable of expressing technical solutions clearly to non-technical management.

Benefits include a staff restaurant, a pension and life assurance scheme, relocation expenses where applicable and 5 weeks' holiday plus bonus.

Please apply, in writing, to John Callow, IAL, Aeradio House, Hayes Road, Southall, Middx, quoting Ref.K/024. Tel: 01-843 2411.

IAL HEAD OFFICE TEL. NO. CHANGED TO 01-843 2411 ON 2ND MARCH 1981

IAL THE HIGH TECHNOLOGY TASK FORCE
COMMUNICATIONS SYSTEMS
COMPUTER SYSTEMS AND SERVICES
AVIATION SYSTEMS AND SERVICES - WORLDWIDE

(1001

UMIST

EXPERIMENTAL OFFICER FOR SILICON DEVICE MANUFACTURE

REF: EEE/25. A new facility is being assembled in the Solid-State Electronics Group of the Department of Electrical Engineering and Electronics, for the manufacture and testing of semiconductor components in ultra-clean conditions. Within a large clean area there will be a total of 60 linear feet of ultra-clean bench housing a wide range of equipment. The Experimental Officer will be responsible for the day-to-day running of this facility, overseeing its use by undergraduate and postgraduate students, and will be responsible for the maintenance of the equipment, including the air filtration plant. He/she may also be required to assist staff of the Solid-State Electronics group in any reseach which involves semiconductor processing. A wide range of skills is required, together with the necessary experience and confidence to allow unsupervised working.

Salary will be in range of £4795-£9595 per annum (under review).

Requests for application forms, quoting the above reference, should be addressed to the Registrar, Room B6, UMIST, PO Box 88, Manchester M60 1QD. The closing date is March 31, 1981.
(973)

TOP JOBS IN ELECTRONICS

Posts in Computers, Medical, Comms, etc. ONC to Ph.D. Free service.

Phone: **01-906 0251**
(8994)

ELECTRONIC SERVICE ENGINEERS

NORTH LONDON – ILFORD

Our company specialises in both sales and servicing of Discotheque Sound and Lighting Equipment. We currently have vacancies for engineers who have had previous experience of either HiFi, Studio PA or similar equipment. Good salary, plus Commission and Bonus.
Please telephone or write to Janet Findlay for further details.

Roger Squire's

Barnet Trading Estate Park Road Barnet Herts EN5 5SA
Telephone: 01-441 1919 (963)

NORTHERN REGIONAL HEALTH AUTHORITY

ELECTRONICS TECHNICAL ASSISTANT (2 POSTS)

Required for Regional Engineer's Division, based at Walkergate, Newcastle-upon-Tyne.

The appointments will be at Technical Assistant Grade 1. Salary £6,633 - £7,824 per annum.

The posts offer technologically interesting and varied work, with excellent working conditions and well-equipped laboratories, and involve visits to hospitals throughout the Region, for which financial reimbursement is made.

Applicants must be of high calibre and have had considerable and broad experience with modern electronic equipment.

Minimum qualifications: HNC or City and Guilds Full Technological Certificate in Electronic Engineering or equivalent.

Application form and job description available from the Regional Personnel Officer, Northern Regional Health Authority, Benfield Road, Newcastle-upon-Tyne NE6 4PY.

Closing date: 1 April, 1981. (971)

PHILIP DRAKE ELECTRONICS LTD.

Manufacture Audio and Intercommunication Equipment for the broadcast industry and have vacancies for the following staff:

PROJECT ENGINEER

to work in the Project Department. The job includes project discussion with customers, the detail design of systems, test supervision, and the compilation of system handbooks. Experience in the broadcast audio industry is essential and a formal qualification is desirable.

ASSISTANT TEST ENGINEER

to test primarily the custom-built products, mainly intercommunication systems, along with the standard product range. Some experience in the testing of audio and digital circuits and in the design of test jigs is desirable.

DRAUGHTSPERSON/TRACER

to work primarily in the Project Department, to prepare handbook drawings and design system metalwork, and also to prepare circuit diagrams and standard products. Experience in control panel layouts and broadcast audio requirements is desirable.

The company offers a 37½-hour week with 20 days' holiday minimum. Experience in the broadcast industry and/or suitable qualifications are desirable for all positions. Salary negotiable dependent on experience.

Apply by telephone or writing to:

**ALAN BRILL, PHILIP DRAKE ELECTRONICS LTD.
23 REDAN PLACE, LONDON, W2 4SA - Tel: 01-221 1476** (1014)

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**CAPITAL HOUSE
29-30 WINDMILL STREET
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Design, Dev. and Test to £10,000
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SALES to £12,000 plus car
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FIELD SERVICE to £10,000 plus car
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We have vacancies in ALL AREAS of the UK

Telephone: 01-637 5551 (3 lines)

Sony Broadcast success story means even more career opportunities!

Tremendous growth and success has created the need for even more first class staff at the Basingstoke International Headquarters of one of the world's leaders in professional television broadcast equipment.

UK Sales Manager/ess – TV Production Houses
£ neg + car
This is a new position created as part of our planned expansion programme. The successful candidate should possess experience of either Production or Engineering Operations within a broadcast television environment. A knowledge of professional VTR's, editing systems and cameras is necessary whilst previous sales experience is desirable, though not essential.

Sales Engineers/Technical Support Engineers for Western Europe
Competent engineers experienced in video cameras and/or VTR's are sought to join our sales team. Successful candidates are likely to be in the age range 25–35 and should be highly motivated and able to work on their own initiative. Experience in dealing with customers would be an advantage as would knowledge of a second European language. Travel within the western European area will be necessary.

Engineers – Commercial/Sales Applications
Openings exist, at various levels for engineers with a wide experience of the TV Broadcast Industry, to utilize their knowledge in a dynamic commercial environment.
The selected candidate will be self motivated, capable of working with a minimum of supervision, and will be appointed to our Proposals/Quotations section. He or she will have the ability to prepare detailed and concise customer presentations/quotations complete with pricing information.
Previous commercial/sales experience desirable, however not considered essential.

Systems Project Engineers
For our young and enthusiastic Special Projects Team. They will be involved in the design, manufacture and commissioning of static and mobile television systems, and in modifications and accessories. The successful applicants will have a thorough knowledge of sound and television principles. Ideally, he or she should have experience in operational television or its allied manufacturing industry.

Product Specialists
Opportunities exist for young engineers from a broadcast television background to be involved in all aspects of development, marketing and support of our entire product range.
We would be particularly interested to hear from you if you are currently working with professional VTR's/VCR's, cameras or microprocessor controlled post production systems and would like to further develop your technical and commercial skills in a challenging environment.

Field Service Engineers
Currently, openings exist at Engineer and Senior Engineer levels for personnel with experience of working on professional VTR's and cameras probably in a Broadcasting organisation or TV Broadcast Equipment Manufacturer. The Engineer level position should appeal to applicants with limited relevant experience who are now seeking a progressive environment in which to broaden their careers. Both positions offer the opportunity for some UK and overseas travel.

R & D Engineers
Sony is now established as the world leader in digital video recording technology. Development is still in the formative stages but rapidly progressing to the new era of the 'All Digital Studio'. The R & D Section is involved in long term investigations into the application of high speed digital techniques to video processing, and in conventional product design. Being part of an international R & D team, the successful applicant may expect occasional opportunities for overseas travel. Applications are invited from engineers offering experience in high speed digital processing or video engineering. Alternatively, a well qualified recent graduate could be considered.

Lecturer
The Lecturer will join our training team and after a suitable familiarisation period will be required to conduct theoretical and practical training courses on our major products, and/or write circuit descriptions and produce training manuals with lucid block diagrams. Ideally, candidates should have had experience of video tape recorders, digital circuits and a practical up-to-date knowledge of the broadcast industry. Knowledge, or an ability to master the techniques of video cameras, digital audio equipment and the application of microprocessors to broadcast equipment will be an advantage although we are prepared to provide the necessary additional training. Promising young graduates may also apply for consideration as a Trainee Lecturer.

If you like the thought of enjoying the success of world leadership then write in strict confidence to Barry White, Personnel Manager, Sony Broadcast, now! And please don't forget a CV.

SONY® Broadcast

Sony Broadcast Ltd.
City Wall House
Basing View, Basingstoke
Hampshire RG21 2LA
United Kingdom

(968)

Challenging positions at home and abroad

RADIO TECHNICIANS COMMUNICATIONS ENGINEERS

EAE Limited install and maintain communications systems for the oil industry, at home and abroad.

Due to rapid and continuing expansion in our activities, we constantly require Radio Technicians, with experience of HF, MF, VHF and UHF, and Engineers (preferably qualified to HNC level or above) in the fields of Microwave, Multiplex and Tropospheric Scatter.

In the North Sea, earnings are in the range £9,000 to £12,000 p.a. Overseas earnings could be up to £20,000 – plus tax concessions and generous home leave.

The work is demanding, but rewarding, offering you the chance to use your skills and your initiative to the full.

The company is based in Great Yarmouth, with offices in Aberdeen and Lerwick – but where relocation is necessary, we will give generous assistance with removal, legal and temporary accommodation expenses.

Please apply, with details of your career to date, to: Personnel Manager, EAE Limited, Dept WW, Offshore House, 284/285 Southtown Road, Gt. Yarmouth, Norfolk NR31 0JB Telephone 0493 58541

EAE Limited

(935)

The following personnel are required by a radio manufacturer in South Africa. Successful applicants will need to be stable and have a desire to emigrate. This is not short term contract work.

Radio development engineers, with experience of domestic radio. Salary R1500 per month.

Radio technicians, preferably with factory experience. Salary R1000 per month.

Draughtsmen, preferably with radio cabinet design experience. Salary R1000 per month.

Radio or cabinet assembly line foreman or chargehands. These applicants must be prepared to train operators. Salary dependent on experience.

Injection moulding machine setters. Salary R1000 per month. Must be prepared for shift work.

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(990)

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FIELD, SUPPORT AND PRODUCTION. VACANCIES IN COMPUTERS, NC, COMMS., MEDICAL, VIDEO, ETC.

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LOGEX

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(321)

INNER LONDON EDUCATION AUTHORITY

Learning Materials Service
Television Centre, Thackeray Road, London, SW8

MOBILE SECTION ENGINEER ST3

The mobile section operates colour broadcast standard television facilities including a three camera (Link 120) mobile control room and battery portable equipment (Sony BVP, BVU). The main function of the section is to make observational classroom recordings for use in teacher education both in London and nationally. All members of the crew share rigging duties and driving of vehicles. A current driving licence is highly desirable and training will be provided leading to an HGV test.

The engineer will join a team of three other engineers who are jointly responsible for the operation and maintenance of the section's equipment. This involves lighting, vision control, microphone rigging, sound mixing and V.T. operation. Experience in one of the fields is essential; however as training in others will be given, it is important that candidates have appropriate academic qualifications and a thorough knowledge of current broadcast engineering practices. Candidates must also possess good health and normal colour vision.

Hours of work will be in accordance with the requirements of the service (the normal working week being 35 hours).

Further details available from the Mobile Videorecording Section, telephone 622 9966.

Salary within the scale £8,115 - £8,709 (plus an irregular hours allowance of £156 per annum).

Application forms available from the Education Officer (EO/Estab 1c), Room 365, County Hall, London, SE1. Telephone 633 7456/7546.
Closing date: 14 days from appearance of advert. (964)

ITN

SENIOR ENGINEER

ENG/OB Maintenance
Salary: £11,406 p.a.

Independent Television News Limited has vacancies for two Senior Engineers in their expanding ENG/OB Maintenance Section at ITN House, London, W.1
The successful candidates would be members of a small team responsible primarily for the maintenance of ENG equipment including Sony BVU series U-matics, RCA Tk76C and Sony BVP330 cameras, TBCs and associated portable equipment. The section is also responsible for the long-term maintenance of our two camera Outside Broadcast Unit.
The work would occasionally involve travel with ENG teams to remote locations.
Previous maintenance experience with U-matic equipment and/or lightweight cameras is essential.
Generous pension scheme, free life insurance.

Please telephone the Personnel Office on 01-637 3144, quoting reference number 30301 for an application form.

(966)

SULTANATE OF OMAN

RADIO AND TV BROADCAST ENGINEERING VACANCIES

The Sultanate of Oman operates a modern colour television and radio broadcasting service with studio centres situated in the North and South of the country, the two centres being linked by satellite. High power VHF and low power UHF transmitters are employed to provide a 625 PAL TV service to populated areas of the Sultanate. The radio broadcasting service uses HF, MF and VHF transmitters of various powers. Both services are managed by the Ministry of Information and Youth Affairs.

Due to expansion of the service vacancies for a variety of posts have arisen and applications are invited from suitable qualified persons.

TRANSMITTER ENGINEERS

For maintenance of high power VHF TV transmitters and low power UHF transposers, high power MF, HF and VHF FM sound transmitters. The work will involve travel and in some cases overnight stops away from base. The transmitters operated within the Sultanate are manufactured by Siemens, Philips, Marconi and Continental Inc., U.S.A.

STUDIO ENGINEERS

For maintenance on cameras, vision mixers, S.P.G.S., vision distribution systems, telecine machines and video monitors, etc. There will also be operational work, particularly on outside broadcasts.
The equipments employed are Philips LDK15 cameras, Bosch Fernseh KCU40 and KCP cameras, vision mixer units by C.D.L. and Bosch Fernseh, telecine by Rank Cintel and Bosch Fernseh.

SOUND MAINTENANCE ENGINEERS

To maintain a wide range of high quality sound broadcasting equipment.

VTR ENGINEERS

For maintenance on Ampex VR1200B and Bosch Fernseh BCM40 machines. There will also be some operational work. During the forthcoming year it is intended that 1in. "C" Format VTR machines will be installed.

PLANNING AND PROJECT ENGINEERS

To carry out planning for a wide range of transmitter installations for both TV and radio. Planning and Systems Engineers are also required for work on new radio studios to be constructed over the next few years.
Successful applicants will be expected to be directly involved with the nuts and bolts of the installation work, in some cases in remote areas.
Applications are also invited for a number of senior positions in the transmitter, studio groups and electro-mechanical services groups. If you feel you can apply your knowledge and expertise to the efficient running of these groups we will be pleased to hear from you.

Applicants should be qualified to degree or HND level and have not less than six years' relevant experience. The senior positions require considerably more years of varied but relevant experience. In most cases a knowledge of Arabic – although not essential – would be useful.

Salaries, which are paid in Rials Omani, are fully remittable and tax-free and range from pounds sterling 1100 to 1300 per month upwards. The senior positions start at pounds sterling 1500 to 1700 per month (depending upon current rate of exchange).

Married accommodation is provided together with free air passage at beginning and end of contract for family. Air tickets are also provided for leave after the first year of service.

Applicants should write stating age, nationality, qualifications and full details of experience to:

Ministry of Information and Youth Affairs, Post Box 600, Muscat, Sultanate of Oman, marking the envelope "Technical Office" in top left-hand corner.

Development Engineers
in Digital Electronics

We have an important client in the Cambridge area who is about to embark upon a major development programme incorporating projects valued at several million pounds. Over the last few years they have been developing and exploiting a specialised area of telecommunications, and to complete the highly specialist and skilled teams which are involved in breaking new ground in digital development, two experienced Engineers are needed immediately.

They will ideally have experience of both hardware and software gained in a development environment where high standards and iminent deadlines are the norm. A Degree standard of education is less important than experience on design and development and they will have the opportunity of seeing a prototype design right through to manufacture.

Our client offers in return the opportunity to become involved in a thriving organisation which offers excellent terms and conditions of employment, good career prospects and, most important, an opportunity to take digital electronics to new frontiers.

Please apply in confidence, quoting Ref. KR77, to:
Andrew Millhouse
Ketchum Recruitment Limited
52 Bedford Row, London, WC1R 4LX.
01-405 1260

(972)

NORTH-EAST LONDON POLYTECHNIC
FACULTY OF ENGINEERING – BARKING PRECINCT
LONGBRIDGE ROAD
DAGENHAM, ESSEX

SCHOOL OF CHEMICAL & SYSTEMS ENGINEERING

SENIOR TECHNICIAN

T5 REF: 83/E/80

required to control and supervise technicians working within the microprocessor laboratory, under the supervision of the Principal Technician. Other duties will include planning and progression of technician work, maintenance of progress and financial reports, and development, including design assistance, of equipment within the laboratory. Candidates should hold a full technological certificate and/or HNC/HND qualifications, and have had 5-10 years' experience in a technical environment.

The inclusive annual salary will be on a scale from £7,233 to £7,695 according to age, qualifications and experience.

For further details and application forms please contact the Personnel Office (R), North East London Polytechnic, Asta House, 156/164 High Road, Chadwell Heath, Romford, Essex, RM6 6LX. Telephone 01-590 7722, Ext. 3121 or 3135, quoting the above reference number.

CLOSING DATE FOR RECEIPT OF APPLICATIONS: April 3, 1981.

(992)

IF THIS IS RECESSION WE LIKE IT

AT LAST ELECTRONIC ENGINEERS ARE BEING PAID WELL AND THEIR WORK IS APPRECIATED . . .

We have hundreds of vacancies which include:

SYSTEMS ENGINEERS: for new company specialising in secure computers based on DEC 11/23 and Z80. Knowledge of image processing and pattern recognition an advantage. To £13,000. SURREY.

RESEARCH ENGINEER/MANAGER: for a group providing support to an international company engaged in research on precious metal refining, cancer research, pollution monitoring, etc. Broad based experience. To £12,000. BERKS.

R.F. ENGINEERS: for small dynamic company engaged on telemetry and remote monitoring instruments for the off-shore industry – tankers, gas rigs, etc. To £10,000. LONDON.

HARDWARE AND SOFTWARE ENGINEERS: to work on a new generation of Printers and Data Terminals based on Z80 Intel 8080 and 8008. To £11,000. BERKS.

PRINCIPAL AND SENIOR MICROWAVE ENGINEERS: for development of V.C.O.s, frequency multipliers, amplifiers and fitters. Good salary but confidential. MIDLANDS.

YOUNG ENGINEER: with 8085 HW/5W experience to join a high flying team working on novel controls for the automotive industry. To £8,500. WEST COUNTRY.

DESIGN ENGINEER: broadcast TV equipment including character generators and teletext terminals. To £8,000. SURREY/HERTS. BORDER.

SENIOR ENGINEER: to design and develop special modules for users of a large international computer network based on ICL 1900 and PDP11. To £8,500. LONDON.

DESIGN ENGINEER: mini and micro computer based control equipment and systems for the heavy mechanical electro mechanical industry. Z80 HW/SW experience essential. To £8,000. NORTH-EAST ENGLAND.

COMPUTER ENGINEERS: vacancies throughout UK in systems test, field service permanent site and technical support.

For further details, please contact: (1003)

Charles Airey Associates
4 Hammersmith Grove, London W6 0NA. Tel: 01-741 4011
PROBABLY THE BEST KNOWN SUPPLIER OF ELECTRONIC ENGINEERS IN THE COUNTRY" Financial Times

ONE IN A MILLION?

Among the million or so leaving school or university this year there is a chance that one — perhaps two — is destined to make a significant development in audio.

That person's first decision might well be to join QUAD in Huntingdon. At school, he or she will have realised that amplifier design is not just a matter of having a listen or a fiddle with standard circuits and their variations. Later will have come an adolescent stage of great discoveries. "Increase the rise time to eliminate TIM". "Regulate the power supply for better imaging".

Following on from such childish things will have come an ability to distinguish between the characteristic impedance of the medium and the third row of the dress circle and between peak flux density and the rather gooey substance fed by spoon to small children. He or she will, nevertheless, be sufficiently down to earth to know that one newton is about the weight of the average apple.

1 in 10^6?

Well, drop us a line anyway.

Mr. P. J. Walker

THE ACOUSTICAL MANUFACTURING COMPANY LIMITED

30 St. Peter's Road, Huntingdon, Cambs. PE18 7DB

(403)

DEPARTMENT OF NUCLEAR PHYSICS

ELECTRONICS TECHNICIAN (Grade 5)

Salary £5249-£6129 rising wef July, 1981, to £5695-£6650

Applications are invited for the post of electronics technician in the Department of Nuclear Physics for interesting and challenging work. The post involves assisting in the development and maintenance of a variety of equipment incorporating fibre-optic data links, 8 and 16-bit and bit-slice microprocessors, as well as some analogue circuitry. Some experience is essential, as are willingness and ability to learn quickly.

Applications in writing together with the names of two referees should be sent as soon as possible to the General Administrator, Department of Nuclear Physics, Keble Road, Oxford OX1 3RH. (967)

THE LEADING TELEVISION FACILITIES COMPANY

REQUIRES

DIRECTOR OF OPERATIONS

EXCELLENT SALARY + CAR + PENSION + BUPA + PROFIT SHARE

The position of DIRECTOR OF OPERATIONS requires a person with drive, initiative and clear thinking, to be able to deal with the day-to-day demands of this high technology Television Facilities Company providing Studio, VTR and O.B. services to its Clientele.

Loyalty, hard work and the ability to lead, will be rewarded by a career in the fast-moving TELEVISION SERVICE and the Operations Director and his/her colleague Directors will have the opportunity of long-term future career development. The Company will be looking forward to one of the senior Directors becoming the next Managing Director.

The applicant must have Engineering ability and have worked or be working in a Broadcasting organisation and have high level Management experience plus that special "something" of being able to lead and drive for the achievement of the Company's policies.

The position of Director of Operations will be a Company Board appointment.

Please apply to the Sole Recruitment Agents in the strictest confidence quoting "OPS DIR 1981":

PERSONNEL & ELECTRONICS LTD.

Triumph House 1096 Uxbridge Road Hayes Middlesex UB4 8QH England UK
Telephone: 01-573 8333 Telex: 934271

(1005)

Can you develop our potential?

Ultra manufacture highly sophisticated communications equipment and are Europe's leading suppliers of Sonobuoys. Our Test Equipment department has been extensively reshaped with new laboratories being built with a view to expansion. We can now offer Test Equipment Development Engineers and Technicians a real opportunity to become involved in the latest technology coupled with positive career development.

Test equipment development engineer £6500-£7500

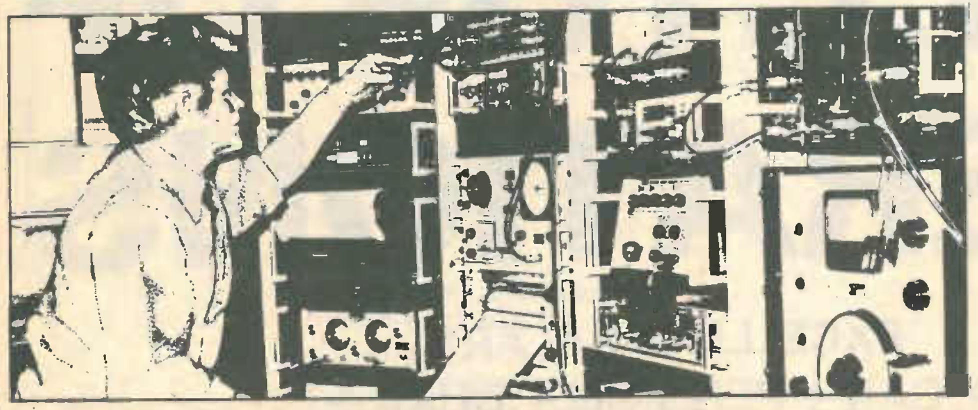
Working closely with our Senior Engineers and outside companies you will primarily assist the Design Engineers in developing Test Equipment Design. In addition, you will develop systems and units from outline specifications through to building prototype units.

As the department is still in its early stages you will have the opportunity to make a positive contribution to its formation and you will also be expected to attend comprehensive training seminars and exhibitions.

Test equipment technicians £5500-£6000

With a minimum of 2 years practical experience in a repair environment and an HNC or C&G in Electronics, you will undertake the repair and calibration of Proprietary and Purpose-Built Test Equipment and Main Units.

In addition to 5 years practical experience in repair and calibration, you should have the ability to communicate with Senior Engineers.



For both positions we offer outstanding career prospects with a company that is looking to the future. Apart from competitive salaries, we offer a sports & social club, 23 days holiday, contributory pension scheme and a subsidised restaurant. For further information, please telephone Julie Foreman on 578 0081 or write to her at:

DOWTY UEL Electronic Communications Ltd.

Ultra Electronic Communications Ltd
419 Bridport Road Greenford Trading Estate
Greenford, Middlesex.

(999)

Technicians/Junior Engineers
(Broadcasting Coverage)

If you like an outdoor life with plenty of travel all over the UK and are qualified to ONC/TEC level in electrical engineering (or a related subject), we may have just the career opportunity for you.

Working as a member of a small team, you would be involved in carrying out tests and surveys for our future television and local radio transmitter sites.

A current driving licence is essential. Previous working experience should have involved testing or taking measurements.

Starting salary will be within the range £4,280-£5,980 per annum, according to experience. Further progression to a maximum of £7,360 per annum is possible after a period of experience.

IBA INDEPENDENT BROADCASTING AUTHORITY

Please write or telephone for an application form quoting Ref: WW/575cc to Glynis Powell, IBA, Crawley Court, Winchester, Hampshire, SO21 2QA. Telephone: 822270.

(These posts are open to men and women).

(985)

THE OPEN UNIVERSITY FACULTY OF SCIENCE

Electronics Technician

Applications are invited for a technical vacancy in the Chemistry Discipline. The main duties of the post will be to maintain and upgrade spectroscopic instruments and other apparatus, including mini-computers, an to take responsibility for the operation of a Varian Electron Resonance Spectrometer. An ability to contribute to the design, particularly in the computer interface area, of electronic equipment would be an advantage.

Candidates should possess HNC (Electronics) or equivalent qualification and have 9-10 years' relevant experience.

Starting salary will be within the Grade VI Technician salary scale £6020-£7191 p.a. (£6,532-£7,802 p.a. from 1st July, 1981).

Further details and application forms are available from the Assistant Secretary Science (3440/1), The Open University, Walton Hall, Milton Keynes MK7 6AA, or telephone Milton Keynes (0908) 653481: there is a 24-hour answering service of 653868.

Closing date for applications: 14th April, 1981. (962)

UNIVERSITY OF SURREY
Audio Visual Aids Unit
Television Engineers
ONCE IN A DECADE CHANCE!

Join a small and lively team providing television services for teaching and research. Now converting to high quality Video 80 colour system, studio based but versatile and mobile. Photography, film, graphics and instrument workshop services available within the Unit. Salaries according to experience and qualifications on scales between £4,870 and £7,873. Further training available where appropriate. Write or telephone now: **Staff Officer, University of Surrey, Guildford GU2 5XH. Telephone Guildford 71281, ext. 776 for full information, quoting reference (16) WW.** (960)

TELEPHONE ENGINEER
ABU DHABI

A Telephone Engineer is urgently required with experience on Siemens ESK 3000E or similar crosspoint exchange.

TELECOMMUNICATIONS TECHNICIANS

We also have vacancies for Radio Techs. able to take up appointments at short notice.

Comprehensive c.vs should be airmailed immediately to:

Mr. George Fee, General Manager
AL MARIAH UNITED CO.
P.O. Box No. 206, Abu Dhabi U.A.E.

Telex: 22323 Phone 326017 giving contact U.K. telephone (1008)

T.V./Video Engineers
Media Librarian

*Salary range
5230-5625 Saudi Riyals per month

for the
King Faisal Specialist Hospital and Research Centre
Riyadh, Saudi Arabia

If you are well qualified in either of these areas, here is an excellent opportunity to make a break for 2 years and work in one of the world's most advanced Hospital and Research Centres. Working conditions are first class and all equipment and systems are the most modern available.

We need experienced T.V./Video Engineers to help maintain the hospital's sophisticated television network (mostly Sony equipment). You will be working with a five channel closed circuit system which is used for patient monitoring, training and medical/surgical recording, and in addition provides entertainment programmes for the hospital's surrounding residential and services complex.

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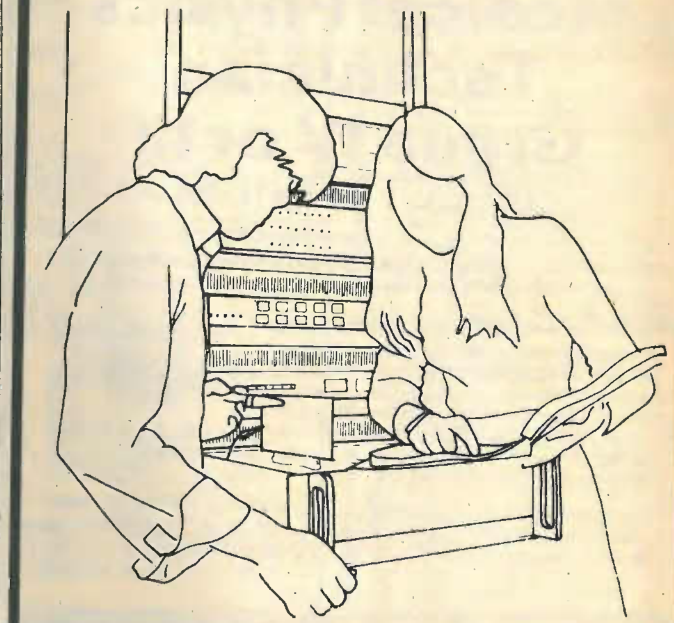

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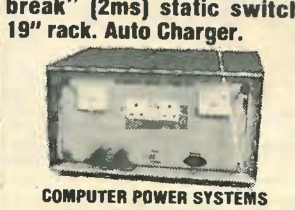

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