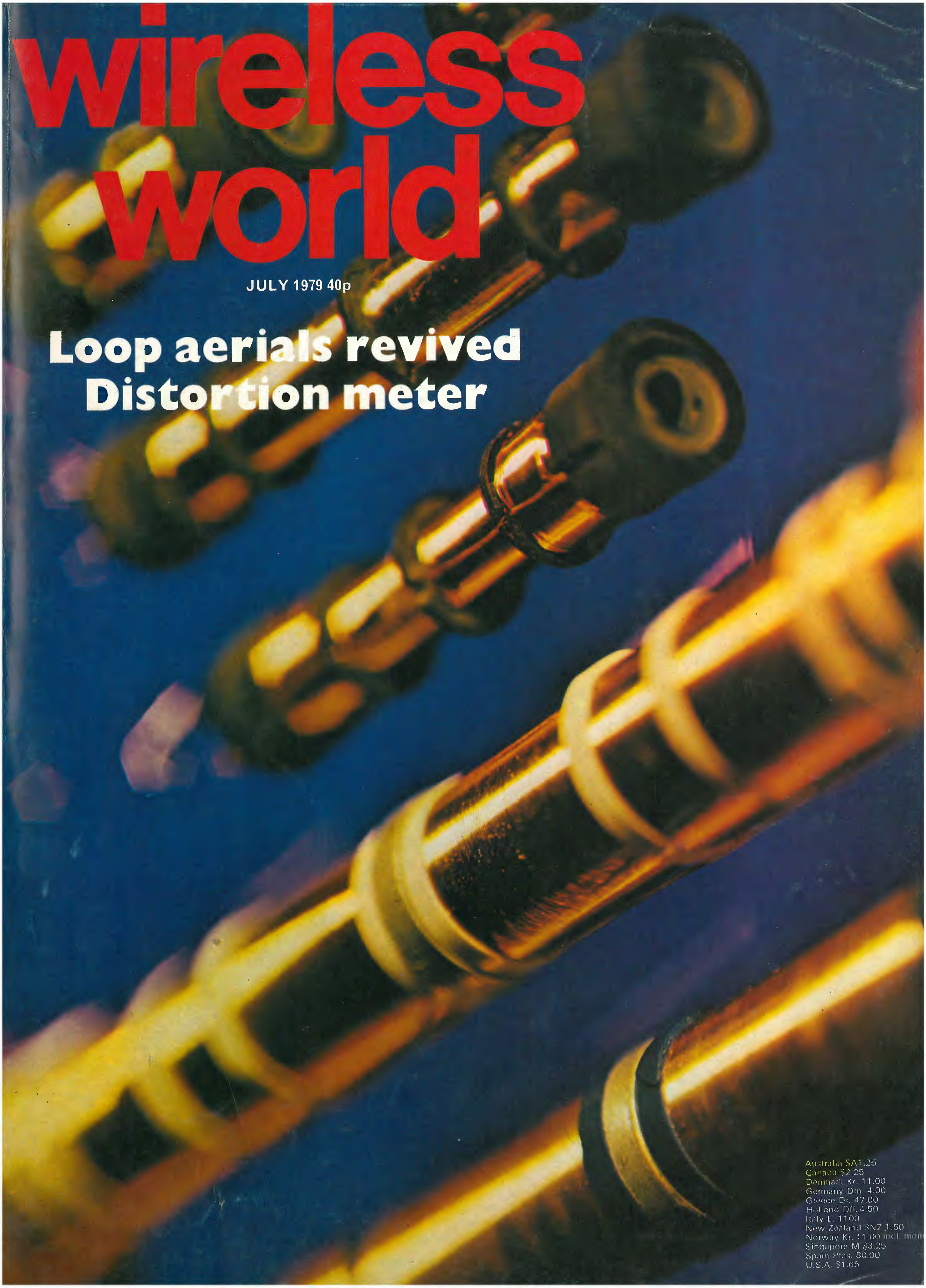
wireless world

JULY 1979 40p

Loop aerials revived
Distortion meter



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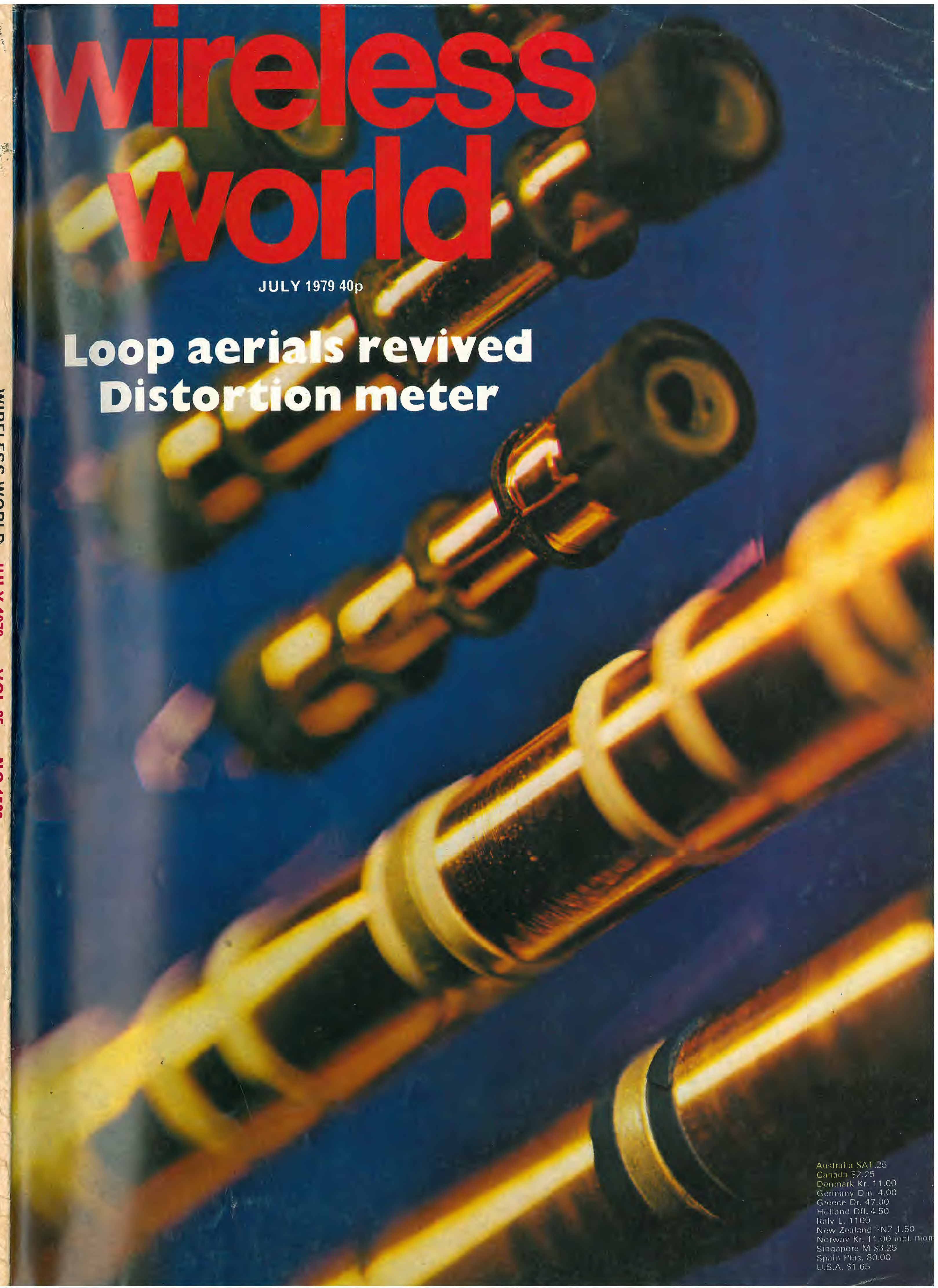
WIRELESS WORLD JULY 1979 VOL 85 NO 1523



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Distortion meter

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Front cover shows transformer windings used in displacement transducers made by Sangamo Transducers Ltd. Photographer: Paul Brierley

IN OUR NEXT ISSUE

From Russia — with no t.i.m. **Simple pre-amplifier with passive RIAA equalization caters for moving-coil pickups.**

Displacement current in radio waves. **An aid to understanding Maxwell's equations as discussed in recent articles and correspondence.**

Interference remover, **an automatic device for removing interference spikes from f.m. recorded data over bandwidths needed for electromechanical transducers.**

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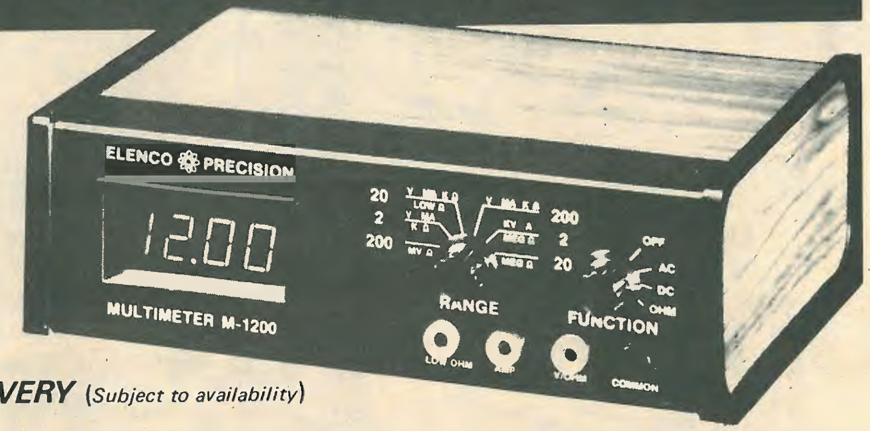
ELECTRONICS/TELEVISION/RADIO/AUDIO

JULY 1979 Vol 85 No 1523

Sullivan
AUTOMATIC COMPONENT ANALYSER AC5555



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RANGE
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Telegraph testing simplified

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Lightweight, portable, Telegdata TCT10 makes light work of on-site circuits and machines.

This new Plessey instrument combines signal generator and analyser in a single briefcase-size unit enabling on-site testing of telegraph circuits and machines to be carried out speedily and with a high degree of accuracy.

Powered from the a.c. mains supply, the TCT10 gives a choice of output levels and test signals in CCITT No 2 and No 5 alphabets including the full 96 character 'fox' message, Q9S and any single character on demand.

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PLESSEY CONTROLS

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600-2-224

At Barr & Stroud we strive constantly to meet all your filtering requirements. To our modular EF3 system we have added two new filter units, the EF3-07 and the EF3-08 to give greater flexibility. To meet a more general filtering requirement we have introduced the self contained EF4 unit.

These new filters, added to the existing six options available in the EF3 system, expand still further their scientific, industrial and medical applications.

EF3-07 This plug-in band pass/band stop unit has a centre frequency variable from 1Hz to 99.9kHz. Six values of Q from 2 to 40 can be switch selected. Pass band gain is switch selected from 0,20 or 40dB settings. Remotely programmable, either by direct line control or TTL logic level.

EF3-08 A universal filter with low pass, high pass, band pass or band stop facilities, EF3-08 has a centre or cut-off frequency variable from 0.001Hz to 9.99kHz. Remotely programmable like the EF3-07.

EF4 For simple band pass filtering our new EF4 unit is the ideal choice. This self-contained filter with integral power supply features a unique linearising circuit allowing continuously variable frequency control over an evenly graduated tuning dial. The filter characteristic is band pass with a centre frequency range from 1Hz to 100kHz, and five Q values plus 1/3 octave response are switch selectable.

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Twenty years' experience, in-house computer facilities and an extensive program library guarantee you a cost-effective system. Designs can be either active or passive, with cut-off rates up to several hundred dB per octave in a frequency range up to around 70 MHz.

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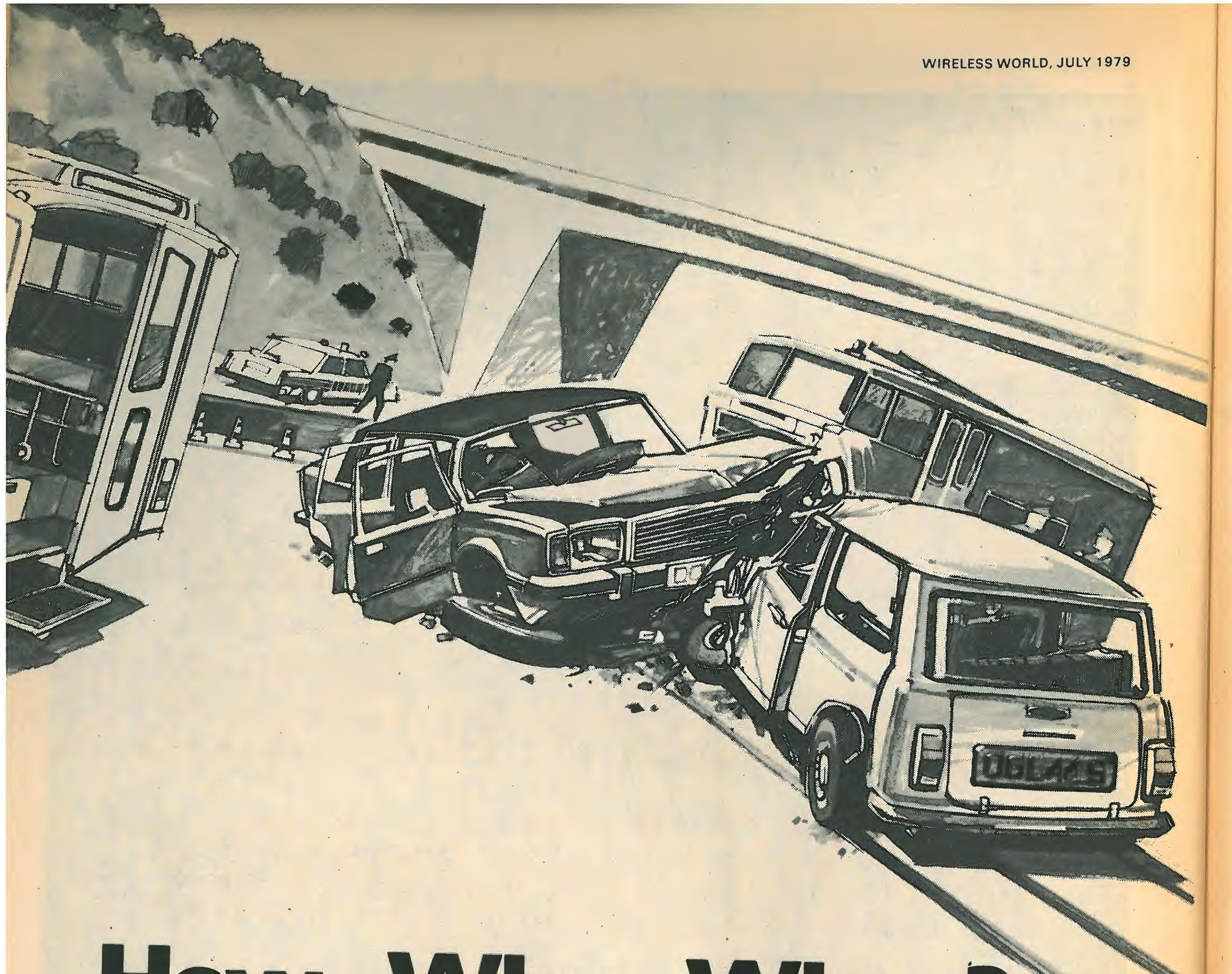

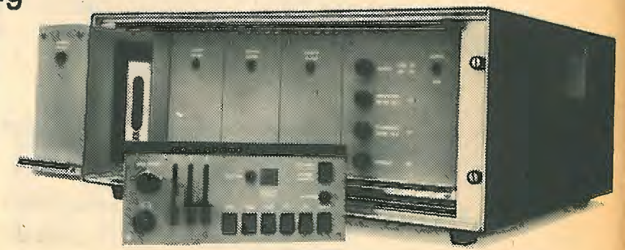

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S 500D — dual channel up to 500W/RMS per channel DC-20 KHZ

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

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

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Dual Channel
19" rack mount 3½" high
500w r.m.s. into 2.5 ohms per channel
900w r.m.s. in bridge mode
DC—20 KHZ at full power
0.005% harmonic distortion (typical) at 300w r.m.s. into 4 ohms at 1 KHZ
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S 250D
Single Channel
19" rack mount 3½" high
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Retro-convertible to dual channel
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Full short and open circuit protection
Drives totally reactive loads with no adverse effects

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NEW

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Look at this unique feature package:

- Philips quality and advanced technology in design and construction. Inside it you'll see an electronic masterpiece, not a "birds' nest."
- Auto triggering from either channel with adjustable level between peaks. TV triggering, too.
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- Big, rectangular screen giving a full 80 sq.cm. trace space.
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SuperScope is ideal for audio and video service, education, production—in fact any application which calls for a sophisticated yet tough all-purpose instrument.

For a leaflet about SuperScope, write to the Philips Electronic Instruments Department at Pye Unicam.

The instrument is also available from the following distributors:
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Wessex Electronics Ltd, 114-116 North Street, Downend, Bristol BS16 5SE. Tel: (0272) 571404

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York Street Cambridge England CB1 2PX
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PHILIPS **Test & Measuring Instruments**

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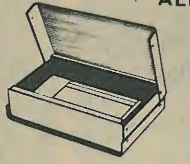
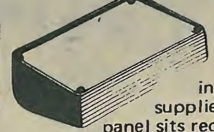
BIMENCLOSURES

ALL METAL BIMCASES



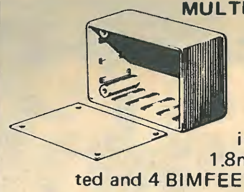
Red, Grey or Orange 14swg Aluminium removable top and bottom covers. 18 swg black mild steel chassis with fixing supprt brackets.
BIM 3000 (250x167.5x68.5mm) £14.58

MINI DESK BIMCONSOLES



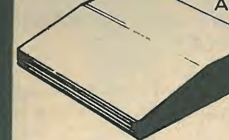
Orange, Blue, Black or Grey ABS body incorporates 1.8mm pcb guides, stand-off bosses in base with 4 BIMFEET supplied. 1mm Grey Aluminium panel sits recessed with fixing screws into integral brass bushes.
BIM 1005 (161 x 96 x 58mm) £2.18
BIM 1006 (215 x 130 x 75mm) £3.05

MULTI PURPOSE BIMBOXES



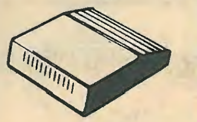
Orange, Blue, Black or Grey ABS with 1mm Grey Aluminium recessed front cover held by screws into integral brass bushes. 1.8mm pcb guides incorporated and 4 BIMFEET supplied.
BIM 4003 (85x56x28.5mm) £1.18
BIM 4004 (111x71x41.5mm) £1.62
BIM 4005 (161x96x52.5mm) £2.19

ALL METAL BIMCONSOLES



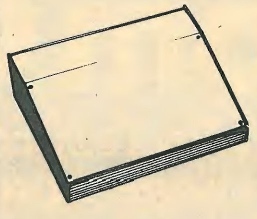
All aluminium, 2 piece desk consoles with either 15° or 30° sloping fronts, sit on 4 self-adhesive non-slip rubber feet. Ventilation slots in base and rear panel for excellent cooling. See latest catalogue for new styles and sizes

Colour Code	Top Panel	Base
A	Off White	Blue
B	Sand	Green
C	Satin Black	Gold



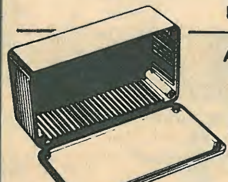
15° Sloping Panel	30° Sloping Panel	
BIM7151 (102x140x51[28] mm)	BIM7301 (102x140x76[28] mm)	£10.67
BIM7152 (165x140x51[28] mm)	BIM7302 (165x140x76[28] mm)	£11.44
BIM7153 (165x216x51[28] mm)	BIM7303 (165x183x102[28] mm)	£12.61
BIM7154 (165x211x76[33] mm)	BIM7304 (254x140x76[28] mm)	£13.82
BIM7155 (254x211x76[33] mm)	BIM7305 (254x183x102[28] mm)	£15.36
BIM7156 (254x287x76[33] mm)	BIM7306 (254x259x102[28] mm)	£16.67
BIM7157 (356x211x76[33] mm)	BIM7307 (356x183x102[28] mm)	£17.58
BIM7158 (356x287x76[33] mm)	BIM7308 (356x259x102[28] mm)	£18.55

LOW PROFILE BIMCONSOLES



Orange, Blue, Black or Grey ABS body has ventilation slots as well as 1.8mm pcb guides and stand-off bosses in base. Double angle recessed front panel with 4 fixing screws into integral brass bushes. 4 BIMFEET supplied.
BIM 6005 (143 x 105 x 55.5 [31.5] mm) £2.37
BIM 6006 (143 x 170 x 55.5 [31.5] mm) £3.08
BIM 6007 (214 x 170 x 82.0 [31.5] mm) £4.12

ABS & DIECAST BIMBOXES

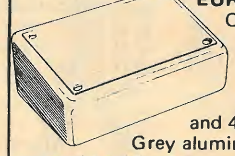


6 sizes in ABS or Diecast Aluminium. ABS moulded in Orange, Blue, Black or Grey. Diecast Aluminium in Grey Hammertone or Natural. All boxes incorporate 1.8mm pcb guides, stand-off supports in base and have close fitting flanged lids held by screws into integral brass bushes (ABS) or tapped holes (Diecast).

	ABS		Diecast	Hammertone	Natural
(50x50x31mm)	N/A		BIM5001/11	TBA	£1.02
(100x50x25mm)	BIM2002/12	£0.96	BIM5002/12	£1.46	£1.19
(112x62x31mm)	BIM2003/13	£1.13	BIM5003/13	£1.78	£1.46
(120x65x40mm)	BIM2004/14	£1.35	BIM5004/14	£2.24	£1.82
(150x80x50mm)	BIM2005/15	£1.52	BIM5005/15	£2.84	£2.28
(190x110x60mm)	BIM2006/16	£2.37	BIM5006/16	£3.94	£3.33

Also available in Grey Polystyrene with no slots and self-tapping screws
BIM 2007/17 (112x61x31mm) £1.00

EUROCARD BIMCONSOLES



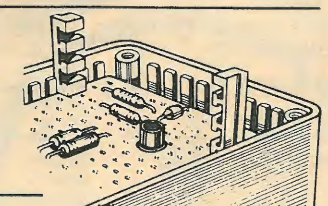
Orange, Blue, Black or Grey ABS body accepts full or ½ size Eurocards, with bosses in the base for direct fixing. 1.8mm wide pcb guides incorporated and 4 BIMFEET supplied. 1mm Grey aluminium lid sits flush with body top and held by 4 screws into integral brass bushes.
BIM 8005 (169x127x70[45] mm) £4.12
BIM 8007 (243x187x103[66] mm) £6.10

BIMTOOLS + BIMACCESSORIES

MAINS BIMDRILLS

Small, powerful 240V hand drill complete with 2 metres of cable and 2 pin DIN plug. Accepts all tools with 1mm, 2mm or .125" dia. shanks Drills brass, steel, aluminium and pcb's. Under 250g, off load speed 7500 rpm. Orange ABS, high impact, fully insulated body with integral on/off switch £10.53
Mains Accessory Kit 1 includes 1mm, 2mm, .125" twist drills, 5 burrs and 2.4mm collet £2.48
Mains Kit 2 includes Mains BIMDRILL as above, 20 assorted drills, mops, burrs, grinding wheels and mounted points, 1mm, 2mm, 2.4mm and .125" collets. Complete in transparent case measuring 230x130x58mm £22.14

BIMDAPTORS

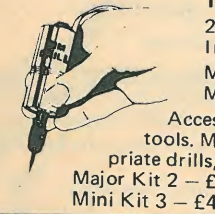


Allows pcb's to be flat mounted sandwich fashion in BIMBOXES, BIMCONSOLES, and all other enclosures having 1.5mm wide vertical guide slots. One plastic BIMDAPTOR on each corner of pcb(s) enables assembly to be simply slid into place. 54mm long, 10 slots on 5mm spacing and can be simply snipped off to length. £1.08 per pack of 25.

BIMFEET

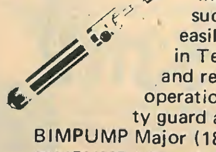
11mm dia. 3mm high, grey rubber self-adhesive enclosure feet. £0.77 per pack of 24

12 VOLT BIMDRILLS



2 small, powerful drills easily hand held or used with lathe/stand adaptor. Integral on/off switch and 1 metre cable.
Mini BIMDRILL with 3 collets up to 2.4mm dia. £ 8.10
Major BIMDRILL with 4 collets up to 3mm dia. £13.60
Accessory Kits 1 have appropriate drills and collets as above plus 20 assorted tools. Mini Kit 1 – £15.12, Major Kit 1 – £19.44. Accessory Kits 2 have appropriate drills, collets plus 40 tools and mains-12V dc adaptor. Mini Kit 2 – £34.02, Major Kit 2 – £39.42. Accessory Kits 3 as appropriate Kits 2 plus stand/lathe unit. Mini Kit 3 – £45.36, Major Kit 3 – £50.76.

BIMPUMPS

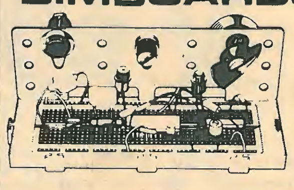


2 all metal desoldering tools provide high suction power and have easily replaceable screw in Teflon tips. Primed and released by thumb operation with in-built safety guard and anti-recoil system.
BIMPUMP Major (180mm long) £7.99
BIMPUMP Minor (150mm long) £6.80

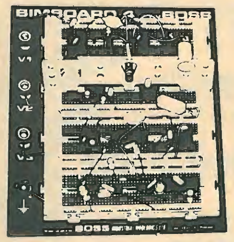
BIMIRONS

• Type 30 General Purpose 27 watt iron with long life, rapid change element, screw on tip, stainless steel shaft and clip on hook. Styled handle with neon. £4.05
Type M3 Precision 17 watt iron, quick change tip, long life element, styled handle with clip on hook. £4.43

BIMBOARDS



DIL COMPATIBLE BIMBOARDS



Accept all sizes (4-50 pin) of DIL IC packages as well as resistors, diodes, capacitors and LEDs. Integral Bus Strips up each side for power lines and Component Support Bracket for holding lamps, switches and fuses etc. Available as single or multiple units, the latter mounted on 1.5mm thick black aluminium back plate which stand on non slip rubber feet and have 4 screw terminals for incoming power.
BIMBOARD 1 has 550 sockets, multiple units utilising 2, 3 and 4 BIMBOARDS incorporate 1100, 1650 and 2200 sockets, all on 2.5mm (0.1") matrix.
BIMBOARD 1 £ 8.83
BIMBOARD 2 £21.01
BIMBOARD 3 £29.84
BIMBOARD 4 £38.79

DESIGNER PROTOTYPING SYSTEM

1, 2, or 3 BIMBOARDS mounted on BIM 6007 BIMCONSOLE with Integral Power Supply (±5 to ±15Vdc @ 100mA and fixed +5Vdc @ 1A) All O/P's fully isolated. Short circuit and fast fold back protection. Power rails brought out to cable clamps that accept stripped wire or 4mm plug.
DESIGNER 1 £55.62
DESIGNER 2 £61.02
DESIGNER 3 £66.42

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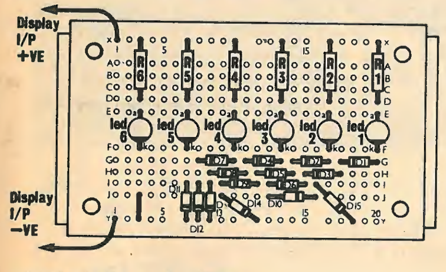
ELECTRONICS BY NUMBERS

LED BAR GRAPH UNIVERSAL INDICATOR

Now using **EXPERIMENTOR BREADBOARDS** and following the instructions in "Electronics by numbers" **ANYBODY** can build electronic projects.
Look at the diagram and select R1, this is a resistor with a value between 120 to 270 ohm. Plug it into holes X20 and D20, now take LED 1 and plug it into holes E20 and F20. Do the same with the Diodes e.g. plug D7 into holes G7 and G10.



YOU WILL NEED

EXP- ANY EXPERIMENTOR BREADBOARD
D1 to D15 – Silicon Diodes (such as 1N914)
R1 to R6 – From 120-270 ohm resistors ¼ watt.
LED1 to LED6 – Light emitting diodes.

LED BAR GRAPHS are replacing analogue meters as voltage-level indicators in many instances.
This circuit uses the forward voltage drop of diodes to determine how many LEDs light up. Any type of diode can be used but you must use all the same type. For full working details of this circuit fill in the coupon.
If you have already built the Two-transistor Radio and the Fish'n'cliks projects you will find that you can reuse the components from these projects to build other projects in the series.

FILL IN THE COUPON AND WE WILL SEND YOU FREE OF CHARGE FULL COPIES OF "ELECTRONICS BY NUMBERS" PROJECTS No 1, No 2 and No 3.

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PC – 16 pin. £2.75.
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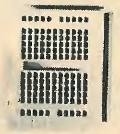
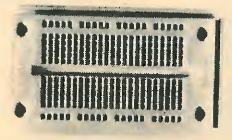
EXPERIMENTOR BREADBOARDS.

No soldering modular breadboards, simply plug components in and out of letter number identified nickel-silver contact holes. Start small and simply snap-lock boards together to build breadboard of any size.
All EXP Breadboards have two bus-bars as an integral part of the board, if you need more than 2 buses simply snap on 4 more bus-bars with the aid of an EXP.4B.

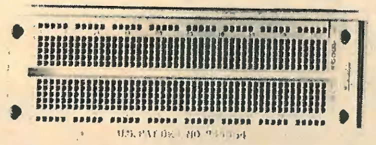
EXP.325. The ideal breadboard for 1 chip circuits.
Accepts 8,14,16 and up to 22 pin IC's.
ONLY £1.60.



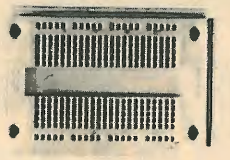
EXP.350. £3.15.
270 contact points with two 20-point bus-bars.



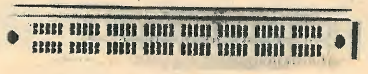
EXP. 300.
550 contacts with two 40-point bus-bars.
£5.75.



EXP. 650 for Micro-processors. **£3.60.**



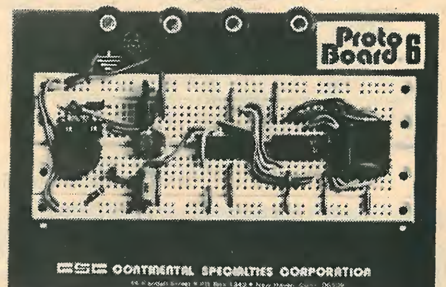
EXP 4B.
More bus-bars.
£2.30.



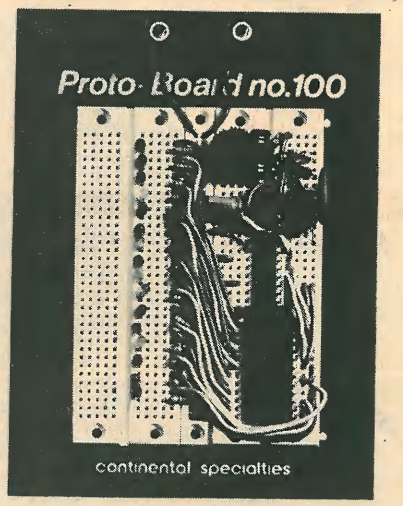
ALL EXP.300 Breadboards mix and match with 600 series.

PROTO-BOARDS.

THE ULTIMATE IN BREADBOARDS FOR THE MINIMUM COST.
TWO EASILY ASSEMBLED KITS.



PB.6 Kit, 630 contacts, four 5-way binding posts accepts up to six 14-pin Dips.
PROTO-BOARD 6 KIT. £9.20.



PB.100 Kit complete with 760 contacts accepts up to ten 14-pin Dips, with two binding posts and sturdy base. Large capacity with Kit economy.
PROTO-BOARD 100 KIT £11.80.

HOW TO ORDER AND RECEIVE FREE COPY OF TWO-TRANSISTOR RADIO PROJECT, FISH'N'CLIKS AND LED BAR GRAPH.

CSC UK LTD. Unit 1, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ.
It's easy. Give us your name and full postal address, in block capitals. Enclose cheque, postal order or credit card number and expiry date. OR telephone 0799 21682 and give us your Access, American Express or Barclaycard number and your order will be in the post that night.

EXPERIMENTOR. BREADBOARDS.	CONTACT HOLES.	IC CAPACITY 14 PIN.DIP.	UNIT PRICE INCLUDING POSTAGE AND V.A.T.
EXP. 325	130	1	£ 2.53
EXP. 350	270	3	£ 4.21
EXP. 300	550	6	£ 7.29
EXP. 650	270	use with 0.6 pitch Dip's	£ 4.69
EXP. 4B.	Four 40 Point Bus-Bars	Bus-Bar Strip	£ 3.29
TEST CLIPS			
PC. 16.			£ 3.78
PC.16-18.			£ 7.56
PC. 16-18 Dual Clip.			£12.15
PROTO-BOARDS.			
PB. 6.	630	6	£11.01
PB. 100.	760	10	£13.82

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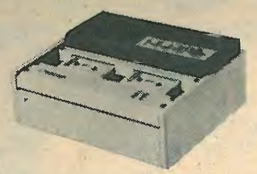
FILL IN COUPON & RECEIVE FREE COPY OF ELECTRONICS BY NUMBERS PROJECTS Nos 1, 2 AND 3

WW — 021 FOR FURTHER DETAILS

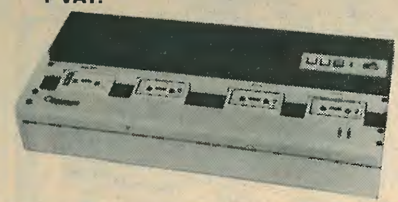
Number 1...

NEW! Cassette copiers from PENTAGON

Simple operation — fully automatic 16 times speed. Choice of one or three copies. C32/34 — outproduces all other makes — 75 C60 per hour. Budget price from **£587 + VAT.**



Model C-1—Mono
Model C-4—Stereo



Model C32S—Mono
Model C23S—Stereo

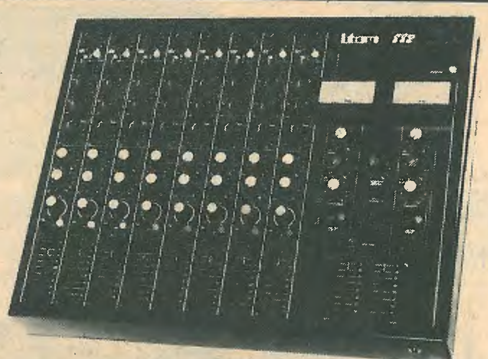
AURATONE

The amazing 5C Super Sound Cube. Used in virtually every major studio as a secondary monitoring source. Ideal for mobile and portable applications. Only 6" x 6" but it sounds enormous! only **£38** per pair + VAT.

...for Professional...

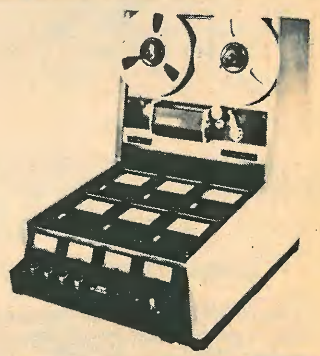
ITAM 882

New Stereo Mixer, built to a specification not a price! Ultra low noise, +8 direct outputs, 2 outputs with VU meters, 2 limiters. XLR mic inputs (balanced). 3 band EQ + mid sweep. **£395 + VAT**



OTARI DP4050 OCF IN CASSETTE DUPLICATOR

Now with 3¾ + 7½ master capability and Ferrite heads. Duplicates 6 cassettes each run at 8 times speed. Over 80 stereo C60 per hour. Unquestionably the finest in cassette copiers available from the world's largest duplicator manufacturer.



...Equipment.

AMPEX ATR-700

Now every studio can afford legendary Ampex performance and reliability. Fully professional specification including balanced inputs/outputs, Cannon connectors, variable tape speed, sel sync. The price will fit this year's budget, not next year's! Sole distribution by ITA.

ORBAN from USA

Dual channel multispring reverb unit. Each channel features four springs — far smoother than single spring systems. "Twang" and "boing" are virtually eliminated by incorporating a floating threshold limiter. Bass, mid-range EQ and bandwidth controls. The best compact reverb unit available.

ITA

1-7 Harewood Avenue, Marylebone Road, London, NW1
Tel. 01-724 2497. Telex: 21879

SUPER RANGE AUTO/STANDBY INVERTERS

Introducing our new CRA range of automatic standby inverter units. Assembled in aluminium instrument cases with rexine covered top.

Features Include

All silicon transistors — Separate driver and output transformers — Choice of models providing 240v off load or 110v off load AC outputs — Frequency choice of models for 50Hz or 60Hz outputs (both + — 5% typical) — Built-in battery charger model, choice of either 12v, 24v, 48v dc 500ma — Square-Wave Output Standard or optional filtered output available — DC line Fused — Rubber 13-amp type mains output socket panel fused — Switchover from mains to inverter supply automatic and almost instantaneous — Automatic control relays designed to only fail in safe modes — Red panel indicator shows mains on — Green panel indicator shows inverter on — Designed for very cool operation — 2-year guarantee.

OPERATION

Simply connect to front panel 13-amp rubber socket any equipment you require to operate permanently from the normal mains supply or built in inverter supply, connect the polarity coloured leads to a suitable battery source and finally plug in the mains cable with 13-amp plug fitted to your normal mains supply socket — you're never need to be in the dark again.

CRA/1—Cased 10" x 8" x 4" 150 watts	**£50.40**
CRA/2—Cased 10" x 8" x 4" 200 watts	**£62.60**
CRA/3—Cased 10" x 8" x 4½" 250 watts	**£74.00**
CRA/4—Cased 12" x 8" x 4½" 300 watts	**£85.00**
CRA/5—Cased 12" x 8" x 5" 400 watts	**£106.00**
CRA/6—Cased 12" x 8" x 5" 500 watts	**£138.00**
CRA/7—Cased 12" x 8" x 6" 700 watts	**£182.20**

ORDER DETAILS
State input/output voltage required
State 50Hz or 60Hz inputs/outputs
Filtered output available at 20% extra

TRANSISTORISED DC TO AC INVERTERS

12v-24v-48v dc input models
110v or 240v AC off load output models
Square-wave output or optional filtered models
Frequency 50Hz or 60Hz models (± 5% typical)

All silicon power transistors
Separate driver and output transformers
Designed for cool continuous operation
Aluminium ventilated cased units
DC input fused

12v dc inputs/110v or 240v outputs
50Hz or 60Hz

N12/A—8"x6"x6" 40 watts	**£18.00**
N12/B—8"x6"x6" 60 watts	**£23.20**
N12/C—8"x6"x6" 100 watts	**£28.10**
N12/D—8"x6"x6" 150 watts	**£34.50**
N12/E—8"x6"x6" 200 watts	**£42.00**
N12/F—8"x6"x6" 250 watts	**£50.60**
N12/G—8"x6"x6" 300 watts	**£58.00**
N12/H—10"x8"x6" 400 watts	**£69.80**

Filtered waveform models available at 15% extra.

24v dc inputs/110v or 240v outputs
50Hz or 60Hz

N24/A—8"x6"x6" 40 watts	**£19.20**
N24/B—8"x6"x6" 100 watts	**£29.80**
N24/C—8"x6"x6" 150 watts	**£36.00**
N24/D—8"x6"x6" 200 watts	**£44.00**
N24/E—8"x6"x6" 250 watts	**£52.50**
N24/F—8"x6"x6" 300 watts	**£60.00**
N24/G—10"x8"x6" 400 watts	**£71.40**
N24/H—10"x8"x6" 500 watts	**£83.00**
N24/I—12"x8"x8" 700 watts	**£101.00**
N24/J—12"x8"x8" 1000 watts	**£150.00**

Filtered waveform models available at 15% extra.

48v dc inputs/110v or 240v outputs
50Hz or 60Hz

N48/A—8"x6"x6" 50 watts	**£20.00**
N48/B—8"x6"x6" 100 watts	**£31.60**
N48/C—8"x6"x6" 150 watts	**£37.00**
N48/D—8"x6"x6" 200 watts	**£45.00**
N48/E—8"x6"x6" 250 watts	**£54.00**
N48/F—8"x6"x6" 300 watts	**£62.00**
N48/G—10"x8"x6" 400 watts	**£73.00**
N48/H—10"x8"x8" 500 watts	**£86.00**
N48/I—12"x10"x8" 700 watts	**£112.00**
N48/J—12"x10"x8" 1000 watts	**£160.00**
N48/K—12"x10"x10" 1500 watts	**£210.00**

Filtered waveform models available at 15% extra.

Please add £5.00 carriage per unit U.K. overseas at cost
Delivery 10 to 21 days subject to availability — Cased sizes subject to variations
Callers strictly by appointment — **Telephone enquiries 01-736 0685**

ELECTROVANCE P.O. BOX 191, LONDON SW6 2LS

Tecknowledgey for sale.

The Mark III FM Tuner

DIY Hi-Fi will never seem the same again. Ambit's Mark III tuner system is electrically & visually superior to all others. Some options available, but the illustrated version with reference series modules: £149.00 + £18.62 VAT

With Hyperfi Series modules £185.00 + £23.12

ALL TUNER KITS £3 carriage

Features of the system:
- Precision construction & design of all parts
- Time/frequency display
- State of the art performance with facilities for updates, using modular plug in systems.
- Deviation level calibrator for recording
- All usual tuner features

Digital Dorchester All Band Broadcast Tuner: LW/MW/SW/SW/SW/FM stereo

A multiband superhet tuner, constructed using a single IC for RF/IF processing - but with all features you would expect of designs of far greater complexity. The FM section uses a three section (air gang) tuned FET tunerhead, with ceramic IF filters and interstation mute; AM employs a double balanced mixer input stage, with mechanical IF filters - plus a BFO and MOSFET product detector for CW/SSB reception. Styled in a matching unit to the Mark III FM only tuner, employing the same degree of care in mechanical design to enable easy construction. MW/LW reception via a ferrite rod antenna.

Electronics only (PCB and all components thereon)	£33.00 + £4.12 VAT
Complete with digital frequency readout/clock-timer hardware	£99.00 + £12.37 VAT
Complete with MA1023 clock/timer module with dial scale	£66.00 + £8.25 VAT

Hardware packages are available separately if you wish to house your own designs in a professional case structure. Please deduct the cost of electronics from complete prices.

LW/MW/FM LCD Digital Frequency Display - July PW feature

Update your old radio, or build this into a new design. Or use it as a servicing aid - this low power unit with LCD display reads direct frequency in kHz/MHz, or with usual AM/FM IF offsets for received frequency. Low power LCD means no RFI - 15-20mA at 9v even with the divide by 100 prescalar. FM resolution is 100kHz, AM 1kHz. Sensitivities better than 10mV

Complete kit £19.50 +*£1.56 VAT. Built and tested version £24.00 +*£1.92 VAT

Various other DFM systems described in our catalogue part 2 - including a one chip solution to providing digital display of FRG7 kHz dial, combined with clock/timers etc.

PW SANDBANKS PI METAL LOCATOR

Maintaining our professional approach to home constructor kits, we offer the pulse induction 'Sandbanks'. Now with injection molded casing for greatly improved environmental sealing. £37.00+ *£2.96vat.

VHF MONITOR RX WITH PLESSEY IC

4/9 channel version of the PW design - but using standard 3rd OT crystals, and TOYO 8 pole crystal filter with matching transformers. Coil sets from our standard range to cover bands from 40 to 200MHz. Complete module kit £31.25 +£3.90vat.

ETI - REMCON RADIO CONTROL

A tried and tested RC system with a full set of supporting hardware from a well known manufacturer. Please send for details - and watch our ads for further news of developments in RC products.

Radio and Audio Modules : The biggest range/ best specs:

EF5801/3/4 6 stage varicap tunerheads with LO feed and various levels of sophistication. New 5804 include pin AGC loop 'on board'. 5801:£17.45+£2.18vat - 5803:£19.75+£2.47vat 5804:£24.95 +£3.18vat. *Frequencies in 40-180MHz on appcn.*

EF5402 4 stage varicap with TDA1062, compound FET/Bipolar input stage, low noise, balanced mixer, pin agc, osc output. A worthy successor to the 5400. £10.75+£1.34vat

The 5402 is available centred on a wide range of frequencies from 30MHz to 180MHz. Non standard units £14.75+£1.84 - 3 weeks.

8319 4 stage varicap tunerhead from Larsholt using MOSFET RF and mixer stages. New temperature compensated oscillator for wide ranges of ambient temperature £13.45+£1.68vat

7252 Complete Larsholt FM tuner less stereo decoder £26.50+£3.31vat

7253 Stereo FM tunerset from Larsholt with FET head. (as 7252)

944378 Hyperfi stereo decoder. The very best. £19.95+£2.49vat

911223 Pilot cancel stereo decoder, priced to make the MC1310 as obsolete as it now deserves to be.£12.50+£1.56vat

Inotec 1-A fully DC tuned and switched LW/MW/FM stereo tuner to interface with synthesiser control etc.A first! Details OA

COMPONENTS for Radio and Audio ICs, HMOS etc.

The list is too long to attempt here, but AMBIT specializes in all types of semiconductor for radio reception, including devices operating from DC to 5GHz. New low cost SBL1 diode ring mixers (equiv case MD108 etc) -first with HMOS fets, now with a PCB for DC amplifier, and offset sense and protection relay for speakers. See catalogue and updates for most info, pse send an SAE for information on anything you cannot find in catalogues.

Radio ICs	cost + vat		Stereo ICs	cost + vat		AF power ICs	cost + vat	
CA3089E	1.94	24	MC1310P	1.50	19	LM380N	1.00	12
CA3189E	2.45	30	uA758	2.20	27	TBA810AS	1.09	14
HA1137W	2.20	27	CA3090A	2.75	34	TDA2002	1.95	24
SN76660	0.75	9	HA1196	3.95	49	TBA820M	0.75	9
TDA1090	3.35	42	HA11223	4.35	54	from the general list:		
TDA1083	1.95	24	KB4437	4.35	54	LEDs:all colours and		
TDA1220	1.40	17	KB2224	2.75	34	low prices		
SL6640	2.75	34	Preamp ICs/switches			2SJ48/2SK134 HMOS		
MC3357	3.12	39	TDA1028	3.50	44	9.90 +£0.80 vat(Pair)		
HA1197W	1.40	17	TDA1029	3.50	44	Signal fets/transistors and		
MC1496	1.25	16	TDA1074	4.14	52	TOKO COILS & FILTERS!		
LM373/4	3.75	49	KB4438	2.22	28			

OSTS: Remember all OSTS stocks are obtained from BS9000 approved sources - your assurance that all devices are very best first quality commercial types. Some LPSN TTL is presently in great demand, so please check by phone before ordering

TTL:Standard AND LP Schottky

All prices listed in pence *

	'N'	'LSN'		'N'	'LSN'		'N'	'LSN'		'N'	'LSN'		'LSN'
7400	13	20	7455	35	24	74126	57	44	74185	134		74377	124
7401	13	20	7460	17		74128	74		74188	275		74378	93
7402	14	20	7463		124	74132	73	78	74190	115	92	74379	130
7403	14	20	7470	28		74133		29	74191			74368	37
7404	14	24	7472	28		74136		40	74192	105	180	74390	140
7405	18	26	7473	32	38	74138		60	74193	105	180	74393	140
7406	38		7474	27	38	74139		60	74194	105	187	74395	139
7407	38		7475	38	40	74141	56		74195	95	137	74396	133
7408	17	24	7476	37	38	74142	265		74196	99	110	74398	180
7409	17	24	7478		38	74143	312		74197	85	110	74399	150
7410	15	24	7480	48		74144	312		74198	150		74445	92
7411	20	24	7481	86		74145	65	97	74199	160		74447	90
7412	17		7482	69		74147	175		74247		90	74490	140
7413	30		7483A		110	74148	109	191	74248		90	74668	110
7414	51		7484	97		74150	99		74249		93	74670	249
7415		24	7485	104	99	74151	64	84	74251		90		
7416	30		7486		40	74153	64	54	74253		105		
7417	30		7489	205		74154	96		74257		108		
7420	16	24	7490	33	90	74155	54	110	74258		153		
7421	29	24	7491	76	110	74156	80	110	74259		420		
7422	24	24	7492	38	78	74157	67	55	74260		153		
7423	27		7493	32	99	74158		60	74261		353		
7425	27		7494	78		74159	210		74266		40		
7426	36	27	7495A	65	99	74160	82	130	74273		124		
7427	27	29	7496	58	120	74161	92	78	74275		312		
7428	35	32	7497	185		74162	92	130	74279		52		
7430	17	24	74100	119		74163	92	78	74283		120		
7432	25	24	74104	63		74164	104	130	74290		90		
7433	40	32	74105	62		74165	105		74293		95		
7437	40	24	74107	32	38	74166			74295		120		
7438	33	24	74109	63	38	74167	20		74298		100		
7440	17	24	74110	54	54	74168			74324		157		
7441	74		74111	68		74169		200	74325		242		
7442	70	99	74112		38	74170	230	200	74326		247		
7443	115		74113		38	74172	625		74327		237		
7444	112		74114		38	74173	170		74352		100		
7445	94		74116	198		74174	87	120	74353		100		
7446	94		74118	83		74175	87	110	74362		715		
7447	82	89	74119	119		74176	75		74365		49		
7448	56	99	74120	115		74177	78		74366		49		
7449		99	74121	25		74180	85		74367		43		
7450	17		74122	46	57	74181	165	350	74368		49		
7451	17	24	74123	48	73	74182	160		74373		77		
7453	17		74124		137	74183		210	74374		77		
7454	17	24	74125	38	44	74184	135		74375		60		

VOLTAGE /PSU REGULATORS

7800 series	95p
7900 series	£1
78M series (TO220 pack)	90p
78LCP series	35p
78MGT2C	175p
79MGT2C	175p
723C	65p
NE550A	73p
L200	195p

MAINS FILTERS

1Amp IEC	4.83
6Amp IEC	5.83
5A wirein	3.87

All BS approved

Requests for the next issue of the catalogue now being "booked" for despatch immediately it is ready (about November). Please send 50p to reserve a copy. (Part 3)

IMPORTANT: ALL OSTS PRICES EXCLUDE VAT - CURRENTLY 8% - BUT MAY BE CHANGED BY THE TIME YOU READ THIS. PLEASE REMEMBER TO ADD VAT, and 25p POSTAGE !!

CD4000 CMOS

4000	17p				
4001	17p	4059	563p	4522	149p
4002	17p	4060	115p	4527	157p
4006	109p	4063	109p	4528	102p
4007	18p	4066	53p	4529	141p
4008	80p	4067	400p	4530	90p
4009	58p	4068	25p	4531	141p
4010	58p	4069	20p	4532	125p
4011	17p	4070	20p	4534	614p
4012	17p	4071	20p	4536	380p
4013	55p	4072	20p	4538	150p
4014	95p	4073	20p	4539	110p
4016	52p	4075	20p	4541	141p
4017	80p	4076	90p	4543	174p
4018	80p	4077	20p	4549	399p
4019	60p	4078	20p	4553	440p
4020	93p	4081	20p	4554	153p
4021	82p	4082	20p	4556	77p
4022	90p	4085	82p	4557	386p
4023	17p	4086	82p	4558	117p
4024	76p	4089	150p	4559	388p
4025	17p	4093	50p	4560	218p
4026	180p	4094	190p	4561	65p
4027	55p	4096	105p	4562	530p
4028	72p	4097	372p	4566	159p
4029	100p	4098	110p	4568	281p
4030	58p	4099	122p	4569	303p
4031	250p	4160	90p	4572	25p
4032	100p	4161	90p	4580	600p
4033	145p	4162	90p	4581	319p
4034	200p	4163	90p	4582	164p
4035	120p	4174	104p	4583	84p
4036	250p	4175	95p	4584	63p
4037	100p	4194	95p	4585	100p
4038	105p	4501	23p		
4039	250p	4502	91p		
4040	83p	4503	69p		
4041	90p	4506	51p		
4042	85p	4507	55p		
4043	85p	4508	248p		
4044	80p	4510	99p		
4045	150p	4511	149p		
4046	130p	4512	98p		
4047	99p	4513	206p		
4048	60p	4514	260p		
4049	65p	4515	300p		
4050	55p	4516	125p		
4051	65p	4517	382p		
4052	65p	4518	103p		
4053	65p	4519	57p		
4054	120p	4520	109p		
4055	135p	4521	236p		

Micromarket

6800 series					
6800P	6.50	8216	1.95	2114	£10
6820P	£6	8224	3.50	2708	£
6850P	2.75	8228	4.78	**Development**	
6810P	£4	8251	6.25	MEK6800	£220
6852	3.65	8255	5.40	TK80	£306
8080 series		**MEMORIES**		AMI, Signetics TI, Intersil, Harris etc. OA	
8080	6.30	2102	£1.70		
8212	2.30	2112	£3.40		
		2513	£7.54		
		4027	£5.78		

MISC. LSI/Scalars/DVMs

NE555 30p NE556 78p NE558 180p
LM3909 72p 95H90DC /320MHz 7.80p
11C90DC /650MHz £14.00

ICM7216BIPI 8 decade 10MHz DFM/timer with direct LED drive and all counter features	**£19.82**
ICM7217AIBI 4 decade programmable cntr.	£9.50
ICM7207 clock pulse generator IC	£4.95
ICM7208 7 decade counter/display driver	£14.95
ICM7106CP LCD DVM IC (3½ digit)	£9.55
ICM7106CPK LCD DVM KIT	£24.80
ICM7107CP LED DVM IC	£9.55
ICM7107CPK LED DVM KIT	£20 65
SP8629 divide by 100/200MHz scalar	£4.20
MSL2318 divide by 100 to 175MHz min divide by 10 to 45MHz min	£4.20

PLEASE REMEMBER TO ADD 8% VAT TO ITEMS LISTED UNDER OSTS

LINEARS non-consumer

BIMOS			
CA3130E	84p	LM324N	71p
CA3130T	90p	LM339N	66p
CA3140E		LM348N	186p
CA3140T	72p	LM3900N	60p
CA3160E	90p	709HC to5	64p
CA3160T	99p	709PC dil	36p
Op amps		710HC to5	65p
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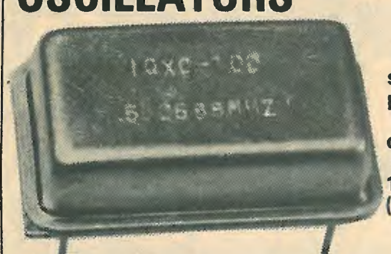

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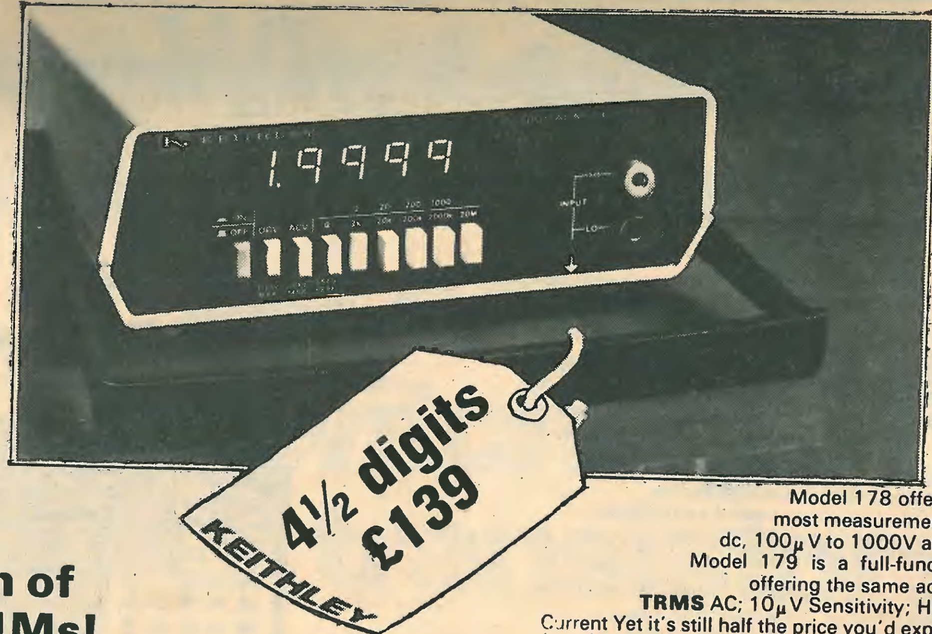

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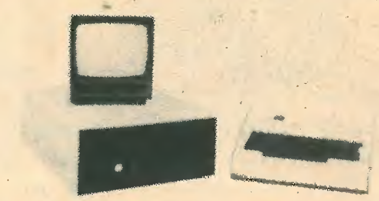	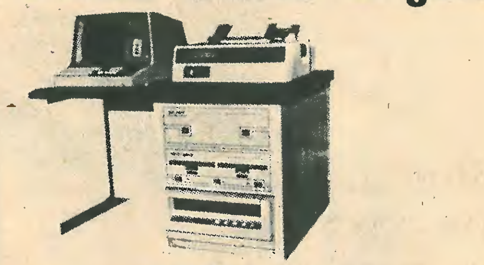
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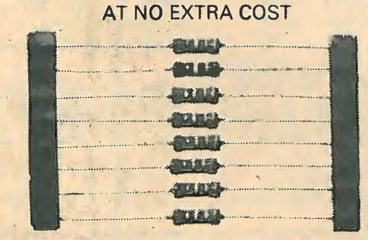

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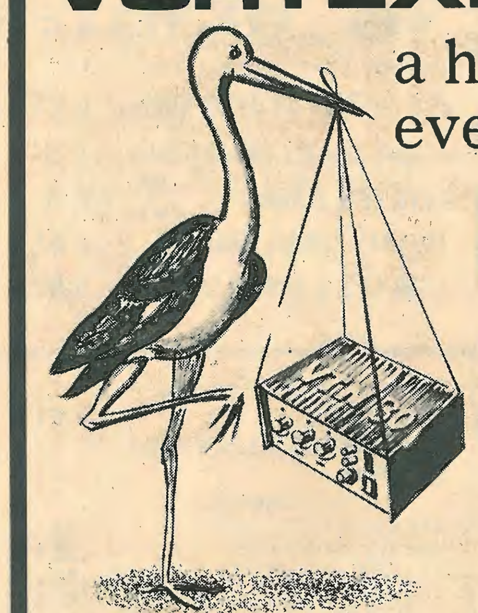

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4043	.57
4044	.57
4046	.82
4047	.95
4049	.28
4050	.31
4051	.51
4052	.51
4053	.51
4060	.94
4066	.33
4068	.15
4069	.15
4070	.15
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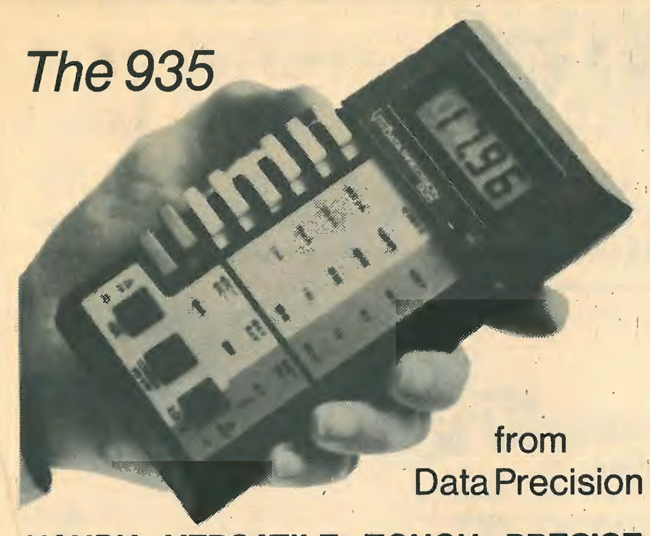

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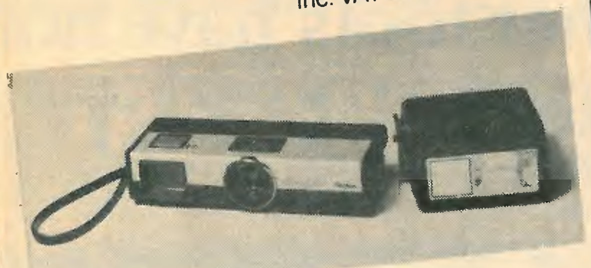

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Information gap

If the new British government pays any attention to a Conservative Party working group report issued just before the election, it will be establishing a definite policy on information technology. The report recommends for example that there should be a government minister to be responsible for the information industries and that strikes by people operating telecommunication and some computer systems should be made illegal. But although it deals with many social aspects of information technology, the report fails to mention that ever-present fear of ordinary people that we are all being taken over by computers. This report above all should have made it clear that such anxieties can be dispelled by the proper use of information — to inform.

Partly conditioned by novels depicting people at the mercy of machines, such as "Brave New World" and "1984," the public view of the advancing computer-state is one of near horror. It is convenient for those in favour of unchecked collection of personal data that the villain of the piece is the device used to sift the evidence rather than the human intelligence at the controls. Add to this the widespread concern at the threat of structural unemployment in the wake of the silicon chip, and the computer really begins to emerge as a fully formed monster.

One misconception could be dispelled by pointing out that, in spite of remarkable increases in memory capacity, no machine has yet been made which could be termed "intelligent" in more than the limited sense mentioned in our November editorial. It is even more important that people should be helped to grasp the inescapable fact that a computer is nothing without a program — that vital human stimulus, like the blow administered to a new born baby to make it breathe, without which the mechanism cannot function.

Some optimistic engineers have seen visions of a perfect society served by an impeccable technology, but realities such as atmospheric pollution and electronics in the service of war limit the fulfilment of such visions. One comes to the sad conclusion that, without a sensitive and cautious approach to the widening problems of the interface between the natural and man-made worlds, industrial unrest and social disruption must follow. A great deal can be done, however, by overcoming ignorance.

Those who have the skills to communicate ideas should begin the attempt to bridge the information gap by showing real evidence of the advantages of data processing in time and labour saving and by describing improvements in operating efficiency not only in industry but in social services such as electricity supply, home heating systems and medicine where computer systems are in use. Such illustrations can be underlined by emphasising that electronics is still subject to control by human will and that as long as technical progress is directed with care it can do much to improve the human condition.

It has been reported elsewhere that the Department of Inland Revenue is to computerise all its PAYE administration areas, and processing operations are to begin in 1984. This really isn't "Big Brother" looming as a tangible reality, but the coincidence is certainly one to produce a knowing smirk on the face of a committed critic of computers and data banks.

On the other hand, if we are not prepared to provide sufficient information to allay the fears of the uninitiated we can hardly blame them for turning a deaf ear to our protestation that all is well. At least, as far as we know all is well. If the worst should happen and 1984 becomes reality in 1994 some of us may recognise that, as with politicians, we only get the systems we deserve.

The loop aerial revived

Three designs for improving broadcast band reception

by R. E. Schemel

When the ferrite rod aerial came into general use in broadcast receivers the loop or frame aerial that had served well for many years fell into obscurity. Here the author takes a fresh look at the loop and shows how it can be used to improve reception of distant and fringe-area m.w. and l.w. stations, particularly in the interference conditions of the average home. After a theoretical analysis and comparisons with ferrite rod and long wire aerials the article presents three designs at different levels of constructional complexity: a simple magnetic field multiplier, which is placed near (but not connected to) a set with a ferrite rod aerial; a large external loop which can be wound round pieces of furniture; and a small loop intended to be fitted inside the case of a receiver.

NOW THAT a new frequency plan for the long and medium wave broadcast bands has been introduced into Europe reception should be improved, particularly after dark. There may therefore be an awakening of interest from readers (and also from the general public) in receiving stations other than those of local origin, but to do this one requires an aerial whose pick-up properties are considerably superior to the ferrite rod incorporated into the majority of modern receivers.

Quite apart from long distance reception, there are also other situations where a better performance is desirable; for example, reception in a much larger fringe area would be possible for the extensive local radio network which is developing. Looking further ahead, a.m. stereo is under active consideration (in the United States at least), and presumably this will call for an improved signal-to-noise ratio, for aesthetic if not for technical reasons. It would thus seem to be an opportune moment to suggest that a good aerial which would meet the above requirements is nothing more than an old fashioned loop, which passed into a sort of technical twilight with the introduction of the ferrite rod.

Ferrite rod aerials are now almost universally used for broadcast reception, and have been so for at least two decades. Prior to this a long wire external to the receiver reigned supreme, except where portability was required, and in these cases a loop was used which was often a part of the cabinet.

Going further back in time, some of the earliest radios often sported frame aerials of large size and impressive shapes. Why the rise and decline in the popularity of the loop should have occurred is not clear, since its advantages for broadcast reception have long been known, but several minor reasons could be cited. One is that early loops could be easily mistuned by hand capacitance effects, another is that of the added complication of making one loop winding tune both the medium and the long waves (but then many parts of the world use only one waveband). Other reasons are less tangible; for example, it may be difficult to manufacture a receiver with a loop external to the main circuit board, the present day ferrite rod being convenient in respect of unitary construction, low magnetic coupling and ease of alignment before assembly; it could simply be the whim of fashion. If this is the only reason, manufacturers please take note!

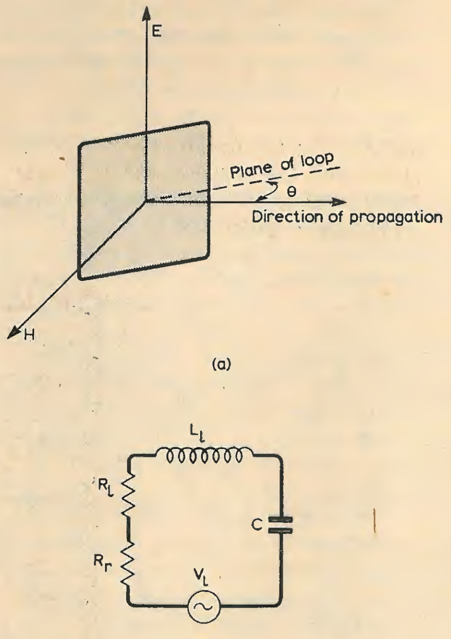


Fig. 1. *A loop aerial immersed in an electromagnetic field. At (a) system of co-ordinates with vertical field strength E volts/metre, horizontal field strength H amperes/metre and θ the angle between plane of loop and direction of propagation. At (b) the equivalent circuit with L_l inductance of loop, R_l loss resistance, and R_r radiation resistance, the loop being tuned by capacitance C.*

The need for magnetic loop reception

The easiest and cheapest aerial for broadcast band reception is almost certainly a longish piece of wire. It gives far more signal than is necessary, and this allows the coupling into the input stage to be so weak that mistuning is minimal. Even a metre or so of wire is adequate if the coupling is increased, as can be confirmed by checking the performance of one of the better car radios. Why, then, bother with anything else? The answer lies in the electromagnetic environment, which has become progressively more harsh. The average house is probably provided with several commutator type motors, innumerable on/off contacts, fluorescent lamps, and that arch villain, the television receiver. Outside of the immediate area around a house, factories, trains, welders, street lighting, high voltage power lines and many other sources all have the potential of causing interference. This is either conducted to the vicinity of the receiver by the mains, overhead lines, etc. or is radiated. The net result, particularly in urban areas, is interference which often is well above the natural background noise level.

Almost all the interference at the broadcast range of frequencies is caused by relatively high r.f. voltages rather than by closed current loops. The electric, electromagnetic, and magnetic fields generated by such voltages can be described in terms of elementary electric doublets (see, for example, any textbook on antennas). The theory is quite straightforward, but for the purpose of this article it is convenient to consider the coupling between the interference source and a wire aerial as being only capacitive and electromagnetic, the inductive (magnetic) effects being negligible. It can be shown that the capacitive coupling between two small doublets varies as the inverse cube of distance, and thus the coupled interference also varies in the same way. Electromagnetic radiation also occurs, and this gives rise to a field which varies inversely with distance. At a large distance from the source the electromagnetic effect predominates,

but near to the source the capacitive, or electrostatic, effect is much larger. The critical distance where the electric and electromagnetic fields are equal is $\lambda/2\pi$ in the case of a small doublet, and at broadcast wavelengths this is 50 metres or more.

A small loop aerial is not responsive to purely electric fields, but only to the magnetic flux threading its area (in this respect it cannot differentiate between an electromagnetic or magnetic field). Inside the critical radius the loop will therefore have superior interference rejection properties compared with a wire aerial. The corollary, that is, a wire would be superior to a loop if the interference were caused by closed current paths, is also true but is not generally of interest in practice.

The superiority of the magnetic loop over a wire aerial can be quite substantial, particularly when the source is localized and close in terms of a wavelength or the interference is conducted. In this last respect, it is particularly advantageous in suppressing television line timebase interference, and readers who have receivers equipped with both ferrite aerials and a connection for a long wire can confirm this. A loop is therefore a natural choice for reception on the broadcast bands, provided that its pick up properties are adequate. That this is so will now be demonstrated.

Loop and ferrite rod principles

Fig. 1 shows an electrically small loop (e.g. all dimensions much smaller than the wavelength) immersed in an electromagnetic field. The field has a vertical strength of E volts/metre and a horizontal strength of H amperes/metre. The plane of the loop is at an angle θ to the direction of propagation. E and H are related by the well known expression $H = E/Z_0$, Z_0 being the characteristic impedance of free space. Z_0 is defined by the relation

$$Z_o = \sqrt{\frac{\mu_o}{\epsilon_o}} = 377 \text{ ohms} = c\mu_o$$

$\mu_0 = 4\pi \times 10^{-7}$ henries/m (free space permeability)

$\epsilon_0 = 8.85 \times 10^{-12}$ farads/m (free space permittivity)
c = velocity of light $= 1/\sqrt{\epsilon_0\mu_0}$

The H field gives rise to a uniform flux density of $B = \mu_0 H$ tesla and the loop area A intercepts a total flux of $BA\cos\theta$ webers. If the flux varies sinusoidally, i.e.,
$B(t) = B.\sin 2\pi ft$
then the flux rate of change is
$\dot{B}(t) = B.2\pi f\cos 2\pi ft$,
and a voltage V is induced into an N turn loop of

$$V = AN\dot{B} = 2\pi fANE(\mu_0/Z_0)\cos\theta, \qquad (1)$$

where the variation with time has been dropped. By substituting for μ_0 and Z_0 and aligning the loop with the direction of propagation, the more familiar expression in terms of wavelength may also be obtained:

$$V = \frac{2\pi NAE}{\lambda}. \qquad (2)$$

The induced voltage is injected in series with the loop, and when the latter forms part of a tuned circuit, the output across the tuning capacitor is

$$V_1 = 2\pi fA_lN_l(\mu_0/Z_0) . E . Q_l . \qquad (3)$$

If a ferrite rod is slipped inside the loop the flux increases, the proportional increase being defined as the effective permeability of the rod and being denoted by the symbol μ_f. Thus, for a ferrite rod, eq. (3) becomes

$$V_f = 2\pi fA_fN_f(\mu_0/Z_0)\, E\, Q_f\mu_f \qquad (4)$$

μ_f is a complicated function of the length to diameter ratio and, to a much lesser extent, the relative permeability of the rod material. Fig. 2 shows the relationship*, from which it can be seen that a value for μ_f of between 50 and 150 can be expected.

Loop vs. ferrite rod

The relative performance of the two aerials can now be examined under the following basic assumptions:
1. Both aerials have the same inductance (so that they tune with the same load capacitance)
2. Each aerial is electrically small and there are no effects other than those discussed.

Before making the comparison the turns required for each type of aerial must be known.

The inductance of any single-layer

*For complete design details of a ferrite aerial see Ref. 1. Also see the December 1978 issue of *Wireless World* for an interesting alternative derivation of eq. (4)

Fig. 2. *Relationship between effective permeability of ferrite rod and length-to-diameter ratio of the rod.*

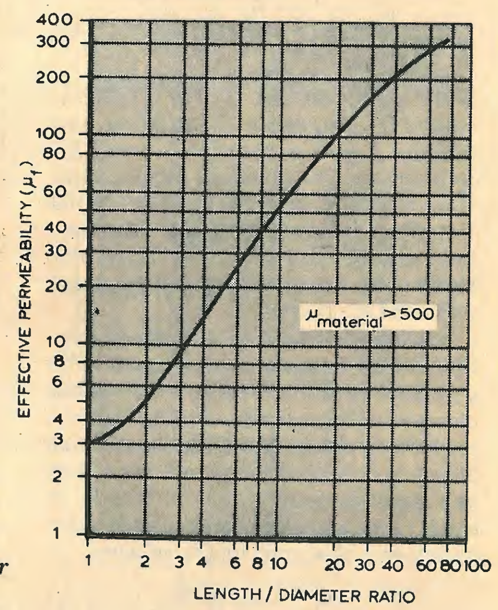
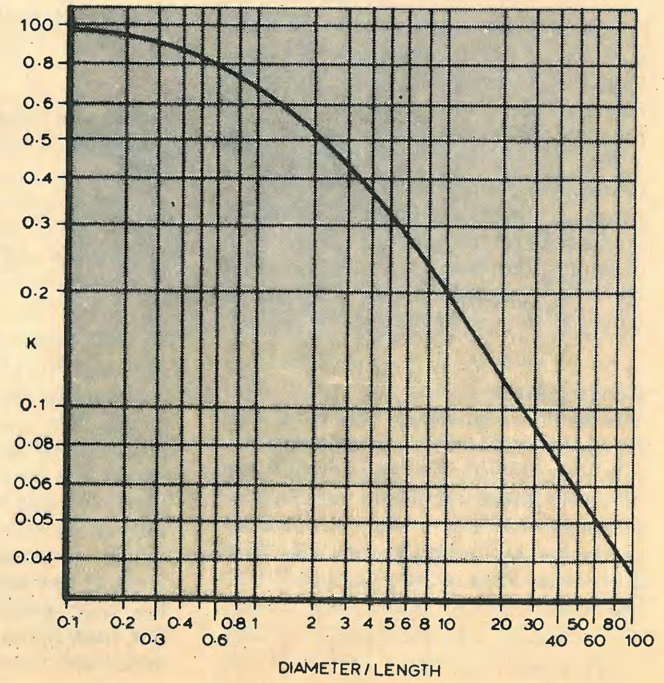


Fig. 3. *Value of form factor K used in inductance calculations for a circular coil, as a function of the ratio: diameter d to length l of the coil.*



coil can be calculated from the general formula

$$L=\frac{\mu_o AN^2K\mu_e}{l} \qquad (5)$$

where K is a form factor which is a function of the diameter d to coil length l, and μ_e is the effective permeability of the magnetic material inserted into the coil. Values of K can be found from Fig. 3, which is strictly valid for single layer coils of circular cross section. Rectangular cross section coils can be allowed for by calculating a value for d based on a circular cross-section of the same area and the formula is also valid for thin multilayer coils. From eq. (5) the number of turns is

$$N=\sqrt{\frac{Ll}{\mu_o AK\mu_e}}. \qquad (6)$$

Substituting for N in eqs (3) and (4), a dimensionless figure comparing the performance of the two different types of aerials is obtained:

$$\frac{V_l}{V_f}=\frac{Q_l}{Q_f}\cdot\frac{1}{\mu_f}\sqrt{\frac{l_l}{l_f}\cdot\frac{A_l}{A_f}\cdot\frac{K_f}{K_l}}\cdot\mu_e \qquad (7)$$

Of the variables in eq. (7), the Q factor is limited by problems of tracking and selectivity, and in practice is equal for both aerials. The effective permeability of the ferrite, μ_f, could be up to about 100 for rods of reasonable length, diameter, and material permeability. μ_e is typically about 12 for the types of coil shapes and rods used in practice.*

The other variables are at the discretion of the designer, but to make the comparison as equitable as possible identical coil geometries will be considered. (In practice it will be found that different coil geometries will not make any significant difference.) Thus K_l is equal to K_f, l will be proportional to the square root of A, and eq. (7) becomes

$$\frac{V_l}{V_f}=\frac{\sqrt{\mu_e}}{\mu_l}\left(\frac{A_l}{A_f}\right)^{3/4}. \qquad (8)$$

A typical cross section of a ferrite rod is $A_f=0.5$ cm^2 and for comparison a small loop 25 × 16 cm will be taken, this being representative of one of the smallest portable radio sizes which could include a 20cm ferrite rod. Substituting these figures, the ratio is found to be about 5 times or 14dB. Commonly available ferrite rods do not seem to exceed 20cm in length, whereas many radios would allow for a larger loop; a 30 × 50cm loop would give gains of 20 times or 26dB.

Performance

The traditional measure of performance for a loop aerial is expressed by eq. (2) or (3); however, this is really only a figure of gain, not a complete measure of performance, and a better indication can be had by finding how much noisier a practical loop is than the ideal (lossless) case.

* See previous footnote

Referring to Fig. 1(b), the loop consists of an inductance (tuned by the capacitor C, which is assumed to be lossless), a loss resistance R_l, and a radiation resistance R_r. The two resistances appear in series and generate thermal noise according to their respective magnitudes and absolute temperatures. R_l is at room temperature, but R_r has a much higher temperature to account for the background of thunderstorms and man-made noise (in free space R_r would have a very low temperature). Denoting the ratio of the temperature of R_r to that of R_l as T, the ratio of the noise powers of Fig. 1(b) to the lossless case is

$$F=\frac{TR_r+R_l}{TR_r}=1+\frac{R_l}{TR_r}.$$

F is a degradation factor, analogous to the noise figure of a receiver, which can be made to approach one by increasing the radiation resistance, i.e. by increasing the size of the loop.

Substituting for the quantities R_r, R_l, and L as follows:

$$R_r=640\pi^4\cdot\frac{A^2N^2}{\lambda^4}$$

$$R_l=\frac{2\pi fL}{Q}=\frac{2\pi cL}{\lambda Q}$$

$$L=\mu_o\frac{AKN^2}{l}$$

F can be written as

$$F=1+\frac{Z_o}{320\pi^3}\cdot\frac{\lambda^3}{TQ}\cdot\left[\frac{K}{Al}\right] \qquad (9)$$

The last term in square brackets is only a function of the factor K and the loop volume. From Fig. 3, K is a minimum when the ratio d/l is a minimum, that is, when the coil is short. In fact, as the loop becomes very short, the inductance L tends to the expression.

$$L\approx\frac{\mu_o d}{2}\left[\ln\frac{8d}{u}-1.75\right]N^2 \qquad (10)$$

where u is the diameter of the conductor bunch. F can then be written in the form

$$F=1+\frac{Z_o}{320\pi^3}\cdot\frac{\lambda^3}{TQ}\cdot\frac{2}{d\pi A}\left[\ln\left(\frac{8d}{u}-1.75\right)\right] \qquad (11)$$

Eq. (11) apparently shows that the degradation increases as the cube of the wavelength, an inevitable consequence of the fact that radiation resistance is proportional to λ^{-4} whilst the loss resistance is only proportional to λ^{-1}. However, this is reckoning without the effects of background noise. Fig. 4, which shows background noise in the form of the noise temperature ratio T, has been extracted from CCIR report 322 (Ref. 2) for selected periods of the year, and is applicable to the United Kingdom†. It shows that T typically varies as λ^5 or even λ^6, and so the loop performance actually improves at longer wavelengths. What is also interesting is the distant man-made noise curve applicable to a quiet receiving location; this varies roughly as λ^3 and thus makes loop performance independent of wavelength.

The absolute levels at 1MHz of all the curves are also of particular interest; not only do they show that T is very high, for example it is 55dB for man-made noise, but they also show that only for a small period during daylight hours in winter does the noise due to thunderstorms fall significantly below the man-made value. For much of the time thunderstorm noise is dominant, and on this basis a design criterion which is often used in practice is the man-made noise curve of Fig. 4. Substituting the 55dB value into Eq. (11) and assuming the following typical values for the loop:

$A=0.1$m^2 ($d=35$cm)
$Q=200$
$u=1$cm
$\lambda=300$m

gives a value for F of only 3.3dB. Practically speaking, it means that even with a small sized loop the dominant noise comes from the background and not from the losses. Readers who are interested in pursuing the ultimate during the very short winter daytime and who are fortunate enough to be quite remote from civilisation could note that a loop with a diameter of 2 or 3m would be suitable. Whether such efforts are worthwhile is open to conjecture.

Some useful designs

Those who wish to proceed with the construction of a loop aerial, but only after convincing themselves that it is worthwhile, can seek refuge in the field multiplier described below. The advantage of the field multiplier is that no modification to the receiver is required. Having verified the performance, they can proceed to a large external loop, which still only calls for a minimum of alterations, and then finally to a purpose designed loop complete with the correct input coupling to the first stage.

The H field multiplier

The H field multiplier consists of nothing more than a simple loop and a 300-500pF tuning capacitor. Select a suitable cardboard box (the sort provided by the supermarket for bringing home the groceries) with an open end cross section of about 0.1m^2 (1ft × 1ft). Cut four pieces of hardboard a little smaller than the sides of the box and stick them with impact glue onto the inside walls. Then stick down the top flaps onto this hardboard to make three layers. The result will be a rigid box with one open end which will withstand the

†It is also applicable to the middle latitudes of North American and to most of Europe.

strain of winding with a fairly heavy gauge wire.

Select, in order of preference: fairly thick Litz; 16 gauge wire; or seven strands of 22-26 gauge wire made by twisting with a drill. Wind about 30 turns around the sides of the box, spacing the turns evenly over a distance of about 15cm. Fasten the two ends by some suitable means and mount a variable tuning capacitor in the middle of the bottom of the box. Connect the two ends to the capacitor and the loop is complete.

The above design relates to medium waveband coverage using a 300-500pF tuning capacitor. Increasing the turns by a factor of 5 will tune the long wave band. If a different value of tuning capacitor or if a widely different shape of loop is used, the exact number of turns can be found from eq. (6) and Fig. 3.

Place a radio receiver using a ferrite rod near (but not too near) to the loop and select a weak station. Tune the loop and the signal level will increase by up to two orders of magnitude. The effect will not be so noticeable on receivers with good a.g.c. characteristics or with strong signals, and so the weakest possible one should be chosen. Signal level may be increased by moving the ferrite rod inside the loop or closer to the sides, but a value of coupling of more than $k^2=1/Q_lQ_f$‡ will cause severe mistuning.

To understand why a passive device can amplify a magnetic field, consider a reasonably long loop. Then the inductance of such a loop is easily calculated, and the series resistance R can be found from

$$R=\frac{\omega L}{Q_l}=\frac{2\pi f}{Q_l}\cdot\frac{\mu_o AN^2K}{l}$$

The reason for choosing a long loop is to allow the shape factor K to equal one, and thus to simplify the mathematics, but the final answer can be generalized to loops of any form.

The induced voltage is given by eq. (4), and can be expressed in terms of the H field by means of the relation $H=E/Z_o$. Thus the current circulating in the loop when the series reactance is tuned out is

$$I=\frac{V}{R}=2\pi fA\mu_o HN/2\pi fA\mu_o\frac{N^2}{Q_l l}$$

$$=\frac{Q_l lH}{N}. \qquad (12)$$

The current I causes a uniform field of IN/l ampere turns per metre throughout the volume of the loop, and thus

$$H_l=Q_lH \qquad (13)$$

The effect of the loop is thus to magnify the H field by a factor Q_l. To reassure

‡ $k^2=M/L_lK_f$, M being the mutual inductance.

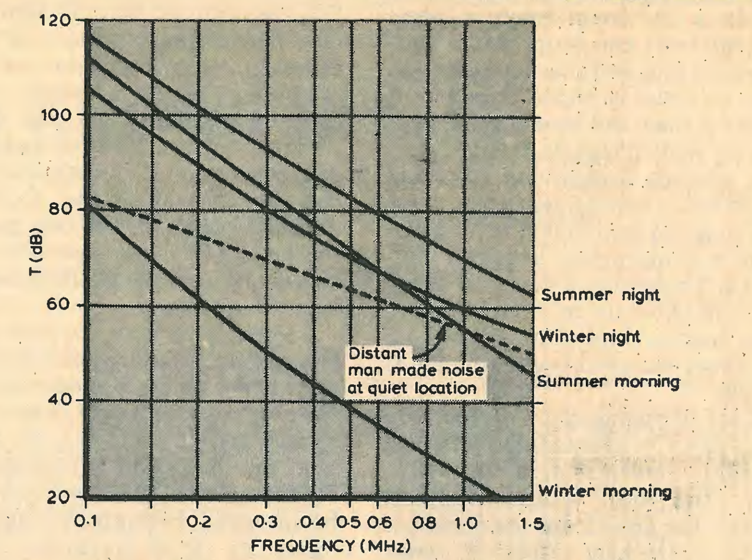


Fig. 4. *Background noise in the form of noise temperature ratio T at different frequencies for selected periods of the year (from CCIR report in reference 2).*

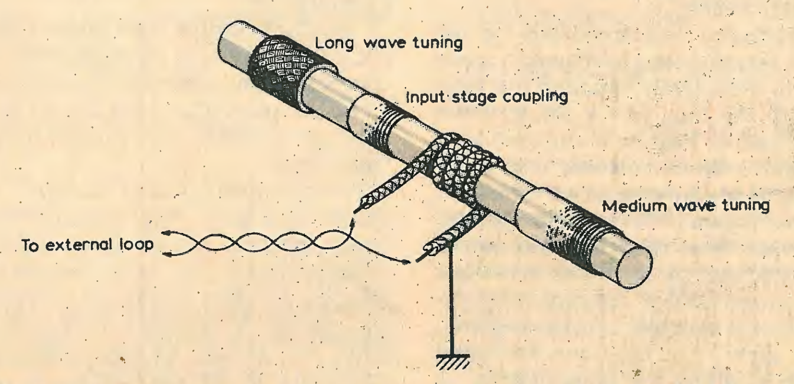


Fig. 5. *How to couple an external loop aerial to a ferrite rod aerial in a radio receiver. The extra coil is preferably made of thin screened cable (with its outer braid earthed at one point only) and the inner conductor is connected to the loop aerial by a twisted pair.*

those who find the apparent increase in field strength incompatible with the principle of the conservation of energy, it should be noted that the field is inductive and that it is in phase quadrature with the incident field.

The external loop

An alternative to the field multiplier is a largish external loop. Such a loop has the dual merit of being almost invisible and covering both the medium and long wavebands without switching. It can also be coupled into the receiver with an absolute minimum of modification.

The loop can be constructed by winding a few turns of wire around the back of a bookcase. An interesting alternative is to use a single strip of thin foil hidden under the wallpaper, but if the latter suggestion is taken up the foil should be run well clear of any mains cabling buried in the wall, otherwise the good interference rejection properties may be lost.

The area of the loop should be at least 2m^2 and preferably larger. By this means the coupling into the input stage can be made small and any mistuning minimized. The orientation should be chosen so that the plane of the loop is within ± 60° of the direction of propagation of the weakest station to be received.

To connect the loop to the receiver a twisted pair should be used and this should be as short as is convenient. The coupling arrangement into the first tuned stage depends upon whether a ferrite rod or a long wire forms the normal receiver aerial. If there is a ferrite rod, a coupling coil should be made from some fairly thin screened cable as shown in Fig. 5. The outer braid should be earthed at one point only and the twisted pair should be connected onto the two ends of the inner conductor to form a screened coupling coil. The reason for the screening is to minimise electrostatic pick-up, but this is not absolutely essential; ordinary insulated wire can be used with the centre point earthed by a high voltage capacitor – say 0.005 microfarad.

To simplify construction, initially wind a trial coupling coil from single strand plastic covered wire around the ferrite rod; as a rough guide use 4 to 6 turns for a $2m^2$ loop. Select a weak signal without the loop connected. Connect the loop and check that there is a large increase in signal strength; if not, add a turn and repeat with progressively weaker signals, finally determining whether background noise can be heard above receiver noise. The turns on the coupling loop should be adjusted to give a compromise between sensitivity and detuning of the input stage, which will show up in different ways but the most obvious is the appearance of stations on seemingly incorrect channels.

The act of adding the external loop has the effect of decreasing the tuning inductance, and for maximum sensitivity the input stage must be realigned. For large loops the degree of coupling can be kept sufficiently weak for the effect to be minimal, but it should nevertheless be borne in mind. It is a simple matter to unglue the ferrite windings and to slide them along the rod, but this is a matter for the individual to decide.

If the receiver is designed only for use with an external long wire aerial, some means of inductively coupling the loop into both the long and medium wave tuning coils is required. An easy and reasonably effective method is to wrap a few turns of wire around each coil and to connect them both in series with the twisted pair from the loop. One side of the twisted pair should be earthed via a high voltage 0.005μF capacitor. No estimate of the number of turns required can be given, but they can be found experimentally in the same manner as for the ferrite rod.

Design for an integral loop

Most receivers sold today are portable in the sense that they have no external aerial, and it is not likely that the public at large would accept the inconvenience of either of the two previous designs.

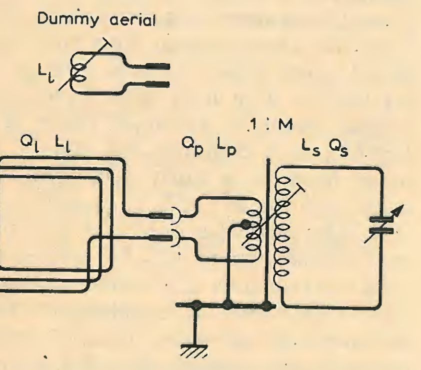


Fig. 6. *Coupling arrangement for a low impedance loop aerial fitted inside the case of a receiver. Transformer is the first tuned circuit of the receiver circuit with a coupling coil added. The dummy aerial, a pre-set inductor, is used for alignment purposes when the set chassis is separated from its case.*

What is required is to incorporate the loop into the receiver and to do this in a manner which enables it to be manufactured and serviced easily. A design which allows for these dual features and for multiband operation is the low impedance loop with transformer coupling shown in Fig. 6. The low impedance (few turns) loop also gives the benefits of easy mechanical construction and reduction of hand capacitance effects.

A suitable form of construction is a rectangular frame whose dimensions just make it a snug fit inside the receiver case. A low impedance loop is wound spirally around the frame using copper tape. Spaces can be left by staggering the tape pitch so that control shafts can be inserted through the supporting frame. As far as practicable the tape should be wound over the entire width of the frame, the object being to minimize the loop resistance. The number of turns should be chosen to give an inductance of about 10 microhenries.

Two thick flexible leads (ideally made of Litz wire) should be soldered to the copper tape and should be terminated in a two-pin plug. The leads should be as short as possible and should form a twisted pair.

The coupling arrangements are shown in Fig. 6. The transformer is really the first tuned circuit with an added coupling coil. As in the previous designs, for best results the coupling coil should be earthed at the centre point and should be electrostatically screened from the secondary.

The inductance of the secondary must be higher than that required to tune with C because of the loading of the loop. This in turn is dependent upon the turns ratio between primary and secondary. Unfortunately there are no fixed formulae for determining the turns ratio M and the primary inductance L_p unless the characteristics of the following transistor or f.e.t. are known. However, a good approximation is to disregard them and to minimize the noise degradation caused by the coupling transformer losses (see the discussion under "Performance"). In this case the design equations can be shown to be:

$$M^2=\frac{L}{L_l}\left(1+\sqrt{1+Q_s/Q_p}\right)$$

$$L_p=\frac{L_l}{\sqrt{1+Q_s/Q_p}} \qquad (14)$$

$$L_s=M^2L_p$$

A common situation is $Q_s = Q_p$, in which case $L_p = L_l/\sqrt{2}$, and from this it can be seen that L_l has a substantial detuning effect. To maximize performance, both Q_s and Q_p should ideally be much higher than the loop Q. As an example, if $Q_s = Q_p = 4Q_l$, the transformer increases the factor F in eq. (9) by about 2.2 times or 3.5dB.

The remaining design features need only be mentioned in passing. In eqs (14), L is the inductance required to tune with a given value of C, and L_p, Q_p, L_s, Q_s refer to the transformer primary and secondary values of inductance and Q factor. The transformer is switched for each waveband covered. For the purposes of alignment a pre-set inductance, equal to the loop inductance, is plugged in whenever the receiver and its cabinet are separated.

Some results

Loops of all three kinds have been constructed on several occasions and have given excellent results. One such loop, with transformer coupling to the input stage, was made up from a single sheet of aluminium baking foil wrapped 7 times around a box of about $0.2m^2$ cross sectional area. A single layer of newspaper was used as insulation, and although this form of construction is not recommended because of the high self capacitance between the turns, it nevertheless worked extremely well.

During a January afternoon, when the propagation conditions were at their worst for long distance reception, it was possible to pick up many European medium wave stations in a quiet London suburb. These included AFN Stuttgart, several Italian stations, and Radio 4 on 602kHz located at Newcastle. Many local stations in the more distant parts of the UK were heard, as well as all the main BBC transmitters that could be identified with particular frequencies. In fact, it was difficult at any time of the day to locate channels sufficiently clear of transmissions to make sure that the aerial was background noise limited. What was even more remarkable was that interference from a television in the same house was barely noticeable, even on weak signals.

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Simple digital filters

Useful algorithms for digital computers in control systems

by **P. A. L. Ham** B.Sc.(Eng.), F.I.E.E. NEI Parsons Ltd

A classical method of stabilising or modifying the response of analogue feedback control systems is to introduce phase-lag or -lead terms by simple RC (sometimes RCL) filters. With the advent of cheap microprocessor technology there is a need to provide similar facilities by means of a stored program. Digital systems can only operate by continuously re-calculating and outputting the control variable. They are thus inherently sampled-data systems for which a rigorous mathematical analysis requires the use of the "z-transform". It is possible, however, to calculate analogue filter time-constants and Bode responses by means of simple rules without going each time into Laplace theory, and the results can be applied very successfully in practice. This article shows that, if we are prepared to work within a similar restricted framework with digital systems, it is quite possible to design useful digital filters in software using simple rules without becoming involved with z-transform theory.

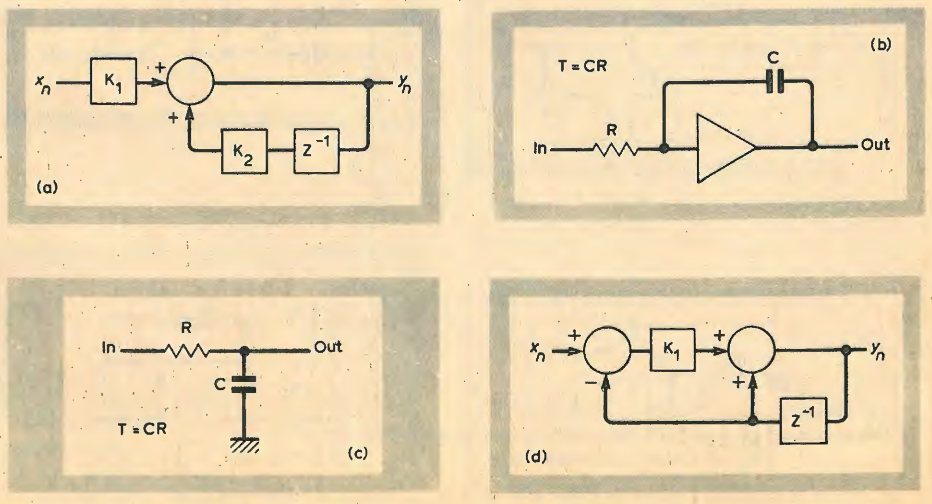
DIGITAL FILTERS are constructed by means of algorithms which use the present and previous samples of both the input and the output data. It is an implicit assumption that the samples occur at fixed intervals of time, under the control of a real time clock or some equivalent timing mechanism. Thus, if x_n denotes the nth sample in a train of data, then x_{n-1} denotes the previous sample. In the literature this sometimes appears as $x(nT)$ and $x(nT-T)$ where T is the time between samples, but the meaning is the same. It is unfortunate that T has been used in this context since it has a universal connotation as the value of a time-constant; in the remainder of this article, therefore, we will use t to denote the time between samples and reserve T for its commoner meaning to avoid confusion.

In analogue filters we can find both active and passive designs employing combinations of L, R and C. The choice of algorithms for digital filters is at least as wide. However, for the achievement of, say, a unity d.c. gain, or a frequency response which resembles that of a known analogue filter, the correct choice of design parameters must be made, and it should be realised that without this a familiar result is unlikely to be obtained.

Filters which use in their algorithm only present and previous values of the input are called "non-recursive," whilst those which use present and previous values of the output are called "recursive." Since the latter constitute a form of feedback loop, they have the possibility of being unstable, and this, too, must be taken care of by correct choice of parameters. In general, non-recursive algorithms are useful for generating frequency responses having a zero, i.e. of a phase-advance characteristic, whilst recursive algorithms are useful for generating frequency responses having a pole, i.e. of a phase-lag or low-pass characteristic.

With all digital filters a useful response for control-system and similar purposes is only obtained up to the frequency defined by the Nyquist rate i.e. $f=1/2t$. Thus for a sampling interval of 10 milliseconds, an absolute limit of 50Hz is obtained for the operation of the digital filter. It should not be assumed that the amplitude response is zero at higher frequencies — quite the reverse, as series of spectra are obtained depending on the frequency ratio. In the present context, however, these only have a nuisance value, and so the components of input frequency around and above the Nyquist rate should be kept as low as possible.

Fig. 1. *(a) Digital first-order lag filter, general network diagram; (b) analogue integrator circuit diagram; (c) analogue low-pass passive filter; (d) modified network diagram for digital low-pass filter when $K_1+K_2=1$.*



At frequencies below the Nyquist rate some significant extra phase lags can be met with because of the existence of a sample-and-hold operation. For practical purposes the phase lag at any particular frequency may be regarded as proportional to the ratio between it and the Nyquist rate — with 45° occurring when the input frequency is half the Nyquist rate. This will have to be considered in working out the overall digital filter response.

Discrete or digital network diagrams

Analogue filter circuits are characterised by a differential equation, which may be worked out from the original component network. Digital systems are characterised by a difference equation, which is an expression relating the present output to the input together with certain of the previous inputs or outputs.

While it is not a very close parallel to the analogue approach, a convenient picture of the difference equation may be obtained with the discrete, or digital, network diagram, of which a simple example is shown in Fig. 1(a). The only unfamiliar element in these diagrams is the square box containing the legend Z^{-1}. This denotes a unit delay equal to the sampling interval t. It will be found easier in the first instance to avoid trying to invest the Z^{-1} symbol with any great mathematical significance, but rather to regard it as a shorthand note for a storage register operation; the actual procedure will become clear in

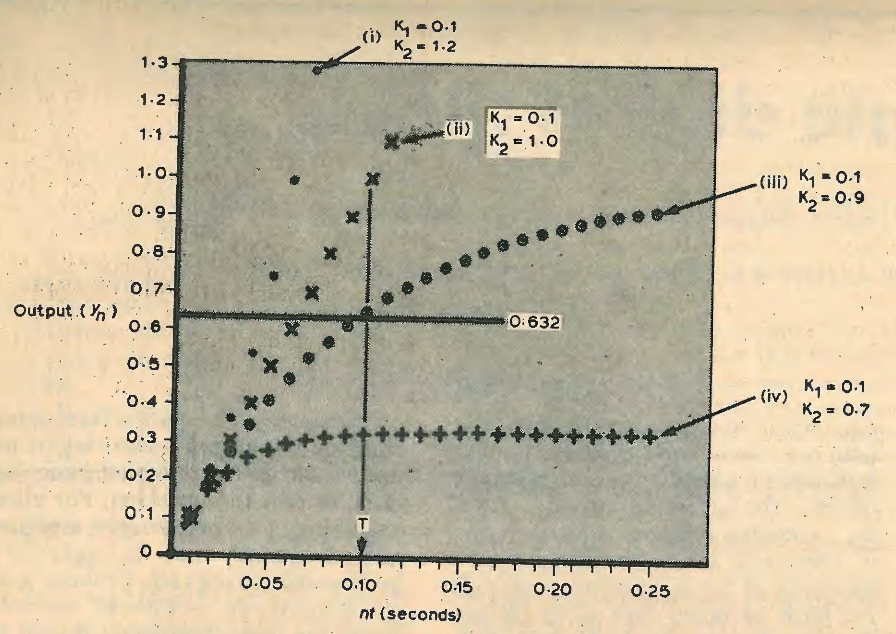
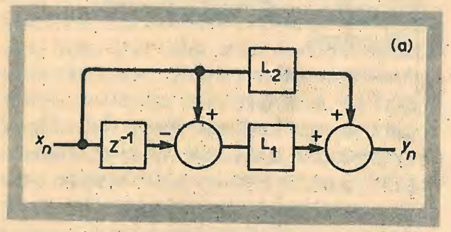
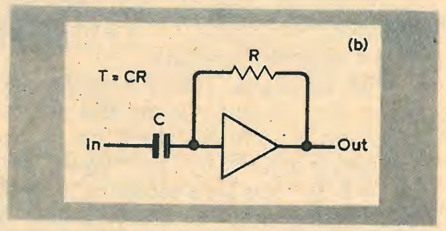


Fig. 2. *Digital first-order lag filter. Computed responses to unit step to show effect of varying K_2.*





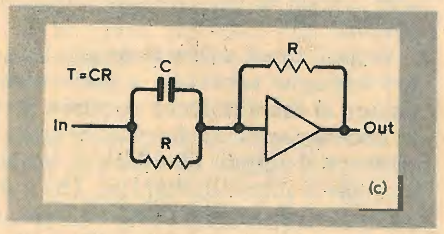
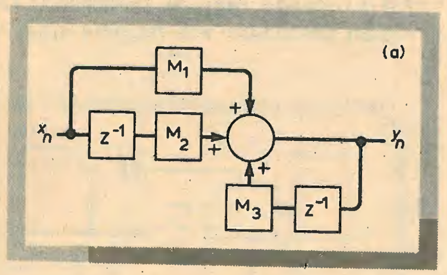
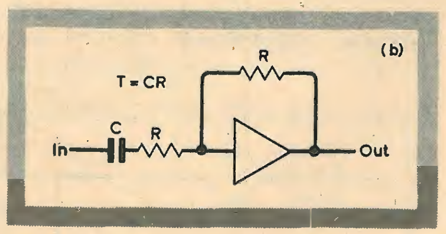
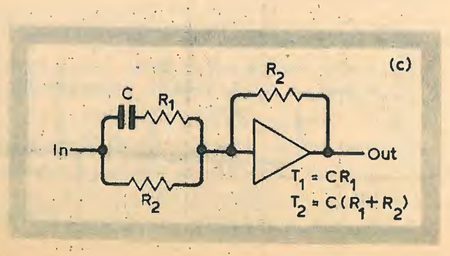


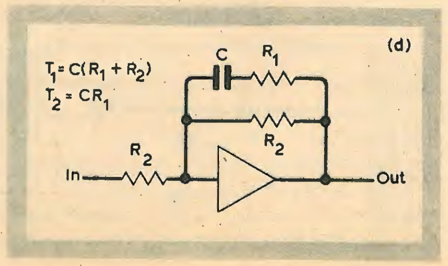
Fig. 3 *(a) Digital first-order lead filter, general network diagram after modification; (b) analogue differentiator circuit diagram; (c) analogue differentiator with one zero, i.e. unity d.c. gain.*

Fig. 4. *(a) Digital first-order filter with one pole and one zero, general network diagram; (b) circuit diagram for analogue differentiator with one pole, i.e. band limited; (c) circuit diagram for analogue one-pole, one zero filter (high-pass characteristic); (d) circuit diagram for analogue one-pole, one zero filter (low-pass characteristic).*









the subsequent paragraphs. As with conventional block diagrams, a square box with the letter K inside denotes multiplication by K and a circle with arrowheads denotes addition or subtraction as indicated.

First order lag network (pole)

The simple first order linear difference equation for a lag function can be written as follows:

$$y_n = K_1x_n + K_2y_{n-1} \qquad (1)$$

where y_n = next output, x_n = next input, y_{n-1} = previous output, and K_1, K_2 are constant. This is represented by the diagram of Fig. 1(a).

The form of response obtained depends upon the values assigned to K_1 and K_2. In particular the system is unstable for all values of $K_2 > 1$. The particular case of $K_2 = 1$ is of interest, since it yields a response similar to an analogue integrator, i.e. with the Laplace transfer function:

$$\frac{\theta_{out}(s)}{\theta_{in}(s)} = \frac{1}{sT_1} \qquad (2)$$

The corresponding analogue circuit is shown in Fig. 1(b). The value of T_1 is found by the relationship:

$$T_1 = \frac{t}{K_1} \qquad (3)$$

Three registers are required to carry out this computation*, which is begun each time a new value of x_n is received at time-intervals t seconds apart. The first register will be designated A and will be used permanently to store the value of K_1. Register B will store the value of output y_n and register C will receive the latest value of input x_n. As soon as a new value of x_n is received, it is multiplied by the number in register A and added to the number already in register B which now becomes re-interpreted as y_{n-1}. The machine is then ready for the next input sample and until that time register B contains the latest value of y_n.

The second case of particular interest is when $K_1 + K_2 = 1$. This yields a response similar to a simple RC low-pass filter, i.e. with the Laplace transfer function:

$$\frac{\theta_{out}(s)}{\theta_{in}(s)} = \frac{1}{1+sT_1} \qquad (4)$$

The corresponding analogue circuit is shown in Fig. 1(c). The value of T_1 is obtained from equation (3) as previously.

For computational purposes it is best to re-write equation (1) so that we are

*Some of the registers may be located in memory; depending on the processor, other memory/register or register/register transfers may be necessary.

left with only one multiplication, as follows:

$$y_n = K_1(x_n - y_{n-1}) + y_{n-1} \qquad (5)$$

This is represented by the diagram of Fig. 1(d). The computation can be carried out with three registers in a similar manner to that previously. As soon as the value of x_n is received in register C the contents of register B must be subtracted from it before it is multiplied by the contents of register A. The result is then added to the number already in register B to complete the cycle.

The variety of responses obtainable from equation (1) can be well illustrated by computing the output resulting from a unit step input. This has been done for $t = 0.01$ and $T = 0.1$ for four representative cases shown in Fig. 2. They are as follows:

(i) unstable case where $K_2 > 1$
(ii) integral action where $K_2 = 1$
(iii) time-constant where $K_1 + K_2 = 1$
(iv) non-exponential response where $K_1 + K_2 < 1$

Note that the initial slope is in each case defined by K_1.

First order lead network (zero)

The simple first-order linear difference equation for a lead function can be written as follows:

$$y_n = K_3x_n + K_4x_{n-1} \qquad (6)$$

where x_{n-1} is the previous input and K_3, K_4 are constants. It is best to re-organise this expression straight away into the following form:

$$y_n = L_1(x_n - x_{n-1}) + L_2x_n \qquad (7)$$

where $L_1 = -K_4$ and $L_2 = K_3 + K_4$. This is represented by the diagram of Fig. 3(a).

This expression is always stable and, as in the case of the first order lag, particular values of coefficient are of interest. If $L_2 = 0$ the response is similar to that of an analogue differentiator, i.e. with the Laplace transfer function:

$$\frac{\theta_{out}(s)}{\theta_{in}(s)} = sT_2 \qquad (8)$$

The corresponding analogue circuit is shown in Fig. 3(b). The value of T_2 is found by the relationship:

$$T_2 = \frac{t}{L_1} \qquad (9)$$

The particular case of $L_2 = 1$ is also of interest, since it yields a response similar to the numerator of an analogue high-pass filter, i.e. with the Laplace transfer function:

$$\frac{\theta_{out}(s)}{\theta_{in}(s)} = 1 + sT_2 \qquad (10)$$

The corresponding analogue circuit is shown in Fig. 3(c). The value of T_2 is obtained from equation (9) as before.

The computation for either result in equations (8) or (10) can be carried out with four registers in a very similar fashion to that described for the lag filter. There is, however, one factor which may have some practical bearing, namely, that it becomes necessary to use the output register to store an intermediate result. If there is any possibility of an interrupt taking place during the short period of time that the output register is holding an intermediate calculation, it may be preferable to employ an extra register for this purpose and only transfer the final answer to the output register when all intermediate computations have been completed. This comment should be noted for any of the more complex filters which follow.

Network with one pole and one zero

The linear difference equation for a one-pole, one-zero network may be written in the following form:

$$y_n = M_1x_n + M_2x_{n-1} + M_3y_{n-1} \qquad (11)$$

where M_1, M_2 and M_3 are constants. This is represented by the diagram of Fig. 4(a).

The characteristics of equation (11) depend, as before, on the values of coefficient used. Only two such results are of practical interest, the first being a high-pass filter where the equivalent Laplace transfer function is as follows:

$$\frac{\theta_{out}(s)}{\theta_{in}(s)} = \frac{sT_1}{1+sT_1} \qquad (12)$$

The corresponding analogue circuit is shown in Fig. 4(b). For this characteristic to apply, we must make:

$$M_1 = -M_2 = 1 \qquad (13)$$

and

$$M_3 = 1 - K_1 \qquad (14)$$

where K_1, T_1 are given by equation (3). For computational purposes the number of multiplications required can be reduced by one by re-writing equation (11) as follows:

$$y_n = (x_n - x_{n-1}) + (1-K_1)y_{n-1} \qquad (15)$$

Five registers are required to carry out this computation. The computed response of equation (15) to a unit step input is illustrated in Fig. 5 for $t = 0.01$ and $T = 0.05$.

The other equivalent Laplace transfer function of practical interest is as follows:

$$\frac{\theta_{out}(s)}{\theta_{in}(s)} = \frac{1+sT_2}{1+sT_1} \qquad (16)$$

The corresponding analogue circits are shown in Fig 4(c) and (d). For this characteristic to apply we must make:

$$M_1 = (K_1L_1 + K_1) \qquad (17)$$

$$M_2 = -K_1L_1 \qquad (18)$$

$$M_3 = 1 - K_1 \qquad (19)$$

where K_1, L_1 are related to T_1, T_2 by the same expression as equations (3) and (9) respectively.

While it is not in general possible to avoid the need for three multiplications with this filter, it is probably better from the computational point of view to re-write equation (11) as follows:

$$y_n = K_1L_1(x_n - x_{n-1}) + K_1x_n \times (1-K_1)y_{n-1} \qquad (20)$$

Seven registers are required to carry out this computation.

General network

The foregoing sections have shown how to build up to a one-pole, one-zero digital filter by progressively more complex networks. It is, in fact, possible to represent all the stages by a single comprehensive equation with a related table of constants so that any desired transfer-function may be obtained by straightforward substitution. The equa-

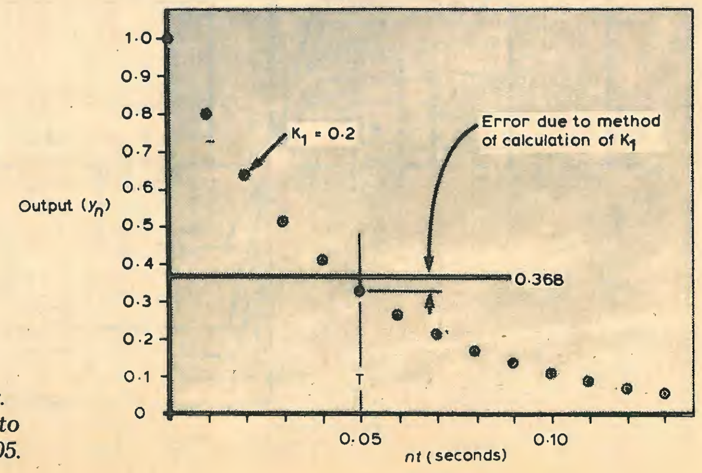


Fig. 5. *Digital first-order lead filter. Computed response to unit step with $T = 0.05$.*

tion and the related table are given in Table 1.

Alternative forms of filters

If we look at the diagram of Fig. 4(a) we can easily see that it is identical in principle to Fig. 3(a) followed by Fig. 1(a). Since impedance problems do not

Fig. 6. *(a) Alternative form of digital first-order filter; (b) canonic form for general network of order r; (c) direct form for general network of order r.*

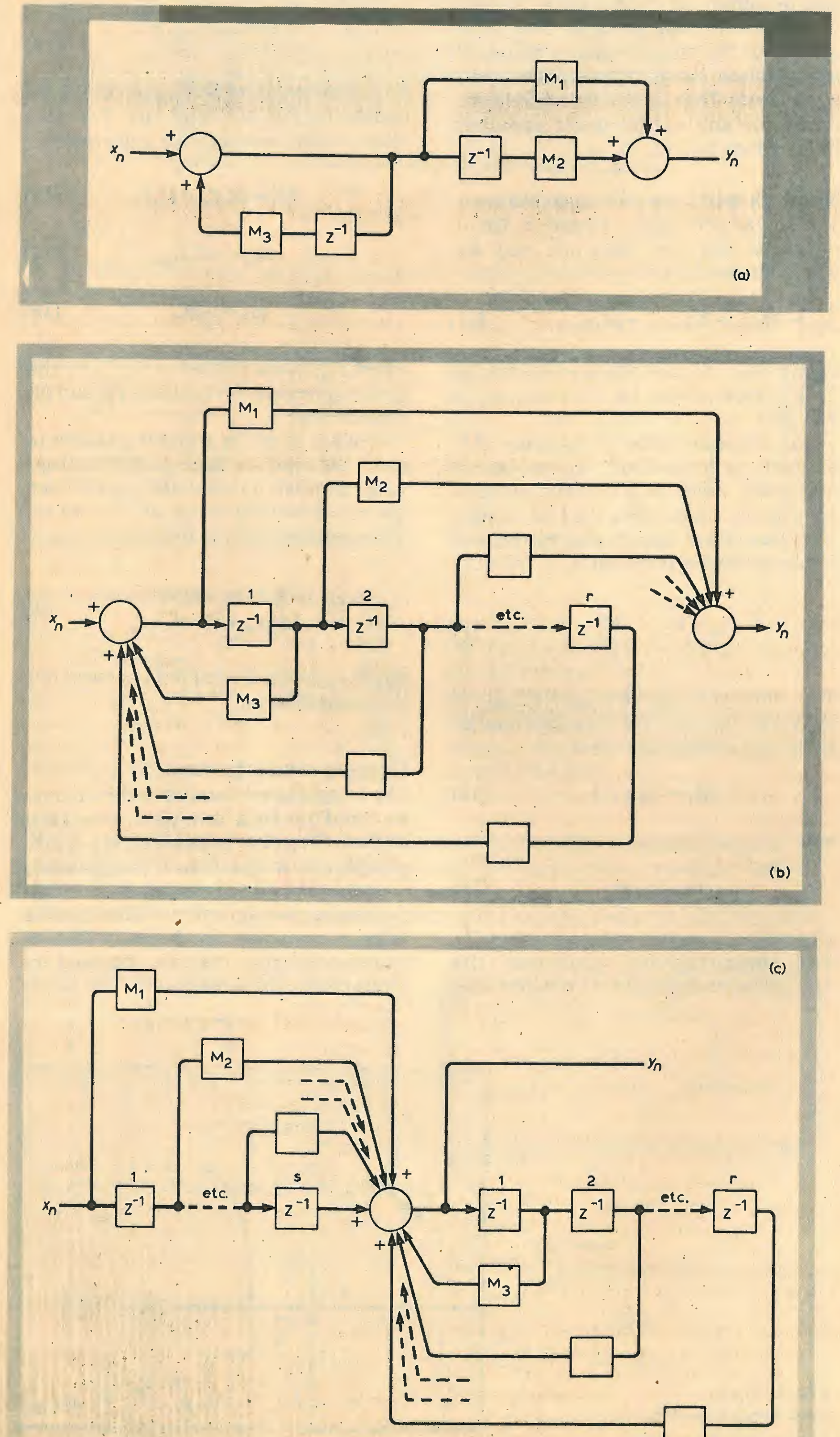


Table 1: constants in the equation $y_n = x_n(K_1L_1 + AK_1) - K_1L_1x_{n-1} + (1-BK_1)y_{n-1}$ for desired transfer functions

	A	B	K_1	L_1
$1/sT_1$	1	0	t/T_1	0
$1/1+sT_1$	1	1	t/T_1	0
sT_2	0	1	1	t/T_2
$1+sT_2$	1	1	1	t/T_2
$sT_1/1+sT_1$	0	1	t/T_1	T_1/t
$1+sT_2/1+sT_1$	1	1	t/T_1	t/T_2

exist with digital filters, an equally valid alternative is to reverse the order as shown in Fig. 6(a). In fact, as soon as we get on to more complex, i.e., higher-order filters a number of different diagram configurations are possible each of which represents an alternative way of implementing the digital filter.

Thus the diagram of Fig. 6(b) is another theoretical equivalent, known as canonic form, in which the same delay is used to both the pole and the zero.Hence it is found that the number of delay terms is equal to the "order" of the difference equation. Yet another version is illustrated in Fig. 6(c) and this is known as the direct form. For higher-order filters, various other forms, such as the serial, parallel or coupled forms can be devised.

This may all seem confusing, but in practice it is not so because *it is generally never advisable to use the direct or canonic forms for any filters higher than second order.* This is because it turns out that the actual values of the poles and zeros are an excessively sensitive function of the multiplying coefficient in the difference equation.

As a general rule, *it is always safer to use cascaded first or second-order algorithms for any more complex filter requirements.* Indeed, for most run-of-the-mill control system requirements the needs can be met quite adequately with cascaded first-order filters only, which we have adequately covered in the previous sections. Certain fields, such as communications, operate in a quite different realm of complexity and for any application of this nature where it may be necessary to go beyond these basic ground rules, the reader would be well advised to refer to the literature [1].

Problems of accuracy

In previous sections we have defined the equivalent analogue time constants by the simple expressions of equations (3) and (9). The strictly accurate expression derived from z-transform theory takes the following form for a pole or zero:

$$K \text{ or } L = 1-e^{-t/T} \qquad (21)$$

In fact, it can easily be shown that if $T \gg t$ then the value of K becomes very close to (t/T). By reference to Fig. 2 (iii), the effective error in time-constant value when $t/T = 0.1$ is less than 5%, which would normally be regarded as quite reasonable by analogue system standards. In cases of doubt the correct expression can always be used.

The expressions of equations (3) and (9) are correct for the pure integration and differentiation cases; what we have done is to use the same expressions for poles and zeros in order to provide a more uniform and physically meaningful approach at a practical level.

A further, and perhaps more serious, class of problems that the programmer might come up against are those resul-

ting from the fact that the registers employed may be shorter than desirable. It is always necessary to have regard to the numerical values of intermediate computations in any digital filter algorithm; with a poor choice of algorithm the values may become excessively large, or small, so leading to parameter truncation or quantisation effects. These are equivalent to saturation and deadband effects in analogue systems.

Difficulties of this kind are particularly severe with 8-bit microprocessor implementations, which suffer from the further disadvantage that the instruction sets generally do not include a multiply/divide facility. A software multiplication, however, is not particularly difficult, even though the number of program steps may be appreciably greater[3].

Digital filter algorithms of the kind described here lend themselves quite well to calculation (but not in real time) on a programmable calculator, provided that it has an adequate number of independently addressable memories, so that previous values of the input and output can be automatically entered for the next computation every time the start button is pressed.

After graduating in 1952, Philip Ham joined GEC (a part of the company that is now Marconi Space and Defence Systems) where he worked on radar antenna positioning, stabilised platforms and vehicle guidance systems. In 1970, in a major career switch, he joined NEI Parsons as manager of a new department set up to apply electronic control techniques to large steam turbine-generators. One of his particular interests lies in high-integrity control and he has several patents in this area. Like many other former analogue circuit designers, he has in recent years been updating himself and his work to embrace digital and microprocessor technology.

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4. T. A. Perkins, Letters to the Editor, *ibid*, July 1977, p.59. □

Faraday and fusion

An extraordinary pulse transformer which induces a current of 3 million amperes in a shorted single-turn secondary is being built by a European team in the heart of the Oxfordshire countryside. The single-turn secondary is not metal but a ring, or torus, of ionized gas held floating by magnetic fields in the middle of a toroidal vacuum chamber which surrounds it. The apparatus is in fact a research machine for investigating the possibility of generating electrical power in the future my means of nuclear fusion — the process that goes on in the sun and, uncontrolled, in hydrogen bombs. Known as the Joint European Torus (JET), it is one of several machines of this type being built in different parts of the world but is claimed by the director of the collaborative research project, Dr Hans-Otto Wüster, to have "the largest capability" and that it will "get closer to the nuclear fusion reaction" in an actual reactor than any other machine.

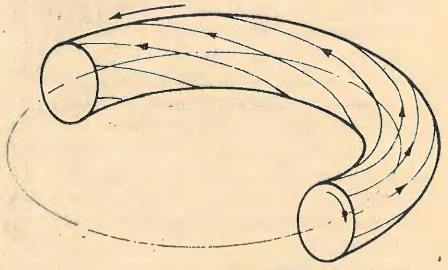
It is because of the enormous cost of the project (about £125 million at 1977 prices) that it has had to be a collaborative effort, and the group organization, called the JET Joint Undertaking, includes Euratom, the nine EEC countries, Sweden and Switzerland. The site chosen for a building to house JET is alongside the UKAEA's fusion research laboratory at Culham, near Abingdon, Oxfordshire, and the foundation stone for this was laid on May 18 by Dr Guido Brunner, the member of the European Communities Commission responsible for energy and science. It's historically appropriate that Britain should provide the site for such a machine because it was in this country that Faraday discovered the phenomenon of electromagnetic induction and demonstrated it in his magnetic induction ring — the first transformer, incidentally a torus – by pulsing the direct current in the primary.

In JET one purpose of the 3MA current induced in the ionized gas — a mixture of deuterium and tritium, both isotopes of hydrogen — is to partly heat it. Ultimately the gas is heated by other means to a temperature of over 100 million degrees C in order to make the positively charged nuclei overcome their mutual electric repulsion and collide at sufficient speed to produce thermonuclear fusion reactions. When the nuclei combine, mass is annihilated and becomes converted into energy ($E = mc^2$) in the form of neutrons, which fly off and, in an actual reactor, would produce heat in a surrounding "blanket". But to achieve sufficient number of fusion reactions by this process the ionized gas, or plasma, must be confined and isolated from its surroundings. In JET this is done by using the well-known ability of magnetic fields to act on free electrons and ions.

Part of the magnetic field pattern which confines the hot plasma is provided by a toroidal field produced by a set of 32 D-shaped coils linking the torus. These give a magnetic flux density at the centre of the plasma of up to 3 tesla. At the same time a poloidal field is generated by external field coils and by the toroidal electric current of 3MA induced in the plasma. The effect of this poloidal field is to slightly twist the lines of force of the main toroidal field so that they have a helical pattern, as shown in the diagram. The result is a "magnetic bottle", in which no field lines escape and the charged particles follow these lines. Machines using this type of confinement are known as tokamaks (from a Russian word for toroidal magnetic chamber) and a number of them have been operating in various parts of the world — including one at Culham called DITE — since the late 1950s.

Because tokamak operation depends on the existence of the plasma current, which is induced by transformer action, the machine is essentially a pulsed device. In fact the field configuration in JET will be maintained for about 20s, once every ten minutes. The operating sequence begins with the energizing of the toroidal and poloidal field coils (the vacuum chamber having been evacuated and the working gas introduced). The primary current responsible for the transformer action is now reduced and the change induces a voltage of about 150V around the torus. This voltage ionizes the gas, forming a plasma, and produces a current in it. The poloidal field circuit is then driven so that the plasma current builds up and is maintained for the pulse duration.

The closeness with which a tokamak approaches the operation of a working fusion reactor — producing net energy — depends on a combination of plasma temperature, plasma density (number of particles in unit volume) and the time the ionized particles are confined within the torus during the pulse action. □



Toroidal "magnetic bottle" to confine plasma is produced by combining toroidal and poloidal magnetic fields to give helical field lines.

NEWS OF THE MONTH

Buying British Electronics

Ivor Cohen, managing director of Mullard Ltd, gave a definite "no" in answer to the question "will the electronics buyer be able to buy British in the future", at a conference held by the Institute of Purchasing and Supply on May 15. This answer was given on condition that what was meant was the buying of the majority of the UK's component requirements from semiconductor manufacturing companies based and owned in the UK. He said, "You cannot do that today and you will not be able to do it in the future". He did add, however, that if the buyers were to buy from UK companies who had a substantial base in the UK with a commitment to continuity of operation, not one which merely handled products designed abroad but one which initiated its own designs, the country would have a much greater chance. To do this, he said, it would require much work on the part of the equipment makers, the component makers and the Government to create the right environment.

The United States and Japan dominate the main electronics markets because they have large home markets which enable them to have steady and large volumes of production, which are essential in this sector of the industry.

The European countries, unfortunately, do not stick together enough, in terms of standards and specifications, for Europe to gain a similar foothold and so in these countries the component companies and equipment companies become more dependent on each other. The other ingredient needed, of course, is unlimited finance — or as Arthur Garratt, director of Value Management Consultants, put it in the conference's closing speech "a bottomless pocket". The Japanese success story is the result of such a bottomless pocket, created by the industrial, commercial and banking set-up in their country and the unlimited support that manufacturers appear to get from their government. UK buyers would like to buy British or European every time but the situation described often forces them to turn to either the Americans or the Japanese for components.

Dr Ian Mackintosh, chairman of Mackintosh Consultants Ltd, said in his paper that even allowing for the many remaining strengths of the American i.c. industry — which presently leads in the western world — there could be no doubt that the balance of advantage was now beginning to swing away from the United States. He concluded that the US domination of this important industrial sector would eventually disappear and be replaced first by a condition of approximate parity between America and Japan, who would possibly be joined later by Europe.

The NEB and INMOS under a new government

The Conservatives, by their election manifesto, are committed to sell off the National Enterprise Board's better assets, cut back its future finance and reduce its role to that of a 'hospital for lame ducks'. However, despite this, the NEB is preparing a totally new project of its own — to build a £10 million titanium granule plant in Teesside in association with Rolls-Royce and Imperial Metals Industries.

Sir Leslie Murphy, the NEB chairman, argues that the change in government should not mean any fundamental change in their corporate plan, but its main effect will be to intensify the course that they are already taking, "in seeking greater joint ventures with the private sector". According to an *Observer* (May 13) report Sir Murphy is already preparing plans to suggest to the Government, proposing greater private shareholding in NEB companies, and wanting to offer shares in sectoral groupings of companies in areas such as computers and electronics. He is also prepared to accept a reduction in the increased funding planned by the Labour Government – something he was against anyway. His apparent wish is to see the NEB operating broadly along its present lines but it is more likely that Sir Keith Joseph will attempt to sell off as many of its assets as he can. The problem, however, is what to sell.

More than half of the NEB's investment is in small companies and some of these, the microelectronics venture INMOS included, are high-risk, high-cost concerns which would not easily be absorbed by other companies or the City of London. The more successful holdings, such as Ferranti, could be absorbed quite quickly by the institutions. Left to fight on its own, INMOS would almost certainly collapse but it could be saved if Sir Leslie's and other civil servants' requests for caution and constraint make Sir Keith change his mind.

A table of the NEB's computer, electrical and electronic holdings, excluding the newly acquired Burndept (see p75, March 79 issue) is shown below.

The new Government will have to decide whether Burndept is fit enought to surface as a wholly-owned subsidiary of Berec Group Ltd, or whether it should retain its 51% share in the company.

*Table of the NEB's computer, electrical and electronic holdings showing the NEB's shareholding, and the turnover and profits for 1978. *INMOS and INSAC are not yet fully operational. Minus quantities represent cost.*

Company name	shareholding %	turnover £m	profit £m
Ferranti	62·5	172·4	9·59
The Cambridge Inst Co.	81·4	3·3	−2·35
Data Recording Inst Co.	63·1	17·5	−0·38
Sinclair Radionics	73·3	6·4	−1·98
Keland Electrics	100	0·9	0·01
INMOS	67·3	*	−0·51
INSAC Data Systems	100	*	−1·30

Investment programme boosts electronic exchanges

Mr Peter Benton, the managing director of Post Office telecommunications, said on April 25 when he opened a TXE2 exchange at Hagley, near Stourbridge, that the number of electronic telephone exchanges in Britain would double during the next five years. This would result from the Corporation's £1000 million a year investment programme to provide a better service for their customers, whose number grows by more than one million every years. "In this programme," Mr Benton said, "the Post Office will be installing electronic telephone exchanges at an overall rate of more than four a week during the next five years, at an average cost approaching £1 million per exchange. With spending of this order, exchange modernisation is the largest single element in our investment programme, and the Post Office is funding virtually all of this programme from its own resources."

The Hagley exchange is part of this investment programme and was the 1000th TXE2 exchange to be opened by the Post Office. Supplied by Plessey Communications Ltd, (the other TXE2 suppliers are GEC and STC), it is one of the larger exchanges to have been installed; serving nearly 4000 customers initially, it can be extended to cater for up to 7000. Since the first production TXE2 was opened at Ambergate, Derbyshire in 1966, the Post Office has spent £160 million on providing electronic exchanges, and over the next five years they plan to spend at least another £150 million, bringing a further 650 new TXE2 exchanges into service during this period. By 1984 they expect nearly three million customers to be served by this type of exchange.

The Post Office is also spending over £800 million on more than 300 TXE4 electronic exchanges over the next five years. These exchanges are designed for densely-populated areas. There are already 17 TXE4 exchanges in operation, and these provide an improved telephone service for about 100,000 customers. By 1984 there should be at least 350 of these exchanges serving more than four million customers.

System X on view to the world

At last Britain's fully electronic telephone switching system — System X — is to appear as a working reality, and not just a lot of guarded statements about plans which is all it seems to have been to most people so far. A working local exchange for about 250 subscribers using this technology will be on view to the public at the Telecom 79 exhibition in the Palais des Expositions at Geneva, 20-26 September. This will be the centre-piece of a joint Post Office and UK telecommunications industry stand showing the latest British products, systems and services in this field. Among them will be new telephone facilities that will be available to customers on System X and a demonstration of how the management and maintenance of the system may be centralized. Later, one of the first two production exchanges will be installed in Baynard House, a major new Post Office centre for Greater London's telecommunications soon to be opened in Victoria Street, London.

The Post Office's 1000th TXE2 electronic telephone exchange at Hagley, near Stourbridge. Here a technician is seen fitting an adaptor into the automatic switching system.

System X has been jointly developed by the Post Office, GEC, Plessey and STC and is the biggest single telecommunications project ever undertaken in the UK. The Post Office alone has contributed £150m to the development costs. The three firms mentioned will be the contractors manufacturing various parts of the installations that will follow, and all four organizations have got together to form a new company, British Telecommunications Systems Ltd, whose purpose is to sell System X overseas. In spite of formidable competition from electronic switching systems originating in other countries, particularly Japan, the new company, which is managed by John Sharpley, expects to be able to sell System X successfully to countries in the Middle East, Asia and South America — the first sale most likely being in the Middle East, according to Sharpley. But Sir William Barlow, chairman of the Post Office, claimed recently in London that System X is in any case viable solely on the basis of the market in the UK. The Post Office is currently spending £250m per year on switching systems, he said, and once the new system gets started it will progressively displace other switching systems now being used and will eventually take over the whole budget. Modernisations should be complete in 1992, he said. Meanwhile any overseas sales would reduce costs still further.

So far the Post Office has ordered eight System X exchanges, worth approximately £12m, to come into service by the end of 1982. These include five local exchanges, at Woodbridge (Suffolk), Arrington (Cambridge), Brixton (London), Hale (Cheshire) and Drighlington (Leeds). There are also two junction exchanges – for switching calls between local exchanges — at Baynard House, London and Lancaster House, Liverpool. The eighth exchange, at Cambridge, is a main network switching centre, handling long distance calls.

System X does its switching entirely electronically by means of integrated logic circuits. All the operations are controlled by a stored program. Calls are set up, faults are identified and the whole system is managed by computer like processes. Consequently the software is crucial to the design. Desmond Pitcher, managing director of Plessey Telecommunications and Office systems, claims that this software is the cheapest and most effective now available in the world for telephone switching. The system also uses common channel signalling, a technique in which the signals controlling calls and managing the network are passed between the System X exchanges as data transmission. Finally, perhaps the most interesting development from the electronic design point of view is that the transmission and switching functions are integrated into a digital mode of operation. The speech and other signals are digitally encoded at an information rate of 2.048Mbit/s and a common method of time-division multiplexing is used in both transmission and switching equipments. Integrated circuits used include c.m.o.s., n.m.o.s. and 10W power Schottky t.t.l.

According to Roy Harris, director of the Post Office's telecommunications systems strategy, components are chosen for their low power consumption, reliability and suitability for automatic production.

Black box protection in arms race

A report in the *Baltimore Sun* (May 16) says that the Americans wish to plant electronic 'black boxes' in Russian territory to verify compliance with an arms treaty. The monitors, which the Russians have so far rejected, would contain seismic and computer equipment. According to a *Daily Telegraph* (May 17) report from Washington, the Carter Administration is considering bringing a team of Russian experts to America to examine the devices.

The Carter plan is related to present talks in Geneva on a nuclear test ban treaty between American and Russian. Britain is taking part in these talks.

Solar-power satellite interference

At an IEE meeting in April it was made clear that solar power satellites, intended to take power from the sun, convert it to microwaves and beam it to earth, may produce so much radio frequency interference that the idea of using them may have to be abandoned. The interference could arise because of the very high powers — from 5 to 10GW — which would be transmitted to earth. It would require only a small fraction of this to cause severe interference.

The ground-receiving array, which would convert the microwave beam into usable electricity would, according to a representative of the Electrical Research Association, produce megawatts of harmonic radiation and it would be difficult to predict its direction and magnitude. A Home Office spokesman from the Directorate of Radio Technology said that further interference problems would result due to the microwave beam being scattered by plasma interactions in the ionosphere and by raindrops. The beam could also have an heating effect on the ionosphere.

Because of the lack of suitable areas on land the best receiving site for a solar satellite delivering power to Europe would be offshore. Patrick Collins, of Imperial College, London, who is making a study of offshore collectors, says that the lowest cost of floating antenna elements of a kind suitable for this is twice that of a land-based system. (Ref. *New Scientist* May 3, 1979).

Radar shows earth-like features on Venus

Pictures of an 80-million square kilometre area of Venus, obtained by a new high-resolution ground-based radar at Arecibo Observatory, Puerto Rico, are providing the most comprehensive view ever seen of the planet's surface. They show a wide variety of terrains, some similar to those on earth and some resembling those on the moon, which cannot be observed using optical telescopes because they are permanently hidden beneath a thick cloud layer. The findings indicate that volcanic and mountain-building processes similar to those on earth, and meteoric impacts, have played a prominent role in shaping the surface of Venus.

According to a report from NASA the pictures show a number of large craters, some 320km in diameter, most of which have prominent central peaks similar to those found in many of the Moon's craters. The Venusian craters, like the lunar ones, seem to be the result of the impacts of large meteorites and appear to have blankets of dust-like material on their floors.

One region of special interest to the observers is the area known as Alpha, which was first noted many years ago because of its very high reflectivity for radar waves. Alpha is circular and has a diameter of 1,120km. It contains a very large number of roughly parallel ridges about 19km apart and some of these can be traced for distances of hundreds of kilometres. The Alpha region does not appear to have a counterpart on earth even though it bears some resemblance to the mountain ridges of the Appalachian Mountains, or perhaps to extensive systems of sand dunes in the Arabian peninsula. A central dark object in Alpha suggests that the region may contain a volcano.

Another region of the planet which is prominent on the radar pictures is an area known as Beta. This is about 800km in diameter and has long tongues of rough material extending irregularly from it as far as 480km. Beta also has a central dark feature which resembles part of a volcano. Information from NASA's Jet Propulsion Laboratory in Pasadena, California, suggests that Beta has a height of about 10km.

Two parallel ridges extending more than 960km have been found in another area of Venus. These ridges are about 2100m high and form a structure exceeding the Grand Canyon in size.

The Arecibo Observatory is part of the National Astronomy and Ionosphere Centre, which is operated by Cornell University under contract to the National Science Foundation. However, the radar programme, being carried out by Donald B. Campbell, Barbara A. Burns and Valentin Boriakoff, is receiving additional support from NASA.

In addition to the ground-based radar studies, scientists associated with the Pioneer Venus orbiter are using a mapper instrument to determine altitude variations of the Venusian surface. The information obtained from both of these studies is expected to provide a large-scale picture of the planet's surface.

Guidance system and laser stick aids for the blind

Two new aids for the visually handicapped are being introduced in Sweden, according to a publication by the Swedish Board for Technical Development (STU). The first is an electronic guidance system, thought to be the first of its kind in the world, which has recently been taken into service at a shopping centre near Gothenburg. This system consists of a portable receiver and a live underground cable that runs under a predetermined route through the shopping centre. The receiver produces a discrete ticking sound as long as the user keeps to the route, but emits another signal if he or she deviates to the left or to the right. It is hoped that, eventually, the system will be modified so that it can inform the blind user where he or she is at given intervals.

The guidance system is based on a design used in a wire navigation system launched by AB Nivåkontroll a member of the Electrolux Group. In this system signals which are emitted by submerged electromagnetic cables are received by ships who use them to navigate in and out of port in poor visibility.

Plans are also under way to produce at least 1000 laser walking-sticks for the blind, but this depends upon the necessary financial support coming from the Swedish Authorities. The sticks emit an invisible laser beam which is bounced back if any solid object lies within two-metres of the user's path. If this happens, the stick, which was developed by the National Defence Research Institute (FOA), produces a sonic signal as a warning.

Regulo 4 receiver no danger to user

A housewife from Wychbold near Droitwich claimed that she was receiving "all sorts of music" from her cooker, and she said "It seems to be coming from one of the rings." Well, we had heard of home-brew receivers, "ringing" tuned circuits, oven crystals and hot anodes, but this, at first anyway, sounded like a cooked-up story.

In fact, her home is very near to the Droitwich transmitter which apart from radiating a standard 200kHz frequency, also broadcasts Radio 4. Because of the high radiation power of the transmission, the electric field near her cooker could be developing tens of volts per metre and this acting on a piece of metal of about one metre length will induce this magnitude of voltage across it. From here on something called the "rusty-bolt effect" takes over. This occurs as a result of, for example, two pieces of metal with an oxidised junction between them acting like a diode or cat's whisker. The transmitted signal arrives at the cooker "antenna" as a modulated carrier envelope. This is rectified, or detected, by the oxide junction and produces an audio signal by mechanically vibrating parts of the cooker — the ring probably. No amplifier is required due to the already high voltage involved, and the carrier is automatically removed because its relatively high frequency is too far away from the natural frequency of the cooker parts.

In a *Daily Mirror* report, where this story appeared, a BBC spokesman said, "There is no danger." This may sound obvious to an electronics engineer at first but it is a very serious comment. With the ever increasing radiation powers of broadcast transmitters and the ever-growing size of industrial structures, it is possible for voltages to be induced capable of igniting gas or oil (see News p.74 Oct. 1978 issue). It has not happened yet as far as we know but radio and refinery engineers should bear this in mind as they are aware that they are approaching the critical powers and sizes. However, as can be seen from our previous report, investigations have shown conditions to be safe so far and it is doubtful whether the housewife will ever be afraid of her gas cooker on this score.

Tories give fourth tv channel to IBA

One of the highlights of the Queen's speech opening the new Parliament on May 15 was that the Tories propose to lay before Parliament a bill to "extend the life of the Independent Broadcasting Authority for a further period beyond the end of 1981" and to give it "the responsibility — subject to strict safeguards — for the fourth tv channel." The IBA will be able to make appropriate use of the resources of the ITV companies, in particular to ensure that the extra channel will not become a burden on the tax payers.

Lady Plowden, the IBA chairman, said afterwards "We welcome the proposal in the Queen's speech to authorize the IBA to operate the fourth tv channel and look forward to discussing with the Government the detailed arrangements". An IBA spokesman told *Wireless World* that this was what the Authority wanted all along. "We have been asking for a second channel for donkey's years", he said.

What happens now really depends upon what appears in the bill which is presented to Parliament. On the technical side at least, it is expected to make little difference to the IBA, who got the job of setting up the Open Broadcasting Authority network anyway. The differences will occur in the programming and financing side. The OBA was never intended to be totally Government-funded — it was hoped that it would eventually become financially autonomous — and the IBA will initially require Government assistance in the initial stages in any case. One argument for the OBA was that it would help the independent producer who wishes to get his programmes broadcast. Safeguards proposed by the IBA should, however, ensure that he will still get the same deal.

...and now the electronic phrase book

The latest consumer offering based on the ubiquitious microprocesser is a pocket language translator. Two similar but independent products have recently been announced in the UK following their launches in the USA about six months ago.

The LK 3000 from Lexicon uses a Mostek 3870 processer and comprises a hand-held keyboard, 16 character alphanumeric l.e.d. display and m.o.s. controller. The unit accepts a range of modules each of which accommodates a 3870 and a 64K r.a.m. for a programme store of around 2,200 words and phrases in, for example, English and French. Lexicon's marketing vice president Christopher Washburn was optimistic when stating that new modules storing around 7,500 words and phrases in a 128K r.a.m. would be available in September. Each module has an internal rechargeable battery which keeps the volatile memory powered for a year. As well as a selection of language modules there is a calculator version which also offers metric and currency conversion.

The Cherry translator is also based on the Mostek 3870 but unlike the LK 3000, it has the processor and 2K of r.o.m. in the main keyboard. With this system a calculator and metric conversion programme are part of the main unit. By plugging in up to three memory capsules, each containing 32 bytes of r.a.m. and 32K of r.o.m., the translator can operate with three languages at once and offers total store of 7000 words and phrases.

Lexicon and Cherry say that their respective units will be supported with new memory modules ranging from games and calorie counters to user — programmable types which can accept data such as telephone numbers via the keyboard. This, say the makers, means that the translator will not become obsolete within a few months as did many of the early electronic calculators and wristwatches.

Denmark produces cheap microcomputer for schools

Borg Christensen of Tonder College of Education in Denmark has designed a microcomputer which, priced at about £1000, can be offered as a cheap replacement for the computers which about half of the Danish schools now use. The computer's software enables it to run a language called COMAL and to link with ICL machines.

The new Danish system, which has been given the name COMET, is similar to the Research Machines 380Z microcomputer which many British schools, use, but it has a much faster cassette backing store and, as yet, does not have television graphics.

According to a report in the *Daily Telegraph* (May 15) orders for 300 machines have already been placed and at least two UK educationalists are showing interest in the COMAL language. Roy Atherton, who is the head of the Computer Education Resources Centre at Bulmershe College, Reading, has already been to Copenhagen for discussions with Mr Christensen and ICL staff there. The other educationalist is Dr Max Bramer, lecturer in computing at the Open University, who is interested in COMAL because it is similar to part of the University's new computer language.

A seminar on computer languages for schools may be arranged this summer in Reading with Mr Christensen as the principal speaker.

Set makers gloomy about teletext

Despite the fact that teletext has now been on the air in Britain for nearly five years (the BBC started broadcasting it in 1974) the sales of television sets fitted with teletext decoders have been disappointing. Officials of BREMA, the set makers' trade association, were unable to give *Wireless World* an exact figure for the total number of teletext sets sold in this five-year period but they estimate that total deliveries to dealers have been no more than 15,000 to 20,000. (For comparison, UK deliveries of colour television sets in the year 1978 alone were 1,736,000). BREMA is obviously worried about this lack of public interest. In its annual report for 1978 it says. "If teletext is not to stagnate, wither and die, a realistic pricing policy, coupled with Government support and further major promotions will be needed in 1979."

At another point the report remarks that the teletext market for 1978 "was sluggish, with sales in the first three-quarters of the year amounting to a mere 2,000 sets . . . However, although deliveries in the last quarter of the year rose to 7,000 the overall response was disappointing". It appears that the bulk of the teletext receiver deliveries have in fact been made in 1978. In introducing the report at this year's annual general meeting, the president of BREMA, Lord Thorneycroft, said that, although there were many exciting things happening in electronics development, in Britain at any rate there was a "huge further step" before the public could be induced to accept them in the form of new consumer electronic products. In the USA, on the other hand there was such a vast market for consumer products that new electronic devices for them could be made and sold in sufficiently large numbers to keep prices very low for the public.

Ministerial responsibilities within the D. of I. allocated

On May 9 Sir Keith Joseph, Secretary of State for In Industry, allocated ministerial responsibilities within the Department of Industry.

The Minister of State, Lord Trenchard, will be primarily responsible for the private sector and regional policy. He will also be the department's spokesman in the House of Lords. The Minister of State, Mr Adam Butler, will be responsible for aerospace, shipbuilding and shiprepairing, the Post Office, steel (including the private sector), Cable and Wireless, the National Enterprise Board and its subsidiaries, and research and development.

The Parliamentary Under-Secretary of State, Mr David Mitchell, will assist Lord Trenchard. The Secretary of State, who will have responsibility for small firms, will also be assisted by Mr Mitchell. The Parliamentary Under-Secretary of State, Mr Michael Marshall, will assist Mr Butler.

Bubble memory business computer

An American Company, Findex Inc., has introduced a general-purpose microcomputer which uses a bubble memory for its mass storage. The computer uses a Basic language and has a upper- and lower-case alphanumeric plasma display, and an integral printer, yet fits into a compact portable unit weighing less than 20lb.

In the bubble memory, which has 128K bytes of memory that can be expanded in increments of 128K, binary information is stored in a stationary, magnetic garnet chip in the form of uniformly-spaced magnetic domains. These are arranged in closed loops, where the presence of a bubble represents a binary "one" and the absence of a bubble represents a binary "zero." Induced magnetic fields cause the bubble loops to rotate within the chip so that information may be recorded by an inbuilt generator, or read by an integral detector.

Spot-frequency distortion meter

Measures very low (0.00001%*) levels of harmonic distortion.

by J. L. Linsley Hood

This article describes a spot frequency distortion measuring instrument which uses a bootstrapped notch filter technique to avoid typical parallel T problems of 2nd and 3rd harmonic attenuation. Oscillator amplitude stabilization is achieved by a Darlington-based Wheatstone bridge arrangement with a thermistor controlling currents in each limb. The final combination of oscillator, notch filter and wide bandwidth millivoltmeter offers marked improvements in noise factor and linearity, permitting the resolution of much lower levels of harmonic distortion than is normally possible.

THERE IS NOW considerable interest among engineers in the use of distortion measuring systems as a general tool for circuit performance analysis. While this can most conveniently be done by the use of a spectrum analyser, giving rapid identification of the nature of the harmonic impurities, with equipment of this type the lower level of detectable distortion is usually about −80dB or 0.01%, while the areas of current interest are 10 to 100 times less than this. For these applications therefore, the somewhat laborious methods of notch filtering for a single measuring frequency are still required.

As it is feasible, with relatively simple circuits, to measure waveform impurities below 0.0001% (−120dB) and to generate sinewaves with impurity contents of about 0.0002%, the methods employed here may be of interest to those engaged in circuit analysis, as a means of attaining a more detailed view of non-linearity. In order to reduce the complexity of construction, the equipment was designed to operate at five 'spot' frequencies within the audio band — 100Hz, 300Hz, 1kHz, 3kHz and 10kHz.

Measuring apparatus

The most straightforward way of determining the amount of distortion present in a pure sinusoidal waveform is to interpose a sharply tuned notch-filter between the input waveform and a measuring circuit and while there are several suitable filters, the most convenient of these is the 'parallel T' network, shown in a schematic measuring apparatus in Fig. 1. The transmission and impedance characteristics of a simple T network are shown in Fig. 2, which demonstrates the difficulty inherent in the use of a passive 'parallel T' of this type in the signal path. There would be significant attenuation of both the second and third harmonics of the incoming signal, leading to an inaccurate measurement of the level of distortion.

The sharpness of this notch can be increased by the application of overall negative feedback around a loop containing the 'parallel T' and a suitable following amplifier so that for the same attenuation at the notch frequency, the transmission at $f_n/2$ or $2f_n$ can be made substantially identical to that at much lower or much higher frequencies and this is an arrangement which has been employed in commercial 'parallel T' distortion meters[1]. Unfortunately this method suffers from the disadvantages that the input circuit is made more complex and that there is some injection of amplifier noise into the notch filter, lessening the sensitivity of the system.

*For 10V r.m.s. input signal.

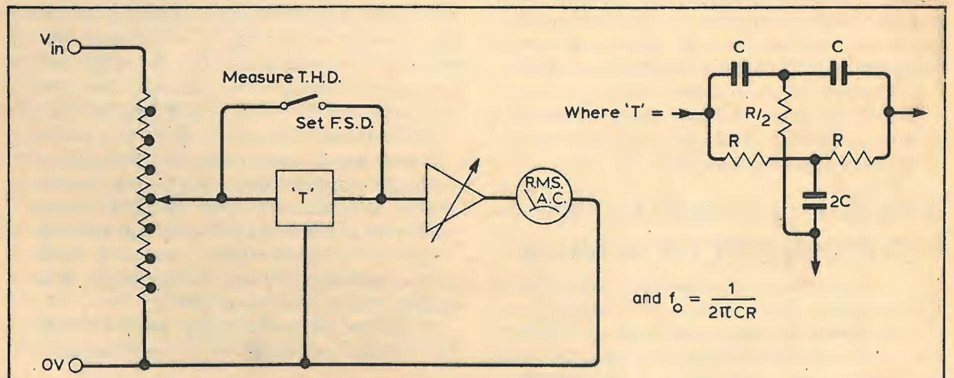


Fig 1: *Conventional parallel T distortion measuring arrangement and the basic T circuit*

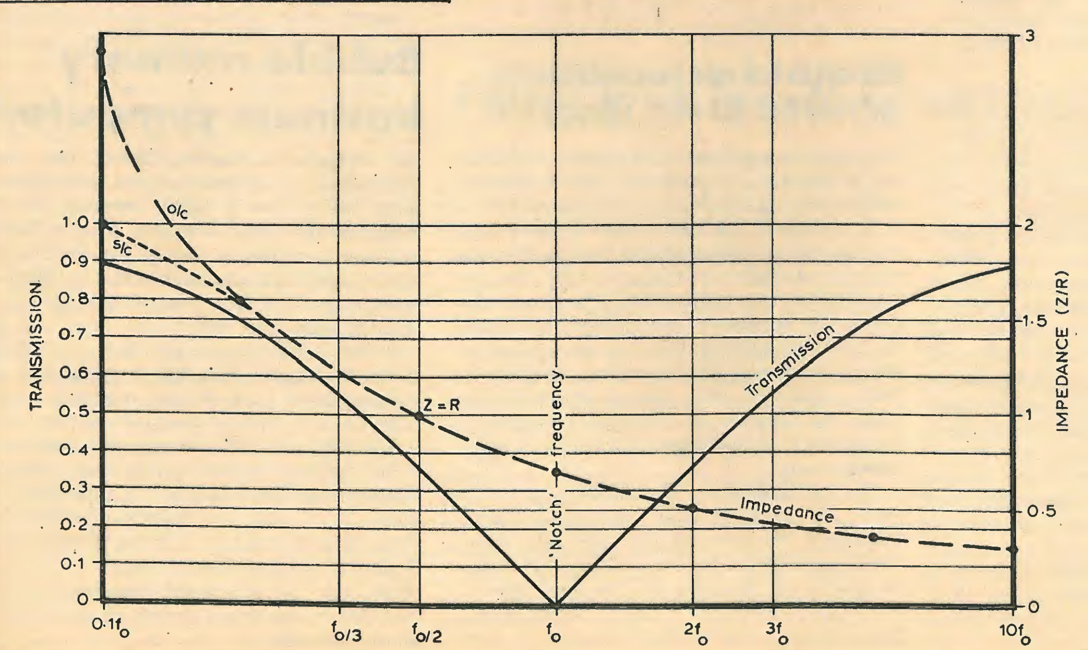


Fig. 2: *Typical attenuation of 2nd and 3rd harmonics in the parallel T signal path*

An alternative approach, which leads to simpler circuit configurations, is to apply positive feedback to the 'common' limb of the T, by means of a 'bootstrap' arrangement of the type shown in Fig. 3. This leaves the input to the T free from other circuit connections, so that it may be taken directly to a low impedance input attenuator. The sharpness of the notch can be controlled by the extent to which the 'bootstrap' voltage approaches that of the input voltage to the amplifier. In general, too sharp a notch will make the equipment less easy to operate, so the proportion of the input voltage applied to the 'bootstrap' connection is chosen so as to achieve a generally flat response in respect of second and higher harmonics.

The characteristics of the notch filter, with regard to both the notch frequency and its equivalent output and 'noise' impedances, are influenced by the impedance seen at the input to the T. The input attenuator should therefore be of the constant impedance type. Suitable values for this can readily be calculated[2]. Ideally, the parallel T should be fed from an impedance which is not more than one-tenth of the nominal impedance of the T and the following amplifier should have at least 10 times its input impedance over the frequency range of interest.

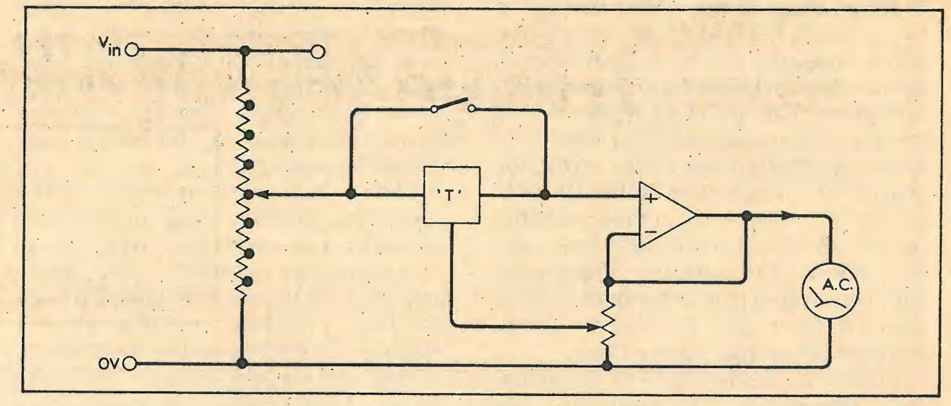


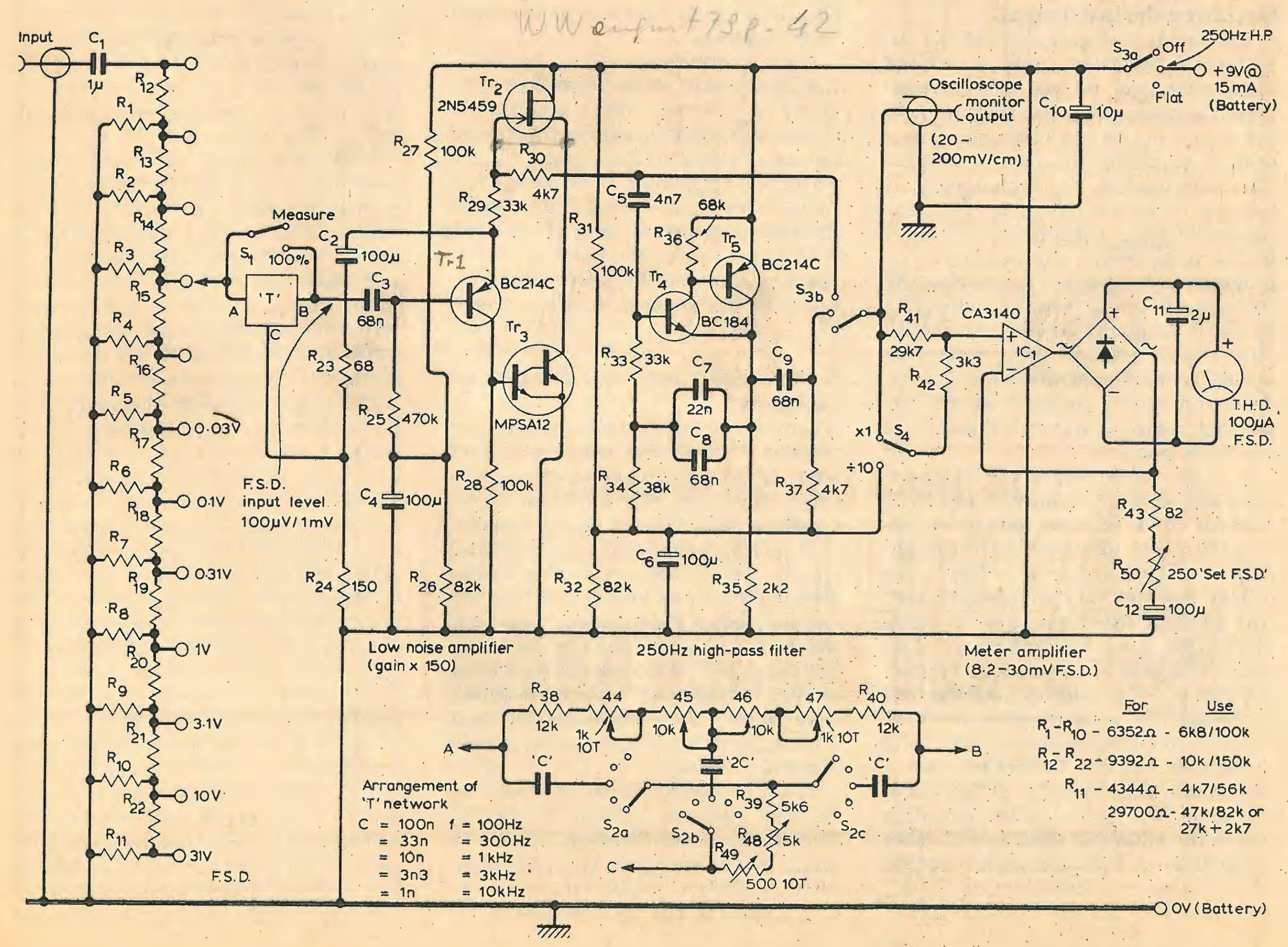
Fig 3: *Bootstrapping the network*

Bootstrapped T circuit

A suitable electronic circuit, which employs a bootstrapped T as the notch element, and largely satisfies the circuit requirements is shown in Fig. 4. In this, the T network is fed from an input attenuator having a voltage attenuation of $\sqrt{10}$. (3.162) or 10dB, and a characteristic impedance of 3.3kΩ. The output of the T is taken to a low-noise amplifier with an input impedance of about 300kΩ, and a gain of 150. The effective input noise is mainly determined by the impedance characteristics of the T.

A wide-bandwidth a.c. millivoltmeter

Fig 4: *Distortion meter circuit. Instructions for making up odd value resistors (R_1-R_{10} etc.) mean "use" 6k8 and 100k in parallel*



is driven from this amplifier through a two position (x1 and x1/10) attenuator and an optional 250Hz, —20dB/octave, 'bootstrap' filter[3], with a high-pass characteristic. The use of an RCA CA3140 c.m.o.s. operational amplifier allows an effective 100kHz bandwidth, ± 1dB, for the meter circuit. The full-scale sensitivity of the meter circuit is adjustable by the 'set f.s.d.' control over the range 8.2 - 30mV. The complete instrument can be operated from a 9 volt transistor radio battery and the current consumption is approximately 15mA.

Tuning of the notch to the nominal 'spot' frequencies is by means of a 10k twin-gang and 5k single-gang potentiometer. Fine tuning is then accomplished by two 1k and one 500Ω ten-turn potentiometers.

The ultimate sensitivity of the instrument, assuming an adequately low noise component in the input signal under test, is less than 0.0001% for a 1 volt (r.m.s.) input signal, or less than 0.00001% for a 10 volt (r.m.s.) input signal. At these harmonic distortion levels, even assuming adequate freedom from mains-frequency hum — which can be obtained with care in the screening of the instruments and the layout of connecting leads — the effectiveness of the plug and socket connections is extremely important and gold-plated connectors should be used if available.

Operating the instrument

The method of operation of the instrument is relatively simple, in that the input attenuator is used in two roles, that of adjusting the input magnitude of the signal fed to the instrument, and that of adjusting the f.s.d. harmonic distortion reading. The technique is as follows — assuming an appropriate sinusoidal signal is applied to the input of the instrument, the sensitivity is progressively increased by moving the slider of the input attenuator switch (S_1) upwards from the lowest sensitivity (30V r.m.s.) position until a suitable setting is found, at which a full scale deflection can be obtained on the output meter with S_4 in the 'x1' and S_5 in the '100%' position.

S_5 is then switched to the 'measure' position, and S_1 is moved upwards towards the maximum sensitivity setting, with each upward step corresponding to a 10dB increase in the meter display sensitivity. In percentage terms, this gives a step sequence of 100%, 31.6%, 10%, 3.16%, 1%, and so on. If an input voltage of 1 volt (r.m.s.) is applied, the maximum sensitivity position will correspond to a f.s.d. value of 0.01%. Since the input noise of the instrument, integrated over the 100kHz measuring bandwidth, gives a meter deflection of less than 1% of the full scale, a reading due to the harmonic residues and other components of the input signal (0.001%) can be seen on a suitable meter. If a 3 volt input signal is available, the maximum f.s.d. input sensitivity setting would be equivalent to 0.00316% and if a 10 volt signal were available, a full scale deflection equivalent to 0.001% would be provided, allowing minimum detection levels of 0.00003% and 0.00001% respectively.

These assumptions have been checked in practice using an oscillator whose t.h.d. at 1 volt (r.m.s.) output was measured at 0.0002% and when amplified to the 10 volt level through the best available amplifier gave a reading of 0.00018% on the 0.001% f.s.d. setting. Once again, at these levels, the fitting of the plug and socket connections is critical and the notching-out of the fundamental is a matter of some skill.

Although the component values for the notch filter of Fig. 4 are those chosen to give an adjustment of ± 30% about the mean centre frequencies, it is obviously practicable to extend this so that the ranges overlap.

The 'scope output point can be used for a visual or instrument analysis of the harmonic structure of the residues and provided that the fundamental has been removed more simple techniques are often adequate such as a phase sensitive rectifier operated from an external oscillator, frequency-locked through a p.l.l. to a simple multiple of the input frequency.

For simplicity, an average-reading millivoltmeter has been employed as the output meter rather than a more complex 'true r.m.s.' (thermal energy equivalent) system.

A minor practical snag in the use of this instrument with the simple constant impedance input attenuator shown is that the capacitive coupling of the input signal to the input to the T across the attenuator switch leads to a small change in the notch frequency as the input attenuation level is changed, with the consequent need for some readjustment of the null frequency. Better input screening could avoid this.

A low-distortion spot frequency oscillator

A similar, but rather more complicated, 'parallel T' distortion meter was built some ten years ago and used as a test instrument for the assessment of oscillator performance characteristics, — a number of experimental oscillator circuits were examined by this means. This exercise was instructive in many ways, of which the two most vital were the demonstration of the need for a very low noise level (which precludes the use of most integrated circuits) and the need for very high frequency stability, if a fundamental-nulling measuring technique is to be used.

The attainment of a stable operating frequency demands a highly frequency-selective feedback network and of the many forms available, the 'parallel T' offers the best ratio of performance to complexity. If this type of network is

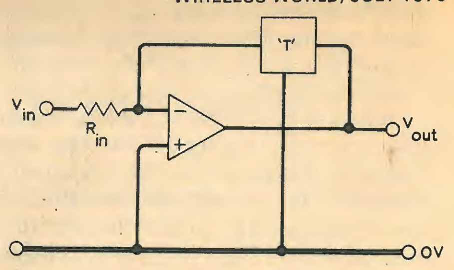


Fig 5: *A high gain null circuit.*

included in the feedback path of a high gain inverting amplifier, of the form shown in Fig. 5, the system gain will be very high at the null frequency and will tend to zero at frequencies remote from this. If the T is slightly unbalanced, in the manner proposed by Bailey[4], so that some positive feedback is given at the notch frequency, the system will oscillate without further persuasion, though with some small penalty in waveform purity due to the lesser discrimination in the feedback ratio.

Alternatively the T network could be left as a straightforward notch element, having zero transmission — and consequently zero negative feedback — at some specific frequency and a small magnitude sinusoidal signal could be injected into the amplifying device from an external source. Since the amplified signal will have a high degree of monotonicity, because of the frequency/gain characteristics of this circuit arrangement it could be anticipated that the harmonic distortion of the input signal would be lessened by such an amplifier stage.

If this input signal could now be derived from the output of the amplifier through a network which adjusted the magnitude of the fed-back signal in a manner which maintained the output at a constant amplitude, the result would be an oscillator having a waveform purity and signal-to-noise ratio determined almost exclusively by the effectiveness of the amplifier arrangement.

The design problem therefore simplifies into that of providing a circuit block of low input noise level, overall good linearity (especially in respect of the output stage which has to handle the greatest signal level) coupled with as high an open-loop gain as is practicable, and some means of deriving a feedback signal from the output of the amplifier whereby its magnitude and phase can be made to be dependent on the output signal level.

In view of the requirement that the amplifier stage should be phase inverting, the practical choice of amplifier configuration is limited to that of a single gain stage or a two-stage amplifier with the input devices arranged as a long-tailed pair. The difficulty of obtaining overall loop stability in a feedback amplifier having three or more gain stages connected in cascade

discourages the consideration of this alternative where a wide bandwidth is necessary.

Initial exploration of the first of these two possibilities showed that it was possible to obtain stage gains in the range 50,000 to 100,000 from a single transistor in a Liniac[5] configuration if the amplifying device was isolated from its load by an f.e.t. in the manner shown in Fig. 6. However, the need to couple the amplifying stage to an output point having an impedance of some 600 ohms required an impedance transformation circuit which added considerably to the component count and detracted from the original simplicity of the concept.

If a two-stage design is chosen, it is essential that the gain of the first stage is sufficient to ensure that the noise contribution of the second can be ignored. In general this implies that a relatively high first stage load is necessary, which in turn indicates the choice of either a field-effect device as the second stage amplifier, or a compound configuration of junction transistors. One of the monolithic small-signal Darlington devices meets this requirement admirably and has an input impedance which is sufficiently high to have little effect on the impedance of the collector load of the preceding stage. Also, the stage gain of such a device feeding a constant-current source has been shown to be of the order of 2000-3000[6].

Taylor shows[7] that the use of an input long-tailed pair, because it is basically a push-pull configuration, leads to the cancellation of even-order harmonic distortions, particularly when the devices are matched in characteristics and operating conditions, but also even when the devices are mismatched. A possible gain stage of this type, using an input long-tailed pair and a Darlington transistor second stage is shown in Fig. 7. This has a low-frequency open-loop gain of the order of 200,000 or geater, which allows a substantial measure of loop feedback to be applied and avoids the pitfall demonstrated by Baxandall[8] that low levels of negative feedback may exchange a small measure of non-linearity for a whole host of high-order distortions.

Fig 6: *Exploratory high gain amplifier*

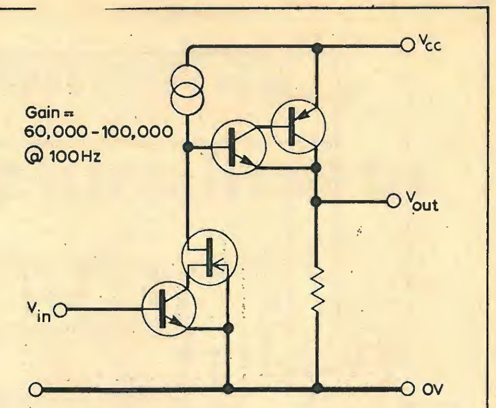


Fig 7: *Simplified design which approaches the shape of the final version*

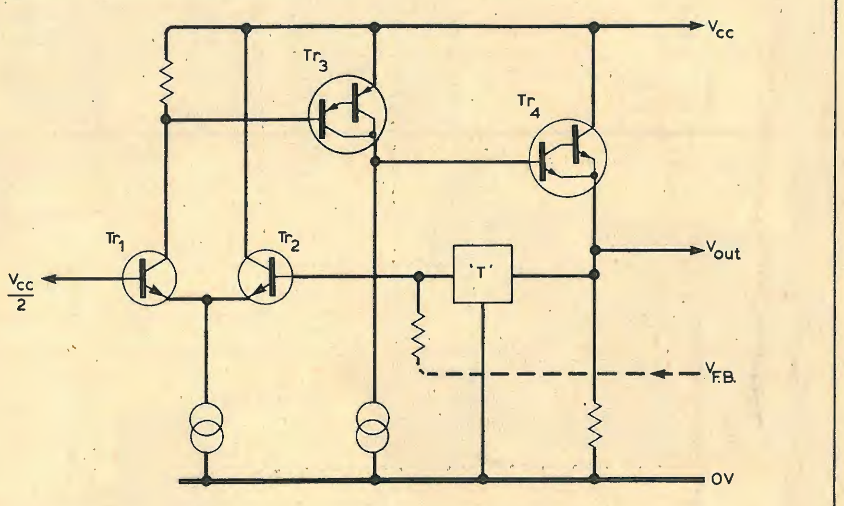
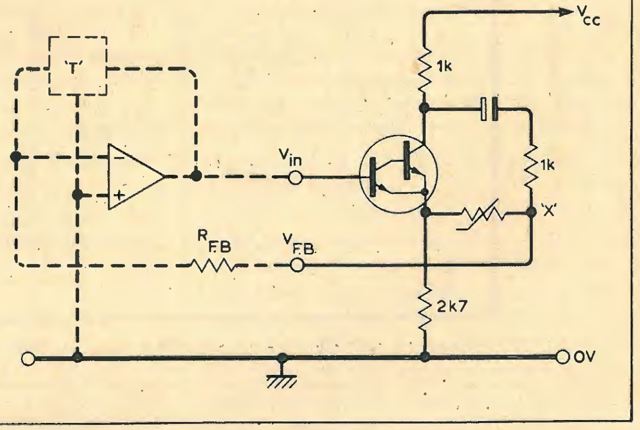


Fig 8: *Thermistor-controlled "Darlington bridge" – this part of the oscillator helps to stabilize output signal amplitude*



Output amplitude stabilisation

The stabilisation of the amplitude of a low-distortion oscillator is a difficult problem, for reasons explained previously[9] and this difficulty is exacerbated by any requirement that the amplitude stabilisation circuit should contribute as little as possible to the overall distortion figure. In this case, the technique adopted is that shown in Fig. 8. This takes advantage of the fact that in a Darlington transistor, the collector and emitter currents are substantially identical and this allows the thermistor to be operated as one limb of a Wheatstone bridge type configuration. Since the ratio of the collector to emitter limbs is 1 : 2.7 the bridge will be balanced (for zero output at point 'X') when the thermistor achieves an internal resistance value, due to the heating effect of the circulating current, of 2.7kΩ. If the applied voltage to the control circuit falls, the thermistor will cool somewhat, which will cause the phase of the feedback signal to be positive, thereby increasing the magnitude of the output. If the magnitude of the signal input to the control circuit increases, then the resistance of the thermistor will fall and the phase of the feedback signal will become negative, causing the output of the oscillator to decrease.

In operation, the total magnitude of the signal present at the base of Tr_2 is very small, so that the non-linearity contribution due to the curvature of I_c/V_b characteristics of the input devices is also very small. This demonstrates one of the reasons for the superiority in performance of this (parallel T) type of circuit over the conventional Wien bridge system, in which there is normally one-third of the output signal present at the base of the input transistor with consequently greater contributions from the input device to the overall non-linearity of the circuit.

The final circuit of the oscillator is shown in Fig. 9 and the measured distortion characteristics are shown in Fig. 10. Loop stabilisation is achieved by

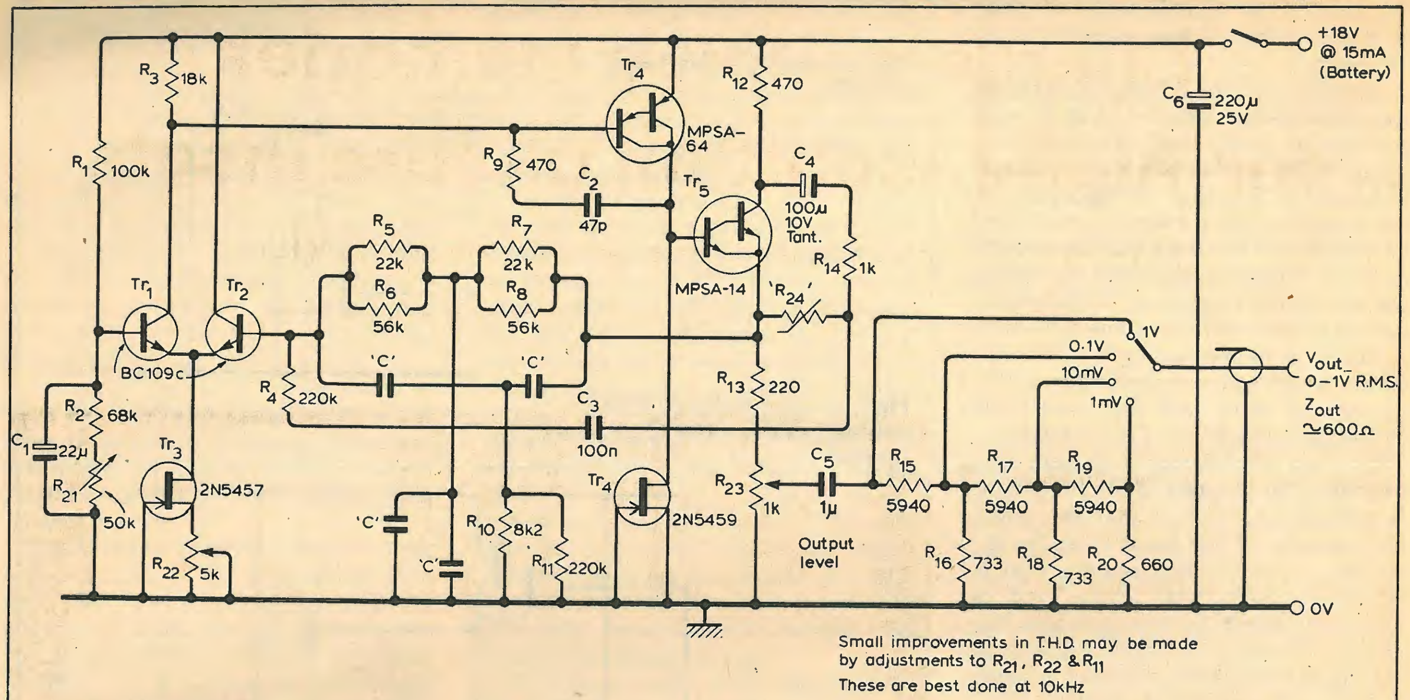


Fig 9: *Complete schematic of the spot-frequency oscillator*

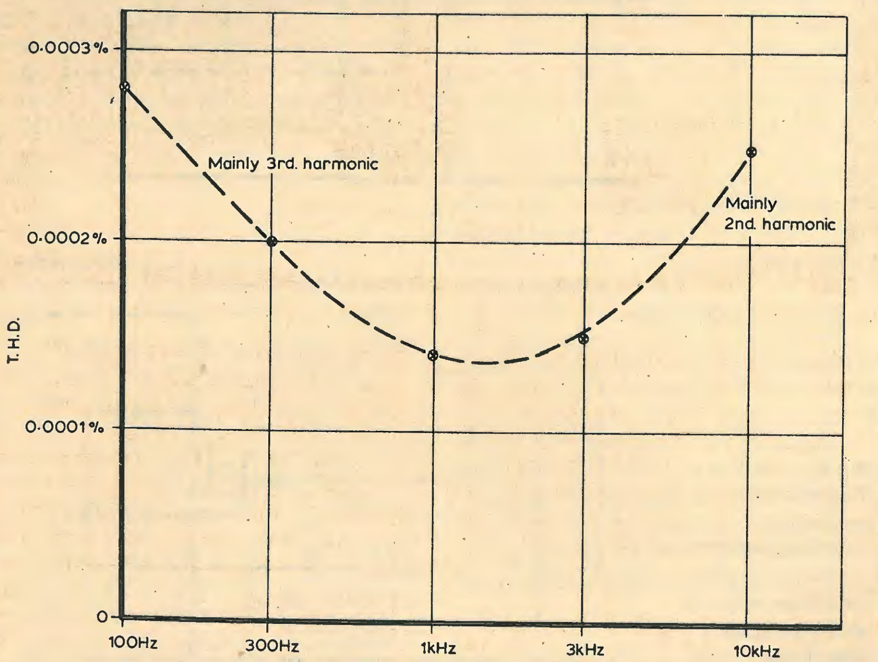


Fig 10: *Measured distortion characteristics*

adding a dominant lag capacitor between collector and base of Tr_4. The values shown have proved adequate to prevent squegging in three experimental models of this oscillator, but in two of the three cases a 3pF capacitor was quite adequate, with consequent improvement in the h.f. open-loop gain and rather lower t.h.d. figures at 10kHz than those shown in Fig. 10.

While the author's own model of this unit operates only at the five spot frequencies shown, obtained by switching the capacitors in the T (polystyrene foil types) there is no reason other than complexity of switching for the restriction of its operating frequencies to those shown.

The first unit of this type was built using resin dipped carbon film resistors, and this is still in service. A subsequent unit employing metal film resistors throughout showed a small improvement both in t.h.d. and background noise level. Unfortunately for the conclusiveness of this experiment, a similar improvement in the prototype was obtained by replacing the Motorola 2N5089 input devices with Motorola BC109Cs. The f.e.ts are also preferably Motorola types.

Thermistor "R24" should be an STC R54 or equivalent type. Resistance at 20°C should be approximately 50k falling to about 270Ω in operation. This makes other items such as the GM473 or VA3410 suitable.

The measurement of the residual harmonic distortion and noise is greatly facilitated by the monitoring of the signal on an oscilloscope. Even so, the operation of any notch filter with a rejection ratio of 120dB or so requires a certain delicacy of touch and conditions of reasonable tranquillity.

Printed circuit boards

Two glass fibre p.c.bs are available for the distortion meter and oscillator at a cost of £5 the set from M.R. Sagin, 23, Keyes Rd., London, N.W.2.

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Charge-coupled memories for high-resolution picture insets

Monitoring a second channel inserted into the main picture

by P. Bouvyn BARCO COBAR Electronics, n.v., Kuurne, Belgium

Charge-coupled device memories have been developed for use in a "picture-in-picture" system, for viewing and monitoring a second channel on a small image, inserted in the main tv picture. The system employs two standard receiver sections tuned to the main viewing channel and the channel for the inset picture. Two 72 x 128 c.c.d. memories store the out-of-phase second channel video information and write it out, synchronized with the main programme, enabling a stable inset location in the upper left hand corner. By choosing the lines to be stored very carefully, an interlaced inset is obtained.

Fig. 1. *Typical inset picture from the BARCO system on a 66cm screen.*

SINCE 1973, several makers have offered second-channel monitoring on consumer television sets. Nordmende was first, marketing a set with two picture tubes which allowed two programmes to be viewed at the same time, one on the main 60cm screen and another on an adjacent 20cm screen. A button allowed switching between the two screens.

Several years later, in 1977, Saba and Telefunken developed their system, making it possible to display a partial black-and-white picture of a different programme in the corner of the main colour picture. The inset measures 16×18 cm on a 66 cm tube. The system uses a video-switch controlled by logic circuitry, which chooses the corner of the main colour picture to use for the inset according to the phase shift of the two transmitters, so that horizontal and vertical blanking bands do not show. The black and white inset has the resolution of a normal picture but only displays part of a picture quadrant.

The Saba system had not been on the market very long when Grundig appeared with their "Vollbild im Bild", developed by ITT. This system delivers a stable second picture located in the middle of the lower edge of the screen. The inset, measuring 8×11.5 cm, consists of a full black-and-white picture of 116 lines (58 per field) with 64 picture elements per line. The system uses two bucket-brigade memories for storing the reduced size picture, synchronized with the second-channel video signal, and to read out the stored video information synchronized with the main picture signal. Only one line in four is stored, while the bandwidth of the second programme video signal is reduced to 0.75 MHz. Sharp is also going to use this system, according to recent information.

Separately BARCO have developed their own system, using two c.c.d. (charge-coupled device) memories. The inset picture is located in the upper, left-hand corner of the main colour picture. The linear dimensions of the monochrome inset are 1/4 of the normal picture.

	Nordmende	SABA Telefunken	ITT-Schaub-Lorenz Grundig Sharp	Barco	Fairchild X still in development	Philips
Display	2-4 picture tubes	picture inset	picture inset	picture inset	picture inset	picture inset
System	separate	video-switch	2 bucket brigade memories	2 ccd memories	2 ccd memories	digital memories
2nd picture format	full picture	picture quadrant	full picture	full picture	full picture	?
Picture size	12 x 16 cm	16 x 18 cm	8 x 11,5 cm	10 x 13 cm	X	?
Lines per field	287,5	116	58	72	90	?
Points per line	525	179	64	128	120	?
Horizontal resolution	5MHz	5MHz	3MHz	5MHz	X	?
Interlaced 2nd pict.	yes	yes	no	yes	X	?
Line time	52,48 µs	17,89 µs	10,67 µs	12,8 µs	X	?

Cc.d. memory

Signals originating from two different transmitters are normally out of phase,

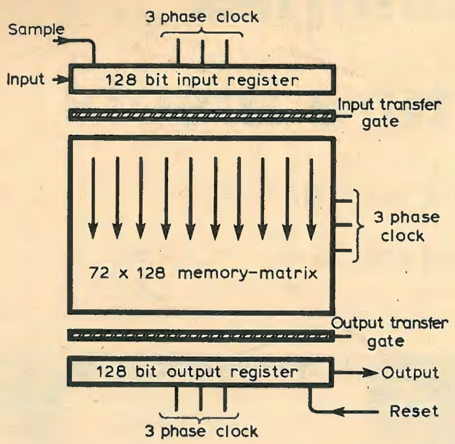


Fig. 2. *Organization of the 72x128 c.c.d. memory.*

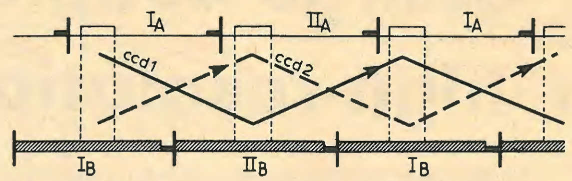


Fig. 3. *Reading and writing of both memories. Main picture is A series; inset is B. C.c.d.2, for example, reads from first field of B, writes in second field of A, reads in first field of B, etc.*

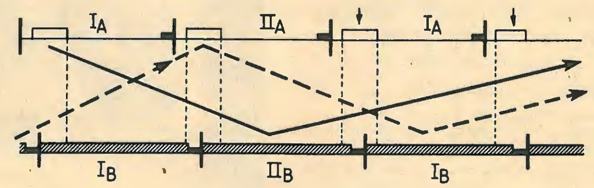


Fig. 4. *Phase variations sometimes mean that a memory would need to read and write simultaneously.*

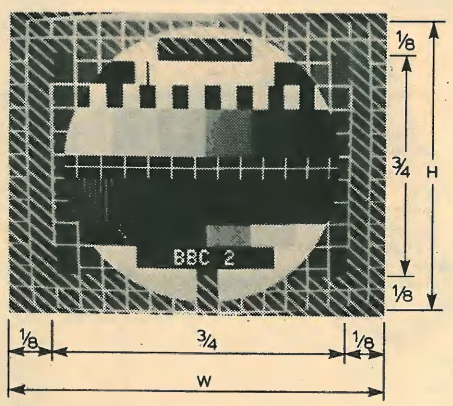


Fig. 5. *Eliminating one eighth of the picture at each edge loses a negligible amount of information.*

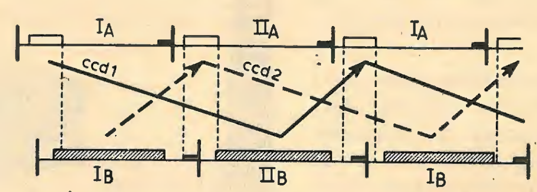


Fig. 6. *Result of reading only three quarters of picture: problem of Fig. 4 avoided.*

the phase difference varying in time. It is therefore necessary to store the second-channel information in a memory until the right moment has come to write out the stored information.

Conventional digital memories cannot be used for this application, since the analogue tv signal then needs a.-d. and d.-a. conversion, which cannot be realized economically at the frequencies required. Analogue memories such as b.b.ds (bucket-brigade devices) or c.c.ds (charge-coupled devices) must then be used. Of both these devices, c.c.ds have the advantage of being able to reach higher read and write speeds, so they can achieve a higher bandwidth and give a better picture resolution. Thanks to a special technology that eliminated the so-called dark current spikes, fabrication of c.c.ds which could contain a whole video field became possible. The spikes caused unacceptable spots in the picture.

C.c.ds may be constructed as memory cells in a serial fashion, one following the other, or as a serial-parallel-serial (s.p.s.) structure. In the latter case the c.c.d. memory cells form a matrix. The information is first serially read into the "read-in" register cells and then shifted in parallel one row down. For the "picture in picture" application the s.p.s. structure is more suitable than the serial type because the maximum bandwidth is determined by the number of shifts the information has to make from cell to cell. For a 100×100 s.p.s. structure there are 200 shifts, while for a serial structure with the same number of cells there are 10,000 shifts.

Memory format. The reproduction of a picture with a cathode ray tube can be taken as a mixed version of point per point reproduction. In the vertical sense the display is discrete (expressed as a number of lines), while in the horizontal sense the picture is continuous (defined by the bandwidth of the transmitted a.m. signal). A tv standard is composed in such a way that horizontal and vertical resolution are the same. The BG standard, for example, has a bandwidth of 5 MHz, where the picture consists of 575 effective lines.

Considering the chosen s.p.s. organization of the c.c.d. memory, the number of elements has to be defined as a product of lines (L) and columns (C). To reconstruct a black and white picture in the BG standard, not only the transmitted bandwidth and the effective information time per line in the horizontal sense must be considered but also the effective number of lines in the vertical sense. So calculation gives L=575 and C=525.

Because the inserted picture is four times smaller, proportionally less lines and columns are needed. The memory capacity can be reduced to (575/4) L × (525/4) C or 144 L × 128 C, in convenient numbers of bits. However, a transmitted picture in the BG standard is composed of two interlaced fields, so the memory can be split into two memories of 72 L × 128 C. Each memory then stores one field of the picture.

BARCO system

Essentially the system works as follows. Two c.c.d. memories read in alternately one field (every fourth line) of the second channel picture after which c.c.d. 1 writes out the information into field 1 of the main picture and c.c.d. 2 into field 2 as in Fig. 3. The field which is read into the c.c.ds is always the first complete field of the second channel picture. As the phase of both transmitter signals varies in time, the situation shown in Fig. 4 can occur. Neither c.c.d. 1 nor c.c.d. 2 in this situation can write out into every field of the main channel, since each time there is an overlap of read and write time. Some fields would, therefore, be lost.

To limit the number of memories to two, one-eighth of the picture is omitted at each edge, since the borders contain least information. Fig. 5 shows the result. By shortening the read-in time to 3/4 of the normal time the problem shown in Fig. 4 is solved, as indicated by Fig. 6.

In writing out the information line by line, the height of the picture is reduced three times, since only one line in three is stored. The height of the inset becomes 3/4 divided by 3 or 1/4 of the normal picture height. In the same way, only 3/4 of a line is read into the memory, so to obtain the resolution of 5 MHz for the inset, the bandwidth of the input memory signal may be reduced to 5/3 = 1.66 MHz, because the writing-out is three times faster. The read-in and write-out clock frequencies, which must be double the bandwidth, are then respectively 3.33 MHz and 10 MHz. This means that in the horizontal sense as well the picture is compressed by 1/3. The width of the inset therefore becomes 1/4 of the normal picture width.

Interlacing of inset. It might be assumed that c.c.d. 1 always reads in the second field of channel 2 and c.c.d. 2 field 1, but this is not the case. There are two critical situations, according to the phase shift between the two transmitters. In the upper diagram of Fig. 7 the field frequency of the second transmitter is

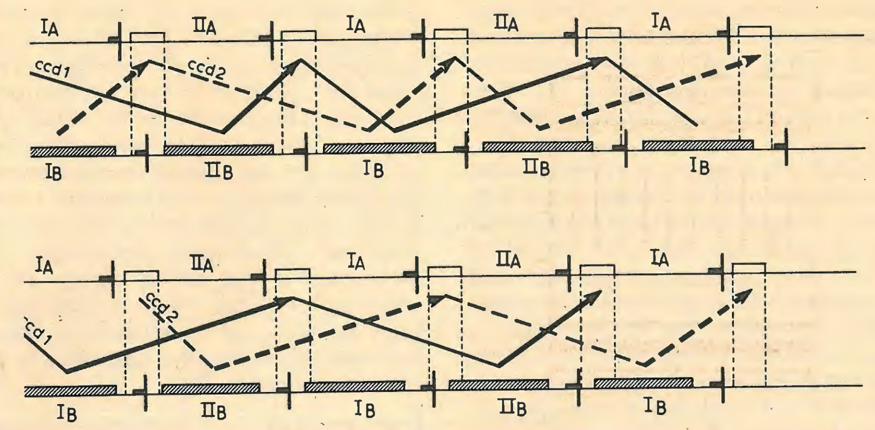


Fig. 7. *If raster frequencies of two pictures differ, one field of inset is either displayed twice or not at all.*

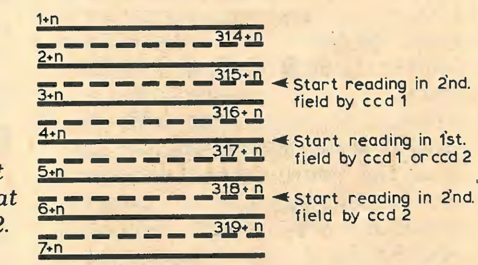


Fig. 8. *Memory 1 always writes in first field of main picture, which means that it reads-in three lines above Memory 2.*

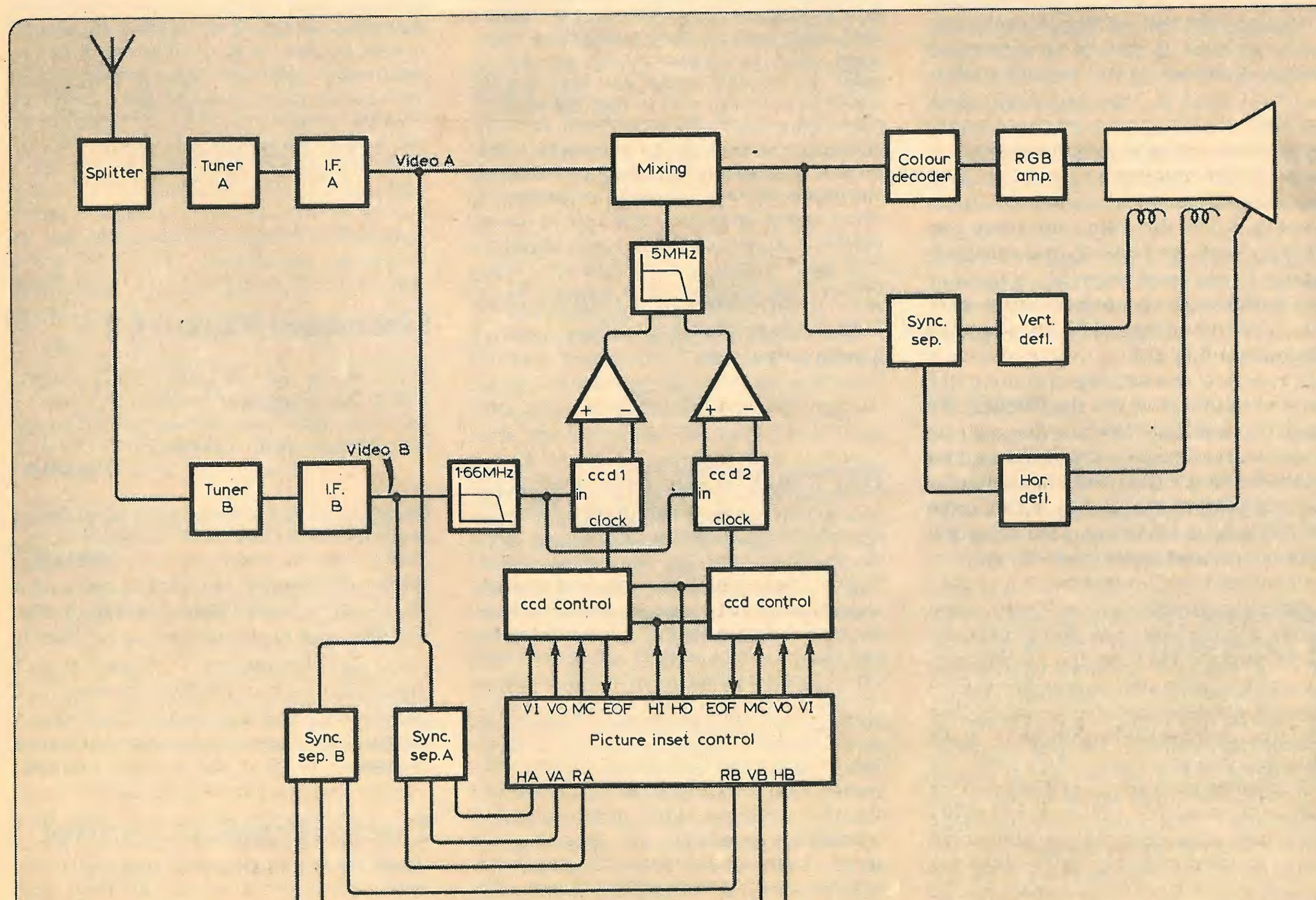


Fig. 9. *Block diagram of 'picture-in-picture' system.*

lower than the field frequency of the main transmitter, and in the lower half, higher. Consequently, the field 1_B is either displayed twice or not displayed at all. At this moment the next complete field to be read in changes from the first to the second memory, or vice versa.

To obtain an interlaced inset, it is necessary to choose very carefully the lines to be stored in the memories. Different systems can be used but the best results are obtained with a system where the writing out of the memories is coupled to the field-information of the main transmitter. The first memory — c.c.d. 1 — always writes out into the first field of the main transmitter, beginning with line 1 + *m* (*m* is the vertical position of the inset) and ending with line 72 + *m*. The second memory – c.c.d. 2 – always writes out into the second field of the main transmitter, beginning with line 313 + *m* (this is the line under line 1 + *m* of the first field) and ending with line 385 + *m*. After a memory has written out, the next complete field of the second transmitter is read into that memory.

If this field is the first field, then reading in is started with line 4 + *n* (*n* defines the line on which we start) without considering for which c.c.d. the information is destined. If the field is the second field, then the line that is read in depends on which c.c.d. the information is destined for.

If the second field is read into c.c.d. 1, then we start with line 315 + *n*. This line is situated above line 4 + *n* of field 1 and is later on written out above the information of c.c.d. 2, so that an interlaced inset is obtained. If the second field is read into c.c.d. 2, then we begin with line 318 + *n*. This line is situated under line 4 + *n*, and is later on written out under the information of c.c.d. 1. Also in this case we obtain an interlaced inset, as in Fig. 8. The diagram shows that the read-in lines of field 2 are situated exactly in between the read in lines of field 1, thus giving optimal resolution. This cannot be obtained with a system that reads 1 line in 4.

In practice, the writing out of c.c.d. 1 starts with line 26 of the first field of the main transmitter. The writing out of c.c.d. 2 starts with line 339 of the second field. The first field of the inset transmitter is read in, beginning with line 56 and the second field begins with line 367 for c.c.d. 1 and line 370 for c.c.d. 2.

C.c.d. matrix. The control circuitry in Fig. 9 generates 13 clockpulses to allow the 72 × 128 c.c.d. memory to operate. The status output (EOF) indicates when the matrix has completely read in or written out. Another output controls the mixing of the output signal of the c.c.d. with the video signal of the main programme. Horizontal and vertical synchronization inputs are provided for read and write timing. Next we have the control-input, (MC) that switches the memory from read to write. In the position "read in" the memory starts reading in after the reception of the vertical start pulse (VI).

Seventy-two lines are read in and shifted down into the parallel register, synchronized by the horizontal start pulse (HI). After all 72 lines are read in, the control logic waits for the write out command. Now writing out happens in a similar way as reading in. Horizontal (HO) and vertical (VO) write-out start pulses now synchronize the whole sequence. First, the information is shifted out of the parallel register into the output register, which is then written out. When all 72 lines are written out, the control circuitry waits for a new read in command.

Inset control. Both memories of the picture-inset generator each have an identical c.c.d. control, controlled in turn by the picture-inset control in such a way that reading in is synchronized with pulses of the inset-transmitter B, while writing out is synchronized with pulses of the main programme transmitter A. The circuitry ensures an interlaced inset. Continuity of the inset is not affected by the two transmitters being out of phase (no half picture or flicker with a change in the phase difference). Therefore, vertical (VA and VB) and horizontal (HA and HB) sync. pulses are needed and also field information (RA and RB) from both transmitters.

The research for this project, commissioned by BARCO-COBAR Electronic n.v., has been carried out partly by the ESAT, division of the Electrotechnic Department of the university of Louvain (Director: Prof. Dr. Ir. R. Van Overstraeten) under the leadership of Dr. Ir. G. Declerck.

Many thanks especially to P. Schreurs, K. Vandamme and V. Jansoone for the very interesting discussions on the subject. We would also like to thank the IWONL (Institute for encouragement of scientific research in Industry and Agriculture) and the CRIF (Centre for research in metal-industry) for their help. □

Books Received

The New Penguin Dictionary of Electronics is compiled by Carol Young, and replaces the earlier dictionary, published in 1962. The word 'electronics' in the title is not an indication of bias towards devices and materials; the book embraces all fields of electronic engineering, including communications and computing. It is obviously hardly possible to include every term in current use and, indeed, there are one or two surprising omissions, such as accelerometer, secondary radar, totem-pole output and the Nyquist criterion. It is also odd to find the spelling Schockley, and to see no reference to Mossbauer, Cerenkov or Czochralski. But these are somewhat pettifogging criticisms and the book is a fine work of reference, which is well up to date with such words as Prestel. Cross-referencing eases problems with such entries as Chebishev and Tchebyshev. This 618-page book costs £1.25, or £7.97 in hardback, and is published by Penguin Books Ltd, 17 Grosvenor Gardens, London SW1W 0BD.

Operational Amplifiers, by G. B. Clayton, is the second edition of an eight-year-old book, now largely rewritten to take account of the many new types of amplifier which have been introduced in the intervening period. This is not simply a collection of circuits using op-amps, but is an attempt to provide the reader with sufficient general information on the characteristics of devices and circuit configurations to enable him to design circuits and systems from scratch. A chapter on fundamentals precedes two sections on performance characteristics and testing, which inform the rest of the chapters on applications. A final chapter provides information on practical points, such as stability, interference avoidance, etc. Exercises are given at the end of each chapter, with answers, and the appendices consist of a number of applications and further calculations on common-mode rejection and frequency/phase response. The book is published by Butterworth and Co. (Publishers) Ltd, 88 Kingsway, London WC2B CAB, contains 410 pages and costs £9.50 in hardback.

Radio Amateur's Examination Manual, by G. L. Benbow (93HB) is designed to provide sufficient information, both procedural and technical, at the level needed to enable readers to pass the R.A.E. The new syllabus and revised multiple-choice format of the examination papers have caused a complete revision of the book, which is the eighth in the series. Two sample examination papers, with answers, are included. The 120 page, paper-back book is published by the Radio Society of Great Britain, 35 Doughty Street, London WC1N 2AE at £2.16 by post.

Literature Received

Brochure on the SE Labs (EMI) model SE6300 12in, ultraviolet oscillograph is available from their Instrumentation Division, Spur Road, Feltham, Middlesex TW14 0TD
WW 419

Equipment for the prototype and small-scale production of printed-circuit boards is illustrated in a brochure from the Cupro Products Divison of Lektrokit Ltd, Sutton Industrial Park, London Road, Earley, Reading, Berks RG6 1AZ
WW 420

A catalogue describing a range of small computers, valves and television picture tubes can be obtained from Solus (Electronics) Ltd, Kirkwood Road, Cambridge CB4 2PF
WW 421

Teletext remote control

Figure 2 of this article, which appeared in the April 1979 issue, contained an error, for which we apologize. A 1 MΩ register, R_5, should be connected between the junction of R_4 and C_5 and pin 5 of IC_3.

WORLD OF AMATEUR RADIO

Super-regeneration — only a toy?

The very simple "super-regenerative" high-gain detector, invented over 55 years ago by Howard Armstrong for medium-wave broadcast reception but rapidly superseded for that purpose by his development of a practical superhet, has always been a technique of tantalising promise but only limited practical application. Admittedly, it helped amateurs pioneer the old 56 and 112MHz bands in the 1930s and was widely used in wartime for such purposes as tank sets and Bert Lane's 450MHz S-phone spy radio; but for many years it has virtually faded from sight except as a beginner's toy and for radio-control receivers. Critics point to the inherent poor selectivity, excessive radiation (this can be much reduced by an r.f. stage or by a simple diode technique developed by Bell Telephone Laboratories a decade ago) and the extremely high inter-station noise. Again, although suitable for both a.m. and broadcast f.m. reception, it presents problems for n.b.f.m., s.s.b. and c.w.

But very much to its credit are high sensitivity (typically around 0.5 microvolts), extremely low-cost, inherent a.g.c. action and good discrimination against impulse interference.

One of the few recent surveys of the potential of the super-regenerative detector appears in the New Zealand journal ***Break-in*** (November 1978) by Nat Bradley, ZL3VN. He has carried out many experiments using field-effect transistors in both self-quenched and separately-quenched arrangements, including the use of squelch gates to tame noise in the absence of signals, and also use of the 'super-regen' for n.b.f.m. reception (by injecting a stable carrier at signal frequency) and for c.w. (by using the squelch gate to key an audio oscillator). His conclusion is that "the super-regenerative receiver is a fascinating and unnecessarily maligned device. Modern techniques can give added performance and versatility at low cost. Its use (up to about 1000MHz) could well be re-examined with an eye to getting the most from the least."

Improving the UA3IAR "quad"

Attention was drawn in the December 1978 WoAR to a novel form of switched quad-type aerial developed by the Russian amateur L. Vsevolzhskii, UA3 IAR. This uses an octahedral wire structure supported by a single pole and requiring no special framework or mechanical rotation, yet capable of being switched to direct the beam towards any quadrant. But it was pointed out that the system is unlikely to have a forward gain exceeding about 3.5dB (reference dipole).

A number of British amateurs have been experimenting with such aerials with a view to increasing gain and bandwidth, reducing sidelobes and providing operation on more than one band. The low gain results primarily from the current maxima being at the pinched-in vertices of the array. One technique which has already been shown largely to overcome this problem (though making quadrant switching rather more complex) has been proposed and tested by Leslie Moxon, G6XN. This consists of re-arranging the feed points so that the array is vertically rather than horizontally polarised. This increases the spacing between the current maxima, while it also automatically decreases this spacing when the aerial is excited at higher frequencies. A multiband version has a gain of the order of 7-8dB on 28MHz and approaching normal quad two-element performance (about 6dB gain) on 14MHz. Further options remain to be tested, but the work seems to confirm that such modified octahedral structures may turn out to provide highly effective wire beam arrays at low cost, relatively simply.

Scanning the bands

A recent issue of *CQ-TV* (journal of the British Amateur Television Club) reports growing interest in fast and slow scan amateur television in Yugoslavia, including the use by YU1PKW of a 1.2kW linear amplifier (built for 432MHz 'moonbounce') with a 128-element colinear aerial.

An amateur tv repeater (432MHz 'in-band') is being set up on Mount Belmont (450m a.s.l.) near Wellington, New Zealand following tests at a temporary location. It works to 625-line PAL (System B) standards with output frequencies 17.5MHz above input frequencies. It operates only on broadband tv type signals, both vision and sound.

WB6NMT, California has become the first amateur station to make 'moonbounce' (earth-moon-earth) contacts on four bands: 50, 144, 220 and 432MHz.

Chris Bartram, G4DGU, has heard meteor-scatter 'pings' on the 432MHz band and is endeavouring to obtain contact with Sweden using this mode: only two 432MHz meteor-scatter contacts have ever been completed by amateurs on this band. These were between Swedish stations SK6AB and SM2AID in 1977 and between W0LER and W2AZL in 1972.

Contacts between New Zealand and Australia were made during January on 144MHz and also, for the first time, on 432MHz. The 432MHz s.s.b. contact between ZL1TAB, Auckland and VK2BQJ, Oyster Bay, near Sydney, was over a distance of almost 2150km.

Fines and costs totalling over £900 have been imposed at Camberwell Court under charges arising from deliberate interference to the London 144MHz repeater at Crystal Palace by two men operating from a vehicle. Local amateurs detected and traced the source of the interference which included transmissions of music and obscene language.

From all quarters

A potential threat to the low-frequency end of the 14MHz band could arise from the demands to be made by many countries at WARC79 for a new 13.6MHz broadcasting band extending right up to the edge of the 14MHz amateur band. Even if the broadcast stations keep within their proposed band, one can imagine the effects of a 500kW station with large aerial array on, say, 13997.5kHz – and even more vividly the possibility of the 'jamming' stations it would be likely to attract!

In what is clearly an effort to keep down the cost of amateur equipment, American and Japanese firms are introducing new low-power (10-20W) h.f. transceivers which could later be used with linear amplifiers or with v.h.f. transverters. Examples include the Trio TS120V and the Atlas 110 which in the USA is being sold (less power supply) at $388 (about £200) and is being claimed as "the first price breakthrough in amateur radio equipment in a decade."

In brief

The Irish Department of Posts & Telegraphs has introduced a Class B licence and such licences will be available to British Class B amateurs visiting the Republic . . . At the end of 1978, the number of UK amateur licences totalled 24,711, an increase of 1427 during the year . . . For the first time membership of the RSGB has exceeded 23,000 in 135 countries . . . The 1979 'Jamboree-on-the-air' organised by the Scouts will take place over the weekend October 20-21 . . . Mobile rallies are due to be held at: June 24 Longleat Park and Castlewellan Forest Park (Bangor); July 1 Upton-on-Severn . . . Raynet (the amateur emergency service) has been authorised to provide ship-to-shore radio links up to two miles from the shore, during oil-pollution operations.

PAT HAWKER, G3VA

The Heaviside signal

An alternative view of the transverse electromagnetic wave

by I. Catt, CAM Consultants

This article proposes a different picture of electromagnetic propagation from the familiar "rolling wave" idea in which electric and magnetic fields topple over and forward, continually changing into each other as they go. The author postulates "an unchanging slab of E x H energy current" travelling forward at the speed of light, and names it "the Heaviside signal" after a concept expressed in the writings of Oliver Heaviside. This process does not rely on a causal relationship between the electric and magnetic fields, which are seen as co-existent.

MAXWELL faced up to the paradox that whereas electric circuits, in order to function properly by allowing the passage of electric current, were thought to require a complete closed circuit of conductors, electric current still seemed to flow for a time when a capacitor (which of course is an open circuit) was placed in series with the closed loop of conductors. He "cut the Gordian knot" (according to Heaviside)[1] by postulating that a new kind of current, which he called "displacement current", leapt across the plates within the capacitor. This electric current, which was uniformly distributed in the space between the capacitor plates, could even flow through a vacuum.

Maxwell followed up this daring idea by suggesting that electromagnetic waves might exist in space. Scepticism about his postulated "displacement current" was silenced in 1887 when Hertz discovered the predicted waves in space. The classic pre-Popperian requirement of a good scientific theory seemed to have been met – the prediction of further results which are later confirmed by experiment.

There are two versions of the transverse electromagnetic wave, the "rolling wave," and what we shall call here the "Heaviside signal." We shall discuss only the wide variety of views among those who believe (with the relativists) that there is no instantaneous action at a distance.

The rolling wave

The lack of action at a distance creates a fundamental difficulty for the wave in space if it is to be launched by a force in the direction of propagation. The key to the ability of a force to project a wave is that there is a pressure difference between two points along the line of propagation. However, knowledge of a difference in pressure between two points A and B which are separated by distance implies instantaneous knowledge at B of the pressure at A; that is, instantaneous action at a distance, which has been outlawed.

This dilemma seems to be overcome if it is postulated that the force which projects the wave is a lateral, shear, force. It seems a shear force can act at a point, and so not contradict relativity whereas a longitudinal force cannot.

The above kind of reasoning, combined with the postulation of displacement current, which seemed to flow at right angles to the direction of propagation, joined forces to create the notion of the rolling wave. The rolling wave contains alternating concentrations of magnetic energy $\frac{1}{2}\mu H^2$ and electric energy $\frac{1}{2}\epsilon E^2$ in the direction of propagation. It is useful to think of a road with alternate red trucks and white motor cars. The magnetic energy or flux (by Faraday's law of induction) generates electric energy and displacement current ahead of itself, which in turn (by the Biot-Savart Law) generates magnetic flux, or energy, ahead of *itself.* Each type of energy, or flux, topples over and forward, changing as it topples into the other kind of energy. It is as though in the road containing the alternate red trucks and white cars, first the red trucks reappear as white cars a little further ahead while at the same time the white cars turn into red trucks a little further ahead; then the trucks and cars change back again, moving forward a little with each metamorphosis. The analogy with the pendulum has been proposed. One can think of a long line of pendulums, alternate ones having potential energy and kinetic energy, and communicating their energy forward step by step with a change of type of energy at each one.

The Heaviside signal

Opposed to the rolling wave is what we have called the Heaviside signal. The most highly developed form of this view is that at any point in space, an electromagnetic signal always contains one kind of energy only, which is equal to the product of E and H at that point, where

$$\frac{E}{H}=\sqrt{\frac{\mu}{\epsilon}}. \qquad \text{Energy density} = \frac{E.H}{c}$$

Further, the Heaviside signal always travels forward unchanged at the speed of light, $c=1/\sqrt{\mu\epsilon}$, and never any slower. E, H and c are always mutually perpendicular.

The two men most likely to understand the "Heaviside signal" point of view and to oppose the "rolling wave" were Oliver Heaviside himself, in honour of whom it has been given its name, and Poynting, the man whose name is attached to the vector $E \times H$. However, their writings show that neither man arrived at a full understanding of the Heaviside signal described in the previous paragraph.

Heaviside vacillated between the two views, the rolling wave and the Heaviside signal. He always applauded the idea of displacement current, which appears to put him on the side of the rolling wave. Further, on page 6, art. 453 of volume 3 of his "Electromagnetic Theory", when he says that the curl of E, not E itself, is the real source of the waves, he is again arguing for the rolling wave. Curliness is obviously a bid for shear, vorticular forces, a concept intrinsic to the rolling wave. However, elsewhere he seems to stand firmly for the Heaviside signal. For instance *(ibid,* art. 451, page 4), he says, "It carries all its properties with it unchanged," which is a clear statement of the Heaviside signal. In art. 452, the mention of a "slab" of signal is strongly on the side of the Heaviside signal. Heaviside mentions the slab elsewhere in his writings. One does not conceive of slabs rolling, or generating shear forces or stresses. Almost by definition, a slab, like a slab of heavy granite, moves forward unchanged at constant velocity.

Professor Poynting, who first suggested that energy was distributed in space with a density $E\times H$, also had a partial vision of the Heaviside signal. He definitely did not know that E is always perpendicular to H, and that the $\times$ in $E\times H$ means simply multiplication. (He had a term $\sin\theta$ for the angle between them.) Poynting was writing before the general agreement that light is electromagnetic, and so did not know that this Poynting energy $E\times H$ always moved forward (in the third dimension) at a constant speed, $1/\sqrt{\mu\epsilon}$, the velocity of light in the medium.

Poynting had a very good grasp of the direction of energy flow and its magnitude, but did not seem to understand

the importance of reflections at a change of medium, which leads one to think of one energy current $E\times H$ flowing backwards along its previous path, passing through the next portion of forward travelling energy current. This superposition of forward and backward energy currents (implicit in the phrases "phase velocity" and "group velocity") has prevented a clear understanding of the electromagnetic wave.

For fifty years, technology did not give us the power to drive the medium with an electromagnetic signal. With the low power at our disposal, all we could do was resonate the medium with periodic (sinusoidal) excitation in the same way as we move a child on a swing. In a resonant medium, energy is necessarily flowing in both directions; most of the forward energy returns to aid the source on the next cycle.

Our inability to drive a medium except periodically insinuated itself into our group psyche, until we came to assert that nature *was* periodic (and even that it was sinusoidal). Implicit in this view were the wrong beliefs that

(1) electromagnetic energy is necessarily contrapuntal,

(2) $E/H=\sqrt{(\mu/\epsilon)}$ is not always true, (e.g. when two waves are passing through each other so that H cancels but E does not, so that $E/H=\infty$), and

(3) signals can travel slower than the speed of light $1/\sqrt{\mu\epsilon}$).

The absurdity of this third idea is easy to demonstrate if we consider a two directional highway. If all cars move at 60 m.p.h. but some (A per hour) move eastwards and some (B per hour) move westwards, no one would argue that the total passage of cars eastwards per hour past a reference point, that is, $(A-B)$, would help us to determine the velocity of cars by the formula

Flow of cars $=(A-B)$ per hour

Distance between cars $=L$

Therefore velocity of cars $=(A-B)L$ m.p.h.

However, this seems to be done, at least subconsciously, with phase velocity and group velocity. The very terms imply some such calculation.

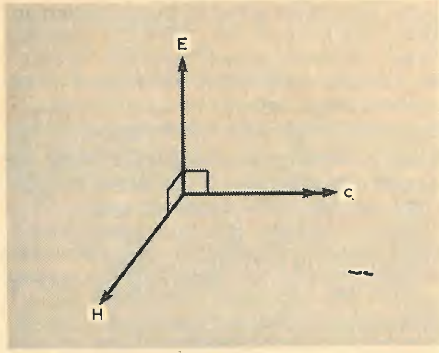
Some ten years ago the successful manufacture of high speed (1ns) logic elements capable of driving a 100 ohm load made it possible, for the first time for fifty years, to drive a medium rather than gently resonate it, as a matter of normal routine. Those driving a high speed logic step could clearly see it travelling at the speed of light for the dielectric (never any slower) and remaining unchanged on its journey. For the first time for seventy years, high speed digital engineers were privileged to see the Heaviside signal, an unchanging slab of $E\times H$ energy current guided between two conductors from one logic gate to the next. Reflections were prevented by proper termination at the destination, so that notions of phase velocity and group velocity evaporated. We saw a slab of energy launched from one point, travelling unaltered, to be absorbed by the terminating resistor at the destination.

At this point we just *had* to unburden ourselves at the theoretical level of implicit contrapuntal notions. A beautiful vision resulted, now called the Heaviside signal, of a lateral strain $E\times H$ (where $E/H=\sqrt{\mu/\epsilon}$ which by definition travelled forward at velocity $1/\sqrt{\mu\epsilon}$. As it travelled forward it filled (or probed) the space ahead of it in the same way as the ripples on the surface of a pond will fill the space (surface) as they come to it. Logic designers maintained a near constant aspect ratio in the space ahead, because whenever this slab came to a change in aspect ratio (= change of characteristic impedance, better termed characteristic resistance) some of the energy current would double back on its tracks according to the well-known laws of reflection. However, this did not lead back to the old "phase velocity" and "group velocity" notions; rather, the slab of energy current split into two slabs, one to continue forward and the other to return, both slabs continuing to probe, or fill, the space presented to them on their journeys.

The Heaviside signal offers us a dramatic simplification of our view of the fundamentals of electromagnetic theory.

Definitions

First define energy current (= TEM wave = Poynting vector) as our primitive, where energy current is as follows:



Now $\sqrt{\mu/\epsilon}$ and $1/\sqrt{\mu\epsilon}$ can be independently defined. Let us define

(a) $\sqrt{\frac{\mu}{\epsilon}}=\frac{E}{H}$

which defines a constant of proportionality for the medium.

(b) $\frac{1}{\sqrt{\mu\epsilon}}=$ velocity of propagation c,

again a constant for the medium.

(c) Define $D=\epsilon E$, $B=\mu H$

Derivations

$$\frac{E}{H}=\sqrt{\frac{\mu}{\epsilon}}, \qquad B=\mu H$$

$$\therefore \frac{E\mu}{B}=\sqrt{\frac{\mu}{\epsilon}} \qquad (1)$$

$$\therefore \frac{E}{B}=\frac{1}{\sqrt{\mu\epsilon}}=c \qquad (2)$$

$$\therefore E=Bc \qquad (3)$$

By definition*,

$$c\frac{\partial E}{\partial x}=-\frac{\partial E}{\partial t}=-c\frac{\partial B}{\partial t} \qquad (4)$$

$$\therefore \frac{\partial E}{\partial x}=-\frac{\partial B}{\partial t} \qquad (5)$$

This is equation (12.5.1) in Carter (G. W. Carter, The Electromagnetic Field in its Engineering Aspects, Longmans, 1954, page 268), when he believes he is *deriving* the TEM wave, which is supposed to *result* from a causality relationship between E and B (Faraday's law of electromagnetic induction). Carter is clearly developing the rolling wave.

We see then that the equation $\partial E/\partial x=-\partial B/\partial t$ is a simple derivation from the definition of the Heaviside signal and is not based on $\partial B/\partial t$ *causing* E, as Faraday thought he had discovered.

We have shown that the passage of a TEM wave and all the mathematics that has mushroomed around it does not rely on a causality relationship (or interchange) between the electric and magnetic field. Rather, they are co-existent, co-substantial, co-eternal. The medium can only be strained in the two lateral dimensions (E and H) in fixed proportion. [In a similar way, *pressure* in a liquid in direction x does not *cause* pressure in the y (and z) direction; they co-exist.]

Faraday's great discovery in the 1830s was *not* electromagnetic induction; not a causality relationship. His great achievement was to discover that *change* was important. This started us on the road to discovering the now postulated primitive, the Heaviside signal, which can only move; it cannot stand still. Heaviside put together the main features of the new concept, but it took another century to put flesh on to the bare bones.

Reference

1. Oliver Heaviside, Electromagnetic Theory, 1893, London, page 28 section 30.

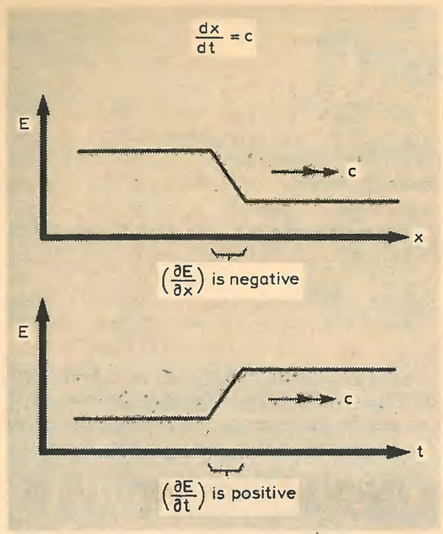
Appendix 1

By convention, if a voltage step is travelling from left to right (i.e. in a positive direction) it has a positive velocity; dx/dt is positive

$\frac{\partial E}{\partial t}$ is positive but $\frac{\partial E}{\partial x}$ is negative. This (reversal) problem is well known by anyone who has drawn out an oscilloscope trace on to paper with voltage and distance axes. This explains the minus sign in equation (4) in the article. When we travel, we *gain* distance while we *lose* time. However, we regard our velocity dx/dt as positive.

It is strange that this ambiguity in sign convention had led to a negative sign in electromagnetic theory. This in turn intro-

*See Appendix 1



duced the idea of a "Lenz's law" reluctance, or back e.m.f., in which lies nested the idea of causality,

$$i \rightarrow \oint H dl \quad \text{and} \quad \frac{dB}{dt} \rightarrow v$$

In fact, electric and magnetic fields have a positive relationship, and co-exist rather than cause each other.

Numerically,

$$c\left|\frac{\partial E}{\partial x}\right| = \left|\frac{\partial E}{\partial t}\right|$$

Therefore, since by convention $\partial E/\partial t$ is positive, $\partial E/\partial x$ is negative and c is positive, we must conclude that

$$c\frac{\partial E}{\partial x} = -\frac{\partial E}{\partial t}$$

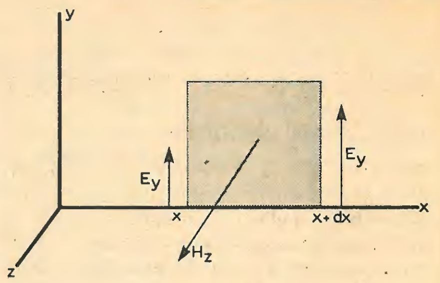
Appendix 2: the rolling wave explained

In this article, two mutually contradictory versions of the transverse electromagnetic wave have been described and compared. These were the rolling wave and the Heaviside signal. This appendix contains the first half of a very clear description of the rolling wave taken from "Fundamentals of Electricity and Magnetism" by Arthur F. Kip, Professor of Physics, University of California, Berkeley, published by McGraw-Hill, 1962, page 320. Only enough of that description is reproduced to make his approach clear.

"... Our demonstration involves the use of the first two Maxwell equations to show that such a postulated time and space variation of E gives rise to a similar time and space variation of H (but at right angles to E) and that this H variation acts back to cause the postulated variation in E. Thus, once such a wave is initiated, it is self-propagating.

"The figure below is used to show the application [of Faraday's law of induction] to the plane E wave, postulated to be moving along the x direction. A convenient closed path is drawn in the xy plane, around which we shall take the line integral of E. This is equated through [Faraday's law] to the rate of change of flux H through the plane bounded by the path of the line integral. Only the vertical parts of the line integral contribute since E is in the y direction, so that $E.\partial x = 0$. If we go around in a counterclockwise direction, the line integral around the path chosen becomes

$$\oint E\,.\,dl = (E_y)_{x+dx}dy - (E_y)_x dy$$
$$= [(E_y)_{x+dx} - (E_y)_x]dy$$



where we are to take the values of E_y at $x+dx$ and x, respectively. The difference between these two values of E_y at the two positions is $(\partial E_y/\partial x)dx$, so we can write the line integral of Faraday's law of induction as

$$\frac{\partial E_y}{\partial x} dx dy = -\mu_o \frac{\partial H_z}{\partial t} dx dy$$

Since this relationship is true for any area $dxdy$, we may write

$$\frac{\partial E_y}{\partial x} = -\mu_o \frac{\partial H_z}{\partial t}$$

(This ends the extract from Kip. To get to the Carter equation we have to replace μH by B, of course.)

This article is taken from "Electromagnetic Theory", published by C.A.M. Publishing, 17 King Harry Lane, St Albans, Herts. The next seminar by CAM Consultants on digital electronics design will be held at St Albans on August 2-3.

A slice of the action

The Faraday Lectures, which started in 1924 as a memorial to Michael Faraday, continue their ever-more spectacular progress. This year's lecture, entitled "The Diagnostic Electron," was concerned with medical diagnostic instruments from wooden stethoscopes to computer tomography. Since the lecture was prepared and staged (Faraday lectures are staged, not read: this one gave the IEE lecture theatre an ambience the Magic Circle would have been proud of) by EMI, the latter equipment was modestly mentioned. Computer tomography(c.t.) is the technique embodied in the EMI brain and body scanners, in which X-rays are passed through the body in many different directions, though all in one place, the differing attenuations being sorted out by computer and assembled to give a picture of the 'slice' through the brain or body. The technique was first announced in 1972 and, since Godfrey Hounsfield, the originator, was a research engineer at EMI, the company was several years ahead of any possible competition.

Not for long, though. The largest market for heavyweight medical equipment is the USA, in which country hospitals have to compete for patients by offering them the latest, shiniest and demonstrably most expensive equipment. Since c.t. is adequately covered by all three adjectives, at half-a-million apiece for a whole-body scanner, it became *de rigeur* for any hospital with a hope of keeping an acceptable image to acquire a scanner. The world's electronics industry, ever on the lookout for a money-spinner, declared civil war for the honour of serving mankind.

The one saving grace about war is that it is a tremendous spur to development, and that characteristic is also true of commercial hostilities. For example, the prototype brain scanner took 4½ minutes to produce a picture: this was the first line of attack and the time has now been reduced to a few seconds. EMI have lost a good deal of the development lead they started with, as was inevitable, but they are still a force to be reckoned with and are currently working on a newer technique of scanning, using the phenomenon of nuclear magnetic resonance instead of X-rays. The newer method is said to be safer than using X-rays, since the stimulating radiation is at radio frequency. N.m.r. also offers the possibility of chemically analysing the substance under examination, rather than simply indicating where it is.

The company has achieved some success already and has a lead once again, but it is known that companies in the US and UK (GEC say they have had a "substantial team" working on the problem for two years) are involved in n.m.r. research and it seems unlikely that anyone will benefit commercially to the extent that EMI did with the X-ray scanners.

N.m.r. is the effect obtained when a steady magnetic field and an r.f. field interact at nuclear level. The nuclei behave as spinning bar magnets, which are caused to precess about the steady field axis when the r.f. field is at the correct frequency. In this condition, energy is absorbed from the r.f. generator, the amount of absorption depending on material density. Variations of the magnetic field produce resonance in different types of material.

LETTERS TO THE EDITOR

WAVELENGTH CHANGES ON LF AND MF

There has been surprisingly little reaction from your readers to the BBC a.m. sound radio changes which, although publicised as wavelength changes, have turned out in fact and more importantly to have been large power and transmitter location (or allocation) changes. In this area for example Radio 3, previously received as a strong interference-free signal from Daventry (150kW, 464m) is now radiated from Brookmans Park at the reduced power of 50kW. In consequence this programme suffers interference, fading and distortion after dark. Judged from a car radio the Daventry transmitter gave a reliable service extending from the south coast to north Yorkshire and it is surprising therefore that this transmitter should have been closed down instead of merely being switched from 464 to 247 metres.

One feels compelled to ask what sort of a new wavelength plan was agreed by our bureaucrats which permitted an important UK wavelength such as that of Radio 3 to be shared with a foreign station?

In contrast with what has happened to Radio 3 in this area we now have two powerful transmissions of both Radio 1 and Radio 2 (i.e. four 140/150kW transmitters on 275, 285, 330, and 433m) located at Brookmans Park and Droitwich. Thus in the unlikely event of interference being experienced on one wavelength an alternative is available in each case.

As I am unable to see the need for two pop channels and require neither, I feel strongly that there is gross imbalance between the service provided for Radio 3 on the one hand and Radios 1 and 2 on the other. In fact it would appear that Radio 3 has been downgraded to the level of local radio because Radio London (206m) is transmitted from Brookmans Park at the same power as Radio 3 (50kW). If the latter power is considered necessary to provide local coverage for Radio London then surely much higher power is needed to serve the larger Radio 3 area.

No doubt the BBC reply to all this would be to say "switch to v.h.f.," but why should I have to go to the expense of replacing my existing a.m. car radio by a more costly v.h.f. type just to receive one station? Furthermore having gone to the trouble and expense of constructing an excellent *Wireless World* design of v.h.f. receiver and stereo decoder it is exasperating to find that many music programmes are not radiated on v.h.f. Instead these frequencies are reserved for Open University or other educational programmes where neither wide frequency range nor stereo are required.

In conclusion, and recognising that radiated power may not be the only criterion, it is clear that nationwide (and neglecting transmitters below 10kW) the changes have produced an increase in the aggregate power of Radio 1 transmissions by a factor of three (260 up to 740kW) and of Radio 2 by nearly 50% (400 up to 580kW), so that no less than 1320kW are devoted to pop. In many areas the m.w. band must now closely parallel that in North America where one may tune from one end of the band to the other finding nothing but inconsequential talk, advertisements and pop.

J. H. Crook
Aylesbury
Bucks

When the BBC announced its wavelength changes a year or so ago, I think it was pretty obvious that it had decided to allocate its transmitters and frequencies on a basis of audience size rather than the quality or importance of the service, presumably with an eye to obtaining the largest possible audiences in competition with the commercial services in order to justify its annual claim for an increased licence fee. If this ploy had resulted in the maintenance of Radios 3 and 4 at their existing coverage, it might have been justified, but all that actually seems to have happened is that they have both disappeared from the medium waves to all intents and purposes.

The Radio 3 transference to 1215kHz has been a complete disaster in this area. Whereas we previously had an excellent fade-free service at all times, we now have a daytime signal ruined by continuous phase distortion caused by the large number of transmitters on the channel, while at night it is simply a non-stop babble of foreign interference. We were told by the BBC that 647kHz was going to be unusable because of Continental interference (from Albania, in daylight?) so the very logical step was taken of handing the channel over to the European Service, so they could have the fun of fighting the interference on its home ground.

The move of Radio 4 to the long wave channel was a move I thought was sensible, and so it has proved to be as far as car radio reception is concerned, but it was certainly a mistake as far as the users of small portables around the house are concerned. Long waves seem much more liable to all sorts of interference, apart from most small portables being apparently less sensitive on this waveband than on medium waves. An advantage I thought might exist, the ability to listen to Radio 4 while on the Continent, has been partly nullified by the Russians apparently opening up a new transmitter on the same frequency. Incidentally, just why is Droitwich transmission so weak compared to other long-wave stations? Last year, I noticed while in Northern Scotland that although this station was rather difficult to listen to, I had no problems hearing the French stations on 164 and 181kHz loud and clear.

Might I dare to suggest to the BBC engineers that they consider the following points?

1. Multiple transmissions on a single channel are a mistake. Unless all transmitters are phase-locked, all it does is guarantee grinding phase distortion in many areas where otherwise the field strength would be perfectly adequate. In the case of R3, why not use the now disused Daventry mast to radiate 1215kHz at high power (500kW?) and switch off all the other transmitters except maybe some in Scotland? This wouldn't help the night-time problem, but we could at least listen at other times.
2. Step up the radiated power on 200kHz. The Droitwich transmitter and aerial are rather old and small by modern standards — is it not time the BBC built a new single-purpose station with a really big and efficient aerial?
3. What about duplicating the R4 service on a single short-wave channel, as the Germans do? The World Service can surely spare one channel in the 49 metre band. Having the 49 metre band on my car radio, I often listen to the World Service on 5975kHz while driving around the UK and Continent, and find reception most reliable even although it is not intended to cover the area.

W. Blanchard
Dorking
Surrey

The BBC replies:

Dr Crook and Mr Blanchard have provided some interesting and thoughtful comments on the frequency changes we made last November, which reflect in many ways the correspondence which we have had from listeners generally.

We have to face the fact that conditions on the long and medium wavebands have been deteriorating for many years, due to the increasing number of transmitters in the European area and elsewhere, and to the use of higher and higher powers. In reviewing the results of the Geneva Conference, it was clear that the interference levels on many of the UK frequencies would increase, as the new transmitters authorised at Geneva came into service. (The Plan provides for the period 1978 to 1989 and many of the stations listed have not yet been built.)

The BBC has four national radio networks and with the medium and long wavelengths available it is possible to provide good, but not perfect, coverage for three of them, and partial coverage for the other. V.h.f. does not provide a complete alternative, firstly because many listeners do not have or use v.h.f. receivers; secondly because at present we only have enough v.h.f. frequencies for three national networks, one of which is shared by Radio 1 and Radio 2.

In planning the changes the first priority was given to Radio 4, which we wanted to make readily available throughout the United Kingdom. Apart from its large audience, Radio 4 is relied upon by many people for important services such as news, weather forecasts and motoring information. Thus, it was decided to use the one long wave channel for Radio 4.

Secondly, it was decided to improve the coverage of Radio 1, which is our most popular programme. This could only be achieved by using two medium wave channels. These provide almost national coverage in the day time, but something very much less at night time.

Thirdly, we wanted to retain the best possible coverage for Radio 2, our second most popular programme. With Radio 4 on long wave, this could only be done by using two medium wave channels, to provide a coverage roughly similar to that of Radio 1.

This leaves Radio 3, with only one medium wave channel remaining. Radio 3 has an audience which is numerically very much smaller and it could be argued that this should be a v.h.f. only service, as in many other countries. We know that a high proportion of Radio 3 listeners normally use v.h.f. but we wanted to retain as much medium wave coverage as possible – particularly for those listeners in motor cars and with small portable receivers.

If anyone should complain about the priority accorded to Radio 4, Radio 1 and Radio 2, they should remember that any broadcaster has an obligation to meet the needs of the audience as a whole, and this must take account of both numbers and programme preferences.

Radio 4's move to long wave has made the programme audible over the whole of the United Kingdom. Unfortunately, long wave reception is more susceptible to many kinds of electrical interference, and especially to television receiver line timebases. V.h.f. provides an alternative for many listeners, but unfortunately the v.h.f. channel has to be used for educational programmes for considerable periods each day. Some experiments have recently been made to see if it would be practicable to transmit some of these programmes at night time when the transmitters are not otherwise required.

The power of our main long wave transmitter has been increased over the years from 25 to 150 and latterly to 400kW. Many of the long wave transmitters on the Continent now use powers of up to 2MW; this certainly achieves greater range and penetration in the face of interference, but it is very expensive both in capital and running costs.

It is doubtful if the use of a channel in the 49 metre short-wave band could be justified for a domestic service, and in any case very few listeners in this country use short-wave receivers.

Mr Blanchard comments on our use of 1215kHz, with a number of medium power transmitters in various parts of the country. Like every other channel, this one is shared with a number of Continental transmitters and it is therefore necessary to provide relatively high field strengths at night time if reasonable reception is to be obtained. The existing system at least provides a service in all of the larger conurbations, but inevitably there are gaps in between, in those areas where signals from two or three different transmitters are received at comparable strengths. Frequency stability is of course crucial and Mr Blanchard will be interested to know that the Radio 4 UK long wave transmitters are already phase-locked. If this proves successful, the principle could be extended to other networks.

The alternative of using a single high-power transmitter at some central point like Daventry has been considered; it would certainly provide a good day time service in central England, and a night time service of sorts to the whole country. We doubt if Radio 3 listeners would take kindly to a sky wave service of this sort and in the day time many areas would be left with no service at all.

In the years ahead, we are convinced that the future development of radio must depend largely on v.h.f. and we are already planning a radical overhaul of our v.h.f. networks. There is also a very real hope that additional v.h.f. frequencies will be made available for broadcasting, and this would enable us gradually to provide a more comprehensive service on v.h.f. so that listeners would be less dependent on medium and long-wave reception.

G. H. Sturge
BBC Engineering Information Department
London W1

UNIONS AND ELECTRONICS

For many years I have looked upon your journal as one which takes a constructive view of the success of electronics. It was disappointing to see two pages of the May issue devoted to the repeated disruptive plugging of a trade unionist ("The role of the specialist in microelectronics").

Professional engineers in the private sector, where I work, are not highly militant. However, the exhortations of unions for engineers to take up cudgels and join the unions are backed up by frequent incompetence of the employers' personnel management. Non-union engineers are neglected by employers who appear to deal only with 'the union'. As the years pass, the sour attitude of the engineers slowly worsens.

I have seen so often that preoccupation with union matters pulls the attention in the opposite direction to work. By joining the staff of a company the engineer signifies his agreement to the terms of employment. If an engineer thinks he is worth better treatment than he is getting, let him prove it by finding an employer who will offer him something better. Until that time, he is under contract to provide a willing service for the rewards which he accepts by agreeing to come to work.

If, on the other hand, he cannot find a better offer, he will not improve society by resorting to artificial salary boosters such as registration, trade union armies and the like.

J. M. Bentley
Old Woodhouse
Leics

OVERSIGHT IN COSMOLOGY

It was refreshing to have Mr Hulme answer my point so painlessly (June letters) and confirm that although the energy is present there is zero field. *Of course* with zero field there can be no detection. *That* was my point. I cannot bring myself to agree with his radius but will retract a little and take Secama's figure of 10^{17} light years. This gives a source/sink ratio of about 10^{53}:1 for about 50 discrete frequencies (hydrogen and helium predominate). Thus we have 2×10^{51} sources for each frequency, which seems good enough odds to escape detection!

Plucking a figure out of the air, let us assume that light which starts at, say, 10^{-6} Mλ is red shifted to 1Mλ, then the energy density at the surface of the earth will be of the order 10^{64} W/cm^2 (quite wrongly, I used the earth-sun distance in the preliminary calculations). This radiation will pass the atmosphere and almost everything else because there can be no excitation and therefore no energy exchange. Why should the light be red shifted? Light is a transverse wave propagated from what is essentially a point source. This being so it is *forbidden*, by geometry, from having parallel boundaries.

If the propagation characteristic of space is constant, and surely it must be, then light *must* be red shifted linearly with distance regardless of Doppler.

This leaves a bit of a problem though, doesn't it? I mean, what shall we do with all that radiation pressure which *doesn't* cancel? Pretend it away as Einstein did with gravity? Or shall we call it gravity? Well, I know that if I call it gravity I can quantify it into the strong force so I *shall* call it gravity.

You know, I really do believe that I have comprehensively falsified Albert Einstein's general relativity!

By the way, the pressure was the *second* oversight!

Alex Jones
Alderney

MILITARY ELECTRONICS

The January editorial on the prostitution of electronics for military purposes is, in my opinion, probably the most important item which *Wireless World* has published in its sixty-odd years of existence, but the reaction of readers, judged by the letters published, has been disappointing.

Professor Bell's attempt in the March issue to equate swords with ploughshares is not convincing. The evil that is done by one far exceeds the good which is done by the other. It is no more necessary to make swords in order to produce ploughshares than to do vice-versa, and the fewer swords that we make the more ploughshares we will have.

In the same issue I attempted to put the blame onto the militarists of *both* sides, but Mr Richardson, in the April issue, distorts the picture by concentrating attention entirely onto the Eastern bloc. I do not deny his criticisms, and will even add to his list by mentioning the massacres at Katyn and of the Russians who were returned under the Yalta agreement, but the actions of the Soviets need to be balanced against the annexations of large areas of Mexico by the USA, their treatment of Indians and blacks, their installation and support of corrupt military dictatorships in Taiwan, Iran, Chile, South Korea and most of South America, their appalling actions in Vietnam, which included according to Colby the CIA chief, the execution of over 22,000 opponents of the Diem regime.

Let the circuit be brought back into balance before *Wireless World* returns to its traditional role and does not become, like many electronics journals in the USA (and probably Russia), just a mouthpiece for the armaments industry.

Roy C. Whitehead
Sutton
Surrey

EXCLUSIVE CB SYSTEM FOR BRITAIN?

I read with some alarm the letter from Mr James Bryant to the previous Prime Minister (News, April). So Mr Bryant wants Britain to "lead the world into a new generation of c.b. radio". In fact his main objective appears to be to ensure that in the event of the legalization of c.b. in this country a new non-standard system will be specified which will enable an exclusive "club" of British manufacturers to cash in on this new consumer bonanza, the consumer being at the mercy of any mutual "arrangements" regarding prices etc they can get away with. I wonder what Mr Bryant's interests are in all this? Is he in the employ of one of the un-named companies who have stated their willingness to manufacture this equipment?* He certainly seems to have some axe to grind against 27MHz!

As for the suggestion of c.b. on 900MHz, I cannot see that being at all practical in built-up areas using cheap hand-held equipment. The "identi-chip" method of determining the origin of a particular transmission sounds fine until one realizes that any electronics "bod" worth the name could easily by-pass or mute its coded output. Assuming that the system was a practical proposition, are we to have yet another computerized monstrosity like the DVLC at Swansea to keep track of all the c.b. sets in Britain?

Britain has always been a country which encourages free international trade. The proposed system seems designed to restrict it.

Finally, are we not supposed to fall in line with the edicts of the EEC in matters relating to the harmonization of technical standards? All other c.b. in Europe is on 27MHz.

A. Blakemore
Ripley
Derbyshire

* Mr Bryant is employed by Plessey and makes no attempt to conceal this fact.—Ed.

DISPLACEMENT CURRENT

The two articles on displacement current which have recently appeared in your magazine (December 1978, March 1979), contain the sensible suggestion that one should regard currents and charge distributions as the consequences of electromagnetic waves rather than as the sources of these waves. Apart from this, the articles are wrong in almost every detail and it is vital that this should be clearly demonstrated before undue damage is done.

The basic demolition process is simple. In Maxwell's equations for a dielectric medium we have,

$$\operatorname{div}\mathbf{D}=0,\quad \operatorname{div}\mathbf{B}=0,$$

$$\operatorname{curl}\mathbf{H}=\frac{\partial\mathbf{D}}{\partial t},\quad \operatorname{curl}\mathbf{E}=-\frac{\partial\mathbf{B}}{\partial t},$$

Writing $\mathbf{D}=\epsilon\mathbf{E}$ and $\mathbf{B}=\mu\mathbf{H}$ for a linear, homogeneous, isotropic medium, these equations give the wave equation for **E** (or **H**),

$$\nabla^2\mathbf{E}=\mu\epsilon\frac{\partial^2\mathbf{E}}{\partial t^2}$$

which means that electromagnetic waves travelling with a speed of $1/\sqrt{\mu\epsilon}$ can exist in the dielectric. The wave equation occurs due to the presence of the term $\partial\mathbf{D}/\partial t$, which Maxwell introduced and called "displacement current". Without this term the wave equation would not appear and electromagnetic waves would not exist. There is a fair amount of evidence that electromagnetic waves *do* exist, and I doubt if Catt, Davidson, and Walton would deny this. I would like to believe that they are only objecting to the name "displacement current", but if that were the case there would hardly be any point in making such a vicious attack, and after re-reading these remarkable essays a number of times I have a feeling that C, D, and W really believe that electromagnetic waves can exist without $\partial\mathbf{D}/\partial t$ occurring in the equations. A consultation with any competent mathematician should convince them that this is not so.

The above argument may not be very convincing to the non-mathematical reader and perhaps C, D, and W won't like it very much, because one gets the strong impression that these gentlemen have probably used Maxwell's equations in only the most trivial of problems. It is therefore necessary to criticise the articles in some detail. Take, for example, the simple reflection treatment given in the appendix to the first article. This applies to a uniform transmission line but not, as stated in the appendix, to a non-uniform line. For a uniform line the wave equation is

$$\frac{\partial^2 v}{\partial x^2}=LC\frac{\partial^2 v}{\partial t^2}=\mu\epsilon\frac{\partial^2 v}{\partial t^2},$$

where L and C are the inductance and capacitance per unit length. The error probably arises due to the following plausible but erroneous argument: "In the circular capacitor L and C vary with r,

$$L=\mu\frac{d}{2\pi r},\quad C=\epsilon\frac{2\pi r}{d}$$

Hence the product LC is still constant and equal to $\mu\epsilon$. So the wave equation for the circular capacitor will be

$$\frac{\partial^2 v}{\partial r^2}=\mu\epsilon\frac{\partial^2 v}{\partial t^2}\text{''}$$

If the wave equation is properly derived from the basic equations it will be found to be

$$\frac{\partial^2 v}{\partial r^2}+\frac{1}{r}\frac{\partial v}{\partial r}=\mu\epsilon\frac{\partial^2 v}{\partial t^2}$$

The reason why the reflection process described for the uniform line does not apply in this case is that there is a continuous reflection from the wave front due to the continuous variation of Z_0. Another serious error is that the authors regard the "radius of the input wires" to be the "input end" of the circular transmission line. If they had taken the trouble to consider the Poynting vector field, they would have discovered that the energy enters the capacitor dielectric at the outside radius, and that this outside radius is the input to the capacitor. When they take a sector of this capacitor (Fig. 1(c) of the first article) they *do* have a line supplied at the inner radius. Hence it is incorrect to regard the complete capacitor as a large number of such sectors ("pie-shaped"!) in parallel.

In the second article, and also in their reply to Mr P. I. Day's sensible letter, the authors ask "where, then, is the displacement current in the transmission line?". The answer, of course, is that in general it flows in all parts of the dielectric, but by choosing a "step" wave (a physical impossibility) they have pushed all of the displacement current into an infinitely thin sheet in the wavefront and have lost sight of it. But we haven't. A step is a very useful concept as the limiting case of, say, an exponential rise, but if the limiting process is improperly understood and causes one to lose things, it is advisable not to use it. And do I detect a rather nervous reaction to Mr Day's use of the frequency domain? Did they for one awful moment think that they saw the ghost of Maxwell's displacement current? They need not worry, it is not dead yet and *they* are certainly not capable of killing it.

These three gentlemen see fit to criticise Maxwell for lack of insight, and assert that Maxwell did not realise that displacement current was not uniformly distributed within a capacitor. In other words, that he was not capable of getting the correct solution to his own equations! And finally they praise Heaviside for "missing it only by a whisker". In fact Heaviside was never in any such danger, but I am afraid that Catt, Davidson, and Walton have dropped right in it!

May I suggest that your readers will be well advised to approach the "further reading" with great caution.

B. Lago
Doxey
Stafford

The authors reply:

Dr Lago's letter raises some interesting points which probably deserve fuller treatment than we are able to give here. We are interested that he should feel that "undue damage" can be done to Maxwell's theory through this series of articles. It would seem that he sees himself in the role of priest defending the faithful from the dangers of heretical doctrine. If this is indeed necessary then it says little for the understanding of electromagnetic theory by the faithful. Surely engineers and scientists are competent to draw their own conclusions from a public debate without such protection.

Dr Lago states "Without this term (displacement current) the wave equation would not appear and electromagnetic waves would not exist". Would that life were so simple! In fact this statement is a non-sequitur. All that he is able to state from his position is something like, "In Maxwell's theory displacement current is essential to the existence of a wave equation and hence of electromagnetic waves; therefore, if displacement current is removed, electromagnetic waves *as understood by Maxwell* would not exist". To illustrate, before Lavoisier it was thought that the process of combustion involved, or rather depended upon, the removal of a substance, 'phlogiston', from the burning material. Someone who believed the phlogiston theory would no doubt have asserted that "without phlogiston it is impossible for things to burn". But he would have been quite wrong because the argument is premised on a faulty theory. In the same way we regard the Maxwellian framework as faulty. We have no doubt that electromagnetic radiation exists and there is nothing in our articles to suggest otherwise. What we chiefly object to is the spurious causality and physical meaning given to the term $\epsilon(\partial\mathbf{E}/\partial t)$ which is a barrier to the deeper understanding of electromagnetic processes.

We would like to assure Dr Lago that our experience in electromagnetic theory goes beyond "the most trivial problems" and one of us (DSW) lectured on electromagnetic theory in Trinity College Dublin.

Dr Lago is quite wrong to impute to us the facile misunderstanding of the pie-shaped transmission line. IC published a paper[1] in which the theory of the pie-shaped line is discussed with reference to power plane decoupling on multi-layer printed circuit boards. In this paper it is made quite clear that there is continuous reflection caused by the changing impedance seen by the step as it travels outwards to greater radii. We did in fact reference this paper at the end of the December 1978 article. In this latter article we do not claim to be treating the case of a circular capacitor in the mathematical appendix. We in fact refer to Fig. 2 which represents a uniform end-fed transmission line. This case is treated since it demonstrates the key features without requiring unnecessarily complex mathematics.

Incidentally, Dr Lago says that a zero risetime step is a "physical impossibility". This interesting statement merits further analysis. One would like to know whether he is attacking the concept or its practical realisation, i.e. is he against the Platonic ideal of a step or is he saying, as might Aristotle, that such a concept is not useful because it is not practically realisable? If the former then we assume he is also opposed to the sine wave concept since infinite time is required for its perfect realisation; if the latter then what physical principle determines the shortest risetime obtainable in practice? In the latter case the principle must precede the concept, i.e. there must be no circularity.

Finally, Dr Lago agrees with us (and Heaviside) when he states that "one should regard currents and charge distributions as the consequences of electromagnetic waves rather than as the sources of these waves." In that case is $\epsilon(\partial E/\partial t)$ a *current* and therefore an effect or a *field* and therefore a cause, or is it both!

I. Catt, M. F. Davidson, D. S. Walton

Reference

1. "Crosstalk (noise) in digital computers", I. Catt, *IEEE Trans. EC-16*, Dec. 1967, pp. 743-763.

CITIZENS' BAND IN THE USA

Recently, while returning from London, I picked up a copy of your magazine at the Heathrow Airport news stand. It appears from the issue I have that certain people in Great Britain are contemplating something akin to the citizens' band, which here in the States is presently the Federal Communications Commission's principal headache. Although, as a licensed amateur, I disliked losing the eleven metre band, which was one of my favourites, I originally thought the idea of a citizens' service wasn't all that bad. Now, in retrospect, permit me a few comments and observations.

1. Enforcement of existing regulations is an impossibility. The FCC could double its existing field staff and still be unable to police the eleven metre band.

2. In a total of six hours of monitoring the c.b. channels here in Grand Rapids, fewer than 10% of the contacts monitored were legal by existing rules.

3. Out-of-band operation is commonplace, with stations heard throughout the spectrum from 26.6 MHz to 27.998 MHz.

4. Although the FCC has banned commercial production of amplifiers capable of operating in the 27-29 MHz portion of the spectrum, linear amplifiers for 27 MHz are readily available and widely used in c.b. circles.

5. Amateur transceivers are converted to c.b. use, giving v.f.o. control and power levels greatly in excess of the legal maximum.

6. Illegal linear amplifiers are often adjusted improperly, resulting in interference with other services.

7. Profanity, vulgarity, and deliberate interference with other stations is common.

The above is only a partial listing of the contents of the Pandora's Box that is c.b. radio. There are, of course, many operators that do their best to operate legally, but they have little chance when competing with the impossibly large number of "dip-sticks" that inhabit the 27 MHz jungle.

The solution . . .? If Great Britain cannot possibly survive without a citizens' service, put the miserable thing up high enough in frequency that the technology is beyond the ken of the week-end experimenter **and** charge a good stiff licensing fee. About fifty pounds per year sounds about right to me!

(Name and address supplied)
Michigan
USA.

INTERFERENCE FROM 555 TIMERS

The 555 and 556 timer integrated circuits are very popular and useful devices. But they are notorious for their tendency to interfere with neighbouring circuits. Interference is through transients on the power supply line. These transients are longer and heavier than those caused by t.t.l., because the 555 has a high-current totem pole output, which is switched comparatively slowly by the timing circuit.

In designing our CCTV Target Locators we found that interference from 555s was not effectively suppressed by decoupling capacitors fitted near the 555s. But we obtained a cheap, effective solution, by fitting two ferrite suppressor beads onto the +5V supply at each 555. Suitable beads are RS Components Type 238-283.

Richard Baker
Hampton Video Systems Ltd
Twickenham
Middx

MICROPROCESSORS FOR CALCULATION

I am delighted to see your series of articles on "A scientific computer", using a microprocessor in conjunction with a 'number-cruncher.'

Having recently started working with microprocessors, I do not think the common items available are at all suited to calculations of any magnitude or complexity and consequently they may well be of far less value than the pundits would like us to think. I still feel that there is far too much rather desperate selling of what is available rather than a real attempt to find out what the market wants.

(Name and address supplied)
Procurement Executive,
Ministry of Defence

WIDEBAND NOISE REDUCER

I should like to compliment D. L. Harrison on his compander design described in your November 1978 issue. Used in conjunction with a Revox A77, it enables me to enjoy recordings made at 3¾ in/s as much as if not more than those made previously at 7½ in/s. The virtual elimination of tape noise is by no means the only improvement. Contributing equally to the comfort of listening is the fact that I no longer need to record at a high level in order to ensure an acceptable ratio of signal to noise, and peaks in the programme can remain undistorted.

Constructors of the compander, like myself, without access to distortion-measuring equipment should nevertheless include the optional trimming components shown dotted in the circuit diagram. A setting can be made by ear which is audibly better than leaving pins 8 and 9 of the compander i.c. disconnected. The adjustment is made easier if a reasonably pure tone from an oscillator can be played through the compander when it is switched to the expand mode.

F. W. Baldock
Salisbury
Zimbabwe-Rhodesia

CARFAX CONFUSION

Horsham is a quiet Sussex country town, normally at peace with the world. Although not well bestowed with dreamy spires it has, as your picture shows (see p.53, May 1979) a Carfax.

It would be interesting to know the name of the spy who provided you with that photograph and what was said in the accompanying message. I also wonder who at *Wireless World* has *assumed* that the home of lost causes had suddenly become up to date. Ve aff vays of bending beams but if Oxford is to be the real target I hope that Horsham is not the actual victim.

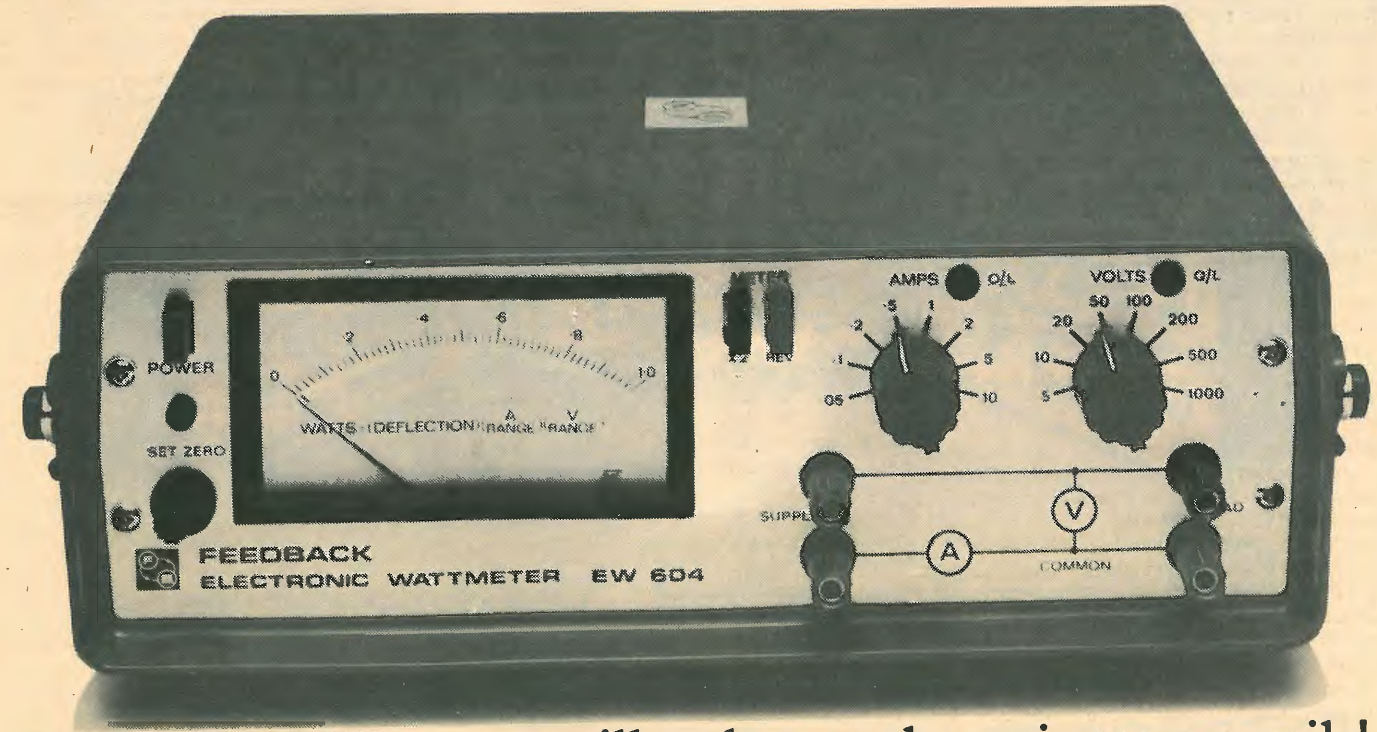
M. J. L. Fadil, G4CC/G4CGY
London N6.

Full marks to sharp-eyed reader Fadil! Ve aff vays of confusing the reader, for which we apologize. However, just to keep the record straight, Oxford does have a Carfax, a cross-roads in the middle of the town. And the origin of this old name, thought to be the Latin *quadrifurcus* or the French *quatre voies*, seems quite appropriate to a traffic information system by indicating the basic four directions in which a vehicle may travel. – Ed.

"SPURIAE" (April letters)

I wonder why
We specify
Spurious
As spuriae?
For instance:
It's curious
(Or curiae?),
That furious
Aint furiae,
Luxurious
Luxuriae.
And so on.
This verse
Has no moralae,
I only ask that
We all try
Hard in future
Not to use
Spurious words
Like spuriae.

J. E. Diggins
South Ascot
Berks



A scientific computer — 4

More programming in high and low level languages

by **J. H. Adams**, M.Sc.

THE MORTGAGE PROGRAM in Table 8 computes, from a given principal, annual interest rate and period for which a loan is to run (represented by P, I and T in the program), the monthly repayment and repayment schedule for a standard mortgage. The format closely follows that of standard BASIC. In line 6, an interest factor

$$K=1+\frac{I}{100}$$

is calculated, whilst the expression evaluated in line 7 is

$$B=\frac{K^T}{K^T-1}\times\frac{IP}{1200}$$

using the stack operation ENT to push K^T into the Y and Z registers of the stack as shown in Table 9. A special

Table 9 Stack operations for the mortgage program.

COMMAND	X	Y	Z	T
YX	K^T	-	-	-
ENT	K^T	K^T	-	-
ENT	K^T	K^T	K^T	-
1	1	K^T	K^T	-
-	K^T-1	K^T	-	0
/	$\frac{K^T}{K^T-1}$	-	0	0

print format is used in lines 13 and 19 to round the displayed values of B and P to the nearest penny.

Table 10 shows two separate programs cascaded into the programming area. The first is run by the command RUN 4 and is a game which simulates the landing of a rocket on Earth. Lines 4 to 8 set a fuel level of 120 (F), a velocity of –50m/s (V) and an initial height of 250m(H). After presenting this information, the computer waits for the player to type in a one second burn of fuel, B, which is checked against the present amount of fuel (line 14) and then used to reduce the velocity by B–5, provided that there is enough fuel available.

The aim, of course, is to simultaneously reduce the velocity and height to zero, without running out of fuel. The

Table 8 Print out of a mortgage program based on the high level language.

```
003 PRINT "                    ***MORTGAGE PROGRAM***"
004 PRINT "    INPUT PRINCIPAL, INTEREST RATE & TERM"
005 INPUT P I T
006 LET K=I 100 / 1 +
007 LET B=K T YX ENT ENT 1 - / I * 1200 / P *
013 PRINT "  MONTHLY REPAYMENT ="B2
014 LET B=B 12 *
015 PRINT "      ***REPAYMENT SCHEDULE***"
016 FOR X=1 STEP 1 UNTIL T
018 LET P=P K * B -
019 PRINT "AFTER"X0, " YEARS YOU OWE"P2, " POU..."
021 NEXT X
024 END

ODED
```

Table 10 Cascaded programs for a rocket landing game and the solutions of F (x)=0.

```
004 LET C=0
005 LET F=120
006 LET V=-50
007 LET H=250
008 PRINT "HEIGHT="H2, "M  VELOCITY="V2, "M/S  FUEL LEFT="F0, "U..ITS".
009 LET C=C 1 +
010 INPUT B
011 IF C<15 THEN 14
012 ERASE
013 LET C=0
014 IF B>F THEN 25
015 LET F=F B -
016 LET B=B 5 -
017 LET J=H
018 LET H=H V + B 2 / +
019 IF H<0 THEN 30
020 LET V=V B +
021 IF H=0 THEN 37
024 GOTO 8
025 PRINT "OUT OF FUEL  PREPARE TO CRASH."
026 END
030 LET V=V SQ J 10 * + RT
031 PRINT "YOU HAVE CRASHED AT"V2, "M/S."
032 END
035 PRINT "WELL DONE, YOU HAVE LANDED.".
036 END
037 IF V=0 THEN 35
038 PRINT "YOU HAVE LANDED TOO FAST.  HAVE A NICE STAY "
039 END
098 PRINT "  THIS PROGRAM USES NEWTONS METHOD FOR SOLVING"
099 PRINT "THE FORMULA F = F(X).  ENTER AN INITIAL GUESS FOR X NOW. . ."
100 INPUT Q
101 ERASE
102 LET X=Q
105 GOSUB 200
110 LET G=F
115 LET X=X 1.00001 *
120 GOSUB 200
125 LET T=G SQ RT
127 TOP
130 IF T<0.000001 THEN 190
135 LET Q=1 F G / 1 - REC 0.00001 * - Q *
137 PRINT Q8
140 GOTO 102
190 PRINT "THE SOLUTION IS X="Q6
195 END
200 LET F=X LN X 3 * + 10.8074 -
205 RETURN

100F
```

exercise is based upon standard Newtonian equations of motion; $s=u+\frac{1}{2}a$ and $v=u+a$. Crash velocities are worked out (line 30), using $v^2=u^2+2as$. In the program execution, C acts as a go counter, clearing the screen every 15 burns. This might seem unnecessary, as it takes some unusual playing to avoid a crash and not win in that number of attempts. There is a simple technique for predicting solutions to this game, but I will leave the reader to deduce this.

One of the most economical solutions uses burns of 0, 0, 0, 25 and 50. For a more daunting version, the 2 in line 18 can be made an inputted variable (which will affect the acceleration due to gravity) or, even more difficult, a function of the value of H.

The second program uses Newton's method to solve the equation $F(x)=0$. The equation in this case, $\ln(X)+3X-10.8074=0$, is written at line 200 and, as it is required twice in the

Table 11 Program for analysing the pre-amplifier in Fig. 19.

```
005 INPUT A D B E C F
006 PRINT "FREQ            GAIN (DB)"
008 LET A=A 1000 *
011 LET B=B 1000 *
014 LET C=C 1000 *
017 LET D=D 1E12 /
020 LET E=E 1E12 /
023 LET F=F 1E06 /
026 LET W=PI 2 *
028 LET G=W D A * * SQ 1 +
030 LET H=W E B * * SQ 1 +
032 LET I=A SQ D * G / B SQ E * H / +
034 LET J=A G / B H / +
036 LET K=W C F * *
038 LET L=J W K I * * - SQ W I * K J * + SQ + RT C / K K REC + /
040 LET L=L 60 / LOG 20 *
044 LET M=W 2 / PI /
047 IF M>20000 THEN 200
048 PRINT M1 LO
052 LET W=W 10 RT RT
053 GO 28
200 END

0E15
```

Table 12 Computer run of results for the pre-amplifier.

```
FREQ        GAIN (DB)
   1.0          6.
   1.8         11.
   3.2         15.
   5.6         19.
  10.          21.
  17.8         21.
  31.6         19.
  56.2         16.
 100.          12.
 177.8          8.
 316.2          4.
 562.3          2.
1000.           0.
1778.3         -2.
3162.3         -5.
5623.4         -9.
10000.        -13.
17782.8       -18.
```

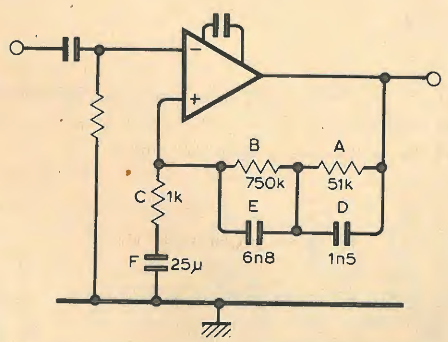


Fig. 19. *Typical RIAA equalised pre-amplifier based on the MC1303. The results of a computer run on this circuit are shown in Table 12.*

Table 13 Program for computing the intercept and gradient of the best fitting straight line.

```
001 LET A=0
002 LET B=0
003 LET C=0
004 LET D=0
005 LET N=0
006 LET E=0
007 INPUT X Y
008 LET N=N 1 +
009 LET A=A X +
011 LET B=B Y +
013 LET C=C X Y * +
015 LET D=D X SQ +
016 LET E=E Y SQ +
018 LET M=C A B * N / - D A SQ N / - /
019 LET L=B N / M A * N / -
021 PRINT 'AFTER'NO, 'PAIRS, M='M7 'C='L7
023 LET R=C A B * N / - SQ D A SQ N / - / E B SQ N / - /
024 LET R=R 100 *
025 PRINT 'COEFFICIENT OF DETERMINATION='R2, '%   '
027 TOP
029 GO 7

0DA7
```


program, it is called as a subroutine at lines 105 and 120. Given an initial guess Q, at line 100, the computer calculates the next guess at Q by

$$Q-\frac{F(Q)}{F'(Q)}$$

calculated by the approximation

$$Q1-\frac{0.00001F(Q)}{F(1.00001Q)-F(Q)}$$

Line 125 assigns the absolute value of G to T, G being the difference between two successive values for Q and, if T is below the criterion of accuracy set in line 130, the program branches to line 190 and prints out a final rounded solution for X.

Note that if these two programs, or any material with more than 31 lines, are loaded, a LIST or DEL command will list the first 31 and then display LIST INCOMPLETE, preceded by the next valid line number on the top line of the screen. To display the rest of the program, or the next 31 lines, press the space bar.

Scientific numbers

The computer switches to a scientific display on numbers greater than 99,999,999 or less than 0.0001. Numbers appearing in programs or being entered in response to an INPUT line, may be entered scientifically or in floating point, provided that they are within the computers range. When entering scientifically expressed numbers, a space is not required at the end of the figures because the E entered in the figures tells the computer that only two more digits are to be entered. The standard form of one figure in front of the decimal point will always occur in displayed results, but need not be adhered to when entering because the computer recognises 1.00E02, 100E00, 0.01E04, .001E05 or 1000000E-04 as all being 100. This is demonstrated in the next program. Fig. 19 shows a recommended circuit for the Motorola MC1303 dual amplifier used as a RIAA equalised phono pre-amplifier. Tables 11 and 12 show the program for, and a run of, an analysis of the circuit. Values are entered in the most convenient units, resistors in kilohms, D and E in picofarads, and F in microfarads, and then scaled to their basic units in lines 8 to 23. The equations for working out the gain at various frequencies are;

$$G=1+(WDA)^2$$

$$H=1+(WEB)^2$$

$$I=\frac{A^2D}{G}+\frac{B^2E}{H}$$

$$J=\frac{A}{G}+\frac{B}{H}$$

$$K=WCF$$

$$L=\frac{((J-WKI)^2+(JK+WI)^2)^{\frac{1}{2}}}{C(K+1/K)}$$

The last equation is a good argument for Reverse Polish. Note that in;

line 26 π can be called as PI.

line 38 full use is made of the 4 level stack for storing intermediate values and results. This line actually consists of more than one v.d.u. line's worth of characters, and it therefore overruns into the next line.

line 38 & 52 RT is an abbreviation of ROOT. In word recognition, the computer only considers the first and last letters of a word, which allows for considerable laxity in typing.

When establishing the relationship between two sets of data, the first test is usually one of proportionality, i.e. will the data, if plotted, give a straight line? Table 13 lists a program which uses linear regression to compute the intercept and gradient of the best fitting straight line for a series of pairs of co-ordinates (horizontal, then vertical), read in at line 7. Each set of data updates the values of M and C, and also takes part in the calculation of a coefficient-of-determination, which gives a measure of the fit of the line to the co-ordinates. Note the use of the command TOP at line 27, which clears and resets the data entry point to the top of the screen each time.

Low level programming

When low level programming is used, charts of the type shown in Table 14 are very helpful for translating between the mnemonics for the Z80 operations and the actual hexadecimal codes. If the charts are used in conjunction with the technical manual for the MK3880/Z80, program assembly and disassembly is

Table 14 Conversion charts for the Z80 instruction set.

Second character of Z80 code (columns); First character (rows)

First character	0	1	2	3	4	5	6	7
0	NOP	LD BC,nn	LD(BC),A	INC BC	INC B	DEC B	LD B,n	RLC A
1	DJNZ	LD DE,nn	LD(BC),A	!NC DE	INC D	DEC D	LD D,n	RL A
2	JRNZ,e	LD HL,nn	LD(nn),HL	INC HL	INC H	DEC H	LD H,n	DAA
3	JRNC,e	LD SP,nn	LD(nn),A	INC SP	INC(HL)	DEC(HL)	LD(HL),n	SCF
4	LD B,B	LD B,C	LD B,D	LD B,E	LD B,H	LD B,L	LD B,(HL)	LD B,A
5	LD D,B	LD D,C	LD D,D	LD D,E	LD D,H	LD D,L	LD D,(HL)	LD D,A
6	LD H,B	LD H,C	LD H,D	LD H,E	LD H,H	LD H,L	LD H,(HL)	LD H,A
7	LD(HL),B	LD(HL),C	LD(HL),D	LD(HL),E	LD(HL),H	LD(HL),L	HALT	LD(HL),A
8	ADD B	ADDC	ADD D	ADD E	ADD H	ADD L	ADD(HL)	ADD A
9	SUB B	SUB C	SUB D	SUB E	SUB H	SUB L	SUB(HL)	SUB A
A	AND B	AND C	AND D	AND E	AND H	AND L	AND(HL)	AND A
B	OR B	OR C	OR D	OR E	OR H	OR L	OR(HL)	OR A
C	RET NZ	POP BC	JPNZ,nn	JP,nn	CNZ,nn	PUSH BC	ADD n	RST 0
D	RET NC	POP DE	JPNC,nn	OUT A,(N)	CNC,nn	PUSH DE	SUB n	RST 16
E	RET PO	POP HL	JPPO,nn	EX(SP),HL	CPO,nn	PUSH HL	AND n	RST 32
F	RET P	POP AF	JPP,nn	DI	CP,nn	PUSH AF	OR n	RST 48

First character	8	9	A	B	C	D	E	F
0	EX AF,AF'	ADD HL,BC	LD A,(BC)	DEC BC	INC C	DEC C	LD C,n	RRC A
1	JR,e	ADD HL,DE	LD A,(DE)	DEC DE	INC E	DEC E	LD E,n	RR A
2	JRZ,e	ADD HL, HL	LD HL,(nn)	DEC HL	INC L	DEC L	LD L,n	CPL
3	JRC,e	ADD HL,SP	LD A,(nn)	DEC SP	INC A	DEC A	LD A,n	CCF
4	LD C,B	LD C,C	LD C,D	LD C,E	LD C,H	LD C,L	LD C,(HL)	LD C,A
5	LD E,B	LD E,C	LD E,D	LD E,E	LD E,H	LD E,L	LD E,(HL)	LD E,A
6	LD L,B	LD L,C	LD L,D	LD L,E	LD L,H	LD L,L	LD L,(HL)	LD L,A
7	LD A,B	LD A,C	LD A,D	LD A,E	LD A,H	LD A,L	LD A,(HL)	LD A,A
8	ADC B	ADC C	ADC D	ADC E	ADC H	ADC L	ADC(HL)	ADC A
9	SBC B	SBC C	SBC D	SBC E	SBC H	SBC L	SBC(HL)	SBC A
A	XOR B	XOR C	XOR D	XOR E	XOR H	XOR L	XOR(HL)	XOR A
B	CP B	CP C	CP D	CP E	CP H	CP L	CP(HL)	CP A
C	RET Z	RET	JPZ,nn	*	CZ,nn	CALL,nn	ADC n	RST 8
D	RET C	EXX	JPC,nn	IN A,(n)	CC,nn	@	SBC n	RST 24
E	RET PE	JP (HL)	JPPE,nn	EX DE,HL	CPE,nn	‡	XOR n	RST 40
F	RET N	LD SP,HL	JPN,nn	EI	CN,nn	@	CP n	RST 56

@, DD or FD preceding underlined codes, exchanges the operand IX or IY respectively, for HL.
In both cases the displacement, implicit in an indexed operation, follows the code.
*, ‡, CB and ED precede codes shown below.

Op-codes preceded by CB

Second (columns); First (rows)

First	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	RLC B	RLC C	RLC D	RLC E	RLC H	RLC L	RLC(HL)	RLC A	RRC B	RRC C	RRC D	RRC E	RRC H	RRC L	RRC(HL)	RRC A
1	RL B	RL C	RL D	RL E	RL H	RL L	RL(HL)	RL A	RR B	RR C	RR D	RR E	RR H	RR L	RR(HL)	RR A
2	SLA B	SLA C	SLA D	SLA E	SLA H	SLA L	SLA(HL)	SLA A	SRA B	SRA C	SRA D	SRA E	SRA H	SRA L	SRA(HL)	SRA A
3									SRL B	SRL C	SRL D	SRL E	SRL H	SRL L	SRL(HL)	SRL A

Bit tests, 01xx xyyy (binary)
Reset bit, 10xx xyyy (binary) where xxx is the bit number, yyy the register code
Set bit, 11xx xyyy (binary)

B—0	H—4
C—1	L—5
D—2	(HL)—6
E—3	A—7

Op-codes preceded by ED

	0	1	2	3	5	6	7	8	9	A	B	D	E	F
4	IN B,(C)	OUT(C),B	SBC HL BC	LD BC,(nn)	RET N	IM O	LDI,A	IN C,(C)	OUT(C),C	ADC HL BC	LD(nn),BC	RET I		LD R,A
5	IN D,(C)	OUT(C),D	SBC HL DE	LD DE,(nn)		IM 1	LD A,I	IN E,(C)	OUT(C),E	ADC HL DE	LD(nn),DE		IM2	LD A,R
6	IN H,(C)	OUT(C),H	SBC HL HL				RRD	IN L,(C)	OUT(C),L	ADC HL HL				RLD
7			SBC HL SP	LD SP,(nn)				IN A,(C)	OUT(C),A	ADC HL SP	DL(nn),SP			
A	LDI	CPI	INI	OUTI				LDD	CPD	IND	OUTD			
B	LDIR	CPIR	INIR	OUTIR				LDDR	CPDR	INDR	OUTDR			

To find the mnemonic corresponding to a particular hex op-code, look for the first digit of the byte down the side of the tables and for the second digit across the top.
To find the op-code corresponding to a particular mnemonic, reverse this process.

quite easy. As an example, Table 15 shows an analysis of the first part of the BURP monitor starting at address 0800. There are many subroutines in the computer's operating system and these are useful when low level programs are being written. Table 16 lists the subroutines with their CALL addresses, mnemonics and a brief description of their functions.

Development and use of machine code programs is generally a matter of personal requirement and therefore the demonstration programs will probably be of little practical use to constructors. One, however, listed in Table 17, which might be of interest to other teachers, shows the results when quanta of energy are randomly swopped between 2048 atoms (as used in Nuffield A level physics). To generate the pseudo random numbers, a 17-bit shift register with its input being the exclusive OR of the 16th and 17th bits, is set up in the

Table 15 Operation of part of the BURP monitor.

Hex bytes	Mnemonic	Operation performed
31 DF 1F	LD SP,1FDF	Loads the Z80 stack pointer with 1FDF
11 00 80	LD DE,8000	Loads the 16-bit register pair, DE, with 8000, which is the address of the top left-hand corner of the v.d.u.
CD CE 03	CALL 03CE	Calls the subroutine at 03CE (see Table)
20 02 02...1D		Data for the preceding subroutine (displays 'BURP')
E7	RST 32	A special one-byte CALL to a subroutine at 0020, its effect is to print a space
E7	RST 32	As above
D5	PUSH DE	Stores DE in a section of the r/w.m., using the stack pointer as a pointer to, and a reminder of, this storage 'stack'
CD C4 03	CALL 03C4	Calls the subroutine at 03C4 (clears the rest of the v.d.u. top line)
D1	POP DE	Restores the stored value of DE to the DE register pair
3E 04	LD A,04	Loads register A with the byte 04
32 EO1F	LD (1FEO),A	Loads memory location 1FEO with the contents of register A
1E 08	LD E,08	Loads register E with 08. Screen address is set eight spaces in on the top line, ready for a command

Table 16

```
*****SUBROUTINES IN MACHINE CODE*****

0254 LEAD  PROVIDES LEADER FOR TAPE.
0260 TCHAR RECORDS (A) ON TAPE AT 300 BAUD
027F PADD  (HL) + A SPACE TO TTY
028E AHEX  CONVERTS 4 BIT HEX TO 'ASCII'
029D ASCII 'ASCII' TO TTY CONVERTER
02A5 PHEX  INSERTS SHIFTS AND SENDS TO TTY
02CC       LOOK-UP TABLE FOR TTY
02EC PSPA  TYPES A SPACE
02F0 PNEW  CARRIAGE RETURN, LINE FEED + FIG SHIFT
0301 PCHAR UART FOR TTY
0317 LIST  LIST SUBROUTINE
0336 TIME  TIME DELAY, FOLLOWED BY LOP COUNT
0345 TCLR  CLEARS TOP LINE AND SETS TO 8000
034E 8SPA  ROUNDS SCREEN ADDRESS UP TO XXX0 OR XXX8
0355 INWRD INPUTS AND ENCODES KEYBOARD (LAST - FIRST)
0372 MSPA  SPACER USED IN LIST AND LOAD
0393 CLR   CLEARS THE SCREEN
039F DADD  (HL) + A SPACE TO VDU
03A9 DHEX  DISPLAY A HEX BYTE ON THE VDU
           (03A9 IF THE BYTE IS IN (HL), 03AA IF IN (A))
03C4 ELIN  CLEARS OFF REST OF CURRENT VDU LINE
03CE DLIST DISPLAY THE FOLLOWING DATA
03DE LADD  LOADS HL FROM KEYBOARD
03E7 INHEX READS IN AND FORMS HEX BYTE
03F6 IN    READS KEYBOARD AND CONVERTS TO 4 BIT HEX
```

Table 17 Demonstration machine code program which shows the results when quanta of energy are randomly swopped between 2048 atoms.

```
1C00 21 00 0C 36   31 23 7C FE   14 20 F8 D9   21 80 0C 11
1C10 80 80 7E 12   13 23 00 7C   FE 14 20 F6   11 00 80 3E
1C20 30 06 0E C5   F5 21 00 0C   01 00 00 F1   F5 BE 20 01
1C30 03 23 7C FE   14 20 F4 C5   E1 C5 D5 11   30 30 01 E8
1C40 03 CD 82 1C   53 1E 30 01   64 00 CD 82   1C 06 30 7D
1C50 FE 0A 38 05   04 D6 0A 18   F7 E1 72 23   73 23 70 23
1C60 C6 30 77 23   EB C1 CD 4E   03 F1 C1 3C   10 B5 D9 06
1C70 00 CD 97 1C   7E FE 30 28   F8 35 CD 97   1C 34 10 F1
1C80 18 89 A7 E5   ED 42 E1 D8   ED 42 1C 18   F5 10 F1 18
1C90 B3 FF FF FF   FF FF FF CB   A9 7A E6 C0   EA A1 1C CB
1CA0 E9 CB 21 CB   13 CB 12 D5   E1 7C E6 07   C6 0C 67 C9
1CB0 21 00 0C 36   31 23 7C FE   1C 20 F8 06   00 CD 97 1C
1CC0 7E FE 30 28   F8 35 CD 97   1C 34 10 F1   D9 21 00 CC
1CD0 11 00 80 7E   12 13 23 00   7C FE 14 20   F6 D9 18 DB
1CE0 FF FF FF FF   FF FF FF FF   FF FF FF FF   FF FF FF FF
```


Z80. There are two versions, RUN 1CCD gives a display of the atomic matrix up-dated every 256 swops and RUN 1C00 does the same, but also totals, in decimal, the number of sites with one quantum, with two quanta etc. Modifying the byte 1C04 from 31 to 32 or 33 alters the initial filling up of the matrix from all ones to all twos or threes respectively.

Tape interface

The tape commands operate in the low level language, therefore, if a high level language program is to be recorded, its final address must be noted from a high level LIST. When recording it is worth spacing the blocks of recorded data because a 2 kilobyte block only requires 45 seconds of tape, and individual blocks are then easier to find. The leader of stop bits recorded automatically at the start of each recording lasts for about four seconds, so, when a recording is to be read into the computer, cue the tape just into this leader, type READ XXX, i.e. the first three characters of the hex address, start the tape and then type the last digit of the address.

In the kit of parts available for this design, one of the panel l.e.ds monitors the data stream and is turned on by the stop bits to indicate by flickering that data is being read in and, by steady illumination, that the recording has finished.

The TAPE command leaves the recording tone in the stop state so that, after the four second trailer, when the computer returns to the READY state the tone is left in the correct state for the next recording. When this trailer is reached during a READ, the computer must be interrupted by pressing a key.

Although the receiver is fairly flexible about frequencies and gives a 1 or 0, depending upon which side of 2kHz the tone is, the input from the tape recorder should be at least IV r.m.s. For recording, the output variable resistor should be set so that, without overloading the input of the tape recorder, it is possible to over-record by a few dB, quantity rather than quality being the main criterion. There is no fine adjustment of the generated frequencies because of the flexibility of the receiver design. Several different interfaces and tape decks have been tried, but a consistent error rate has been impossible to establish, even with a judiciously placed finger slowing down the tape transport.

To be continued

Converting between analogue and digital quantities — 3

Analogue-to-digital converters using the feedback technique

by **G. B. Clayton,** B.Sc., Liverpool Polytechnic

In this section, the author examines the commonly-used methods of converting analogue information into a digital form, limiting the discussion to those types for which cheap integrated circuits are obtainable.

TWO MAIN CLASSES of analogue-to-digital converter can conveniently be established: the feedback converter and the integrating type.

Feedback converters

The general circuit technique underlying the operation of a feedback converter is illustrated by the block diagram in Fig. 14, in which the system consists of a d.-to-a. converter, a comparator and digital logic circuitry. The logic circuitry increments the digital input number applied to the d.-to-a. converter and the comparator senses when the analogue signal produced by the converter becomes equal in value to the analogue input signal which is to be measured. Conversion is complete when this equality occurs and the digital number which is then present at the d.a.c. input represents the digitally-encoded value of the analogue input signal. The ramp type a.-to-d. converter, the tracking converter and the successive-approximation type are all feedback designs based upon the general schematic of Fig. 14, the three techniques differing in the type of digital logic circuitry which they use.

Ramp-type converter. The ramp, or count-up, converter is probably the simplest in concept, the digital logic circuit consisting essentially of a counter. At the start of a conversion the counter is set to zero: it then counts up clock pulses, while the digital logic levels representing the count are applied to the logic inputs of the d.-to-a. converter. The count is stopped by the comparator when the converter output becomes equal to the externally-applied analogue input signal, at which point the stored count constitutes the digital output of the a.-to-d. converter system.

A ramp-type converter system can be implemented by simply adding a comparator to the d.a.c. counter system described in Fig. 11 of part 2 of the article, a suitable arrangement being shown in Fig. 15. The data inputs of the 4-bit 74191 binary counters are connected to logic 0, whereupon bringing the load inputs on pin 11 to logic 0 sets the counters to zero. When the load input is returned to logic 1 (open), clock pulses are counted and the d.a.c. output is incremented until the voltage I_oR_{in} becomes equal to the analogue input voltage. The comparator output then goes to state 1 and stops the count. The static counter outputs represent the natural-binary digitally-encoded value of the analogue input signal expressed as a fraction of the full-scale analogue input, where the normalized full-scale analogue input has the value $I_{ref}R$. $V_{in} = 255/256\ I_{ref}\ R_{in}$, giving a digital output 11111111.

In a ramp-type converter the conversion is completed at the instant at which the d.a.c. analogue output becomes equal to the analogue input signal. The system in Fig. 15 uses a current comparison technique and in this case conversion is completed when $I_0 = V_{in}/R_{in}$. If the analogue input now decreases The digital output in a ramp-type a.d.c. 'holds' until the analogue input increases, when the counter increments up again until equality of analogue input and d.a.c. output is again reached. The digital output in a ramp-type d.a.c. thus represents the maximum value of the analogue input during the time between counter resets.

The conversion time in a ramp-type converter is not fixed, but depends upon the size of the analogue input expressed as a fraction of the full scale. In the system of Fig. 15

$$\text{conversion time} = (V_{in}/I_{ref}R_{in})2^nT_c \quad \text{Eq. 12}$$

where n is the number of logic bits in the d.a.c., ($n=8$ in Fig. 15) and T_c is the period of the clock pulses. For example, if the clock frequency were 1 MHz, $T_c = 1\mu s$ and a full scale less one l.s.b. conversion involving all eight bits would take 256.255/256 = 255 μs.

Tracking converter. This circuit is very similar to a ramp-type converter, but employs an up/down counter instead of an up counter. A few simple changes to the connections between the comparator and counters of the system of Fig. 15 will turn it into a tracking converter. The comparator output is connected to the counter up/down control inputs on pin 5, instead of to the enable inputs.

The comparator in a tracking converter controls the counting mode; if the output of the d.a.c. in the system is less than the analogue input signal, the converter is made to count up until the d.a.c. output becomes equal to the analogue input signal. If the analogue input now decreases the change is sensed by the comparator, which makes the counter count down. The comparator at all times sets the counting mode to force equality between the d.a.c. output and the analogue input: once this equality is reached, the logic levels present at the d.a.c. input represent the digitally en-

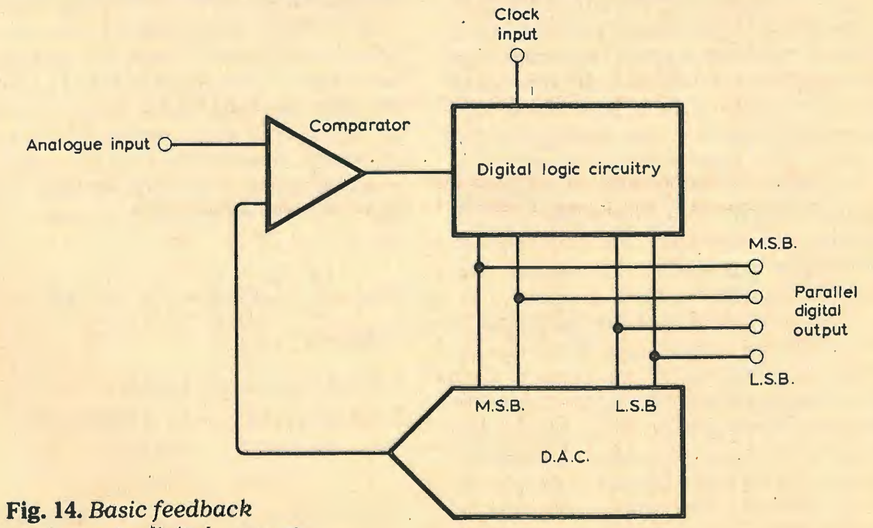


Fig. 14. *Basic feedback analogue-to-digital converter.*

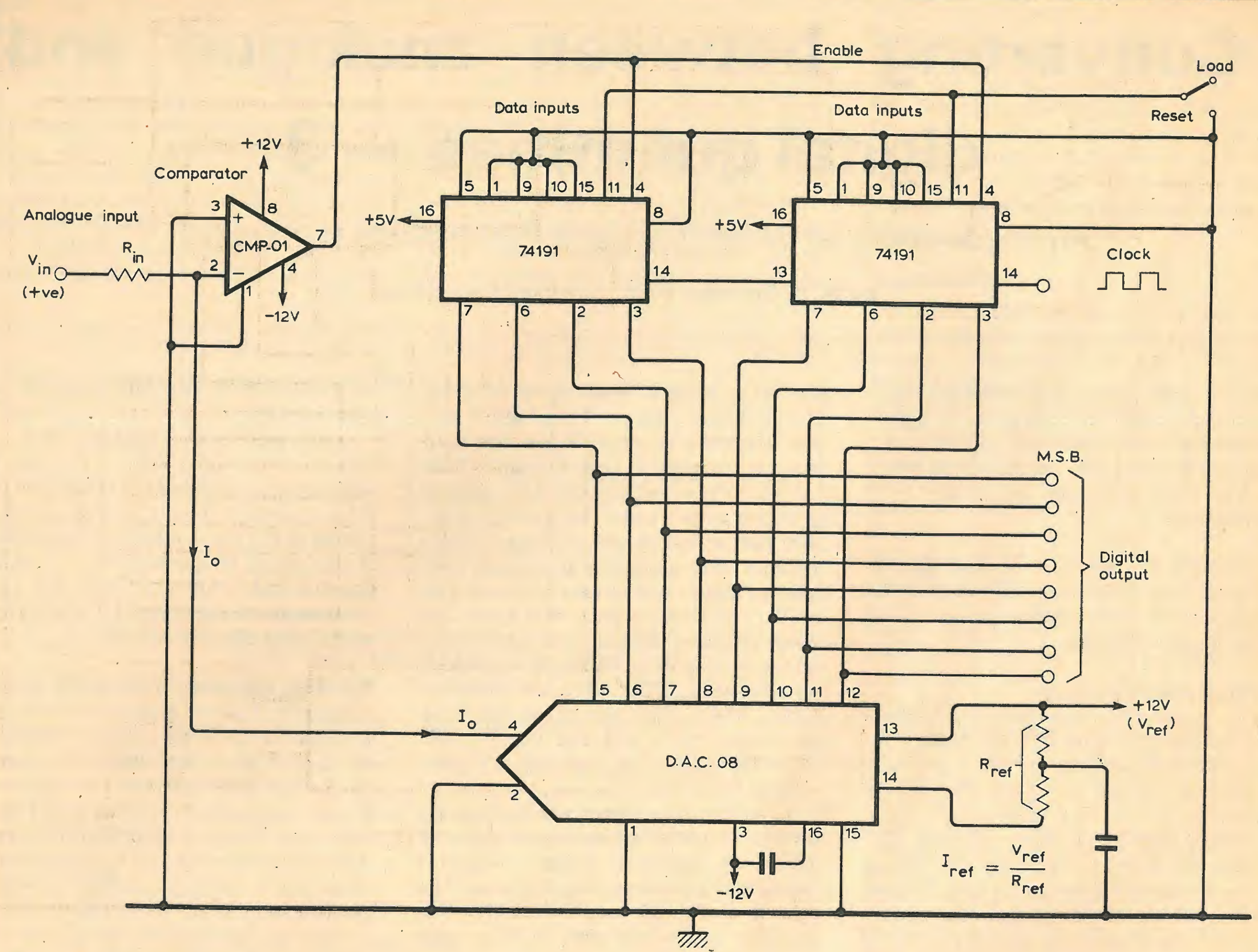


Fig. 15. *Practical ramp-type a.-to-d. converter, with up counter.*

coded value of the analogue input. In fact, with a constant analogue input signal the digital output 'dithers' or alternates between the two output states which span the theoretically correct output value.

A bipolar tracking a.-to-d. converter can be made by using offset binary operation of the d.a.c. in the system – an example of such a system is given in Fig. 16. The operational amplifier converts the DAC 08 output current into a bipolar output voltage. The comparator now performs a voltage comparison and in this configuration it presents a high input impedance to the analogue input signal. The type D flip-flop which is connected between the comparator output and the counting mode control inputs ensures that the comparator completes a transition before the next change in counting mode occurs.

The conversion code for the circuit of Fig. 16 is the symmetrical offset-binary code previously given in Table 6. If an alternating analogue input signal is applied the digital output tracks the analogue input provided its rate of change does not exceed the loop slew rate, which is the maximum rate at which the d.a.c. output can change. Since this output is incremented one l.s.b. at a time:

Loop slew rate $= f_c \times V_{LSB}$ ... (13)

where f_c = clock frequency

and $V_{LSB} = \frac{1}{128} \cdot I_{ref} \cdot R_1$

(From Table 7)

Note that the analogue input signal is reconstructed at the output terminal of the operational amplifier in Fig. 16, the loop forcing the output of the operational amplifier to track the analogue input signal. The trace in Fig. 17 shows the effect on this output signal of using an alternating input signal whose rate of change exceeds the loop slew rate. A clock frequency of 100kHz was used and with the component values of Fig 16,

$$V_{LSB} = \frac{1}{128} \cdot \frac{V_{ref}}{R_{ref}} \cdot R_1 = \frac{1}{128} \cdot \frac{12}{6} \cdot 3.9$$

$= 60.9\text{mV}$

Substitution in Eq. 13 gives

Loop slew rate $= 10^5 \times 60.9 \times 10^{-3}$

$= 6090\text{V/s}$

$= .006\text{V}/\mu\text{s}$

Examination of the slew-rate-limited portion of the trace in Fig. 17 gives a measured loop slew rate of

$$\frac{9.5}{1.6 \times 10^{-3}} = 5.94 \times 10^3 \text{ V/s.}$$

If the counter in a tracking converter is stopped (in Fig. 16 by bringing the 'enable' inputs to logic 1) the system acts as a sample hold with arbitrarily long hold time and no droop. Both analogue and digital outputs are available.

Successive approximation. This conversion method provides a more rapid conversion than the other two feedback techniques. In this type of circuit, the logic performs a series of 'trial' conversions, instead of incrementing the d.-to-a. converter one l.s.b. at a time. In the first trial, the control logic applies the m.s.b. to the d.-to-a. converter and the analogue output (½ full-scale) is compared with the analogue input signal by the comparator. If the d.a.c. output is less than the analogue input, the m.s.b. is retained, being switched off if the d.a.c. output is greater. The control logic then goes onto apply the next m.s.b. which is again retained or discarded. The process of trying the addition of successively smaller bits and retaining or discarding them goes on until the l.s.b. is reached. The conversion is then complete.

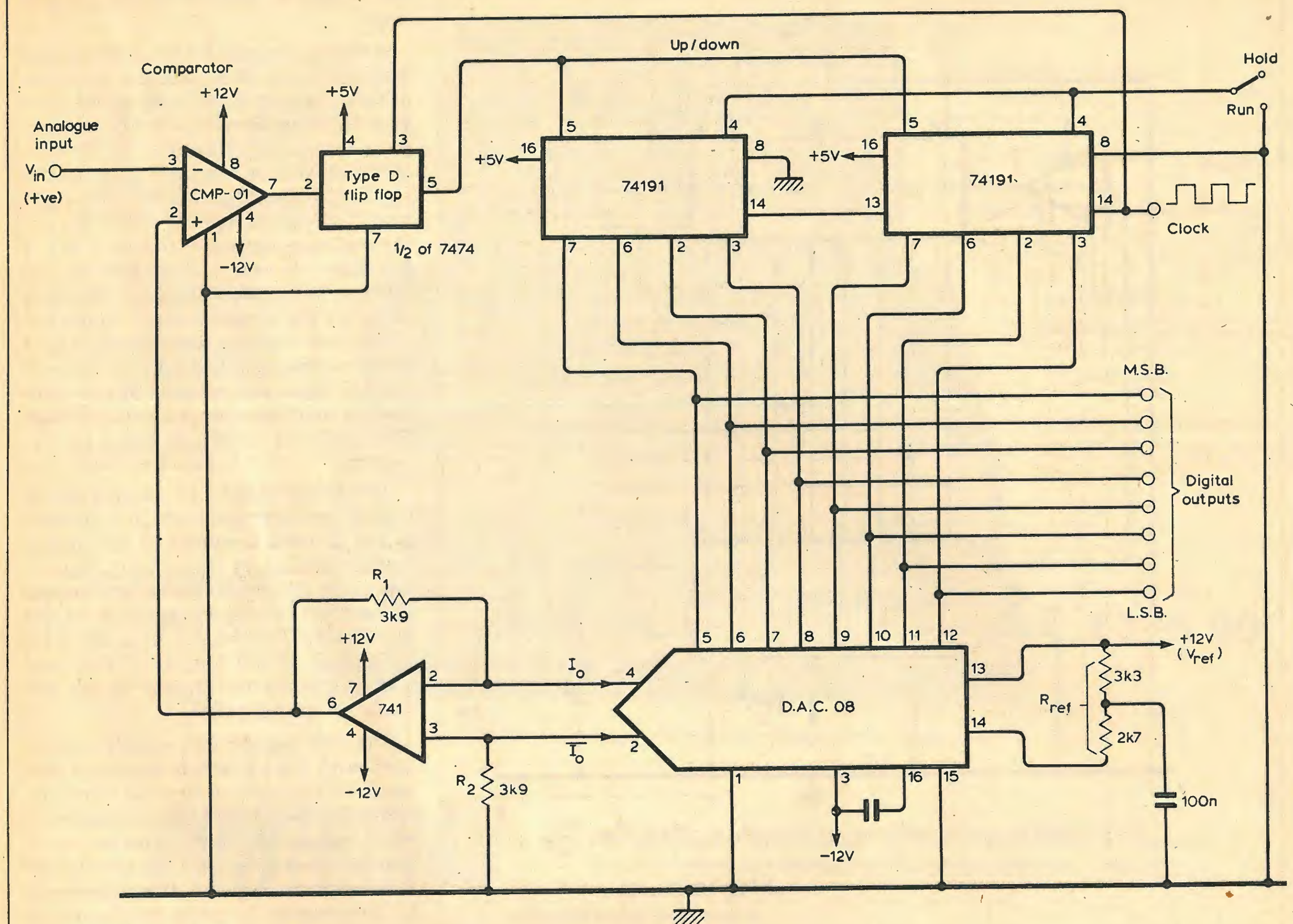
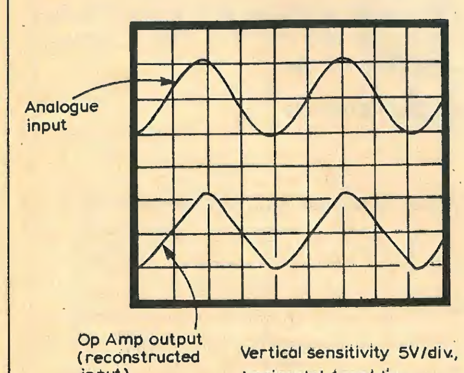
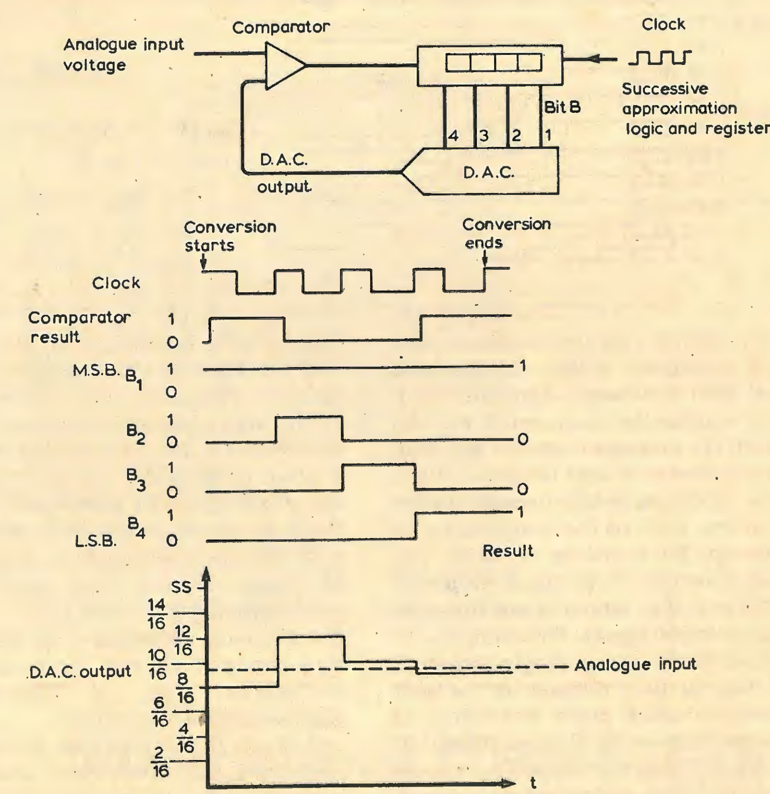


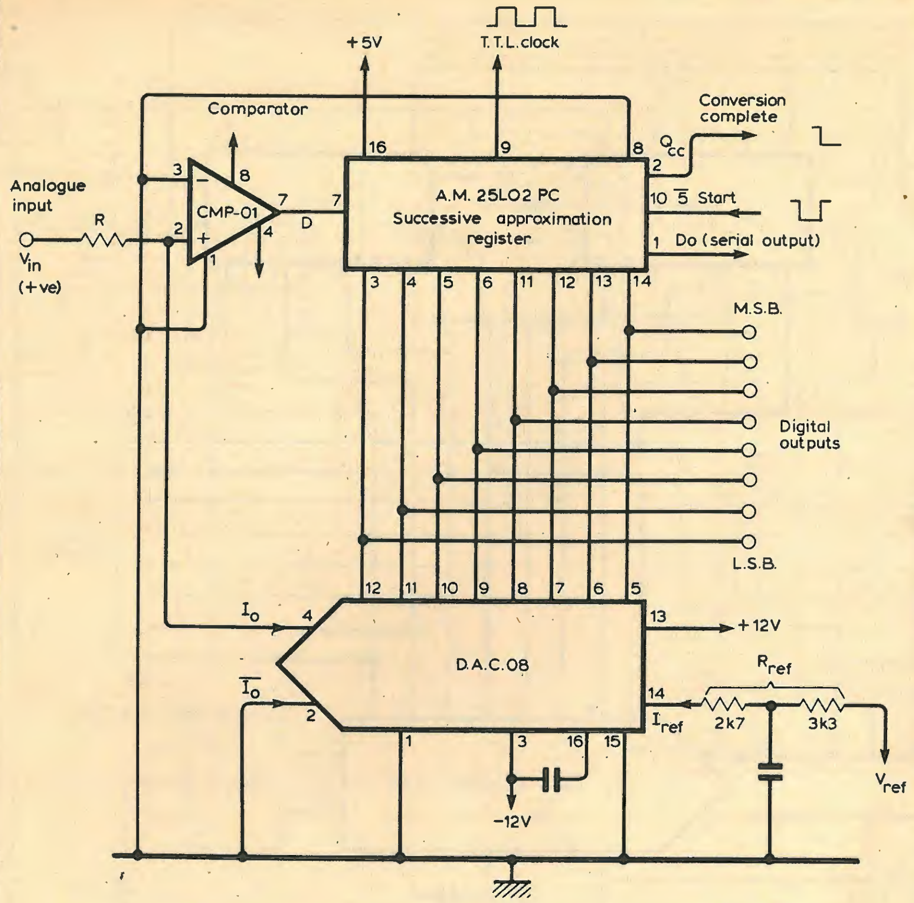
Fig. 16. *Tracking a.-to-d. converter, using up/down counter mode of 74191.*

Fig. 18. *Sequence of operations in successive-approximation converter.* ▶

Fig. 17. *Bottom trace shows slew-rate-limited version of the input (top) to circuit of Fig. 16. Clock frequency 100kHz.*







▲**Fig. 19.** *Practical successive-approximation converter.*

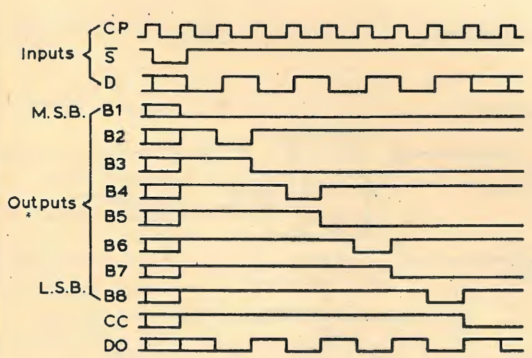


Fig. 20. *Timing diagram of circuit in Fig. 19.*

A simplified representation of the timing sequence which occurs in a typical 4-bit successive-approximation a.-to-d. conversion is shown in Fig. 18, in which the analogue input is assumed to lie between 9/16 and 10/16 full scale. On the clock pulse low-to-high transition, at the start of the conversion, all bits except bit 1 are set to zero. The analogue output of the d.a.c. produced by bit 1 is 1/2f.s., which is less than the analogue input signal. The comparator indicates this by giving a logic 1 which is fixed into the Bit 1 register on the next low-to-high clock pulse transition, at the same time as bit 2 is switched on. The d.a.c. output of 12/16f.s. is now bigger than the analogue input signal, so the comparator sets a logic 0 in the Bit 2 register on the next clock low-to-high transition, at which time Bit 3 is switched on. So the conversion proceeds and is completed (digital output 1001) on the fifth low-to-high transition of the clock pulse.

The digital logic circuitry required to implement a successive-approximation a.-to-d. conversion can be assembled using standard t.t.l. logic gates and flip flops, but from a user standpoint it is generally more convenient to make use of an m.s.i. device called a successive-approximation register (s.a.r.). These are available in single d.i.p. packages, and contain all the logic circuitry necessary for a successive-approximation converter.

A system which can be readily assembled for experimental evaluation is shown in Fig. 19. It consists of a d.a.c., a comparator and a successive approximation register. The 2502 t.t.l. s.a.r. is suggested for use, since it gives a digital output, obtained as a result of a conversion, in both serial and parallel form.

A timing diagram for the 2502 register is shown in Fig. 20. Notice that its action differs slightly from that given previously in Fig. 18 in that the first clock-pulse low-to-high transition at the start of the conversion sets all bits except the m.s.b. to logic high rather than logic low. If all bits except the m.s.b. are on, the analogue output of the d.a.c. is 1/2 full scale − 1 l.s.b., rather than 1/2 full scale, as in Fig. 18. If the d.a.c. output is less than the analogue input signal the conversion requires that the m.s.b. (1/2 full scale) be switched on and retained and the input connections to the comparator must be arranged so that a high level appears at the D input to the register.

The action of the s.a.r. is such that it causes the logic state which is present at the D input to appear at the appropriate position in the output register and at the DO output pin (serial output) at each low-to-high transition of the clock pulse. At the same time, the level appearing at the output of the next less-significant bit register is set low ready for the next trial.

The 2502 register can equally well be used with d.a.c.s which require a low logic level to turn on their bit currents. It is simply necessary to interchange the input leads to the comparator so that it presents the current turn-on level to the D input of the register. This action can be investigated by using the $\overline{I_0}$ output line of the DAC 08 (pin 2 instead of pin 4) and interchanging the comparator input leads. The $\overline{I_0}$ analogue output current bits are turned on by a low logic level and the digital output obtained as a result of a conversion should now be interpreted as logic low, representing a logical 1. Alternatively, if the positive-high logic interpretation is retained, the digital output code must be interpreted as complementary binary.

The action of the successive-approximation a.-to-d. converter system of Fig. 19 can be investigated experimentally by observing the waveforms which appear at various circuit points during a conversion. In order to obtain repetitive conversions the conversion complete output signal (at pin 2 of the s.a.r.) is connected to the start conversion input (pin 10 of the s.a.r.) and the signal which appears here is used as the external trigger input to the oscilloscope.

To be continued □

Reference

5. H. Taub and D. Schilling. Digital Integrated Electronics. McGraw Hill, 1977.

CIRCUIT IDEAS

L.e.d. mains indicator

A light emitting diode can be used in place of the conventional neon mains indicator which can cause interference. Most of the 240V a.c. is dropped across the capacitor which does not dissipate any power. A resistor is included to limit the current during switch-on/off, and the diode prevents reverse voltage breakdown of the l.e.d. After switch-off the capacitor is normally discharged through the load, but care should be exercised if no load is connected.

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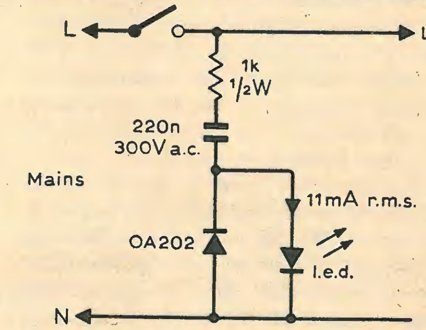

Constant power panning

Stereo mixers usually include one or more mono microphone inputs with a pan control. Fig. 1 shows a basic circuit which requires a ganged control and suffers from a response which declines by —3dB at the centre.

The circuit in Fig. 2 gives a practically constant audio power at any position by closely approaching the condition where $R_1 = R_2/\sqrt{2}$. There is a slight deviation from constant power intermediately between centre and L or R of about 0.13dB but this is negligible. The outputs are buffered by the non-inverting voltage follower stages.

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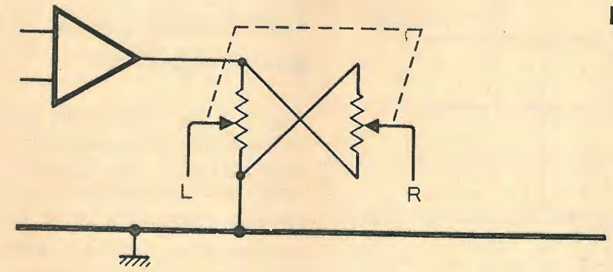

Fig. 1

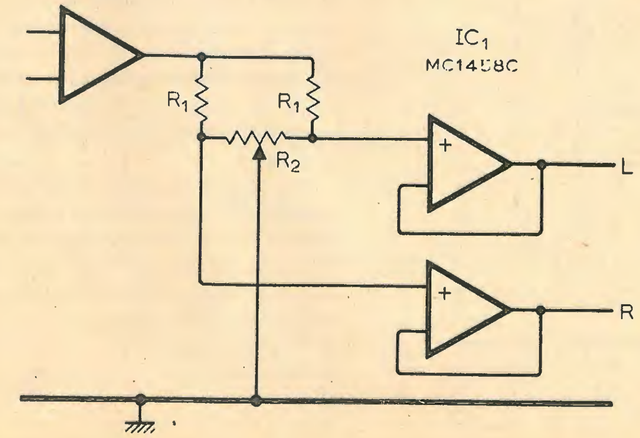

Fig. 2

High voltage regulator

For regulator applications such as the video output stage of a colour monitor, this unit only uses one high voltage transistor and does not use a high voltage Zener diode. Transistor Tr_3 forms an error amplifier which compares the voltage at the junction of R_5 and R_6 with the base of the series pass transistor. Resistors R_2, R_3 and Tr_2 form a current limit. Purists will doubtless observe that the voltage drop across the current sensing resistor is not cancelled by the feedback loop, but this was of no consequence in my application.

E. R. Lisle
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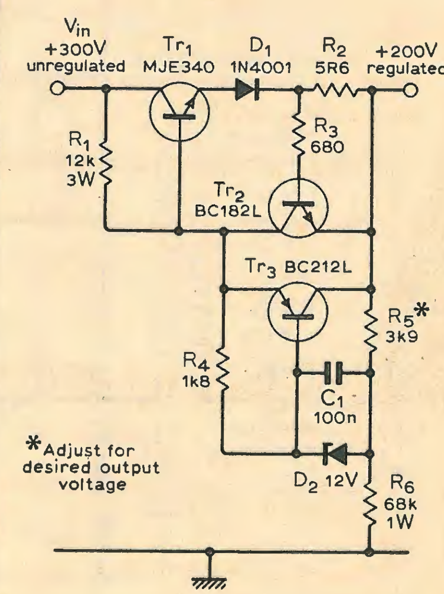

Pulse controlled power dissipation

When operating a three-phase stepper motor at clock rates below 20Hz, a power dissipation problem occurs. For example, if each phase is 15Ω and is on for 50ms when operating from a 28V supply, each winding will develop $28/15\times50\times10^{-3}=13$W.

This can be reduced by switching the motor supply on and off in synchronism with the phase clock as shown. The phase energising voltage is reduced to a holding voltage V_2 which generates enough torque at the motor pinion until the phase pulse is removed.

Transistor Tr_1 and a Zener diode switch the series transistor Tr_2 between 28V and 6V2. The monostable fires on the negative edge of each phase pulse and R_2 in parallel with C_1 causes the base voltage of Tr_1 to decrease exponentially after each 1ms pulse. With this system the dissipation in each phase is reduced to $28/15\times1.2\times10^{-3}$. $=2.24$W.

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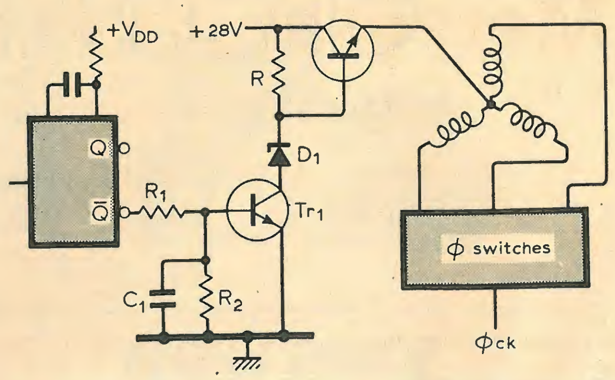

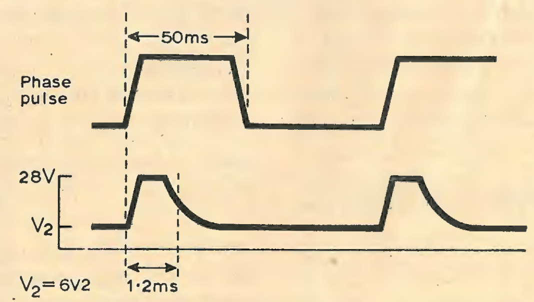

Cascode microphone pre-amplifier

This unconventional pre-amplifier offers low noise, wide dynamic range and stability. To obtain a low noise level it is usual to operate the first transistor with a very low collector voltage. This, however, limits its output and requires a second voltage amplifier. With two transistors the open loop gain is high and this requires a large amount of negative feedback. In the cascode circuit the diodes bias the base of Tr_2 to about 1V and the collector of Tr_1 is thus at about 0.5V. Transistor Tr_1 acts as a current amplifier and therefore the noise contribution of Tr_2 is very small. All of the voltage gain is provided by Tr_2 with its collector bootstrapped, and emitter follower Tr_3 reduces loading on this stage.

Transistor Tr_1 should be a low noise type and Tr_3 should have a gain of about 200. With a nominal input of 60μV into 50Ω, the output is 30mV into a load of not less than 25kΩ and the overload margin is about 45dB.

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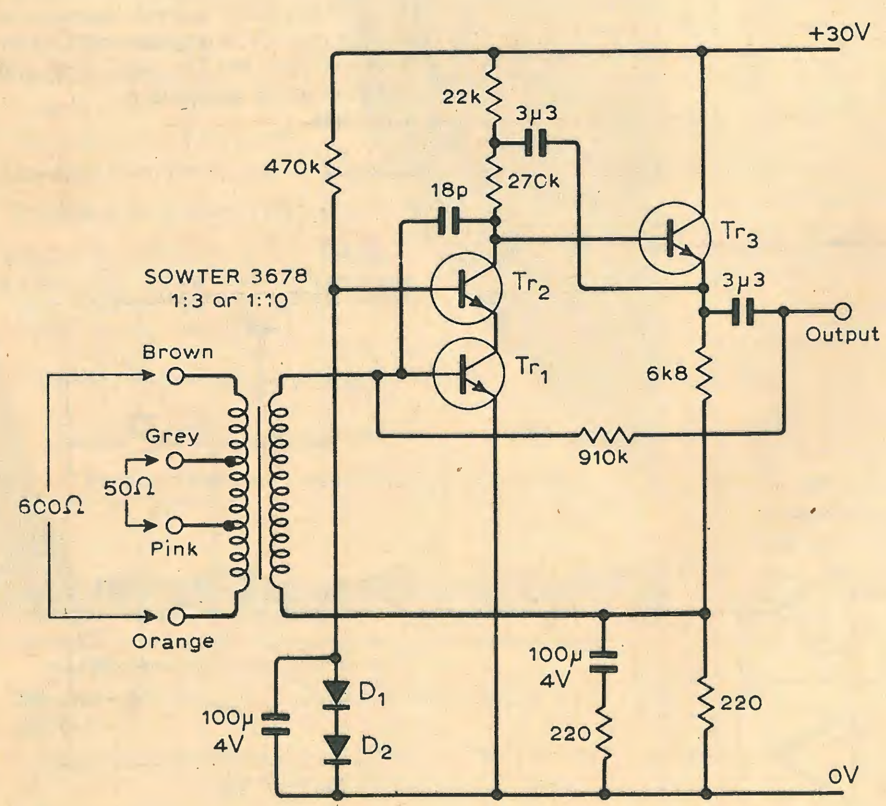
Saffron Walden
Essex



Meteosat earth station — 2

V.h.f. receiver and demodulator details

by M. L. Christieson

The first part of this article described the oscillator, mixer and antenna stages for the s.h.f. section of the Meteosat earth station. It also provided p.c.b. details for the mixer and amplifier circuits used. This second part describes the v.h.f. receiver and demodulator and gives further background information relating to the operation of the satellite.

NO REFERENCE has been made so far to the v.h.f. receiver for 137.5MHz. As shown in the general block diagram, Fig. 1, the receiver consists of a 137.5/26MHz converter and a tunable receiver with an i.f. of 455kHz. Because there are many designs for crystal-controlled converters working in this region, particularly for the 144MHz amateur band, no design is specified here. However, some converters are a little noisy, and a good preamp should be used after the S-band mixer if the noise performance is to be determined mainly by the antenna preamp. Fig. 9 shows the schematic diagram of the preamp used, although there is nothing special about it. The usual screening precautions should be taken in the construction.

The final receiver is a modified commercial type in the prototype system. The major change is the 25kHz i.f. bandwidth which is much wider than a normal 455 kHz i.f. amplifier. This low i.f. was chosen to give a large output voltage swing from the phase-lock-loop f.m. demodulator. The i.f. bandwidth problem, and general nonlinearity, can be improved by using degenerative or frequency compressive feedback, a technique often employed in satellite receiver systems for threshold extension of f.m. demodulators[2]. The circuit diagram of the demodulator is shown in Fig. 10. This uses a phase-lock-loop i.c., followed by a feedback amplifier.

A varicap diode has been added to the local oscillator of the receiver and the control voltage is obtained from the output of the feedback chain. (Automatic frequency control can also be added if required.) The amount of compressive feedback is controlled by a preset resistor. The simple circuit used here is liable to oscillate if too much feedback is used but the desired effect can be obtained before the onset of such oscillation. Amplification at sub-carrier frequency is achieved using operational

Fig. 9. *Circuit diagram of the 137MHz preamplifier used between the mixer and converter to increase the signal-to-noise ratio at the converter output.*

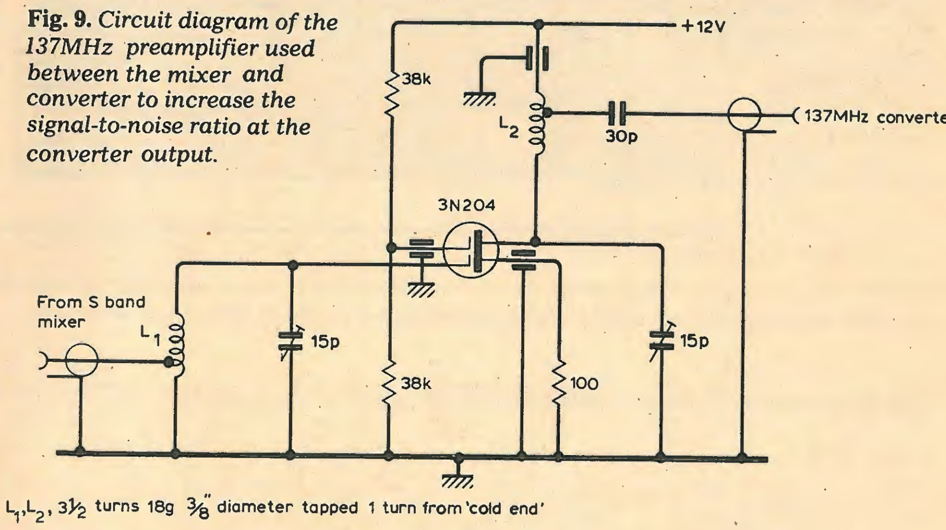
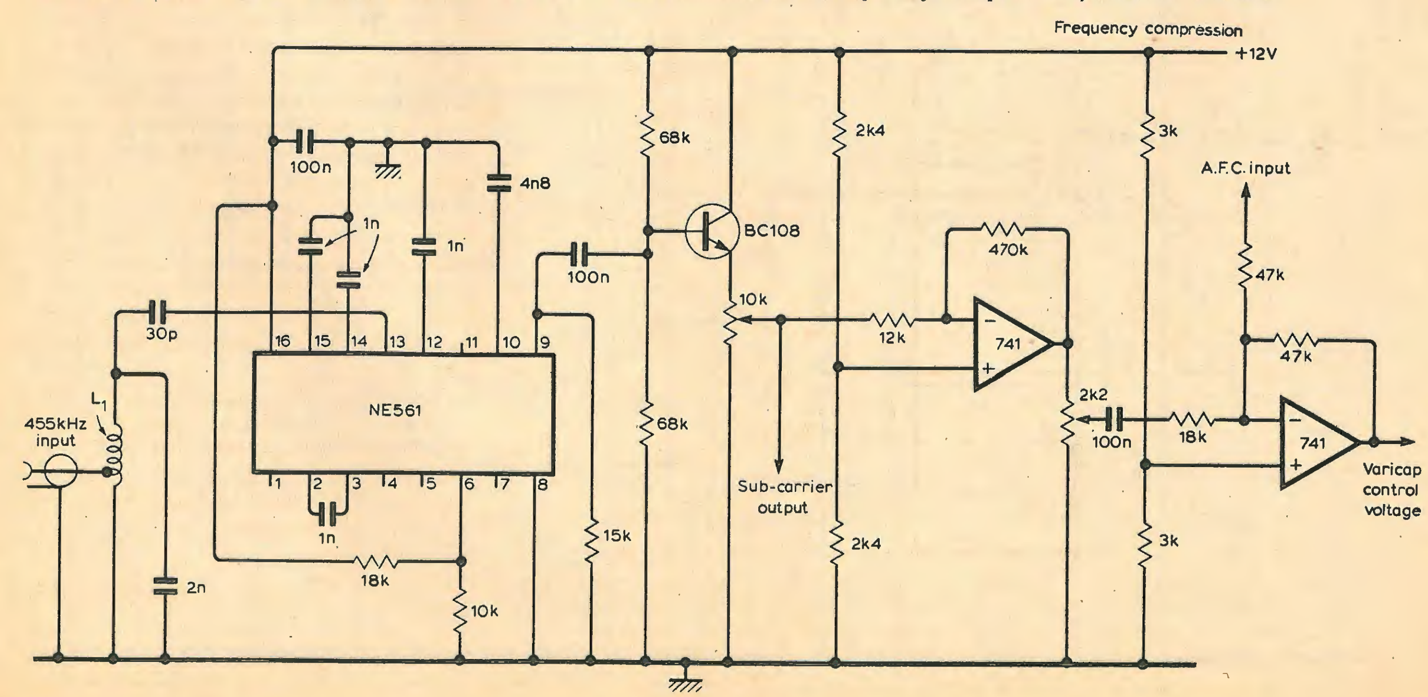


Fig. 10. *F.m. demodulator and frequency-compressive feedback circuits.*



amplifiers. These are arranged to work on a single supply to make interfacing with the other equipment easier. The output from the demodulator is the amplitude-modulated 2400Hz sub-carrier.

Several methods have been described for amplitude demodulation of the sub-carrier. This system uses the sample-and-hold method described in a previous design for A.P.T.[3]. To obtain high quality pictures some signal processing is necessary. This is most easily achieved before the sample and hold stage and also means that a.c. coupling can be used in the processor unit. The modulation characteristics are different according to the type of picture being radiated. Two switched positions are available on the contrast expander, one for visual, and one for infrared and water vapour. After expansion the signal is passed to a variable gain amplifier for setting the required contrast.

Fig. 11 shows the circuit diagram of the contrast expander and amplifier and includes expected waveforms. The presets controlling the diode bias must be adjusted to give equal positive and negative peaks on the output waveform, while maintaining the required centre dead-band. The video bandwidth, as shown in the modulation characteristics, is approaching the sub-carrier frequency. On an initial test, only positive peaks of the sub-carrier were sampled. A modification was incorporated such that both positive and negative peaks were sampled, resulting in better picture definition due to the increased sampling rate. The circuit shown in Fig. 12 is a precision full-wave rectifier, with a preset to ensure the minimum of modification to the dead-band characteristic. These should be set in conjunction with the diode bias presets in the expander to give equal pulse heights derived from both positive and negative half cycles of the sub-carrier at all input amplitudes. For this stage, a single-ended 24V supply is used because the peak levels are quite high. If the signal is applied directly to the sampling stage, noticeable 'whiting out' occurs on pictures when the contrast is set high enough to display geographical features. It is necessary, therefore, to compress the white portion of the signal. Various methods were tried but the most successful was the circuit shown in Fig. 12, which has the advantage of a variable compression characteristic. When there is no signal the compression transistor should be just switched off by means of the diode chain voltage drop. The output then follows the input for small signal levels quite closely. As the signal becomes larger, the compression transistor switches on and forms the lower end of a potential divider and this reduces the output level proportionally to the input signal as set by the preset. Sufficient compression can be applied to leave some variation in cloud (peak white) while expanding the grey land areas. This applies to the visual pictures and to a lesser extent to the other two types. The compressor is left in for all pictures. The output, which is d.c. restored as the signal is not symmetrical, is applied to the sample-and-hold stage in Fig. 12. This is a modified version of the previous design[3].

The sample pulse generator appears in Fig. 13. The signal is derived from the amplified sub-carrier output in the expander. It is limited and filtered to ensure solid locking at very low black levels when the signal to noise ratio is worst. The preset in the filter adjusts the phase shift and must be set such that the sample pulses coincide with the sub-carrier peaks. A phase-lock loop is

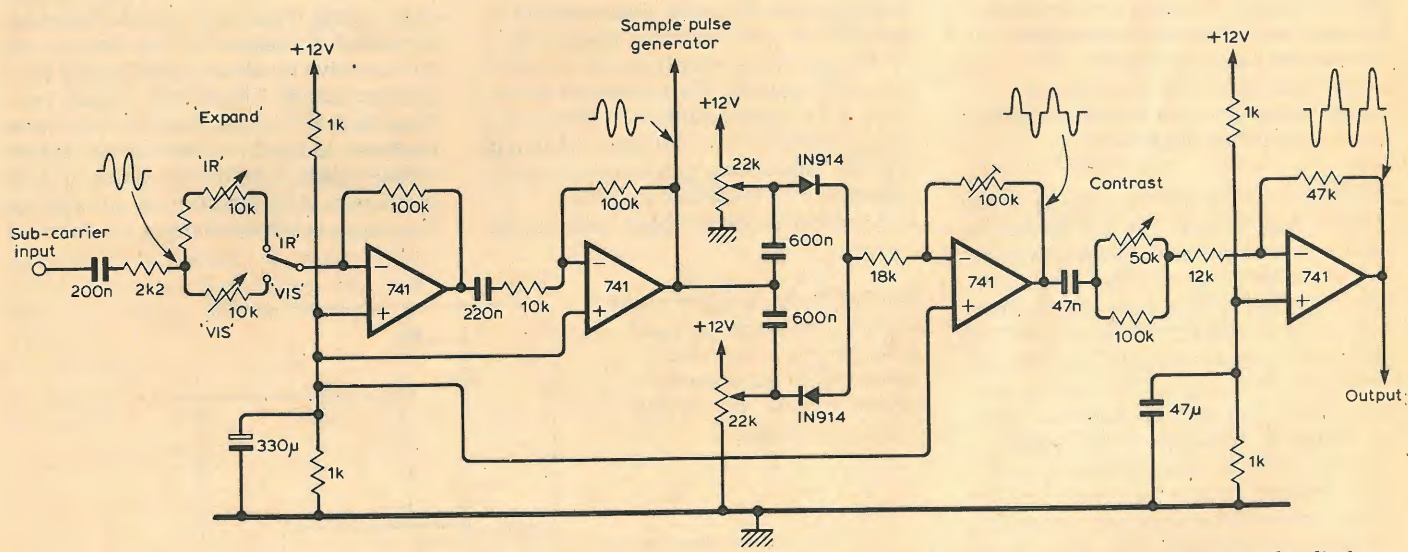
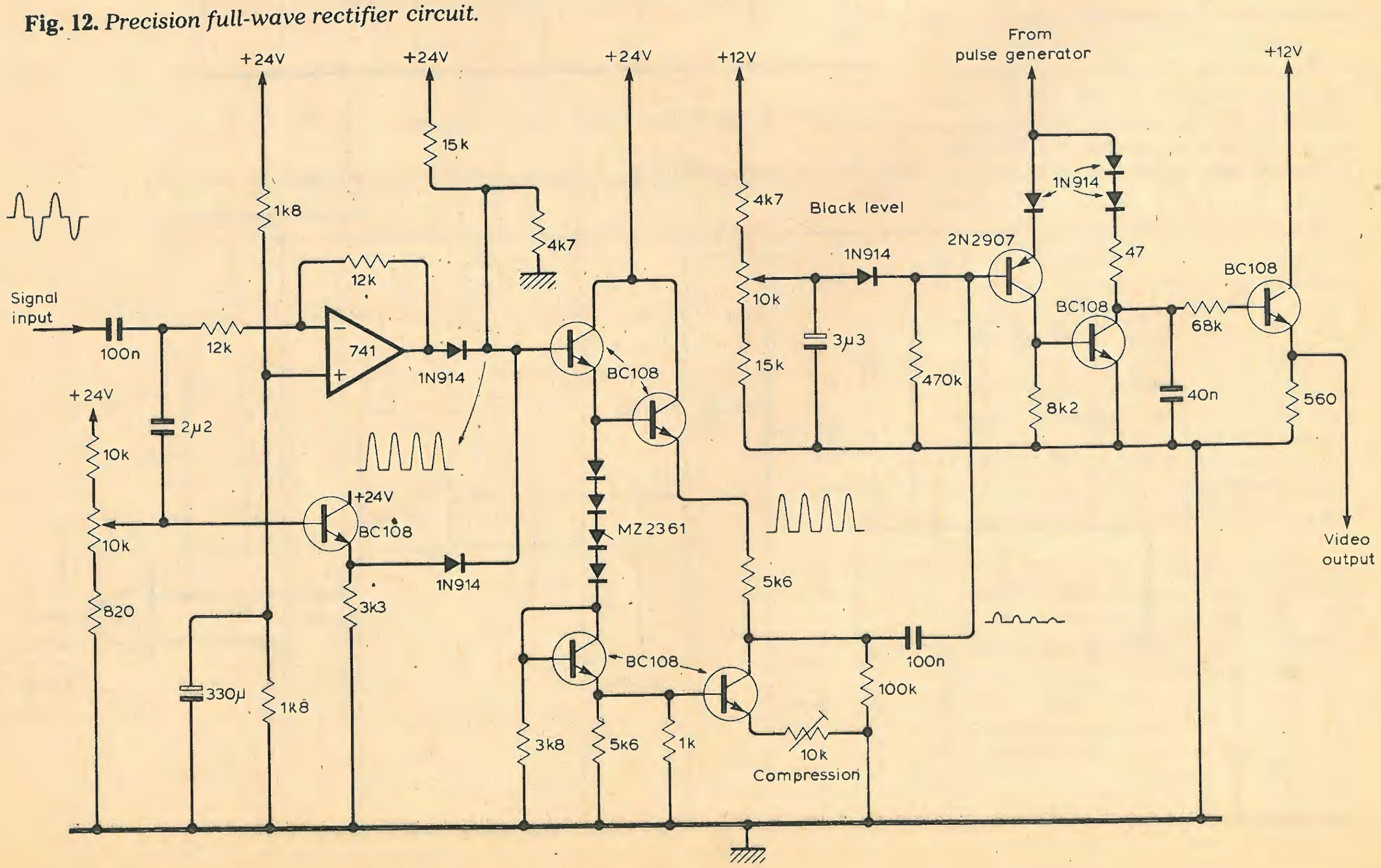
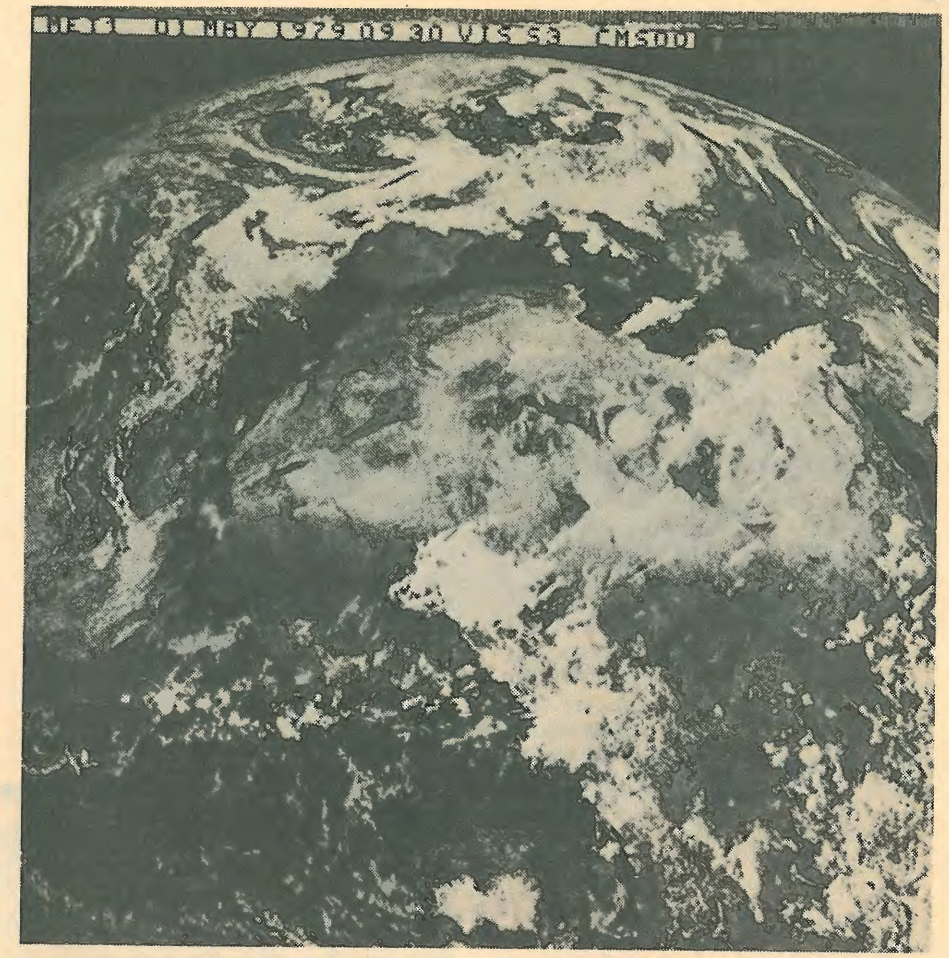


Fig. 11. *Circuit diagram of contrast expander and amplifier, showing expected waveforms. The presets controlling the diode bias are adjusted to give equal positive and negative peaks on the output waveform.*

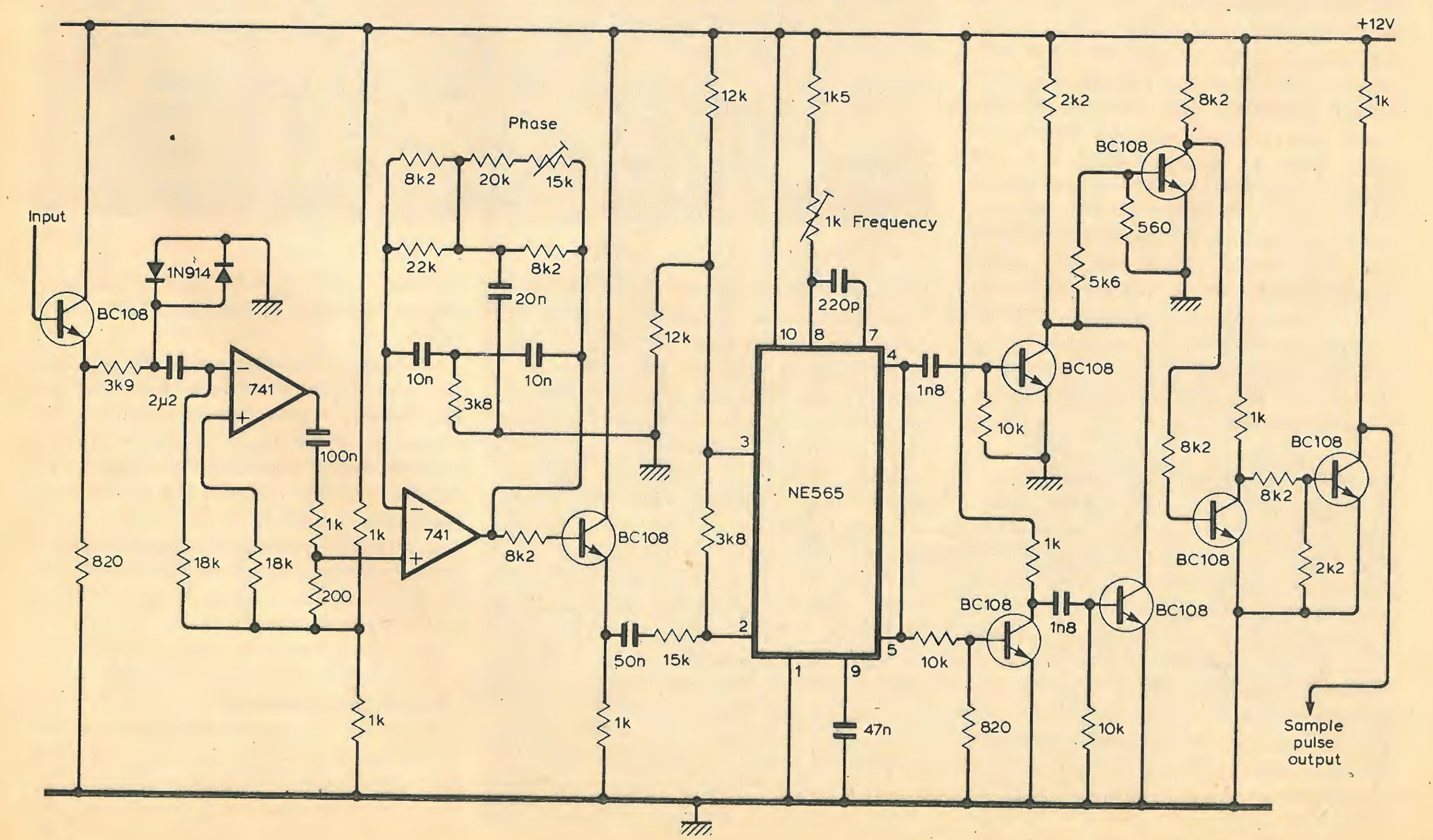
Fig. 12. *Precision full-wave rectifier circuit.*





Visible picture taken on May 1, 1979 using the author's new seven-foot diameter dish antenna. Area shown is only a portion of the area covered by the satellite camera. See "Modifications" on page 97.

Fig. 13. *Circuit diagram of the sample pulse generator.*



locked to the filtered output and the square wave edges from it generate the pulses required. These pulses are then squared up by the succeeding stages and applied to the sample-and-hold detector. The output from the detector is a waveform of IV pk-to-pk (positive polarity) and is taken via an emitter follower.

Meteosat pictures taken in September 1978 using the author's four-foot dish antenna.

Picture printing technique

There are several ways to produce a hard copy image from the video output. Two methods suitable for amateur construction have been described fully in previous articles [3, 4, 5]. They employ rotating drums and oscilloscope tube photography and are both capable of producing excellent results. The video output must of course be interfaced with the selected system. The prototype described here uses a Mufax wet-paper facsimile machine, converted for the correct speed, and a rebuilt picture-writer amplifier. This has the advantages that pictures can be inspected while they are being printed, and the images produced are somewhat larger than those produced by the photographic processes. Whichever method is used, the phasing signal and line speed will have to be set to suit the Meteosat A.P.T. The picture has an aspect ratio of 1:1 or an index of cooperation of 267.

The entire video chain is finally adjusted on test to produce the most pleasing pictures.

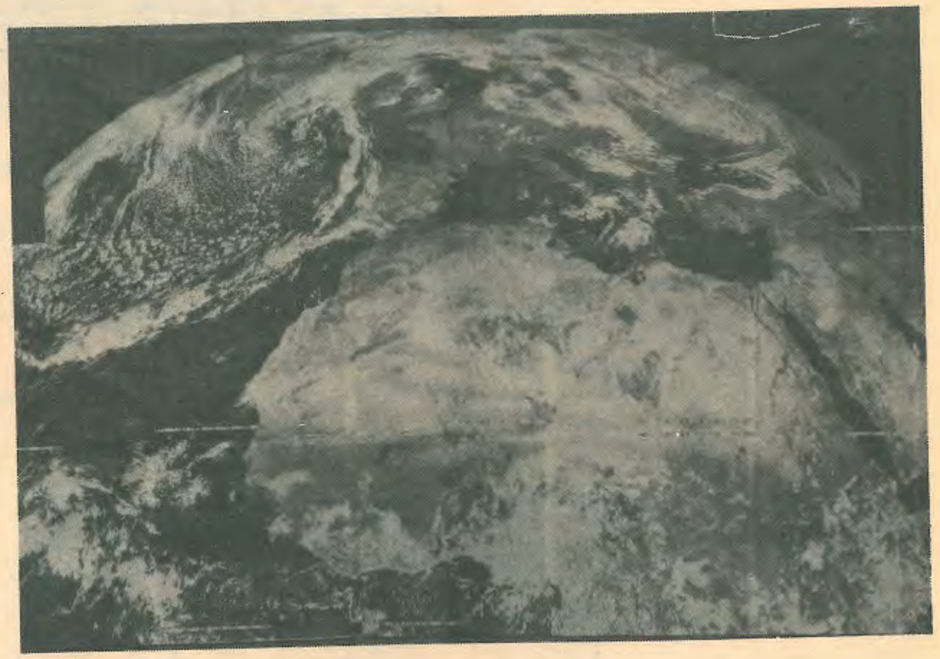
Table 2. Coil details. All dimensions in inches. The **local oscillator coils** L_1 to L_9 and the relays RL_1 and RL_2 in the table below are shown in Fig. 7.

Coil	Turns	Dia.	Length	Wire SWG	Tapping details
L_1	6	0·25	0·5	22	3t from collector
L_2	8	0·25	0·5	22	7t " "
L_3	3	0·4	0·5	18	2t " "
L_4	3	0·4	0·5	18	Centre tap
L_5	Copper plate 14SWG. 1·2 long, 0·25 wide tapped at 0·6 and 1·0 from cold end				
L_6	1	0·4	0·2	18	———
L_7	Copper plate 14SWG 0·8long 0·4 wide				
L_8	" " " " 0·6 " 0·35 "				
L_9	" " " " " " " "				
RL_1, RL_2	Dual in line reed relays, energised for channel selection.				

The **mixer coils** L_1 to L_3, shown in Fig. 4, are fabricated on 1/16 E10 glass-fibre board, with the earth plane retained.

L_1, L_2 } 1 turn, 36 SWG wire 1/16 diameter r.f. chokes.

L_3 6 turns, 18 SWG wire 3/16 diameter, 3/8 long



Satellite operation characteristics

Although Meteosat runs a daily schedule, due to the experimental nature of the system at this time, it is subject to change and occasional interruptions. Each hour is divided into four-minute periods, the first starting at 2 minutes past the hour and the last starting at 58 minutes past the hour. A particular picture will occupy one of these slots and will start at the slot time and end 30 seconds before the next slot time. The carrier is not radiated when no picture is scheduled. Pictures in digital form conform to a different standard and can be recognized by the apparently unmodulated carrier and pulsed sidebands. At certain times of the day a test pattern is radiated, and at other set times 'Administration Notices' are transmitted containing operational information such as schedule changes. A greater number of pictures are transmitted during daylight hours when the visual images are sent. A complete set of visual images are usually sent once a day enabling a composite picture of the world to be constructed. Pictures of the European area are sent more often. Regular sets of nine infrared and water vapour pictures are sent to enable a composite world picture to be constructed.

Exact schedule information can be obtained from the European Space Agency at the following address: Meteorological Operations Manager, E.S.O.C. — M.D.M.D. (MET), Robert Bosch Strasse 5, 61 Darmstadt, W. Germany.

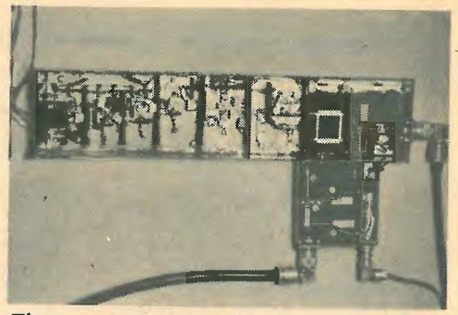
Although the system described is for the European Meteosat, there is no reason why the frequency cannot be changed slightly to receive other meteorological satellites operating in S band over other parts of the world, the American GOES for example. It is intended that a series of five satellites will provide pictures of all parts of the world in the next few years, Meteosat and GOES being the first.

Acknowledgements

I would like to express my thanks to Mr J. Morgan, European Space Agency Met. Operations Manager, Darmstadt, for supplying Meteosat operations information, and his detailed replies to individual questions: to Mr J. Berden, G3RND, for initial information on Meteosat; to my colleagues at Feedback Instruments Ltd for their encouragement during the project, and to Mr A. P. Turnball, G4CUS, who helped me erect the antenna dish.

Modifications

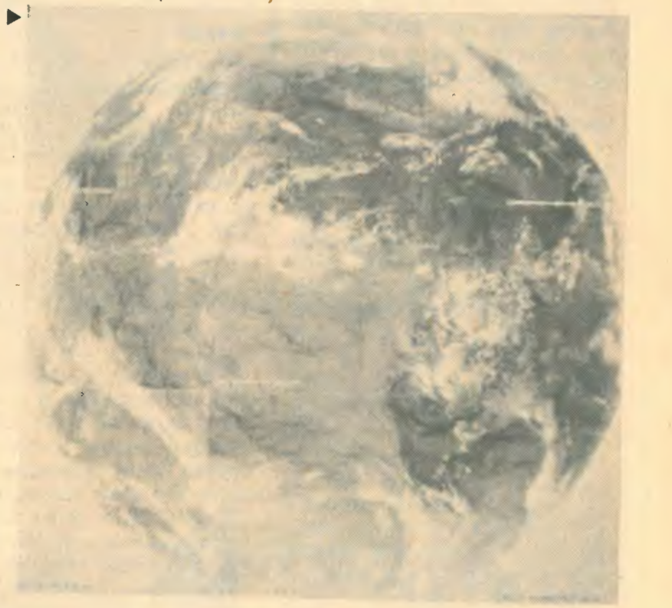
Since the author wrote this article he has made some modifications to his own Meteosat station. These have significantly improved the picture quality but have unfortunately also increased the component cost. The phase-lock-loop circuit in Fig. 10 has been changed to incorporate a Plessey SL650. This has improved subcarrier linearity, and thus the performance of the frequency-compressive feedback circuit. In order to further reduce the signal noise, which produces faint 'smudges' on the picture, he has replaced the four-foot-diameter dish antenna with one measuring seven feet in diameter and replaced the dipole antenna with a waveguide-fed horn antenna. A picture produced using the modified station is shown on page 95. This picture demonstrates the wide coverage area which Meteosat can provide because of its high 'orbit' height.



The converter (also shown in schematic form in Fig. 8, Part 1). Picture clearly shows the mixer and preamplifier (far right) and the oscillator and tripler stages (left). The prototype is not fitted with covers.

◀ *Four-foot diameter dish antenna used by author on his Meteosat earth station. Dipole and reflector can just be seen mounted at the dish focus.*

A composite infrared picture of hemisphere received during September 1978 on the author's four-foot diameter dish antenna. ▶



References

2. Tant, M. J., Automatic characterisation of satellite earth stations, *Marconi Instrumentation*, Spring 1978.
3. Kennedy, G. R., Weather satellite ground station, *Wireless World*, Nov. 1974 to Jan. 1975, Weather satellite picture facsimile machine, *Wireless World*, Dec. 1976 to March 1977.
4. Sollom, Rev. P. W., Just look at the weather, *Radio Communication*, Nov. to Dec. 1971.
5. Specialized communications techniques, American Radio Relay League, p83.

Notes on Part 1.

The polarities of the two MBD102 diodes in Fig. 8 should be as per Fig. 4. Ref. 2 on page 61 should read Ref. 1.

Mike Christieson is 24 and is currently working as a development engineer for Feedback Instruments Ltd. Prior to this he worked in the broadcasting field and served his apprenticeship with the broadcasting division of the Foreign and Commonwealth Office. He then spent a short period of time in the USA and thereafter he was responsible for modifying and commissioning transmitters installed at sites in Iran — the Afghanistan border — and also in Venezuela and Nigeria. Mike is a radio amateur with the call sign G8FCD.

NEW PRODUCTS

Electret pick-up cartridge

Claiming that it is the first electret disc-playing cartridge to be introduced in Europe, Toshiba maintains that its Aurex C-400 cartridge offers certain advantages in terms of transient response and lower than usual levels of distortion. The principle of operation permits the stylus cantilever itself to act as the moving electrode with two electret cells feeding a specially-developed linear i.c. which is contained within the cartridge body. This results in movements of the stylus being converted directly into electrical energy, obviating the inherent distortion which results from the larger mass of the moving magnet type. Output signal level is 30mV (at 1kHz and 3.54cm/s), frequency response (before equalisation) is flat from 20Hz to 35kHz, channel separation is 30dB and the recommended load is 30kΩmin. The cartridge operates from a d.c. supply of 6 to 9V and tracking force is 1.5g. An equaliser should be used in conjunction with this cartridge and Aurex offer the SZ-1000 unit for this purpose. Harmonic distortion is 0.005% over the frequency range 20Hz to 20kHz at the equaliser's rated output of 500mV. Development of the new cartridge began in 1972 and the built-in i.c. pre-amplifier clearly accounts for the final s/noise ratio of 70dB and the claimed flat frequency response from d.c. to 100kHz, after equalisation. Aurex Division of Toshiba (UK) Ltd., Frimley Rd., Frimley, Camberley, Surrey, GU16 5JJ.

WW 301

High power M.O.S.F.E.T. audio amplifier

If the quoted technical specification is anything to go by, the SR402 power f.e.t. audio amplifier lives up to some of the popular expectations of equipment using such devices. This amplifier is in production by Pace Studio Equipment and the specification indicates a power output of 250 watts "r.m.s." per channel into 8Ω. Coupling is d.c. throughout, although internal capacitors may be switched in so as to limit

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potentially speaker-damaging frequencies below about 20Hz. However, the amplifier is expected to operate in the a.c. coupled mode in normal use. Other performance details include a frequency response of 20Hz to 20kHz (+0 and −0.2dB) when a.c. coupled and total harmonic distortion of less than 0.008% (measured at 1kHz and 200 watts into 8Ω). Hum and noise are both claimed to be −110dB referred to maximum output. The amplifier is also provided with twin l.e.d. columns labelled "peak watts" in 6 notches up to a maximum of 200. Since the peak output (which may only be of short duration) would indicate a figure well in excess of the claimed 250W "r.m.s." output, the designation "peak" appears to have little relation to the true output power. Rear panel switching permits the unit to operate in the bridged mono mode, in which case more than 500 watts continuous should then be available. Pace Studio Equipment Ltd., 32 Tresham Road, Orton Southgate, Peterborough, Cambs.

WW 302

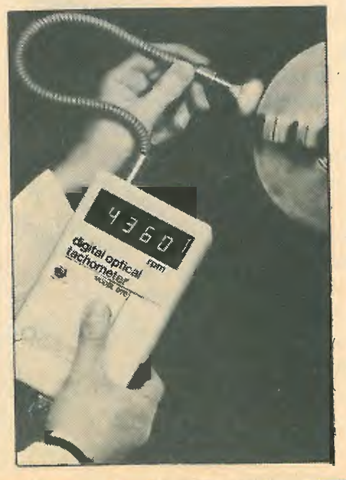
4k STATIC n-mos r.a.m.

Unlike dynamic r.a.ms or earlier pseudo-static devices, the Motorola MCM6641 requires no clock pulses, timing strobes, precharge or refresh actions, thereby reducing to a minimum the number of devices required in a memory array. This new device is claimed to be totally free of the system timing problems exhibited by many m.o.s.—r.a.ms. Its static operation allows chip selects to be tied low in small arrays and data access is made particularly simple as there are no address set-up time restrictions to be observed. Output data has the same polarity as input data and the device is organised on a 4096 × 1 bit basis with separate input and output data pins. Operation is from a single 5V supply with a power dissipation of 550mW (typical) or 385mW where the MCM66L41 is used, standby power dissipation being 125mW. A range of access times from 200ns to 450ns ensures that the device can be used with all popular microprocessors and it is t.t.l. compatible. Packaging is 18 pin d.i.l. with industry-standard pin-out. Motorola Ltd., Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex HA9 0PR.

WW 303

Fibre optic tachometer

Measurement of the speed of very small shafts and shaft diameters in remote locations is made relatively simple by means of an add-on unit for a direct-reading tachometer. The D20 digital tachometer, manufac-



tured by Graham and White, now includes a fibre optical fibre extension probe which enables a beam of light to be projected on to the rotating surface. Light pulses, reflected from a strip of suitable tape, are accepted by the single lens reflex system in the instrument; these are ultimately displayed as a numerical reading. Measuring range is from 50 to 20,000 r.p.m. with typical accuracies of ±2 r.p.m. at 5,000 r.p.m. After a measurement has been made, the last reading can be recalled by pressing the memory button. Graham and White Instruments Ltd., 135 Hatfield Road, St. Albans, Herts AL1 4LZ

WW 304

CB receiver/monitor

What is believed to be the first commercially-produced citizens' band receiver in the UK is now being marketed by Chromatronics. The manufacturer claims that it is "useful in war-

ning operators of radio-controlled models of any potential sources of interference on the 27MHz waveband, including illegal citizens' band radio transmissions, other radio modellers or even sunspot activity. The early detection of such interference sources can help to prevent expensive models being "shot down" or sent out of control." The "Bristal" is a 3 band superhet receiver with facilities for tuning over the whole of the 27MHz model control band, as well as receiving broadcast a.m. (medium wave) and f.m. transmissions. Clearly, this receiver can also be used to check the operation of model control transmitters. The unit is portable and weighs 0.45kg (1lb) and is powered by a single 9V battery. It has a built-in 76mm loudspeaker and a jack is provided for earpiece use. The price is £17.95 including v.a.t. and post and packing. Chromatronics, Coachworks House, River Way, Harlow, Essex.

WW 305

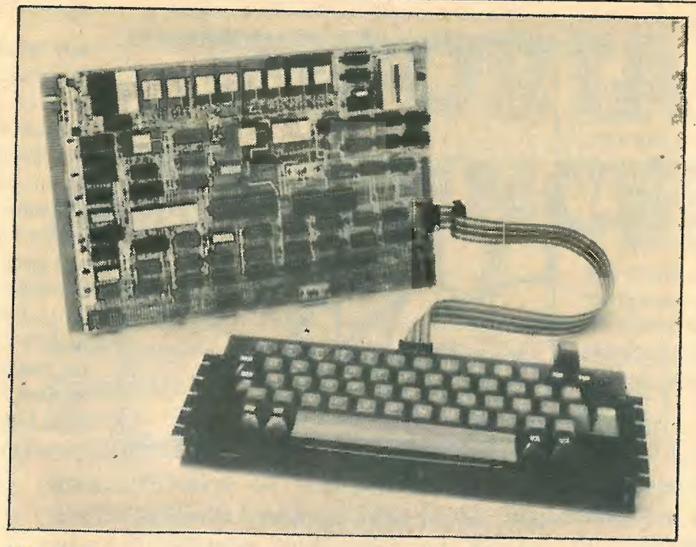
Home computer

The introduction of the Nascom 2 microcomputer marks a further development of this company's popular Nascom 1 home computer. The more powerful version also uses the Z80 processor and is equipped with a new 2K monitor known as Nas-Sys 1, a 1K video r.a.m., a standard 8K microsoft Basic r.o.m., and an 8K static r.a.m. The computer is assembled on a single 305×203mm p.c.b. and all of the bus lines are compatible with the existing Nasbus. Serial operation for the on-board cassette and teleprinter interfaces is handled by a u.a.r.t. whose input and output are independently switchable. Nascom 2 also incorporates an uncommitted parallel i/o which gives 16 programmable lines, addressable as 2 × 8-bit ports. A 2K r.o.m. socket is provided for a graphics option which is software selectable and is based on a 96 × 48 point grid. The basic Nascom 2 is priced at about £295 + v.a.t. Nascom Microcomputers Ltd., 121 High Street, Berkhamsted, Herts.

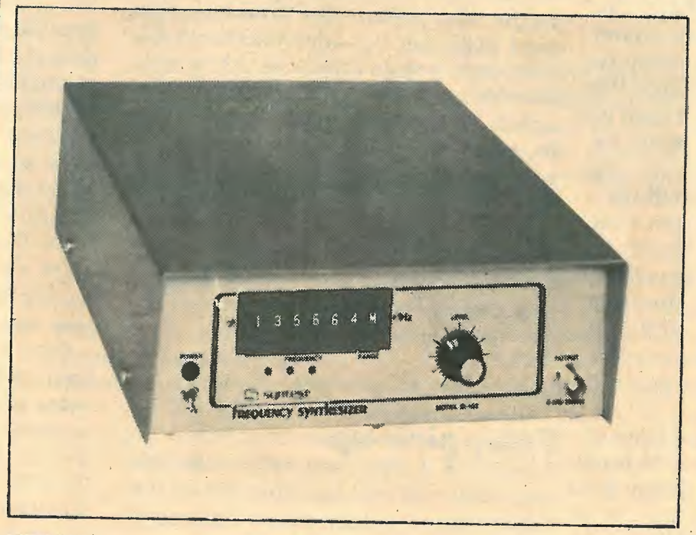
WW 306

Frequency synthesiser

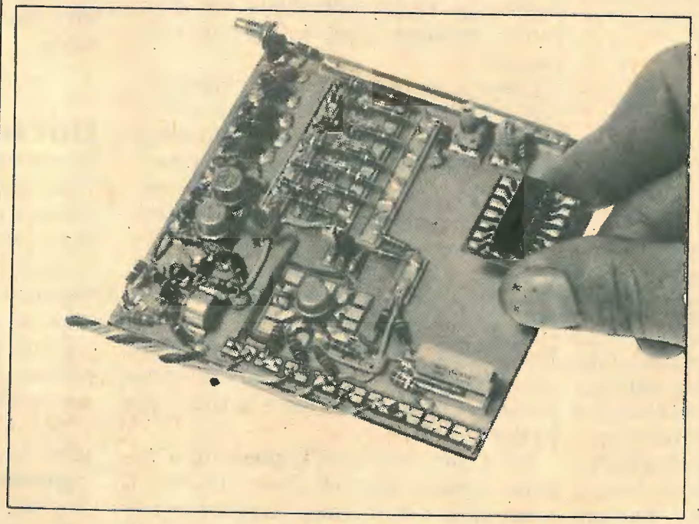
Covering a frequency range of 0.1Hz to 16MHz with 5½ digit resolution, the Lyons Instruments' "Syntest" frequency synthesiser instrument (SI-102) and a basic module (SM-102) are available at "a fraction of the cost of other products." Output is a square wave, with a sine wave converter available as a further module to provide low distortion sine (as well as triangle and square) output over the range 0.001Hz to 160kHz. This amounts to 1/100 of the synthesiser output frequency. Possible applications of the units include testing of audio and power circuits, r.f. transmitters and receivers, filters, psychological and acoustic studies etc. A particular application for the sine wave converter is variable mains frequency drive, where the synthesiser is set in the region of 5kHz, so providing a highly stable output variable in steps as fine as 10 millihertz or even down



WW 306



WW 307



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to 1 millihertz The SI-102 is a self-contained instrument priced at £425 while the SM-102 module is contained on a 110 × 165mm card priced at £295. Some lower cost 4½ digit resolution models are also available and the SM-010 sine wave converter costs £180. Lyons Instruments, Hoddesdon, Herts.

WW 307

Printed circuit breadboard

The act of converting a circuit design to the final printed board presents a number of problems and in most cases the practical results differ from the theoretical expectations. The Wainwright Mini-mount is a novel breadboarding system which consists of 23 different small printed circuit elements with pressure-sensitive adhesive on one side and an etched pattern of solder pads on the other. Components are soldered to the pads, the backing is removed and the circuit element is placed in the most practical position on a flat surface. In this way, a layout which very closely resembles the final version can be obtained and circuit performance quickly estimated. Tinned, copper-clad boards are available as a ground-plane base and stray capacitance to ground is claimed to be very small — comparable with that of a double-sided printed circuit. An advantage of the method is that each mini-mount can be used again, thereby saving components for re-use and in addition to easing prototyping problems the system can be used in the electronics hobby and educational fields. Wessex Electronics, 114-116 North Street, Downend, Bristol BS16 5SE.

WW 308

Cordless soldering iron

Service engineers literally "working in the field" should find the new Cordless gas-operated soldering iron from Kam Circuits a reasonable temporary substitute for the heat generally available from the mains. The iron operates for about two hours from a standard lighter fuel pressure can, and 80 watts equivalent heat is generated safely by a no-flame catalyser combustion process. The iron is self-igniting, temperature-controlled and is designed in such a way that it will not touch any surface on which it is placed at rest. Kam Circuits Ltd., Porte Mash Road, Calne, Wilts.

WW 309

Schottky diode switch

Switching speeds of better than 2ns and a bandwidth up to 500 MHz are features of a new solid state electronic switch recently introduced by Hatfield Instruments. This device is designated Type 2551 and is a single throw (s.p.s.t.) Schottky diode switch designed for remote switching applications. The specified operating temperature range is −55°C to +70°C and the on-off ratio is typically 80dB at mid-band. The unit is packaged in a standard relay header enclosure and is hermetically sealed as well as being shielded against electromagnetic interference. Hatfield Instruments Ltd., Burrington Way, Plymouth, Devon PL5 3LZ.

WW 310

SIDEBANDS by Mixer

Pub crawl

I suppose we've all heard the one about the motorist's insurance claim which stated quite categorically that his car had been struck in the rear by a stationary tree. Well, it might not be as funny as all that, because one or two of these mobile plants have been discovered in America, according to reports from the land of the free. Free? Traffic cops over there seem to have been a bit free with their traffic radar, it appears, because they have been observing trees doing an illegal 85 mile/h and the odd house loitering about at a contemptible 26 mile/h.

This had led to a lot of aggrieved drivers claiming to have been mistaken for motels and high-speed oak trees, to the consternation of police and judges. The standard type of radar used in the States is of the hand-held variety, aimed down the road, and while these seem to be reasonably accurate instruments, the common view is that they aren't used in the proper way. They can also be affected by electrical installations and large, stationary objects like buildings.

The Home Office here point out that the Americans use 100 mW of transmitter power, which is ten times as much as that used over here, and think that this may have something to do with the somewhat extravagant claims for mobility in otherwise unexceptional inanimates.

British police tend to use the Marconi Peta, which is an across-the-road type, but the American Muniquip down-the-road instrument is also in use in a reduced-power form. Individual forces decide which equipment to use in their own areas.

Tit for tat

Those readers of this journal who pause briefly on the preceding two or three pages to their natural goal — this page – will find a reasonable mixture of new components, instruments and tools, selected in a way we think will interest them.

We are not noticeably short of material for the new products pages, since we receive, on the average, around twenty press handouts per day, or perhaps four hundred a month which can be considered for inclusion and any amount which are unsuitable. Those have to be screened and selected down to the few that are printed, having first been re-written, with an inevitable wastage of 95%.

All this is really self-defence. It is intended as a blanket reply to manufacturers whose press handout hasn't been selected and who ring up to ask why we haven't written a piece about their new breakthrough in grommet design, because it ought to have been, since they advertise in *Wireless World*. Selection of new products is solely on the basis of interest or enlightenment and has nothing whatever to do with advertising in any way. The people who prepare the product pages don't even see the advertisements before they are printed, or have any knowledge of what ads. are to be inserted. There, that's plain enough. Perhaps we will now receive a few less handouts which describe the new bit of gear and then go on to say "I feel sure this will interest your readers and by the way, please send your ad rates," thereby implying that if it is selected, the company will advertise.

Stray pick-up

Confession, so they say, is good for the soul. Well, my soul can do with all the help it can get, so here goes – I'm one of those people who peer over your shoulder in the train, trying to see what you're reading. There! I feel better already.

I also listen to snatches of conversation and, although it has been remarked that eavesdroppers never hear anything to their credit, they do have the consolation that what they do hear can make a perfectly ordinary, spirit-dulling train journey almost worthwhile. Either electronics is a more widely recognised art form than I had supposed, or the majority of practitioners of the art head south early every evening, but whatever the reason there's usually some conversation on the subject in the 17:33 to Epsom.

It's a pity they won't speak up a bit more though, because from the bits I hear, their little chats sound fascinating. The man I heard to declare "It uses op-amps that glow" clearly had something of importance to disseminate and if only I hadn't trodden on someone's toes in my excitement, thereby losing the rest of his dissertation, we might all be much wiser today.

There are moments of pathos, of course. One's heart goes out, for example, to the poor wretch who, it appears, "had his ear fixed to the wall" . . . Now, I'm not too clear on the precise method adopted here, neither am I certain whether the unfortunate was still an integral part of his ear at the time, but the whole business struck me, I remember, as hardly the sort of thing one would normally wish to broadcast.

One can actually learn quite a lot, in a random way, from the isolated little moments of revelation. I now know, for instance, that ". . . a.m. is yer ante meridian, ennit?" Well, of course, so it is, and if the propounder of this theory hadn't been looking for Capital Radio on the medium-wave band at the time, I would have been in absolute accord with him. I suppose he reserves v.h.f. for the afternoons.

Jumbo radio

If any visitor to Windsor Safari Park has been surprised at the sight of a warden, rifle at the trail, galloping along and trying to fly, I can explain. He has quite possibly just picked up a message on his personal radio, advising him that he is clear to take off on Runway 28 Left. They have been having problems at Windsor, it seems, with transmissions from Heathrow, which is only eight miles away. So much so that they are having a new Burndept system with tone squelch to get rid of the intrusions.

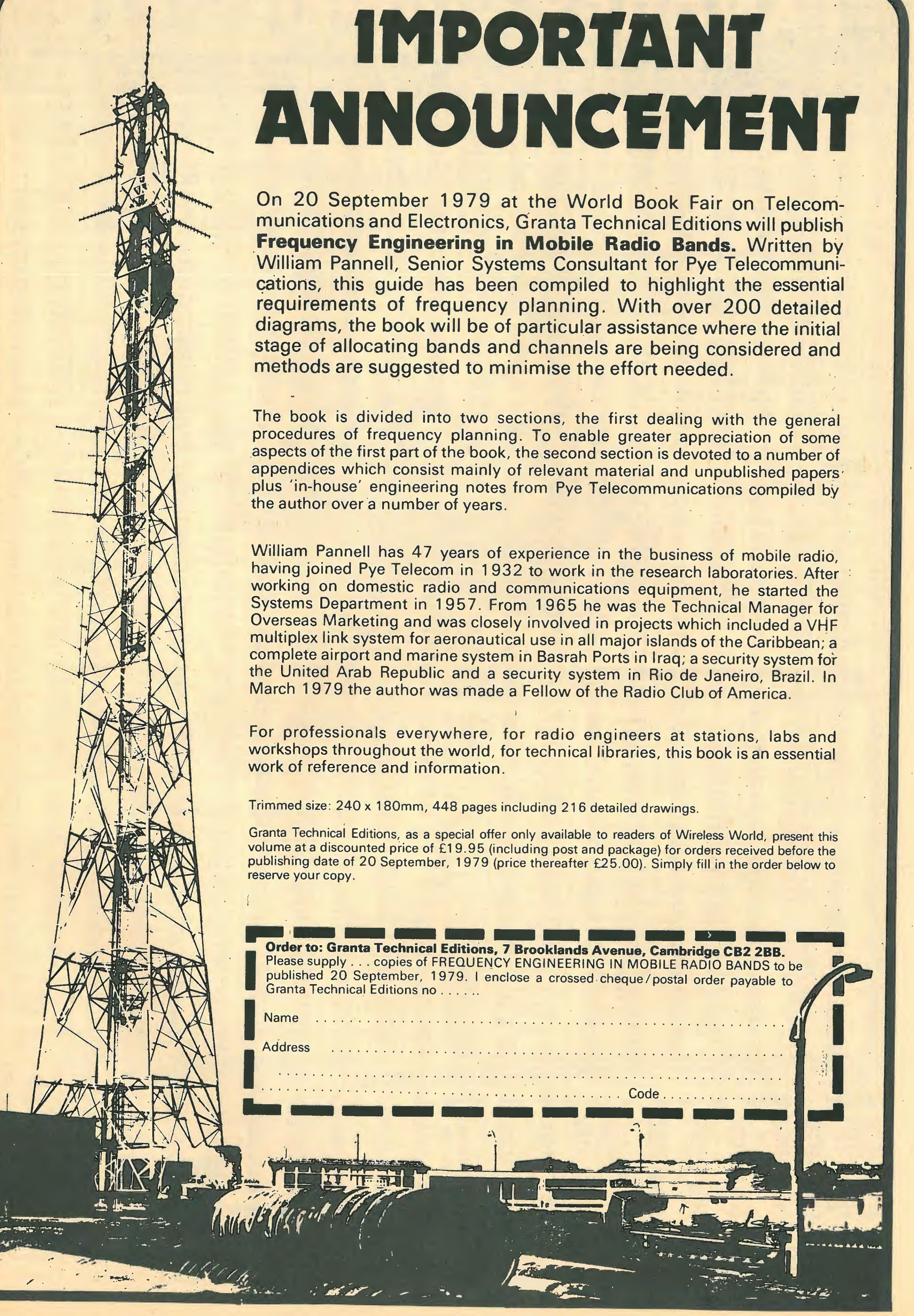
One wonders whether the interference has been a two-way problem. Many pilots of large airlines would want to check the accuracy of an instruction to switch on their headlights and wait for assistance in the event of a breakdown and would find little to argue with in an exhortation to refrain from winding their windows down, particularly when lions are with twenty-five yards.

Hot news

Devotees of J. B. Morton will remember with affection his life's work – the compilation of the list of Huntingdonshire Cabmen, published with becoming modesty under the nom-de-plume of Beachcomber. Those who regret the lack of a sequel to this absorbing chronicle of stormy, home-counties passion will be overjoyed to hear of a new work by a yet unrecognised author – the Complete Bibiliography of Hot-Wire Anemometry – said to be the most complete work of its kind in the world. The publishers feel that this bibliography may well be unique, and define the readership as being "anyone involved in hot-wire anemometry."

I think it very likely that it is unique. And it will be extremely difficult to surpass this feat, although the forthcoming guide to Victorian Manhole Covers in Greater London should run it a close second.

The bibliography appears in TSI quarterly, obtainable from Biral, P.O. Box 2, Portishead, Bristol, whose forgiveness I now ask. □



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AF186	1.30
AF239	0.49
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AFZ12	2.97
ASY26	0.43
ASY27	0.43
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ASZ16	1.35
ASZ17	1.35
ASZ20	1.62
ASZ21	2.16
AU113	1.84
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BA145	0.15
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BA155	0.11
BA156	0.10
BAW62	0.06
BAX13	0.07
BAX16	0.10
BC107	0.13
BC108	0.13
BC109	0.14
BC113	0.13
BC114	0.14
BC115	0.15
BC116	0.17
BC117	0.19
BC118	0.11
BC125	0.18
BC126	0.23
BC135	0.16
BC136	0.17
BC137	0.17
BC147	0.10
BC148	0.09
BC149	0.10
BC157	0.10
BC158	0.09
BC159	0.11
BC167	0.14
BC170	0.12
BC171	0.11
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BC173	0.13
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BC179	0.17
BC182	0.12
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BC212	0.14
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BC237	0.10
BC238	0.14
BC301	0.27
BC303	0.26
BC307	0.11
BC308	0.11
BC327	0.23
BC328	0.21
BC337	0.21
BC338	0.19
BCY30	1.08
BCY31	1.08
BCY32	1.08
BCY33	0.97
BCY34	0.97
BCY39	3.24
BCY40	1.08
BCY42	0.27
BCY43	0.27
BCY58	0.17
BCY70	0.16
BCY71	0.18
BCY72	0.14
BCZ11	1.62
BD115	0.49
BD121	1.30
BD123	1.30
BD124	1.40
BD131	0.38
BD132	0.41
BD135	0.37
BD136	0.37
BD137	0.38
BD138	0.43
BD139	0.46
BD140	0.48
BD144	2.16
BD181	1.19
BD182	1.27
BD237	0.43
BD238	0.59
BDX10	0.98
BDX32	2.16
BDY20	1.35
BDY60	1.62
BF115	0.27
BF152	0.19
BF153	0.22
BF154	0.18
BF159	0.25
BF160	0.17
BF167	0.22
BF173	0.22
BF177	0.26
BF178	0.26
BF179	0.27
BF180	0.32
BF181	0.32
BF182	0.32
BF183	0.27
BF184	0.27
BF185	0.27
BF194	0.10
BF195	0.10
BF196	0.11
BF197	0.14
BF200	0.29
BF224	0.23
BF244	0.30
BF257	0.26
BF258	0.28
BF259	0.35
BF336	0.32
BF337	0.32
BF338	0.33
BFS21	4.28
BFS28	2.41
BFS61	0.23
BFS98	0.23
BFW10	0.70
BFW11	0.70
BFX84	0.24
BFX85	0.25
BFX87	0.23
BFX88	0.23
BFY50	0.28
BFY51	0.28
BFY52	0.28
BFY64	0.28
BFY90	1.35
BSX19	0.23
BSX20	0.22
BSX21	0.22
BT106	1.35
BTY79/400R	3.45
BU205	1.97
BU206	2.53
BU208	2.25
BY100	0.49
BY126	0.15
BY127	0.16
BZX61 Series	0.19
BZY88 Series	0.14
CRS1/40	0.65
CRS3/40	0.81
CRS3/60	0.97
GEX66	1.62
GEX541	1.89
GJ3M	0.81
GM0378A	1.89
KS100A	0.51
MJE340	0.86
MJE370	1.26
MJE371	0.66
MJE520	0.56
MJE521	0.59
MJE2955	1.35
MJE3055	0.81
MPF102	0.34
MPF103	0.34
MPF104	0.34
MPF105	0.34
MPSA06	0.26
MPSA56	0.29
MPSU01	0.41
MPSU06	0.52
MPSU56	0.55
NE555	0.49
NKT401	2.16
NKT403	1.87
NKT404	1.87
OA5	1.03
OA7	0.59
OA10	0.65
OA47	0.15
OA70	0.32
OA79	0.32
OA81	0.32
OA85	0.32
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OA91	0.09
OA95	0.09
OA200	0.10
OA202	0.10
OA211	1.08
OAZ200	1.08
OAZ201	1.08
OAZ206	1.08
OAZ207	1.08
OC16	2.16
OC20	2.70
OC22	2.70
OC23	2.97
OC24	3.24
OC25	0.97
OC26	0.97
OC28	2.16
OC29	2.16
OC35	1.62
OC36	1.62
OC41	0.86
OC42	0.81
OC43	2.43
OC44	0.65
OC45	0.59
OC71	0.59
OC72	0.59
OC73	1.08
OC74	0.70
OC75	0.70
OC76	0.59
OC77	1.30
OC81	0.70
OC81Z	1.30
OC82	0.70
OC83	0.70
OC84	0.70
OC122	1.62
OC123	1.89
OC139	2.43
OC140	2.97
OC141	3.51
OC170	1.08
OC171	1.08
OC200	1.62
OC201	1.89
OC202	1.89
OC203	1.89
OC204	2.70
OC205	2.70
OC206	2.70
OC207	1.89
OCP71	1.35
ORP12	1.08
R2008B	1.97
R2009	2.43
R2010B	1.97
T1C44	0.32
T1C226D	1.30
T1L209	0.22
T1P29A	0.46
T1P30A	0.50
T1P31A	0.49
T1P32A	0.52
T1P33A	0.75
T1P34A	0.79
T1P41A	0.68
T1P42A	0.76
T1P2955	0.72
T1P3055	0.60
T1S43	0.51
ZS140	0.28
ZS170	0.24
ZS178	0.61
ZS271	0.26
ZS278	0.64
ZTX107	0.12
ZTX108	0.11
ZTX109	0.14
ZTX300	0.14
ZTX301	0.15
ZTX302	0.17
ZTX303	0.19
ZTX304	0.21
ZTX311	0.14
ZTX314	0.23
ZTX500	0.15
ZTX501	0.16
ZTX502	0.18
ZTX503	0.19
ZTX504	0.23
ZTX531	0.23
ZTX550	0.18
1N914	0.06
1N916	0.08
1N4001	0.07
1N4002	0.07
1N4003	0.08
1N4004	0.08
1N4005	0.09
1N4006	0.09
1N4007	0.10
1N4009	0.07
1N4148	0.07
1N5400	0.14
1N5401	0.14
1S44	0.05
1S920	0.08
1S921	0.08
2G301	1.08
2G302	1.08
2G306	1.19
2N404	1.08
2N696	0.27
2N697	0.27
2N698	0.32
2N705	1.30
2N706	0.16
2N708	0.22
2N930	0.22
2N1131	0.28
2N1132	0.28
2N1302	0.38
2N1303	0.38
2N1304	0.49
2N1305	0.49
2N1306	0.54
2N1307	0.54
2N1308	0.59
2N1309	0.59
2N1613	0.27
2N1671	1.62
2N1893	0.27
2N2147	1.89
2N2148	1.78
2N2218	0.27
2N2219	0.26
2N2220	0.19
2N2221	0.19
2N2222	0.19
2N2223	2.97
2N2368	0.18
2N2369A	0.23
2N2484	0.22
2N2646	0.59
2N2904	0.27
2N2905	0.27
2N2906	0.23
2N2907	0.23
2N2924	0.24
2N2925	0.25
2N2926	0.16
2N3053	0.27
2N3054	0.54
2N3055	0.76
2N3440	0.65
2N3441	0.86
2N3442	1.19
2N3614	1.62
2N3702	0.12
2N3703	0.15
2N3704	0.15
2N3705	0.15
2N3706	0.15
2N3707	0.15
2N3708	0.11
2N3709	0.15
2N3710	0.11
2N3711	0.11
2N3771	1.87
2N3772	2.16
2N3773	3.24
2N3819	0.41
2N3820	0.51
2N3823	0.62
2N3866	0.81
2N3904	0.15
2N3905	0.15
2N3906	0.15
2N4058	0.16
2N4059	0.11
2N4060	0.14
2N4061	0.14
2N4062	0.15
2N4124	0.18
2N4126	0.18
2N4286	0.23
2N4288	0.25
2N4289	0.27
2N5457	0.39
2N5458	0.39
2N5459	0.39
2S017	7.02
2S019	7.02
2S026	12.96
2S103	1.62
2S302	0.81
2S303	0.81
2S322	0.86
2S324	1.35
2S701	1.62
2S703	1.62
2S721	3.24
2S745A	0.38
2S746A	0.38

VALVES

Type	Price
A1834	9.72
A2087	12.75
A2134	7.29
A2293	8.10
A2426	12.09
A2521	10.92
A2900	8.19
A3343	24.00
AZ31	1.24
AZ41	1.29
BK448	29.11
BK484	106.92
BS90	29.43
BS810	29.43
BT5	38.88
BT17	70.25
BT19	23.98
BT29	214.22
BT69	219.13
BT75	90.34
BT95	84.29
CBL31	1.69
CL33	2.25
CY31	1.13
C1K	11.25
C3A	11.25
C3JA	21.82
DA41	20.20
DA42	11.56
DA100	49.68
DAF91	0.45
DAF96	1.13
DET22	22.68
DET24	49.68
DF91	0.45
DF96	1.13
DK91	1.18
DK92	1.41
DK96	1.24
DL92	1.24
DL94	1.35
DL96	1.24
DLS10	8.91
DLS15	11.62
DLS16	11.62
DLS19	11.62
DM70	1.35
DM71	1.35
DM160	3.54
DY86/7	0.72
DY802	0.95
E55L	23.64
E80CC	6.22
E80CF	10.69
E80F	6.82
E80L	6.44
E81CC	6.22
E81L	9.19
E82CC	6.61
E83CC	6.73
E86C	11.18
E88C	6.00
E88CC	3.63
E90CC	6.34
E90F	6.39
E91H	5.02
E92CC	5.83
E99F	6.86
E130L	18.20
E180CC	6.34
E180F	7.00
E182CC	6.85
E186F	8.68
E188CC	5.70
E280F	23.14
E283CC	8.48
E288CC	16.20
EA52	18.25
EA76	1.90
EABC80	1.35
EAF42	1.41
EAF801	1.97
EB41	2.25
EB91	0.95
EBC33	1.97
EBC41	1.41
EBC81	1.24
EBC90	0.96
EBF80	0.57
EBF83	1.41
EBF89	0.96
EBL31	2.81
EC90	1.26
EC91	7.04
EC92	1.41
EC157	259.69
ECC33	303.26
ECC35	3.94
ECC40	1.41
ECC81	0.99
ECC82	0.81
ECC83	0.99
ECC84	1.34
ECC85	1.35
ECC86	2.25
ECC88	2.03
ECC89	1.77
ECC91	7.45
ECC189	1.87
ECC807	1.97
ECC808	2.53
ECF80	1.22
ECF82	1.35
ECF86	1.69
ECH35	2.25
ECH42	1.29
ECH81	1.35
ECH83	1.41
ECH84	1.44
ECL80	1.13
ECL81	1.69
ECL82	1.13
ECL83	1.69
ECL84	1.58
ECL85	1.26
ECL86	1.35
EF37A	3.94
EF39	3.09
EF40	1.29
EF41	1.35
EF42	2.25
EF50	1.69
EF54	5.63
EF55	2.81
EF80	0.90
EF83	1.97
EF85	0.90
EF86	1.71
EF89	1.80
EF91	2.03
EF92	5.63
EF93	1.13
EF94	1.22
EF95	4.91
EF98	1.41
EF183	0.90
EF184	0.95
EF804S	7.02
EF805S	7.56
EH90	1.58
EK90	1.22
EL32	1.69
EL33	3.94
EL34 Thorn	2.48
EL34 Mullard	2.52
EL36	1.80
EL41	1.41
EL42	1.97
EL81	1.24
EL83	1.41
EL84	1.13
EL86	2.43
EL90	1.08
EL91	6.92
EL95	1.49
EL156	17.55
EL360	5.98
EL500/504	2.13
EL509	3.56
EL821	9.30
EL822	7.29
EM34	5.63
EM80	1.24
EM81	1.13
EM84	1.13
EM85	1.41
EM87	1.69
EN32	17.16
EN91	2.76
EN92	6.99
EY51	1.97
EY81	1.86
EY83	1.97
EY84	7.79
EY86	0.95
EY88	1.97
EY500A	2.18
EY802	92
EZ35	96
EZ40	1.41
EZ41	1.41
EZ80	0.95
EZ81	0.95
EZ90	1.35
FW4-500	2.81
FW4-800	2.81
G1.371K	21.82
G551K	11.88
G180.2M	17.30
G240.2D	12.07
G400.1K	18.11
GN4	8.10
GN4A	8.10
GS16	9.72
GT1C	9.97
GU18	25.16
GU50	13.45
GU51	12.80
GXU1	13.47
GXU2	26.71
GXU3	28.64
GXU4	30.78
GXU50	12.80
GXU51	12.80
GY501	2.89
GZ32	1.41
GZ33	4.50
GZ34	2.14
GZ37	4.50
KT61	3.94
KT66	6.19
KT88	7.59
KTW61	1.97
KTW62	1.97
KTW63	1.97
M8079	10.37
M8080	6.88
M8081	8.91
M8082	6.03
M8083	6.77
M8091	9.71
M8096	4.05
M8097	3.84
M8098	3.67
M8099	5.62
M8100	7.35
M8136	7.57
M8137	7.81
M8140	4.86
M8141	5.24
M8142	4.13
M8144	4.05
M8149	5.51
M8161	7.04
M8162	6.77
M8163	4.86
M8190	4.97
M8195	4.00
M8196	7.02
M8204	6.18
M8212	10.53
M8223	2.48
M8224	3.02
M8225	2.81
M8248	8.59
MU14	1.13
MX119	26.73
MX123	54.00
MX145	42.12
MX151	14.71
MX152	97.20
MX161	101.52
MX163	17.01
MX164	18.78
MX166	118.80
MX168	35.64
N78	10.13
OA2	2.16
OA3	5.57
OA4	3.78
OB2	1.35
OB3	2.07
OC2	2.86
OC3	2.07
OD3	2.07
OZ4	1.80
PC86	1.58
PC88	1.58
PC95	1.47
PC97	1.35
PC900	1.35
PCC84	1.13
PCC85	1.35
PCC88	1.35
PCC89	1.53
PCC189	1.58
PCC805	1.49
PCC806	2.03
PCE82	2.03
PCF80	1.13
PCF82	1.13
PCF86	1.80
PCF87	1.80
PCF200	2.77
PCF201	2.40
PCF801	1.80
PCF802	1.78
PCF805	1.80
PCF806	1.80
PCF808	1.80
PCL82	1.13
PCL83	1.78
PCL84	1.13
PCL85	1.22
PCL86	1.22
PCL805/85	1.22
PD500	4.05
PE06-40N	29.48
PFL200	2.03
PL36	1.35
PL81	1.35
PL81A	1.35
PL82	1.35
PL83	2.50
PL84	1.22
PL504/5	1.58
PL508	2.03
PL509	3.38
PL519	3.65
PL801	1.24
PL802	3.33
PY33	1.24
PY81	0.95
PY82	0.90
PY83	0.79
PY88	0.95
PY5000A	2.03
PY800	0.95
PY801	0.95
QQU02-6	11.23
QQU03-10	5.11
QQV03-20A	18.90
QQV06-40A	18.90
QQV07-50	48.09
QQZ03-20A	29.70
QQZ06-40A	51.74
QU37	13.50
QV03-12	3.24
QV04-7	2.70
QV08-100	101.27
QY3-65	48.06
QY3-125	12.96
QY4-250	61.92
QY4-400	71.06
QY5-500	149.69
QY5-3000A	265.36
QZ06-20	26.03
R10	5.40
R17	1.86
R18	4.59
R19	1.35
R20	1.62
RG3-250	28.86
RG3-250A	30.35
RG3-1250	26.41
RG4-1250	40.50
RG4-3000	67.50
RR3-250	43.31
RR3-1250	76.68
S11E12	28.62
S130	2.16
S130P	2.70
STV280-40	10.80
STV280-80	22.68
SU41	2.70
SU42	9.72
TD03-10	23.22
TD03-10E	23.22
TD03-10F	25.92
TT15	23.76
TT21	13.29
TT22	13.29
TT100	55.89
TY2-125	61.35
TY3-400	67.25
TY4-500	89.60
TY5-500	138.24
TY6-800	155.62
TY6-5000A	247.04
TY6-5000B	222.48
TY6-5000W	222.05
TY7-6000A	269.46
TY7-6000W	218.32
TZ40	16.20
U18-20	2.81
U19	9.70
U25	1.31
U26	1.62
U37	9.72
UABC80	1.41
UAF42	1.41
UB41	1.41
UBC41	1.69
UBF89	1.35
UCC84	1.24
UCC85	1.35
UCF80	1.29
UCH42	1.35
UCH81	2.61
UCL82	1.17
UCL83	1.62
UF41	1.13
UF42	1.41
UF80	1.62
UF85	1.62
UF89	1.62
UL41	1.82
UL84	1.35
UM80	1.13
UY41	1.41
UY85	1.17
VLS631	14.31
XG1-2500	28.84
XG2-6400	81.97
XG5-500	34.70
XGQ2-6400	84.89
XR1-1600A	24.30
XR1-3200	68.15
XR1-3200A	68.15
XR1-6400	71.06
XR1-6400A	71.06
YD1120	222.48
YD1240	226.80
Z759	10.37
Z803V	8.53
ZM1000	5.66
ZM1001	5.81
ZM1020	10.17
ZM1021	9.55
ZM1022	9.96
ZM1023	8.27
ZM1040	14.86
ZM1041	12.50
ZM1042	14.27
ZM1051	93.96
1B3GT	2.44
1B24	10.80
1B35A	27.00
1B63	54.00
1R5	1.18
1S5	0.45
1T4	0.45
2AS15	10.80
2C39A	20.52
2C43	19.44
2D21	2.76
2E26	7.34
2J42	84.24
2J55	189.00
2J70A	253.80
2J70B	270.00
2K25	37.80
3-400Z	48.60
3-500Z	48.60
3A5	1.46
3B24	8.64
3B28	4.86
3B29	10.80
3B240M	16.20
3B241M	16.20
3C23	13.05
3C45	21.38
3CX100A5	21.60
3E29	27.86
3S4	1.24
465A	27.38
4-125A	39.43
4-250A	39.43
4-400A	48.98
4B32	27.39
4C35	43.20
4CX250B	26.79
4CX350A	33.86
4X150D	27.00
5B254M	18.09
5B255M	18.09
5C22	43.20
5J180E	499.20
5R7GY	2.25
5U4G	4.25
5U4GB	2.54
5V4G	1.71
5Y3GT	0.96
5Z3	1.69
5Z4G	1.71
5Z4G7	1.69
5Z180E	799.20
6-30L2	1.76
6AB4	1.41
6AB7	1.69
6AC7	1.58
6AF4A	1.80
6AG7	2.25
6AH6	5.40
6AK5	3.89
6AK6	2.75
6AL5	0.99
6AM4	2.59
6AM5	4.29
6AM6	2.03
6AN5	5.99
6AN8A	4.66
6AQ5	1.08
6AR5	1.80
6A56	6.28
6A57G	7.29
6AT6	0.96
6AV5G7	4.70
6AV6	1.22
6AV5GA	4.25
6AV6	0.96
6AX5GT	3.49
6B7	1.69
6B8	1.97
6BA6	1.13
6BA7	5.76
6BA8A	4.22
6BC4	4.17
6BE6	1.22
6BH6	1.71
6BJ6	1.22
6BK4	4.74
6BL6	91.80
6BL7GT	4.34
6BL6	91.80
6BN6	1.86
6BQ7A	4.05
6BR7	4.50
6BR8	1.97
6BS7	4.50
6BW6	4.50
6BW7	1.71
6BX7GT	5.58
6BZ6	2.57
6C4	0.99
6CB6A	2.70
6CD6GA	5.51
6CG7	2.50
6CH6	7.31
6CL6	4.03
6CW4	8.15
6D2	0.99
6DK6	2.53
6DQ6B	4.39
6EA8	3.24
6EB8	2.39
6EW6	1.69
6F6	1.99
6F23	1.80
6F28	1.31
6F33	17.28
6H1	13.50
6H2N	1.18
6H3N	1.18
6H6	1.69
6J4	5.96
6J6	3.51
6J7	8.84
6K4N	1.41
6K6GT	1.46
6K7	1.69
6K8	1.97
6KD6	6.93
6L6G	2.81
6L6GA	1.69
6L6GT	0.96
6L6GC	2.19
6L7	2.25
6N2P	1.18
6N3P	1.18
6N7	1.69
6P25	4.05
6Q7	2.48
6R7	2.03
6SA7	1.63
6SC7	1.69
6SF7	1.80
6SH7	1.69
6SJ7	1.80
6SK7	1.46
6SK7GT	3.02
6SN7GT	1.80
6SQ7	1.47
6SR7	1.69
6SS7	2.03
6U5G	2.25
6U8	0.90
6U8A	3.17
6V6GT	1.80
6X4	1.35
6X5GT	96
7B7	1.91
7C5	1.97
7C6	1.41
7H7	2.25
7R7	1.69
7S7	2.53
7Y4	1.80
7Z4	2.08
11E3	57.12
12AT6	1.35
12AT7	0.99
12AU6	2.77
12AU7	0.81
12AV6	2.25
12AV7	3.89
12AX7	0.99
12AY7	5.13
12B4A	3.42
12BA6	2.36
12BE6	2.50
12BH7	1.26
12BY7	2.95
12E1	7.67
12E14	32.40
13E1	58.42
19H4	27.00
19H5	37.80
24B9	38.88
30C15	1.80
30C17	1.80
30C18	1.80
30F5	1.89
30FL1/2	1.26
30FL12	2.03
30FL14	1.80
30L1	1.13
30L15	2.03
30L17	2.03
30P4	1.04
30P19	1.35
30PL1	1.49
30PL13	2.03
30PL14	1.89
30PL15	2.03
35W4	0.68
50C5	0.79
75B1	2.12
75C1	1.91
85A1	8.10
85A2	2.00
90AG	8.60
90AV	8.60
90C1	1.94
90CG	14.77
90CV	14.36
92AG	8.60
92AV	8.60
95A1	5.24
150B2	2.32
150B3	4.21
150C2	1.62
150CH	1.89
211	6.48
723AB	37.80
803	10.80
805	21.60
807	3.89
811A	9.18
812A	9.02
813	34.56
833A	81.00
866A	6.21
872A	14.85
922	4.71
931A	13.22
1624	2.43
1625	1.93
2050	7.52
4212E	159.56
4212H	194.40
5544	58.32
5545	63.72
5551A	75.33
5552A	101.84
5553A	243.32
5642	5.69
5654	3.80
5651	1.94
5670	4.97
5675	13.18
5687	6.65
5696	4.26
5718	6.91
5725	5.90
5726	3.80
5727	5.18
5749	5.38
5751	5.03
5763	3.89
5814A	4.51
5840	4.75
5842	14.64
5876A	12.27
5879	4.23
5886	11.34
5963	3.24
5965	3.82
6005	6.14
6021	4.82
6057	3.78
6058	9.76
6059	4.32
6061	4.58
6062	4.05
6063	3.94
6064	6.10
6072	6.14
6080	7.40
6097A×B×C	43.20
6146A	5.53
6146A	6.03
6159	8.62
6189	8.27
6201	5.57
6442	16.20
6883B	6.39
6973	3.96
7025	2.57
7551	6.68
7586	12.80
7587	22.05
7609	34.34
7868	4.43
7895	14.51
8005	32.40
8068	6.19
6122	45.36
8136	2.75
8417	6.01
19042	6.50
18045	9.54
4CX250B Tested Ex-Equipment	5.40

BASES

Type	Price
B7G unskirted	0.16
B7G skirted	0.32
B9A unskirted	0.16
B9A skirted	0.32
Int Octal	0.22
Loctal	0.59
Nuvistor base	0.59
8 pin DIL	0.16
14 pin DIL	0.16
16 pin DIL	0.18
Valve screening cans all sizes	0.32

CRTs

Type	Price
2AP1	9.18
2BP1	9.72
3BP1	8.64
3DP1	5.40
3EG1	7.56
3FP7	6.48
3GP1	6.48
3JP1	8.64
3JP2	8.64
3JP7	10.80
3KP1	16.20
3RP1	37.80
5ADP1	37.80
5BP1	10.89
5CP1	5.40
5CP1A	43.20
5FP15A	16.20
5UP7	15.12
DG7-5	27.00
DG7-32	38.88
DH3-91	33.48
DH7-11	73.44
VCR97	5.40
VCR138	10.80
VCR138	10.50
VCR138A	13.50
VCR139A	8.64
VCR517A	10.80
VCR517B	6.48
VCR517C	6.48
Tube Bases	0.81

INTEGRATED CIRCUITS

Type	Price
7400	0.17
7401	0.17
7402	0.17
7403	0.17
7404	0.18
7405	0.17
7406	0.43
7407	0.43
7408	0.22
7409	0.22
7410	0.17
7412	0.28
7413	0.35
7416	0.35
7417	0.35
7420	0.18
7422	0.22
7423	0.35
7425	0.32
7427	0.32
7428	0.46
7430	0.18
7432	0.32
7433	0.39
7437	0.35
7438	0.35
7440	0.19
7441	0.92
7442	0.78
7447AN	0.97
7450	0.19
7451	0.19
7453	0.19
7454	0.19
7460	0.19
7470	0.38
7472	0.36
7473	0.39
7474	0.43
7475	0.58
7476	0.43
7480	0.59
7482	0.81
7483	0.97
7484	1.08
7486	0.38
7490	0.56
7491	0.86
7492	0.65
7493	0.65
7494	0.86
7495	0.78
7496	0.86
7497	3.24
74100	1.62
74107	0.49
74109	0.76
74110	0.54
74111	0.76
74116	1.89
74118	1.08
74119	1.62
74120	0.90
74121	0.43
74122	0.65
74123	1.08
74125	0.59
74126	0.59
74128	0.65
74132	0.76
74136	0.59
74141	0.86
74142	2.48
74143	2.70
74144	2.70
74145	0.97
74147	2.16
74148	1.89
74150	1.73
74151	0.92
74154	1.89
74155	0.92
74156	0.92
74157	0.81
74159	2.27
74170	2.48
74172	4.75
74173	1.51
74174	1.62
74175	0.97
74176	1.19
74178	1.35
74179	1.35
74180	1.25
74190	1.62
74191	1.62
74192	1.46
74193	1.46
74194	1.35
74195	1.08
74196	1.30
74197	1.19
74198	2.43
74199	2.43
76013N	1.97
TAA570	2.59
TAA630S	3.94
TAA700	4.22
TBA480Q	2.07
TBA520Q	2.59
TBA530	2.23
TBA540Q	2.59
TBA550Q	3.62
TBA560CQ	3.62
TBA673	2.46
TBA700	1.71
TBA720Q	2.59
TBA750Q	2.33
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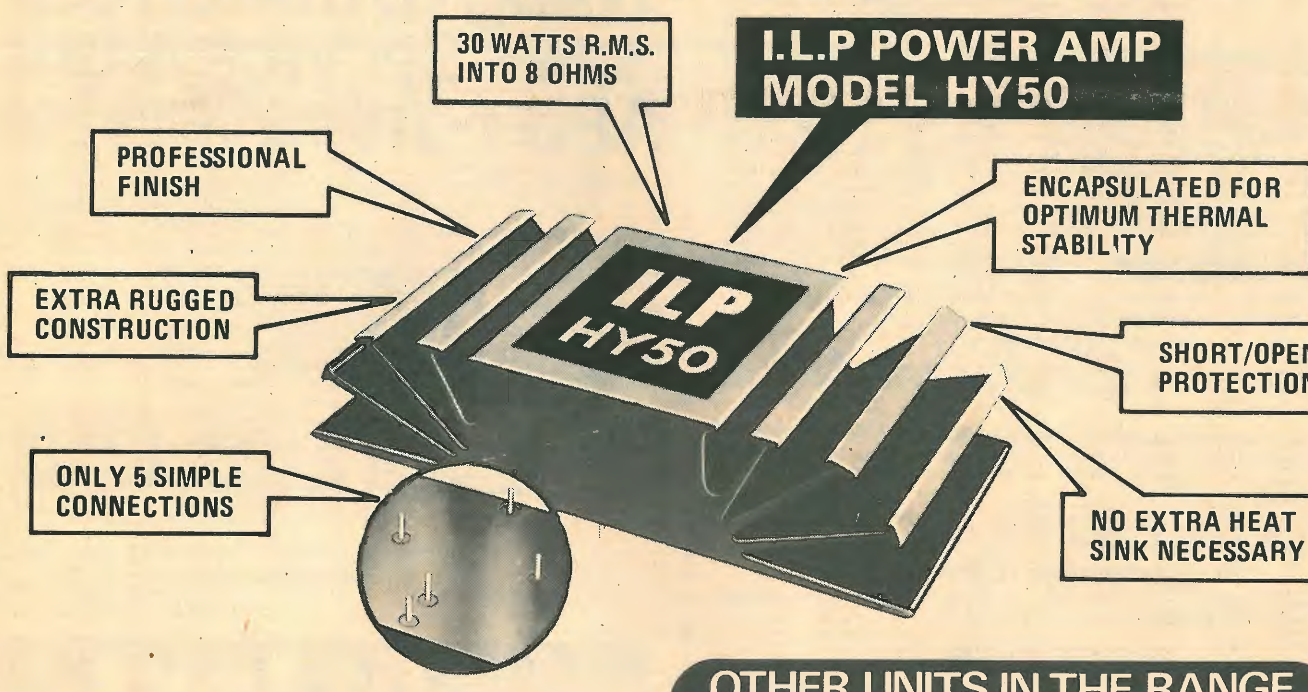

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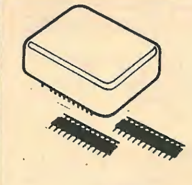

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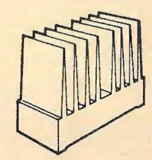

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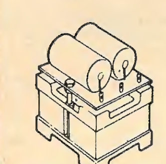

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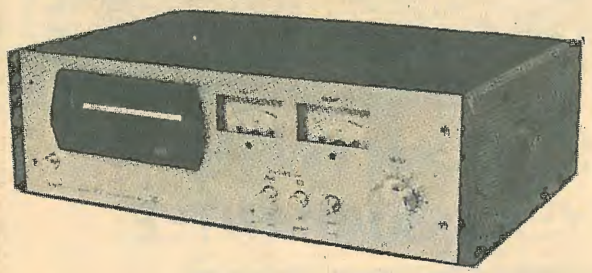

We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, easily built and tested layout. All these features added to the high quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our new HS15 Sendust Alloy record/play head, available separately at **£7.60** plus VAT, but included FREE as part of the complete kit at **£81.50** plus VAT.

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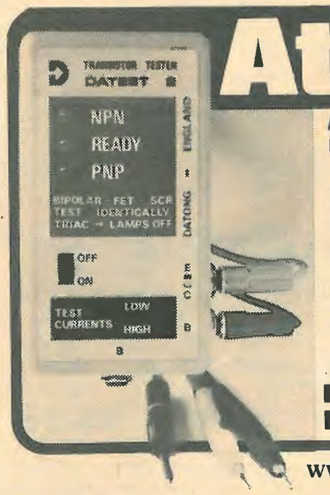

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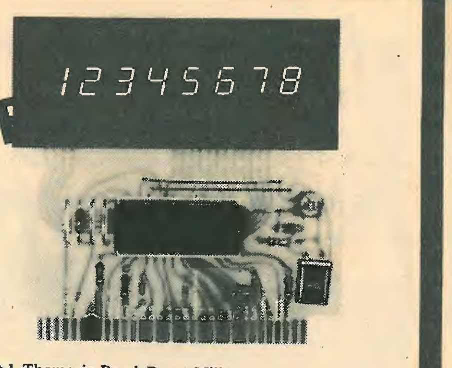

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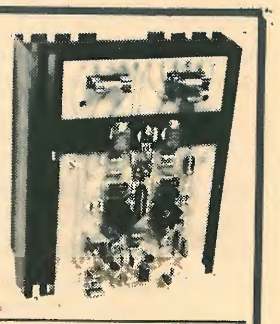

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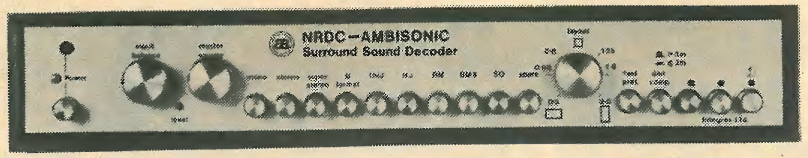
ATMOSPHERE LTG & SOUND, 57 Nelson Street, Aberdeen, Scotland, Tel. 0224 572905, Mr. Keith Main

FRANCE
MUSIQUE & SON, 1 Residence Bel-Event, 35260, Cancale, France, Tel. (99) 89 67 77, Mr. Yves Jamois

WW — 041 FOR FURTHER DETAILS

NRDC-AMBISONIC UHJ



SURROUND SOUND DECODER

The **first ever** kit specialy 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 **£49.50** + VAT
or ready built and tested **£67.50** + VAT

NEW S5050A STEREO AMP

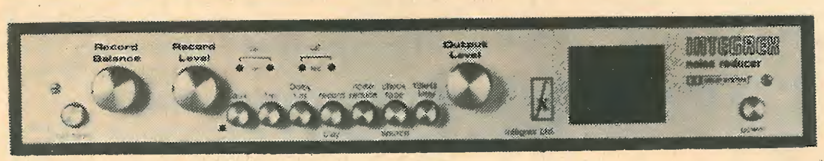
50 watts rms-channel. 0.015% THD. S/N 90 dB, Mags/n 80 dB.

Tone cancel switch. 2 tape monitor switches.

Complete kit only **£63.90 + VAT.**

Wireless World Dolby(TM) 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.

Featuring:

- switching for both encoding (low-level h.f. compression) and decoding
- a switchable f.m. stereo multiplex and bias filter.
- provision for decoding Dolby f.m. radio transmissions (as in USA).
- no equipment needed for alignment.
- suitability for both open-reel and cassette tape machines.
- check tape switch for encoded monitoring in three-head machines.

Complete Kit **PRICE: £43.90** + VAT

Also available ready built and tested .... **Price £59.40** + VAT

Calibration tapes are available for open-reel use and for cassette (specify which) .... **Price £2.40** VAT *

Single channel plug-in Dolby(TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components .... **Price £9.00** + VAT

Single channel board with selected fet .... **Price £2.75** + VAT*

Gold Plated edge connector .... **Price £1.75**+VAT*

Selected FETs **65p** each + VAT, **110p** + VAT for two, **£2.10** + VAT for four.

Please add VAT @ 12½% unless marked thus*, when 8% applies (or current rates)

We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?

Buy it with Access | BARCLAYCARD | EUROCARD | master charge

Please send SAE for complete lists and specifications

INTEGREX LTD.

**Portwood Industrial Estate, Church Gresley, Burton-on-Trent, Staffs DE11 9PT
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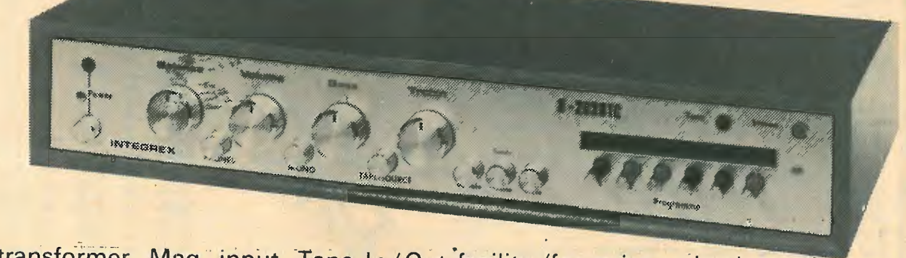
INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET

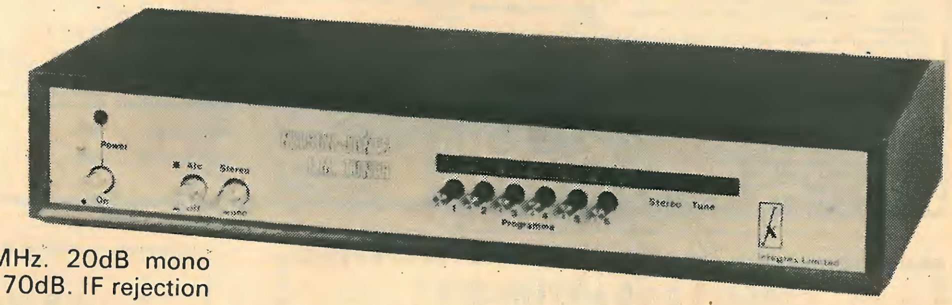
A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.



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. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter. **PRICE: £59.95** + VAT
Nelson-Jones Mk. 2 Stereo FM Tuner Kit. Price: **£69.95** + VAT.

NELSON-JONES MK. I STEREO FM TUNER KIT

A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.



Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.
Compare this spec. with tuners costing twice the price.

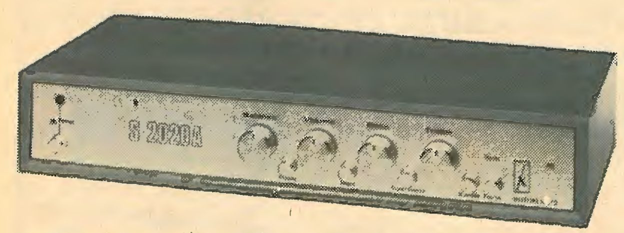
Mono £36.40 + VAT
With ICPL Decoder £40.67 + VAT
With Portus-Haywood Decoder £44.20 + VAT

STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter Push-button tuning

Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

PRICE: Stereo £33.95 + VAT



S-2020A AMPLIFIER KIT

Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring Power 'on/off' FET transient protection.

Typ Spec. 24+24W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £35.95 + VAT

BASIC NELSON-JONES TUNER KIT £15.70 + VAT
BASIC MODULE TUNER KIT (stereo) £18.50 + VAT
PHASE-LOCKED IC DECODER KIT ... **£4.47**+VAT
PUSH-BUTTON UNIT .... **£6.00** + VAT
PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT .... **£8.80** + VAT

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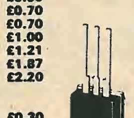
TIC226D	400v	8A	£0.70
TIC236D	400v	12A	£1.00
TIC246D	400v	16A	£1.21
TIC253D	400v	20A	£1.87
TIC263D	400v	25A	£2.20



THYRISTORS

*TIC44†	0.6A	30v	£0.30
*TIC46†	0.6A	100v	£0.60
*TIC47†	0.6A	200v	£0.60
*2N5060	0.5A	25v	£0.32
*2N5061	0.5A	50v	£0.33
*2N5062	0.5A	100v	£0.40
*2N5063	0.5A	150v	£0.43
*2N5064	0.5A	200v	£0.45

See catalogue for full range.

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NEW TELETEXT CHIPS
from Mullard — available now from Marshall's — Sole UK distributor to the hobbyist market.
SAA Series, for the reception, display and control of television based text display systems. Suitable for 'CEEFAX' and 'ORACLE'

Remote Control	
SAA5000 Infrared/Ultrasonic	£3.40
SAA5010 Station selector/DICS	£8.13
SAA5012 Binary Input Tuners	P.O.A.
TELETEXT (Dedicated I.C.'s)	
SAA5020 TIC (Timing Chain)	£8.71
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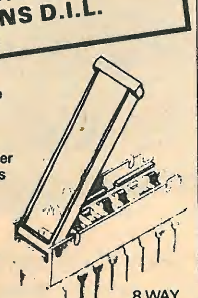
TIC, TAC & TROM are NMOS — VIP is linear bipolar. We recommend using DIL sockets with these chips.

SOLE U.K. DISTRIBUTORS FOR SIEMENS D.I.L. SWITCHES

The new dual-in-line switch of printed circuits.

The transparent cover protects the contacts against dust.

Voltage rating 24V⎓
Current rating p.5A
All contact parts are nickel plated and gold plated.

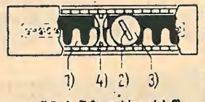


8 WAY D.I.L. **£2.86**

NEW

SIEMENS TURN-SLIDE SWITCHES

This new version of the rotary switch is especially reliable for setting programs. The rotary switch is of a 1 element on stops.
Voltage rating 60V—
Current rating 0.5V—
Fixed contacts gold plated £2.65.



1) Rack. 2) Screwdriver slot. 3) Switching element. 4) Stop

Price
Fixed contacts gold-plated £2.65

DUAL IN LINE PLUGS
These connectors are compatible with conventional AWG26 and AWG28 tape cable on a 1.27mm (0.05") centre spacing. An additional metal latch is provided for strain relief.
Available in 16 and 24 pins

Price
16 pin DIL **£1.60**
24 pin DIL **£2.00**

40 Pin Coming Soon!

TRANSISTORS
See catalogue for full range

2N1524	0.00	2N2195	.43	3N154	.93	AD143	1.45
2N1553	1.50	2N2195A	.49	3N159	1.35	AD149	2.05
2N1613	.30	2N2217	.53	3N187	1.00	AD150	3.10
2N1637	.72	2N2218	.35	2N200	2.83	AD161	1.00
2N1638	.70	2N2218A	.33	3N201	1.35	AD162	1.00
2N1711	.30	2N2219	.30	40050	1.70	AF106	.90
2N1639	.35	2N2219A	.33	40081	1.20	AF109	.82
2N1630	.30	2N2220	.33	40232	.90	AF114	.70
2N1633	.30	2N2221	.25	40233	.70	AF115	.70
2N1537	5.93	2N2221A	.25	40235	.65	AF116	.70
2N1974	.60	2N2222	.25	AC151	.43	AF117	.70
2N1820	.43	2N2222A	.25	AC152	.54	AF118	.70
2N1591	1.10	3N81	3.50	AC153	.50	BC113	.22
2N2088	7.00	3N83	2.25	AC153K	.50	BC114	.22
2N2102	.50	3N128	1.33	AC176K	.70	BC115	.22
2N2147	1.53	3N139	1.00	AC176	.54	BC116	.21
2N2160	1.53	3N140	1.10	ACK187	.50	BC116A	.22
2N2192	.50	3N141	.83	AC187K	.63	BC117	.22
2N2193	.50	3N142	.70	AC183	.54	BC118	.22
2N2193A	.52	3N143	.68	AC183K	.65	BC119	.33
2N2194	.42	3N152	1.10	AD136	2.75	BC122	.61
2N2194A	.45	3N153	1.00	AD142	1.45	BC123	.65

CONVERT TV SET TO VDU

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Full cursor control 5 volts
TTL compatible, line erase,
full card includes UART, Modem, Char. gen etc. Comp video out from encoded keyboard in.

CHIP £17.20
FULL CARD £151

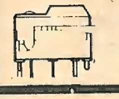
NEW

PCB MOUNTING KEYBOARD SWITCHES

Digitast is a remarkable new modular electronic switch input component for use with dual in-line packages (DIP). The inner construction in connection with standard TTL-ICs, eliminates more costly and troublesome conductor plate sandwiched switches. Suitable for mounting on 1" matrix board.

Standard SPST SR £0.95

or with LED TYPE SRL £1.65



NEW LOW PRICE
"KIM" The Ready to Use Microprocessor System

Not a kit but supplied fully tested, wired and guaranteed. Expandable Memory that grows with your system not just an evaluation kit. Starting with KCR 1 at £107.95 VAT inclusive you get immediate capability which can be expanded to a complete system capable of addressing up to 65K BYTES of Memory.
KIM IS EXPANDABLE. Expand as you learn up to 65K.

KIM 1 — Basic board with above features assembled	£107.95
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TTL See catalogue for full range

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A reference amplifier for disc monitoring and transfer when replay signals of the highest quality are required.

Based on the Surrey Electronics Disc Amplifier 2 and manufactured under licence this unit offers the same unmatched technical performance. Intended for situations where the ability to drive balanced lines is not required, two equalised outputs are provided enabling Line and DIN level inputs to be driven simultaneously.
To facilitate cartridge matching a wide range of independently switchable load capacitance and resistance values are provided, together with left and right 20 turn gain presets.

Price: Cash with order. UK postage and 12½% VAT inclusive **£165.**

For THD and IMD specifications see page 116, May issue
INPUT STAGE CLIPPING LEVEL
—10dBV.7 (270mV RMS) at 1KHz
+9dBV.7 (2.4 Volts RMS) at 20kHz
CLIPPING POINT, HIGH OUTPUT LOADED WITH 10kΩ
+23dBV.7 (11 Volts RMS) AT 1KHz
CLIPPING POINT COMPLEMENTARY TO IEC 98-4 RECORDING CHARACTERISTIC
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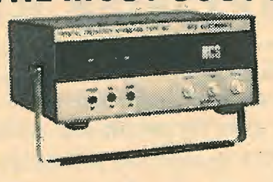

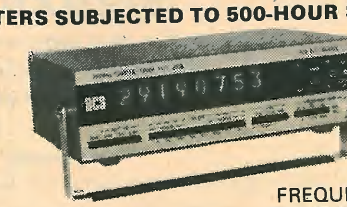

OFF/AIR FREQUENCY STANDARD TYPE 103 **£115**
10MHz, 1MHz Stability 1 part 10^8
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10MHz, 1MHz, 100KHz
Stability 5 parts 10^{10} **£125**

501	50MHz 8 Digit	**£165**
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LED COUNTERS
303MHz. 5 digits **£130**
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All standard counters in centre column now available as the 02 Series with LEDs.

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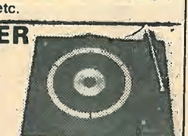
Ideal for record decks, tape decks, etc.

BSR SINGLE PLAYER

Ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds. Large turntable, modern design
£19.50 Post £1



BSR P182 3 speeds flared aluminium turntable "S" shape arm, cueing device, ceramic cartridge **£22.50.** Post £1.
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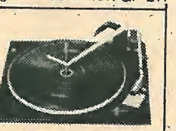
GARRARD HI-FI AUTO CHANGER Model 2025

3-speed stereo cartridge. **£14.95**
Cueing devices Post £1

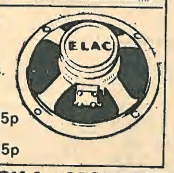


B.S.R. P163 BELT DRIVE QUALITY DECK

Manual or automatic play. Two speeds. Precision balanced arm. Slide in head, cueing device. Bargain price
£27.50. Post £1.
Suitable magnetic cartridge **£6.50.**

ELAC HI-FI SPEAKER 8in. TWIN CONE

Large ceramic magnet. 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance. 10 watts RMS. **£5.95** Post 35p
20 watt woofer bass unit only **£7.95** Post 45p



LOW VOLTAGE POWER PACK for MODELS

Ready made. Famous make. Will supply 10 volts D.C. at 400mA. With terminals and mains lead. **£2.50** Post 50p

VOLUME CONTROLS

5kΩ to 2MΩ. LOG or LIN.
L/S **35p.** DP **60p.**
Stereo L/S **85p.** DP **£1.**
Edge Pot 5K. SP **45p.**

80 Ohm Coax

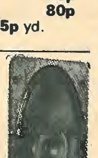
FRINGE LOW LOSS **15p** yd.
PLUGS **10p.** SOCKETS **10p.**
LINE SOCKETS **25p**
OUTLET BOXES **80p**
300 ohm FEEDER **5p** yd.

EMI 13½ x 8in. LOUDSPEAKERS

With tweeter and crossover. 10 watt. 3 or 8 ohm.
£8.95 Post 45p

Bass woofer only 8 ohm. 15 watt.
£10.50 Post 65p

Bass woofer only 15 ohm. 20 watt. **£11.50** Post 75p



Suitable Bookshelf Cabinet
Teak finish. For EMI 13 x 8 speakers. Size 16 x 11 x 8 inches approximately. **£8.50** Post £1.00

THE "INSTANT" BULK TAPE ERASER
Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. Will also demagnetise small tools. **£5.50** Post 50p
Head Demagnetiser only £4.75.

RELAYS. 12V DC **95p.** 6V DC **85p.** 240V AC **95p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**95p;** 8 x 6—**£1.40;** 10 x 7—**£1.55;** 12 x 8—**£1.70;** 14 x 9—**£1.90;** 16 x 6—**£1.85;** 16 x 10—**£2.20. ANGLE ALI.** 6 x ¾ x ¾in—**20p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
PLASTIC AND ALL BOXES IN STOCK. MANY SIZES
VARICAP FM TUNER HEAD with circuit & connections. Some technical knowledge required **£4.95.**
TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type, **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.** 8 amp **£2.50.**
TOGGLE SWITCHES SP 30p. DPDT 40p. DPDT **50p.**
MANY OTHER TOGGLES IN STOCK. Please enquire.
PICK-UP CARTRIDGES ACOS, GP91 **£2.00.** GP94 **£2.50.**
SONOTONE 9TAHC Diamond **£3.75.** V100 Magnetic **£6.50.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **15p.**
CASSETTE MOTOR. 6 volt **£1.00.**
CASSETTE MECHANISM. No motor **£3.00.**

RCS SOUND TO LIGHT KIT Mk. 2 £17

Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Suitable for home or disco. Post 35p
Easy to build. Full instructions supplied. Cabinet **£4** extra.
Will operate from 200MV to 100 watt signal.

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c. Output voltages available. 6 or 7.5 or 9 or 12V d.c. up to 100mA or less. Size 3 x 2½ x 1¼in. Please state voltage required.
£2.95 Post 45p

R.C.S. POWER PACK KIT

12 VOLT, 750mA. Complete with printed circuit board and assembly instructions. **£3.35** Post 30p
12 VOLT 300mA KIT. **£3.15.**

RCS "MINOR" 10 watt AMPLIFIER KIT

This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£12.50;** Stereo, **£20.** Post **45p.** Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx. SAE details. Full instructions supplied. AC mains powered. Input can be modified to suit guitar.

RCS DRILL SPEED CONTROLLER/LIGHT DIMMER KIT
Easy to build kit. Printed circuit and all parts. **£3.25**
Will control up to 480 watts AC mains Post 35p

R.C.S. STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel. With volume control and P.C. Board **£2.95**
Can be ganged to make multi-way stereo mixers Post 35p

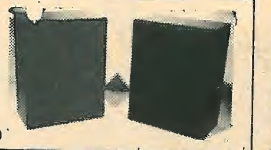
MAINS TRANSFORMERS ALL POST 75p
250-0-250V 70mA, 6.3V, 2A **£3.45**
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A **£4.60**
350-0-350V 80mA, 6.3V 3.5A, 6.3V 1A **£5.80**
300-0-300V 120mA, 2 x 6.3V 2A C.T., 5V 2A **£8.50**
220V 45mA, 6.3V 2A **£1.75**
HEATER TRANSFORMER. 6.3V ½ amp **£1.50.** 3 amp **£1.75**
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs available
2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V **£6.30**
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£6.30**
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.80**
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.00**
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£14.50**

12V, 100mA	£1.00	20V, 40V, 60V, 1 amp	£3.50
12V, 750mA	£1.30	12V, 3 amp	£2.95
10-0-10V 2amp	£2.45	10V, 30V, 40V, 2 amp	£2.75
30V, 5 amp and 17V-0-17V, 2 amp	£3.45	40V, 2 amp	£2.95
0, 5, 8, 10, 16V, ½ amp	£1.95	20V, 1 amp	£2.20
9V, 3 amp	£2.75	20V-0-20V, 1 amp	£2.95
25-0-25V 2 amp	£3.50	30V-0-30V, 2 amp	£7.00
30V, 2 amp	£3.00	2 of 18V, 6 amp, each	£9.00
30V, 1½ amp	£2.75	12-0-12V, 2 amp	£2.95
		9V, ¼ amp	£1.30

AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£7.00**
250W ......**£8.00** 400W ......**£9.00** 500W **£10**
FULL WAVE BRIDGE CHARGER RECTIFIERS.
6 or 12V outputs. 2 amp. **75p.** 4 amp......**£1.25**
CHARGER TRANSFORMERS: 1½ amp......**£3.50.** 4 amp......**£6.50.**
12V, 1½ amp Half Wave Selenium Rectifier **25p**

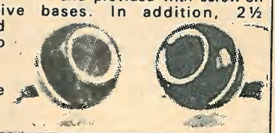
COMPACT SPEAKERS

Teak 4 or 8 ohm
White 4 ohm only
13 x 10 x 6in. approx.
50 to 14,000 cps. 10 watts.
£16 pair Post £1.30



EXTENSION SPEAKERS £3.95 ea.

Globe shaped cases in high gloss mouldings of red or green, are finished with chrome frontal trim and provided with screw-on rubber inset protective bases. In addition, 2½ metres of strong lead already fitted with phono plug is supplied.
Full Range Quality
Frequency Response
Impedance: 8 ohms
Power Peak: 5 watts



LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p;** 420mF/500V **£1.30.**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
3900mF 100V **£1.60.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**
5000mF 35V **85p.** 5600mF/76V **£1.75**

HIGH VOLTAGE ELECTROLYTICS

8/350V	22p	8+8/450V	50p	50+50/300V	50p
16/350V	30p	8+16/450V	50p	32+32/450V	75p
32/500V	75p	16+16/450V	50p	100+100/275V	65p
50/350V	50p	32+32/350V	50p	150+200/275V	70p

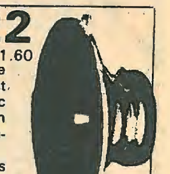
MANY OTHER ELECTROLYTICS IN STOCK
SHORT WAVE 100pf air spaced gangable tuner, **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0.01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0.1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0.001 to 0.05 **12p;** 0.1 **15p;** 0.25 **25p;** 0.47 **35p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over.
TWIN GANG, 385 + 385pF **50p;** 500pF slow motion **75p.**
365 + 365 + 25 + 25pF, Slow motion drive **65p.**
120pF **TWIN GANG, 50p; TRANSISTOR TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
ILLUMINATED ROCKER SWITCH. single pole. Red **65p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, 20% **2p;** 2W, **10p.**
HIGH stability. ½W 2% 10 ohms to 1 meg., **12p.**
Ditto **5%.** Preferred values 10 ohms to 10 meg., **5p.**

ELECTRO MAGNETIC PENDULUM MECHANISM 95p Post 30p.

1.5V DC operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or metronome, strobe, etc.

BAKER SUPERB £22
12in 25 watt

Post £1.60
Quality loudspeaker, low cone resonance ensures clear reproduction of the deepest bass. Special copper drive and concentric tweeter cone. Full range reproduction with remarkable efficiency in the upper register.



Bass resonance	25 c/s
Flux Density	16,500 gauss
Useful response	20-17,000 c/s

8 or 16 ohms models

BAKER "BIG-SOUND" SPEAKERS. Post £1

'Group 25'	'Group 35'	'Group 50/15'
12 inch 30 watt **£12**	12 inch 40 watt **£14**	15 inch 75 watt **£33**
4 or 8 or 16 ohm	4 or 8 or 16 ohm	8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT.
GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER.
FULL RANGE PROFESSIONAL QUALITY.
RESPONSE 30-16,000 CPS **£21**
MASSIVE CERAMIC MAGNET Post £1.60
WITH ALUMINIUM PRESENCE CENTRE DOME.

TEAK VENEERED HI-FI SPEAKER CABINETS
For 13x8in. or 8in. speaker **£8.50** Post £1
For 6½in. speaker and tweeter **£5.95** Post 75p
Many other cabinets in stock. Phone your requirements.
SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, PA, where high quality power is required. 5 speaker outputs. AC mains operated. Slave output socket. Produced by demand for a quality valve amplifier. 100V line output to order £10 extra. Send for leaflet.
Suitable carrying cab **£21** Price **£99** carr. £6.00

HORN TWEETERS 2-16kc/s. 10W 8 ohm or 16 ohm **£3.60.**
AUDAX TWEETERS 3-18kc/s. 50W 8 ohm **£7.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps. **£2.20.**
LOUDSPEAKERS PM 3 OHM 7x4in. **£1.50;** 6½in., **£1.95;** 8x5in., **£1.90;** 8in., **£2.50.**
SPECIAL OFFER: 80 ohm, 2¼in., 2¾in., 35 ohm, 3in., 25 ohm, 2½in., 3in., 5x3in., 7x4in., 8 ohm, 2½in., 3in., 3½in., 5in., 15 ohm, 3½in. dia, 6x4in., 7x4in., 5x3in., 3 ohm, 2½in., 2¾in., 3½in., 5in. dia. **£1.50 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, **£2.50.**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in. diameter 4W **£2.50.** 10in. diameter 5W **£3.50;**
12in. diameter 6W **£4.50.** 3/8/15 ohms, please state.
MOTOROLA PIEZO ELECTRIC HORN TWEETER. £7.95
Handles up to 100 watts. No crossover required.
BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER

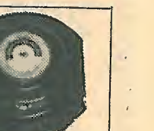
All purpose transistorised.
Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing. Output 4 8/16 ohms. A.C. Mains. Separate treble and bass controls. Master volume control.
100 volt line model **£99** **£79** £1.50 carr.

BAKER 50 WATT AMPLIFIER
£59 Post £1

Superior quality ideal for Halls/PA systems, Disco's and Groups. Two inputs with Mixer Volume Controls. Master Bass, Treble and Gain Controls. 50 watts RMS. Three loudspeaker outlets 4, 8, 16 ohm. AC 240V (120V available). Blue wording on black cabinet.

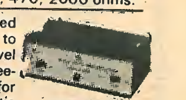
GOODMANS COMPACT 12-INCH BASS WOOFER

Standard 12in. diameter fixing with cut sides 12 x 10. 14,000 Gauss magnet. 20 watts R.M.S. 4 ohm imp. Bass resonance = 30 c.p.s. Frequency response 30-8000 c.p.s.
£9.95 each Post £1



ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 5" x 4" x 1" **95p.** 6½" x 2" x 2¼" **65p.**
JACK PLUGS. Plastic 25p; Metal 30p.
JACK PLUGS Stereo Plastic 30p; Metal 35p.
JACK SOCKETS. Open 20p; Closed 25p.
JACK SOCKETS Stereo Open 25p; Closed 30p.
FREE SOCKETS — Cable end 30p.
2.5mm and 3.5mm JACK SOCKETS 15p.
2.5mm and 3.5mm JACK PLUGS 15p.
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin 10p. Free Sockets 3-pin, 5-pin 25p.
Plugs 3-pin 20p; 5-pin 25p.
PHONO PLUGS and SOCKETS ea. 10p.
Free Socket for cable end ea. 15p.
Screened Phono Plugs ea. 15p.
TV CONVERGENCE POTS **15p each**
Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms.

MONO PRE-AMPLIFIER. Mains operated solid state pre-amplifier unit designed to complement amplifiers without low level phono and tape input stages. This free-standing cabinet incorporates circuitry for automatic R.I.A.A. equalisation on magnetic phono and N.A.B. equalisation for tape heads. Phono sockets for input and output.
£4.50 Post 50p



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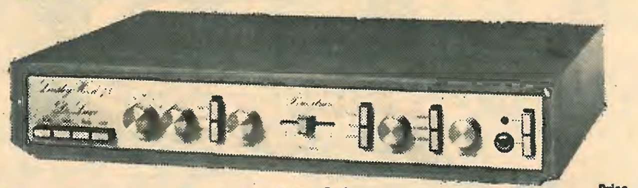
Radio Books and Components Lists 20p. (Minimum posting charge 30p.) Cash prices include VAT. Access or Barclaycard. Telephone: 01-684 1665

ELECTRONIC KITS OF DISTINCTION FROM POWERTRAN

DE LUXE EASY TO BUILD LINSLEY-HOOD 75W AMPLIFIER



AVAILABLE AS SEPARATE PACKS
PRICES IN OUR FREE CATALOGUE

SPECIAL PRICE FOR COMPLETE KIT £99.30 + VAT

The standard model of our kit for Mr. Linsley-Hood's 75 watt design has for a long time offered exceptional performance at a very modest cost with high quality high power ready-built units of comparable quality generally being over three times the price.

Features of the amplifier include very low distortion (less than 0.01%), 75W rms per channel power output, rumble filter, variable slope scratch filter, variable transition frequency tone controls, tape monitoring facilities and individually adjustable inputs. This model is based on 5 circuit boards which not having the controls mounted on them can, if desired, be effectively used separately in high performance audio systems not based on our metalwork.

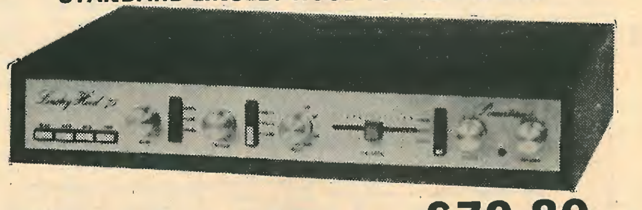
Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and are designed to have the potentiometers and switches mounted upon them. This system almost eliminates internal wiring, making installation, after their assembly, delightfully straightforward, and as each board can be easily removed in seconds from the chassis, checking and maintenance is so simple that even newcomers to electronics will be able to cope competently with the kit. Additional features of our new model are inclusion of the latest circuit improvements, generously sized heat sinks for heavy duty use, even in tropical climates, and metal oxide resistors throughout for long-term stability and reliability.

Pack	Price	Pack	Price
1. Fibreglass printed circuit board for power amp	£1.15	11. Fibreglass printed-circuit board for power supply	£0.85
2. Set of resistors, capacitors, pre-sets for power amp	£2.80	12. Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£4.90
3. Set of semiconductors for power amp	£6.20	13. Set of miscellaneous parts including DIN skts., mains input skt., fuse holder, interconnecting cable, control knobs	£6.70
4. Pair of 2 drilled, finned heat sinks	£1.10	14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£8.20
5. Fibreglass printed-circuit board for pre-amp	£1.90	15. Handbook	£0.75
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£4.50	16. High Quality Teak Veneer cabinet 18.3" x 12.7" x 3.1"	£10.70
7. Set of low noise, high gain semiconductors for pre-amp	£2.00		
8. Set of potentiometers (including mains switch)	£3.50		
9. Set of 4 push-button switches, rotary mode switch	£5.40		
10. Toroidal transformer complete with magnetic screen/ housing primary: 0 117-234 V; secondaries: 33-0-33 V, 25-0-25 V	£12.95		

2 each of packs 1-7, 1 each of packs 8-16 inclusive are required for complete stereo amplifier. Total cost of individually purchased packs £93.25

PACK PRICES FOR STANDARD KIT

STANDARD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT £79.80 + VAT

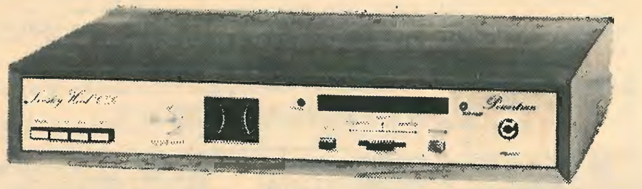
WIRELESS WORLD FM TUNER

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley-Hood 75W Amplifier, this kit provides the perfect match. The Wireless World (Skingley and Thompson) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m. rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push-button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout.

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

SPECIAL PRICE FOR COMPLETE KIT £70.20 + VAT

LINSLEY-HOOD CASSETTE DECK



SPECIAL PRICE FOR COMPLETE KIT £79.60 + VAT

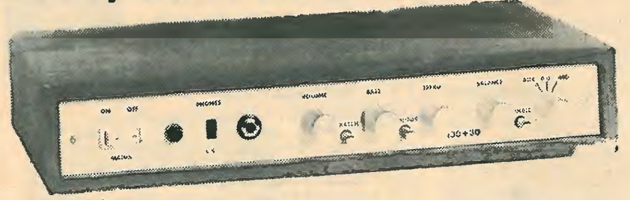
Pack	Price	Pack	Price
1. Stereo PCB (accommodates 2 rep. amps, 2 meter, amps, bias/erase osc. relay)	£3.35	10. Set of capacitors, rectifiers, I.C. voltage regulator P.C.B. for power supply (Powertran design)	£2.80
2. Stereo set of capacitors, M.O. resistors, potentiometers for above	£8.95	11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc	£3.80
3. Stereo set of semiconductors for above	£7.90	12. Set of metalwork including silk screened fascia panel, internal screen, fixing parts, etc	£7.10
4. Miniature relay with socket	£2.90	13. Construction notes	£0.50
5. PCB, all components for solenoid, speed control circuits	£3.40	14. High Quality Teak Veneer cabinet 18.3" x 12.7" x 3.1"	£10.70
6. Goldring-Lenco mechanism as specified	£18.50		
7. Function switch, knobs	£1.90		
8. Dual VU meter with illuminating lamp	£6.95		
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V. Sec. 15V	£4.90		

One each of packs 1-14 inclusive are required for complete stereo cassette deck. Total cost of individually purchased packs £87.75

Matsushita WY 436 AZ head (optional extra) . £4.50
(free with compete kit)

Published in Wireless World (May, June, August 1976) by Mr. Linsley-Hood, this design, although straightforward and relatively low cost, nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Pushbutton switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry. This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier. Circuit changes as published in February, 1978, follow-up article are included in the kit AT NO EXTRA COST! A higher performance head (Matsushita WY 436 AZ head as recommended in the follow-up article) is offered as an optional extra but this will be automatically supplied FREE OF CHARGE with all orders for complete kits!

T20+20 AND T30+30 20W, 30W AMPLIFIERS



Designed by Texas engineers and described in Practical Wireless, the Texan was an immediate success. Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20+20 delivers 20W rms per channel of true Hi-Fi at exceptionally low cost. The **easy to build** design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers including scratch and rumble filters, adaptable input selector and headphones socket. In a follow-up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30+30. These include RF interference filters and a tape monitor facility. Power output of this model is 30W rms per channel.

SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE £33.10 + VAT

T30+30 KIT PRICE £38.40 + VAT

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

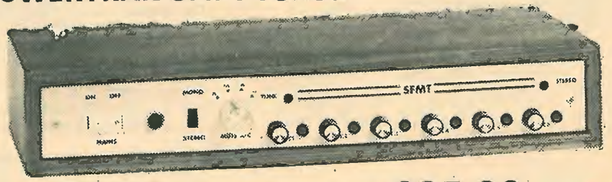
WWII TUNER

SPECIAL PRICE FOR COMPLETE KIT £47.70 + VAT

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

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

POWERTRAN SFMT TUNER



PRICE FOR COMPLETE KIT £35.90 + VAT

AVAILABLE AS COMPLETE KIT ONLY

This is a simple, low cost design which can be constructed easily without special alignment equipment but which still gives a first-class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the **T20+20** and **T30+30** amplifiers.

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200+200 watt AMPLIFIER

As featured in Electronics Today International

400W rms continuous —— 800W peak!
0.03% THD at FULL power!
PLUS all the following features too!

- ★ Each channel totally independent with its own stabilised power supply driven by custom designed TOROIDAL transformers!
- ★ Inherent reliability — monster heat sinks for cool running at the hottest venues — electronic open and short circuit protection!
- ★ Ultra low feedback (an incredible low 14dB overall!), super high slewing rate (20V/µs), 200W rms continuous to 4 ohm from EACH channel, input sensitivity 0.775V (0dB).
- ★ Professional quality components, sturdy 19" rack mounting chassis complete with sleeve and feet for free standing work too.
- ★ Easy to build — plenty of working space with ready access to all components, minimal wiring, extensive instruction suitable for both experienced constructors and newcomers to electronics.
- ★ Value for money — quality and performance comparable with ready-built amplifiers costing over £600!

PSI 4002 STUDIO MODEL

Cabinet size 17.2" x 6.7"

COMPLETE KIT ONLY £196.90 + VAT

READ THE REVIEW IN SOUND INTERNATIONAL DEC 78!

TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

As featured in Electronics Today International

The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or ½% metal film!) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibre glass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £700!

COMPLETE KIT ONLY £172.00 + VAT!

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

CHROMATHEQUE 5000 5-CHANNEL LIGHTING EFFECTS SYSTEM

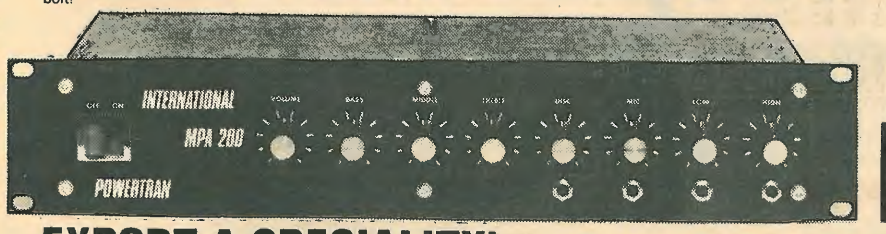
This versatile system featured as a constructional article in ELECTRONICS TODAY INTERNATIONAL has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound-to-light or have it strobe all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

Kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. — Complete right down to the last nut and bolt!

COMPLETE KIT ONLY £49.50 + VAT

MPA200 100W MIXER/AMPLIFIER

Featured as a constructional article in Electronics Today International the MPA 200 is an exceptionally low-priced but professionally finished general purpose, rugged, high-power amplifier which has an adaptable range of inputs such as disc, microphone, guitar, etc. There are 3 wide range tone controls and a master volume control. Mechanically the design is simplicity in the extreme with minimal wiring making construction very straightforward. Kit includes fully finished metalwork, fibreglass PCB's, controls, wire, etc. — Complete right down to the last nut and bolt!



COMPLETE KIT ONLY £49.90 + VAT

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

EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits. This will be sent free on request, by airmail, together with our "Export Postal Guide" which gives current postage prices. There is no minimum order charge. Prices same as for U.K. customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentaton and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U.K. Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London.

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UK Carriage FREE

PRICE STABILITY. Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until August 31st, 1979, if this month's advertisement is mentioned with your order. Errors and VAT rate changes excluded.

U.K. ORDERS: Subject to 12½%* surcharge for VAT (i.e. add ⅛ to the price). No charge is made for carriage. *Or current rate if charged.
SECURICOR DELIVERY: For this optional service (U.K. mainland only) add £2.50 (VAT inclusive) per kit.
SALES COUNTER: If you prefer to collect your kit from the factory, call at Sales Counter (at rear of factory). Open 9 a.m.-4.30 p.m. Monday-Thursday.

QUALITY: All components are brand new first grade full specification guaranteed devices. All resistors (except where stated as metal oxide) are low noise carbon film types. All printed circuit boards are fibreglass, drilled roller tinned and supplied with circuit diagrams and construction layouts.

FOR FURTHER INFORMATION PLEASE WRITE OR TELEPHONE FOR OUR FREE CATALOGUE

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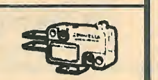
WINDSCREEN WIPER CONTROL

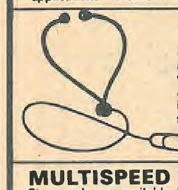
Vary speed of your wiper, to suit conditions. All parts and instructions to make **£3.75.**

MICRO SWITCH BARGAINS



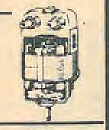
Rated at 5 amps 250V. Ideal to make a switch panel for a calculator and for dozens of other applications. Parcel of 10 (two types) for **£1.25**

RADIO STETHOSCOPE



Easiest way to fault find, traces, signal from aerial to a speaker, when signal stops you've found the fault. Use it on, Radio, TV, amplifier, anything. Kit comprises transistors and parts including probe tube and twin stetho-set **£3.95.**

MULTISPEED MOTORS



Six speeds are available 500, 800 and 1,000 r.p.m. and 7,000, 9,000 and 11,000 r.p.m. Shaft is ¼ in. diameter and approximately 1 in. long. 230-240V. Its speed may be further controlled with the use of our Thyristor controller. Very powerful and useful motor size approx. 2 in. dia. x 5 in. long. Price **£2.50.**

6 DIGIT COUNTER

One pulse at mains voltage moves 1 digit — not resettable — real bargain @ **80p.**

MAINS BLOWER

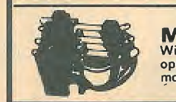
The Torrin — quiet but powerful outlet size 2½ × 1⅞ for cooling equipment, etc. will extract of outlet is blowing outwards price **£5.50.** **Other models from £2.00.**

INDUCTION MOTORS

One illustrated is our reference MM11 made for ITT ⅜ stack 1½ spindle **£2.26,** ½ stack model **£1.75,** 1 stack **£2.75.** 1½ stack **£3.25.**

EXTRACTOR FAN

Ex-computers — made by Woods of Colchester. Ideal for fixing through panel — reasonably quiet running — very powerful 2,500 r.p.m. Choice of two sizes 5in or 6¼in. **£6, £6.**



MAINS RELAYS

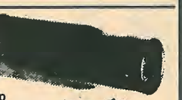
With triple 10 amp changeover contacts — operating coil wound for 230V a.c. Chassis mounting one screw fixing. Price **£1.25.**

BURGLAR ALARM ITEMS

(Circuit free on application)

Trigger mats 24in × 18in	£2.45
13in × 10in	£1.95
Relay 24 volt	95p
9-12 volt	95p
Alarm Bell 24 volt	£7.50
9-12 volt	£2.25
Mains	on application
Reset, Switch, ordinary	45p
Secret type with key	95p
Wire — 100 metres	£1.50
24V Power unit mains operated	£5.35

MERCURY BATTERIES



Bank of 7 Mercury cells type 625 which are approx. ⅝in. diameter by ⅜in. thick in plastic tube giving a total of 10.7V.

Being in a plastic tube it is very easy to break up the battery into separate cells and use these for radio control and similar equipment. Carton of 25 batteries **£1.60.**

PP3/PP9 REPLACEMENT

Japanese made in plastic container with leads size 2in. × 1½in. × 1 1/3in., this is ideal to power a calculator or radio. It has a full wave rectifier and smoothed output of 9V suitable for loading of up to 100mA. **£2.53.**

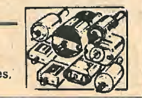
MAINS TRANSISTOR PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises: mains transformer, rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **£1.95.**

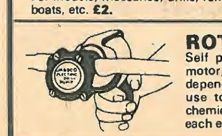
DRILL CONTROLLER

Electronically changes speed from approximately 10 revs to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **£3.45**

8 POWERFUL BATTERY MOTORS



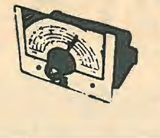
For models, Meccanos, drills, remote control planes, boats, etc. **£2.**



ROTARY PUMP

Self priming, portable, fits drill or electric motor, pumps up to 200 gallons per hour depending upnorevs. Virtually unbreakable, use to suck water, oil, petrol, fertiliser, chemicals, anything liquid. Hose connections each end. **£2.**

SHORTWAVE CRYSTAL SET



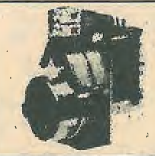
Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 10, 25, 29, 31 metre bands. Kit contains chassis front panel and all the parts **£1.94** — crystal earphone **65p** including VAT and postage.

MULLARD UNILEX

A mains operated 4+4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone in easy-to-assemble modular form and complete with a pair of speakers this should sell at about **£30** — but due to a special bulk-buy and as an incentive for you to buy this month we offer the system complete at only **£15** including VAT and postage.

HUMIDITY SWITCH

American made by Honeywell. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive micro-switch, quite sensitive — breathing on it for instance will switch it on. Micro 3 amp, at 250V a.c.

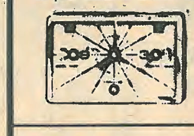


DELAY SWITCH

Mains operated — delay can be accurately set with pointers knob for periods of up to 2½ hrs. 2 contacts suitable to switch 10 amps — second contact opens few minutes after 1st contact **£1.50.**

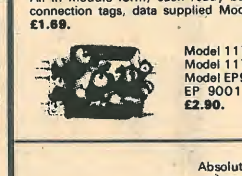
25A ELECTRIC PROGRAMMER

Learn in your sleep. Have radio playing and kettle boiling as you wake — switch on lights to ward off intruders — have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours independent 60 minute memory jogger. A beautiful unit. **£4.50.**



MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied Model 1153 500mW, power, output **£1.69.**



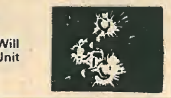
Model 1175 — 10 watts power output **£3.94**
Model 1172 1W, power output **£2.25**
Model EP9000 4 watt power output **£2.90.**
EP 9001 twin channel or stereo pre-amp **£2.90.**

Absolutely brand new, in fact still in the makers packing cases. The H1200 primarily is a VDU with Ascii Keyboard, but it has many features which makes it ideal for almost any application from main frame to home MPU systems. Main features are:

- ★ 1920 Characters (80 c 24 lines)
- ★ V24/RS232 Interface
- ★ Selectable Baud Rates (110-9600)
- ★ Local, Half or Full Duplex
- ★ Screen Size 12in. Diagonal
- ★ 55 Key TTY Format Keyboard
- ★ Automatic Scroll UP
- ★ Parity Error Indication
- ★ Ascii Code
- ★ Full Service Manual Available

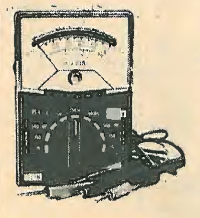
Export and Trade enquiries welcome. Sorry our quantity price does not apply to these but we welcome trade enquiries and where possible some small discount will be given, **Price for the Terminal £350 + £24** Carriage.

SOUND TO LIGHT UNIT



Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450W). Unit in box all ready to work. **£9.95.**

MINI-MULTI TESTER



Amazing, deluxe pocket size precision moving coil instrument jewelled bearings — 1000 opv — mirrored scale.

11 Instant ranges measure:—
DC volts 10, 50, 250, 1000
AC volts 10, 50, 250, 1000
DC amps 0-1 mA and 0-100 mA
Continuity and resistance 0-150K ohms.

Complete with insulated probes, leads, battery, circuit diagram and instructions.

Unbelievable value only **£6.50 + 50p** post and insurance.
FREE Amps ranges kit enables you to read DC current from 0-10 amps, directly on the 0-10 scale. It's free if you purchase quickly but if you already own a mini tester and would like one send **£1.50.**

TERMS: Cash with order — but orders under **£6** must add **50p** to offset packing, etc.

BULK ENQUIRIES INVITED. PHONE: 01-688 1833.
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J. BULL (ELECTRICAL) LTD

(Dept. WW), 103 TAMWORTH RD., CROYDON CR9 1SG

IT'S FREE

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived — often bargains which sell out before our advertisement can appear — It's an interesting list and it's free — just send S.A.E. Below are a few of the Bargains still available from previous lines.

TELEPHONE ANSWERING MACHINES
We supply these machines on the understanding they are broken up or at least not used for their original purpose. The Machines are second hand but so far as we can see they are complete and quite possibly in good working order. We do not test them but guarantee to replace any part of the machine should it be missing or faulty.

THIS MONTH'S SNIP
Is a brand new two piece intercom, with 50ft. inter-connecting lead. Master station and sub station in neat cream coloured cases suitable for office or home or as a baby alarm etc. These are new stock but some we understand may need slight attention. Offered at half regular price only **£3.74.**

PORTABLE FLUORESCENT LAMP
Ideal for camping but really a must for you if you are a motorist. You never know when you need a light and unlike the average torch this lamp will illuminate the whole engine. With a lead which you can plug into the car lighter socket thus its saving internal batteries. A real bargain complete with 9in. tube ready to operate. Price **£7.99.**

SETTING UP A WEATHER STATION?
We have two only professional Anemonitors. Quite complete i.e. a generator with its rotating cups weather proofed for mounting on a mast, and the ma instrument which directly indicates wind speeds of up to 100mph. Furthermore there is a facility for setting off an alarm should the wind speed reach a pre-determined level (adjustable) say 80mph. These are brand new and complete with handbook. Price **£189.**

ENAMELLED COPPER WIRE
Available on one pound reels or four ounce reels. We keep a stock of even numbered sizes but will also get odd numbered sizes to order. Price for 10, 12, 14, 16, 18 SWG **£2.70** per pound, **81p** oer quarter pound. 30, 32, 34 **£3.24** per pound. 36, 38, 40, **£3.78 + 28p** per pound, **£1.26** per quarter pound. Thinner sizes also available to order price on request.

WANT A CHEAP ELECTRIC FAN?
We can offer the ¾in. stack induction motor with a 6in. five-bladed fan, mount this on a stiff wire frame or a piece of handy angle and you will be able to keep yourself cool this summer.

WANT A MILLION RESISTORS?
These are ½ watt, 1 watt and 2 watt types, all neatly packed in boxes with values clearly marked. Resistors themselves are colour coded and are perfectly standard, not every value of the range is included but they are reasonably spread over and there is not an unreasonable quantity of any one value. Ideal stock for retail shop or service depot. Price **£1,000 + VAT.**

SERVICE ENGINEERS ASSORTMENT IFs AND OSC COILS
Standard for many Jap and Hong Kong portable radios and cassettes etc. 100 assorted, price **£5.60.**

HEATING PAD
11in.×8¼in., wafer thin 250 watt. Price **£1.16.**

HEAT AND LIGHT LAMP
500 watt tubular like a short fluorescent tube, ideal for paint drying etc. Price **£3.95 + 20p,** post and special packing **£1.25.**

RADIOMOBILE CAR RADIO
12 volt L & M push button operation. Price **£28.12.**

CAR RADIO
L & M and with FM good quality, Far Eastern make, 12 volts. Price **£19.95.**

MAINS TRANSFORMER
30 volts 2 amp secondary upright mounting, primary and secondary wound on separate bobbins for additional safety. Price **£3.84.**

RELAY
Plug in, 3 changeover in clear plastic case 12 volt DC or 25 volt AC (or 3 volt DC), same price.

MERCURY OPERATED SWITCH
Glass encapsulated, 15 amp with 12in. very flexible leads. Price **£1.62.**

SPECIAL MULTI-CORE CABLES
14.0076 cores. PVC insulated and colour coded and each core with metal screen, PVC outer cover. The following types in stock: 4 core **75p,** 6 core **90p,** 7 core **£1.15,** 12 core **£1.50.** All per metre + VAT. Cut to any length, carriage extra if order under £6.

0-1 mA PANEL METER
Flush mounting and in a waterproof case made for American equipment, scale divided into zones but not numbered. Price **£2.70.**

TAPE HEAD CLEANERS
Suitable for any cassette or reel to reel machine, special fluid (Isopropyl alcohol) in felt-tipped dispenser. Price **35p.**

UNISELECTOR
Base mounting Tamsa 9 pole, 12 way 50 volt operation. Price **£4.66.**

PLUG IN UNISELECTOR
Ref No: AP 212958. Definitely a piece of precision equipment, it measures approximately 5in. high × 1½in. wide × 1in. thick, plugs into a 20 pin base. Probable cost would be at least £20 each. We only have a few, **£5.40.**

RE-DOING YOUR LIVING ROOM?
If you are thinking of making a log effect fire-piece, we have the fibreglass tops, which when lit up give the full log effect. Size approximately 17in.×10½in. Prica **£2.35.**

PAPST MOTORS
Sometimes described as the motor with the built-in flywheel. These are used in many good quality tape recorders and in other aquipment where wow and flutter has been reduced to a minimum. We have five different motors in stock, these are all physically about the same size (about 3in. dia. × 2½in. deep). We quote their type numbars but we have no other technical information. Price includes the capacitor required: HSZ 20.50—4 540D dual voltage 125/220 50Hz **£7.50+60p+50p p.p.** HSZ 20.50—4 255D 110V 50/60Hz **£5.50+44p+50p p.p.** KLZ 20.50—4 540D 220V 50Hz **£7.50+60p+80p p.p.** KLZ 20.50—4 425D 115V 60Hz **£5.50+44p+50p p.p.** KLZ 20.50—4 468D 110V 50Hz **£5.50+44p+50p p.p.**

BATTERY CONDITION TESTER
Suitable for most batteries. That is zinc carbon types, marcury, manganese, nicad, silver oxide and alkaline batteries. The taster puts dummy lead on the battery and the meter scale indicates the condition by settling in a zone labelled 'Replaca', 'Weak' or 'Good' etc. Complete in case, size approximately 3¾in.×6½in.×2in. with laads, prods and instructions. Price **£5.95.**

TORQUE MOTORS
Elinco (USA make) ref. no: NCH3/1 1600 1/30 horse, 150V 50Hz, brand new condition. Unused spares for computers. Price **£5.95.**

TWO TRACK RECORD/PLAYBACK HEADS
For transistor circuits with separate erase head. Special offer this month **£1.08.**

CASSETTE MECHANISM
Jap made to rigid specification. These will fit many music centres and cassette players. Chassis size approx. 4½in. wide by 5¼in. deep, 6V motor and tape position counter at the rear. The six levers for 'play', 'fast forward', 'rewind', 'stop', 'record, and 'eject' are all at the front, as is the auto mechanism to stop the motor when tape end is reached. These are new and unused end have stereo heads. Limited quantity, price **£15.25.**

COOKER CLOCKS
All are less knobs and glass fronts, but you will no doubt be able to take these from the clock you are replacing. Replacements for Tricity and other well known cookers, these are also suitable for other timed switching operations. All are 230/40 working, with switches rating at 25-30 amps, famous makes: — Cat. No. 5856 L, 40 amp, large clear dial size 5in.×3¾in. approximately. Made by Lux Time Canada Ltd. This has a normal stop and start facility plus 60 second minute minder. Price **£2.60.** Cat No. DDS 0663/2 made by Smiths, dial size approximately 40in.×3in. this has the clock on the right-hand side and the stop and start switches on the left-hand side. There is no minute minder: Price **£1.62+12p.** Cat. No. OCU/5600/2 made by Smiths, this has a round black dial approximately 3in. diameter, the stop and start is set by a knob in the lower right corner, a knob in the upper right corner opens a red section on the dial, this red section indicates the time the oven will be on. Price **£2.70.** Cat. No. 84363, this is a 5hr timer, the control knob of which automatically winds the mechanism and starts the timer, at the end of the selected time on a warning will ring. This can be very accurately set in mins, up to 5 hours. One complete rotation of the dial is 1 hour, as you wind for the second and subsequent hours the hours are shown through a panel in the dial. This sounds a bell-like alarm but could be made to operate a micro-switch. Price **£1.62.** Cat. No. ST 82/7, as above but with black dial instead of silver. Price **£1.08.** Cat. No. ST 82/8, similar to one above but for one hour only. Price **£1.08.**

SEMICONDUCTORS

TRANSISTORS

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AC107	£0.23	BC116	£0.21	BD179	£0.81	BIP20	£0.41	TIP2955	£0.65	2N4284	£0.20
AC113	£0.21	BC116A	£0.21	BD180	£0.61	BIP19/20	£0.86	TIP3055	£0.54	2N4285	£0.20
AC115	£0.21	BC117	£0.23	BD181	£0.98	BSX25	£1.57	TIS43	£0.24	2N4286	£0.20
AC117	£0.32	BC118	£0.16	BD182	£0.97	BSX19	£0.19	TIS90	£0.20	2N4287	£0.20
AC118K	£0.36	BC119	£0.27	BD183	£1.03	BSX20	£0.19			2N4288	£0.20
AC121	£0.21	BC120	£0.43	BD184	£1.19	BSY25	£0.17			2N4289	£0.20
AC122	£0.15	BC125	£0.19	BD185	£0.73	BSY26	£0.17			2N4290	£0.20
AC125	£0.19	BC126	£0.25	BD186	£0.73	BSY27	£0.17	UT46	£0.22	2N4291	£0.20
AC126	£0.16	BC132	£0.20	BD187	£0.81	BSY28	£0.17			2N4292	£0.20
AC127	£0.19	BC134	£0.20	BD188	£0.81	BSY29	£0.17			2N4293	£0.20
AC128	£0.15	BC135	£0.17	BD189	£0.84	BSY38	£0.21			2N4921	£0.62
AC128K	£0.28	BC136	£0.20	BD190	[illegible]	BSY39	£0.21	ZTX107	£0.11	2N4923	£0.73
AC132	£0.21	BC137	£0.20	BD195	£0.97	BSY40	£0.31	2N707	£0.52	2N5135	£0.11
AC134	£0.21	BC139	£0.35	BD196	£0.97	BSY41	£0.31	2N708	£0.15	2N5136	£0.11
AC127	£0.21	BC140	£0.32	BD197	£1.03	BSY51	£0.27	2N711	£0.32	2N5138	£0.11
AC141	£0.23	BC141	£0.30	BD198	£1.03	BSY95	£0.14	2N717	£0.32	2N5172	£0.16
AC141K	£0.32	BC142	£0.24	BD199	£1.07	BSY95A	£0.14	2N718	£0.27	2N5194	£0.60
AC142	£0.21	BC143	£0.24	BD200	£1.07	BRY39	£0.49	2N718A	£0.54	2N5245	£0.45
AC142K	£0.32	BC145	£0.52	BD201	£0.86	BU105	£1.51	2N726	£0.31	2N5294	£0.37
AC151	£0.21	BC147	£0.08	BD202	£0.86	BU105/02	£2.11	2N727	£0.31	2N5296	£0.39
AC153	£0.23	BC148	£0.08	BD201/		BU204	£1.51	2N743	£0.22	2N5457	£0.35
AC154K	£0.32	BC149	£0.08	202mp	£1.84	BU205	£1.51	2N744	£0.22	2N5458	£0.35
AC154	£0.21	BC150	£0.23	BD203	£0.86	BU208	£2.05	2N914	£0.16	2N5459	£0.38
AC155	£0.21	BC151	£0.25	BD204	£0.86	BU208/02	£2.43	2N918	£0.32	2N5551	£0.41
AC156	£0.21	BC152	£0.23	BD203/				2N929	£0.22	2N6027	£0.37
AC157	£0.27	BC153	£0.28	204mp	£1.84			2N930	£0.19	2N6121	£0.76
AC165	£0.21	BC154	£0.21	BD205	£0.86			2N1131	£0.19	2N6122	£0.76
AC166	£0.21	BC157	£0.11	BD206	£0.86	E1222	£0.41	2N946	£0.43		
AC167	£0.21	BC158	£0.11	BD207	£1.08			2N1132	£0.19		
AC168	£0.27	BC159	£0.11	BD208	£1.08			2N1302	£0.16		
AC160	£0.21	BC160	£0.28	BD222	£0.51	MAT100	£0.21	2N1303	£0.19		
AC171	£0.27	BC161	£0.41	BD225	£0.51	MAT101	£0.22	2N1304	£0.19	2S301	£0.54
AC176	£0.19	BC167	£0.14	BD232	£0.59	MAT120	£0.21	2N1305	£0.19	2S302	£0.46
AC176K	£0.28	BC168	£0.14	BD233	£0.52	MAT121	£0.22	2N1306	£0.27	2S302A	£0.46
AC178	£0.27	BC169	£0.10	BD234	£0.50	MJ480	£1.03	2N1307	£0.27	2S303	£0.60
AC179	£0.27	BC169C	£0.11	BD235	£0.50	MJ481	£1.13	2N1308	£0.32	2S304	£0.77
AC180	£0.21	BC170	£0.10	BD236	£0.63	MJ490	£1.03	2N1309	£0.32	2S305	£0.86
AC180K	£0.30	BC171	£0.16	BD237	£0.59	MJ491	£1.24	2N1599	£0.38	2S306	£0.86
AC181	£0.21	BC172	£0.10	BD238	£0.65	MJE340	£0.49	2N1613	£0.22	2S307	£0.86
AC181K	£0.30	BC173	£0.10	BD239A	£0.54	MJE370	£0.59	2N1711	£0.22	2S321	£0.62
AC187	£0.19	BC174	£0.17	BD240A	£0.54	MJE371	£0.65	2N1889	£0.49	2S322	£0.46
AC187K	£0.30	BC175	£0.39			MJE520	£0.49	2N1890	£0.49	2S322A	£0.46
AC188	£0.19	BC177	£0.17			MJE521	£0.70	2N1893	£0.32	2S323	£0.62
AC188K	£0.30	BC178	£0.17	BDX32	£2.38	MJE2955	£0.97	2N2147	£0.81	2S324	£0.77
ACY17	£0.37	BC179	£0.17	BDY11	£1.40	MJE3055	£0.65	2N2148	£0.76	2S325	£0.77
ACY18	£0.37	BC180	£0.27	BDY17	£1.94	MJE3440	£0.56	2N2160	£1.08	2S326	£0.77
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

74 SERIES TTL ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
7400	£0.10	7427	£0.26	7473	£0.27	74110	£0.39	74166	£0.84
7401	£0.12	7428	£0.28	7474	£0.27	74111	£0.63	74174	£0.70
7402	£0.12	7430	£0.12	7475	£0.31	74118	£0.86	74175	£0.67
7403	£0.12	7432	£0.24	7476	£0.27	74119	£1.27	74176	£0.63
7404	£0.12	7433	£0.32	7480	£0.48	74121	£0.26	74177	£0.63
7405	£0.12	7437	£0.23	7481	£0.92	74122	£0.42	74180	£1.62
7406	£0.24	7438	£0.23	7482	£0.73	74123	£0.43	74181	£0.63
7407	£0.24	7440	£0.13	7483	£0.63	74136	£0.56	74182	£0.76
7408	£0.14	7441	£0.54	7484	£0.95	74141	£0.59	74184	£0.76
7409	£0.14	7442	£0.43	7485	£0.73	74145	£0.59	74190	£0.73
7410	£0.12	7443	£0.76	7488	£0.24	74150	£0.73	74191	£0.67
7411	£0.18	7444	£0.76	7489	£1.84	74151	£0.52	74192	£0.65
7412	£0.16	7445	£0.70	7490	£0.34	74153	£0.52	74193	£0.63
7413	£0.26	7446	£0.65	7491	£0.69	74154	£0.88	74194	£0.67
7414	£0.54	7447	£0.52	7492	£0.38	74155	£0.54	74195	£0.65
7416	£0.25	7448	£0.60	7493	£0.32	74156	£0.54	74196	£1.13
7417	£0.25	7450	£0.12	7494	£0.81	74157	£0.54	74197	£1.13
7420	£0.12	7451	£0.12	7495	£0.54	74160	£0.63	74198	£2.00
7421	£0.22	7453	£0.12	7496	£0.54	74161	£0.67	74199	£2.00
7422	£0.17	7454	£0.12	74100	£0.92	74162	£0.67		
7423	£0.23	7460	£0.12	74104	£0.42	74163	£0.67		
7425	£0.20	7470	£0.27	74105	£0.41	74164	£0.73		
7426	£0.25	7472	£0.22	74107	£0.26	74165	£0.73		

CMOS ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CD400	£0.15	CD4015	£0.82	CD4026	£1.30	CD4043	£0.95	CD4070	£0.18
CD4001	£0.16	CD4016	£0.45	CD4027	£0.54	CD4044	£0.89	CD4071	£0.18
CD4002	£0.17	CD4017	£0.81	CD4028	£0.73	CD4045	£1.51	CD4072	£0.18
CD4006	£0.99	CD4018	£0.92	CD4029	£0.92	CD4046	£1.40	CD4081	£0.18
CD4007	£8.18	CD4019	£0.45	CD4030	£0.52	CD4047	£0.94	CD4082	£0.19
CD4008	£0.99	CD4020	£0.97	CD4031	£2.16	CD4049	£0.45	CD4510	£1.07
CD4009	£0.49	CD4021	£0.87	CD4035	£1.08	CD4050	£0.45	CD4511	£1.03
CD4010	£0.52	CD4022	£0.87	CD4037	£1.03	CD4054	£1.19	CD4516	£1.08
CD4011	£0.16	CD4023	£0.16	CD4040	£0.95	CD4055	£1.08	CD4518	£1.08
CD4012	£0.17	CD4024	£0.70	CD4041	£0.82	CD4056	£1.46		
CD4013	£0.45	CD4025	£0.16	CD4042	£0.78	CD4069	£0.18		

LINEAR ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CA3011	£0.90	CA3130	£1.00	MC1350	£1.35	UA710C	£0.45	SN76115	£2.14
CA3014	£1.52	CA3140	£0.76	MC1352	£1.57	72710	£0.34	SN76660	£0.84
CA3018	£0.73	LM301	£0.33	MC1469	£3.19	UA711C	£0.30	SL414A	£2.19
CA3020	£1.91	LM304	£1.73	MC1496	£1.01	72711	£0.36	TAA550B	£0.30
CA3028	£0.90	LM308	£1.12	NE536	£2.99	UA723	£0.49	TAA621A	£2.25
CA3035	£1.57	LM309	£1.62	NE550	£1.03	72723	£0.49	TAA621B	£2.81
CA3036	£1.12	LM320-5V	£1.62	NE555	£0.26	UA741C	£0.27	TAA661	£1.09
CA3042	£1.09	LM320-12V	£1.62	NE556	£0.65	72741	£0.27	TAD100	£1.46
CA3043	£2.06	LM320-15V	£1.62	NE565	£1.35	741F	£0.22	TBA540	£2.36
CA3046	£0.79	LM320-24V	£1.62	NE566	£1.09	UA747C	£0.97	TBA810S	£0.84
CA3052	£1.80	LM380	£0.96	NE567	£1.91	72747	£0.67	TBA810	£1.10
CA3054	£1.24	LM381	£1.63	UA702C	£0.52	UA748	£0.39	TBA820	£0.79
CA3075	£1.09	LM3900	£0.65	72702	£0.52	72748	£0.39	TBA9200	£2.81
CA3081	£1.09	MC1303L	£0.96	UA703	£0.28	748P	£0.39	TCA270S	£2.25
CA3089	£2.25	MC1304	£2.14	UA709	£0.28	SN76660013N	£1.97		
CA3090	£4.05	MC1310	£1.07	72709	£0.52	SN76023	£1.97		
CA3123	£2.14	MC1312	£2.14	709P	£0.28	SN76110	£1.09		

DIODES

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AA110	£0.09	BAX13	£0.08	BY164	£0.55	OA10	£0.37	S010	£0.06
AA120	£0.09	BAX16	£0.09	BY176	£0.84	OA47	£0.09	S019	£0.06
AA129	£0.09	BY100	£0.23	BY206	£0.32	OA70	£0.09	IN34	£0.08
AAY30	£0.10	BY101	£0.23	BYZ10	£0.46	OA79	£0.11	IN34A	£0.08
AAZ13	£0.16	BY105	£0.23	BYZ11	£0.46	OA81	£0.11	IN914	£0.65
BA100	£0.11	BY114	£0.23	BYZ12	£0.48	OA85	£0.11	IN916	£0.06
BA102	£0.34	BY124	£0.24	BYZ13	£0.43	OA90	£0.11	IN4148	£0.06
BA148	£0.16	BY126	£0.16	BYZ16	£0.44	OA91	£0.11	IS44	£0.05
BA154	£0.13	BY127	£0.17	BYZ17	£0.38	OA95	£0.11	IS920	£0.06
BA155	£0.15	BY128	£0.17	BYZ18	£0.38	OA182	£0.14		
BA173	£0.16	BY130	£0.18	BYZ19	£0.38	OA200	£0.09		
BB104	£0.16	BY133	£0.23	OA5	£0.64	OA202	£0.09		

TRIACS

2 amp Volts	TO5 Case No.	Price	10 Amp Volts	TO48 Case No.	Price
100	TR12a/100	£0.31	100	TR110a/100	£0.77
200	TR12a/200	£0.51	200	TR100a/200	£0.92
400	TR12a/400	£0.71	400	TR100a/400	£1.12

6 Amp Volts	TO66 Case No.	Price	10 Amp Volts	TO220 Plastic Case No.	Price
100	TR16a/100	£0.51	400	TR100a/400p	£1.12
200	TR16a/200	£0.61		DIACS	
400	TR16a/400	£0.77		8R100 £0.20 D32	£0.20

ORDERING Do not forget to state order number and your name and address.

V.A.T.
All prices include V.A.T. at the appropriate rate.

P & P: 35p unless otherwise stated.

BI-PAK

DEPT. WW7, P.O. BOX 6, WARE, HERTS.

SHOP AT 18 BALDOCK ST., WARE, HERTS. OPEN 9 to 5.30 MON—SAT.

VALVES

Minimum Order £1.00

VALVES VAT IS INCLUDED

	£												
A1065	1.40	EF92	1.00	PCF801	1.05	UBL1	1.15	6AH6	0.80	6Q7G	0.90	20P5	1.15
AR8	0.70	EF95	2.95	PCF802	0.75	UBL21	0.85	6AK5	0.85	6SA7	0.85	25L6GT	0.90
ARP3	0.70	EF183	1.40	PCF805	2.05	UCC84	0.70	6AK8	0.45	6SG7	0.85	25Z4G	0.70
ATP4	0.60	EF184	1.60	PCF806	0.95	UCC85	0.70	6AL5	0.45	6SJ7	0.80	30C15	1.15
B12H	3.35	EF804	2.00	PCF808	2.05	UCF80	0.90	6AL5W	0.75	6SJ7GT	0.80	30C17	1.25
CY31	0.60	EFL200	0.75	PCH200	0.90	UCH81	0.70	6AM5	1.15	6SK7	0.70	30C18	
DAF96	0.70	EH90	0.60	PCL81	0.70	UCL82	0.85	6AM6	0.75	6SL7GT	0.85	see PCF805	
DET22	21.95	EL32	0.90	PCL82	0.75	UF41	0.90	6AN8	0.95	6SN7GT	0.85	30F5	1.15
DF96	0.70	EL34	2.60	PCL84	0.80	UF80	0.55	6AQ5	1.45	6SQ7	0.85	30FL2	1.35
DK96	1.05	EL37	3.00	PCL86	0.80	UF85	0.60	6AQ5W	0.95	6V6GT	0.90	30FL12	1.35
DH76	0.90	EL38	4.50	PCL805/85	0.85	UL41	0.85	6AS6	0.85	6X4	0.70	30FL14	2.05
DL92	0.60	EL41	0.90	PD500	3.65	UL84	0.85	6AT6	0.85	6X5GT	0.85	30L15	1.15
DY86/87	0.65	EL81	1.20	PFL200	2.80	UM80	0.45	6AU6	0.45	6Y6G	1.10	30L17	1.15
DY802	0.65	EL82	0.70	PL36	0.90	UM84	0.45	6AV6	0.60	6Z4	0.75	30P12	1.15
E55L	8.45	EL84	0.70	PL81	0.85	UY82	0.65	6AX4GT	0.85	6-30L2	1.95	30PL1	1.15
E88CC/01	1.50	EL86	1.50	PL82	0.60	UY85	0.60	6AX5GT	1.15	7B7	0.90	30PL13	1.25
E180CC	1.50	EL90	1.45	PL83	0.60	VR105/30	2.05	6B7	0.60	7V4	0.70	30PL14	1.25
E180E	6.75	EL91	1.80	PL84	0.75	VR150/30	1.40	6BA6	0.45	9D2	0.70	35L6GT	1.15
E182CC	3.95	EL95	0.80	PL504	1.60	Z66	1.05	6BE6	0.45	9D6	0.70	35W4	0.80
EA76	2.25	EL504	0.90	PL508	1.50	X61M	1.70	6BG6G	1.15	10C2	0.70	35Z4GT	0.80
EABC80	0.60	EL802	1.70	PL509	3.65	Z800U	3.40	6BJ6	1.25	10F18	0.70	50C5	1.35
EB91	0.45	EL822	5.05	PL802	3.15	Z801U	3.90	6BQ7A	0.70	10P13	0.70	50CD6G	1.15
EBC33	1.15	EM31	0.85	PL810	3.40	Z900T	1.70	6BR7	2.60	11E2	12.40	75	0.90
EBF80	0.60	EM80	0.70	PY33	0.70	1A3	0.70	6BW6	3.10	12A6	0.70	75C1	0.90
EBF83	0.60	EM81	0.70	PY80	0.70	1L4	0.40	6BW7	1.15	12AT6	0.55	76	0.85
EBF89	0.60	EM84	0.45	PY81/800	0.65	1R5	0.65	6C4	0.45	12AT7	0.65	78	0.85
EC52	0.45	EM87	1.15	PY82	0.55	1S4	0.45	6C6	0.45	12AU7	0.60	80	2.50
ECC81	0.65	EY51	0.55	PY83	0.60	1S5	0.45	6CH6	5.05	12AV6	0.80	85A2	2.40
ECC82	0.60	EY81	0.55	PY88	0.75	1T4	0.45	6CL6	1.70	12AX7	0.60	723A/B	6.75
ECC83	0.65	EY86/87	0.55	PY500	1.50	1U4	0.70	6CY5	1.00	12BA6	0.80	803	20.25
ECC84	0.50	EY88	0.55	PY859	6.45	2D21	0.65	6D6	0.85	12BE6	0.70	805	11.80
ECC85	0.60	EZ80	0.55	PY801	0.70	2K25	12.40	6EA8	0.90	12BH7	0.70	807	11.80
ECC86	1.40	EZ81	0.70	QQV03-10	2.80	2X2	0.90	6F6GB	0.85	12C8	0.65	813	12.40
ECC88	0.70	GY501	1.05	QQV03-12	2.80	3A4	0.70	6F8G	0.75	12E1	4.80	832A	3.15
ECC189	0.60	GZ32	0.75	WQV06-40A	15.75	3D6	0.50	6F12	0.90	12J5GT	0.50	866A	6.75
ECF80	0.60	GZ33	3.95	QV03-12	2.80	3D21	22.50	6F13	0.70	12K7GT	0.70	931A	0.60
ECF82	0.55	GZ34	2.25	SC1/400	4.50	3E29	6.20	6F14	1.15	12K8GT	0.70	954	0.55
ECF801	0.60	GZ37	2.80	SC1/600	4.50	3S4	0.60	6F15	1.15	12Q7GT	0.60	955	0.60
ECH34	1.15	KT66	5.65	SP61	0.95	5B/254M	8.45	6F17	1.00	12SC7	0.65	956	1.00
ECH35	1.70	KT88	6.45	TT21	11.80	5B/255M	8.45	6F24	4.75	12SH7	0.70	957	1.15
ECH42	0.95	MH4	1.15	U25	1.15	5B/258M	8.45	6F33	1.10	12SJ7	0.65	1625	0.80
ECH81	0.55	ML6	1.15	U26	0.95	5R4GY	1.25	6H6	1.95	12SQ7	0.85	1629	1.15
ECH84	1.15	OA2	0.65	U27	1.15	5U4G	1.05	6J4WA	0.85	12Y4	0.45	2051	2.80
ECL80	0.65	OB2	0.70	U191	0.85	5V4G	0.75	6J5	0.85	13D6	0.70	5763	7.35
ECL82	0.65	PABC80	0.60	U281	0.60	5Y3GT	0.75	6J5GT	0.60	14S7	1.15	5842	3.40
ECL83	1.40	PC85	0.60	U301	0.60	5Z3	1.15	6J6	0.50	19AQ5	0.85	5933	0.95
ECL85	0.75	PC86	0.95	U801	0.90	5Z4G	0.80	6J7G	0.60	19G3	11.25	6057	0.95
ECL86	0.75	PC88	0.85	UABC80	0.60	5Z4GT	0.85	6K7	0.80	19G6	6.75	6060	0.95
EF37A	1.70	PC900	0.85	UAF42	0.85	6AB7	0.65	6K7G	0.45	19H5	19.15	6064	1.35
EF39	3.30	PCC84	0.75	UBF80	0.65	6AC7	0.70	6K8GT	0.85	20D1	0.70	6065	1.15
EF40	0.80	PCC89	0.65	UBF89	0.60			6L6M	2.15	20F2	0.70	6067	4.80
EF41	0.85	PCC189	0.75					6L6GT	1.05	20L1	1.15	6080	8.45
EF80	0.45	PCF80	0.90					6L7G	0.45	20P1	0.45	6146	2.25
EF83	1.70	PCF82	0.45					6L18	0.70	20P3	0.60	6146B	6.20
EF85	2.25	PCF84	0.75					6LD20	0.70	20P4	1.25		
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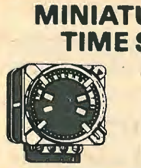

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★ 46 instructions ★ 16 pin package
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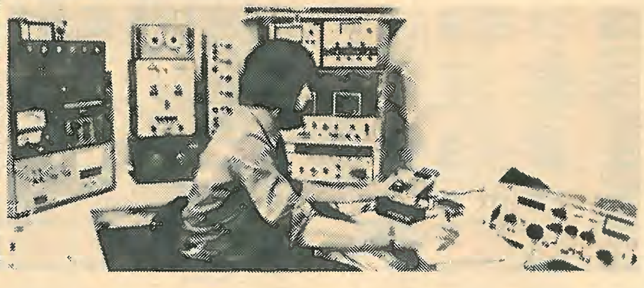

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Our own service laboratory checks each item that arrives at our Pancras Road headquarters. Electronic test equipment is then thoroughly cleaned and a schedule prepared for any work which needs to be carried out to meet customer's requirements. Whether it is new test equipment or used, all items pass through the service laboratory where they are given final tests to ensure they meet manufacturers' specifications, before delivery to the customer.

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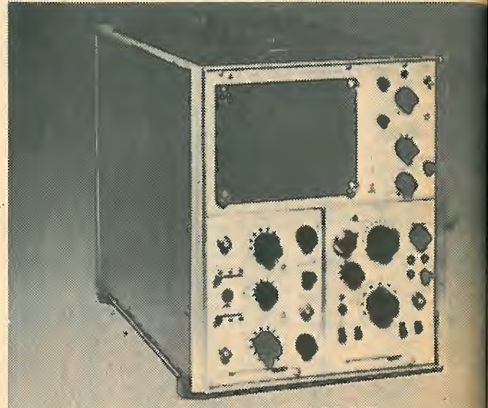
Add 8% VAT to ALL PRICES

Carriage and Packing charge extra on all items unless otherwise stated.

A copy of our trading conditions is available on request.

WW — 106 FOR FULL DETAILS



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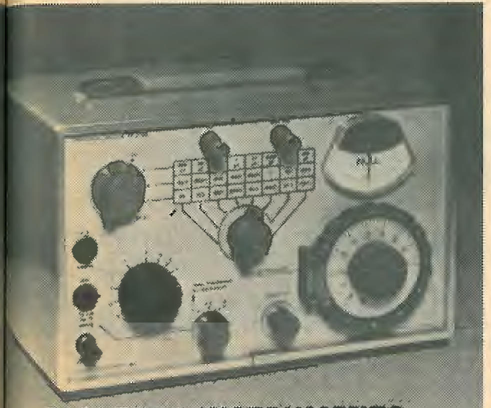
OS2200 Storage Oscilloscope Main Frame
with 2006X and 2007Y plug-in units.
DC—25MHz. 10mV—10V/div.
0.1μS—2S/div. with x5 mag. Max writing speed 1 div/μS.

£745.00



MARCONI INSTRUMENTS

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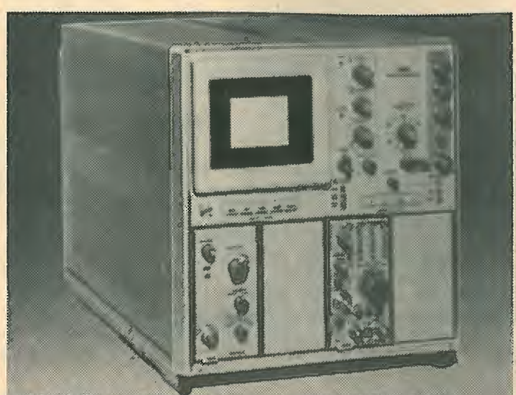
Ranges: 0.2μH—110H,
0.5pF—1100μF
0.01Ω — 11MΩ. Accuracy typically 1%
Battery operated

£210.00



TEKTRONIX

7904 Oscilloscope Main Frame with 7A26 — 7A19 — 7A21 — 7B92
Bandwitch: 350MHz with 7A26
500MHz with 7A19
1GHz with 7A21
Sweep speeds 0.5nS—0.2S/div,
Full delayed sweep.
SUPERB/QUALITY AT VERY SENSIBLE PRICE

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OSCILLOSCOPE 1707B
DC-75MHz. 10mV-10V sensitivity.
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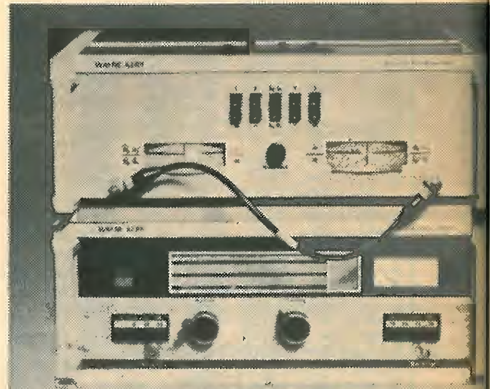

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Wayne Kerr B602 VHF Admittance Bridge c/w SR268 source and Detector
Frequency Range 100kHz—100MHz
Ranges: 1fF—1mF, 100μΩ—100MΩ
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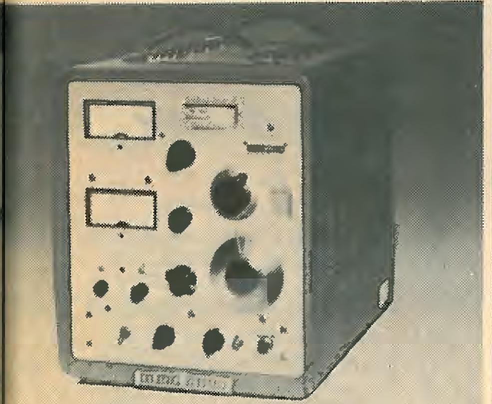
Accuracy typically 1%

£1900.00



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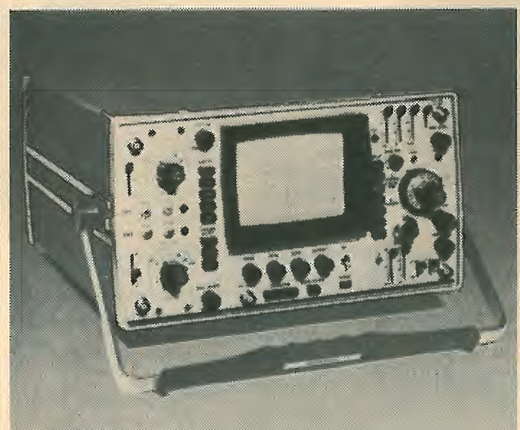

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DC1—75MHz 5mV—2V/div.
0.05μS—0.2S/div with x 10 mag
Full delayed sweep

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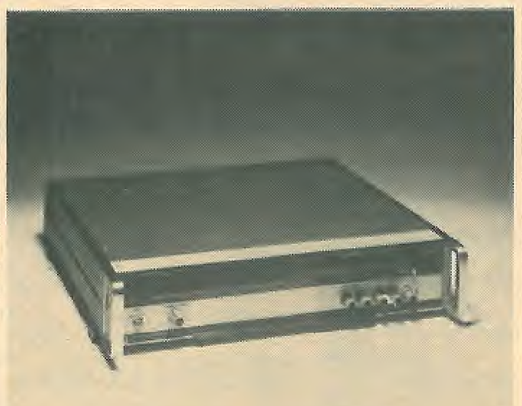

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AC-DC volts
and resistance
Self check facility

only £550.00

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7D11 Digital Delay Unit.
Digital Delay Readout to 7½ digits
100nS—1S delay time. 1nS resolution. Delay by time or events. Events delay range 1 to 10^7 events. Max event frequency 50MHz. For use in 7000 series main frames

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FLUKE
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VHF Sig. Generator 608D **£495**
VHF Sig. Generator 608E **£675**
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Vibration Analyser 1911A **£2100**
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Sine Sq. Pulse & Bar Generator TF 2905 .... **£450**
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Superb specification includes full edit capability, direct cursor addressing, standard V.24 (RS232) interface. 90 days warranty

HAZELTINE H-2000A NOW ONLY **£395**
HAZELTINE H-2000B NOW ONLY **£495**

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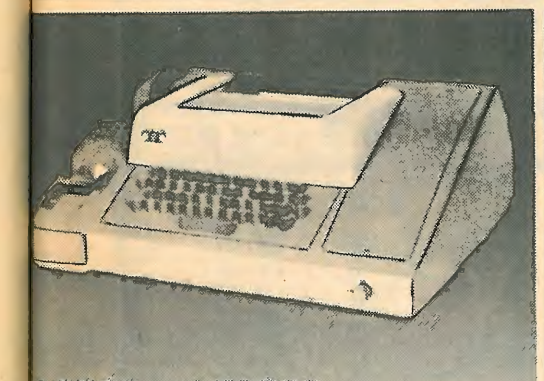
Receive-only impact printer with switch-selectable print speeds of 10, 30 and 120 cps. 120 print positions with adjustable pinfeed paper tractor. 94-character upper and lower case ASCII. Current loop interface.

PRICE **£695.00**



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KB756 ROM-encoded 56-station keyboards with full 128 ASCII character set. Standard TTL logic. Power requirements +5 — 12V. Supplied with full technical data and circuitry (see next column for prices).

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PRICE £95 (mail order total **£108)**
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Quantity Discounts available.
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Electronic Brokers

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*A44-510W	38.68
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AH238	24.45
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*AZ31	1.65
*AZ41	1.70
*B65	1.60
*B309	0.80
*B319	0.84
*B329	0.68
B1153	109.98
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BK448	73.25
BK484	99.00
BT5	36.00
BT5B	26.70
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BT95	78.05
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D13-26GH-01	151.00
D14-170GH	90.56
D14-172GH	90.56
D14-172GM	106.82
*DAF91	1.00
DCG4-1000ED	26.72
*DF61	1.50
*DF91	0.75
*DF92	0.85
DG7-31	47.25
DG7-32	47.25
DG13-2	21.00
DH3-91	40.29
*DH77	1.40
*DH109	1.28
*DH142	2.00
*DH719	1.10
*DK91	0.95
DLS15	4.67
DLS16	10.50
DR2000	4.45
DR2010	4.85
DR2100V1	5.70
*DY86	0.60
*DY87	0.60
*DY802	1.04

Type No.	Price Ea.
E55L	21.00
E80CC	5.00
E80CF	7.00
E80F	6.32
E81CC	2.40
E81L	8.51
E82CC	7.48
E83CC	4.50
E83F	5.64
E86C	10.35
E88C	5.56
E88CC	4.98
E88CC-01	5.48
E90CC	5.40
E90F	4.92
E99F	6.35
E130L	20.33
E180CC	5.87
E180F	6.48
E182CC	6.34
E186CC	8.04
E188CC	5.28
E280F	21.43
E283CC	
E288CC	15.00
*EAA91	0.88
*EABC80	1.15
*EB91	0.88
*EBC90	1.25
*EC90	2.20
*EC91	6.09
*EC92	1.02
*ECC81	0.80
*ECC82	1.15
*ECC83	1.15
*ECC84	1.19
*ECC85	1.16
*ECC88	1.90
*ECC91	6.58
*ECC804	1.12
*ECC2000	9.32
*ECF80	1.36
*ECF82	1.04
*ECH81	2.32
*ECL80	1.32
*ECL82	0.88
*ECL85	1.12
*ECL86	1.58
*EF37A	3.35
*EF39	3.75
*EF80	0.80
*EF85	0.91
*EF86	1.44
*EF89	1.77
*EF91	3.99
*EF92	5.00
*EF93	0.80
*EF94	0.60

Type No.	Price Ea.
*EF95	4.19
*EF183	1.36
*EF184	1.44
*EH90	1.25
*EK90	0.96
*EL34	2.24
*EL36	1.94
*EL37	6.75
*EL38	10.50
*EL41	2.25
*EL81	1.60
*EL83	1.20
*EL84	1.15
*EL85	4.20
*EL86	2.16
*EL90	1.12
*EL91	5.58
*EL95	1.32
*EL360	4.12
*EL509	3.40
EL821	8.20
EL822	6.44
EN10	15.00
EN32	15.66
EN91	5.80
EN92	5.85
*EY51	2.37
*EY81	3.38
*EY84	6.81
*EY86	0.84
*EY87	0.84
*EY88	1.05
*EY91	2.25
*EY802	0.91
*EZ35	1.15
*EZ40	1.25
*EZ80	0.98
*EZ81	0.72
*EZ90	1.08
GL5751	4.00
GR31	8.95
GU50	12.00
GXB160	34.00
GXH120	43.85
GXQ250	237.80
GXU1	16.63
GXU4	33.00
GXU51	15.45
*GY501	2.57
*GZ30	1.12
*GZ31	2.25
*GZ32	1.65
*GZ34	1.90
*GZ37	3.50
GXU50	14.00
*KT66	6.75
*KT88	8.72

Type No.	Price Ea.
M24-302GH	26.50
M24-302W	26.50
M31-312GH	33.00
M31-312W	33.00
M31-334GH	33.00
M31-334W	33.00
M38-312GH	37.50
M38-312W	37.50
M8079	9.60
M8081	7.79
M8082	3.00
M8091	8.99
M8098	4.80
M8100	6.81
M8136	7.01
M8137	7.23
M8161	6.52
M8162	6.27
M8204	8.70
M8223	2.70
M8248	9.12
ME1400	4.85
*N77	6.00
*N309	2.22
*N359	0.60
*PC86	1.45
*PC88	1.55
*PC97	1.15
*PC900	0.95
*PCC84	0.84
*PCC85	1.25
*PCC 88	1.12
*PCC89	1.38
*PCC189	1.60
*PCF80	1.15
*PCF82	0.95
*PCF86	1.58
*PCF200	2.20
*PCF801	1.28
*PCF802	1.28
*PCF808	1.44
*PCH200	2.32
*PCL82	1.25
*PCL83	1.25
*PCL84	1.15
*PCL85	1.45
*PCL86	1.58
*PCL88	1.68
*PCL805/85	1.10
*PD500	3.90
PE1-100	70.00
*PFL200	1.98
*PL33	1.00
*PL36	2.05
*PL81	1.10
*PL83	0.80

Type No.	Price Ea.
*PL84	1.00
*PL95	1.20
*PL500	1.20
*PL504/505	2.00
*PL508	2.20
*PL509	3.15
*PL802	2.95
*PY33	1.00
*PY81	1.00
*PY82	0.75
*PY83	0.75
*PY88	1.36
*PY500	2.24
*PY500A	2.24
*PY800	1.26
*PY801	1.00
QQV02-6	9.90
QQV03-10	4.50
QQV03-20	18.00
QQV03-20A	18.00
QQV06-40A	31.00
QQV07-40	9.50
QS83-3	1.75
QS95-10	4.85
QS150-15	4.10
QS1200	2.25
QS1205	1.75
QS1209	1.75
QS1212	3.55
QS1215	1.80
QV05-25	3.12
QV06-20	7.92
QY2-100	51.80
QY3-125	46.60
QY4-250A	55.14
QY4-400	62.67
QZ06-20	22.25
*R12	2.37
RG1-240A	21.80
RG3-250A	28.10
RG3-1250	24.45
RG4-1250	25.80
RR3-250	7.15
RR3-1250B	71.00
TB3-750	59.30
TB4-1250	76.82
TY3-250	59.30
TY4-350	86.57
TY4-400	59.30
TY4-400C	84.78
TY4-500	76.82
TY6-800	150.96
*UABC80	1.28
*UAF42	1.25

Type No.	Price Ea.
*UBF80	1.10
*UBF89	1.10
*UBL21	1.40
*UCC85	1.10
*UCH81	1.50
*UCL81	0.75
*UCL82	1.66
*UF80	0.75
*UF85	0.65
*UF89	0.75
*UL84	1.44
*UY41	0.95
XG1-2500	58.35
XG2-500	45.87
XG5-500	30.62
XR1-1600A	22.50
XR1-3200	104.54
XR1-6400A	80.00
ZM1550	3.38
ZM1551	3.76
ZP1200	26.25
ZP1210	28.35
ZP1230	32.13
ZP1240	26.60
ZP1300	15.00
ZP1310	12.53
ZP1320	15.17
ZP1470	47.25
ZP1481	31.50
ZP1530	43.26
ZT1011	22.50
ZX1051	87.00
ZX1052	158.77
OA2	1.45
OA2WA	2.55
OA3	1.80
OB2	2.36
2D21	2.24
2K25	14.00
3B28	7.50
3C45	8.25
3E29	8.25
5AR4	2.25
5A/163K	6.48
5B/252M	12.00
5B/254M	17.37
5C22	39.50
5CP1	26.00
5R4GY	3.90
5U4G	2.63
5Y3GT	1.28
5Z4G	1.12
5Z4GT	1.12

Type No.	Price Ea.
*6/30L2	1.56
*6AB4	1.25
*6AJ8	2.32
*6AK5	2.44
*6AK6	2.33
*6AK8	1.15
*6AL5	0.88
*6AM5	6.00
*6AM6	1.60
*6AQ5	1.12
*6AQ5A	2.62
*6AQ6	1.68
*6AQ8	1.16
6AS6	6.40
6AS7G	1.95
*6AT6	1.25
*6AU6	0.96
*6AV6	1.88
*6AW8	2.20
*6B4G	3.10
*6BA6	0.80
*6BE6	0.96
*6BH6	1.44
*6BJ6	1.00
*6BL8	1.36
6BQ7A	1.55
6BR7	6.00
6BS7	3.84
*6BW6	6.35
*6BW7	1.40
*6BX6	0.80
*6BY7	1.40
*6C4	2.20
*6C5GT	1.10
*6C12	2.32
*6C16	1.36
*6CA4	0.72
*6CA7	2.24
*6CB6A	0.75
*6CH6	1.76
*6CJ6	1.60
*6CK6	1.70
*6CL6	6.44
*6CM5	1.94
*6CS6	1.28
*6CW4	4.72
*6CW7	1.19
*6D2	0.75
*6DA6	1.77
*6DQ5	6.93
*6DJ8	1.68
*6DL5	1.32
*6EH7	1.36
*6EJ7	1.44
*6ES8	1.32
*6F12	3.99
*6F26	0.91
*6F29	1.36
*6F30	1.44

Type No.	Price Ea.
*6F6GB	1.75
*6GA8	1.56
*6GW8	1.58
*6J4	1.50
*6J6	6.58
*6J5GT	4.80
*6L12	1.16
*6L13	0.68
*6L16	1.19
*6L6GA	1.44
*6N7GT	3.00
*6PL12	0.88
*6P15	1.15
*6R3	3.38
*6S2	0.84
6SL7T	2.44
*6SN7GT	1.60
*6SQ7	1.22
*6U8	1.04
*6V4	0.98
*6V6GT	1.24
*6X4	1.08
*6X5GT	1.15
7FC7	1.38
*12AL5	2.15
*12AT7	0.80
*12AT7WA	1.20
*12AU6	1.28
*12AU7	0.68
*12AV6	1.50
*12AX7	0.68
*12B4A	2.56
*12BA6	0.90
*12BE6	1.42
*12BH7	1.50
*12BH7A	1.45
*12BY7A	1.54
12E1	10.17
12E14	32.78
1303	5.60
1308	3.75
29C1	13.30
*30AE3	1.36
*30C1	1.36
*30FL14	1.44
*30FL2/1	1.12
*30L1	0.84
*30P18	1.58
*30P19	1.00
*30PL12	0.96
*30PL14	1.68
*31A3	
*54KU	1.65

Type No.	Price Ea.
56TVP-03	466.70
75C1	1.80
85A1	7.00
85A2	1.75
90AG	8.10
90AV	8.10
90C1	1.62
90CG	13.68
90CV	13.30
92AG	7.96
92AV	7.96
108C1	2.36
150B3	4.10
150C2	1.45
150C3	1.92
150C4	1.75
927	10.95
14748	96.00
1913	6.75
2050A	4.84

Type No.	Price Ea.
5551A	73.25
5552A	99.00
5557	19.15
5559	36.45
5651	1.75
5654	2.50
568	6.34
5696	2.60
5867	59.30
5868	76.82
5894	31.00
5726	9.75
5751	4.00
5763	3.12
6057	2.10
6058	2.10
6060	1.00
6064	£1.65
6080	7.00
6084	6.32
6085	5.76
6155	46.60
6158	2.76
6189	7.01
6199	59.00
6201	1.05

Type No.	Price Ea.
6227	5.98
6252	26.75
6267	1.44
6360	4.50
6574	15.66
6689	5.64
6922	4.98
6939	9.90
6973	3.70
7062	5.87
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7643	9.90
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Audio Test Sets Services type CT373 bench test set comprises audio osc 17c/s to 170Kc in 4 decade ranges direct calibration O/P var 300Uv to 10v into 600 ohm bal or unbal. valve voltmeter this can be swt to read o/p of osc or ext I/P 30 Mill/V to 100v FSD freq range 17c/s to 170Kc, tuned filter amplifier 20c/s to 20Kc enables distortion to be measured in 3 FSD ranges of 10,30 & 100%. Various O/P impedances can be selected for the osc inc Bal or Unbal 25,100,300,600 ohm and a fixed 75 ohm o/p. Unit contained in metal case with front cover standard 200/250v I/P with instructions made by Wayne Kerr, **£65.**

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Test Set RTTY STC TS for checking 7B series teleprinters, Auto Tx, drive magnets, polarised relays etc (no supply for motor) standard mains I/P with inst book circ etc. ext soiled cases **£14.**

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UHF Cavities new spares to take 2C39 type valves will tune over ranges 990/1040 Mc/s with int fittings. **£6.50** also Rx section preselector 4 section tunes 1080/1130 Mc/s with 1N21 mixer diode new cond circ supplied. **£4.50.**

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X & S Band Test Sets standard mains I/P S band uses DET. 29 osc plus 2Kc pulse mod var O/P complete in carrying case with mon meter, X band same but as CV5897 Osc both in new cond price either type **£25.**

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EMI telemetry osc nom freq 450 Mc/ with limited adjustment uses DET22 valve size 3 x 2¼ **£5.40.**

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DESIGN ENGINEER ELECTRONICS
AUSTRALIA

Hills Industries Ltd. of Adelaide, South Australia, invite applications from Engineers and otherwise experienced personnel to develop and design antennae and associated equipment for communications and TV broadcasting.

The successful applicant would work with an enthusiastic team who have established a range of equipment held in high esteem throughout Australia.

Duties would be to investigate, examine and develop new designs, specifications and standards, and contribute to planning within the refined limits of V.H.F. and U.H.F. equipment and antennae arrays so specified.

The successful applicant may or may not have had experience in the antennae development area, but ideally will have a good working knowledge of antennae design, theory and practical experience in the installation of maintenance of broadcasting and communication antennae systems.

A salary of £7,500 is envisaged dependent on qualifications and experience. Superannuation is available after a qualifying period.

Hills are an Australian company, broad based, operating in each state as well as New Zealand and the U.K. The U.K. operation does not include the electronics field.

Written applications in the first instance giving experience and qualifications along with marital status etc. to the below address. An assurance of strictest confidence is given.

Interviews will be held in London mid June to early July. Please address applications to:

The Managing Director
HILLS INDUSTRIES LIMITED
Pontygwindy Industrial Estate
Caerphilly, CF8 1XF, Mid. Glam.
South Wales

(9364)

FOREIGN AND COMMONWEALTH OFFICE

has vacancies for

BROADCAST RELAY ENGINEERS

to serve a one year contract (unaccompanied) tour of duty on the island on Masirah (off the coast of Oman).

Applications are invited from engineers with experience of the operation and maintenance of high-powered radio transmitters, and who hold a third year City and Guilds Certificate in Telecommunications, or its equivalent.

SALARY: £9961 per annum (increase pending) plus a tax free allowance of £980 per annum for a single officer or £2705 per annum for an unaccompanied married officer.

Please apply To: **Recruitment Section, Foreign and Commonwealth Office, Hanslope Park, Hanslope, Milton Keynes, MK19 7BH.**

(9325)

UNIVERSITY OF LONDON
KING'S COLLEGE

ELECTRONICS TECHNICIAN

CHEMISTRY DEPARTMENT

Required for the construction of specialised equipment used in research and the maintenance of laboratory teaching instruments. Good conditions. 5 weeks' annual holiday. Contributory pension scheme. Interest-free loans for annual season tickets. Salary on scale £3998 p.a. rising to £4580 p.a. (inclusive). Apply in writing with full details to: **The Head Clerk (Ref. 214747/W.W.), King's College London, Strand WC2R 2LS.**

(9318)

A.B. ELECTRONIC PRODUCTS GROUP LTD.
ABERCYNON, MID GLAMORGAN

MICRO ELECTRONIC ENGINEERING OPPORTUNITIES

Due to continued expansion A.B. Micro Electronics, a subsidiary of the A.B. Electronic Products Group are seeking to fill vacancies for qualified Engineers and Technicians.

The positions are in Design, Development, Applications and Test Engineering. Applicants should possess experience in at least one of these fields. A background in thick film micro electronics and/or semi conductor technology is ideal.

Candidates should be educated to H.N.D./Degree standard, in either Electronics, Electrical Engineering or Physics, although exceptional experience will be considered in the absence of academic qualifications in some instances.

Attractive salaries are by negotiation. Promotion prospects are excellent in this expanding division. Assistance will be given with relocation expenses.

Write or telephone for an application form and for further information on these positions to:—

Staff Personnel Officer
A.B. Electronic Products Group Ltd.
Abercynon
Mid Glamorgan
Tel: (0443) 740331

(9354)

SALARY CURRENTLY UNDER REVIEW

RADIO TECHNICIANS

Keep police lines open

Police depend on communications equipment every hour of the day — so if this equipment suddenly acts up, the police are seriously handicapped. That's where you can make a difference. As a Police Radio Technician in Central or South London, you'll help make sure our wide range of equipment is in top working condition.

Qualifications: two years' experience together with either C & G Telecommunications Technicians Intermediate Certificate; ONC or equivalent.

Salary: from £3151 - £4224 p.a. according to age at entry, rising to £4776 p.a. including Inner London Weighting Allowance. There are substantial extra allowances for those employed on shiftwork at New Scotland Yard. Benefits include day-time release to study for higher qualifications, assistance with course fees and 4 weeks' holiday a year. Good prospects of promotion.

For details and an application form, contact:
The Secretary, Room 213/WW/RT, 105, Regency Street, London SW1P 4AN. Telephone 01-230 3122 (24 hour answering service).

(9355)

SIEMENS

Computer Service Engineers
To £6,400+excellent benefits

When your job becomes so predictable and routine that you perform by habit instead of by thought and initiative, then it's time to move on.

At Siemens, you'll be working in a technically stimulating environment that will provide you with all the scope and backing you need to develop your career. As part of a further expansion programme, we offer the following opportunities to experienced computer service engineers:

Word Processing

We are a European market leader in word processing technology and, in addition to our well-established Text 580 system, we have recently introduced a new generation of microprocessor-controlled systems.

This is a fine opportunity for you to join a developing service team. You'll be involved with acceptance-testing equipment received from Germany, modifications, field maintenance and service, sometimes to component level, commissioning and systems installation.

Ideally you should have experience in mini-computers and associated peripherals. A knowledge of microprocessor technology would be an advantage. Full systems training will be given. The post is based in Sunbury but will involve some travel, mainly in the Greater London area and to Germany for training purposes.

Process Computer for Defence Project

A ground-based Siemens 300/16-bit system is used for in-flight analysis and testing as part of a NATO defence programme. Peripherals are card and tape readers, floppy discs and disc controllers. You'll also be involved in system assembly, installation and maintenance.

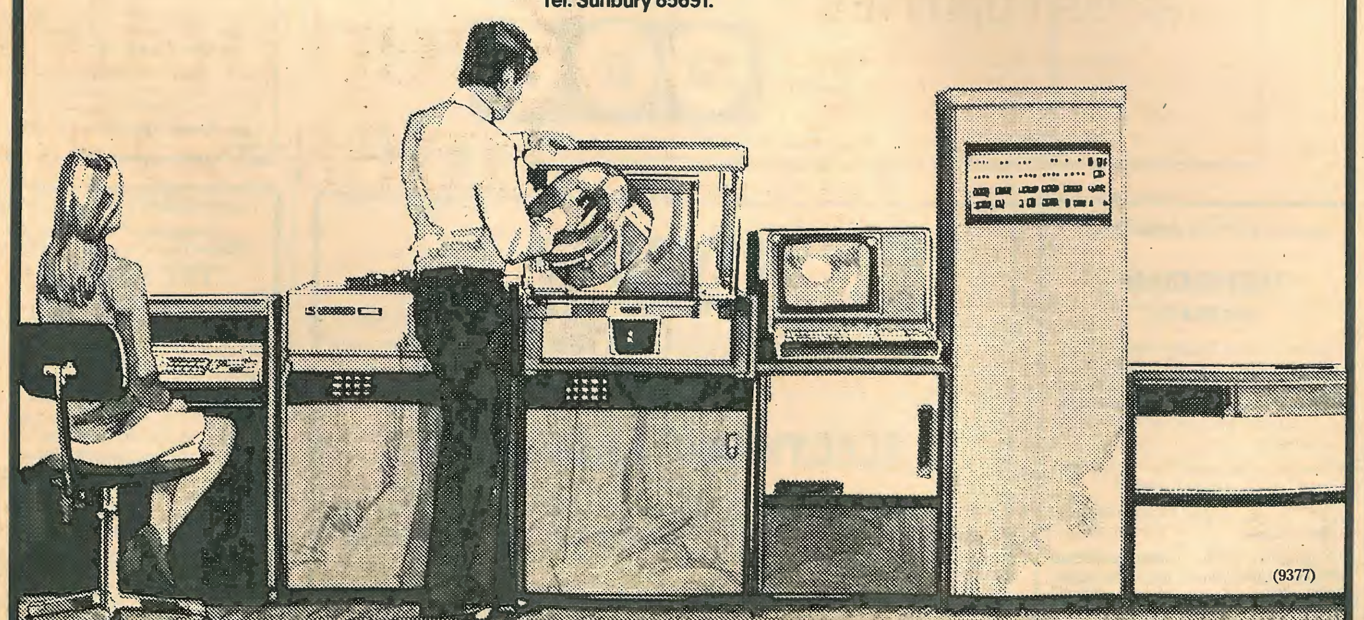
We'll give you full initial training—much of it in Germany—on all aspects of our system, including software. The post is based in Sunbury but will involve travel throughout the UK, for which a company car will be provided.

GLC Traffic flow

This is a site-engineering job based at New Scotland Yard, where you'll become heavily involved in the complex task of controlling the capital's traffic. You'll be working on main frame computers and peripheral equipment such as VDU's, discs and printers.

All these positions carry competitive salaries and an attractive package of company benefits includes generous expenses, sick-pay scheme, BUPA discount and a first-class, non-contributory pension scheme.

Male and female applicants should contact Phil Bainbridge, Deputy Personnel Manager, Siemens Ltd., Windmill Road, Sunbury-on-Thames, Middlesex. Tel: Sunbury 85691.

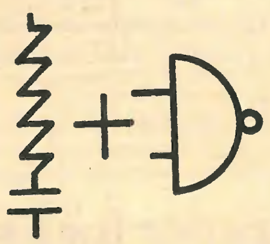


(9377)

RADIO ENGINEERS

M.E.L. specialists in Radio Systems, require Engineers to develop an Advanced family of Multirole H.F. Radio Products. With an ambitious programme of High Technology design, vacancies exist at all levels for Development Engineers, Specialists in HF/VHF techniques and allied equipment and Technical Assistants.
If you have experience or qualifications in any of the following

- ✳ Receivers
- ✳ Transmitters
- ✳ H.F. Systems
- ✳ Remote Control
- ✳ Digital Processing
- ✳ E.C.M. E.C.C.M.
- ✳ E.M.C.
- ✳ Power Supplies
- ✳ Technical Proposal Authorship



Then we would be pleased to talk to you.
All positions attract excellent starting salaries, generous holiday and sickness entitlements, staff shop, subsidised restaurant facilities and generous relocation expenses will be given plus help with your increased mortgage where necessary.
Please write to or telephone Anne George, Personnel Officer, M.E.L. Manor Royal, Crawley, Sussex. Tel: Crawley 28787.

MEL

BIRKBECK COLLEGE
(University of London)
DEPARTMENT OF PSYCHOLOGY

GRADE 4 TECHNICIANS

Applications are invited for three Grade 4 posts as follows:

1. Mechanical Technician
2. Electronics Technician
3. Laboratory Technician

Posts 1 and 2 will involve design and construction of equipment for teaching and research. The duties of post 3, for which basic electrical/electronic skills are required, will be to assist in running the undergraduate teaching laboratories. Applicants for all posts should be 23 or over with relevant experience and should possess ONC or equivalent qualification or have served an appropriate recognised apprenticeship. Salary on scale £3746-£4232 including London Weighting. 31 days' leave p.a. + public holidays. Further particulars and application form from Administrative Assistant, (WW), Birkbeck College, Malet Street, London WC1E 7HX (Tel: 01-580 6622, ext. 271).

Completed forms, which should state clearly which post is applied for, should be returned as soon as possible.

(9333)

THE THOMSON FOUNDATION TELEVISION COLLEGE

VACANCIES AVAILABLE:

A) SENIOR ENGINEERING LECTURER

B) ENGINEERING LECTURER

Applicants must have had professional broadcast television experience of not less than three years for Lecturer, and seven years for Senior Lecturer. Duties include theoretical and practical training of broadcast engineers and technicians from overseas professional television stations.

These posts are based in a Student Residential College which houses a fully operational television station, and is situated in the rural suburb of Newton Mearns, near Glasgow.

Desirable qualifications: Degree, HND or equivalent. Recent practical broadcast experience essential.

Starting salary negotiable — Engineering Lecturer £7,000+, Senior Engineering Lecturer £8,000+.

Applications in writing to The Principal, Thomson Foundation Television College, Kirkhill House, Broom Road East, Newton Mearns, Glasgow, G77 5RH.

(9385)

UNIVERSITY OF SHEFFIELD

TECHNICIAN

(GRADE 5)

Required for the Department of Electronic and Electrical Engineering for employment in the Electrical Machines Laboratories. Applicants should be conversant with machine test facilities.

Minimum qualifications — recognised Electrical trade apprenticeship.

Salary on scale £3474-£4056 p.a. (under review).

Please write to the **Administrative Officer (Personnel), (Ref. S1229/WW), The University, Sheffield S10 2TN.**

(9292)

LWT
London Weekend Television

requires experienced

ELECTRONIC ENGINEERS

to work in their Video Tape Recording Section. Salary £4208 to £5777 p.a. according to experience. Salary review due 1st July, 1979.

Please telephone 01-261 3237 for an application form.

(9361)

UNIVERSITY OF LIVERPOOL
Institute of Child Health
Alder Hey Children's Hospital

TECHNICIAN

To assist with research. Work includes assistance with design and development of medical electronic instruments and operation of the Institute's digital computer. Applicants must possess ONC or equivalent as minimum qualification and be experienced in fault diagnosis and use of digital and analogue integrated circuits. Knowledge of programming an advantage. Salary in a range up to £4056 p.a. according to qualifications and experience.

Application forms may be obtained from The Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote L69 3BX. Quote RV/595/WW.

(9215)

Electronics Engineers on the move

INVEST 5 MINUTES IN YOUR FUTURE

DESIGN, TEST, Q.A.; FIELD SERVICE, MANAGEMENT, ETC.

Take advantage of the best opportunities being offered in the Electronics Industry from amongst over 3,000 U.K. Companies with whom we deal. We are seeking all categories of Electronics Engineers for equipment ranging from computers to communications.

By returning the application form below, your job requirements will be matched against our clients' numerous vacancies, many of which are not advertised. Your application will be treated in strict confidence and no approaches will be made to existing employers or to any other companies you care to specify. Please remember, our service is completely FREE to applicants.

So don't delay — act now to give yourself the best chance of finding the perfect job.

If you wish to discuss any aspect of the Electronics job market, you are welcome to phone any time. Please ask for Brian Cornwell.

Capital Appointments Ltd. 29/30, Windmill St. London. W.1. ☎ 01-637 5551

PLEASE WRITE IN BLACK INK.

NAME: ______ ADDRESS: ______

Tel: (Home): ______ (Office): ______

Date of Birth: Place of Birth: Nationality now: If not British, is a Work Permit req'd?

Marital Status: Car Driver: Car Owner:

Type of Position required: Approx. Salary level:

Please indicate areas in which you are prepared to work:					
Cent. London		S. Coast		E. Midlands	
S.E. London		West Country		W. Midlands	
S.W. London		N.E. England		E. Anglia	
N.E. London		N.W. England		Wales	
N.W. London		Scotland		Overseas	
Home Counties: N.W.	N.E.		S.W.		S.E.

Are you a houseowner?	Are you willing to relocate?
Are you prepared to travel — In U.K?	Overseas?
State of health:	
Notice Period required:	Availability for Interview:

EDUCATION:
Secondary School Qualifications:
College or University Qualifications:
Any Professional Membership:

INDUSTRIAL EXPERIENCE: Period of Employment	Company & Location	Products	Job Title	Responsibilities	Reason for leaving	Final Salary
1. Current or last employment From: To:						
2. Previous employment From: To:						
3. Previous employment From: To:						

ELECTRONICS PROFILE: Indicate extent of experience— A—Extensive; B—Moderate; C—Limited; If Nil experience, leave blank.

Telephone Eqpt.	Data Commns.	Radio/Hi-Fi/T.V.	Broadcast Eqpt.
Digital/Logic	Analogue Eqpt.	Software/Programming	Minis/Microprocessors
Computers/Periphs.	Test Gear/ATE.	Process Control	Power Supplies
UHF/VHF. Comms.	Microwave	Radar/Navaids.	Medical Electronics
Signalling Systems	Security Eqpt.	Avionics	Simulators
Weapons	Scientific Eqpt.	Data Recorders	Photocopiers
Phototypesetting	Servo-mechs.	Components-Active	Components—Passive
Production Eng.	Electrical Eng.		

Others — Please state.

Please indicate any Companies you do not wish us to contact.

If you wish to detail further aspects of your experience or job requirements, please enclose on a separate sheet.

(9334)

Technicians
all areas throughout the UK

Storno are one of the world's major manufacturers of VHF, UHF and FM telecommunications equipment and control systems. Currently undergoing a planned phase of expansion we produce mobile, portable and personal systems with many and varied uses. To strengthen our team we are looking for the following people in all areas of the U.K.

Installation Technicians

to install and commission Mobile Radio equipment and assist in installation of major systems.

Radio Technicians

to service VHF/UHF radio telephone equipment and associated control systems. Vacancies for Workshop and Field Technicians. Knowledge of digital techniques an advantage.

For all posts we offer highly competitive salaries. Write or telephone for an application form to Mrs. M. Mackett, Personnel Manager, Storno Limited, Frimley Road, Camberley, Surrey. Tel: Camberley 29131.

Storno
RADIO COMMUNICATION SYSTEMS

(9378)

University of Liverpool
Department of Physics

ELECTRONICS TECHNICIAN

to assist in developing and commissioning digital and analogue electronic equipment. A good opportunity to gain experience of complex systems for data acquisition and processing, using micro and mini computers linked to powerful main frames. Applicants must possess recognised qualification (H.N.C. or equivalent), and have had some previous experience. Salary on a scale up to £4,758 p.a., according to qualifications and experience.

RESEARCH TECHNICIAN

to assist with preparing, commissioning and running apparatus in a Solid State Physics Group. Relevant experience necessary and some knowledge of electronics or workshop practice an advantage. Initiative and ability to work co-operatively important. H.N.C. or equivalent qualification essential. Salary on a scale up to £4,056 p.a., according to qualifications and experience.

Applicaiton forms may be obtained from **The Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote Ref. RV/592/WW.**

(9214)

VIDEO ENGINEER

Experienced all-round Video Engineer required by leading company in North London. Good pay, Bonus, Pension, Company Car. Phone J. Rabin or A. Brown, 01-951 0466.

(9359)

CHIEF ENGINEER

COVENTRY ILR

The company awarded the contract to provide Independent Local Radio in Coventry is seeking a Chief Engineer with experience in sound broadcasting studio operations and maintenance. The successful candidate will act as the senior executive responsible for technical installations, maintenance, operational routines and liaison with the IBA on technical matters. A competitive salary will be offered.

Applications with full curriculum vitae, which will be treated in strictest confidence, should be addressed to:

THE MANAGING DIRECTOR
MIDLAND COMMUNITY RADIO
2 MANOR YARD
NEW UNION STREET
COVENTRY, WEST MIDLANDS CV1 2PS

(9341)

PIONEER®

An extensive expansion programme to diversify our after sales service activity has created additional vacancies at our service centre in Iver.

We require service personnel to join a friendly team of Technicians in our modern well-equipped service department and laboratory to assist in repair and maintenance of sophisticated Audio and In-Car stereo equipment of our world renowned brand.

BENCH SERVICE TECHNICIANS

Applicants should hold C&G Radio and TV, Electronics Technician or equivalent certificate with a minimum of two years experience in the Audio field. Alternatively five years' of relevant experience with sound knowledge of Electronics is acceptable.

Salary in the area of £3,500 to £4,500 per annum, according to experience.

LABORATORY ASSISTANT ENGINEER

Applicants should hold a Degree, HND or equivalent with a minimum of five years' relevant experience. Thorough knowledge of amplifiers, tuners and magnetic recorders is essential. The work entails measurements and modification of existing designs, investigation of special consumer complaints, writing technical reports, etc.

Salary negotiable, according to experience.

If you think that you can help us in our expansion programme then contact us now and find out more about our generous staff benefits. We offer excellent working conditions, training programmes and day release to advance your career and knowledge in the field of high fidelity.

Luncheon vouchers; Pension Scheme.

Apply in writing to:

Mr A. H. K. Littlemore
Pioneer High Fidelity (G.B.) Ltd.
Pioneer House, The Ridgeway
Iver, Bucks. SL0 9JL
or Telephone: Iver (0753) 652222

(9336)

TEST EQUIPMENT ENGINEERS

ARE YOU SEEKING AN OPPORTUNITY TO WORK ON SOPHISTICATED TEST GEAR EMPLOYING THE LATEST ANALOGUE AND DIGITAL TECHNIQUES?

If so, join Rediffusion and work on a number of exciting projects associated with the design and development of equipment for production line testing of our future colour TV receivers.

Effective testing plays an important part in ensuring that the finished product reaches the high quality levels necessary for success during the 80's. To increase the scope and flexibility of our testing, new equipment will be microprocessor controlled. Even if you only have limited knowledge of digital techniques this opportunity will enable you to learn the mysteries of microprocessors and their application to testing complex electronic sub-assemblies.

Applications are invited from engineers with a creative ability to work in a congenial and stimulating environment at our Engineering Centre at Chessington, Surrey. We have vacancies at senior and intermediate levels offering opportunities for career advancement. The salary range extends to £6000+, the higher end of which is for the ideally qualified engineer.

The usual big company benefits, such as pension scheme, free life insurance, 4 weeks' holiday with choice of leave period, sports facilities and assistance with relocation expenses are offered for these posts.

If you are interested in these challenging positions and would like more details or wish to discuss the matter in depth, please write or telephone:—

Mr H. Brearley,
Head of Technical Services,
Rediffusion Consumer Electronics Ltd.,
Fullers Way South,
Chessington, Surrey KT9 1HJ
Telephone: 01-397 5411

REDIFFUSION

(9327)

DPC ELECTRONICS LTD.

1. PRE-PRODUCTION SERVICES MANAGER
2. PLATING CHEMIST
3. QUALITY ENGINEER

DPC Electronics Ltd, a major Producer of both Plated Through and Print and Etch PCBs, are now entering the Fine Line field. Owing to expansion and the introduction of new products the Company require the above named staff.

The first position requires a good knowledge of PCB Production techniques including Press Work, NC Drilling, Photomechanical Processing and photography, coupled with proved ability in the administration of a similar function.

The other two positions require relevant experience in the PCB or a similar field together with appropriate qualifications.

These three positions carry competitive starting salaries, a comprehensive benefit programme, including Profit Sharing Scheme, Contributory Pension Scheme, Free Life Assurance. The successful applicants will be given a re-allocation allowance.

The factory is situated in a New Town Development area with easy access to Motorways.

Please forward details of your experience and qualifications to:

Mr. M. H. T. McKenzie-Folan
Personnel Manager
DPC Electronics Ltd.
Garnett Place
Gillibrands Road
Skelmsersdale, Lancs.
Telephone: Skelmersdale 22444

(9291)

Make your hobby more Constructive and Profitable!

Become an

ELECTRONICS ENGINEER or a TECHNICIAN ENGINEER

At PNL we offer two, interesting, full-time courses.

★ B.Sc. in Electronic and Communications Engineering.
2 'A' levels, usually Maths and Physics could qualify you for this 3-year full-time degree. Specialise in Acoustics, Digital Electronics and/or Radar and Microwaves in the final year.

★ Technican Engineer Certificate
3 'O' levels, usually Maths, Physics and English, are the entry requirements for this two year full-time certificate, specialising in Computer Engineering, Sound Studio Engineering and Radar and Microwaves.

Details from: Secretary, DECE, PLN, Holloway Road London N7 8DB

The Polytechnic of North London

(9288)

PHILIPS Medical Systems

PHILIPS

X-Ray Service Engineers

We require for contract work throughout the world experienced X-ray engineers to install and maintain the very latest in advanced diagnostic apparatus.

If you feel that you have the qualifications to take this opportunity of joining a major Company in this field, then you will be amply rewarded with a job that is both satisfying and financially very worth while. Contracts will be initially for a period of two years, generally in the Middle East with the possibility of a further term if mutually agreed.

Although Philips Eindhoven would be the employer, please contact initially:

Mr. J. O. Skinner, Regional Co-ordinator, Philips Medical Systems, Kelvin House, 63-75 Glenthorne Road, Hammersmith, London W6 0LJ. Telephone No. 01-741 1666.

(9328)

Development Test Engineers

Electronics

Wouldn't you like to work in a well-equipped laboratory that's got the best in modern equipment, including ATE and manual testers?

And wouldn't you like to work for a company renowned for advanced technological innovations?

Ferranti are looking for Development Test Engineers to prove specifications and test equipments; also to test and fault diagnose on a wide variety of prototype, pre-production and production equipment.

If you have an ONC/HNC or C & G in electronics together with the experience and enthusiasm to tackle the job, Ferranti can offer you a good salary (opportunities for overtime if you want it), a productivity bonus scheme, flexible working hours and other benefits associated with a large and successful company.

You have nothing to lose, and probably a great deal to gain by talking to us. So why not telephone or write to:

Personnel Department, Ferranti Computer Systems Limited, (Bracknell Division), Western Road, Bracknell, Berkshire.
Tel 0344 3232 ext. 471

Please quote ref. no. B/2/WW

These appointments are open to male and female applicants.

FERRANTI
Computer Systems

UNIVERSITY OF SURREY

ELECTRONIC/ ELECTRICAL ENGINEERING OPPORTUNITIES

Owing to the expansion of the highly successful Industrial Electronics Group in the Department of Electronic and Electrical Engineering at the University of Surrey, vacancies exist, immediately, for technicians (engineers) who are keen to further their experience in a wide range of electronic fields and are qualified to ONC level or higher.

The work will involve operating on a project basis, covering all phases of prototype equipment manufacture, development and documentation. There is an opportunity to specialise in electro-mechanical design and draughting if desired.

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

Commencing salary according to age and experience within the range £3222 to £3708 and £3474 to £4056 (both under review pending comparability study).

Holiday entitlement is four weeks plus one week at Easter and Christmas and other public holidays. Generous sick pay and superannuation schemes exist.

Normal hours are 37½ per week and flexible working can be arranged.

Day release is possible for study leading to higher qualifications.

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

An informal discussion or visit can be arranged by telephoning Mr. Matley, Head of Industrial Electronics Group (Guildford 71281 ext. 341) or write in confidence to The Staff Officer, University of Surrey, Guildford, Surrey GU2 5XH.

(9212)

WESTWARD TV

ENGINEERS — try a move to the WEST COUNTRY

WESTWARD TV seeks several additional experienced Electronics Broadcast Engineers for the Studios at Plymouth, Devon, to operate and maintain Telecine and VTR Equipment including our new 1" helical scan VTR suite. We offer attractive locality and conditions of service, including over four weeks' annual holiday, free life insurance and salaries of up to £6,100 per annum, including supplements (under review).

Telephone the Personnel Manager for further details on 0752 69311 or write to Westward Television Limited, Derry's Cross, Plymouth PL1 2SP.

(9331)

ADVISION RECORDING STUDIOS

have a vacancy for a

SENIOR TECHNICAL ENGINEER

The post includes a wide range of duties, but primarily the applicant will be involved with the maintenance, development and installation of recording equipment at our London based Studios.

The successful applicant will have a sound electronic knowledge coupled with a good background in digital technology.

Applications in writing please to:

Roger Cameron
ADVISION RECORDING STUDIOS
23 Gosfield Street, W.1

(9293)

TOP JOBS IN ELECTRONICS

Posts in Computers, Medical, Comms, etc. ONC to Ph.D. Free service.

Phone or write: **BUREAUTECH AGY, 46 SELVAGE LANE, LONDON, NW7. 01-959 3517.**

(8994)

THE MANOR MOBILE AND THE MANOR STUDIO

have a vacancy for a Maintenance Engineer. Phone Rhonda at the Manor 08675 2128.

(9360)

TEST ENGINEERING PROFESSIONALS FOR ADVANCED AVIONIC SYSTEMS

MEL, a division of the International Philips Electronic and Associated Industries Group, are looking for professional test personnel to work on sophisticated Avionic and associated systems. We design and manufacture a wide range of equipment including Air and Shipborne Radar, navigational aids, microwave communications and radar control systems so those appointed can look forward to involvement in a wide and diversified range of projects utilising an equally wide range of electronic techniques including:

DATA PROCESSING. DIGITAL. MICROPROCESSING ANALOGUE. RADAR. TTL & MOS. PULSE. SCAN CONVERSION.

We are looking for:

SENIOR TEST ENGINEERS, TEST ENGINEERS AND TEST TECHNICIANS

with experience in one or more of these fields together with HNC or C & G qualifications.

We also consider people with T.V. Bench engineering experience and H.M. Forces 3rd Line Servicing personnel with a background in fault finding.

We offer excellent conditions of employment, including relocation expenses and nomination for local authority housing in this attractive part of Sussex where appropriate.

If you feel you have relevant experience and would like to make your future with our successful organisation, please contact: Alistair Budd – Personnel Department, M.E.L., Manor Royal, Crawley, Sussex. Tel: Crawley 28787 Ext. 364.

(8662)

M E L

ROHDE & SCHWARZ

require

SENIOR TEST AND CALIBRATION ENGINEERS

With a background in RF and microwaves, experienced in analogue, digital techniques, logic and microprocessor controlled ATE.

Also vacancies exist for

TEST AND CALIBRATION ENGINEERS

with knowledge on one or more of the above techniques.

We offer an exceptional salary ★ Performance related bonus scheme ★ Training abroad ★ Prospects of promotion ★ A wide variety of work ★ A happy atmosphere ★ Non-contributory pension scheme ★ Subsidized restaurant ★

Please write or phone to:
Mr. Z. Eres (Technical Manager) extension 43.

Electronic Instruments & Communications Equipment

aveley electric LTD

Roebuck Road, Chessington, Surrey KT9 1LP
Tel: 01-397 8771. Telex: 928479 Aveley

(9342)

DUBAI RADIO AND COLOUR TELEVISION

DRCTV requires a number of technical staff to operate and maintain two new radio transmitting stations now completing construction. These two stations comprise a 2 x 750 KW medium wave am station and a 3 x 300 KW shortwave station with extensive aerial arrays for worldwide coverage.

All applications will be considered, preference given to those with experience of high power operation at transmitting stations.

Outline terms of employment would be:—

1. Salaries in the range £8,000/£12,000 per annum — there is no income tax in the Emirate of Dubai.
2. Fully furnished air conditioned accommodation for applicants and dependants free.
3. Car allowance payable.
4. Water and electricity free.
5. Medical attention free.
6. Working week is 45 hours 6 days with shift rota working for most posts advertised.
7. Economy class airfares for applicants and dependants paid by Government.
8. One month's leave after 11 months' service with economy class airfares paid by Government for applicant and dependants.
9. Contracts of 12 or 24 months' duration.

Candidates will be interviewed in London and elsewhere within two months.

All replies in strict confidence by airmail please to:—

Director General
DRCTV
P.O. Box 1695
Dubai
UNITED ARAB EMIRATES

(9351)

SCIENCE RESEARCH COUNCIL

APPLETON LABORATORY has vacancies for

ELECTRONIC ENGINEERS

to work on the Stabilised Balloon Platform Project

The Platform, which in itself weighs approx. 1 ton, is designed to carry astronomy experiments for the UK scientific community and point them with near arc-second accuracy, operating at altitudes up to 40 km. The Platform was largely re-designed at Appleton Laboratory during 1977 and 1978 and successfully flown with an experimental payload in September/October 1978. Flight campaigns are planned for the US or Australia during spring and autumn each year and some service overseas will be required.

There are two posts at Professional and Technology Officer III level and the successful applicants will be responsible for production, testing and maintenance of electronic systems on the Platform and its ground checkout equipment. There is also a vacancy for a Professional and Technology Officer IV to assist in these duties.

The post will initially be based at Slough with a move to Chilton in Oxfordshire at a later date.

Candidates must possess an ONC or a TEC/SCOTEC certificate, or an equivalent or higher qualifications in a relevant subject and for the higher posts 8 years' experience (including training). Some knowledge of telemetry (PCM) and telecommand systems, electromechanical systems, optical systems and experience of environmental testing and field trials would be useful.

Salary including Outer London Weighting for PTO III grades will be on the scale £4601-£5144 p.a. and for PTO IV grades will be £3320-£4601 dependent upon age and experience. Salaries are currently under review. A non-contributory pension scheme exists.

Further information and application forms may be obtained from: **Mr. N. J. Myer, Science Research Council, Appleton Laboratory, Ditton Park, Slough, SL3 9JX, Berks. Tel. Slough 44234, Ext. 153.** Closing date: July 6, 1979.

(9335)

ELECTRONICS COMPONENTS BUYER

Bristol Aerojet Limited are designers and manufacturers of rocket motors, rocket vehicles and underwater systems.

Electronics is an increasingly important aspect of our business and we require an Electronics Components Buyer who will be expected to select suitable suppliers.

Candidates will be expected to have a mechanical drawing qualifaction at ONC level.

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Contact: Ron Moir, Personnel Manager,

BRISTOL AEROJET

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(9338)

A new challenge in Radio Systems Development

ITT Components Group Europe has a world-wide reputation for the quality and reliability of its products which cover virtually the whole spectrum of electronic components technology.

At the Company's headquarters in Harlow there is an expanding programme of development work in progress and additional Electronics Engineers are now required to join a small, enthusiastic and highly professional team developing synthesizers and oscillators for professional and military radio systems.

This is an important new project and we are looking for self-motivated Electronics Engineers with initiative, who have experience in radio frequency design. An appropriate degree is desirable but less qualified men and women with sound practical experience and an interest in this type of development work, would also be considered.

We offer an attractive salary with contributory pension scheme with transfer option and assistance with relocation expenses where necessary.

Write with details of experience to Miss R. Wayper, ITT Components Group Europe, Edinburgh Way, Harlow, Essex. Telephone: Harlow 26811 ext. 2221.

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Electronics Technician

Required to work with team of Engineers on world's leading industrial radio controls.

Duties include assembly, wiring and test of complete equipment as well as testing small batches of PCBs.

Previous experience of high quality wiring essential. Previous production testing experience would be an advantage.

Suitable candidate must be able to work unsupervised.

Telemotive looks only for above average personnel, and this is reflected in conditions of employment offered.

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Telemotive U.K. Limited

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BYFLEET 47117**

(9346)

UNIVERSITY OF LEICESTER

EXPERIMENTAL OFFICER

Applications are invited for the academically related post of Experimental Officer in the Department of Chemistry. The person appointed will be concerned with the design, development and construction of electronic equipment and the modification and maintenance of analytical instruments in the department. A knowledge of modern electronics including digital, data logging and R.S. circuitry is essential.

Candidates should be graduates or have equivalent professional qualifications. Salary on an incremental scale, £3,689 to £6,108 p.a., according to qualifications and experience.

Applications should be sent to Head of Department, Department of Chemistry, University of Leicester, Leicester, LE1 7RH.

RADIO TECHNICIANS

At the Government Communications Headquarters we carry out research and development in radio communications and their security, including related computer applications. Practically every type of system is under investigation, including long-range radio, satellite, microwave and telephony.

Your job as a Radio Technician will concern you in developing, constructing, installing, commissioning, testing, and maintaining our equipment. In performing these tasks you will become familiar with a wide range of processing equipment in the audio to microwave range, involving modern logic techniques, microprocessors, and computer systems. Such work will take you to the frontiers of technology on a broad front and widen your area of expertise — positive career assets whatever the future brings.

Training is comprehensive: special courses, both in-house and with manufacturers, will develop particular aspects of your knowledge and you will be encouraged to take advantage of appropriate day release facilities.

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You should be at least 19 years of age, hold or expect to obtain shortly the City and Guilds Telecommunications Technician Certificate Part I (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

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You start at £3900 rising to £5530, and promotion will put you on the road to posts carrying substantially more. There are also opportunities for overtime and on call work paying good rate.

Get full details from our Recruitment Officer, Robby Robinson, on Cheltenham (0242) 21491, Ext. 2269, or write to him at GCHQ, Oakley, Priors Road, Cheltenham, Glos. GL52 5AJ. If you seem suitable we'll invite you to interview in Cheltenham — at our expense, of course.

(9106)

Nene College Northampton

Applications are invited for the temporary post of

Senior Lecturer in Electrical Engineering

Candidates should be graduates or Chartered Engineers with recent industrial experience. The successful applicant will be able to lecture in one of the fields of Industrial Control, Power or Electronics.

The Post is tenable for one academic year from September, 1979.

Salary Scale: £6051-£7065 (under review) point of entry depending on previous experience.

Application forms and further particulars are available from The Senior Administrative Officer, Nene College, Moulton Park, Northampton NN2 7AL.

(9356)

Applications are invited from experienced

ELECTRONIC ENGINEERS

(Graduates or equivalent)

to participate in development and research projects within the Department of Physiotherapy, primarily in measurement of muscle function. Ongoing activities in which he/she would be expected to play a role include development of a chair to measure isokinetic work, and general duties in connection with these projects. A knowledge of torque and velocity transducers would be an advantage.

Applications should be made to **Mr. G. Smith, Assistant Personnel Officer, Hammersmith Hospital, Du Cane Road, London W12 0HS.**

(9344)

VAN DE GRAAFF TECHNICIAN

Required to assist with the operation and maintenance of the 4 MV accelerator recently installed at the Gray Laboratory. This machine is being used for research aimed at improving the radiation treatment of cancer.

Experience in any of the fields of Electrical, Electrical/Mechanical, Electronics or Vacuum Technology a distinct advantage.

Candidates should possess H.N.C. or equivalent, time served tradesmen will be considered.

Starting salary up to £5034 (under review) according to experience, age and qualifications.

Further information and application form, in confidence, from

**Deputy Director
CRC Gray Laboratory
Mount Vernon Hospital
Northwood, Middx. HA6 2RN**

(9371)

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(9261)

SIEMENS

Telecommunications Engineers

Expansion of our Telecommunications Test Equipment Workshop has resulted in a requirement for experienced Electronics Engineers to join the service team at our modern complex in Sunbury.

Your main function will be the repair and calibration of telecommunications test equipment both in the workshop and on site. There will be travel within the UK and occasionally Europe and training will be provided both in this country and Germany.

You should have a good background in servicing both analogue and digital equipment, preferably within the telecommunications industry. Familiarity with inspection techniques used by the armed forces, Post Office or British Rail would be a considerable advantage. Previous involvement in small design projects and prototype modelling will be necessary for the occasional modification of equipment to customer specifications and considerable emphasis is placed on the use of automatic test equipment.

Employment benefits are excellent; in addition to a competitive salary, we offer an excellent, non-contributory pension scheme, sick-pay scheme, active sports and social club, subsidised restaurant and very good working conditions.

Interested applicants should telephone or write for an application form to Phil Bainbridge, Deputy Personnel Manager, Siemens Limited, Siemens House, Windmill Road, Sunbury-on-Thames, Middlesex. Telephone: Sunbury 85691 ext. 325.

CHELSEA COLLEGE
University of London

ELECTRONICS TECHNICIAN ENGINEERS/ TECHNICIANS

required for interesting work in Electronics Workshop serving Electronics and Physics research and teaching. Work includes prototype instrument design, development and construction, and the servicing of electronic equipment. We have two vacancies, one at Grade 5 — Salary £3996 to £4580 per annum — and the other at Grade 3 — Salary £3455 to £3860 per annum. Both salaries are inclusive. Generous holidays. Day release for further study may be arranged at Grade 3.

Details and application form from Mr M. E. Cane (3/5EW), Department of Electronics, Chelsea College, University of London, Pulton Place, London, SW6 5PR.

(9322)

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Please write or telephone for an application form to the **Personnel Officer, Grundig International Ltd., Newlands Park, Sydenham, London SE26. Telephone no.: 01-659 2468.**

GRUNDIG

(9395)

Radio Officers

If your trade or training involves radio operating and you are no more than 35 years of age, you qualify to be considered for a Radio Officer post with the Composite Signals Organisation.

A number of vacancies will be available in 1980 for suitably qualified candidates to be appointed as Trainee Radio Officers. Candidates must have had at least 2 years' radio operating experience or hold a PMG or MPT certificate.

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

Trainee Radio Officers start on £2,605 at 19 up to £3,034 at 25 or over. After completion of specialist training Radio Officers start on £3,571 at 19 rising to £4,675 if you are 25 or over: then by 5 annual increments to £6,340 inclusive of shift and weekend allowances. Salaries at present under review.

GCHQ

For further details apply to:
The Recruitment Officer
Government Communications Headquarters
Priors Road, Oakley
Cheltenham, Glos. GL52 5AJ
Telephone: Cheltenham 21491 Ext. 2269

(9105)

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In addition to an attractive starting salary based on experience and qualifications, the company offers excellent career prospects, generous fringe benefits and relocation expenses where appropriate.

This position is open to both male or female applicants and for further information please write or telephone in confidence, quoting REF/RRA to:

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JS&A

(9211)

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Please send applications in handwriting, with a detailed curriculum vitae to:
Sheilagh Browne, Personnel Manager, Macmillan Publishers Ltd., 4 Little Essex Street, London W.C.2.

M MACMILLAN

(9370)

Nene College Northampton

Principal Lecturer in Microelectronics

Applications are invited for the above post.

Candidates should be Graduate Chartered Engineers with considerable recent experience of the industrial applications of microelectronics.

The successful candidate will be expected to initiate and contribute to the development of courses in microelectronics including microprocessor applications to industrial systems.

Salary Scale: £7047-£7818 (under review).

Application forms and further details from: The Dean, School of Technology, Nene College, St. George's Avenue, Northampton.

(9381)

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(University of London)
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required to provide a comprehensive service of maintenance, repair, modification and calibration for a wide range of scientific instrumentation. Applicants should be suitably qualified and experienced. Salary on scale £3474-£4056, plus £275 a year London allowance.

Applications giving details of age, qualifications and experience together with the names and addresses of two referees should be sent to the **Personnel Officer (WW).**

(9337)

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UNIVERSITY OF KEELE
DEPARTMENT OF PHYSICS

ELECTRONICS TECHNICIANS

required for teaching and research laboratories. Posts at Grade 5 and Grade 4 are available for which the salary scales are £3747-£4056 and £3222-£3708 per annum respectively. Application forms and further particulars available from the Professor of Psychics, The University, Keele, Staffs. ST5 5BG, to whom applications should be returned by July 6th, 1979.

(9393)

Electronic Test Engineers

TO £4800 p/a

We manufacture and market audio noise reduction equipment which is used by major recording companies, recording studios and broadcasting authorities throughout the world and have enjoyed successful growth since incorporation in 1968.

The increased demand for our equipment in the recording and cinema industries has necessitated the recruitment of experienced test engineers.

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London SW9 9AP
Telephone 01-720 1111

(9372)

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BRIGHTON POLYTECHNIC
£4245-£5073 P.A.

To work with a team of experienced engineers and technicians developing Audio Visual Facilities throughout the polytechnic. The wide range of systems developments includes sound and colour television production, video recording and editing to near broadcast standards. The electronic engineer will apply digital and analogue techniques to develop and install new equipment, upgrade existing facilities, and assist with it's maintenance. Formal training to degree, HNC or equivalent standard will be expected and experience with electronic design and construction, preferably including television.

Application forms and further details from: Personnel Officer, Brighton Polytechnic, Moules Coombe, Brighton BN2 4GJ. Tel. Brighton 693 655, Ext. 2536. Closing date 6th July, 1979. (9396)

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The work will be concerned with installation and service of communication equipment on board commercial vessels of all types.

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For further details on both these positions please contact: Jonathan Smith, International Marine Radio Co. Ltd., Intelco House, 302 Commonside East, Mitcham CR4 1YT, Surrey. Tel: 01-640 3400.

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is required in the School of Film and Television to assist in the daily operation and maintenance of colour television studio and mobile equipment. A sound knowledge of colour television systems is essential and some experience with studio equipment would be an advantage. Candidates should hold C&G Part II Certificate or equivalent although Part I Certificate holders may be considered. The salary will be in the range £3998-£4580 according to qualifications and experience. 4 weeks' holiday. Pensionable appointment.

Interested applicants should write giving full details of previous experience, etc., to: Assistant Registrar (Staff), Royal College of Art, Kensington Gore SW7 2EU. (9397)

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Applications are invited for a vacancy in the above. Applicants must be able to develop analogue and digital circuitry for use in data collection and handling, including a knowledge of micro processors and computer interfaces. Qualification to HNC or HND (electronic) standard or have equivalent practical experience. Salary within the range £4701-£6123 p.a. (pay scale under review). Applications to Mr. E. A. Beckett, Department of Physics As Applied to Medicine, Middlesex Hospital Medical School, Cleveland Street, London W1P 6DB. (9379)

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ITN

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Applicants must be experienced in this field and be prepared to work either a 5-day week or on a shift pattern.

Contributory pension scheme, free life insurance, 4 weeks' holiday, subsidised staff restaurant. Salary up to £6,500 depending on experience.

Telephone the Personnel Office on 01-637 3144 for an application form, quoting reference 31005. (9348)

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9376

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THE TOWN HOUSE is a new recording studio complex in Goldhawk Road, Shepherds Bush. We require

TECHNICAL MAINTENANCE ENGINEERS

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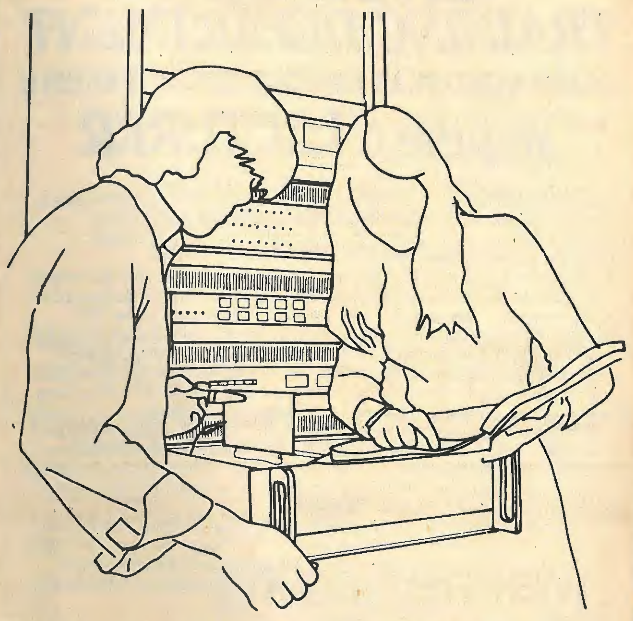
The job requires a certain amount of unsocial hours and weekend working.

Please write to the Studio Manager, Ms Susie O'List, giving a brief account of your career and experience to date. All applications will be treated in confidence. (9383)

Professional Careers in Electronics



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The successful candidate should have a good degree in a relevant subject such as Electronics or Communications. Direct experience of broadcast engineering, although desirable, is not expected. Up to date knowledge and experience of training techniques, together with a keen interest in people and a sympathetic manner are essential.
The post is based at the Corporation's Engineering Training Centre near Evesham, Worcestershire. Work away from base is necessary occasionally.
The salary scale, depending on experience, would initially be between £5935 and £6425 per annum, increasing annually, subject to satisfactory performance, to a maximum of £7955 per annum.
Salaries are currently under review.
For more information and an application form, please write to:
Head of Training Section (Engineering), BBC, Wood Norton Hall, Evesham, Worcestershire quoting reference 79.E.4066/WW and enclosing an addressed foolscap envelope. Closing date for completed application forms is 14 days after publication.

(9384)

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GELLER

(9347)

Norwich Airport

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Due to continued Airport expansion there are 2 vacancies for experienced persons as Technical Officers (Electronic Technician-Engineers) at Norwich Airport to assist the Senior Technical Officer in the maintenance and installation of a wide range of navigational, communications and airfield lighting equipment, including ACR 430, PLAN 17-18 ILS, EO VDF, VHF/UHF AM/FM transmitters and receivers. Experience of Plessey ILS maintenance would be a distinct advantage.

National Joint Council Conditions of Employment apply, subject to the Norwich City Council's local variations and agreements. Grade T.5, Basic scale £4,461 to £4,761 per annum, plus supplement of £312 per annum. It is planned to introduce shift working shortly which will attract a shift allowance of 14% of basic salary plus payments for working at weekends and on Public Holidays. Re-location expenses of up to £650 and temporary housing accommodation available in approved cases.

Norwich is a Cathedral City of some quality, with a thriving shopping/commercial centre, within easy reach of the Broads and Coast.

For fuller details and an application form write to the Deputy Airport Manager, Norwich Airport, Fifers Lane, Norwich NR6 6JA. The Senior Technical Officer can be contacted on Norwich 411923 for informal discussion about the nature of the work involved.

Application forms must be returned within 21 days of publication of this advertisement.

(9392)

South East Kent Health District

Electronics Technician

To be based at the new William Harvey District General Hospital, Ashford, Kent.

Qualifications: ONC, HNC preferred.

Salary scale: £4470 rising by annual increments to a maximum of £5610 per annum.

This is a newly established post offering an exceptional opportunity for the establishment of a section responsible for the maintenance of Electronics and Bio-Medical Equipment.

Candidates, male or female, should possess broad experience of electronics together with an understanding of the safety aspects of equipment.

In addition to a sound technical background, applicants should possess the managerial qualities required to organise and supervise both subordinate staff and contracted work and be capable of developing and sustaining successful working relationships with all levels and disciplines of hospital staff.

For job description and application form, write to Mr. G. W. Kelsey, District Works Officer, South East Kent Health District, Westfield, St. Mary's Hospital, Etchinghill, Nr. Folkestone, Kent.

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The William Harvey Hospital Ashford, Kent

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SITUATIONS VACANT

Television Engineer

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(9382)

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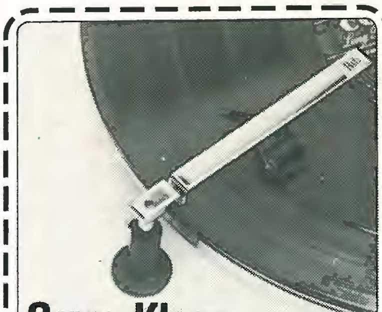

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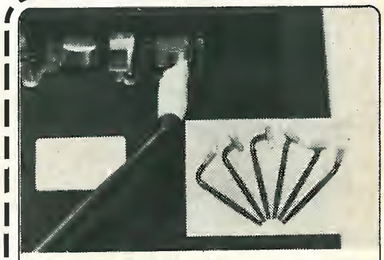

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