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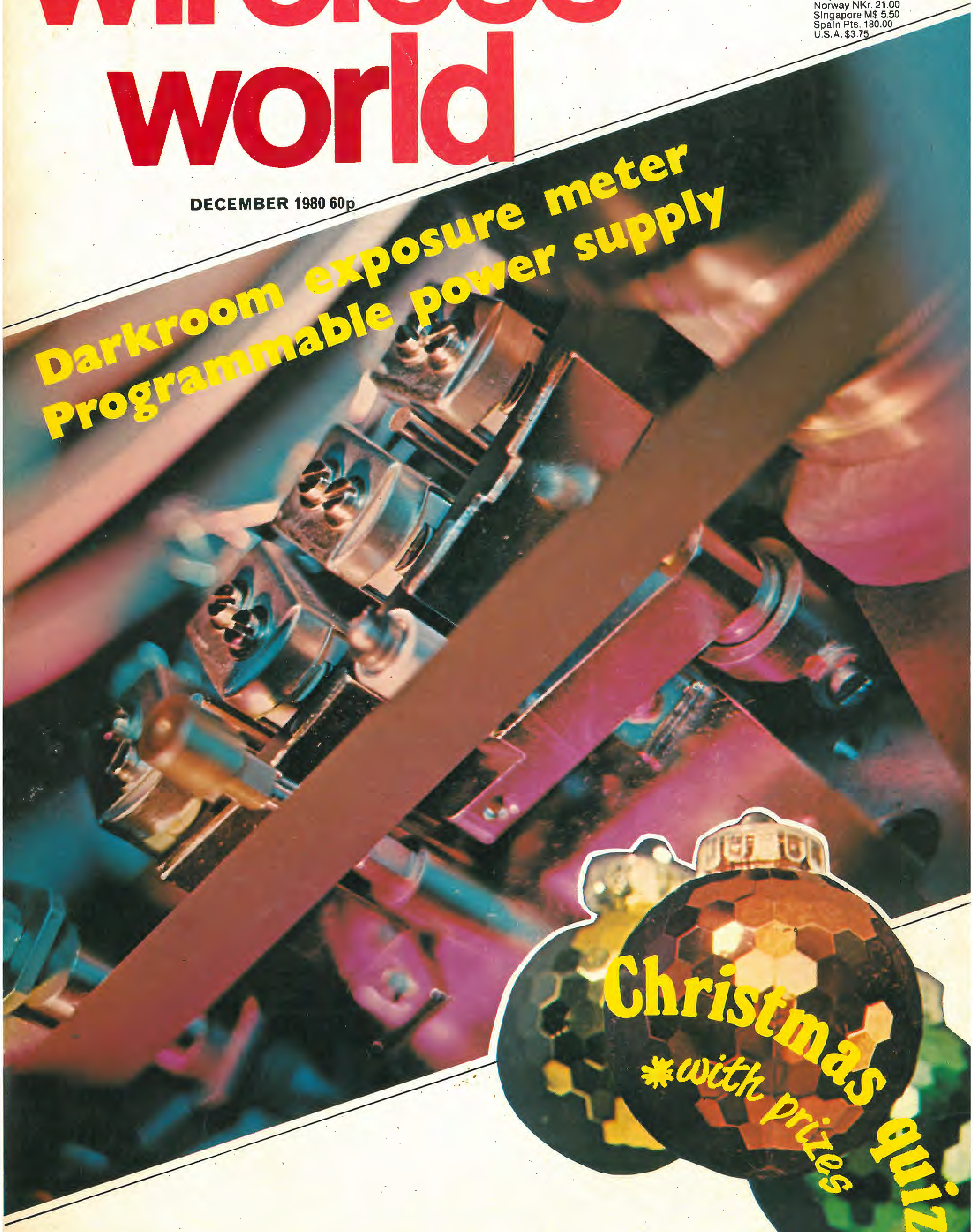
DECEMBER 1980 60p

Darkroom exposure meter
Programmable power supply



Christmas quiz
*with prizes

WIRELESS WORLD DECEMBER 1980 VOL 86 NO 1539

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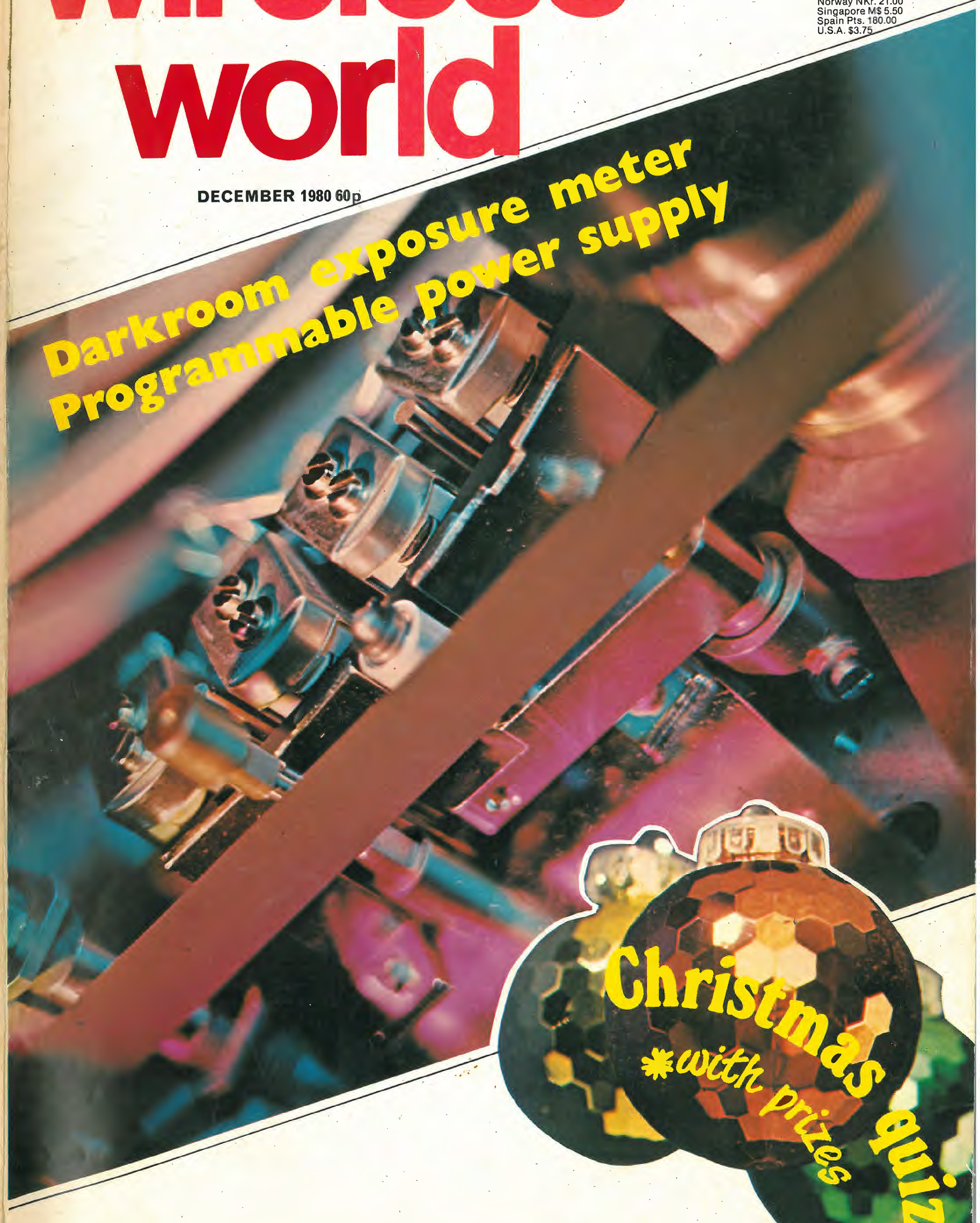

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Front cover is a Paul Brierley photograph of the tape system in a Philips analogue instrumentation recorder.

IN OUR NEXT ISSUE

Microprocessor trainer. **Designed to familiarize the complete beginner with microprocessors, this small unit with hex keyboard and six-digit display has enough facilities to make a useful tool later on.**

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Sutton, Surrey,
SM2 5AS
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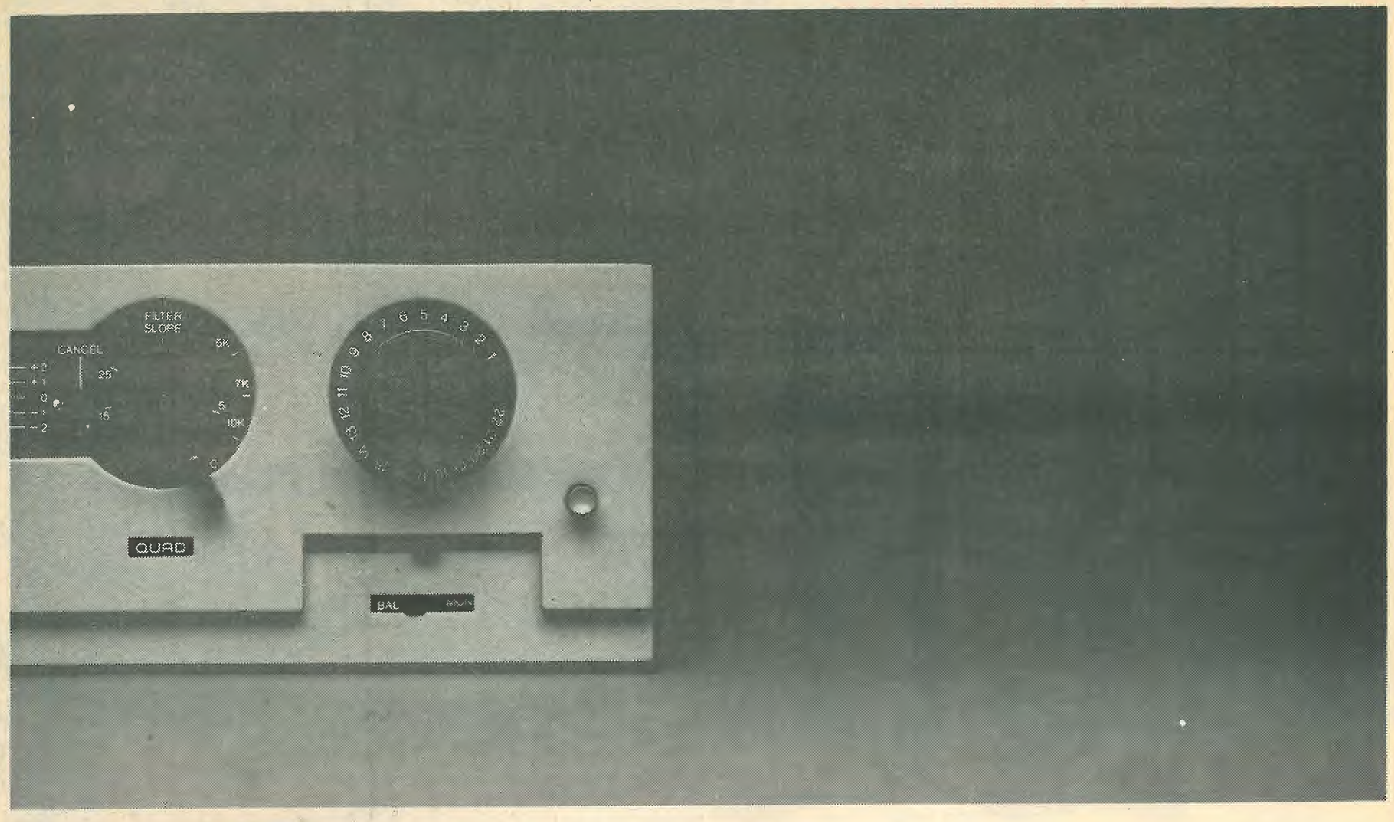
wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

DECEMBER, 1980 Vol 86 No 1539



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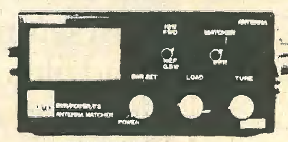

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5308A 0-75 MHz. Universal Module. 50mV sens. 1MΩ — 100
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5345 DC-500 MHz Time Int. Ave. Burst Total Ratio — 1225
10590A Adaptor converts 5245 Plug-ins to 5345 — 225

RACAL
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585A/82. DC-80 MHz. dual trace 10 mV sensitivity — 525
547/1A1. DC-50 MHz. dual trace DTB — 525
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7403N DC-60 MHz 3 Plug-in Mainframe — 450
7704A DC-200 MHz. CRT Readout. Mainframe for 4 Plug-in — 1200

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D75 Dual Trace DC-50 MHz Dual Timebase — 600
D83 DC-50 MHz. Dual trace. Large 6½" CRT. Dual Time Base — 650

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1A2 dual trace Plug-in DC-50 MHz — 180
1A4 four trace Plug-in DC-50 MHz — 375
1A5 Differential Plug-in — 175
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7A12 Dual Trace DC-105 MHz 5mV/div. — 410
7A18 Dual Trace DC-75 MHz 5mV/div — 370
7A22 High gain diff. amp. 0.1 Hz-1 MHz 10μV — 450
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8558B For 180 Mainframe 100 kHz-1.5 GHz 1 kHz-res — 1750

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022. DC-100 kHz. Dynamic range 60dB fits into various 500 series CRO's — 350

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LN40A Log Amplifier — 105

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PHILIPS
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RACAL
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FLUKE
8000A 1999 FSD. AC/DC/OHMS/Current — 115

HEWLETT PACKARD
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LM1420.2BA. 2300 FSD AC True RMS/DC — 110
A200.19999 FSD DC only — 160
A203.19999 FSD AC/DC/Ω. Sensitivity: (1μV DC, 10μV AC, 100mΩ resistance) — 300
A205.19999 FSD AC/DC/Ω — 300
A243. 119999 FSD AC/DC/Ω. Sensitivity: (1μV DC, 10μV AC, 10mΩ resistance) — 325
7050.99999 Auto AC/DC/Ω — 350

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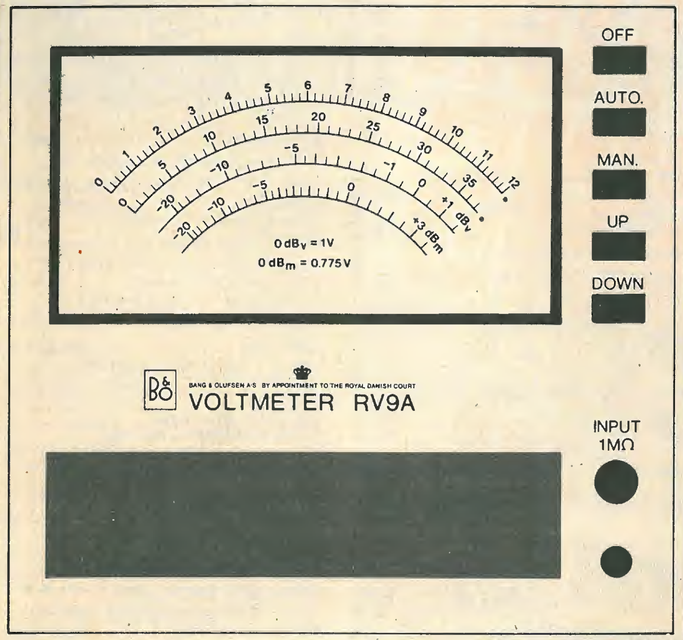

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Frequency characteristics:	10 Hz – 1 MHz ±0.2 dB 10 Hz – 10 MHz ±1.0 dB

Bang & Olufsen electronic instruments are also wow/flutter meters, power supplies, oscillators, milliohmmeters, voltmeters, and distortion meters.

UK agent: Danbridge (UK) Limited, Sherwood House, High Street, Crowthorne, Berkshire RG11 7AT
Tel: (034 46) 2369 TLX: 847782

Bang & Olufsen

DK – 7600 Struer

WW — 024 FOR FURTHER DETAILS

People who listen for a living...

More than 50% of professional recording engineers choose Beyer Dynamic headphones.
Why? For the same reasons that our headphones are ideal for home use.
For Clarity. Beyer Dynamic headphones are backed by more than fifty years of pioneering research and production experience to give you the purest, most authentic sound available.
For Comfort. A recording engineer spends long periods listening through headphones. For him, Beyer Dynamic lightness and softness is essential. For you, it's part of the pleasure of listening to be able to forget you're wearing headphones at all.
For Reliability. Your private listening will not make such demands on a pair of headphones as recording studio work, but it's good to know that the quality you enjoy is lasting quality.
Beyer Dynamic headphones. Prices from £20

listen to us.

Beyer Dynamic

Beyer Dynamic (GB) Ltd, 1 Clair Road, Haywards Heath, Sussex RH16 3DP. Tel. (0444) 51003.

WW — 027 FOR FURTHER DETAILS

The alternative source that's near to hand . . . KGM. A video production line with high volume capability, here in Europe. Ready to meet your orders for open frame monitor chassis that neatly replace those long-range imports you're using currently. Same mounting, same international-standard connections. But one big, competitive advantage . . .

We're so much nearer, with the stocks, fast production response, spares and service you could only expect from a home based source. KGM prices are highly competitive too, especially on big orders. We can prove that with a quote, but how about product performance? . . .

The specifications you want... bright, clear CRT data display, with superior resolution. The quality you get from years of video experience. Your popular screen sizes, in any phosphor colour. Latest miniaturised pcb construction of course, in an open chassis that allows screen tilt and mounting variations to fit your package.

So if **you** buy video display this way . . . call KGM now. See how keen we are to win your next order.

KGM ELECTRONICS LIMITED
Clock Tower Road, Isleworth, Middlesex TW7 6DU, England.
Telephone: 01-568 0151. Telex: 934120

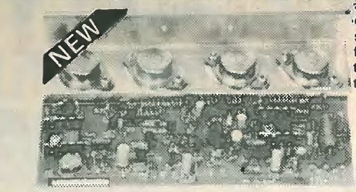
KGM ELECTRONICS LIMITED

WW — 068 FOR FURTHER DETAILS

The finest amplification kits from Crimson Elektrik

★★★★★ LATEST DEVELOPMENTS ★★★★

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



★ ★ ★ ★ BEST VALUE ★★★★

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

★ ★ ★ ★ ★ SOUND ADVICE ★ ★ ★ ★ ★

Crimson Amplifiers are versatile and dependable. The new CP3000 will give up to 300 watts into 4 ohms at 0.03% THD and is the obvious choice for P.A. and Discos requiring the best performance. For Hi-Fi we produce the ever-popular pre- and power amp hardware kits which enable our advanced modules to be houses in attractive metalwork and include everything down to the last nut and bolt.

Our Pre-amplifier can be fitted with the moving coil module allowing it to be used with the latest M.C. cartridge (which can now be bought for as little as £30).

Write for details, specifications and full price list or send 50p, cheque/P.O. for our comprehensive application/user's manual.

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

★ Power Amp Modules (single channel)	
CE 60C (60 WRMS/8 ohms)	**£23.10**
CE 1708—(170 WRMS/8 ohms)	**£38.50**
CP 3000 —(300 WRMS/4 ohms)	**£58.00**
★ 60 + 60 watt stereo pre and power amplifier complete kit	**£208.86**
★ Stereo Moving Coil Pre-Pre Amplifier Module MC1	**£28.50**
★ 3 Way Active Crossover (single channel)	**£32.60**

Don't forget, Crimson modules are available throughout the country from all branches of Marshalls and Mail Order from Badger Sound Services and, of course, Crimson Elektrik.

Prices include V.A.T. and post to anywhere in the U.K.

Crimson Elektrik

BARCLAYCARD

1A STAMFORD STREET, LEICESTER LE1 6NL
TELEPHONE: 0533 553508

Access — Buy it with Access

WW — 051 FOR FURTHER DETAILS

SEMI-CONDUCTORS

High quality-good value

Extensive range of Germanium and Silicon semi-conductors. Quick delivery from stock. Exporters of international repute, established over 20 years. Direct supplies for OEM, industrial and rental users and wholesalers. Private and retail users please send for list of distributors. Overseas distributor enquiries welcomed. Write, ring or telex for details and prices:

Edicron

Edicron Ltd., Redan House, Redan Place, London W2 4SA
Telephone: 01-221 4717 Telex: 265531

Germanium and Silicon Semi-conductors • Valves • Tubes • TV tube guns

WW — 026 FOR FURTHER DETAILS

INPUT FROM PHILIPS TEST & MEASURING INSTRUMENTS

OSCILLOSCOPES

NO WAITING FOR THESE TOP PRODUCTS

MULTIMETERS

The PM 2517 has set the standard and the pace in Europe for hand-held digital multimeters - and still it remains in a class of its own.

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

Some other **PM 2517** plus points:

- ●LED or LCD display
- ●True RMS readings of AC voltage and current
- ●Autoranging with manual override
- ●Optional accessories include temperature and data hold probes

Reader inquiry number 220

The PM 3207 - Super Scope - is a tough, general purpose oscilloscope which offers at a low price the quality and technology you expect from Philips Test and Measuring Instruments.

- ●15 MHz dual trace
- ●Auto triggering from either channel with adjustable level between peaks and TV triggering
- ●5 mV sensitivity, Y and X (via A input)
- ●B invert facility

Reader inquiry number 221

Both these instruments are available off the shelf from the **Philips Electronic Instruments Department** (see address below) or from the following distributors. **British Tungsram,** West Road, Tottenham, London N17 0RN. Tel: 01-808-4884. **Philips Service Centres** (25 throughout the country). Tel: 01-686-0505 for the address of your nearest branch. **Wessex Electronics Ltd,** 114-116 North Street, Downend, Bristol BS16 5SE. Tel: (0272) 571404.

PATTERN FOR THE FUTURE

The **PM 5519** colour TV pattern generator is already a widely used instrument. As a major manufacturer of Video cassette recorders, and colour television receivers - and the company which has developed the world's most advanced video disc system - Philips have carefully selected the best patterns for aligning and testing these products. With over 20 colour and b/w test patterns to choose from it is the most versatile pattern generator on the market.

- **PM 5519 I** for British system - versions available for other TV systems
- RF signals available in bands I, III, IV and V
- Variable Video Output (with 1 volt fixed position)
- External video and sound modulation facility
- Composite sync output for triggering - includes the line frame and blanking pulses to the local TV standard
- Built-in 5 digit counter
- 50mV RF output at 75Ω can be attenuated to over 100dB
- Electronically stabilised output level
- Wobbulator facility

Reader inquiry number 222

Some other Philips audio and video service instruments:

PM 5326 RF SIGNAL GENERATOR

- 100 kHz-125 MHz in 9 overlapping ranges

Reader inquiry number 223

PM 6307 WOW AND FLUTTER METER

- X-tal controlled oscillator
- High accuracy and frequency stability
- 3150 Hz or 3000 Hz switchable
- Separate 'Drift' and 'Flutter' indication

Reader inquiry number 224

TV GENERATORS

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

Input advertisements are designed to meet the needs of our professional customers. They are a shop window for Philips Test and Measuring Instruments - and we will be changing the display frequently because we have a lot of products to show you.

Where you require full information about a product, tick the coupon and attach it to your name and address, or letterhead - or, of course, use the journal's reader inquiry service. You will receive in return a detailed information pack reflecting your specific requirements.

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

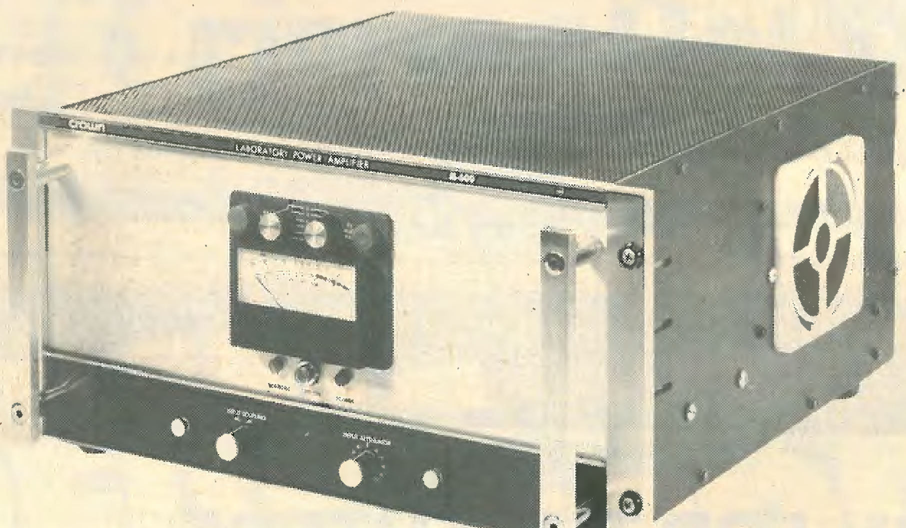
Pye Unicam Ltd
Philips Electronic Instruments Dept.,
York Street, Cambridge, England CB1 2PX
Tel Cambridge (0223) 358866 Telex 817331

PHILIPS **Test & Measuring Instruments**

PHILIPS

amcron

INDUSTRIAL MUSCLE



Model — M600

★ POWER RESPONSE DC — 20KHz ± 1dB.
★ OUTPUT POWER IN EXCESS OF 1.5kW INTO 2.75 Ohm LOAD (CONTINUOUS R.M.S.).
★ D.C. OUTPUT 20 AMPS AT 100 VOLTS OR 2KVa.
★ HARMONIC DISTORTION LESS THAN 0.05% DC-20KHz AT 1kW INTO 6 OHMS
★ PLUG-IN MODULES: CONSTANT VOLTAGE/CURRENT, PRECISION OSCILLATORS ★ UNIPOLAR AND BIPOLAR DIGITAL INTERFACES, FUNCTION GENERATORS, AND MANY OTHERS.
★ OUTPUT MATCHING TRANSFORMERS AVAILABLE TO MATCH VIRTUALLY ANY LOAD.
★ FULL OPEN AND SHORT CIRCUIT PROTECTION GUARANTEED STABLE INTO ANY LOAD.
★ TWO UNITS MAY BE CONNECTED TO PROVIDE UP TO 4kW.
★ INTERLOCK CAPABILITY FOR UP TO EIGHT UNITS.
★ 3-YEAR PARTS AND LABOUR WARRANTY.

For full details on all Amcron Products write or phone Chris Flack

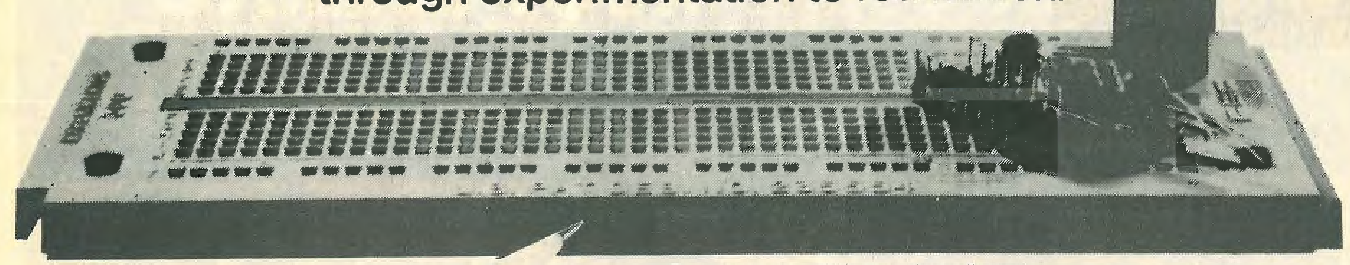
Kirkham Electronics

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

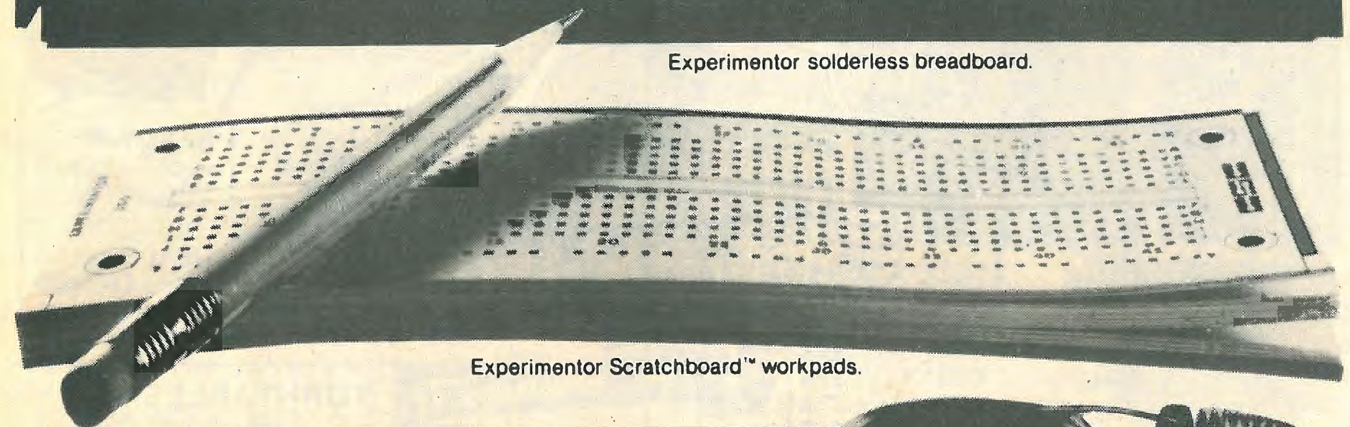
WW — 057 FOR FURTHER DETAILS

You can't beat The System.

The Experimentor System™ — a quicker transition from imagination through experimentation to realization.



Experimentor solderless breadboard.



Experimentor Scratchboard™ workpads.

Experimentor Matchboard™ pre-drilled PCBs.

When you have a circuit idea that you want to make happen, we have a system to make it happen quicker and easier than ever before: The Experimentor System.

You already know how big a help our Experimentor solderless breadboards can be. Now we've taken our good idea two steps further.

We've added Experimentor Scratchboard workpads, with our breadboard hole-and-connection pattern printed in light blue ink. To let you sketch up a layout you already have working so you can reproduce it later.

With Experimentor Matchboard you can go from breadboard to the finished product nonstop! We've matched our breadboard pattern again, this time on a printed circuit board, finished and ready to build on. All for about £1.32.

There's even a letter-and-number index for each hole, so you can move from breadboard (where they're moulded) to Scratchboard™ (where they're printed) to Matchboard™ (where they're silkscreened onto the component side) and always know where you are.

When you want to save time and energy, you can't beat The Experimentor System.

1. EXP-300PC, which includes one item. A Matchboard pre-drilled PCB **£1.32**	**2.** EXP-302, which includes three items. Three 50-sheet Scratchboard workpads **£1.68**	**3.** EXP-303, which includes three items: Two Matchboards and an EXP-300 solderless breadboard **£8.60**	**4.** EXP-304, which includes four items Two Matchboards, an EXP-300 breadboard and a Scratchboard workpad **£9.30**

CONTINENTAL SPECIALTIES CORPORATION

C.S.C. (UK) Limited, Dept. 7W2
Unit 1, Shire Hill Industrial Estate,
Saffron Walden, Essex. CB11 3AQ.
Telephone: Saffron Walden **(0799) 21682**
Telex: 817477

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Inc P&P and 15% VAT

1.EXP 300PC **£2.38**	Qnty.Reqd.	2.EXP 302 **£2.79**	Qnty.Reqd.
3. EXP 303 **£11.04**	Qnty.Reqd.	4. EXP 304 **£11.85**	Qnty.Reqd.

FREE Catalogue tick box☐

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£ ____________

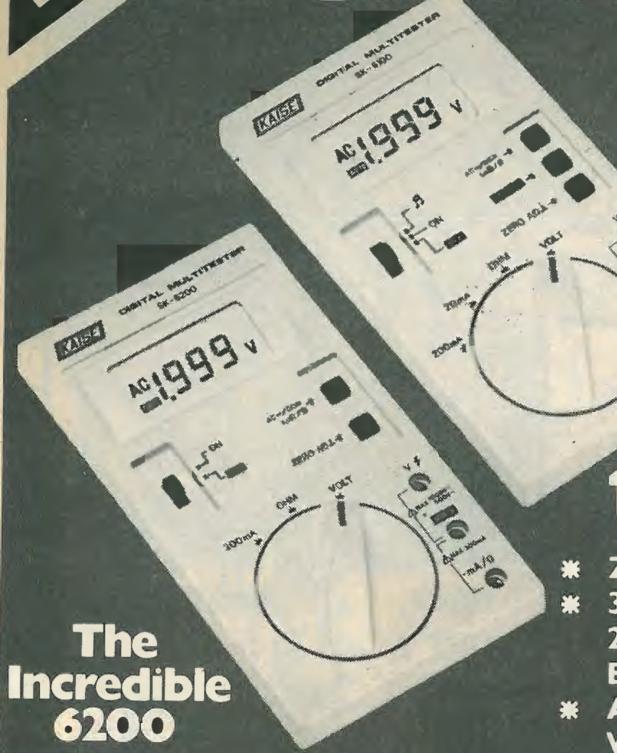
Phone your order with Access, Barclaycard or American Express

Card No. ____________ Expiry date ____________

WW — 025 FOR FURTHER DETAILS

NEW! DMM BREAKTHROUGH!

If you want an Autoranging, Auto Unit Display, 3½-digit LCD DMM. For only £39.95 (inc VAT) We've got to hand it to you!



The Incredible 6200

- ZERO ADJUSTMENT
- 3½-DIGIT LCD WITH 200 HRS CONTINUOUS BATTERY LIFE
- AUTO 'BATT' WARNING
- FULL AUTORANGING
- AUTO UNIT DISPLAY
- CONTINUITY TEST (6110 and 6100 only)
- 10 AMP AC/DC (6110 and 6220 only)

Introducing the latest professional state-of-the-art 3½-digit DMM – at really old-fashioned prices! From just an unbelievable £39.95 inc. VAT, plus £1.15 p&p!

	6100	6110	6200	6220
RESOLUTION	1 mV, 10μA, 0.1 Ω		1 mV, 100μA, 0.1 Ω	
FULL AUTO RANGING	✓	✓	✓	✓
RANGE HOLD	✓	✓		
UNITS OF MEASUREMENT DISPLAYED	mV, V, mA	mV, V, mA, A	mV, V, mA	mV, V, mA, A
FUNCTIONS DISPLAYED	Ω, KΩ, AUTO, BATT, ADJ, LO, – and AC			
MEASURES DC VOLTAGE TO	1000V	1000V	1000V	1000V
MEASURES AC VOLTAGE TO	600v	600v	600v	600v
MEASURES AC DC CURRENT TO	200mA	10A	200mA	10A
MEASURES RESISTANCE TO:	2 Megohms	2 Megohms	2 Megohms	2 Megohms
ZERO ADJUSTMENT	Zeros out minute test-lead resistances for precise measurements			
ACCURACY	0.5%	0.5%	0.8%	0.8%
LOW POWER OHM RANGES	For in-circuit resistance measurements on all models			
BUZZER – Continuity Test	✓	✓		
BUZZER – Over Range Indicator	✓	✓		
COMPLETE WITH	Batteries, pair of Test Leads, Spare Fuse, six months' guarantee			
PRICE	ONLY £64.95	ONLY £74.95	ONLY £39.95	ONLY £49.95
p&p	£1.15	£1.15	£1.15	£1.15

Why such a low, low price? Because the A/D converter and display are custom built! This is a genuine top-spec DMM. Check these features for *unbeatable* value – you won't find a hand-held DMM with these features at these prices again!

I believe you! Please send me the DMM s as marked.

_____6200 @ **£41.10** each, inc. VAT, p&p. Total price £_____
_____6220 @ **£51.10** each, inc. VAT, p&p. Total price £_____
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Total cash cheque enclosed £_____
Cheques payable to
Maclin-Zand Electronics Ltd., please.

ACCESS orders taken. Please write card no. and signature.

ACCESS NO_____

Name_____

Address_____

Signed_____

38 Mount Pleasant, London WC1X 0AP.
Tel. 01-278 7369/01-837 1165

ME
Maclin-Zand
Making state-of-the-art affordable.

To: Maclin-Zand Electronics Ltd., 38 Mount Pleasant, London WC1X 0AP.
For overseas orders, please add £5 to cost of total order package.

3WW

AND THERE'S MORE WHERE THIS CAME FROM

It's a long time since one of our adverts was presented in 'list' form - but simply because we do not try to squeeze this lot in every time doesn't mean that it's not available. Our new style price list (now some 40 pages long) includes all this and more, including quantity prices and a brief description. The kits, modules and specialized RF components - such as TOKO coils, filters etc. are covered in the general price list - so send now for a free copy (with an SAE please). Part 4 of the catalogue is due out now (incorporating a revised version of pt.1).

LINEAR ICs - NUMERIC LISTINGS

TBA120S	1.00
L200	1.95
U237B	1.28
U247B	1.28
U257B	1.28
U267B	1.28
LM301H	0.67
LM301N	0.30
LM308H	0.96
LM308N	0.65
LM339N	0.66
LM348N	1.86
LF351N	0.38
LF353N	0.76
LM374N	3.75
LM380N-14	1.00
LM380N-8	1.00
LM381N	1.81
ZN419CE	1.95
NE544N	1.80
NE555N	0.30
NE556N	0.50
NE560N	3.50
NE562N	4.05
NE564N	4.29
NE565N	1.00
NE566N	1.60
NE570N	3.85
SL624	3.28
TBA651	1.81
uA709HC	0.64
uA709PC	0.36
uA710HC	0.65
uA710PC	0.59
uA741CH	0.66
uA741CN	0.27
uA747CN	0.70
uA748CN	0.36
uA753	2.44
uA758	2.35
TBA810AS	1.09
TBA820M	0.75
TCA940E	1.80
TDA1028	2.11
TDA1029	2.11
TDA1054	1.45
TDA1062	1.95
TDA1072	2.69
TDA1074A	5.04
TDA1083	1.95
TDA1090	3.05
HA1137	1.20
HA1196	2.00
HA1197	1.00
TDA1220	1.40
LM1303	0.99
LM1307	1.55
MC1310P	1.90
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MC1350	1.20
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SL1612P	1.60
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SL1624C	3.28
SL1625P	2.17
SL1626P	2.44
SL1630P	1.62
SL1640P	1.89
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TDA2002	1.25
TDA2020	3.00
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CA3090AQ	3.35
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CA3130E	0.80
CA3130T	0.90
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CA3189E	2.20
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LM3914N	2.80
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KB4400	0.80
KB4406	0.60
KB4412	1.95
KB4413	1.95
KB4417	1.80
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KB4420B	1.09
KB4423	2.30
KB4424	1.65
KB4431	1.95
KB4432	1.95
KB4433	1.52
KB4436	2.53
KB4437	1.75
KB4438	2.22
KB4441	1.35
KB4445	1.29
KB4446	2.75
KB4448	1.65
NE5044N	2.26
NE5532N	1.85
SD6000	3.75
SL6270	2.03
SL6310	2.03
SL6600	3.75
SL6640	2.75
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LN1242	19.00
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MSM5523	11.30
MSM5524	11.30
MSM5525	7.85
MSM5526	7.85
MSM5527	9.75
MSM55271	9.75
ICM7106CP	9.55
ICM7107CP	9.55
ICM7216B	19.25
ICM7217A	9.50
SP8629	3.85
SP8647	6.00
SP8660	2.75
95H90PC	6.00
HD10551	2.45
HD44015	4.45
HD12009	6.00
HD44752	8.00

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4001	0.17
4000	0.17
4002	0.23
4008	0.80
4009	0.58
4010B	0.58
4011AE	0.20
4011B	0.20
4012	0.55
4013	0.55
4015	0.95
4016	0.52
4017	0.80
4019	0.60
4020B	0.93
4021	0.82
4022	0.90
4023	0.17
4024	0.76
4025	0.17
4026	1.80
4028	0.72
4029	1.00
4030	0.58
4035	1.20
4040	0.83
4042	0.85
4043	0.85
4044	0.80
4046	1.30
4047	0.99
4049	0.52
4050	0.55
4051	0.65
4052	0.65
4053	0.65
4063	1.09
4066	0.56
4068	0.25
4069	0.20
4070	0.20
4071	0.20
4072	0.20
4073	0.20
4075	0.20
4076	0.90
4077	0.20
4078	0.20
4082	0.20
4093	0.78
4175	0.95
4503	0.69
4506	0.51
4510	0.99
4511	1.49
4512	0.98
4514	2.55
4518	1.03
4520	1.09
4521	2.36
4522	1.49
4529	1.41
4539	1.10
4549	3.50
4554	1.53
4560	2.18
4566	1.59
4568	2.18
4569	3.03
4572	0.30
4585	1.10

TTL N and LSN

7400N	0.13
74LS00	0.20
7401N	0.13
74LS01	0.20
7402N	0.14
74LS02	0.20
7403N	0.14
74LS03	0.20
7404N	0.14
74LS04	0.24
7405N	0.18
74LS05	0.26
7406N	0.28
7407N	0.38
7408N	0.17
74LS08	0.24
7409N	0.17
74LS09	0.24
7410N	0.15
74LS10	0.24
7411N	0.20
74LS11	0.24
7412N	0.17
7413N	0.30
7414N	0.51
74LS15	0.24
7416N	0.30
7417N	0.30
7420N	0.16
74LS20	0.24
7421N	0.29
74LS21	0.24
7422N	0.27
7425N	0.27
7427N	0.27
74LS27	0.44
7428N	0.35
74LS28	0.32
7430N	0.17
74LS30	0.24
7432N	0.25
74LS32	0.24
7437N	0.40
7438N	0.33
74LS38	0.24
7440N	0.17
74LS40	0.24
7441N	0.74
7442N	0.70
74LS42	0.99
7443N	1.15
7444N	1.12
7445N	0.94
7446N	0.94
74LS47	0.89
7448N	0.56
74LS48	0.99
74LS49	0.99
7451N	0.17
74LS51	0.24
7453N	0.17
7454N	0.17
74LS54	0.24
74LS55	0.24
7460N	0.17
74LS63	1.24
7470N	0.28
7472N	0.28
7473N	0.32
74LS73	0.38
7474N	0.27
74LS74	0.28
7475N	0.38
7476N	0.37
74LS76	0.38
74LS78	0.38
7480N	0.48
7481N	0.86
7482N	0.69
7485N	1.04
74LS85	0.99
74LS86	0.40
7489N	2.05
7490N	0.33
74LS90	0.90
7491N	0.76
74LS91	1.10
7492N	0.38
74LS92	0.78
7493N	0.32
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7494N	0.78
7495N	0.65
74LS95	1.14
7496N	0.58
74LS96	1.20
7497N	1.85
74LS107	0.38
74109N	0.63
74LS109	0.70
74110N	0.54
74111N	0.68
74LS112	0.38
74LS113	0.38
74LS114	0.38
74118N	0.83
74120N	1.15
74121N	0.42
74122N	0.46
74123N	0.73
74LS124	1.75
74125N	0.38
74LS125	0.44
74126N	0.57
74LS126	0.44
74128N	0.74
74132N	0.73
74LS132	0.78
74LS136	0.40
74LS138	0.60
74141N	0.56
74142N	2.65
74143N	3.12
74144N	3.12
74LS145	0.97
74147N	1.75
74148N	1.09
74LS148	1.19
74150N	0.99
74151N	0.55
74LS151	0.84
74153N	0.64
74LS153	0.54
74154N	0.96
74155N	0.54
74LS155	1.10
74156N	0.80
74157N	0.67
74LS157	0.55
74LS158	0.60
74159N	2.10
74160N	0.82
74LS160	1.30
74161N	0.92
74LS161	0.78
74LS162	1.30
74163N	0.92
74LS163	0.78
74164N	1.04
74LS164	1.30
74165N	1.05
74LS165	1.04
74167N	2.50
74LS169	2.00
74170N	2.30
74LS170	2.00
74LS174	1.20
74175N	0.87
74LS175	1.10
74176N	0.75
74177N	0.78
74181N	1.65
74LS181	3.50
74LS183	2.10
74184N	1.35
74185N	1.34
74LS190	0.92
74192N	1.05
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220N,470N........0.22
1uF..............0.29

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47N,68N,100N.....0.08
220N.............0.11
20mm LEAD SPACING
220N,330N,470N...0.18

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270P,330P,390P...0.09
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2N2,2N7,3N3,3N9..0.12
4N7,5N6,6N8,10N..0.13

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- Unique syntax check. Only lines with correct syntax are accepted into programs. A cursor identifies errors immediately. This prevents entry of long and complicated programs with faults only discovered when you try to run them.
- Excellent string-handling capability–takes up to 26 string variables of any length. All strings can undergo all relational tests (e.g. comparison). The ZX80 also has string input–to request a line of text when necessary. Strings do *not* need to be dimensioned.
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- FOR/NEXT loops nested up to 26.
- Variable names of any length.
- BASIC language also handles full Boolean arithmetic, conditional expressions, etc.
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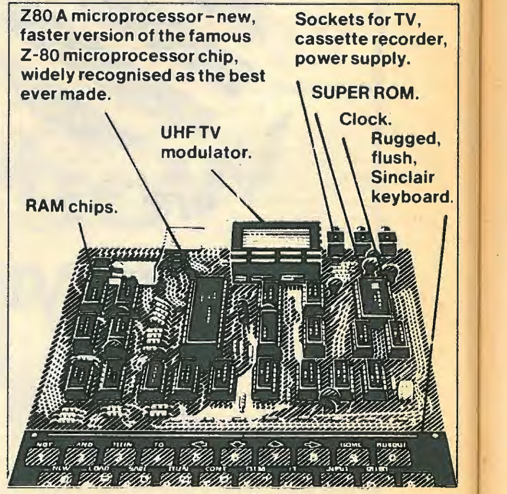

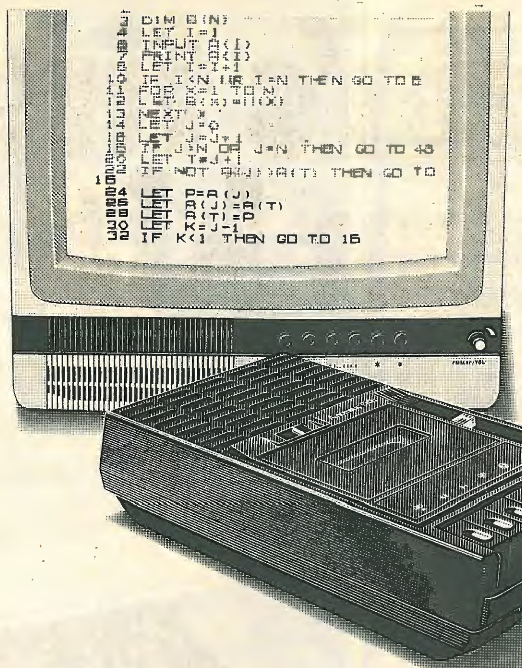

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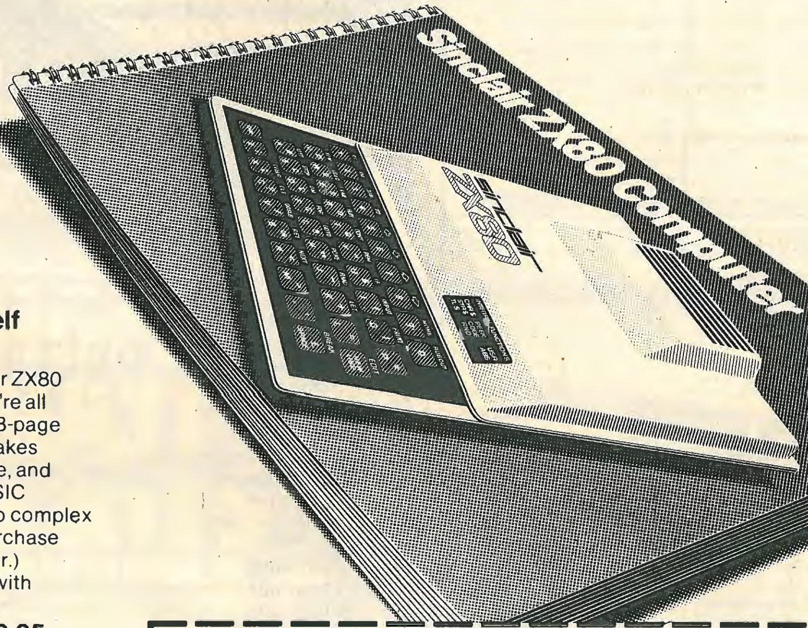

The Sinclair teach-yourself BASIC manual.

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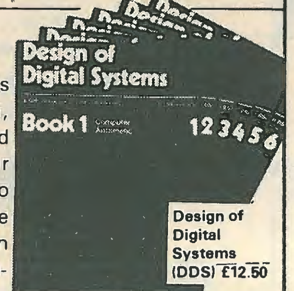

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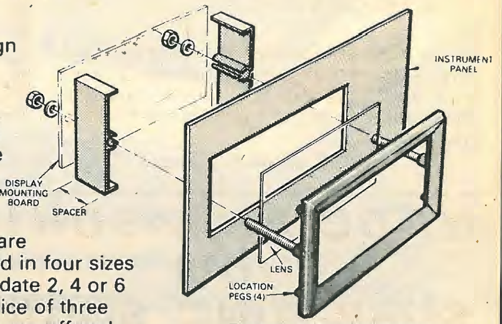

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WW12

S-2020TA STEREO TUNER/AMPLIFIER KIT

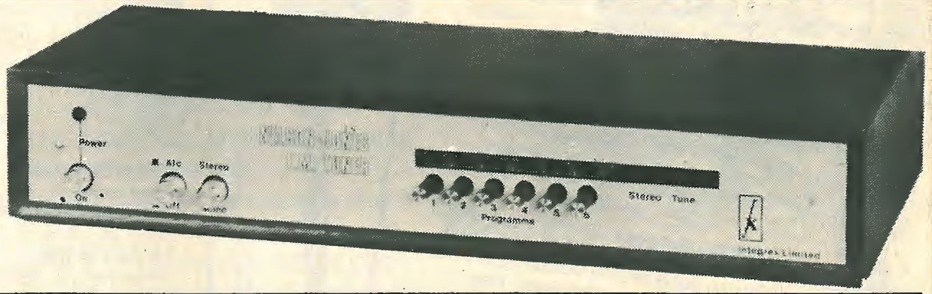
NEW HIGH PERFORMANCE TUNER

A high-quality push-button FM Varicap Stereo Tuner with pilot cancel decoder combined with a 24W r.m.s. per channel Stereo Amplifier, using Bifet op. amps.

Brief Spec. Amplifier Low field Toroidal transformer, Mag. input. Tape In/Out facility (for noise reduction unit, etc.) THD less than 0·1% at 20W into 8 ohms. **High Slew Rate.** Low noise op. amps used throughout. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses UM 1181 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC pilot cancel, stereo decoder, LED tuning and stereo indicators. Tuning range 88-108MHz 30dB mono S/N @ 0.7µV. THD 0.3%.

PRICE: £69.95 + VAT

NELSON-JONES Mk. 2 STEREO FM TUNER KIT



A very high performance tuner with dual gate MOSFET RF and Mixer ready built front end, triple gang varicap tuning, linear phase I.F. and 3 state MPX decoder.

PRICE: £74.95 + VAT

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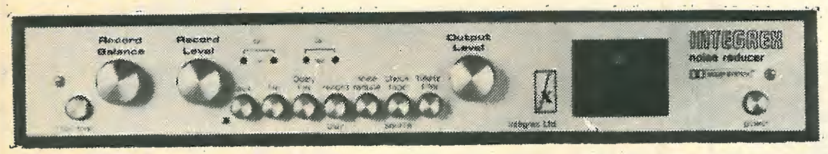
Wireless World Dolby noise reducer

Trademark of Dolby Laboratories Inc.



Typical performance
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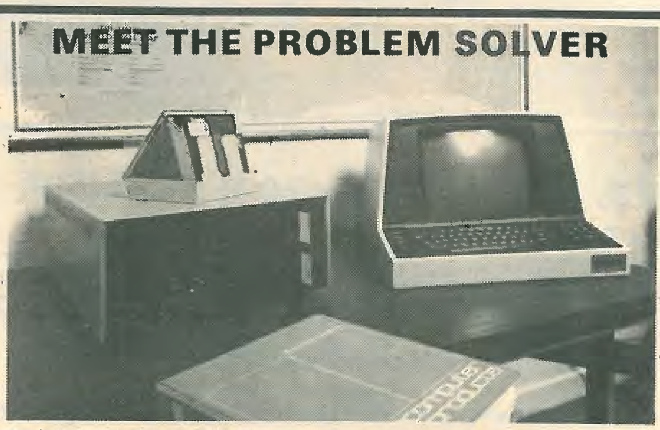

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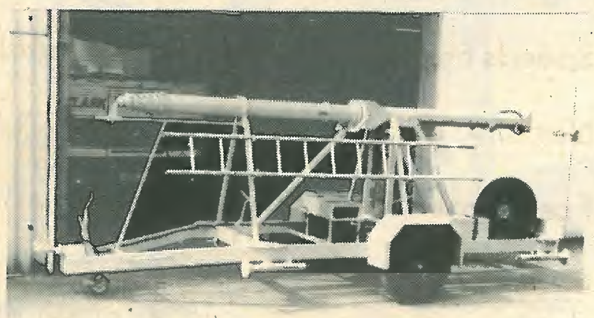

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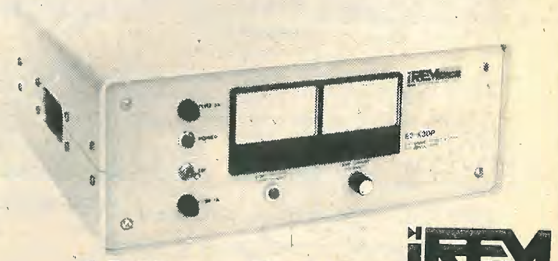

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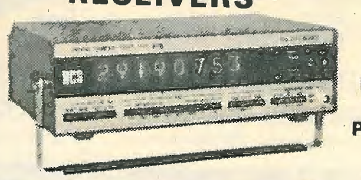

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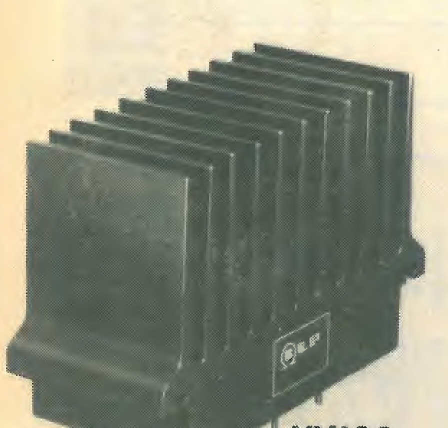
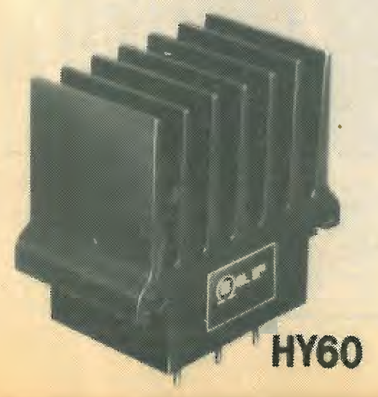


HY120



HY60

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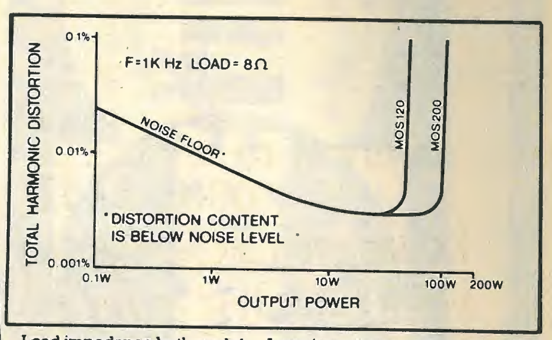
ILP POWER AMPS ARE ENCAPSULATED FOR THERMAL STABILITY AND LONGER LIFE



Load impedance both models 4Ω-∞ Input sensitivity both models 500mV Input impedance both models 100KΩ Frequency response both models 15Hz-100KHz - 3dB

BIPOLAR

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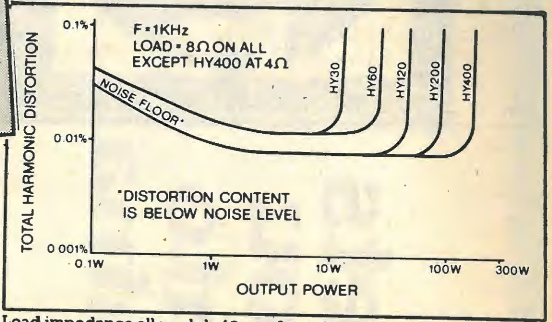
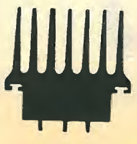
HY400	240W into 4Ω	0.01%	15V/μs	5μs	100dB	£27.68 + £4.15



Load impedance all models 4Ω-∞ Input sensitivity all models 500mV Input impedance all models 100KΩ Frequency response all models 15Hz-50KHz - 3dB



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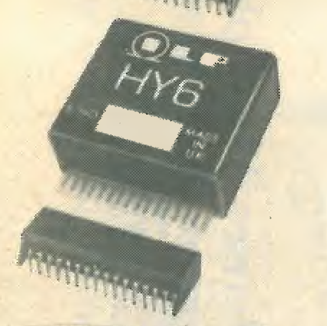

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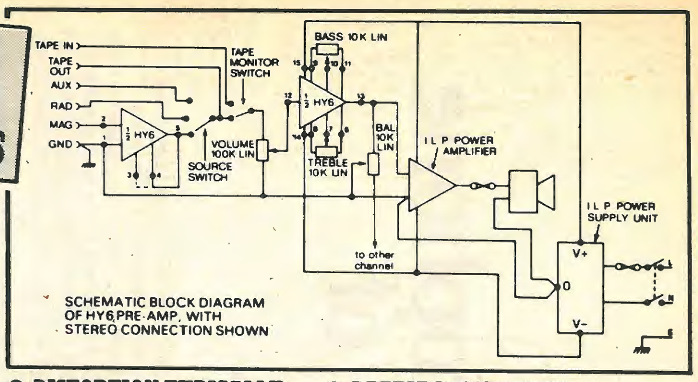

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Save our public service broadcasting

"Listen to the BBC while you can, because it is getting quieter every day and it is going to get quieter a lot quicker than you think". These words from Allen Holden, the recently retired manager of Radio London, might be thought alarmist by people who have not been following the latest events in British broadcasting. They are in fact a fair comment on a process of attrition that has been affecting the BBC for almost a decade. During 1980 this process has been accelerated by the Government's decision to cut down the Corporation's resources – forcing reductions in staff and projects and preventing the colour tv licence fee from being raised to the £41 that was needed. (George Howard, the new chairman of the BBC's board of governers, has said he could get no satisfactory reason from the Government for this last refusal.) And the process has been officially confirmed by Ian Trethowan, the Corporation's director-general, in stating (what many people have noticed anyway) that the BBC's services are deteriorating absolutely.

These restrictions may be intended as a temporary measure but they will permanently impair public service broadcasting relative to commercial broadcasting in Britain. For example, on the engineering side the BBC has had to postpone the development of studio centres, local radio stations, teletext and v.h.f. sound transmitters. The damage done on the programme side is well known. But apart form these actions the present government has further increased the financial imbalance between public service and commercial broadcasting by handing over the fourth tv channel to the IBA (as we write the Broadcasting Bill is just about to be enacted). For years the BBC has been contending with the growing strength, professionalism and revenues of commercial broadcasting. This may well be the final blow. From the position where it now finds itself the BBC can move in only two directions: it can either retire into a minority service, like public service broadcasting in the USA – a move which the commercial broadcasters would of course welcome – or it can compete for large audiences on the terms set by commercial broadcasting – a process which has already started – and so become virtually indistinguishable from that type of service.

Which of these alternatives do we, the public, want? The answer must be a resounding *Neither!* British life will be impoverished without a good, strong-voiced public service broadcaster, independent of the state, creative and risk-taking, with the kind of standards and values which the BBC has maintained throughout its fifty-odd years' life. And if we want such a public service we must be prepared to pay for it, at the proper rate for the job. Let us not be misled by the polite euphemism "independent" used to disguise commercial broadcasting. It is not independent at all, but closely *interdependent* with trading activity, stimulating sales of food, drink and toilet-rolls and drawing its revenues from the proceeds, which come out of our pockets. It does not even sell programmes directly to the public, in the manner of theatres or book publishers, but, with the money from advertisements, produces the programmes it calculates will get the largest possible audiences for those advertisements and the quickest possible sales of the products. It is in the game for profit, and the service it provides is incidental, a means to that main purpose.

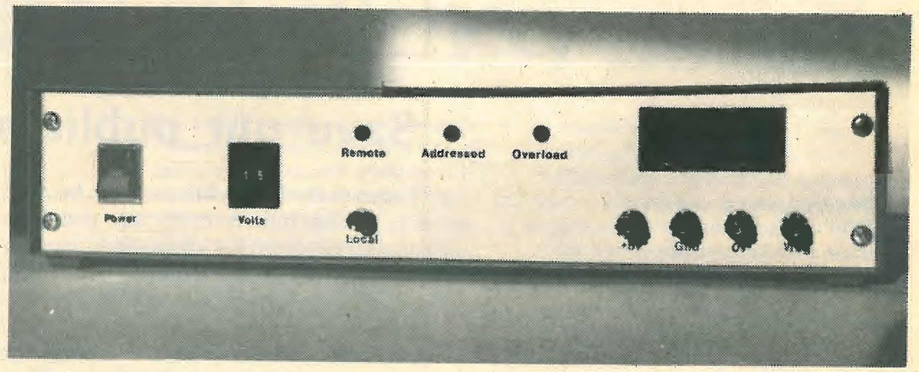
To achieve this purpose the output of commercial broadcasting is designed to insulate people from reality, to keep them quiet, uncritical and accepting. It purveys a synthetic culture in which safe routines ensure predictable responses and the glossy package becomes a substitute for the real thing. If this is what is to become the predominant "British" broadcasting, then it will be for the BBC to change its name and become our Independent Broadcasting Corporation.

Programmable power supply

Digital control via the IEEE–488 General Purpose Interface Bus

by J. Summers, B.Sc., M.Sc., M.Inst. P.

The General Purpose Interface Bus, defined by IEEE Std 488 (1978) and IEC 652-1, provides a facility whereby electronic instruments can communicate using a standard for the hardware circuits and recommended practice for the data and software protocol. This article describes an interface for a programmable power supply which can be used as a listener/talker via the GPIB.



The heart of the GPIB interface contains a 96LS488 low-power Schottky l.s.i. device, see Fig. 1, which is dedicated to interpreting the bus commands and messages outlined in Fig. 2. The remaining logic decodes ASCII digits from the bus and stores the b.c.d. numbers which are converted to a binary format and then passed to a d-to-a converter as shown in Fig. 3. The d-to-a output is amplified and current-boosted to provide the appropriate power supply output. Additional features include thumbwheel-switched programming for manual operation, an overload detection circuit which signals the fault to the bus controller, and a remote reset facility which allows the controller to set the power supply voltage to zero and clear any overload condition by a single command message. In this design the power supply operates in the listener/talker mode with single-byte addressing. During the Listener Active State (LACS) the interface automatically receives data transmitted over the GPIB by a talker and, in particular, recognizes and stores two ASCII-coded decimal digits. The message is terminated by an ASCII carriage return which, if the power supply manual controls are disabled by the controller, passes the received digits to the d-to-a converter.

At switch on, the interface is in the offline initialized state, the data registers are cleared and the power supply is in the manual mode. If the GPIB controller sends a listen address which corresponds to the d.i.p.-switch programming, the "addressed" l.e.d. is illuminated. The "remote" l.e.d. is also switched on if the front panel "local" switch is not pushed and the controller is continuously sending the Remote Enable (REN) message.

If the remote l.e.d. is on, the power supply output voltage will be zero because the data register is empty. Pushing the local switch restores the unit to manual control. However, the controller may issue a Local Lockout (LLO) message which prevents the user from returning to manual control. This facility allows an automated program to remotely set a voltage and prevent interference by accidental button-pushing. The power supply may be unaddressed by the Unlisten (UNL) command or by the system command Interface Clear (IFC), either of which will leave the unit in the remote state. If the controller sends the REN message false, the supply will revert to the manual mode.

The programmed voltage can be altered by the controller re-addressing the supply and sending two digits followed by a carriage return. Alternatively, the voltage may be set to zero by a Device Clear (DCL), or Selected Device Clear (SDC) command which is functional only on listener-addressed instruments. The "clear" messages also clear the overload latch. If the supply output is overloaded, the condition is detected and a latch is set which illuminates a warning light, forces the d-to-a output to 0V, activates the "request service" (rsv) input to the bus interface, and passes the overload signal to the "individual status" (ist) input of the bus interface. Under manual control, the operator can try to clear the overload by pressing the overload reset switch. If the fault condition disappears, the supply will return the output to the previous programmed voltage. If the fault condition persists, the overload latch will remain in the set state. The 96LS488 relays the rsv input to the controller via the Service Request (SRQ) message. The SRQ line is a wire-OR of all the service request messages on the bus, and the controller should be programmed to conduct a serial poll of instruments on the bus to determine which have requested service. To perform a serial poll on the power supply, the controller issues the talk address (which is in this case the same as the listen address) and the Serial Poll Enable (SPE) command. During a serial poll the 96LS488 in the power supply outputs the Requested Service (RQS) signal, which is bit 7 of the 8-bit data byte. In this design the other seven

Fig. 1. 96LS488 functional block diagram.

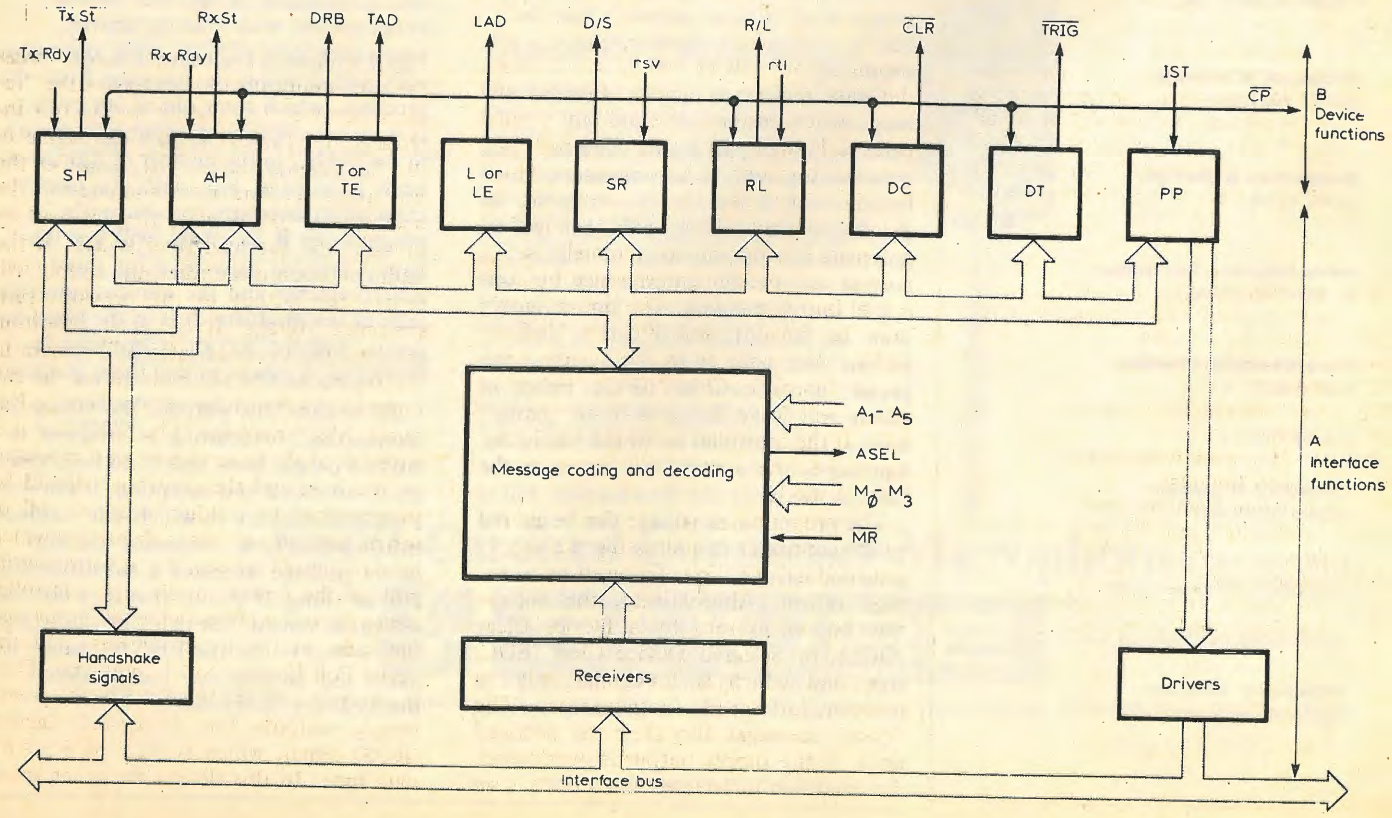


Table 1. The programmable power supply responds to the following GPIB remote interface messages.

MLA	My Listen Address, set by d.i.l.-switch. On receipt goes into Addressed state.
DAB	Data Byte. ASCII digits and Carriage Return (CR).
DCL	Device Clear message, may be received at any time. Sets the remotely programmed voltage to zero and clears the overload condition if active.
SDC	Selected Device Clear (only when Addressed). Function as DCL.
LLO	Local Lockout, prevents the operator returning the supply to the local control state.
GTL	Go to Local. The GPIB controller allows the supply to be programmed locally by the operator.
REN	Remote Enable. If this message is true, then receipt of MLA sets the supply in the remotely controlled state.
MTA	My Talk address. Used by the controller to set the supply interface in the Talker mode to send a status byte(s). Used to transmit the overload condition.
SPE	Serial Poll Enable. Used in conjunction with MTA.
SPD	Serial Poll Disable.
IFC	Interface Clear } Reset the GPIB interface logic.
UNT	Untalk } Reset the GPIB interface logic.
UNL	Unlisten } Reset the GPIB interface logic.

The supply will send the following GPIB messages.

SRQ	Service Request, in response to overload condition (rsv=request service).
RQS	Requested Service, transmitted as bit 7 (D107) of the status byte in response to the MTA and SPE messages. RQS will be active if rsv was active. The remaining bits of the status byte have no meaning and are transmitted passive false.
PPR_n	Parallel Poll Response n, programmed by the GPIB controller. The local message "individual status" (ist) is in this case hard-wired to the overload condition signal. An active Parallel Poll response in PPAS therefore indicates an overload condition if ist=1, or no overload if ist=0.

GPIB interface function subsets incorporated in the power supply.

SH1	Source Handshake.
AH1	Acceptor Handshake.
T6	Talker.
TE0	No Extended Addressing.
L4	Listener.
LE0	No Extended Addressing.
SR1	Service Request.
RL1	Complete Remote/Local.
PP1	Parallel Poll with Remote Configuration.
DC1	Device Clear.
DT0	No Device Trigger Capability.
C0	No Controller Capability.

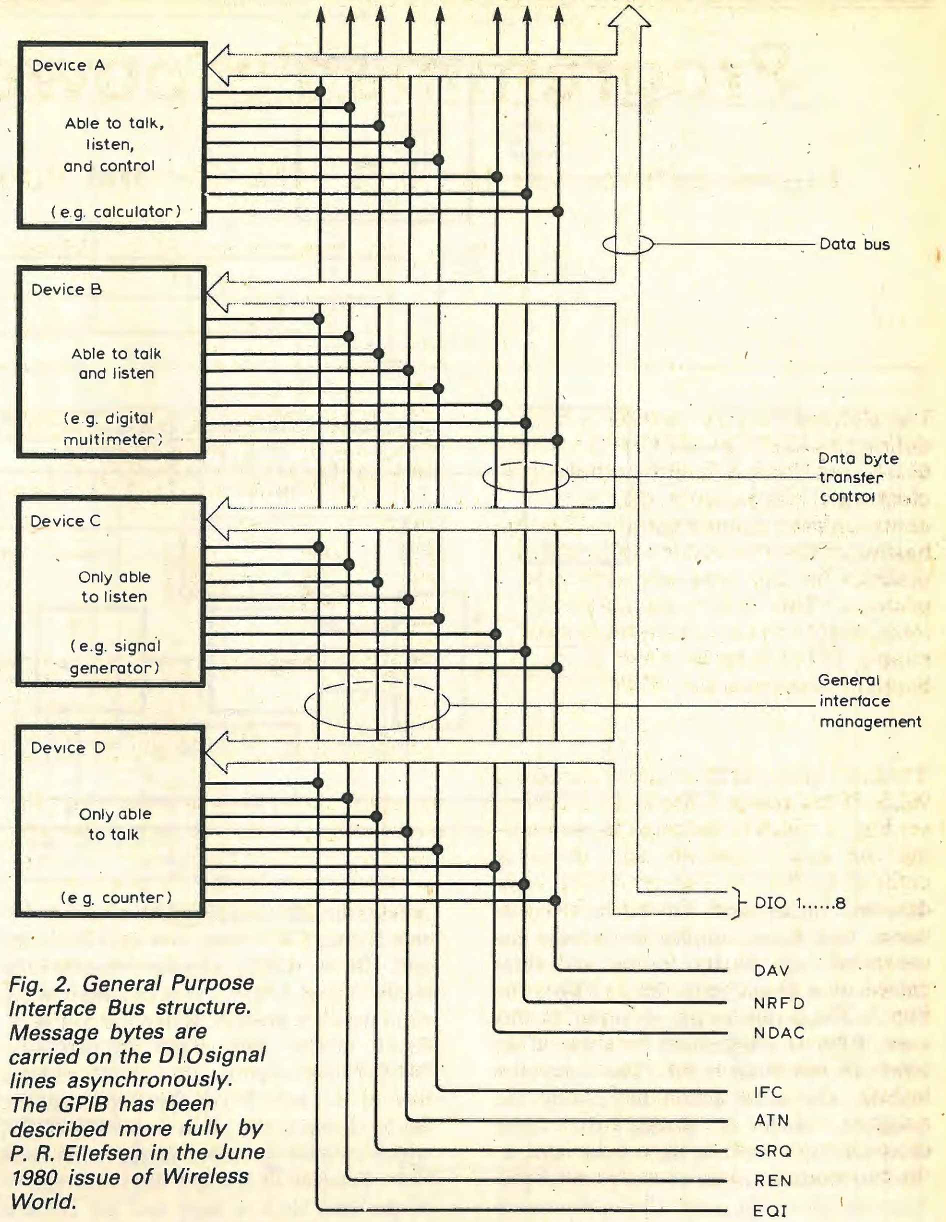


Fig. 2. General Purpose Interface Bus structure. Message bytes are carried on the DIO signal lines asynchronously. The GPIB has been described more fully by P. R. Ellefsen in the June 1980 issue of Wireless World.

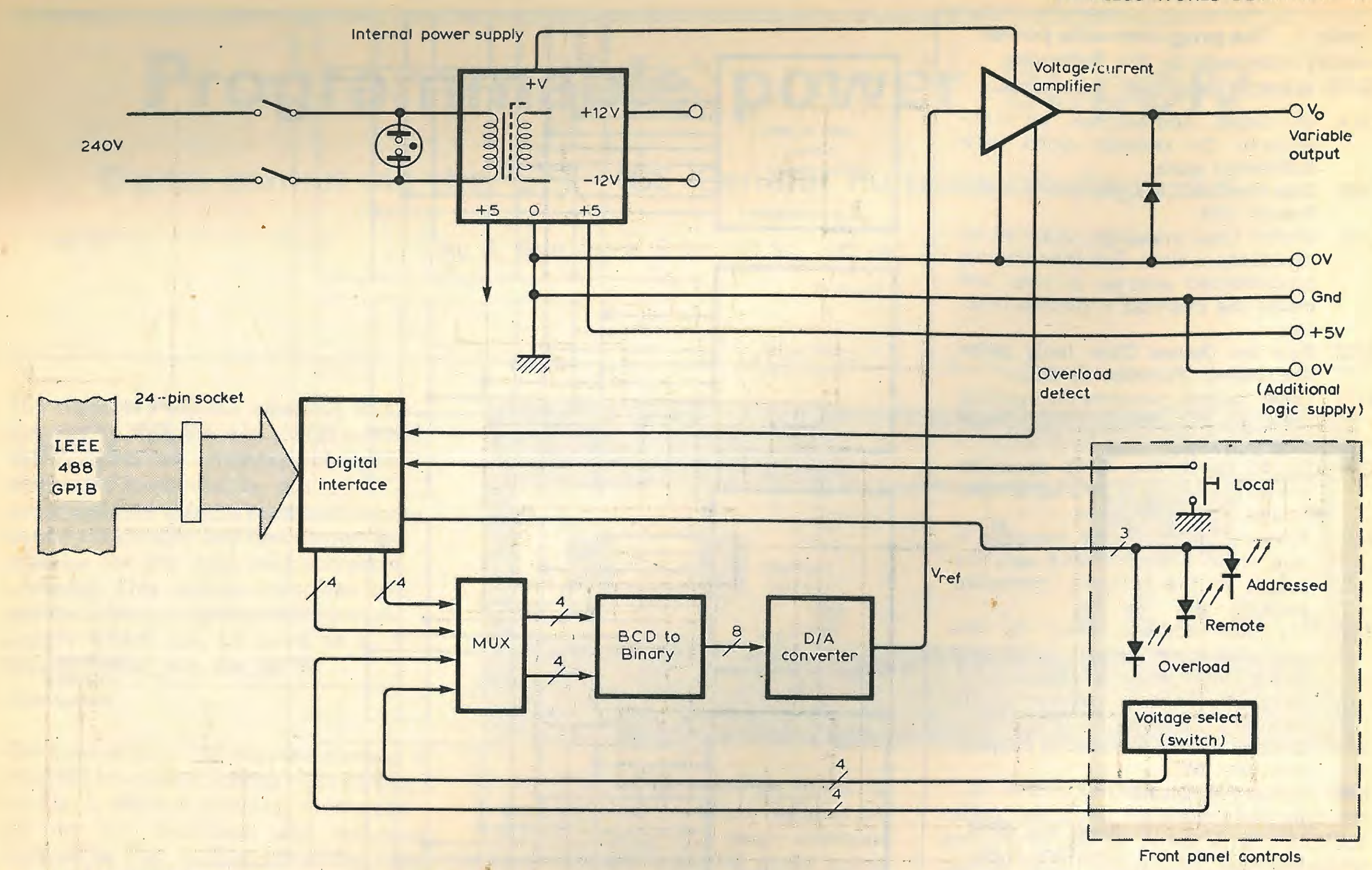


Fig. 3. Programmable power supply block diagram.

bits are unused and will be received as zeros. In a more complex instrument the seven bits can be transmitted as useful information in a Status Byte (STB), the RQS message reflects the rsv input. In this case, RQS is transmitted as a one if an overload condition exists. The controller should take some action to remedy the problem, such as issuing the Clear command and resetting the output voltage. The ist message input to the parallel poll function allows the controller to determine the state of the overload latch at any time.

Logic operation

The 96LS488 is assumed to be a black box with only the named pins in Fig. 4 connected to the circuit – the Acceptor Handshake RxSt (output) RxRDY (input), the Listener Addressed ($\overline{LAD}$) Remote/Local ($\overline{R}$/L), and Clear ($\overline{CLR}$) outputs, and the Source Handshake pins Status Strobe (StSt) and Ready (St RDY). Inputs from the power supply are the Return to Local (rtl) and Request Service (rsv) signals. Other necessary connections are the mode pins (M0 to M3), used to maintain the bus interface in the listener/talker (addressable) state, and the switchable address inputs (A1 to A5) which provide 31 talk and listen addresses. A reset pin ($\overline{MR}$) initializes the clock and the interface at power-on. The i.c. can use a crystal oscillator on the Xtal and $\overline{CP}$ pins but, because there is no critical timing within the power supply, a relaxation oscillator running at about 10MHz is adequate.

When the 96LS488 is in the Listener Active state, the $\overline{LAD}$ output is active low and drives the addressed l.e.d. The bus data uses negative logic so the 74LS240 inverting buffer provides positive logic signals within the supply. The message format is <nn CR> where n is an ASCII digit and CR is ASCII carriage return. The strobe signal (RxST) is active high when valid data are present. Referring to Fig. 4, RxST is the clock input to two 4-bit 74LS173 registers (positive clock) and one half of a 74LS73 JK flip-flop (negative clock). Initially the JK is reset so Q is low, which enables the clock to the units latch ($\overline{E1}$). Because $\overline{Q}$ is high, the clock enable of the tens latch is high and the clock is ineffective. If an ASCII digit is present it is detected by the three gates connected to the second clock enable ($\overline{E2}$) of both latches. The code for an ASCII digit is 011xxxx, where xxxx is the b.c.d. representation of the number. Therefore, the clock will only be effective when a digit is present. This ensures that only b.c.d. digits can be loaded into the registers. The 74LS73 is clocked on the trailing edge of RxST, Q goes high which disables the units latch and enables the tens latch. If the second data byte received is an ASCII digit, it is clocked into the tens latch by the next positive edge of RxST. Therefore, the two sequential ASCII digits are stored as b.c.d. data in the two registers. RxST is inverted and fed back to the RxRDY input of the 96LS488, which causes the Acceptor Handshake function to cycle synchronously with the local clock. The power supply does not hold up the three-wire handshake because the 96LS488 is probably the fastest interface adaptor connected to the bus. The $\overline{RxST}$ signal is taken with the buffered bus data to an ASCII carriage return decoder comprising a 74LS27 NOR gate and a 74LS138 eight-way demultiplexer. Output $\overline{07}$ of the demultiplexer goes active-low when an ASCII CR is present and RxST is active, denoting valid data. The detection of CR is terminated when RxST goes inactive.

Carriage return has two functions, it sets the J input of the 74LS73 to zero so that the falling edge of RxST clocks the flip-flop to the reset state. Secondly, the positive edge of $\overline{07}$ clocks the 74LS273 8-bit intermediate register. The two b.c.d. digit output of the octal register is used as the input to the b.c.d.-to-binary and binary-to-analogue circuits. The purpose of dual-rank registers is to prevent spurious variations in the power supply output before a carriage return message delimiter has been received from the bus.

The logic is expandable to more digits by replacing the JK flip-flop with a binary counter and adding further data registers. The flip-flop in this system operates as a counter to identify the two ASCII digits. By using an n-bit counter with fully-decoded states, 2^n digits can be stored in an equivalent number of registers. A diagram of this system is shown in Fig. 5. Further possible enhancements include the recognition of remote programming parameters such as V for volts preceding the ASCII digits. Delimiting the data string at each end has the added benefit of increased data protection because the supply will only respond to a remote message comprising <Vnn CR>. An alternative delimiter such as A for amps can be used to load a different set of register if, for example, a current-limit control is included.

The two b.c.d. digits in the 74LS273 are multiplexed with the b.c.d. data on the

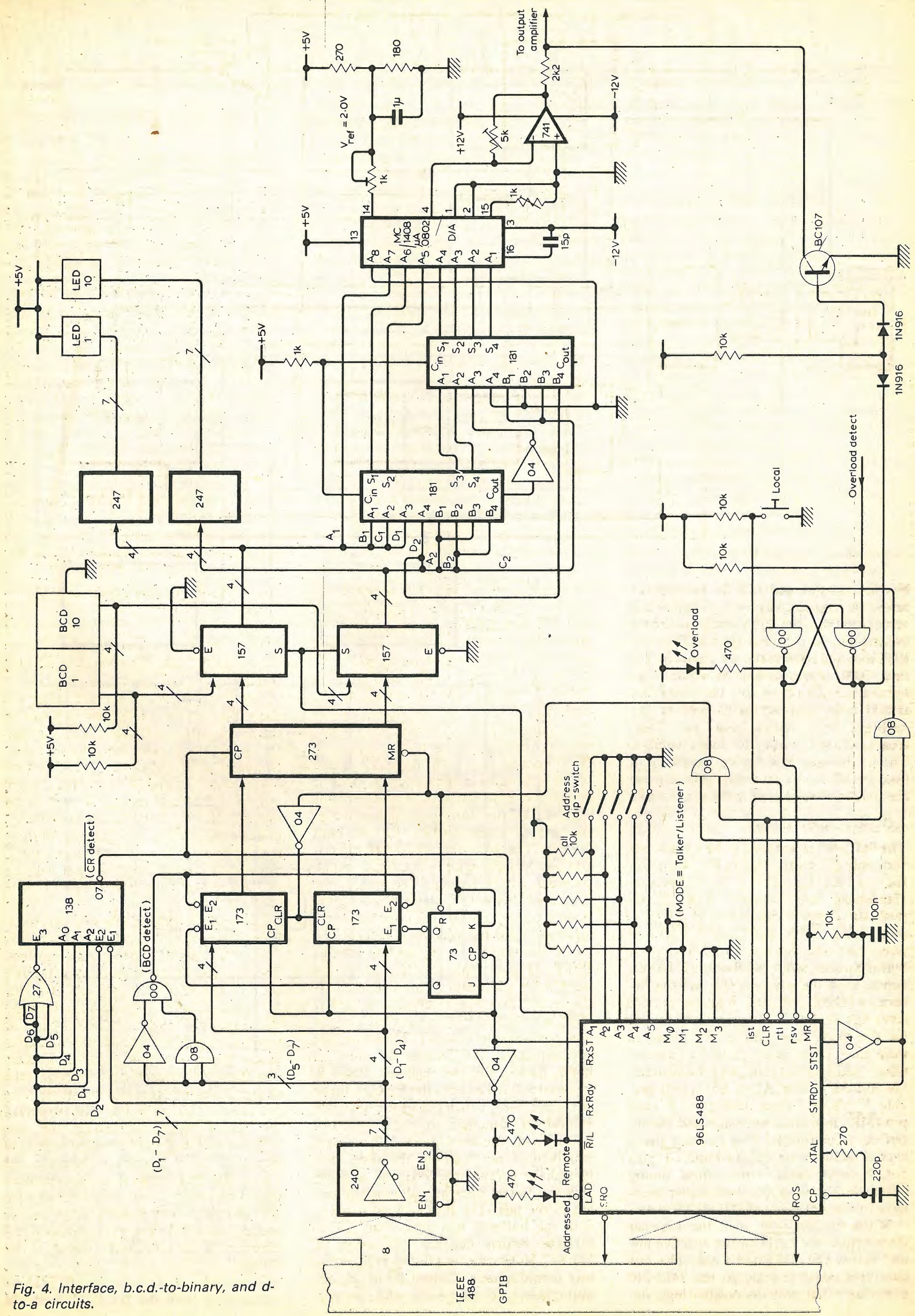


Fig. 4. Interface, b.c.d.-to-binary, and d-to-a circuits.

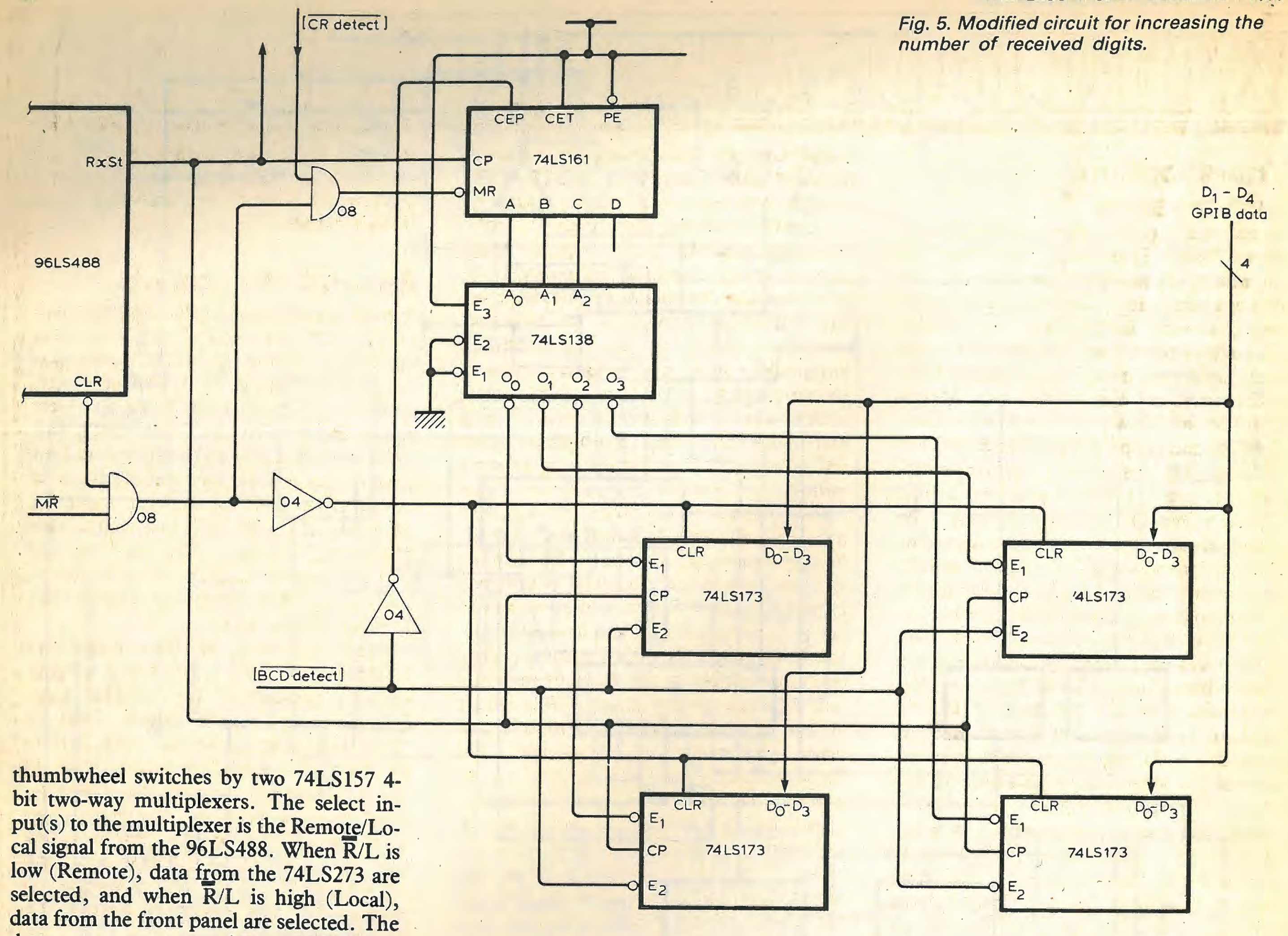


Fig. 5. Modified circuit for increasing the number of received digits.

thumbwheel switches by two 74LS157 4-bit two-way multiplexers. The select input(s) to the multiplexer is the Remote/Local signal from the 96LS488. When $\overline{R}$/L is low (Remote), data from the 74LS273 are selected, and when $\overline{R}$/L is high (Local), data from the front panel are selected. The d-to-a converter uses a binary-coded digital input. The two b.c.d. digits are converted to a binary equivalent by two 74LS181 4-bit adders. This technique, which can be expanded for more than two digits, allows for the binary weighting of each bit in the b.c.d. digits. The conversion takes place by adding the appropriate weighting to each decimal line. Therefore, the units digit contains the weighting values 2^0, 2^1, 2^2, 2^3,

A^1	2^0			
B^1		2^1		
C^1			2^2	
D^1				2^3

and the tens digit contains weighting values 2^1, 2^2, 2^3, 2^4, 2^5, 2^6, summed as shown below.

A^{10}	2^1		2^3			
B^{10}		2^2		2^4		
C^{10}			2^3		2^5	
D^{10}				2^4		2^6

If more digits are required, more adders can be included to sum the binary weightings of higher order digits.

The Master Reset ($\overline{MR}$) input to the 96LS488 and data registers is active at power-up to initialize the bus interface and clear the data registers. $\overline{MR}$ is gated with the Clear ($\overline{CLR}$) bus message output from the 96LS488 so that the bus controller can re-initialize the power supply and clear the data registers at any time. The overload-detect signal from the analogue circuit is fed, via an RS latch, to the bus interface as the request service (rsv) interrupt. The overload-detect latch also drives the overload l.e.d., and is cleared by the operator, by a bus Clear message or by a Serial Poll, which causes the Source Handshake signal Status Strobe (STST) to pulse active high.

Analogue circuits

The d-to-a converter is referenced to +5V by a simple resistive divider, which is adequate unless a highly stable and accurate output is required. The output is buffered and normalized to one quarter of the supply output voltage by a 741 op-amp as shown in Fig. 6. The output buffer provides a voltage-gain of four and a current capacity of two amps. A current-limiting circuit detects excessive current and signals this overload condition to the logic

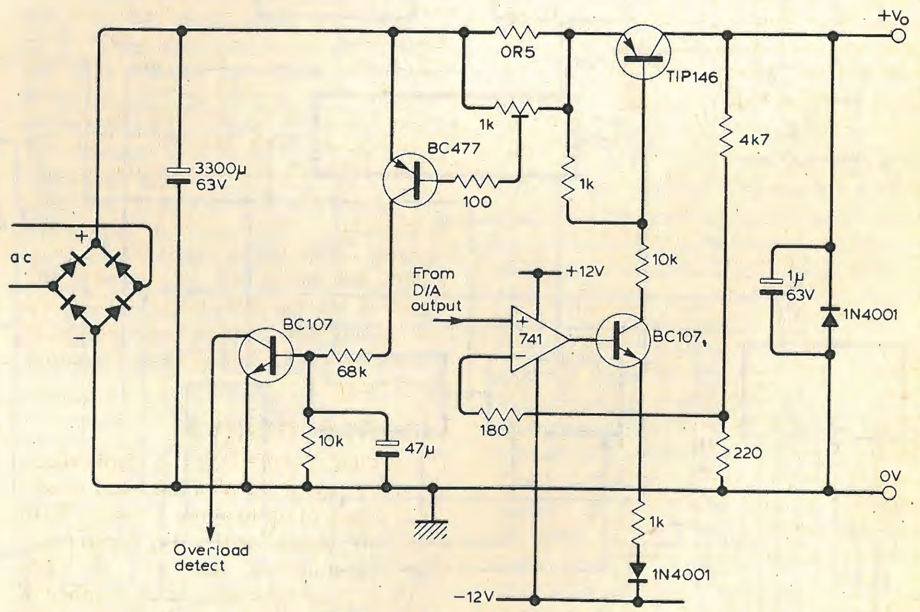


Fig. 6. Output amplifier and current trip. This circuit can be modified to provide alternative outputs.

Continued on page 57

WORLD OF AMATEUR RADIO

Transhorizon microwaves

Transhorizon propagation on frequencies above 30MHz is generally considered an unwanted, anomalous phenomenon by telecommunications and broadcast engineers, causing interference to carefully planned systems. But for the enthusiast such conditions are the very essence of his endeavours to work over ever longer distances with low power, no matter how fleeting and unpredictable may be the contacts. The results of experiments carried out over several years by British Telecom (Post Office) are thus likely to be more welcome to amateurs than to professionals, (papers by M. T. Hewitt and A. R. Adams presented at URSI Commission F Symposium, Canada, May 1980). For they show that measurements made over 1300 hours on 11GHz signals received at Martlesham, Suffolk from Rockonje, Netherlands, a mostly sea path of 191km, indicate some degree of signal enhancement due to ducting for no less than 10 per cent of the total time, with a daily maximum occurrence around 1800GMT, apparently due to the presence over the path of air originating on the mainland during the warmest part of the day. Very long events (over 64 hours) have been recorded when an air flow around an anticyclonic system produces a drift of warm air from the mainland over the cooler sea air, producing ducts that can extend over several hundreds of kilometres. Good results have been achieved in identifying periods of advection from temperature and humidity data while subsidence inversions can be identified from radiosonde levels. British Telecom are also carrying out research into 17GHz transhorizon propagation.

Martlesham and Ipswich amateurs won the RSGB's 1980 VHF National Field Day with equipment that included a solid-state 120W 70MHz transmitter (two BLY90 transistors in final amplifier); 144 and 432MHz equipment based on transmitters using 4CX250B valves; and a 1.3GHz transmitter producing 200W output from four 7289 valves. Their receiver front-end devices included SD306 (70MHz), BFT66 (144MHz), NE21935 (432MHz), NE64535 (1.3GHz).

EMC and domestic equipment

The problems of operating transmitters in close proximity to domestic electronic equipment (i.e. electromagnetic compatibility or e.m.c.) continue to occupy the thoughts of those concerned with the regulatory aspects of amateur radio. The IARU Region 1 Bureau has recently released a report covering replies to a questionnaire on e.m.c. matters sent to its member-societies. This shows that attitudes towards radio-frequency interference by different licensing authorities differ considerably, ranging from those that are sympathetic to the amateur and recognise that the problem stems basically from the poor immunity of many domestic equipments, to those holding the amateur responsible for any interference not only to broadcast reception but even to non-broadcast equipment such as electronic organs, record-players, etc. The Sierra Leone society was in the happy position of being able to reply that "there has been no report on record of interference by amateur radio".

In a number of countries (Poland, Cyprus etc.) all cases of interference are referred to the national society. Norway insists that equipment showing insufficient immunity is modified by the manufacturers or importers fitting any necessary filters. In Denmark the offical attitude is generally favourable to the amateur operator but cases can involve delays during which he has to cease operation at those times when interference may be caused. The Swiss authorities are very helpful to the amateur but there is an unofficial recommendation that equipment should not be expected to provide immunity at levels above 1V/m (which does not cover all circumstances) and efforts are being made by the USKA society to raise the immunity level to 5 or 10V/m. Dutch amateurs complain that they cannot persuade their authorities to admit that "an electronic organ is not a radio receiver" and this makes it difficult for the VERON society to co-operate with the PTT licensing authority (Dutch amateurs seem to be particularly badly placed). The Swedish manufacturers supply, free upon request, highpass filters and/or mains filters; radio dealers are authorised by the Swedish Electrical Testing Authority (SEMKO) to make minor modifications to equipment to increase their immunity to radio-frequency interference.

Licence delays

The annual autumn bulge in applications for new amateur licences has been resulting in delays of up to about 8 weeks. With over 2500 "passes" at the May Radio Amateurs' Examination, and with all signs pointing to an unusually large number of candidates for the December exam, the Home Office licensing section is also having to cope with the public response to the invitation to comment on the "Open Channel" proposals. This may be one reason why the Home Office is not showing any enthusiasm towards the proposals for the introduction of a British "novice" licence.

It is not widely know that while the Home Office accepts RAE "pass slips" from licence applicants, it issues an "Amateur Radio Certificate" to persons who have passed both the RAE and the Post Office Morse Test but who do not wish to take out their own station licence: this certificate permits operation of amateur stations under the direct supervision of the licence holder.

Around the bands

Further experiments aimed at establishing 144MHz "meteor scatter" contacts across the Atlantic during the summer came near to success. A group of British amateurs, using the callsign G4DGU/P, set up a temporary station in North Devon with a 400-metre-long rhombic aerial erected on four 8-metre poles. Positive identification of signals from this station were made by Andy McLellan, VE1ASJ in St John, New Brunswick, Canada, but no two-way contacts proved possible. It is hoped to hold further tests during the August 1981 Perseids meteor shower.

Stewart Perry, W1BB, long-time 1.8MHz enthusiast, is proposing a "gentleman's agreement" for 1.8MHz long-distance operation in which 1800 to 1810kHz is reserved for c.w. only, 1810 to 1825kHz for s.s.b./c.w. and 1825 to 1830kHz ("the dx window") for c.w. only. Band-planning problems should be eased when the 1979 WARC allocations come into effect since these will include a common international allocation whereas at present different countries impose different band limits.

The Radio Amateur Invalid and Blind Club has reminded its members that it is possible to take an oral or written Radio Amateur's Examination at home, provided that application, with a doctor's certificate, is made in good time to the City and Guilds of London Institute (Mrs S. Conacher).

The Royal Signals Amateur Radio Society now has more than a thousand members, membership having risen to 1084 of whom 575 are life members . . . Attempts are being made to raise £40,000, half of the estimated cost of replacing the OSCAR "3A" satellite lost last May. A further Ariane launch opportunity may occur in early 1982 . . . A v.h.f. repeater operated by the Amateur Radio Association of Bahrain on 144MHz channel R6 enables amateurs on vessels in the Arabian Gulf to work over distances of up to about 300 miles. Since it is regularly used by only four local A9X amateurs, other amateurs sailing in the Gulf are welcome to make use of this repeater which has an output of 20 watts from an aerial height of 220 feet above sea level . . .The death has been reported of Patrick Conway, E13Z a veteran Irish amateur and long-time reader of the IRTS's Sunday morning 3.5MHz news bulletins. . . . West Germany has introduced a new form of transitional licence (prefix DH) providing limited facilities for c.w. and rtty operation between 3520 to 3600kHz and 21090 to 21,150kHz.

PAT HAWKER, G3VA

Intermodulation at the amplifier-loudspeaker interface

Part 2: Causes/how to avoid it/measurements on four types of amplifier circuit

by **Matti Otala and Jorma Lammasneimi** Technical Research Centre of Finland

The effect described is but one of the numerous phenomena affecting the quality of low-frequency sound reproduction. It does not seem probable that its distortion could be dramatically higher than the measured SMPTE – intermodulation distortion of the amplifier, unless protection circuitry malfunctions. However, the theory presented may explain some of the subtle differences in the sound quality between different circuit topologies having otherwise equal standard measurement data. Noting that most valve amplifiers have basically a high open-loop output impedance and employ moderate amounts of feedback (the situation is the inverse for many solid state amplifiers), the theory may also explain some of the audible differences of these amplifiers.

The analysis of part 1 shows that the loudspeaker reflects back to the amplifier signal which may be of the same order of magnitude as the original drive signal. The situation is worse when the open-loop output impedance of the amplifier is comparable to, or greater than, the specified load impedance.

Inside the feedback loop, the amplifier must now handle two simultaneous large signals – the original drive signal and the loudspeaker reaction signal. If the amplifier has any internal non-linearities, these two signals may interfere and produce intermodulation components with each other. As the input signal is normally composed of a full frequency spectrum, but the loudspeaker-generated reaction consists predominantly of frequency components near the cone resonances and crossover filter resonances, the nature of this distortion is to add coloration to the sound. In addition, the positive maxima shown may cause unwanted clipping near amplifier maximum output power.

The basic reasons for the distortion are that (a) the loudspeaker does not simply consume energy; it also stores and returns it. (b), Although the closed-loop output impedance of the amplifier is apparently very low, it is not a true physical impedance as it has been generated by feedback. The feedback, in turn, forces the loudspeaker reactive current to cause a corrective signal which circulates around the feedback loop. (c) In the internal non-linearities of the amplifier this signal will intermodulate with the forward signal to produce a change in the spectral composition of the distortion products.

The two basic characteristics affecting the magnitude of this distortion are the open-loop output impedance and the amount of feedback. The dependence is fundamental, i.e. if one or both of these characteristics is brought to zero, interface intermodulation will not occur. The effect increases with feedback if the feedback is small or moderate say, below 20 dB. Above that, increasing feedback will no longer increase distortion. Also, it is generated in the internal non-linearity of the amplifier. As it is basically a low-frequency effect, the stage where the non-linearity is situated in the forward path is immaterial.

The above analysis requires sufficient linearity from the amplifier for the transforms to be valid. In high-quality audio amplifiers this condition is usually met in the normal operating range of the unit. However, a large reaction signal can cause the amplifier to enter a region of severe non-linearity when operated in the vicinity of its maximum output power. The need of a non-linear analysis is indicated in this case.

We propose the following general definition

Interface intermodulation is a form of distortion in a feedback two-port network, caused by non-linear interaction between the input signal of the two-port and a signal externally injected to the output port propagating into the input via the feedback network.

This general definition is specifically used in sound reproduction equipment to denote the distortion caused by the energy stored or generated in the loudspeaker system re-entering the output of the power amplifier.

Measurement

It is possible to measure interface intermodulation by using normal distortion measurement methods. In this case the standard output loading resistor is replaced with a simulated reactive load or with a real loudspeaker. In many cases the measured distortion is increased and the spectral composition of the distortion products changes. However, in the real-world situation, a set of standardized loudspeaker loads would be needed and, because of the frequency dependencies of these loads, it would be necessary to resort to swept CCIF-type difference tone measurements. This tedious procedure can be replaced by a simpler universal method described below. The loudspeaker reaction can be simulated by letting the amplifier operate on a forward signal, while injecting a backward signal to its output. If interface intermodulation is generated, it will manifest itself through intermodulation products between the two signals appearing at the output. The measuring procedure is thus a variant of the two-tone difference-frequency method. In real life there is a dependence between the forward and backward signals. In this method, these signals are independent, to facilitate measurement. However, as far as the generation of intermodulation in the amplifier is concerned, this does not change the physical phenomenon considered.

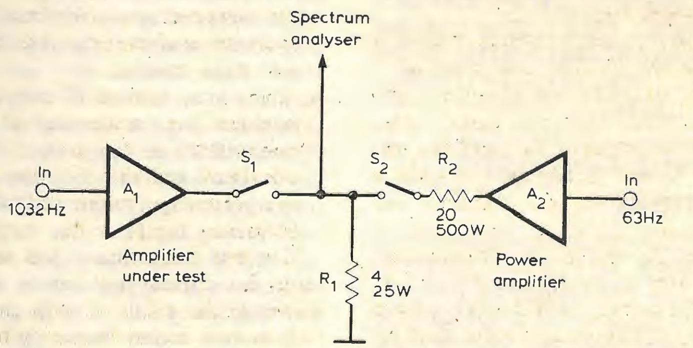


Fig. 8. Measurement setup for interface intermodulation. Amplifier under test A_1 is fed by audio frequency signal while high-quality high-power auxiliary amplifier A_2 delivers a low-frequency signal. By alternately closing switches S_1 and S_2 both signals are adjusted to have same power level in load resistance R_1. After closing both switches, intermodulation products are measured with a spectrum analyzer and referenced to the audio frequency signal. Numerical values shown are for the tests detailed in text.

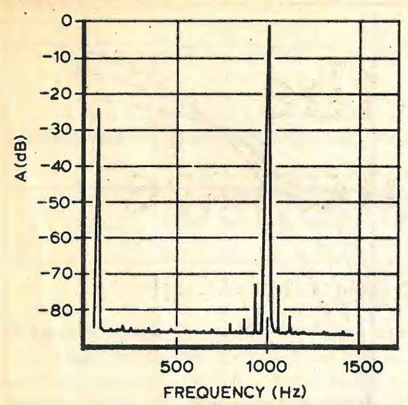


Fig. 9. Typical measurement result from high-quality commercial power amplifier using the method described in text. Note how the 63 Hz signal has been attenuated 24 dB by the feedback. Interface intermodulation in this case was 0.038%.

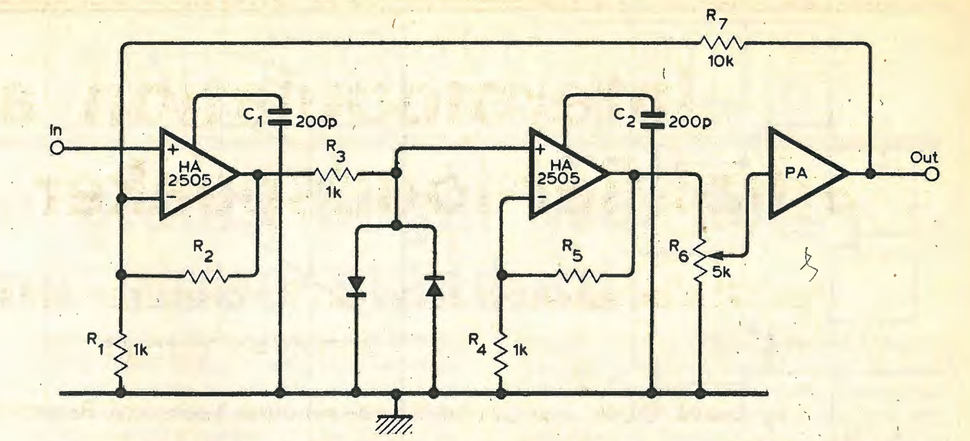


Fig. 10. Circuit used in the distortion measurements. Operational amplifiers HA2505 form the driver stages, and diodes constitute the dominant non-linearity. Various output sections PA are shown in Figs 11 to 14.

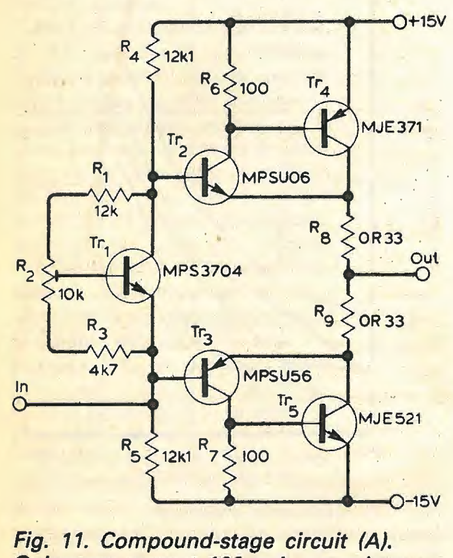


Fig. 11. Compound-stage circuit (A). Quiescent current 100 mA, open-loop output impedance 0.9 ohm.

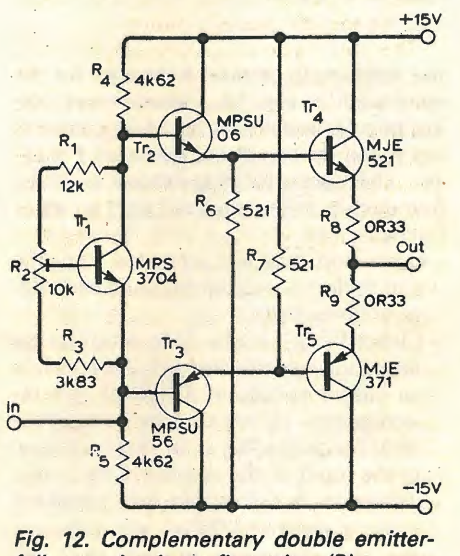


Fig. 12. Complementary double emitter-follower circuit configuration (B). Quiescent current 500 mA, open-loop output impedance 1.2 ohm.

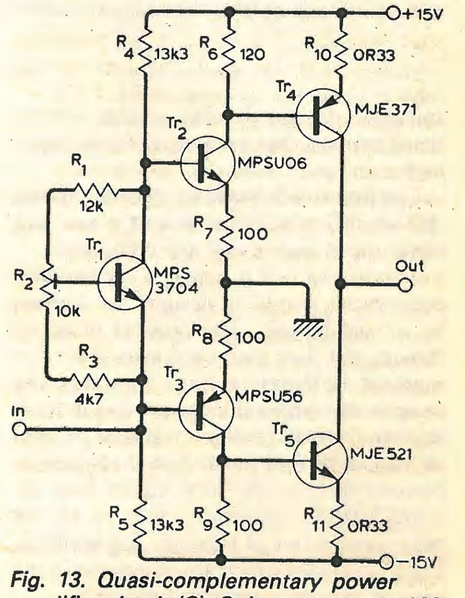


Fig. 13. Quasi-complementary power amplifier circuit (C). Quiescent current 100 mA, open-loop output impedance 2.7 ohm.

A proposal for a measurement method is depicted in Fig. 8. The procedure is

1. Switch S_1 is closed and S_2 opened. An audio-frequency sinusoidal signal is connected to the input of the amplifier under test A_1 and is adjusted to yield a desired output level to a specified load resistance R_1.
2. Amplifier A_1 output is disconnected from the load R_1 by opening switch $S_1$1. A low-frequency sinusoidal power source A_2 is connected to the load by closing switch S_2 and is adjusted to yield the same output level across load R than in step 1. Note: power source A_2 has to have sufficient internal resistance R_2 so as not appreciably change the apparent load of A_1 when switch S_1 is closed. This power source must also have sufficient power output. A safe rule is that the rating of the power source is five to ten times greater than that of the amplifier under test.
3. Both switches S_1 and S_2 are closed, with both output signals being fed simultaneously to the load. The intermodulation products between the two signals are measured across the load by using a spectrum analyser or an intermodulation distortion analyser.
4. The r.m.s. sum of all intermodulation products (i.e. neglecting all harmonic components of the primary signals) is calculated and the distortion indicated as a percentage, referenced to the audio-frequency signal at the output of A_1.

The test frequencies used are in most cases not critical and can be selected to minimize the effect of such external disturbances as mains frequency hum. Their frequency ratio may be optimized so that the harmonic frequencies of the low-frequency signal do not coincide with the frequencies of the intermodulation products. Various frequencies and load resistances may be used in different countries, depending on mains frequency and standard loudspeaker impedances. The results reported were obtained using a load resistance of four ohms and frequencies of 63 Hz and 1032 Hz. A typical measurement result is given in Fig. 9, which shows the intermodulation spectrum generated.

Comparison of amplifier circuit topologies

The theory developed predicts that the amount of interface intermodulation distortion depends primarily on three basic power amplifier characteristics: Open-loop output impedance, amount of feedback, and closed-loop non-linearity of the circuit. The first two properties especially vary considerably among amplifier circuit topologies. To make a valid overall comparison of different topologies, all the circuits should have

- the same closed-loop gain
- equal closed-loop distortion, and
- same output damping factor, i.e. closed-loop output impedance.

These rules represent the market place reality of various commercially competing

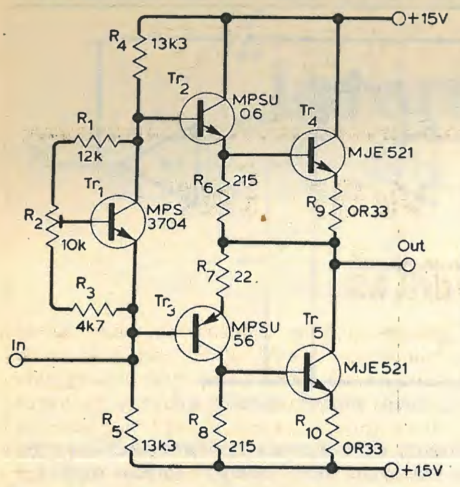


Fig. 14. Grounded-emitter complementary output circuit (D). Quiescent current 100 mA, open-loop output impedance 60 ohm.

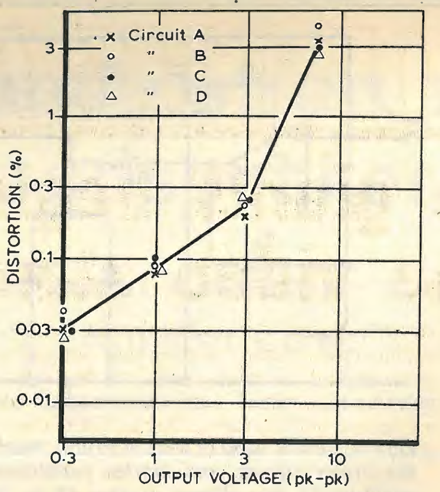


Fig. 15. Measured closed-loop intermodulation distortion for the various amplifier topologies after adjustment detailed in text.

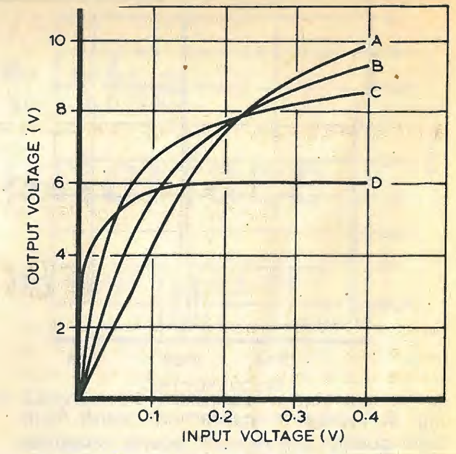


Fig. 16. Measured open-loop transfer characteristics of the various circuits after adjustment discussed in text.

amplifier designs having similar overall specifications, irrespective of basic topology.

The first rule is based on the assumption that amplifiers of equal output power and equal input sensitivity are compared.

The second rule is based on the fact that commercial amplifier designs are limited by a fixed budget. The number of active devices and thus their total gain-distortion quotient is therefore fixed in competing designs of comparable price. Local feedback and overall feedback can then be used in various proportions, but in otherwise optimal designs the total closed-loop intermodulation distortion tends to be the same irrespective of topology, especially at low frequencies which are of interest in the case of interface intermodulation.

The third rule is dictated by the commercial necessity of having a reasonable or comparable damping factor specification, irrespective of topology.

The circuit shown in Fig. 10 was used for the comparative measurements. Diodes 1 and 2 create an artificial non-linearity, the magnitude of which can be adjusted by changing values of R_2, R_5 and R_6. The same resistors also set the open-loop gain and thereby the amount of overall feedback and damping factor.

In the measurements four different output stage configurations were used for the section PA in Fig. 10. Circuits representing popular topologies found in commercial power amplifiers are shown in Fig 11-14. The operating characteristics of the four circuits to be compared were set up as follows.

—Open-loop gain was increased until the r.m.s. closed-loop output impedance decreased to 0.20Ω.

—Closed-loop total intermodulation distortion was adjusted to 0.2% r.m.s. at an output voltage of 3V pk-pk. By injecting two signals of equal amplitude (63Hz and 1032Hz as in previous case) to the input of the amplifier, the r.m.s. distortion at the output was measured using a resistive 4Ω load and referencing the distortion to the 1032 Hz signal.

– These two were repeated several times in iterative fashion, as a change in the open-loop non-linearity affected the effective amount of feedback and thereby the output impedance.

In all the measurements, it was made certain that the intrinsic non-linearities of the various output circuits were negligible, as compared to the logarithmic non-linearity of D_1, D_2 in Fig. 10.

Figure 15 shows the measured closed-loop intermodulation distortion of the various circuits, while Fig. 16 shows the measured open-loop transfer characteristics of the circuits. After adjustment of the circuits, intermodulation measurements were carried out following the procedure outlined earlier. The main results are summarized in the table. Fig. 17 shows the measured values of distortion as functions of the output level. The results are in agreement with the theory presented. They also coincide accurately with earlier results measured for the same circuits using a constant value of feedback in the comparisons[2].

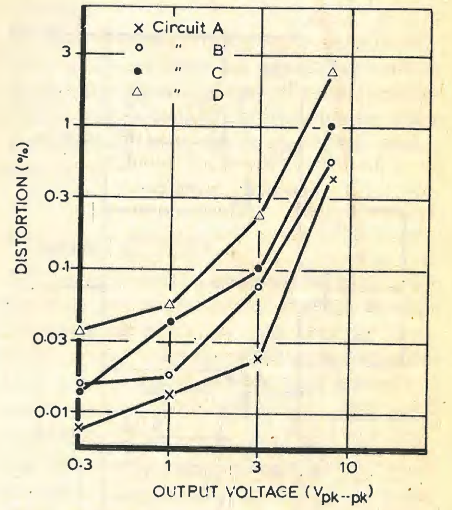


Fig. 17. Measured interface intermodulation distortion for the various amplifier circuit topologies. Results indicate clearly the roles of open-loop output impedance and feedback.

The results demonstrate clearly the role of the open-loop output impedance of a power amplifier in the generation of interface intermodulation distortion, the various amplifier topologies differing with each other by almost two decades. However, you must not draw far-reaching conclusions of the general usefulness of the various output circuits tested. There may exist ingenious ways to modify any of the topologies so that they will satisfy criteria for low interface distortion. Furthermore, the circuits seem to differ considerably in

continued on page 55

Summary of measurement results and conditions

	A compound	B grounded collector	C quasi-complementary	D grounded emitter
Interface distortion at 3V [%]	0.005	0.01	0.1	0.2
Open-loop output impedance [Ω]	0.9	1.2	2.7	60
Open-loop gain [dB]	33	36	43	70
Feedback [dB]	13	16	23	50
R_2 [kΩ]	1	1.5	3.2	1000
R_5 [kΩ]	42	36	32	13

General conditions for circuits: closed-loop gain 20dB; closed-loop output impedance 0.2Ω; closed-loop intermodulation distortion (CCIF) 0.2%; interface intermodulation distortion shown at output level of 3V pk-pk.

NEWS OF THE MONTH

Japanese giants begin war for home video standard

Early in July, Sony unveiled its Video Movie unit, which represents the hardware end of its professed aim to establish a home video standard format, similar in scope to the 8mm worldwide film standard. This is based on the Sony XCI c.c.d. camera, 13 of which were supplied to Nippon Airways in January.

Blaupunkt, Eumig and Kodak are rumoured to be in the act of producing similar machines but Sony seems to have got in first, if only with non-production samples.

Most of the cameras will feature, as do the Sony and Hitachi, "dubbed sound" which can be added during or after filming.

The challenge, according to Sony, has been to develop a colour video camera and video recorder in the same box which could rival the portability of 8mm film cameras. Although the unit was demonstrated at the recent Photokina Exhibition in Cologne, Sony say they "don't want too much said about it at the moment, because it will not be available to the public for about five years." Even so, many interested parties have been provided with technical material.

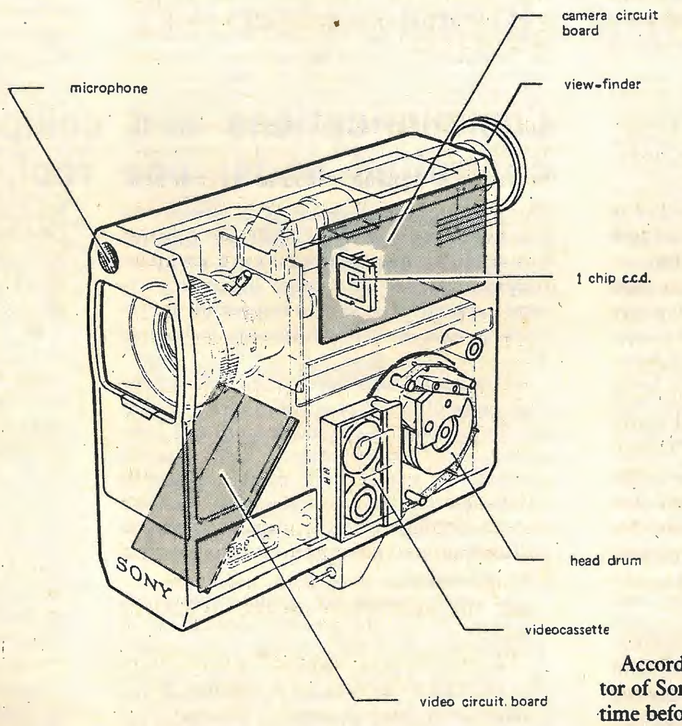
Whatever the reason for this reticence it seems that the Video Movie, which uses a flat 1×1.2cm charge-coupled device image sensor and 8mm metal particle tape as well as featuring "fast search" and "still-frame playback", it is likely to suffer stiff competition, especially from Hitachi, who demonstrated the "Mos Camera" in Tokyo in September. Hitachi say their camera will be ready for production early next year, complementing the company's "Mag Camera," which appeared simultaneously.

It seems that all these units will depend upon a portable electro-optical system which replaces the conventional vidicon-based camera and offers advantages such as the capacity to deal with 100 times more light than the vidicon type without "blooming" or producing a "burn-in," which appears as a black spot on the face of the tube.

However, there are some notable differences between the Sony and Hitachi cameras including 12.7mm wide tape in the Hitachi and a difference in weight, with the Hitachi at 7.5lb and the Sony at 4.4lb. While the Hitachi runs for 2 hours the Sony runs for 20 minutes, but since no details of tape speed have been given for the Hitachi camera (Sony unit runs at 2cm/s) it's difficult to make a direct comparison.

The self-contained v.c.r. in the Sony unit employs the helical scan, slant-azimuth technique used in the company's highly successful Betamax video system and although it is by no means certain that identical principles are used in the Hitachi version, the description "Mag Camera – portable v.c.r. camera combination" suggests a common circuit approach. Power consumption of the Sony unit is 4W, with energy supplied by rechargeable cells (replay, editing and/or format transfer units are mains powered) and the camera slots into the replay unit where it is wound back before being viewed on the user's TV receiver. During filming, exposure control is automatic.

Sony's apparent hurry to get the public interested in the Video Movie is presumably an attempt to bring commercially advantageous order to the currently chaotic state of the home video market place, where three incompatible systems are fighting for ascendancy, each with little chance of breaking through to be accepted world standard system. Clearly, the companies in the field, including Sony and Hitachi at the front line, are preparing to exploit to the full potential of new devices, without threatening (if possible) the conventional home video range of products – this could account for Sony's apparent ambivalence in not wanting too much said. The public reaction to the sudden partial redundancy of several relatively bulky units already purchased (the hardware of the VHS, Betamax and V2000 systems) may well be a matter of acute concern to the home video marketing men.



Matsushita has also demonstrated a prototype machine, using what it calls "charge priming transfer," reputed to combine the dynamic range of m.o.s. devices with the very low noise of c.c.d. devices and this unit is expected to go into production within two years.

The price of all such video cameras units is likely to be close to £700, which is the figure predicted for the Hitachi machine at its introduction to the Japanese market in Spring 1981.

According to Howard Steele, managing director of Sony Broadcast Ltd, it is only a matter of time before a domestic c.c.d. camera/recorder is developed for ENG (electronic news gathering) in television broadcasting.

Computer servicing course at Slough College

A unique course designed to educate and train people with backgrounds in engineering, science, or computing, and to fit them for employment as customer service engineers in the computer industry, began this year in Slough.

The first meeting to discuss the proposed course was held at Slough College of Higher Education in March 1978 and was attended by several computer manufacturers, representatives of the Manpower Services Commission and college lecturers. A working party including manufacturers and lecturers was set up and the result was a completely new course, which duly received approval by the Technician Education Council (TEC) as being suitable for the award of a Higher Technician Certificate in Computer Technology. At the same time a moderator was appointed, who visits the college at regular intervals to check progress.

In February 1980 the first full-time one-year course began for students who had been carefully selected by the three manufacturers responsible for their periods of industrial training (Data General, Digital Equipment and Hewlett Packard), also by the Manpower Services Commission (offering support under the TOPS scheme) and by computing and engineering lecturers at Slough.

The industrial training slot (ten weeks during the Easter and summer vacations) ensures that students will be skilled in aspects additional to those presented at the college. Hewlett Packard has lent a HP 2100 computer to the college to provide training in the use of disc systems and programming techniques and they, along with the other companies involved, have given lectures on specialist subjects.

Recruitment for the sixteen TOPS-supported places for the next course, which runs from January 1981 to December 1981, has begun. Some previous work experience is essential, the course having been intended for people who want to be re-trained for the computer industry, and initial qualifications can be wide-ranging.

Further details of entry requirements and the course structure are available from Dr E. Huzan, Head of Computing Division, Slough College of Higher Education, Wellington Street, Slough SL1 1YG, Berks. Telephone Slough 34585, ext. 37.

European drive on microelectronics

Because individual European electronics companies, left to themselves, are obviously unwilling to compete with the Americans and Japanese in integrated circuits, the European Communities Commission says there is now an urgent need for concerted action within the Common Market group of countries. If one of the Commission's proposals goes through this could mean that, from January 1981, up to fifty per cent of the cost of R&D in the manufacture of devices using sub-micron technology could be paid for directly out of public funds. This aid would include the development of prototype equipment intended to come on the market by 1985. It would also include up to 50 per cent of the cost of the lease or purchase of the prototypes by users, as well as engineering work to be carried out by them and by the equipment suppliers to bring the equipment to the required performance.

Conditions for aid, however, would require commitment from a number of Community companies to use the prototypes from a particular manufacturer and to invest their resources in the necessary engineering work. The number of companies would vary according to the type of equipment concerned and would be settled type by type. The Commission suggests that approved projects should be nationally financed within a co-ordinated framework of commitment and that, where at least three Community countries are participating, *governments* of member countries could be reimbursed by the Community up to half the cost of the support they are providing. Such a financial method would be a compromise designed to combine the advantages of using national resources and mechanisms quickly, with the Community providing a coherent framework and incentive subsidies when the project had a true Community dimension.

The ECC is worried by the fact that the Community lags behind the USA and Japan in both the production and the application of microelectronic devices. It notes that it is 65 per cent dependent on imports of integrated circuits and has a far higher dependence on the most advanced digital i.cs. The weakness of European production (under 10 per cent of the total today) is the more unfortunate because this is a growing world market, expected to reach some $70 billion in 1980-84, and the USA and Japan are the only major competitors. They, however, have invested millions in well planned strategies, while The Community market remains fragmented.

To try and change this situation the Council of Ministers in September 1979 asked the Commission to submit proposals for specific joint projects at Community level with a view to encouraging the Community to take a leading role in developing this technology. The Commission has now produced its proposals for a Community strategy for 1985, based on discussions with governments and industry and unanimous agreement on technical objectives that need to be achieved if European industry is to be competitive with the USA and Japan in 1985.

The strategy includes a co-ordination of national programmes. The Commission is proposing to set up a data bank and arrange for systematic distribution of information (taking confidentiality into account) to interested governments of the member countries. In addition research into new concepts is thought to be needed, and a committee has identified four major areas of work covering chip architecture, device modelling, language and data structure, and testing. This could be undertaken by universities and research institutes in close co-operation with industry.

The strategy also identifies the need to promote a European equipment industry. The Commission sees this as the weakest Community sector. Production knowledge and equipment has generally been licensed or purchased from the USA, when it is usually already out of date. There is need for investment and close collaboration between prospective European users of the equipment and the equipment manufacturers if the Community is to make headway in this field, but national markets alone are too small and resources inadequate for development on the scale needed.

The proposals to help European microelectronics are in fact part of a much larger initiative on "telematics" (a word derived from "telecommunications" and "informatics") – the combination of telecommunications and computers which is becoming known as information technology. The ECC says that Europe is losing out in the "telematics revolution" to its competitors in the USA and Japan. Even though today, within the European Community, national governments are spending millions of pounds to support the new technology, the fragmentation and lack of standardisation in the Community market hinders development. If the Community is not increasingly to rely on external suppliers for the most dynamic growth industries of the latter part of the century, says the ECC, there must be greater co-ordination of national plans and cross-frontier co-operation in research, development and marketing of products. Given a determined strategy, thinks the Commission, with its population of 260m the Community can catch up where it is now lagging seriously behind. "But it will have to act fast."

A strategy to deal with information technology has been decided and the principles were approved by heads of government at their European Council summit in November 1979.

Communications and computing should be controlled under one roof, says ACARD

The main recommendation of a report published in September by ACARD, the Advisory Council for Applied Research and Development, is that one minister and one government department should be responsible for organising what it calls information technology (IT).

These initials have been coined to cover the wide range of technical activities which fall under the headings of communications and computing, covering conventional radio communication, the use of word processors, digital telephone exchanges, electronic mail, viewdata systems and other aspects of digital information propagation and processing including optical fibre networks.

The report surveys the developments which are likely in IT, the possible applications in different sectors of the economy and contrasts (as does the Labour Party's report entitled *Microelectronics*, also reviewed in this issue) the absence of coherent government policies in the UK with the developed and developing French strategy for exploitation of the technology.

A further important recommendation is that the Post Office (or its successor) should "have the mandate to provide a world-competitive UK communications network and should have sufficient finance for procurement and installation, whether from private or public sources."

Further recommendations include modification of the copyright laws to cover information held in forms other than paper, thus giving protection to users of IT. Perhaps more important, they urge the government to bring forward proposals for data protection legislation immediately, i.e. to implement the recommendations of the Lindop Committee.

The failure of the government to act upon such recommendations, taken with strident criticism in the technical press *New Scientist* equates the work of a commission with "wise monkeys", playing on the keys of a typewriter long enough to write all of Shakespeare's plays) must give pause for thought about the usefulness of numerous reports which are seldom, if ever, acted upon by government.

Sir Monty Finniston, whose report on the engineering profession was published in April and which has largely been ignored by the present government, said last year that in the course of his work he had read upwards of 30 such reports produced since 1852 – none had been acted upon! The Finniston Report cost £401,000 and, as reported in *Wireless World* (October 1980), although not completely ignored by the government, it has not been implemented in the way Finniston recommended.

● It seems very odd that British taxpayers and engineers continue to tolerate this gigantic waste. Quite as serious is the fact that little is done to point out to the non-technical decision-makers in government that, for example, the electronics industry and its offshoots are least likely of all western industrial processes to fall apart. After most of the UK's heavy industry has disappeared, the electronics/communications industries will be thriving and yet the British government and people do not see it (i.e. the need to invest both cash and initiative) and the British engineer does not shout loud enough about it.

The most extraordinary aspect of the subject is the utter docility of those who are both British tax-payers and engineers – to deny status simultaneously with ignoring the economic importance of the industry and the engineer's personal contribution would probably result in continuous lobbying of M.P.s in many Continental countries, but in the UK it is left to the press and dedicated people like Finniston to harangue impotently an apathetic and ignorant legislature.

Even when fundamental financial action is clearly imperative, as in the case of Inmos, where the government stalled over providing the essential second payment, the obsession with saving cash holds sway over more intelligent acts of enterprise.

It is amazing that the frustration of engineers has not turned into an angry demand reverberating through the institutions.

Information Technology is available from HMSO or on order from booksellers, price £3.30.

News in brief

Creative Strategies International, a California-based market research firm, predicts that the world-wide market for teleprinters in 1985 will exceed $1 billion, reflecting a compound annual growth rate of 21%. Most of the increase is likely to be due to the extension of business-based data communications networks and automatic mail systems.

The BBC's money

Background to this month's editorial: According to a participant in a "Man Alive" BBC television programme last May the independent television companies had a total income of £385 million in the year 1978/79 to run their one television network, whereas in the same year the BBC received £315 million to run its two television networks and the whole of its sound broadcasting services. In 1980 both of these figures can be expected to be higher, in excess of £400 million. The Home Secretary, William Whitelaw, stated in a *Radio Times* interview (4 October, 1980) that the BBC's "net income for this financial year and the next one together should be about £1000 million." For ITV, the new franchises for programme companies, due to be announced on 28 December, have been reported to be worth about £560 million p.a.

It is well known that a large number of engineers in the IBA and the ITV programme companies have been recruited from the BBC. Another participant in the "Man Alive" programme mentioned that about 70% of applications for engineering jobs in ITV were received from BBC staff. The salary differences that could account for much of this drift have been substantial. For a particular senior engineering job in ITV the maximum salary in 1979 was £8,600, whereas the BBC maximum for the equivalent job was £6,480. In general the salary differences at that time ranged from 25% to 33%. At present the BBC is not losing many engineers to ITV. They say they are having no difficulty in recruiting staff now that they are reducing the number of available jobs and there is much unemployment anyway.

The engineering economies which the BBC has made in response to Government pressure have been in both jobs and capital spending. General policy has been to arrange the cuts to have the least possible effect on programme production. Consequently the Corporation has not done anything to impair the operation of its transmitters and communications systems. Staff levels in engineering training have also been maintained since this training has to continue to keep the programmes going out.

On capital projects (studios, transmitters, buildings etc) staffs are being kept at a level matching the capital spending which the television, radio and external broadcasting directorates are able to budget for. Without the present restrictions staffs in these departments would have had to be increased.

Other engineering departments have in general suffered a 15% cut in permitted expenditure. Very largely this has meant a 15% cut in jobs, amounting to about 130 in the whole of the Engineering Division. This is being achieved by natural wastage rather than by redundancies. In research and design work this has meant a corresponding reduction in the range of projects which can be pursued. In engineering information there is a slowing in rate of response to demand for transmitter surveys and investigation of reception problems, and also a reduction in the range and amount of published technical information and participation in exhibitions. Fewer technical manuals are being produced for maintenance engineers and others.

In capital spending there has been a deferment of new developments, such as studio centres in the regions, additional local radio stations, regional extension of Ceefax services and a new radio production centre in Central London. There has also been a slowing down in the re-development of the radio v.h.f. transmitter network. Capital spending is being concentrated on the replacement of worn-out plant.

G.I. to expand its Scottish base

A new plant, fully supported by government grants and costing £8.5 million, is to be built by General Instrument Microelectronics (a subsidiary of the US General Instrument Corporation) at its establishment in Glenrothes, Scotland.

This expansion, due for completion in 1985, follows a previous grant to the company by the Department of Industry to aid the completion of a non-volatile memory production unit on the same site under the Microelectronics Industry Support Scheme.

G.I. is the only company manufacturing r.o.m. chips in Europe at present and in addition produces a wide range of devices for operation in microcomputer systems, telecommunications equipment and entertainment systems and games. When complete, the workforce at Glenrothes is expected to be twice its present size.

News in brief

The ubiquitous microprocessor finds yet another (general) application with the introduction by the National Physical Laboratory of a counselling service for manufacturers of measuring equipment, gauges, and other forms of measuring tools, generally grouped under the heading of "metrology." The NPL can provide teams which specialise in measurement techniques and combine this expertise with a knowledge of computing methods to produce simplified measurement practice, giving faster and more accurate methods to those small firms which constitute the major company element in the measurement and scientific instrument industries. Full details of the service can be obtained from Mr A. Williams, Division of Mechanical and Optical Metrology, National Physical Laboratory, Teddington, Middlesex TW11 0LW, telephone 01-977 3222, ext. 3031.

The BBC's tape reclamation equipment which was recently brought into service for radio and external services in London, is being used here to make tapes suitable for re-use, no matter what their previous recording function. The service is expected to be extended to regional departments fairly soon.

New regulations governing the control of human exposure to lead come into force on 18 August 1981. It has been estimated that 10,000 people in the UK are "significantly" exposed to lead and the new requirements will extend the scope of the 1961 Factories Act, which was largely industry-based. Copies of The Control of Lead at Work Regulations 1980 are available from HM Stationery Office, price £1.40.

A plague of fleas at Plessey's telephone equipment factory in Beeston, Nottingham, led to a walk-out of more than 100 shop floor workers early in October. They returned to work a few days later after the factory had been fumigated.

After holding meetings throughout the UK to test public opinion of current IBA day-time TV programmes, the corporation is to interview 43 contenders for the 15 commercial TV franchises which come up for renewal by Christmas 1981.

A microprocessor-controlled fuel injection system for diesel engines is to be developed jointly by Lucas and TRW, the American conglomerate with interests in optics and semiconductors. The sensors, actuators and other hardware will be manufactured by Lucas and the system is expected to be ready for production by mid-1983. Oddly enough, economy of fuel use is not a major objective and a spokesman for Lucas points to the US Environmental Protection Agency's exhaust emission requirements as the main purpose of the unit's use.

Microelectronics and Labour

The Labour Party's discussion document entitled Microelectronics, published in September, apart from one or two howlers such as that on page 1, where we learn that "semiconductors are popularly known as "chips" (!) contains a wealth of depressing conclusions about the state of the British microelectronics industry, as well as some worrying international comparisons in technical education and management.

At the same time it emphasises (predictably) the need for far more national involvement and ownership of companies in the field, with special reference to GEC, which it describes as playing "a particularly malign role in British microelectronics." The need for more national investment is stressed by quoting Sir Arthur Knight's conclusion (as the new chairman of the NEB) that the private market does not provide enough capital for the sector and that even under the last labour government, it was not enough to ensure success."

The document refers to what it sees as Sir Keith Joseph's "political attack" upon the Post Office, through the break-up of the monopoly, at least where the supply of terminal equipment is concerned and comments that "The combined effect of these measures will certainly be to reduce the profitability of the new Telecommunications Authority by allowing private companies to cream off the most lucrative business and so put their major investment programme at risk." At the end of this section, the point is made that such action could lead to increased imports of telecommunications equipment, to the detriment of the major UK suppliers and the workers employed by them. . . . "In accordance with party policy these powers and activities will be restored to public ownership and control by the next Labour government."

The comparisons between, for example, the French and British telecommunications programmes are in some aspects startling, by mentioning that the French are committed to increasing the number of telephone subscribers from 14 million to 34 million by 1992, the provision of a free viewdata terminal to each subscriber (to permit the eventual replacement of telephone directories) and the introduction of a direct broadcast telecommunications satellite for business use.

Comparisons are also made between the level of state aid in the two countries, the example of Inmos being used, where the amount of aid is less than the total provided by the French government to three small-company projects in France. The conclusion is drawn that large sums of money must be spent if progress is to be made – "where private industry does not or cannot spend, government must – a point accepted by the government of every advanced economy but our own."

The discussion document refers to research policy in a manner which suggests that bodies such as ACARD (see news report in this issue) are little more than toothless bulldogs. "The new microtechnology clearly throws up a need to fill (the) gap which ACARD (attached to the cabinet office and composed largely of employers' representatives and academics) does not meet." Apart from these criticisms, the document notes the need for legislation to protect personal privacy, in the face of the power provided to organisations such as the police by computers and other interconnected data systems.

In a section called "Wider Horizons," the idea of a better use for "own time" is mooted but not developed. The possibiloities offered by technological change in the development of leisure activities seem to emerge as a pretext for a puffing piece of political dogma, uncharacteristic of the document as a whole.

The main recommendations, however, are linked with the main areas of criticism, covering research and development, where private industry funds only about 30% (this, the document says, should be extended by harnessing the expertise of public corporations, universities and government laboratories), public purchasing, telecommunications and public investment.

In the two latter subject areas, the report says that the development of optical fibre transmission systems and the extension of System X must not be restricted by the imposition of strict cash limits. "Britain needs to match the political and financial commitment that the French have shown towards their telecommunications system." In the section on public investment, the activities of the NRDC and NEB are provided as examples of methods of filling the "equity gap."

The final points concern Labour's objectives for the application of new technology, where the point is made that this necessarily differs from the approach of private enterprise in that the profit motive should not be the major consideration, where at present resources are put into entertainment systems rather than medical electronics, into broadcasting rather than personal communications and into missiles rather than computer aids for education.

Perhaps the most damning comment, which occurs earlier in the document, is in the section dealing with education, science and research, where Britain's failure to respond properly to the challenge of the chip is emphasised and one important factor isolated – that we have "consistently undervalued practical technological understanding and this in turn has produced generation after generation of decision-makers in our society who do not have it."

More jobs lost to recession

Within the next 18 months, another 3,800 jobs will be lost in the radio and tv manufacturing industry. The £10 million Rank-Toshiba link-up, formed two years ago and crowned by a £3 million modernization programme as well as saving many jobs in Rank's Plymouth and Redruth factories, has fallen foul of the strong pound and the cheap goods challenge from the Far East, according to Rank.

About 2,700 jobs, many of them re-deployed after the closure of the Stoke plant by Rank, are currently in danger. Meanwhile, Philips has announced the closure of its tv manufacturing plant in Lowestoft, with the loss of 1100 jobs, the actual closure being planned for mid-1982. This factory has been making domestic radio and tv sets for 30 years and all future production will be transferred to the company's remaining factory in Croydon.

Another British-Japanese consumer electronics business in trouble is the GEC-Hitachi joint venture colour tv plant at Aberdare, Wales. A GEC spokesman told the *Observer* (19 October): "There is a lack of consumer demand and the pressure on margins is continuing . . . if there is no improvement in the future then its lack of viability will have to be faced."

Data Recording Heads at Egham, Surrey, has had to lay off 97 of its 295 employees because of "crippling recession". The managing director has said: "We have no choice . . . the cutbacks are to ensure the survival of the company."

News in brief

The prizes offered by the Department of Industry to secondary schools participating in a competition launched in April and reported in our June/July 1980 issue, have now been awarded. Schoolchildren were asked how a microcomputer would benefit their school and the range of suggestions included the development of a school teletext system, programming of new dance movements(?) and the running of the school's administration. Winners were selected from 650 entries and 117 microcomputers were eventually awarded (100 planned) with six "star" prizes being awarded by Sir Keith Joseph to schools in Renfrewshire, C. Armagh, Uttoxeter, Mid-Glamorgan, Ewell and Camberley. The idea behind the competition was to act as a catalyst in a national effort to spread computing experience quickly into education. Several companies and organisations, including Shell, GEC, Plessey and the Post Office have made major financial contributions and are offering individual schools continuing help.

On the heels of Teac and Marantz, who recently introduced cassette recorders using DBX noise reduction circuits, Matsushita has now made an agreement with DBX, a wholly-owned subsidiary of the UK company BSR, to market cassette recorders using the system under its Technics brand name. DBX claims that its noise reduction technique offers the best signal to noise ratio available and that it "virtually eliminates tape hiss." Distribution will begin in Japan at first, followed by world-wide distribution.

The 7th European Conference on Optical Communication will be held in Copenhagen from September 8 to 11 1981. A call for papers has been issued in relation to the conference and further details are available from the Secretary of 7th ECOC, M. Danielsen, Electromagnetics Institute, Technical University of Denmark, DK-2800 Lyngby, Denmark.

Zaerix Electronics has acquired the Rochester-based Mazda radio valves and tubes marketing business from Thorn Brimar Ltd. The complete valve stock, as well as the testing facilities, have been taken over by Zaerix and customer service and quality control procedures will be maintained at the company's headquarters at 46 Westbourne Grove, London, W2.

Background information on legislation and current safety standards relating to electrical equipment exported to the US has been published by the British Standards Institution. The document surveys the most widely used certification schemes and details are give of organisations which test and certify electrical products. The survey, called *Electrical Equipment Certification in the USA* has been prepared by the BSI's **Technical Help to Exporters** service and costs £24 to THE members or £30 to non-members. It is available from THE Sales Office, British Standards Institution, Maylands Avenue, Hemel Hempstead, Herts HP2 4SQ.

Inmos will be opening its first large-scale production factory in Newport, Gwent during the summer of 1982. The factory will manufacture v.l.s.i. products. Production samples of 16k static r.a.m. devices are now available from the company's Colorado Springs unit.

Darkroom exposure meter and enlarger timer

Measures print exposure time and controls enlarger

by G. G. R. Rutter

The unit described will measure the required exposure for a black and white print, giving a digital readout in seconds and tenths; it will then time this exposure. The meter may also be used as a ten minute process timer to count minutes and seconds. Two such meters have now been in use for over a year, and have proved to be accurate, stable, and convenient to use.

The circuitry is constructed from easily available components, largely using c.m.o.s. logic, at a cost of about £30, which is less than commercial units offering much inferior performance.

Most of the circuitry of the meter/timer is in one box, which provides control of manual exposure setting, 'on' and 'off', 'expose' and 'time', together with a paper-speed adjustment. The sensor is contained in a separate small box, with the 'measure' switch, used for the meter-set exposure time.

Circuit operation

The circuit diagram of the sensor is shown in Fig. 1. D_1 is the sensing photodiode, a Siemens LD57C, which is intended by the makers for use as a l.e.d., but which is used here as a blue-green sensitive photodiode because of its ready availability. Its sensitivity to orange safelight is very low, probably roughly equivalent to printing paper. The 'C' suffix denotes the high-output type.

The current from D_1 and D_2 is integrated by IC_1, Tr_1, the output of which feeds a Schmitt trigger ($Tr_{2,3,4}$). Feedback to the integrator is via D_2 and D_3, both small, red l.e.ds, D_2 being used as a photodiode – an arrangement which provides excellent isolation of the sensitive input of the integrator. The output of the Schmitt trigger is in the form of negative pulses, whose length is inversely proportional to the current through D_1, or the incident light, and directly proportional to the required exposure.

The specified input leakage current for the CA3140 (IC_1) is 10pA, but this seems to be much reduced by operating the inputs at earth potential, and nine out of ten samples leaked considerably less than this. It is thus possible, with selected devices, to resolve currents of 10^{-16}A. In normal operation, D_1 gives a current of at least 1pA, and although this sounds an excessively small current for accurate measurement, it does not give rise to problems if the circuit is constructed on good-quality, glass-fibre p.c. board. The integrating capacitor is very small (about 1pF), and must have a very low leakage; I found that two lengths of 1-2cm 30s.w.g. enamelled wire, twisted together, perform better in this application than commercial capacitors, and, furthermore, can be trimmed to size.

The Schmitt trigger, $Tr_{2,3,4}$, has a temperature-sensitive hysteresis, to compensate for the increased sensitivity of D_1 with temperature rise.

The output of the Schmitt is taken to the logic circuit which is given in Fig. 2. When measuring exposures, $IC_{2,3,4}$ are used to count pulses from a v.c.o., which is controlled by the paper speed potentiometer, during the negative periods of the output of the sensor circuit. At the completion of each count, the measured exposure is transferred to $IC_{5,6,7}$ and displayed. If the count runs overrange, the 'carry' output triggers IC_{14}, and the count stops at 000.

Manual setting of exposure time can be accomplished using four buttons, providing fast and slow, up and down counting. The frequencies (10 and 100Hz) are derived from the rectified 50Hz mains waveform via Schmitt trigger IC_{9d}. Switching is by two latches ($IC_{8a,8c}$) to abolish contact bounce. Each pulse, in addition to clocking $IC_{2,3,4}$ also sets $IC_{5,6,7}$.

After either manual or sensor-determined setting, the exposure time is left in $IC_{2,3,4}$. $IC_{5,6,7}$ may then be used as a timer without losing this information. In this mode, after initial setting to zero, IC_5 is clocked by 1Hz pulses from IC_{13}. IC_6 is reset at a count of 6, so that IC_7 counts minutes.

For timing exposures, $IC_{2,3,4}$ count 10Hz pulses down to zero, the exposure time being set into $IC_{5,6,7}$ before counting starts. On reaching zero, the carry output goes high, terminating the exposure, and setting the counters again for repeat exposures. An exposure may be terminated early by pressing the "Off" button.

The display circuit in Fig. 3 includes a separate voltage regulator (D_4 and Tr_6). This is because the LM723 (IC_{17}) was found to give inadequate regulation for the v.c.o. when loaded by the display l.e.ds. Also included in the display circuit is the variable mark-space ratio strobe oscillator IC_{18}, which may be omitted if a variable brightness display is not needed.

The voltage-controlled oscillator in Fig. 4 deserves special mention. For convenience, the paper speed control is logarithmic: a linear potentiometer is used, to control a log. v.c.o. IC_{16} is a CA3046 transistor array, used as a temperature-controlled log. voltage-to-current converter. This i.c. consists of five n-p-n transistors on a single chip, the transistors therefore being accurately matched, and having close thermal coupling. Four are used as a thermostat: set to about 40°C, the oscillator is stable to better than 2%, and settles in 15 seconds. The reference voltage for thermostat and log. converter is derived from the 7.15V reference of the 723 regulator. IC_{15}, an NE555, is the oscillator, whose capacitor is charged rapidly by the 1kΩ resistor, and discharged relatively slowly by the log. converter; thus, the frequency is closely proportional to the discharge current.

As shown, the adjustment range on the speed control is approximately ×10, a further preset adjustment of ×10 being provided by the 1kΩ preset. The range

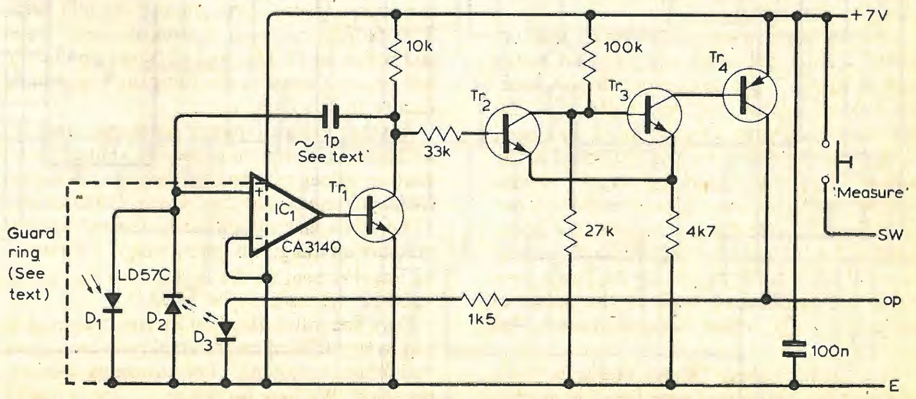


Fig. 1. Photoelectric sensor unit. Width of negative-going pulses at output depends on amount of light from enlarger – the brighter the light, the narrower the pulse.

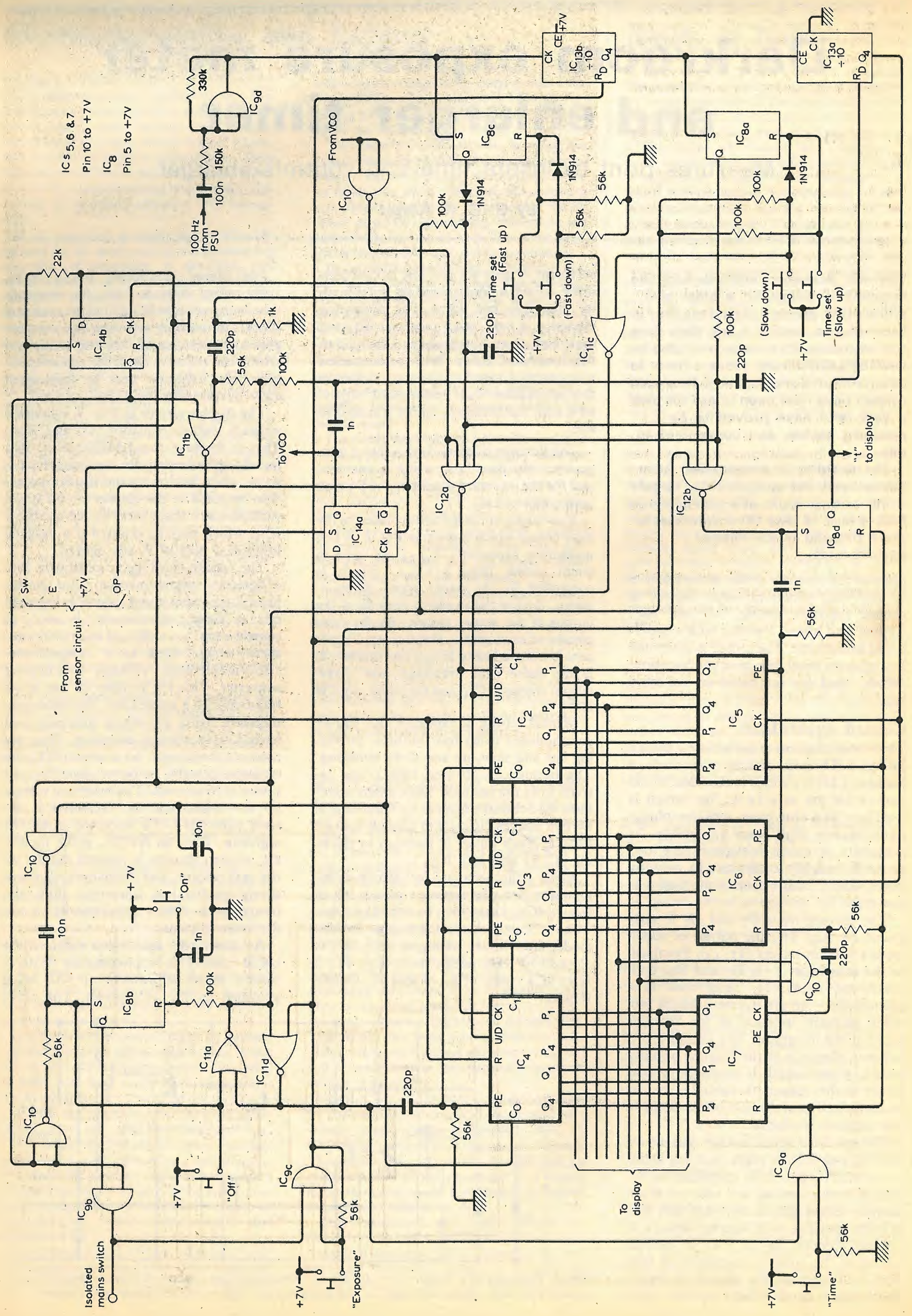
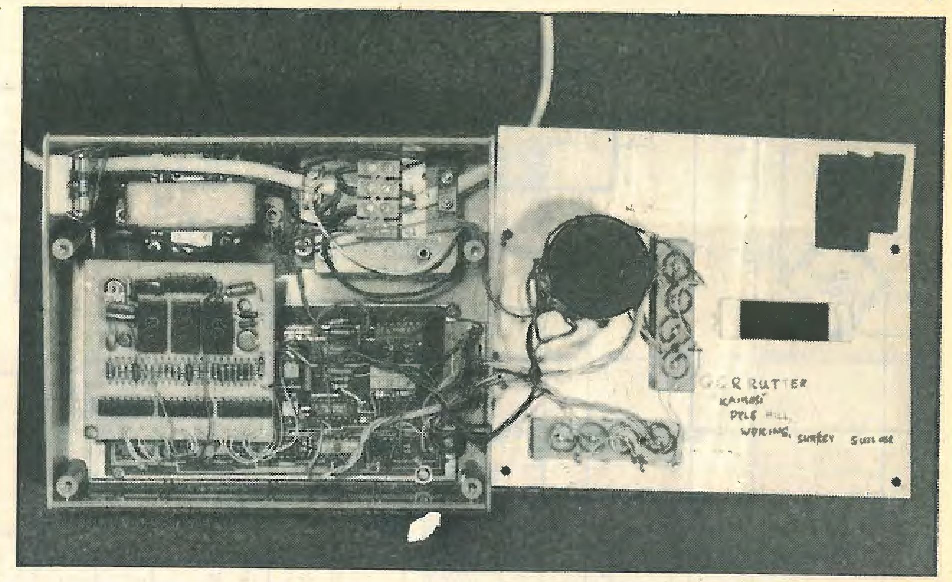


Fig. 2. Control logic circuit. Display is driven by counters IC_5 to IC_7. Omitted from the diagram are the connexions of the carry pins: IC_5 carry in (pin 5) is connected to earth; IC_5 carry out (7) is connected to IC_6 carry in (5); and IC_7 carry in (5) to earth.



may be widened by increasing the 6k8 resistor.

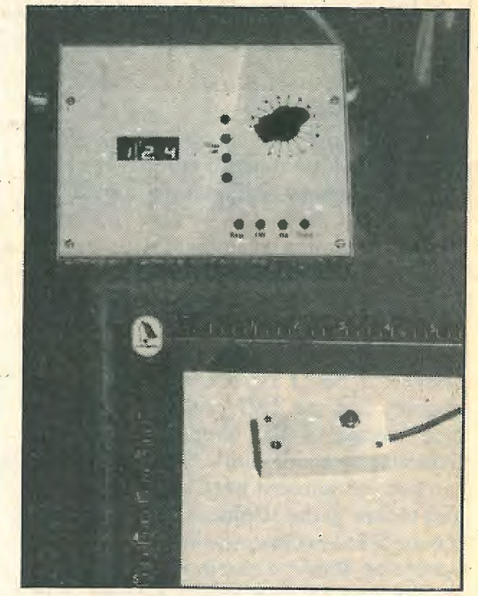
The isolated mains switch is shown in Fig. 5. The power supply is derived from the mains, using the transformer primary as a current limiter. Some triacs require a trigger current of 50mA, and in this circuit, narrow, high-current pulses are provided by the NE555 oscillator. A current of 0.5mA through the optical isolator l.e.d. will stop the oscillator and turn the enlarger off.

Construction

I constructed the meter on four printed circuit boards: one double-sided, with the main logic circuitry, power supply stabilizer, and log. v.c.o., a separate, single-sided board for the display circuit and two small boards for the sensor circuit and isolated triac switch.

All except the sensor circuit were housed in a "BIMBOX" 6006 (Boss Industrial Mouldings): the sensor was fitted into a home-made metal and plastic box, which must be electrostatically screened by a layer of aluminium cooking foil.

Layout of the majority of the circuit is not at all critical. The isolated triac circuit, since it is at mains potential, should be suitably shielded. The sensor circuit should be arranged to minimize leakage current to the input of the integrator. IC_1 is mounted in a socket made of Soldercon pins, which provide no additional leakage path. Pin 1 has no connexion, and no socket to allow a complete earthed guard ring to be put around pins 2 and 3, and D_1 and D_2. The use of an i.c. socket allows the CA3140 to be changed, to select one with a low leakage. D_1, as supplied, has a domed encapsulation, to provide focusing, which makes it highly directional, so that it is necessary to grind this off, leaving a flat top. Emery paper is suitable for this, finishing on fine grit (600), then metal polish: some care is necessary to avoid straining the leadouts. D_1 should, obviously, be under a transparent window in the box. D_2 and D_3 face each other, and should be shielded from the light illuminating D_1. All components at the input of the integrator, including IC_1, should be clean: fingerprints could cause leakage currents.



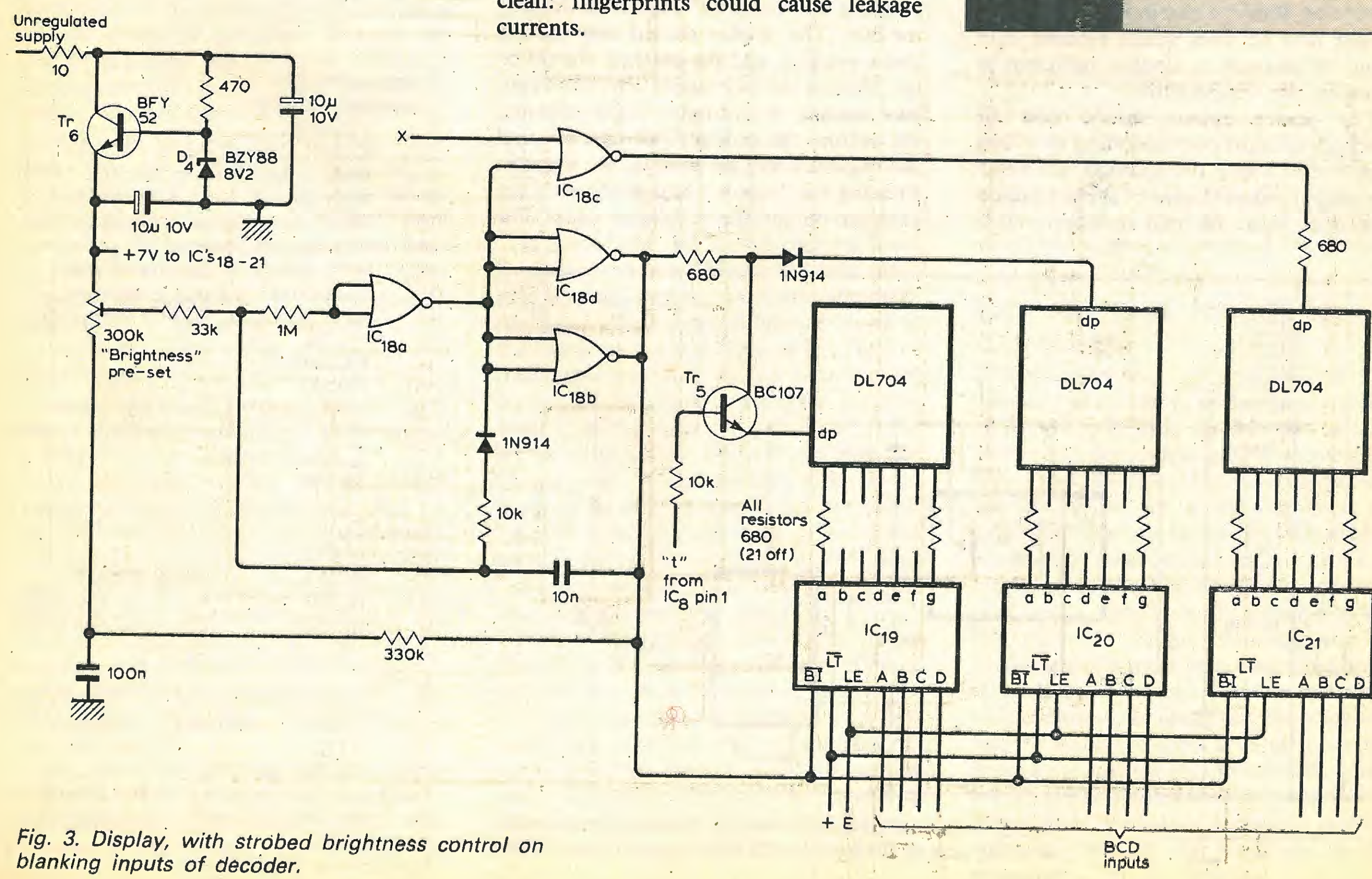


Fig. 3. Display, with strobed brightness control on blanking inputs of decoder.

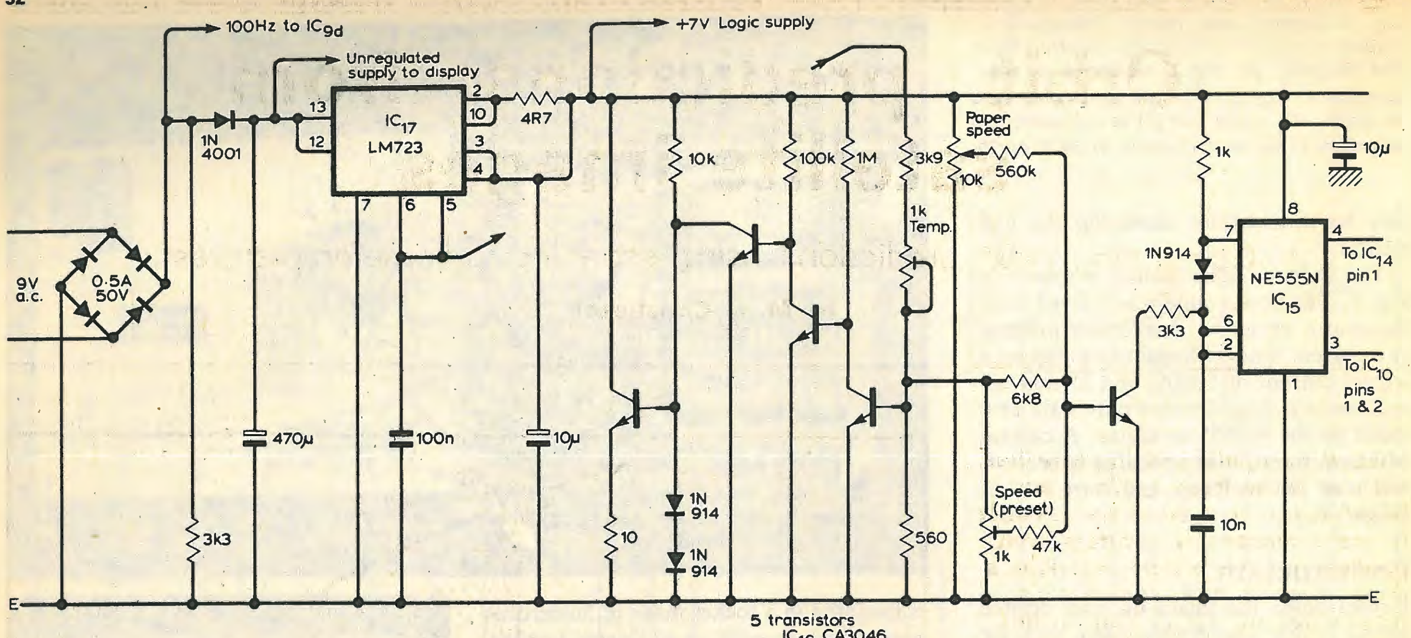


Fig. 4. Voltage-controlled oscillator and p.s.u. Four transistors of CA3046 on left form thermostat.

Setting up

After checking the circuit and supply voltages, the first thing to set up is the log. converter, whose temperature should be set to about 40°C: this is not, however, critical. Assuming an ambient temperature of 20°C, one method is as follows: set the 1kΩ "temp" preset to minimum resistance, and check that no current flows in the 10 ohm resistor of the heater transistor. Connect a 56kΩ resistor across the 3k9 resistor, and the 1kΩ preset, raising the base voltage of the temperature-sensing transistor by about 40mV. The 1kΩ preset can now be adjusted until current just begins to flow in the 10 ohm resistor. Removing the 56kΩ resistor now reduces the base voltage by 40mV; a rise in heating current should now be seen which reduces over about 30 seconds to a value sufficient to maintain the temperature.

The sensor circuit should now be checked. In light corresponding to a long exposure of about 100 seconds, the negative output pulses should be approximately 2 seconds long. In total darkness, these pulses should be at least 10 times longer; if not, try another 3140. Adjustment of the output pulses is by trimming the 1pF capacitor (made of twisted wire). The paper speed preset is adjusted to give a suitable span on the panel mounted control, calibration being by trial and error, with test strips. Paper manufacturers do not usually quote a speed, so each box needs to be tried, and the appropriate speed setting noted down.

Using the instrument

In measuring exposures, a piece of ground glass, or other diffuser is placed under the lens, and the sensor placed on the printing frame directly under the lens, before pressing the "measure" button on the sensor box. The display should now show a stable reading, and the enlarger should be on. Moving the iris should alter the exposure reading accordingly. Upon releasing the button, the enlarger will turn off, and the exposure will be held on the display. Pressing the "expose" button will turn the enlarger on for the displayed time. The "on" and "off" buttons are to control the enlarger for focussing, etc.

The manual setting buttons should cause the display to count up or down, fast or slow. Pressing "time" causes the decimal point to move one digit left (to between the left and middle digits), sets the display to 0.00, and starts it counting seconds and minutes. This is cancelled by any other function except "on" and "off", and the previous exposure time is recovered.

Component list
Integrated circuits

1	CA3140
2-7	4510 (b.c.d. up/down counter)
8	4043 (quad. 3-state Nor R/S latch)
9	4081 (quad. 2-input And gate)
10	4011 (quad. 2-input Nand gate)
11	4001 (quad. 2-input Nor gate)
12	4012 (dual, 4-input Nand gate)
13	4518 (dual, b.c.d. up counter)
14	4013 (dual, D flip-flop with R/S)
15	NE555
16	CA3406
17	LM723
18	4001 (quad. 2-input Nor gate)
19-21	4511 (b.c.d.-to-7-segment latched encoder/driver)
23	TIL111

Transistors

1-3	ZTX109
4	BC214
5	BC107
6	BFY52

Triac 3A, 400V

Zener diodes

4	BZY88 C8V2
5	BZY88 C6V2

L.e.ds

1	LD57C (Marshall's, Kingsgate House, Kingsgate Pl., London NW6 4TA)
2,3	TIL209, DL 704

Passive components as in circuit diagrams.
Resistors ⅛W, carbon film, presets miniature carbon
Transformer 9V, 150mA

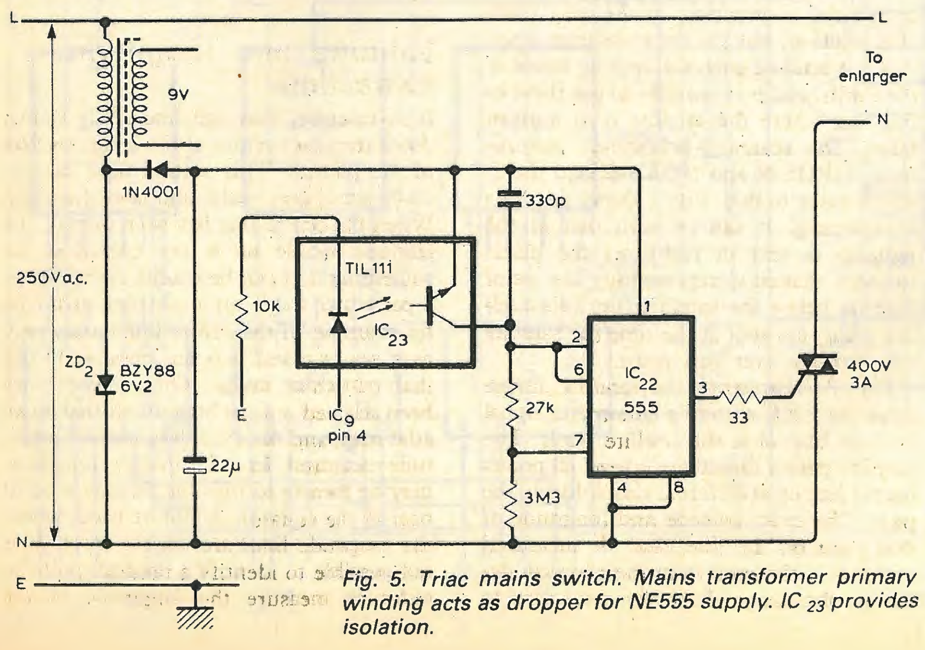


Fig. 5. Triac mains switch. Mains transformer primary winding acts as dropper for NE555 supply. IC 23 provides isolation.

Orbit predictions from satellite images

Calculating orbit predictions using scanning-radiometer pictures

by M. L. Christieson

Images from polar orbiting satellites, such as those from TIROS-N and NOAA-6, can be used by the amateur to make reasonably accurate orbit predictions. This article describes a method which has enabled a.o.s. (acquisition of signal) time to be predicted to within a half a minute for up to a fortnight. After this period, some updating of data is required if the accuracy is to be maintained.

A significant problem encountered by amateurs receiving images from polar orbiting satellites such as TIROS-N and NOAA-6 is the need to maintain reasonably accurate orbit predictions. The degree of accuracy needed depends on the level of automation, and if the station is fully automatic it is often necessary to keep errors to less than half a minute in time and one degree of equator crossing longitude.

The simplest solution is to obtain a reference orbit from an outside source, and, using the orbital period, calculate successive orbits either manually or by using a simple computer program. It soon becomes apparent that without occasional updates the drift of the prediction is intolerable. Further data can be obtained from outside, but this is not always easy to obtain, and sometimes can be quite inaccurate because of the long term nature of their production. It is very difficult even using large professional computer systems to produce accurate long-term predictions because the magnitude of the drag on a satellite in a low-orbit depends on the outer atmosphere, which is affected to a large extent by solar activity. The level of solar activity is difficult to predict and hence errors can reach tens of minutes over a period of months.

It is therefore necessary to update both reference orbits and orbital parameters regularly; say every two weeks or so. Assuming that the amateur wishes to be independent, some direct observational method must be used. The most obvious is to use an astronomical telescope to observe the satellite, and provided it is well calibrated, these observations will give the required data. There are several disadvantages to this method:

- the capital outlay in equipment is large.
- It requires some expertise to use it.
- Observations are restricted to a time when the sky is dark but the satellite is not in the earth's shadow.
- It must be known approximately where to look and when.
- It is dependent on the weather.

In most cases this method would, apart from radar observation, be the only available solution, but the earth imaging satellites are sending pictures looking down at the Earth, and it is possible to use these to find out where the satellite is at a given time. The scanning-radiometer pictures from TIROS-N and NOAA-6 lend themselves easily to this. Fig. 1 shows this type of scanning. It can be seen that as the imaging is sent in real-time, the pixels (picture elements) representing the point directly below the satellite (the sub-satellite point) are sent at the time the satellite was directly over this point.

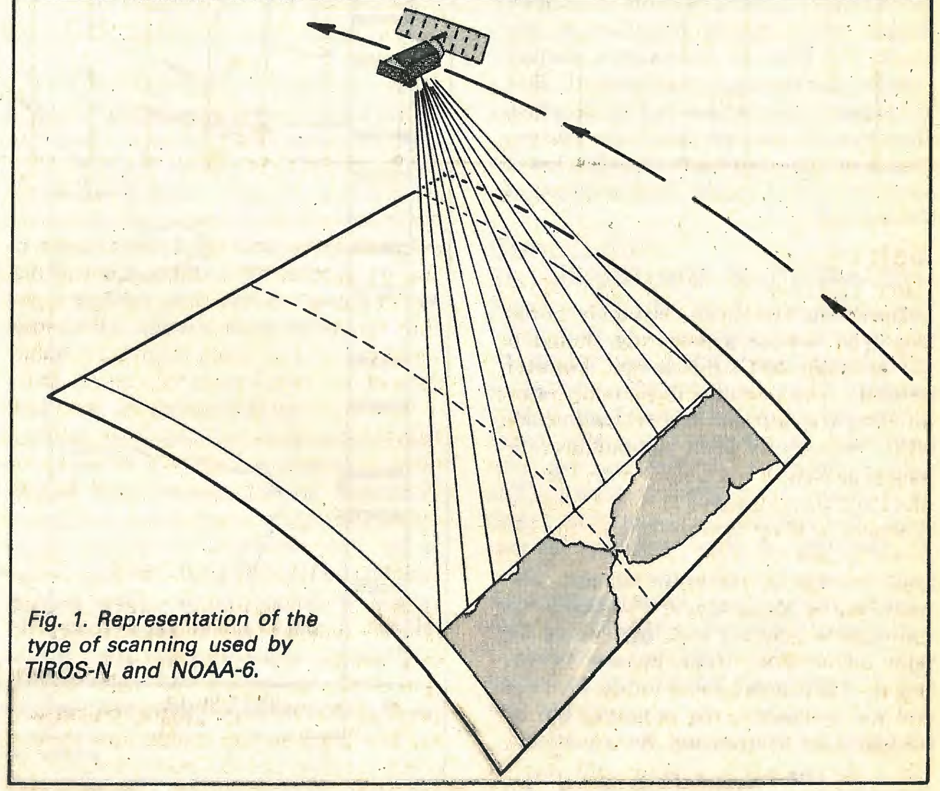


Fig. 1. Representation of the type of scanning used by TIROS-N and NOAA-6.

Fig. 2. represents the satellite image from the v.h.f. scanning radiometer signal and the line *ab* is the satellite track. The satellite passes directly overhead all points on the line *ab* at different times during the pass. The exact latitude and longitude of one point on the line must be measured and this is obtained from the physical detail on the image. It is also necessary to determine the exact time that the pixels representing this point were sent. The accuracy with which this information is extracted from the image has an important effect on the final accuracy of the method.

Latitude and longitude extraction

It is essential that the line *ab* is drawn down the exact centre of the image section of the picture. This section does not include sync, grey-scales and timing-marks. When the centre-line has been drawn, the features visible on it are examined for something that can be readily identified – a particular shape on a coastline or a lake for example. If the centre-line passes only over sea or cloud it is not possible to use that particular image. Once a point has been selected it must be re-identified on an atlas map, and the exact latitude and longitude measured. In order that the longitude may be measured most accurately a point near to the equator should be used, where the longitude lines are widest apart. It is not possible to identify a random point in order to measure the longitude of the centre-line because even after processing on board the spacecraft the image scale is not linear.

Time extraction

The v.h.f. signal also contains timing marks down one side of the image (Fig. 2.) These are short horizontal lines set one minute apart. In order to measure time exactly these marks must be referenced against an outside time standard. This must be done in real-time, and if a tape recording technique is used for printing it must be done as the picture is recorded. In the prototype, which in fact also prints the pictures in real time, a small white line is added every ten minutes. This ten-minute marker can be readily identified on the image, and from an approximate starting time the minute markers referenced. This technique is also shown in Fig. 2. which illustrates the construction lines. The accuracy of time measurement also has a significant effect on the final accuracy of the method.

Calculation of the result

This sections deals with calculations relevant to an ascending orbit, Fig. 3(a), and the formulae used are based on spherical geometry. For a satellite in a circular orbit with period P minutes and orbital inclination to the equator ϕ the sub-satellite latitude is given by

$$lat = \sin^{-1}\left[\sin\left(\frac{360t}{P}\right)^{\circ}\sin\phi\right] \qquad (1)$$

t minutes after it crosses the equator. The value for the inclination is well published and varies only slowly with time. Using the value for lat (L_{obs}) from the observation, and an approximate value for P, which is also well published, the value of t can be calculated by rearranging the equation

$$t = \left[\sin^{-1}\left(\frac{\sin L_{obs}}{\sin\phi}\right)\right]\left[\frac{P}{360}\right] \qquad (2)$$

The time of the observation is known, so

$$t_{eq} = t_{obs} - t$$

where t_{eq} is the time the satellite crossed the equator. This is the required result.

The longitude of the satellite is given by an equation consisting of three parts

$$LG = \cos^{-1}\left[\left(\cos\frac{360t}{P}\right) \div \cos L_{obs}\right] + \frac{t}{4} + L_{eq} \qquad (3)$$

where LG is the longitude and L_{eq} is the longitude at which the satellite crossed the equator. The first part of the equation is the actual movement of the satellite, the second is to take account of the Earth's rotation, and the third the starting longitude. All the variables in the equation are known except for L_{eq} which is required.

$$L_{eq} = LG_{obs} - \cos^{-1}\left\{\left[\cos\left(\frac{360t}{P}\right)\right] \div \cos L_{obs}\right\} - \frac{t}{4} \qquad (4)$$

This gives the equator crossing longitude which, together with the time, represents a reference orbit.

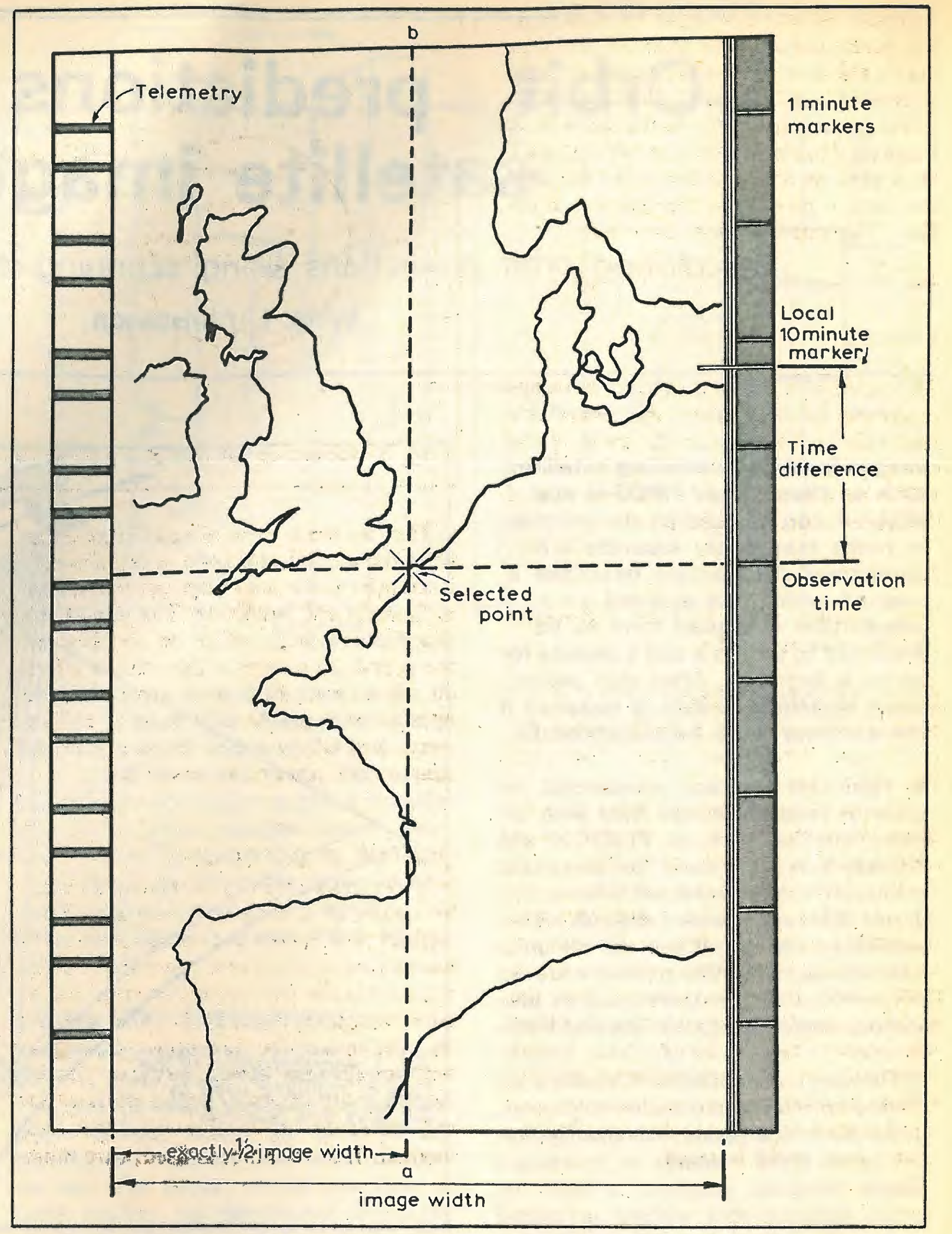


Fig. 2. Typical compilation of a scan received from the satellite. The horizontal line has been chosen to cross ab, the satellite path, at a point on the coast to enable accurate determination of latitude and longitude from a map.

A more accurate value of period is required for longer term prediction, and this can be calculated from two observations taken some days apart and the total number of minutes between the two calculated. This is divided by the approximate value of period. Obviously the result should represent an integral number of orbits, so it is rounded up to the nearest integer and the total number of minutes divided by that. This gives the orbital period. The procedure can be repeated regularly to keep the value of period accurate.

Descending orbits

The equations given above are valid for ascending orbits only, i.e. those that cross the equator into the observer's hemisphere on the same side of the Earth as the observer. This type of orbit is shown in Fig. 3(a). Half the usable passes a day result from orbits crossing the equator on the other side of the Earth, coming over the Pole and into the user's view, and then crossing the equator into the other hemisphere. This type of orbit, a descending orbit, is shown in Fig. 3(b). If the observation is made on a descending orbit, the existing equations must be modified. At the point when the orbit goes over the Pole, the equations go through a discontinuity thus becoming useless. A convenient solution is to imagine the orbit to be inclined to the equator in the opposite sense,

$$\phi' = 180 - \phi$$

Using equation 2, the value of t can be calculated using the modified value ϕ' This produces the time taken for the satellite to reach the equator crossing into the other hemisphere. Therefore the equator crossing into the observer's hemisphere was half an orbit before, ie. $P/2$ minutes, so:

$$t_{eq} = t_{obs} + t - \frac{P}{2}$$

In order to calculate the equator crossing

longitude equation 4 must be modified. For inclinations of less than 90° the sign before the first part of the equation must be reversed. (ϕ' will now be less than 90° if ϕ was greater than 90°). As the equation is being used in reverse the sign before the $t/4$ term must be reversed due to the fact that the earth is rotating in the opposite direction. The equation now becomes

$$L_{eq}' = LG_{obs} + \cos^{-1}\left\{\left[\cos\left(\frac{360t}{P}\right)\right] \div \cos L_{obs}\right\} + \frac{t}{4}$$

This value of L_{eq}' is the equator crossing-longitude passing from the observer's hemisphere. To calculate the value of the crossing-longitude half an orbit before, 180° plus a correction for the rotation of the earth must be subtracted.

$$L_{eq} - L_{eq}' - 180° - \frac{P°}{8}$$

This, together with the time, represents another reference orbit.

Source of errors

Several assumptions are made during the calculation of reference orbits. There are two main ones:

1. The satellite radiometer looks directly downwards, i.e. the scanning plane is at right-angles to the axis of motion.
2. The orbit is perfectly circular.

The results using this method are reasonably accurate indicating that the errors resulting from these assumptions are quite small. It is also assumed that the observer is not located very close to either the North Pole or South Pole. Errors involved with the measurement of time depend to a large extent on the user. If a suitable method is used, the contribution to the total error is small.

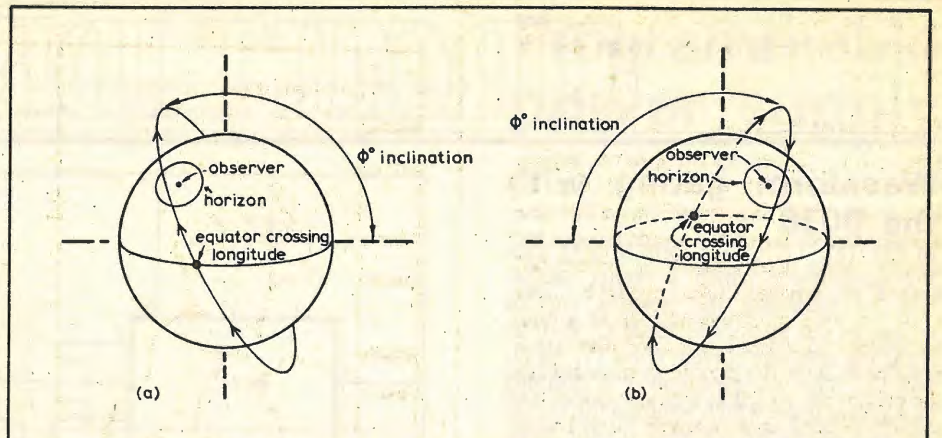


Fig. 3. Ascending (a) and descending (b) orbits shown in relation to an observer.

The two main areas of significant error lie in the identification of a selected point, its transfer to the atlas map and conversion to latitude and longitude. The size of the image has a large effect on the first of these, and the quality of the atlas an effect on the second. Both these errors will be reduced with practice. In order to reduce errors generally it is best to use a point as near to the equator as possible.

Use of a computer

It is very much easier to calculate the result by means of a computer program. This method was developed using Fortran-4 routines on a mainframe computer, but it could easily be implemented on a microcomputer, using Basic. The computer also makes the generation of longer term predictions easier, using a simple looping program based upon parameters and reference orbits obtained from this method. If a computer is used, care must be taken to prevent longitudes from being negative. This was achieved by using Fortran-4 IF statements for results either side of zero longitude. All longitudes were expressed as degrees west.

Conclusions

The results achieved using this method have enabled orbit predictions to be held better than half a minute for a.o.s. The equator crossing longitudes are used by an antenna tracking computer which has also proved most satisfactory. It has been found necessary to update the reference orbit approximately once every two weeks, and the value of period every month. If a greater error could be tolerated, only occasional updating would be necessary.

Acknowledgement. I would like to thank Miss C. Thoburn of the Royal Greenwich Observatory, Herstmonceux, for her ever helpful remarks during the preparation of this article. □

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their distortion behaviour close to clipping. Although these questions would be of great interest, they are not discussed as the purpose of this article is only to illustrate the basic theory.

The analysis and measurements show

- a loudspeaker, being reactive by nature, is capable of storing much of the energy it receives from the amplifier.
- this stored energy will be reflected back to the amplifier output terminals.
- the closed-loop output impedance of an amplifier is normally very low, but the open-loop impedance may be several ohms. To damp the reflected signal, feedback will generate a correction signal within the amplifier.
- the signal in the forward path of the amplifier thus consists of two components; the original input signal and the loudspeaker reaction signal, both of the same order of magnitude.
- these two signals may interact in the non-linearities of the amplifier, generating intermodulation products between the two.
- this distortion, termed interface intermodulation, will be most prominent at low frequencies where the loudspeaker reactive load is largest.

Amplifier design rules to avoid interface intermodulation

The output should provide a low open-loop output impedance to adequately attenuate the loudspeaker reaction signal so that the need for a feedback-generated damping is minimized.

Heavy overall feedback should be applied with caution.

- the susceptibility of the amplifier to interface intermodulation can be measured by using a modified difference-tone method, where one of the signals is injected to the input and one to the output of the amplifier. To create conservative worst-case test for this effect, the latter signal may be increased to equal in power the rated output power of the amplifier.

This investigation was performed under a research grant from the Technical Research Centre of Finland and under partial support of Harman/Kardon, Inc. We are grateful to Eero Leinonen for many discussions during the early stages of this work, and Kari Nieminen for performing a part of the measurements presented. Both are with the Technical Research Centre of Finland. Prof. J. Robert Ashley of the University of Colorado, and Robert Cordell of Bell Laboratories are gratefully acknowledged for their constructive expert criticism of an early version of this paper. Several people have also contributed in numerous discussions, notably Leon Kuby and Robert Furst of Harmon International Industries, Inc. and Richard Heyser of the NASA Jet Propulsion Laboratory.

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CIRCUIT IDEAS

Waveform gating with the 8038

In Fig. (a), Tr_1 to Tr_4 form a unity gain Voltage-follower which prevents oscillation by balancing the positive current source in the 8038, and feeds C_1 with an equal but opposite current from Tr_1 via D_1 and D_2. The voltage-follower is disabled by a gating pulse which removes the bias to Tr_1 and allows its collector to rise about 0.7V above the voltage on C_1. This reverse biases D_1, D_2 and allows normal operation of the 8038.

When the logic enables Tr_1 at the next positive transition of the 8038 square-wave output, D_1 and D_2 are still reverse biased and waveform generation continues until the triangle waveform reaches the voltage set by VR_1. At this point D_1 and D_2 become forward biased and the oscillation stops. In the single-cycle mode, the gating signal produces a short pulse on its rising edge which allows one full cycle of oscillation. Fig. (b) shows a c.m.o.s gating circuit and Fig. (c) illustrates a faster t.t.l. version.

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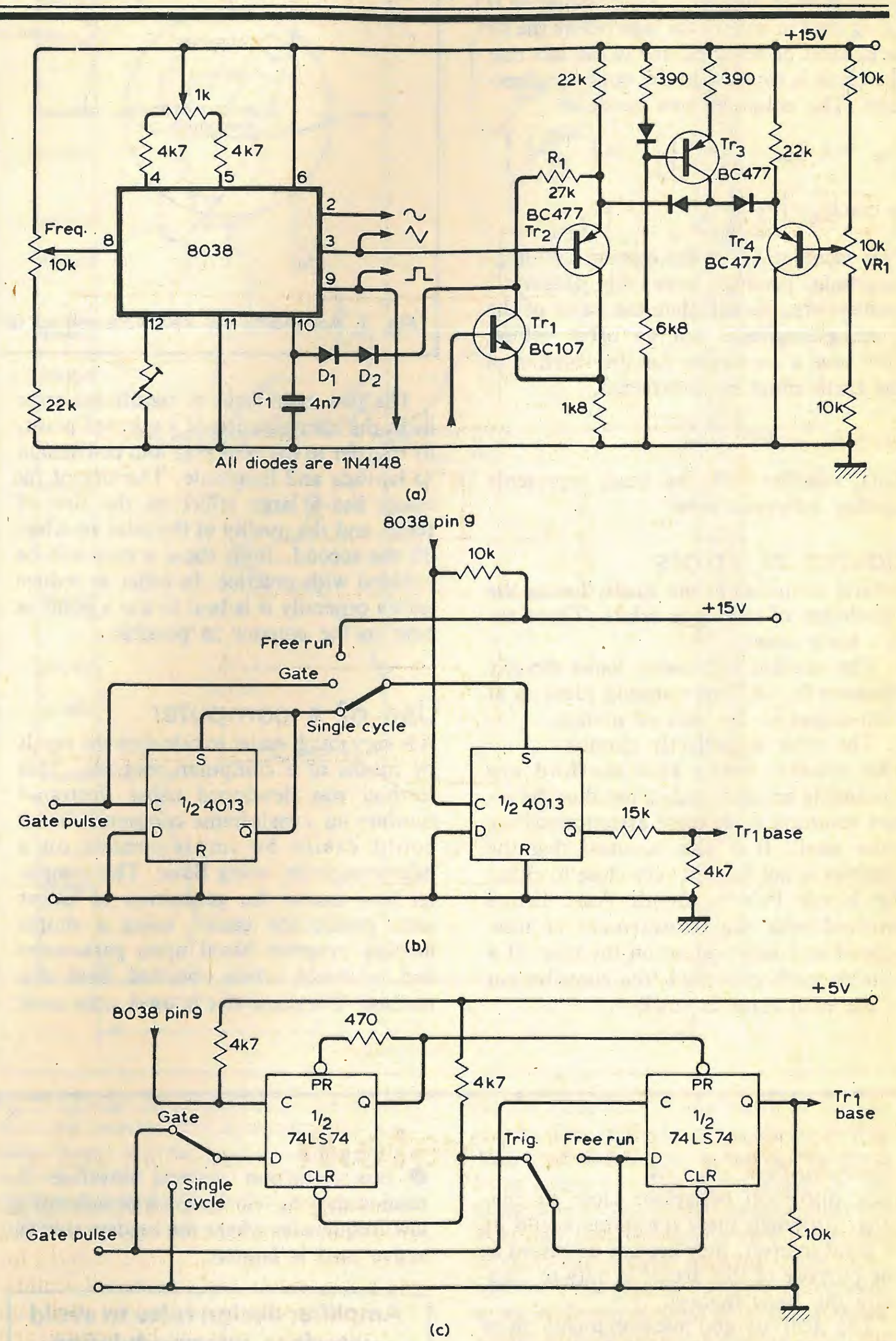

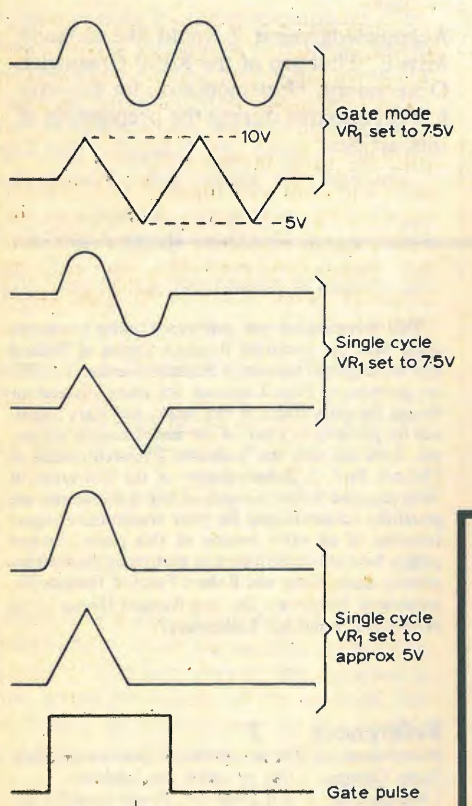

F.e.t. tester

Because the pinch-off voltages of f.e.ts of the same type vary considerably, it is often necessary to test them before use. This simple circuit reveals the bias required for a given current. Resistor R_1 is chosen to equal $0.6/I$ so that the bipolar transistor provides sufficient current to produce the required bias across R_2, which is measured by a voltmeter. The value of R_2 should be less than the reciprocal of the f.e.t.'s mutual conductance at zero bias, and for most devices 150Ω is suitable. The meter does not need a high impedance, and for accurate matching, a d.v.m. can be used.

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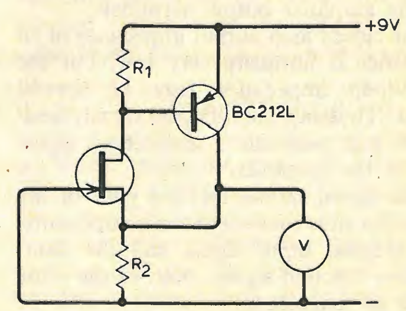

Time-base generator

Components IC_1 and C form an integrator with time constants controlled by the range resistors. Schmitt trigger IC_2 controls the discharge of C through IC_3 attenuator and the transistor. IC_4 is a buffer with a gain control to change the output amplitude.

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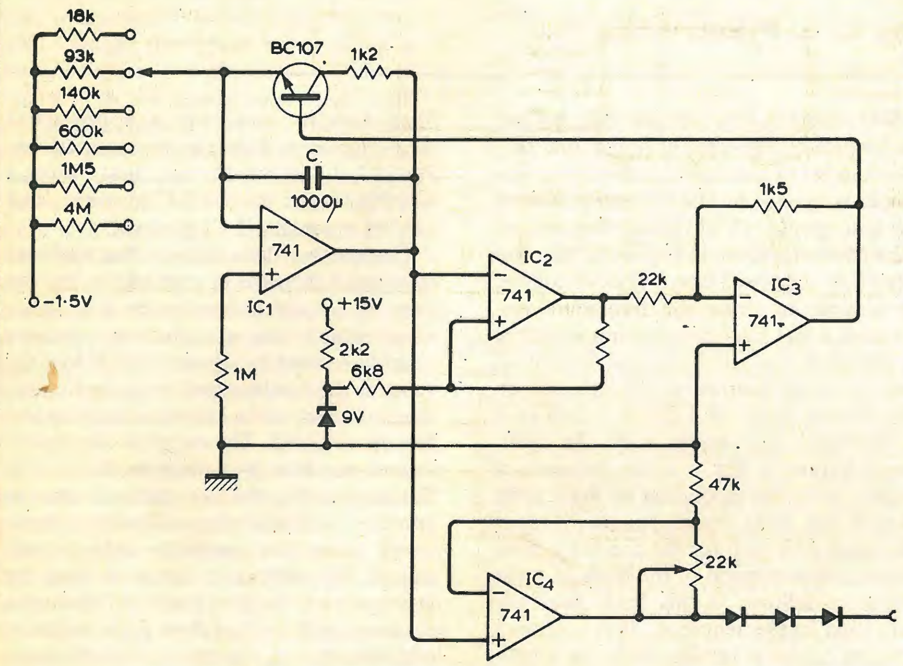

Floppy disc system

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explained in Table 6, two controller commands have to be altered, 1D63 to write the complete track, and 1E47 to delete the attempt to verify the head position after the seek operation, as presumably the track is being re-formatted because it is impossible to verify on that track.

Re-formatting is accomplished by proceeding as with a standard Write operation, giving the start of the block as a source and dummy data, say 1, 1 and 1 for the track, sector and number of sectors. The head should move in, load itself and write the track. After this has occured and the head has released, the computer should be manually reset using the Reset key or, preferably, Control Z. □

Table 7. Sequence for a DRQ interrupt. Note that interrupts can be accepted during LD, SP, HL, in which case the HALT will not be executed, but instructions up to and including LD, SP, HL are always executed unless $\overline{NMI}$ occurs.

(Mode 2 Interrupt)	9½ μs	
IN A,1D	5½ μs	Data read in
CPL	2 μs	Data inverted to true
LD (DE),A	3½μs	Stored in memory
INC DE	3 μs	Move to next location
EI	2 μs	Enable interrupt
LD SP,HL	3 μs	Pull back SP
HALT	2 μs	Halt for interrupt
	30½ μs	

Programmable power supply

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board. The overload latch then sets to zero the input voltage to the output amplifier. The voltage is maintained at zero until the overload condition is cleared and the reset command is received.

Maximum output voltage of the circuit is dependent on the transformer rating and the voltage/current rating of the series pass transistor. The prototype used a 100VA transformer rated at 40V/2A. However, with two decimal digits of programming, the potential output is 99V with suitable modifications.

The current-limit sense amplifier is conventional and allows variation of the trip current with a preset potentiometer. An unusual feature of this circuit is the use of a t.t.l. i.c. in the power-down feedback loop.

A wholly digital interface would permit further improvements in the power supply. For example, if the d-to-a converter is driven by optically coupled devices, and the overload-latch is also optically-coupled, the analogue section of the supply can be electrically floating. This system retains the features of remote programming but does not need complex linearization feedback networks normally necessary in optically-coupled analogue circuits.

A very accurate power supply with four significant digits of programming could incorporate digital correction of the output signal by monitoring the analogue output with a digital voltmeter and comparing it with the programmed voltage present at the d-to-a converter input. The difference between the two values is added to the binary signal to correct the analogue output. Such a system provides very accurate outputs with excellent long-term stability. □

Tone filters for electronic organs

Part 2: design procedure and practical problems

by C. E. Pykett B.Sc., Ph.D.

This article derives frequency responses of tone filters for four organ tones, whose acoustic spectra were given in part one. It completes the design procedure, discusses the number of filters needed per stop and the combining of tone colours, and various other practical points.

The frequency response of the required filter is obtained by subtracting the sawtooth spectrum from the relevant organ pipe spectrum. In practice this merely means that the numbers in Table 2, representing the individual harmonic amplitudes, are subtracted one by one from the corresponding numbers in Table 1. The resultant four series of values are presented in Table 3, and graphically in Fig. 5. (In all cases the frequency response is represented on a scale that does not indicate absolute frequency but is normalized to the frequency of the first harmonic or fundamental of the original spectra. To implement a real filter circuit one needs to first convert the frequency scale back to true frequency values, which immediately begs the question of which design frequency is chosen for the filter, a subject treated later.

Also shown in Fig. 5 by the full lines are the frequency responses of four actual filters intended to simulate the frequency responses suggested by the discrete points on the four graphs. (The circuit diagrams of these filters are given in Fig. 6 and they are more fully discussed later.) It is, of course, permissible to draw the frequency response of a real filter as a continuous curve as the filter has a defined gain/loss at all frequencies in contrast to the experimentally derived points of Table 3, which exist at harmonic frequencies only. An additional feature in Fig. 5 is the presence of broken lines corresponding to Bode plots used in the filter design process. This is discussed later, but for the present a short qualitative discussion of the form of these responses follows as this leads naturally onto filter implementation. It is necessary that the reader is familiar with the amplitude versus frequency response of simple filter sections and (where appropriate) their equivalent Bode plot representations. Particularly important are first, second and third-order passive RC networks, and parallel resonant (LC) sections.

The claribel flute filter is characterized by a rapid increase in attenuation for the first six or seven harmonics, Fig. 5(a), after which the attenuation remains roughly constant at about 35dB below the value at the fundamental frequency. After the 15th harmonic no further experimental data are available. The nature of the experimental points in this diagram shows why flutes are among the most difficult tones to emulate. It is difficult to discern a simple trend from the available information, though an interesting feature is that the attenuation at the first few even harmonics is consistently higher than at the adjacent odd harmonic frequencies. This suggests that the flute stop in question consisted of stopped pipes, though it was not possible to confirm this by an examination of the interior of the organ. Whilst a stopped construction is unusual for claribel flutes, this assumption enabled a filter response to be chosen that was based on the first four or five odd harmonic frequencies only; even harmonics were ignored. This filter consisted of a third-order passive RC network whose breakpoint was the fundamental frequency. Driven with a sawtooth wave, a reasonably satisfactory flute resulted though the effect when using a square wave was not satisfactory. (This is at odds with the strong suggestion from the filter response that odd harmonics ought to predominate.) It seems that the relative proportions of odd to even harmonics are critical for flutes, and experiments with other filter configurations in which particular harmonics were selectively reinforced confirmed this. The simple filter just described makes no attempt to emulate the part of the frequency response suggested by frequencies above the tenth harmonic. Even though such high-order structure may be crucial to the production of a good flute tone as previously discussed, it was found difficult to derive a straightforward way of doing this that also yielded subjectively good results.

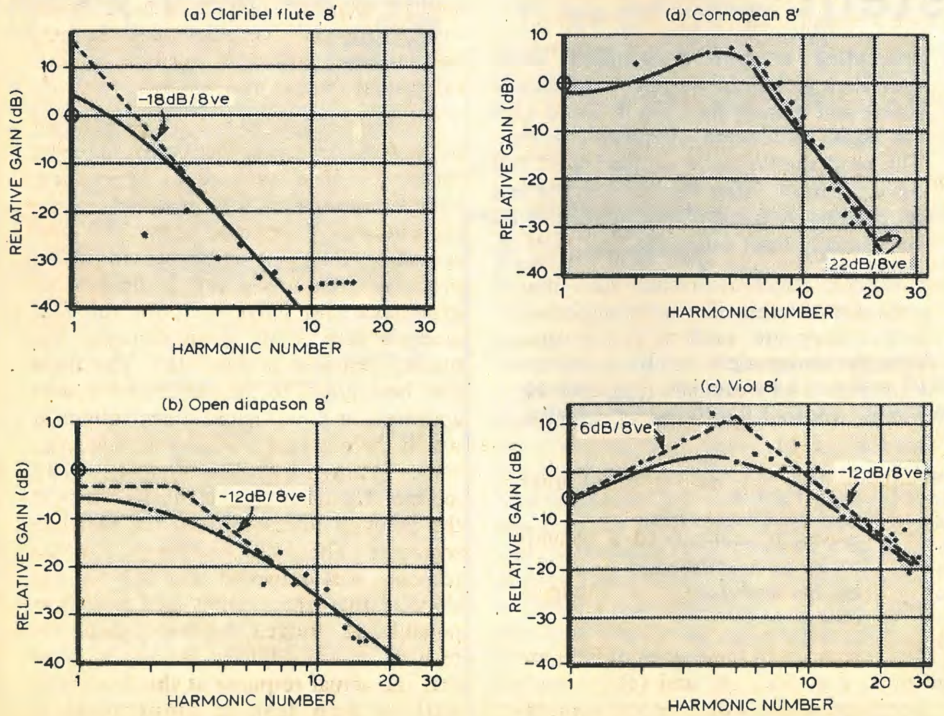


Fig. 5. Filter frequency response curves for the tones in Fig. 2. Dots represent values of the required response at the harmonic frequencies as in Table 3. Full lines are measured frequency responses of actual filters, broken lines are Bode plots. Responses calculated assuming a sawtooth driving waveform.

Table 3. Normalized frequency responses in dB of tone filters for four organ tones assuming a sawtooth drive waveform corresponding to Fig. 5.

	organ stop name			
harmonic	claribel flute	open diapason	viol	cornopean
1	0	0	−5	0
2	−25	−8	2	4
3	−20	−5	7	5
4	−30	−13	12	6
5	−27	−17	2	7
6	−34	−24	4	4
7	−33	−17	3	4
8	−37	−24	1	0
9	−36	−22	6	−4
10	−36	−28	2	−7
11	−35	−25	1	−12
12	−35	−30	−4	−13
13	−35	−33	−6	−22
14	−35	−35	−9	−22
15	−35	−36	−10	−27
16	–	−36	−10	−29
17	–	–	−10	−26
18	–	–	−12	−29
19	–	–	−13	–
20	–	–	−12	–
21	–	–	−16	–
22	–	–	−13	–
23	–	–	−14	–
24	–	–	−18	–
25	–	–	−12	–
26	–	–	−21	–
27	–	–	−18	–
28	–	–	−18	–
29	–	–	–	–
30	–	–	–	–

Turning now to the open diapason, the response fits a second-order Bode plot very nicely, with the break point occurring at a frequency equal to 2.6 times the fundamental. The actual response of such a filter (full curve) fits the experimental points well, with only a few reaching a maximum divergence of 6dB. Subjectively this simple diapason filter produced entirely acceptable and realistic sounds that were hard and bright rather than dull and woofy. A complete diapason chorus, from a 16-foot double diapason to a three-rank mixture, was built up using a total of 32 such filters and the effect had something of the tonal excitement of a similar flue chorus on a pipe organ.

The experimental points for the viol filter suggest a bandpass characteristic, and they are again well approximated by the Bode plot illustrated in the diagram. This consists of a 6dB/octave rise changing to a 12dB/octave fall, the transition between the two being at the fifth harmonic of the fundamental. Such a filter has the true response indicated by the full curve. The subjective verdict on this filter was again favourable, though it was too stringy for some tastes. This is possibly due to the fact that this filter was derived from Boner's data[2], in which measurements were made in a free field with the microphone close to the pipe. In an organ, a viol rank would be placed well inside the organ case and almost certainly inside a swell box (a large box equipped with movable shutter to enable the volume to be varied). Therefore significant high frequency attenuation would result, with the tone of ther pipe sounding less stringy to a listener in the auditorium.

Finally, the cornopean data are again strongly suggestive of a bandpass characteristic. In this case the filter was implemented using a parallel resonant circuit tuned to the fifth harmonic with a Q of about 2. To achieve the asymmetry of the response, which rapidly falls above resonance, a third-order RC filter was also used breaking at the eighth harmonic. The reasons for using this particular bandpass filter configuration instead of one akin to the viol are given in the next section. For the present the actual response is seen to fit the experimental values closely. The effect of this filter was a convincing bright reed tone, definitely typical of a cornopean or a trumpet rather than of a close-toned tromba or tuba. Again, a family of such filters was built with worthwhile results.

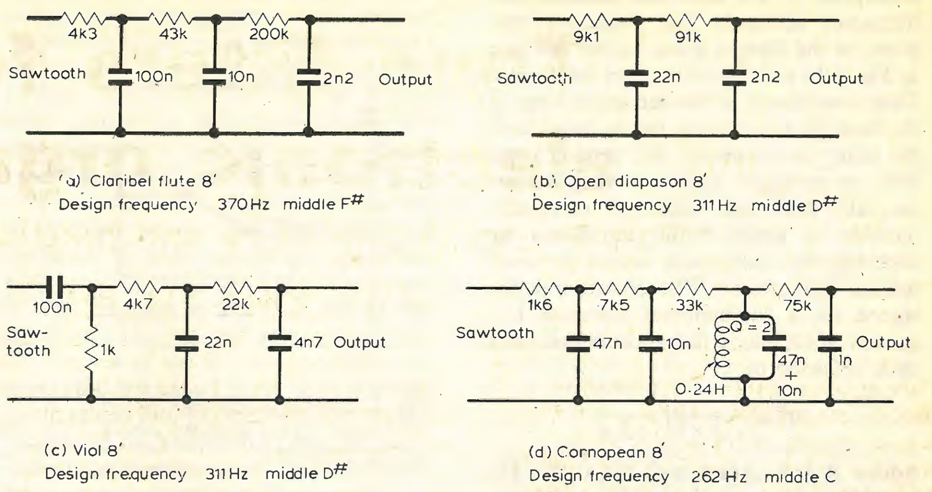


Fig. 6. Filter circuits giving the frequency responses of Fig. 5. Inductor in (d) can be realised electronically.

The unique tone of an organ reed pipe seems, in part at least, to be due to an harmonic structure that is relatively constant in amplitude up to an harmonic order between the fifth and tenth, depending on the particular tone. After this frequency the amplitude falls off rapidly; this falling characteristic is reflected in the filter response. It is therefore essential to copy the "asymmetrical resonance curve" of the filter, as without the rapid attenuation above resonance the effect is completely synthetic and quite unlike the original.

Hardware realisation

Filter response need not be matched exactly to the calculated values at each harmonic frequency of the driving waveform. These points originate from experimental measurements in which a large number of variables, most of them uncontrollable, affect the results such that divergences of a few dB can be neglected provided they are random rather than noticeably systematic.

Flue pipe tones can nearly always be well approximated by the use of a simple passive RC filter

- flutes generally need a third-order lowpass system
- diapasons generally need a second-order lowpass system
- strings generally need a bandpass system.

Circuit examples of these types of filter are given in Fig. 6(a), (b) and (c).

Reeds can nearly always be well approximated by implementing the asymmetrical bandpass characteristic previously described. It is usually found that the Q of the hump in this bandpass is significantly greater than unity for reeds, whereas for strings (which also require a bandpass) the Q tends to be less than this. Therefore, whilst a simple RC passive bandpass filter can be used for strings as noted above, a resonant circuit or its equivalent is usually necessary for reeds. If a parallel LC circuit is used, as in the example in Fig. 6(d), the rapid rolloff on the high frequency side of the resonant peak can be achieved by using an additional passive RC network. In Fig. 6(d) this network is of third order.

The majority of organ tones are best derived from a sawtooth wave, or one that has both odd and even harmonics. However, there are some important exceptions where a waveform containing only the odd harmonics (e.g. a square wave) is preferable if not actually essential. A partial list of stops where odd harmonics predominate might have names such as stopped diapason, lieblich gedackt, bourdon (all stopped flue pipes), and clarinet, vox humana, cromorne (reed pipes with cylindrical resonators).

These design guidelines just given apply to the filter circuits in Fig. 6. For flue pipe tones, the Bode plot of an appropriate passive network is first matched to the experimental points and then the corresponding filter is implemented. This procedure requires a certain amount of experience and judgement; for the first example turn to the open diapason frequency response in Fig. 5(b). The Bode plot best suited to the experimental data appeared to be a second-order system in which there is first a horizontal line (zero slope) followed by a line of slope −12dB /octave. The breakpoint is the frequency at the point of intersection of the two line segments. The −12dB/octave part of the response was drawn so that it fitted the slope of the experimental data as well as possible as judged by eye, then the breakpoint was adjusted bearing in mind that the actual response at this frequency will be 6dB less in amplitude. A breakpoint of 2.6 times the fundamental frequency resulted. The frequency response of the filter is given by the full line in Fig. 5(b) and Fig. 6(b) gives the circuit. This corresponds to the particular form of the Bode plot in that the two sections have the same time constant (RC product) and they are arranged such that they do not mutually load each other. (It is usually possible to avoid buffer amplifiers by choosing the component values to avoid mutual interaction). The circuit was designed for a fundamental sawtooth frequency of 311Hz, so that each section has a time constant of

$$RC=\frac{10^6}{2\pi\times311\times2.6}$$

where R is in kohm and C in nF. The question of how to choose the design frequency of the filter is deferred until later as it raises some important practical issues.

The flute filter of Fig. 6(a) was designed in exactly the same way, though in this case the frequency response data of Fig. 5(a) offered less precise guidance as to the form that the Bode plot should take. A third-order system was used, matched to the first few odd harmonics for the reasons stated previously. The three time constants were again equal and the three RC sections were again buffered. The breakpoint was chosen to be the fundamental frequency which in this case was 370Hz. There would have been little point in using a breakpoint lower in frequency than the fundamental; this would merely have resulted in greater overall insertion loss with little effect on the tone quality.

For the viol frequency response, Fig. 5(c) there were two segments clearly indicated, forming a Bode plot with slopes /z6dB/octave and −12dB/octave. The breakpoint turned out to be at the fifth harmonic. This is a simple bandpass filter formed from three RC sections in which one is highpass and the other two lowpass. The particularly simple form of the Bode plot means, again, that the time constants are all equal and that the sections must not interact. Such a circuit is shown in Fig. 6(c) and was designed for optimum operation at 311Hz.

Reed tones generally require bandpass characteristics with Qs not less than 1.5 and often more, which implies the use of circuits such as LC resonant sections. The higher the Q, the more "reedy" the tone and the smaller the frequency range over which the circuit is effective. A Q in excess of three or four is seldom required for the imitation of organ reeds. The cornopean frequency response in Fig. 5(d) has a clearly defined resonance peak at the fifth harmonic, and a Q of about 1.5 is implied by the locus of the experimental points below resonance. To achieve the rapid attenuation above resonance, an additional rolloff of about −22dB/octave starting at the eighth harmonic is also indicated. This result was obtained after a certain amount of juggling with ruler and pencil on the original graph points. The filter constructed used a resonant circuit with a Q of 2 rather than 1.5 because it sounded better and a −18dB/octave rolloff instead of

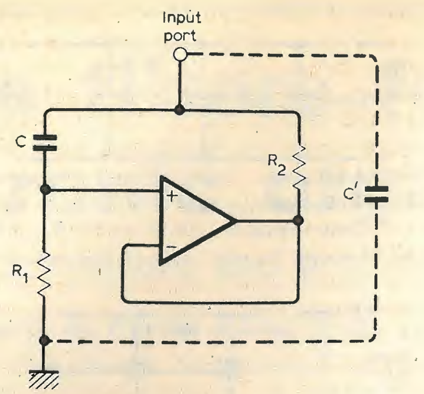


Fig. 7. Simple electronic inductor realisation using op-amp where C′ is the tuning capacitor.

−22dB/octave, for practical reasons. A version of this circuit designed for a 262Hz sawtooth is shown in Fig. 6(d), and its frequency response is the full curve in Fig. 5(d). The first two and the final RC sections produce a slope of −18dB/octave at the eighth harmonic, and the central LC section is responsible for the resonant characteristic. A parallel tuned circuit has to be driven and terminated so that its Q is not significantly affected by the adjacent circuitry. The terminating impedance can simply be a sufficiently large resistor which in this case is also used as an element of one of the low-pass sections. The source resistor feeding the resonant circuit must then be chosen according to the following conflicting criteria. It must not appreciably load the preceding RC section nor must it reduce the Q of the resonant circuit. Hence its value must be as high as possible. The insertion loss of the complete filter is influenced by the value of the source resistor because the effective resistance of the LC section at resonance equals Q^2R, where R is the equivalent resistance of the inductor. Hence the source resistor and the LC section itself form a potential divider that controls the amount of signal handed on to the rest of the circuit. For this reason the value of the source resistor should be as low as possible.

The circuit in Fig. 6(d) thus contains a certain amount of compromise, though mainly in the interests of economy. If total component cost is of no account, the various sections of the filter can be buffered using active devices thereby easing the design process. Such a course seems scarcely worthwhile when it is possible to approximate to the desired response as well as is indicated by Fig. 5(d).

In the interests of simplicity it had been implied that the resonant circuit was constructed with a wound inductor. This was not the case since an electronic inductor was synthesized using a simple circuit, Fig. 7. The advantages are that the filter can be readily adjusted until a subjectively optimum effect is produced; it is much cheaper than its wound counterpart, consisting only of two resistors, a small capacitor and a cheap operational amplifier; and it is much less bulky.

Design equations are as follows:

$$L=\frac{QR_2}{2\pi f}$$

where f is the resonant frequency

$$\therefore C=\frac{L}{R_1R_2}$$

(Suitable values for R_1 and R_2 are 82Ω and 1Ω respectively.) The value of the parallel capacitance C required to tune the circuit to f is

$$C'=\frac{1}{4\pi^2f^2L}$$

The final version of the cornopean filter using an electronic inductor based on the above is in Fig. 8.

Qualitatively at least, Fig. 5(d) is suggestive of a Q-enhanced Sallen and Key active filter response, though in practice this alone would not achieve the rate of attenuation required above resonance and additional sections would be required. Nevertheless, the use of this type of circuit is a distinct possibility instead of the parallel LC circuit used, and design information is available from many sources for those wishing to experiment. Linsley Hood[6], for example, describes a related system for achieving high frequency preemphasis in his cassette recorder instead of using coils.

How many filters per stop?

A single tone filter, implemented at one design frequency, will not produce the same tonal effect across an entire keyboard which (in the case of five octaves) might represent a frequency range of 32:1. Yet there is evidence in favour of using single filters when cost is paramount: the single filter approach often produces subjectively reasonable results. In my experience this statement is true for flue pipe tones that are simulated using simple low-pass filters (flutes and diapasons), where an effective range of three or four octaves can be obtained without difficulty. Beyond this, these tones begin to sound unnaturally stringy in the bass and too characterless in the treble, and in addition there is an overall reduction in amplitude when going from low to high frequencies. This last problem can be mitigated by grading the isolating resistors that are nearly always found in the keying system.

6. Linsley Hood, J.L. Low-noise, low-cost cassette deck, Wireless World May, June & August 1976 and Feb. 1978.

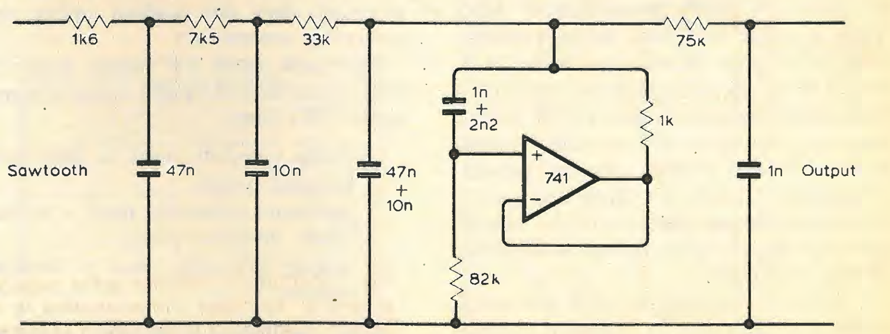


Fig. 8. Cornopean reed filter using synthesized inductance as alternative to circuit of Fig. 6(d).

There are two reasons why a single low-pass filter has such a large effective frequency range. First, it is easy to show that if the filter characteristic and the source waveform spectrum both approximate to linear slopes, not necessarily numerically identical, over a sufficiently large frequency range then the relative harmonic proportions in the output signal remain constant over this range. There is also an overall amplitude variation that can be dealt with as previously described. These approximations are valid for the claribel flute filter and the sawtooth spectrum already discussed, and also for the open diapason though to a lesser extent. The second reason why a single filter is usable in these cases is that to achieve a uniform acoustic output, the pipes in a real diapason or flute stop are scaled so that they have a relatively larger proportion of higher order harmonics in the bass than in the treble. This effect is the same as that produced by driving a single flute or diapason type filter over a wide frequency range.

With other tones (strings and reeds) an effective range of only two octaves or less is usual because of the more selective frequency response of the filter networks. Beyond this range the effect is artificial, particularly in the bass, where the stops sound "sizzly" and thin. There is little that can be done in these cases except to use multiple filters for each stop, each one designed to operate over a particular segment of the keyboard. The limiting extreme, of course, is to employ one filter per note, a tour-de-force that has certain advantages in spite of the enormous component count. The advantages stem from

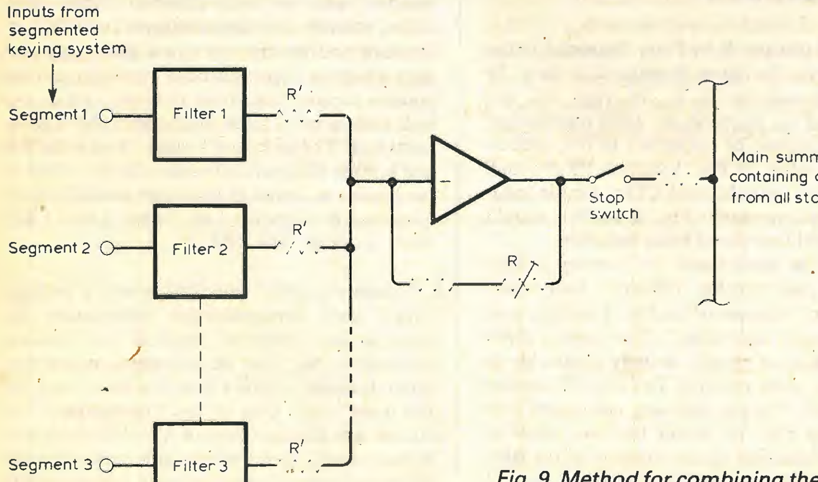


Fig. 9. Method for combining the outputs of a number of filters corresponding to one stop. R′ controls the regulation of the stop across the keyboard, R controls the overall amplitude of the stop.

supplied with a sawtooth wave at the same amplitude as the existing one but at three times the frequency, i.e. at the interval of a twelfth above the note being keyed. The twelfth corresponds to 2⅔′ in footage quate results can be achieved using different filters for each half-octave; indeed even this is usually an overkill. I have built a classical instrument of 36 speaking stops, all of which employ only four filters and the result is most satisfactory, especially with regard to such features as the sound of reed choruses at the bass end of the keyboard. The method used to combine the outputs of the filters comprising one stop is illustrated in Fig. 9. Each is terminated in a resistor R′ that can be used to regulate its amplitude. Judicious variation of the relative amplitudes is useful in hiding the breaks between each pair of filters, yet another psychoacoustic feature of the auditory system that works in our favour. Overall gain variation is provided by making part of the negative feedback resistor R variable.

More practical points

All of the filters discussed here must be driven from a low impedance source, in practice a few tens of ohms, and terminated in a high impedance, at least five times greater than the impedances involved in the final stage of the filter. Straightforward operational amplifier techniques are suitable here.

A pronounced change can be imparted to particular tones if only one or two harmonics are selectively augmented. For example, increasing the level of the third harmonic in the claribel flute Fig. 2(a) changes the tone to that of quite a good lieblich gedackt. Similarly, diapasons and flutes can be distinctly brightened by augmenting the second harmonic. In each case this can be done by borrowing the appropriate sawtooth wave from the multiple keying system that usually exists in which several frequencies are switched simultaneously for each note. The additional frequencies are combined in the filter simply by providing more input resistors, as in Fig. 10. This shows the claribel flute filter together with an additional input which is

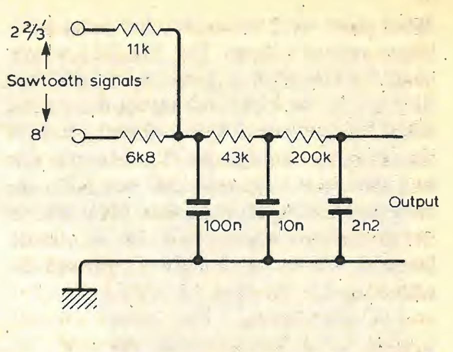


Fig. 10. Converting the claribel flute into a lieblich gedackt by augmentation of the third harmonic.

the ability to regulate the tone quality and loudness on a note-by-note basis, and the audible "breaks" between filters that can be troublesome when a lesser number is used do not exist. However, entirely ade- nomenclature if the stop is of eight foot pitch. Three points to remember:

–It is important that the impedance of the sawtooth wave sources should be low, otherwise incorrect summation will result.

–The parallel combination of the various input resistors must approximate to the resistance calculated for the original filter.

–It is not necessary that the frequency relationships between the fundamental and the augmented harmonics be mathematically exact. This makes it possible to borrow the required harmonics from an equally-tempered tone generating system. Such borrowing can only be done to a limited extent; some intervals will be grossly out of tune, though in the case of the twelfth the effect is not serious. For all octavely related intervals, of course, this is irrelevant. A certain amount of trial and error is required to achieve the desired results by this means.

Many organs use a single generator system from which all tones are derived. This means that all stops of the same footage are fed with the same waveform when a given key is depressed, and the various signals emerging from the tone filters are then usually electronically recombined before being amplified and fed to a loudspeaker system. Take care that filters do not introduce inadvertent phase shifts due to the indiscriminate use of inverting amplifiers within the filter itself. Such amplifiers might have been used for buffering purposes. Without first designing the tone forming system as a whole and taking account of detailed points such as this, the ability to add stops one to another will be adversely affected. Buffers are therefore best implemented using non-inverting amplifiers, for example, voltage followers. The problem of combining tone colours is further considered below.

The construction of analogue filter circuits for most purposes usually involves close-tolerance components, and the free use of resistors from the E24 range in the tone filters illustrated in these articles might imply that the same applies in this case. These values were used simply because they were available; for most purposes resistors from the 5% E12 range should be adequate. Capacitors in active filters, e.g. the synthetic inductor circuits, should be at least 5% but elsewhere 10% should prove satisfactory. The object is not to produce a highly precise scientific instrument but to reproduce musical effects in a context where 3dB in amplitude (around 30%) is fortunately of little significance.

Combining stops

Regardless of deliberately introduced phase inversion filters normally produce a certain amount of phase shift, usually frequency dependent. With a common generator system, in which the same waveform is split into several paths through various filters before being recombined and amplified, there is bound to be a degree of emphasis or attenuation of particular harmonics in the final signal. This has the practical effect that the result of adding stops will be the production of a composite sound that is not necessarily the subjectively expected result of adding the individual tone colours. The effect is most noticeable for stops of the same footage, and if the problem is troublesome then various remedies can be used. The best technique is to have a multi-rank generator system in which there are as many ranks as stops that are likely to be combined. The various ranks are not phase locked to each other but must run independently. Whilst there are various technical problems inherent in this approach, not to mention cost, the chorus effect of the result can rival that of a pipe organ and it is worthwhile if economics allow. The other method, less effective but still expensive, is to retain a single generator system but only allow recombination of the filter outputs to occur acoustically through the use of a multiplicity of sound channels. Electronic "chorus" can also be judiciously applied to each channel to enhance the effect.

The combining problem is sometimes exaggerated, and a cost-effective compromise is obtainable at minimal expense simply by applying a few artistic guidelines when developing the specification (stop list) of a new instrument. In normal pipe organ registration, that is the art of selecting stops to achieve a particular tonal effect, it is preferable to minimize the number of stops of the same footage that are used. Even with the pipe organ, which has the ultimate in chorus effects owing to its huge variety of non-synchronized tone sources, it is inartistic to pile tone on tone when one or two carefully chosen stops would suffice. When major tonal build-ups are required, this should be achieved by adding stops of different footages, and exactly the same guidelines apply to an electronic organ of whatever sort though particularly if it only has a common generator system. In this case, the addition of a 4′ stop to an 8′ one introduces a new harmonic series that only interferes, in the technical sense, with half as many harmonics in the basic 8′ tone as would be the case if a second 8′ stop had been added. The resultant tone is much more realistic in general. The only expense involved in following this principle is that the single generator rank has to be extended upward by the appropriate number of octaves to cater for the extra upperwork present in the stop list, and the keying system is also made correspondingly more complex.

It might be thought that adjustable filters can be used in the filter design process to quickly arrive at a subjectively satisfactory result simply by twiddling knobs. A useful configuration, it might be argued, would be a resonance filter module as used in synthesizers in which the tuned frequency and Q are independently variable through the use of state-variable techniques. This approach has been eschewed as it represents a return to the total empiricism that negates the design methodology outlined. If it is possible to calculate a frequency response, then the starting point should be a filter that approximates this response in a reasonably cost-effective manner. This does not disallow small changes to the prototype circuit to secure a better result, but too much dabbling will quickly lead the ear in a false direction that becomes all too obvious if an A-B comparison is subsequently attempted. If it is impossible to achieve a satisfactory simulation of the desired sound, then the original experimental data should be suspected as being unreliable, and an attempt to obtain new data should be made. □

Audio gain controls – corrections

In Part 1 of this article by Peter Baxandall in the October issue, the figure shown as 2 in the p. 59 footnote should be $\sqrt{2}$. In Fig. 16, the secondary of the microphone input transformer should, of course, be connected to the control-grid of the valve. In Fig. 1 caption "Two small gain controls" should read "Two simple gain-control arrangements". Fig. 3 caption should read "Dotted line shows noise variation . . . .". Fig. 6 caption should end " – varying emitter resistance and varying collector load resistance." For "equivalent" in Fig. 8 caption read "approximately equivalent". The caption given for Fig. 14 is, of course, equally applicable to most of the other circuits! The Fig. 15 caption should read "Curves showing calculated performance of Fig. 14 circuit for two values of R_b". The simplified circuit diagram of the BBC OBA9 microphone amplifier shown in Fig. 17 should have been acknowledged as taken from "Studio Engineering for Sound Broadcasting" by J. W. Godfrey. BBC Eng. Training Manual, pub. by Iliffe & Sons, 1955.

Literature received

Intelligent v.d.us, namely the BH912 and BH920, are the subjects of two new publications which are available on request from Burnt Hill Electronics. They illustrate the terminals and provide data on operating features, together with keyboard layouts and dimensions etc. Burnt Hill Electronics, Holder Rd, Aldershot, Hampshire GU12 4RH.

A folder containing a selection of data sheets on **analogue monolithic i.cs** has been sent to us by Pascall. Analog Systems, who manufacture the products described, seem to specialize in making devices with "out of the ordinary" specifications such as an audio op-amp with a t.h.d. of typically 0.0002% and a wide-band op-amp with a 1.5GHz gain bandwidth product. Application notes are included on the sheets and some of the other products available through this distributor are described on the actual folder. Price list and "short-form" data list were also included in the package. Pascall Electronics Ltd, Hawke House, Green St, Sunbury-on-Thames, Middx TW16 6RA.

Full data for the range of fixed frequency and tunable **quadrature oscillators** manufactured by Frequency Devices Inc. is available in catalogue form from their UK representatives, Lyons Instruments Ltd. A series of modular power supplies is also described in the catalogue which is available free of charge from Lyons Instruments Ltd, Hoddenson, Herts.

Twelve articles are included in volume eight of the series of Chromatography Newsletters from Perkin-Elmer Ltd. These regular publications feature articles on advanced technology applications in both **liquid and gas chromatography**, the latest of which can now be obtained from Perkin-Elmer Ltd, Post Office Lane, Beaconsfield, Bucks, at no cost by requesting order number CHN-15.

Solid-electrolyte **tantalum chip capacitors** for use in hybrid circuits are described in an "Engineering Bulletin" received from Hy-Comp Ltd. This two-page leaflet gives full data for the Type 194 Midget series and is available from Hy-Comp Ltd, 7 Shield Rd, Ashford Industrial Estate, Ashford, Middx TW15 1AV.

Details of Evershed & Vignoles' **stepping motors** based on three different design principles, namely permanent magnet, variable reluctance and hybrid types, are given in a six-page brochure. Specifications provided include holding torque, maximum pull-out torque, no-load pull-in rate, rotor inertia and physical dimensions. The company's range of unipolar RL and bipolar chopper drives are also described in the brochure, copies of which are available from Evershed & Vignoles Ltd, Acton Lane, Chiswick, London W4 5HJ.

Commodore have provided us with a package which gives comprehensive information not only on their range of personal and business **computers** but also on **software**, microcomputer **training courses** and seminars, and the Pet users' club. One of two "newspapers" included was the first issue of Microcomputers in Schools and Colleges which, although obviously Pet biased, should provide useful information to teachers and lecturers who are thinking of acquiring a computer for use as a teaching aid. Commodore Information Centre, 360 Euston Road, London NW1 3BL, for details.

Developments in air traffic control

Royal Signals and Radar Establishment looks ten years ahead

An expected huge increase in the number of aircraft using UK airports and airspace (between 50% and 100% over the next two decades) would overload existing air traffic control equipment and procedures to an impossible degree, causing greatly increased delays in handling aircraft and consequent increases in fuel consumption and engine hours. The kind of display a controller uses means that he needs to carry some kind of mental picture of the position, height and direction of flight of many aircraft and attempt to predict the situation as far ahead as possible. Currently, two to three minutes is as far as he can go.

Since the late 1960s, the Royal Signals and Radar Establishment at Malvern has been working on several projects to alleviate the pressure on controllers. On behalf of the Civil Aviation Authority, scientists at RSRE have evolved a system known as ADSEL, which is Address-Selective secondary radar. They also have some novel ideas on ways to avoid aircraft being inadvertently directed to fly too close to each other, and on methods of smoothing out the flow of traffic on arrival at and departure from airports.

ADSEL

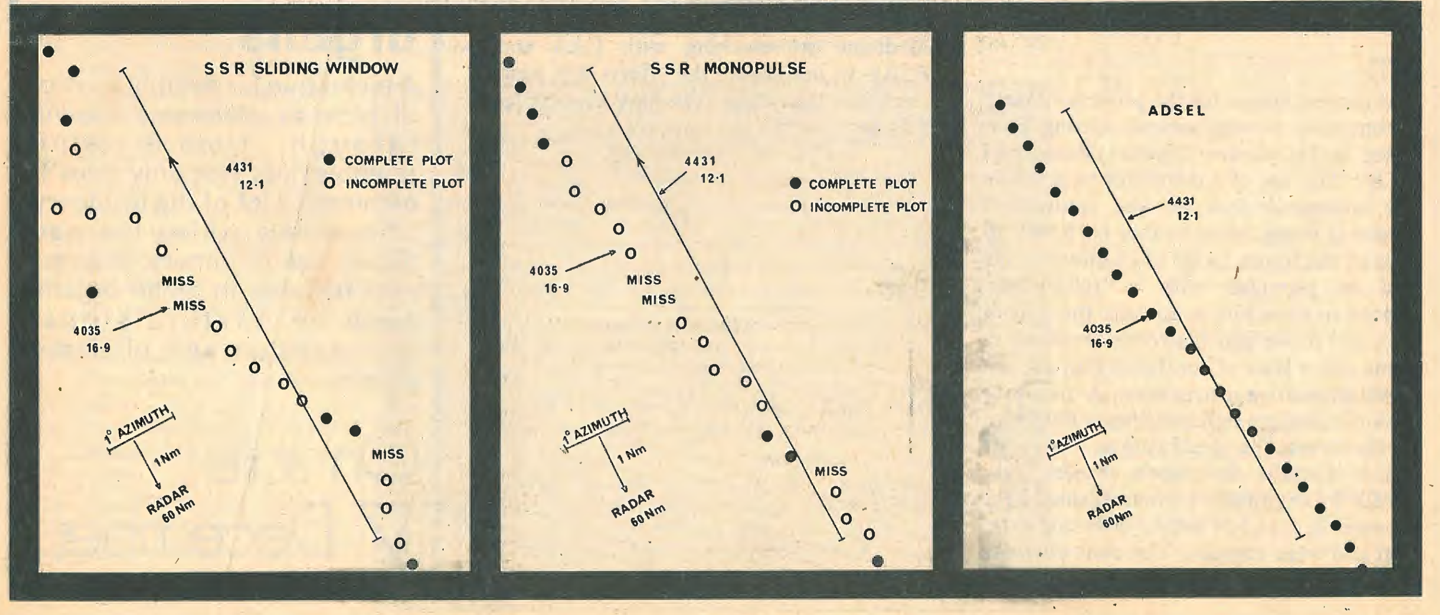
For many years, secondary surveillance radar has been the mainstay of air traffic control. Its shortcomings have been accepted in the past, but a growth in the number of aircraft may make it unacceptable: ADSEL is suggested as an alternative.

Secondary radar relies on the aircraft under control carrying a transponder, which receives pulses from the ground at 1030 MHz when the aircraft is in the beam, and immediately responds with a series of pulses at 1090 MHz to form a 12-bit code for identification purposes. (In primary radar, the transmitted pulse is reflected from the aircraft which, incidentally, necessitates a much more powerful ground transmitter.) During the time the aircraft is in the beam, it receives and responds to around 30 interrogations. Range is easily measured, since it corresponds to the time taken for the aircraft's response to be received, or the distance from the centre of the controller's plan position indicator (p.p.i.) tube to the brightened-up, coded group of responses. Bearing is more difficult, since the group of responses is as wide as the beam, and is undertaken by a computer plot extractor, which attempts to find the 'centre of gravity' of the group by a 'sliding-window' technique. In a perfect set of replies, the centre would be aligned with the aircraft and would correspond to the bearing, but missed responses would mean that the plot extractor would determine a false 'c.of.g.' and give a wrong bearing, or even misread the imperfect set as two aircraft.

Missed responses, perhaps due to the aircraft banking and obscuring its aerial or trying to reply to two ground stations and not succeeding with either, are not the only problem. If two aircraft are on roughly the same bearing and are at about the same slant range from the transmitter, their groups of replies overlap, rendering them unreadable, or 'garbled'. There is also the condition known as 'fruit', which is the reception at the ground station of replies to interrogation by other transmitters. These are not synchronous and are not, therefore, as serious a fault as garbled replies but, nevertheless, constitute a lowering in readability of the display.

ADSEL, which is being developed in parallel with a very similar American system, called Discrete-Address Beacon System (DABS) because the Americans refer to s.s.r. as 'beacon', avoids most of the above trouble by selecting the aircraft the controller wishes to respond. In ordinary s.s.r. two pulses are transmitted (actually three, but that is irrelevant to this discussion) all aircraft being thereby commanded to respond with their codes. In contrast, after first interrogating all aircraft (all-call), ADSEL's computer determines each aircraft's position at the next scan and transmits a uniquely coded interrogation when it is next in the beam, ensuring that only one replies, after which all-call is locked out. If a subsequent reply is lost, the interrogator reverts to the all-

Comparison of displays of one aircraft (4035) overtaking another (4431), using ordinary s.s.r. with 'sliding window', ordinary s.s.r. with a monopulse receiver and aerial and ADSEL. ADSEL suffers no misses due to garbling and the monopulse technique used in ADSEL produces a greatly increased bearing accuracy. The track of 4431 is shown idealized.



call mode. Garble is thereby avoided and, since only a single reply is received per scan for each aircraft, the number of redundant responses on the display is much reduced. Up to four repeat interrogations are transmitted in the event of a missed response.

The interrogation and reply include message bits, which could be used to pass instructions and the transponder to send information on airspeed, rate of turn, air temperature, etc. Interrogations carry a 24-bit parity/address field, which ensures a very low probility of undetected error in the presence of s.s.r. interference.

To complete the set of data, the target's bearing must be determined using the single reply which, since the bearing of the target is indeterminate to an extent depending on the width of the transmitted beam, dictates on extremely narrow beam. A technique known as monopulse is the answer here. Instead of a single transmitter aerial, a split type is used in an interferometric configuration. As the beam tracks across the target, its return signals at the two halves of the aerial vary in phase; only when the aircraft is exactly on the boresight (centreline) are the two signals exactly in phase. On reception, both halves of the aerial are used, in such a way that sum and difference signals are combined. Separate, logarithmic i.f. amplifiers are followed by a circuit which subtracts the log. sum from the log. difference. Since the ratio of the two is the same at any bearing, the video amplitude is the same at all ranges. The position of any aircraft within the beam can be measured to an accuracy of 5 minutes of arc.

The increased bearing-determination accuracy of the monopulse technique means that the track of an aircraft is not a somewhat irregular succession of returns on the controller's screen, but a smoothed-out, almost perfectly regular train of dots. (The final appearance of a target on the screen is not the 'raw' response, but a computer-manipulated symbol composed of a dot with the aircraft's identification and height.) Indeed, the CAA and RSRE take the view that the use of monopulse alone would improve the quality of the display enough to cope with expected traffic increases until 1990.

ICR

The current jargon for the process of using a computer to stop aircraft hitting each other is Interactive Conflict Resolution (ICR). The use of a computer to generate the annotated dots on the controller's screen is being taken further by RSRE to predict the future by up to 15 minutes. He will be provided with a 'rolling-ball' control to allow him to advance the state of play and to see which aircraft are likely to come into a state of conflict if they are not given alternative instructions. A 'menu' of possible changes in flight plan is displayed on the screen, the ideal being to choose one which disturbs the pilot's chosen flight profile by the smallest amount, since large changes in speed or height consume extra fuel and wear engines. The controller can 'try out' any of the possible changes and the computer will indicate whether the alteration would resolve the conflict. If not, he tries another possibility until the computer indicates "no conflict for this aircraft", whereupon he returns to real time and instructs the pilot accordingly. The computer will also warn automatically of impending conflicts.

Terminal control

Computers and v.d.u.s are also of use in the scheduling of aircraft on the ground, using data from other a.t.c. centres to ensure that flights are not allowed to take off if, by doing so at that particular time, they are likely to arrive at a 'pressure point' (a congested sector of airspace) at the same time as another. The computer shows all such aircraft at the correct times at each pressure point, the display changing minute by minute, and allows the controller to determine when a flight can be allowed to leave without possible conflict en route.

RSRE and CAA are at pains to point out that the work described is in the experimental stages. ADSEL is well advanced, several sets of equipment having been evaluated successfully, but even so, it will not be in service for two or three years, chiefly for economic reasons – it requires aircraft to carry updated transponders and ground stations to instal new interrogators. Re-equipment will take time and, since a.t.c. is international, ICAO will need to agree ADSEL/DABS before it can be used although it is compatible with s.s.r. and can be introduced gradually. ICR is in the early stages and may not be in service for ten years, although equipment working in a shorter time frame may be introduced sooner than this.

The ICR system, and other applications of computers to activities which involve safety, are responsible for a certain amount of psychological questioning. Some controllers who have used ICR in simulations of actual air activity have noticed a tendency in themselves to rely rather too much on the computer. If it indicates 'no conflicts', they find themselves a little too ready to believe it: they do not care for the feeling they have of losing part of their control of the situation. The University of Aston and the RAF Institute of Aviation Medicine are working with CAA and RSRE to investigate the effects this kind electronic 'assistance' can have on people.
P.R.D. □

IN OUR NEXT ISSUE

Microprocessor trainer

Designed to familiarize the complete beginner with microprocessors, this small unit with hex keyboard and six-digit display nevertheless has enough facilities to become a useful tool later on. The circuitry contains 9 i.cs on one double-sided p.c.b. with storage of 4Kbytes of e.p.r.o.m. and over 1Kbyte of r.a.m.

Off-air frequency reference

This instrument provides a 10MHz signal phase locked to the BBC's 200 kHz Radio 4 Droitwich transmission. Modifications are available to allow for the eventual change of the transmission to 198kHz. The reference comes from a 10MHz crystal oscillator tuned via a varicap diode from the error signal in a phase locked loop.

Multiplex keying for organs

A technique for flexible control of pipe or electronic organs through time-division multiplexing. Not only does it eliminate a lot of the drudgery of repetitive wiring but also allows use of hitherto impractical features in small organs such as mixture stops, transposition and pizzicato effects.

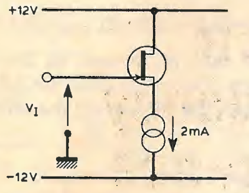
On sale 17 December

Test your knowledge

Multiple-choice quiz for students and circuit designers

by R. W. Ellingham and B. L. Hart North East London Polytechnic

1. A low power bipolar junction transistor operates at a temperature of 26°C in the forward active mode at a collector current of 1.5 mA. The mutual conductance in mS is approximately
(a) 20
(b) 40
(c) 60
(d) 80.

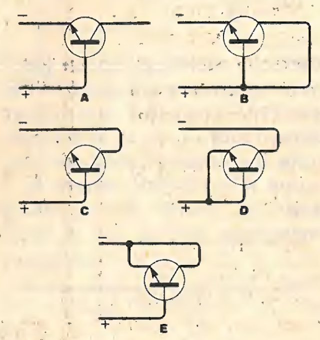


2. The junction f.e.t. shown has an ideal square-law mutual characteristic with I_{DSS} 4 mA, V_P (pinch-off voltage) −4 V. The f.e.t. enters the pre-pinch-off state when V_I, in volts, reaches
(a) 6
(b) 8
(c) 10
(d) 12.

3. *Assertion:* When a bipolar junction transistor is operated in the saturated mode the magnitude of the collector-emitter voltage must always exceed zero, *because*
Reason: the operation of a bipolar device depends on the existence of two polarities of carrier.

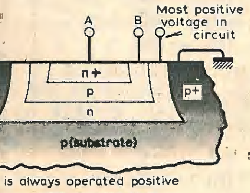
(a) both assertion and reason are true statements and the reason is a correct explanation of the assertion
(b) both assertion and reason are true statements but the reason is not a correct explanation of the assertion
(c) the assertion is true but the reason is a false statement
(d) the assertion is false but the reason is a true statement
(e) both assertion and reason are false statements.

The figure shows five ways in which the leads of a monolithic integrated circuit transistor can be connected to obtain a diode type volt-ampere characteristic.



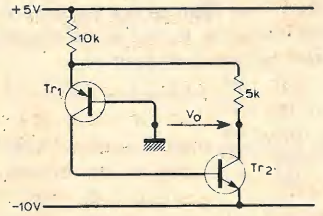
4. For medium and high current levels the highest forward conductance is exhibited by connection
(a), (b), (c), (d) or (e).

5. For a given forward current and specified reverse current the connection exhibiting the smallest minority carrier storage time is
(a), (b), (c), (d) or (e).

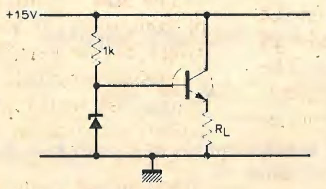


A is always operated positive with respect to B

6. The diagram represents a cross-section of a monolithic integrated circuit structure. The element between the terminals A and B is designed to function primarily as a
(a) resistance
(b) diode
(c) capacitance
(d) silicon controlled rectifier
(e) lateral transistor.
A is always operated positive with respect to B.

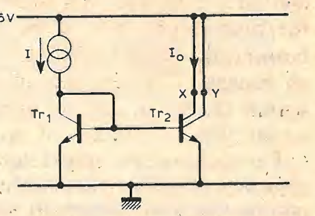


7. For the circuit shown the transistors both have $h_{FE} > 100$. Assuming that the forward voltage drop of the base-emitter junction of a conducting transistor junction may be taken as zero volts, the approximate value of v_0, in volts, is
(a) +5
(b) +2.5
(c) −2.5
(d) −5
(e) −10.

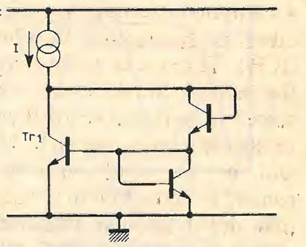


8. The circuit arrangement of a simple voltage stabilizer is shown. For the 200mW zener diode V_Z is 5V and for the transistor I_C/I_B=10. The maximum current in the load R_L, in mA, for which the load voltage is stabilized is
(a) 90
(b) 100
(c) 110
(d) 150
(e) 165.

9. In the voltage stabilizer circuit a load current in R_L of 99 mA is switched on for 1 ms and off for 1 ms continuously. The mean power is dissipated in the zener diode under these conditions, in mW, is approximately
(a) 55
(b) 50
(c) 27.5
(d) 25
(e) 22.5.



10. The circuit shows two monolithic transistors in a current mirror configuration. The emitter area of Tr_1 is *A* units, whereas the emitter area of Tr_2, which has two separate identical collector regions with output terminals at X and Y, is 3*A* units. The current I_o at terminal X, neglecting transistor base currents, is
(a) $I/3$
(b) $I/2$
(c) $2I/3$
(d) I
(e) $3I/2$.



11. Assume the monolithic transistors are identical. For each device the d.c. behaviour is completely specified by $|I_C|=\alpha|I_E|$. In terms of I, the collector current of Tr_1 is

(a) $\dfrac{\alpha I}{(1+\alpha)}$

Christmas Quiz Prizes

Prizes for the Christmas Quiz will be copies of "Circuit Designs 3", the latest volume of collected Circards from the Wireless World series produced by P. Williams, J. Carruthers, J. H. Evans and J. Kinsler (normally £14). Winners may, however, choose the alternative prize of a one-year free subscription to Wireless World (normally £10 in the UK, $33.80 overseas).

UK prizewinners will be the first ten entries with the correct answers opened after 5 January 1981. More time has to be allowed for the distribution of the journal to readers outside the UK, so in this case the prizewinners will be the first ten overseas entrants with the correct answers opened after 2 March 1981. The correct answers will be published in the Apiril issue Wireless World.

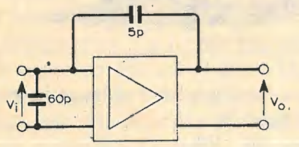
Your entry must contain your name and full address and also a note stating which of the two prizes you would like if you qualify as a winner. Send your entry to: Christmas Quiz, Editorial Department, Wireless World, Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS, England.

(b) $\frac{l}{2}$

(c) $\frac{l}{(1+\alpha)}$

(d) $\frac{\alpha l}{2}$

(e) $\frac{2\alpha l}{(\alpha+2)}$.



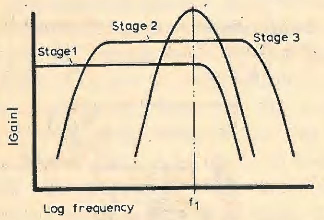
12. The amplifier shown has a voltage gain $A_v=V_0/V_i=9\angle 180°$. The effective input capacitance C_i, in pF, is
(a) 20
(b) 65
(c) 100
(d) 105
(e) 110.

13. An amplifier of nominal gain A=1000 has negative feedback applied so that the gain with feedback A' has a nominal value of 100. The feedback is constant. If A increases to 1500, A' is
(a) 103.4
(b) 105
(c) 125
(d) 133.3
(e) 150.

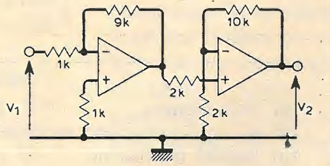
14. An amplifier consists of three identical stages in cascade. Each stage has a voltage gain G at any frequency f (MHz)

$$G=-\frac{10}{1+j10f}.$$

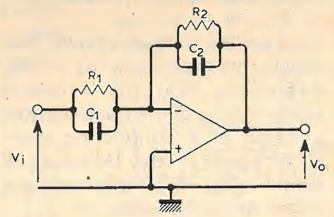
A real positive fraction β of the output voltage is fed back to the input circuit to reduce the overall gain at low frequencies. The value of β required to provide a gain margin of 12 dB is
(a) 0.001
(b) 0.002
(c) 0.004
(d) 0.008
(e) 0.016.



15. The frequency response of each of three cascaded amplifier stages is shown. The asymptotes to the response slopes increase or decrease 6 dB/octave and each stage introduces a phase inversion at the frequency f_1. Overall feedback (real positive feedback fraction) is introduced. As the feedback fraction is progressively increased the three-stage amplifier will
(a) remain unconditionally stable
(b) oscillate at a frequency f_1
(c) oscillate at a frequency less than f_1
(d) oscillate at a frequency greater than $f1$
(e) oscillate at frequencies less than and greater than f_1



16. Assuming each of the operational amplifiers to be ideal, the ratio of the incremental voltages, V_2/V_1, in the circuit arrangement shown is
(a) +54
(b) +45
(c) −45
(d) −50
(e) −54.



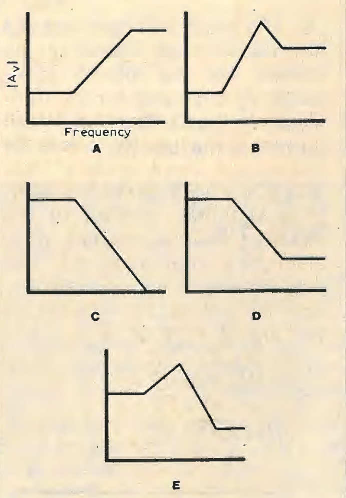
17. The operational amplifier in the circuit arrangement shown is ideal and

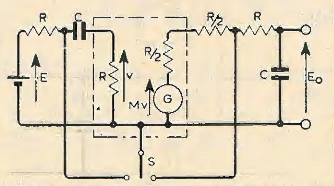
$$\frac{C_2}{C_1} > \frac{R_1}{R_2}$$

The frequency response

$$|A_v|=\left|\frac{v_o}{v_i}(j\omega)\right|$$

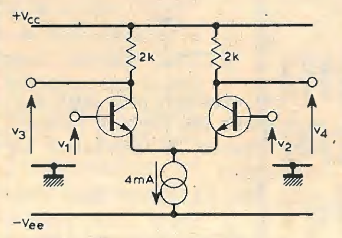
approximately as shown at A, B, C, D or E.





18. In the basic circuit of a chopper amplifier shown, if $CR \gg T$, where T is the period during which the contacts of the switch S are open or closed, the output voltage E_o is approximately
(a) $\frac{ME}{9}$
(b) $-\frac{ME}{9}$
(c) $\frac{ME}{4}$
(d) $-\frac{ME}{4}$

Perfectly matched bipolar junction transistors are used in the emitter-coupled amplifier shown and v_1, v_2, v_3 and v_4 denote incremental voltages. Assume KTq=25 mV, where K, T and q have their usual meanings.

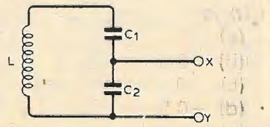


19. If $v_1=-v_2$=0.5 mV the differential output voltage v_3-v_4, in mV, is approximately
(a) 0
(b) 80
(c) −80
(d) 160
(e) −160.

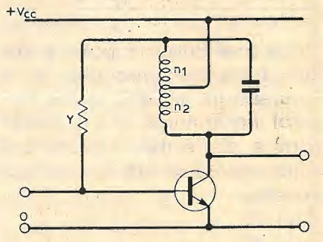
20. If $v_1=v_2$=1mV the differential output voltage v_3-v_4, in mV, is approximately
(a) 0
(b) 160
(c) −160
(d) 320
(e) −320.

21. If v_1=1 mV and v_2=0 the single-ended output voltage v_4, in mV, is approximately
(a) 0
(b) 80
(c) −80
(d) 160
(e) −160.

22. An emitter-coupled amplifier has a differential gain magnitude of 1000 and a common-mode rejection ratio of 100. For input voltages of 1.1 mV and 0.9 mV a possible value for the magnitude of the differential output voltage, in mV, is
(a) 200
(b) 210
(c) 220
(d) 400
(e) 420.



23. In the parallel tuned circuit shown the capacitors are loss-free and the effective parallel loss resistance of the inductor L is 90 kΩ. So that the connection of a load resistor, resistance 10kΩ, between X and Y results in a resonant circuit Q factor of one half of the unloaded value, the ratio of the capacitance of C_1 to the capacitance of C_2, is
(a) 1/3
(b) 1/2
(c) 2
(d) 3.

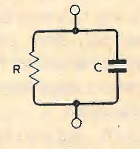


24. For the transistor used in the single-stage narrow-band tuned amplifier shown

y_{11}=(0.6+j7.2)mS y_{12}=j0.2 mS.

The coil is tapped at $2n_1=n_2$ turns. For neutralization of the stage the value of the admittance Y, in mS, is
(a) 0.6−j7.0
(b) j0.1
(c) −j0.1
(d) j0.4
(e) −j0.4.

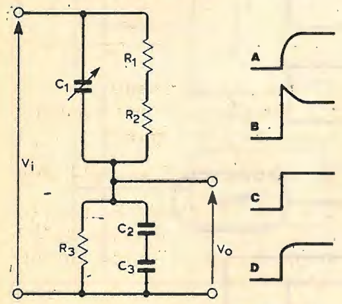
25. The mean square open-circuit thermal noise voltage generated between the ends of a resistor R at absolute temperature T in a bandwidth of 1Hz is directly proportional to the product of R and T. The thermal noise power dissipated in two equal resistors in parallel at temperatures of 300 K and 330 K exceeds that in the two resistors at the same temperature of 300 K by
(a) 1%
(b) 2½%
(c) 5%
(d) 10%
(e) 15%.



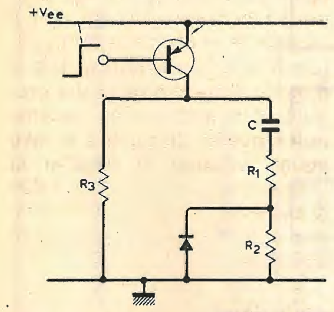
26. In the circuit arrangement shown the resistance of R is doubled, the capacitance of C is halved and the temperature of both components is unchanged. The r.m.s. value of the noise voltage developed across the terminals will
(a) increase by a factor of 2
(b) increase by a factor of √2
(c) not change
(d) decrease by a factor of 2
(e) decrease by a factor of √2

27. An amplifier is matched to a signal source of purely resistive internal impedance. If the only noise generated within the amplifier is thermal noise in the input resistance the noise figure of the amplifier, in dB, is approximately
(a) 0
(b) 1
(c) 2
(d) 3
(e) 6.

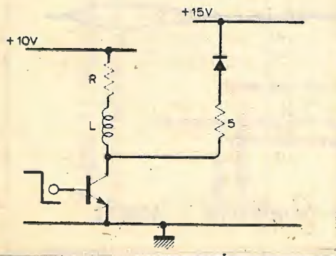
28. In the amplifier of the previous question the internal resistance of the signal source is decreased without change to the signal e.m.f. The effect on the signal-to-noise ratio at the output of the amplifier is
(a) an increase
(b) no change
(c) a decrease
(d) indeterminate.



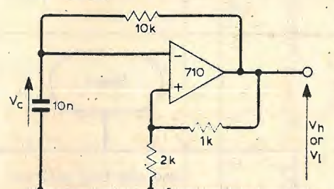
29. If $v_i(t)$, for the circuit shown, is a positive-going voltage step and C_1 is adjusted for the condition $C_1(R_1+R_2)=(C_2+C_3)R_3$, then the shape of the output voltage waveform $v_o(t)$ is most closely represented by A, B, C or D.



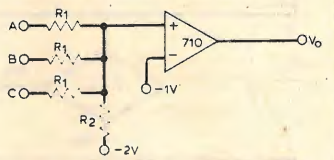
30. Assume the transistor and diode have the characteristics of perfect switches. When the transistor is abruptly switched off, from a state of saturation, the initial current in the diode decays with a time constant
(a) CR_3
(b) $C\left(R_3+\frac{R_1R_2}{R_1+R_2}\right)$
(c) $C(R_1+R_3)$
(d) $C\left(R_2+\frac{R_1R_3}{R_1+R_3}\right)$



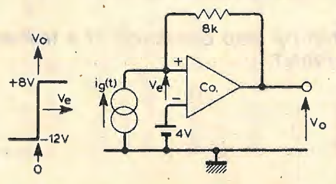
31. The saturated transistor maintains a steady 0.5 A in the relay coil till the transistor is abruptly cut off. Ignoring carrier storage and depletion layer capacitance effects, and assuming the voltage drop across the diode when conducting, is constant at 1 V, the minimum collector-emitter voltage rating to prevent breakdown is
(a) 16.0
(b) 18.5
(c) 21.0
(d) 28.5.



32. The type 710 comparator used in the astable circuit arrangement shown has V_h 3.3V and V_l −0.6V. The amplitude of the voltage waveform V_C, in volts, is
(a) 0.9
(b) 1.3
(c) 1.8
(d) 2.6
(e) 3.9.



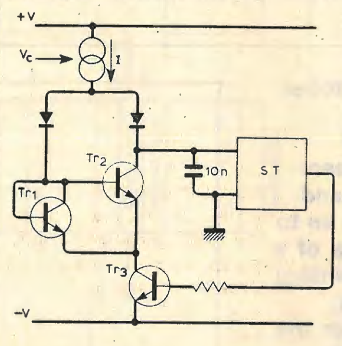
33. In a majority logic gate, circuit arrangement as shown, each input A, B, C can be either 0 V or 5 V. The maximum ratio R_1: R_2 to ensure V_o is high when any two inputs are at 5 V is
(a) 18
(b) 13
(c) 12
(d) 6
(e) 5.



34. The Schmitt trigger circuit shown includes an integrated circuit comparator, C_o, which has the d.c. transfer characteristic given. Neglecting the input current to the comparator, the upper trip current level in mA on the waveform $i_g(t)$, is
(a) −1
(b) +1.5
(c) +2
(d) +3.

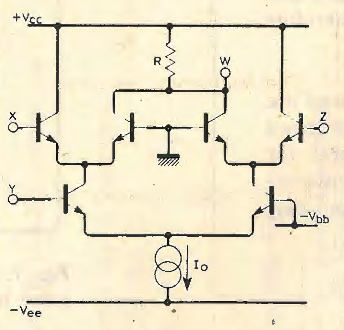
35. Referring to the previous question, the lower trip current level, in mA, on the waveform $i_g(t)$ is
(a) −1
(b) −0.5
(c) 0
(d) +0.5
(e) +1.

In the voltage-controlled oscillator circuit shown, transistors Tr_1 and Tr_2 are closely matched. The conducting state of the saturating switching transistor Tr_3 is controlled by the output of the Schmitt trigger circuit, ST. The controlled current source is variable over the range 200μ to 2mA and the upper and lower trip levels of ST are 3V and 1V respectively.

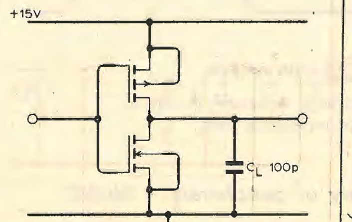


36. The maximum frequency of oscillation, in kHz, is
(a) 5
(b) 10
(c) 25
(d) 150
(e) 100.

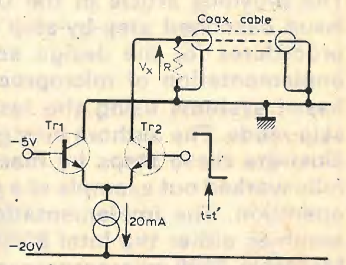
37. The minimum frequency of oscillation, in kHz, is
(a) 5
(b) 10
(c) 25
(d) 50
(e) 100.



38. For the integrated-circuit current switching logic scheme shown the input voltage logic swing is ±0.5 V about the reference potential applied to the base of the associated transistor of a long-tailed pair. Using the positive logic convention the output, W, in terms of the inputs X, Y, Z, is
(a) $W=\overline{X}Y+\overline{Y}Z$
(b) $W=XZ+Y\overline{Z}$
(c) $W=XY+\overline{Y}Z$
(d) $W=\overline{XY}+Y\overline{Z}$.



39. A c.m.o.s. inverter stage is shown in which device leakage currents may be ignored and inter-electrode capacitances are negligible compared with the load capacitor. The power dissipation in the stage, in μW when the input switches between 0 and V+, at an operating frequency of 10 kHz, is approximately
(a) 56
(b) 113
(c) 225
(d) 450.



40. Transistor Tr_2 is on, Tr_1 is off, and d.c. conditions prevail. At $t=t'$, Tr_2 is assumed to switch off instantaneously following the application of a suitable step voltage at its base.
Assertion: If the collector-base capacitance of T_2 is ignored v_x does not change when T_2 switches off, *because*
Reason: v_x=0 for $t<t'$ and there is no collector current in Tr_2 for $t \geq t'$.
(a) both assertion and reason are true statements and the reason is a correct explanation of the assertion
(b) both assertion and reason are true statements but the reason is not a correct explanation of the assertion
(c) the assertion is true but the reason is a false statement
(d) the assertion is false but the reason is a true statement
(e) both assertion and reason are false statements. □

Solutions will be published in the April issue.

Designing with microprocessors

6 – Illustrating a test-and-skip system

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

The previous article in the October issue described step-by-step procedures for the design and implementation of microprocessor-based systems using the test-and-skip mode. The authors now go on to illustrate these steps by means of a fully worked out example of a printing operation. The implementation assumes either the Intel 8080 or the Motorola 6800 microprocessor.

The problem chosen for illustration is to design and implement a test-and-skip system that would allow the programmer to produce a hard copy of data, which is stored in consecutive memory locations. The problem requires the use of an action-/status printer and either the Intel 8080 or the Motorola 6800 to implement the design.

Solution

Our first three design steps are independent of the microprocessor, and therefore are common to both solutions.

Step 1: aim of the design. The aim of the design is to expose the inexperienced reader to uncomplicated procedures for designing and implementing microprocessor-based systems using the test-and-skip mode.

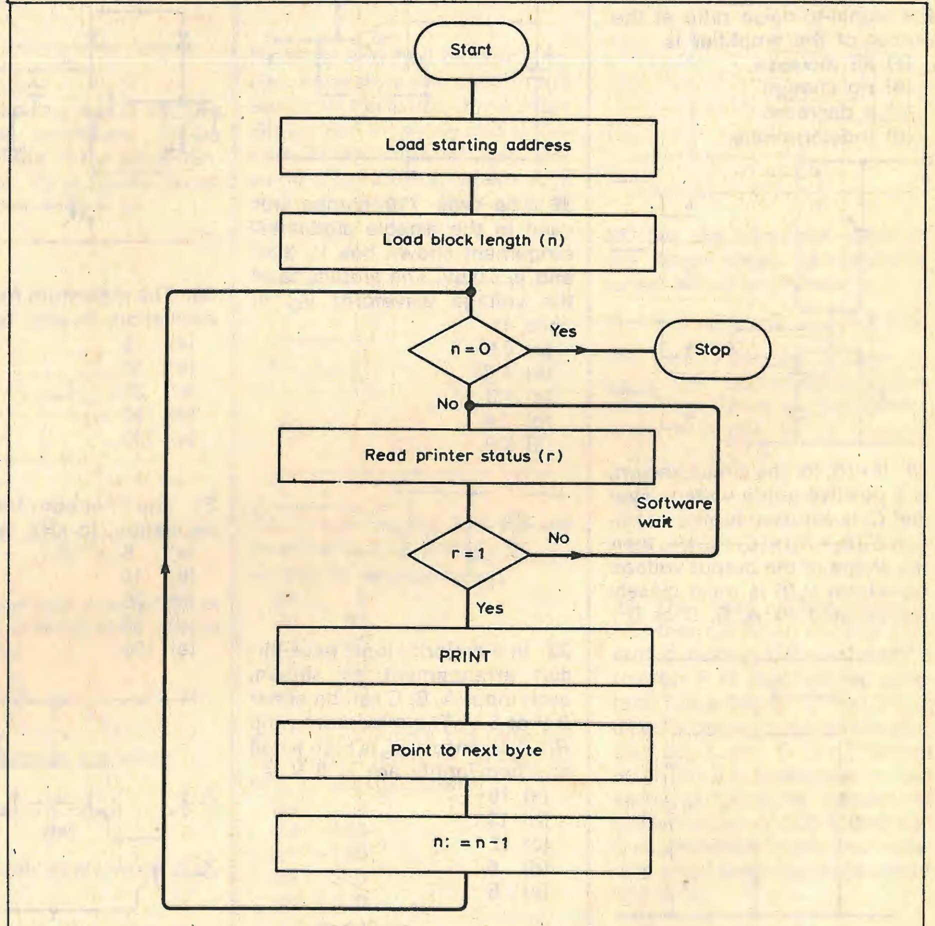


Fig. 1. Step by step operation of a test-and-skip system used to PRINT.

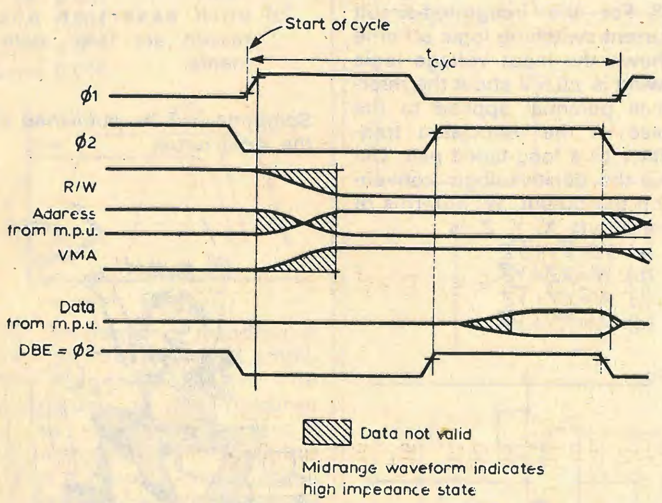


Fig. 2. Read data from memory or peripherals – M6800.

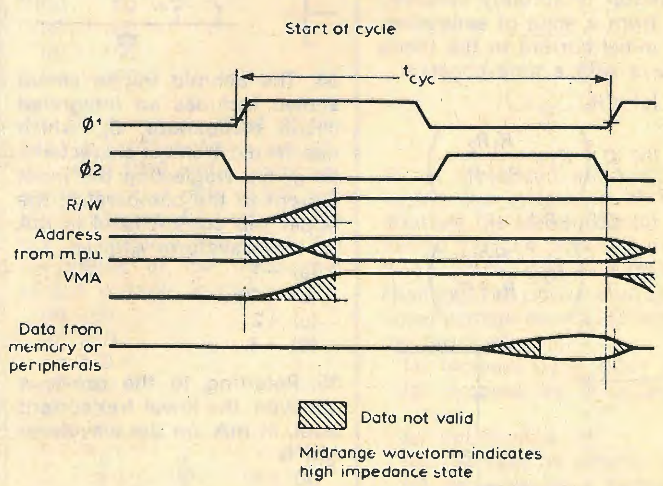


Fig. 3. Write data in memory or peripherals – M6800.

Table 1: Hex listing of the PRINT problem when implemented using the test-and-skip mode and the Motorola 6800.

Hex address	Hex listing	Mnemonics	Comments
0300 01 02	CE 20 40	LDX	Load index register with line 40 on page 20 – location of the first byte to be printed
03 04	86 n	LDAA	Load acc. A with block length (n)
05 06 07	97 01 60	STAA	Copy acc. A (n) into memory location (line 10 page 20) to be used as a counter
08 09	27 10	BEQ	Branch (+16) to L1 if n = 0
L2: 0A 0B 0C	A6 20 07	LDAA	Read printer status
0D	49	ROLA	Rotate left through carry
0E 0F	27 FA	BEQ	Branch (-6) to L2, if printer not ready
10 11	A6 00	LDAA	Copy into acc. A next byte to be printed
12 13 14	B7 20 06	STAA	PRINT
15	08	INX	Point to next byte
16 17 18	7A 20 10	DEC	Decrement byte count (held in memory location 2010)
19 20	20 F0	BRA	Branch (-16) to L2
L1: 21	3E	WAI	Stop

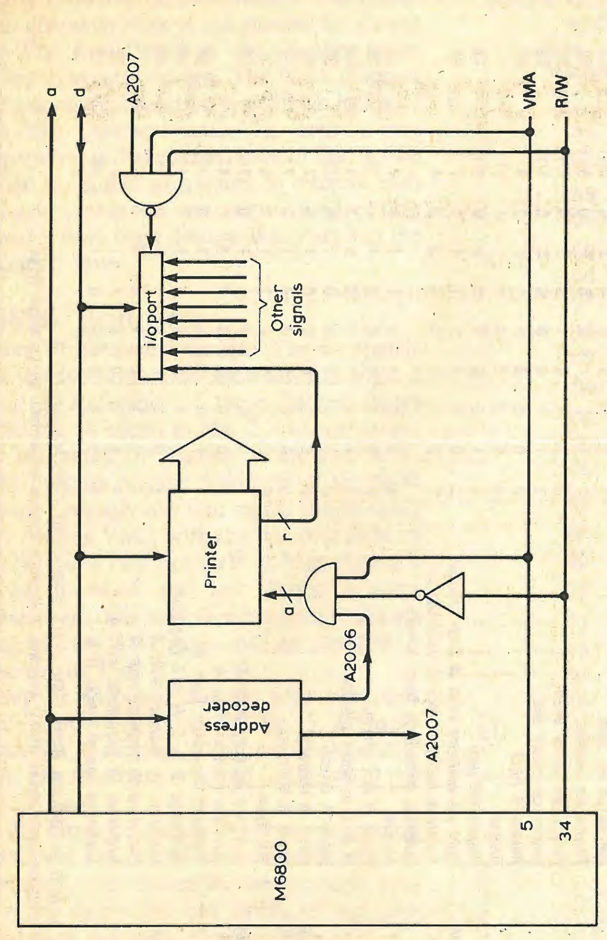


Fig. 4. Interface hardware of the PRINT problem using test-and-skip and the M6800.

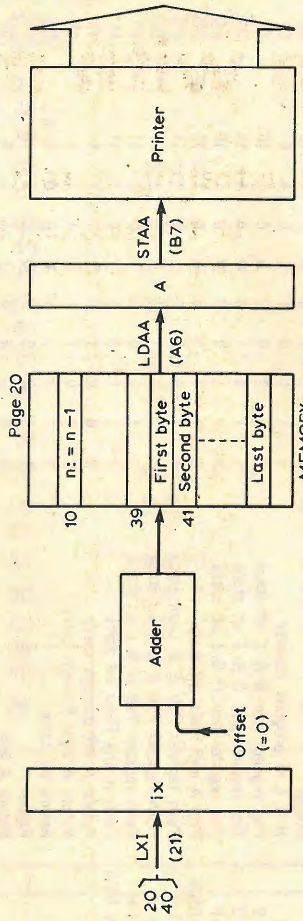


Fig. 5. Programming model for the PRINT problem using the M6801.

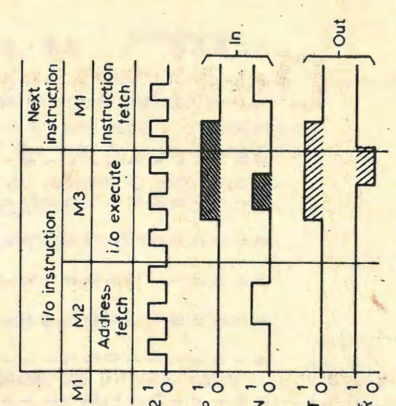


Fig. 6. Input/output (i/o) signals of the Intel 8080.

Table 2: Instruction set for the Intel 8080

Mnemonic	Description	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	Clock (2) Cycles	Hex Code
		Instruction Code (1)									
AC1	Add immediate to *A* with carry	1	1	0	0	1	1	1	0	7	CE
ADC M	Add memory to *A* with carry	1	0	0	0	1	1	1	0	7	8E
ADCr	Add register to *A* with carry	1	0	0	0	1	*S*	*S*	*S*	4	
ADD M	Add memory to *A*	1	0	0	0	0	1	1	0	7	86
Add r	Add register to *A*	1	0	0	0	0	*S*	*S*	*S*	4	
ADI	Add immediate to *A*	1	1	0	0	0	1	1	0	7	C6
ANA M	Add memory with	1	0	1	0	0	1	1	0	7	A6
ANA r	And register with *A*	1	0	1	0	0	*S*	*S*	*S*	4	
ANI	And immediate with I	1	1	1	0	0	1	1	0	7	E6
CALL	Call unconditional	1	1	0	0	1	1	0	1	17	6D
CC	Call on carry	1	1	0	1	1	1	0	0	11/17	D6
CM	Call on minus	1	1	1	1	1	1	0	0	11/17	FC
CMA	Complement *A*	0	0	1	0	1	1	1	1	4	2F
CMC	Complement carry	0	0	1	1	1	1	1	1	4	3F
CMP M	Compare memory with *A*	1	0	1	1	1	1	1	0	7	BE
CMP r	Compare register with *A*	1	0	1	1	1	*S*	*S*	*S*	4	
CNC	Call on no carry	1	1	0	1	0	1	0	0	11/17	4
CNZ	Call on no zero	1	1	0	0	0	1	0	0	11/17	C4
CP	Call on positive	1	1	1	1	0	1	0	0	11/17	F4
CPE	Call on parity even	1	1	1	0	1	1	0	0	11/17	EC
CPI	Compare immediate with *A*	1	1	1	1	1	1	1	0	7	FE
CPO	Call on parity odd	1	1	1	0	0	1	0	0	11/17	E4
CZ	Call on zero	1	1	0	0	1	1	0	0	11/17	CC
DAA	Decimal adjust *A*	0	0	1	0	0	1	1	1	4	27
DAD B	Add *B* & *C* to *H* & *L*	0	0	0	0	1	0	0	1	10	09
DAD D	Add *D* & *E* to *H* & *L*	0	0	0	1	1	0	0	1	10	19
DAD H	Add *H* & *L* to *H* & *L*	0	0	1	0	1	0	0	1	10	29
DAD SP	Add stack pointer to *H* & *L*	0	0	1	1	1	0	0	1	10	39
DCR M	Decrement memory	0	0	1	1	0	1	0	1	10	35
DCR r	Decrement register	0	0	*D*	*D*	*D*	1	0	1	5	
DCX B	Decrement *B* & *C*	0	0	0	0	1	0	1	1	5	0B
DCX D	Decrement *D* & *E*	0	0	0	1	1	0	1	1	5	1B
DCX H	Decrement *H* & *L*	0	0	1	0	1	0	1	1	5	2B
DCX SP	Decremental stack pointer	0	0	1	1	1	0	1	1	5	3B
DI	Disable interrupt	1	1	1	1	0	0	1	1	4	F3
E1	Enable Interrupts	1	1	1	1	1	0	1	1	4	FB
HLT	Halt	0	1	1	1	0	1	1	0	7	76
IN	Input	1	1	0	1	1	0	1	1	10	DB
INR M	Increment memory	0	0	1	1	0	1	0	0	10	34
INR r	Increment register	0	0	*D*	*D*	*D*	1	0	0	5	
INX B	Increment *B* & *C* registers	0	0	0	0	0	0	1	1	5	03
INX D	Increment *D* & *E* registers	0	0	0	1	0	0	1	1	5	13
INX H	Increment *H* & *L* registers	0	0	1	0	0	0	1	1	5	23
INX SP	Increment stack pointer	0	0	1	1	0	0	1	1	5	33
JC	Jump on carry	1	1	0	1	1	0	1	0	10	DA
JM	Jump on minus	1	1	1	1	1	0	1	0	10	FA
JMP	Jump unconditional	1	1	0	0	0	0	1	1	10	C3
JNC	Jump on no carry	1	1	0	1	0	0	1	0	10	D2
JNZ	Jump on no zero	1	1	0	0	0	0	1	0	10	C2
JP	Jump on positive	1	1	1	1	0	0	1	0	10	F2
JPE	Jump on parity even	1	1	1	0	1	0	1	0	10	EA
JPO	Jump on parity odd	1	1	1	0	0	0	1	0	10	E2
JZ	Jump on zero	1	1	0	0	1	0	1	0	10	CA
LDA	Load *A* direct	0	0	1	1	1	0	1	0	13	3A
LDAX B	Load *A* indirect	0	0	0	0	1	0	1	0	7	0A
LDAX D	Load *A* indirect	0	0	0	1	1	0	1	0	7	1A
LHLD	Load *H*& *L* direct	0	0	1	0	1	0	1	0	16	2A
LXLB	Load immediate register Pair *B* & *C*	0	0	0	0	0	0	0	1	10	01
LXLD	Load immediate register Pair *D* & *E*	0	0	0	1	0	0	0	1	10	11
LXLH	Load immediate register Pair *H* & *L*	0	0	1	0	0	0	0	1	10	21
LXLSP	Load immediate stack pointer	0	0	1	1	0	0	0	1	10	31
MVI M	Move immediate memory	0	0	1	1	0	1	1	0	10	36
MVI r	Move immediate register	0	0	*D*	*D*	*D*	1	1	0	7	
MOV M_1r	Move register to memory	0	1	1	1	0	*S*	*S*	*S*	7	
MOV r_1 M	Move memory to register	0	1	*D*	*D*	*D*	1	1	0	7	
MOV , r2	Move register to register	0	1	*D*	*D*	*D*	*S*	*S*	*S*	5	
NOP	No-operation	0	0	0	0	0	0	0	0	4	00
ORA M	Or memory with *A*	1	0	1	1	0	1	1	0	7	B6
ORA r	Or register with *A*	1	0	1	1	0	*S*	*S*	*S*	4	
ORI	Or immediate with *A*	1	1	1	1	0	1	1	0	7	F6
OUT	Output	1	1	0	1	0	0	1	1	10	D3
PCHL	*H* & *L* to program counter	1	1	1	0	1	0	0	1	5	E9
POP B	Pop register pair *B* & *C* off stack	1	1	0	0	0	0	0	1	10	C1
POP D	Pop register pair *D* & *E* off stack	1	1	0	1	0	0	0	1	10	D1
POP H	Pop register pair *H* & *L* off stack	1	1	1	0	0	0	0	1	10	E1
POP PSW	Pop *A* and Flags off stack	1	1	1	1	0	0	0	1	10	F1
PUSH B	Push register Pair *B* & *C* on stack	1	1	0	0	0	1	0	1	11	C5
PUSH D	Push register Pair *D* & *E* on stack	1	1	0	1	0	1	0	1	11	D5
PUSH H	Push register Pair *H* & *L* on stack	1	1	1	0	0	1	0	1	11	E5
PUSH PSW	Push *A* and Flags on stack	1	1	1	1	0	1	0	1	11	F5
RAL	Rotate *A* left through carry	0	0	0	1	0	1	1	1	4	17
RAR	Rotate *A* right through carry	0	0	0	1	1	1	1	1	4	1F
RC	Return on carry	1	1	0	1	1	0	0	0	5/11	D8
RET	Return	1	1	0	0	1	0	0	1	10	C9
RLC	Rotate *A* left	0	0	0	0	0	1	1	1	4	07
RM	Return to minus	1	1	1	1	1	0	0	0	5/11	F8
RNC	Return on no carry	1	1	0	1	0	0	0	0	5/11	D0
RNZ	Return on no zero	1	1	0	0	0	0	0	0	5/11	C0
RP	Return on positive	1	1	1	1	0	0	0	0	5/11	F0
RPE	Return on parity even	1	1	1	0	1	0	0	0	5/11	E8
RPO	Return on parity odd	1	1	1	0	0	0	0	0	5/11	E0
RRC	Rotate *A* right	0	0	0	0	1	1	1	1	4	0F
RST	Restart	1	1	*A*	*A*	*A*	1	1	1	11	
RZ	Return on zero	1	1	0	0	1	0	0	0	5/11	C8
SBB M	Subtract memory from *A* with borrow	1	0	0	1	1	1	1	0	7	9E
SBB r	Subtract register from *A* with borrow	1	0	0	1	1	*S*	*S*	*S*	4	
SBI	Subtract immediate from *A* with borrow	1	1	0	1	1	1	1	0	7	DE
SHLD	Store *H* & *L* direct	0	0	1	0	0	0	1	0	16	22
SPHL	*H* & *L* to stack pointer	1	1	1	1	1	0	0	1	5	F3
STA	Store *A* direct	0	0	1	1	0	0	1	0	13	32
STAX B	Store *A* indirect	0	0	0	0	0	0	1	0	7	02
STAX D	Store *A* indirect	0	0	0	1	0	0	1	0	7	12
STC	Set carry	0	0	1	1	0	1	1	1	4	37
SUB M	Subtract memory from *A*	1	0	0	1	0	1	1	0	7	96
SUB r	Subtract register from *A*	1	0	0	1	0	*S*	*S*	*S*	4	
SUI	Subtract immediate from *A*	1	1	0	1	0	1	1	0	7	D6
XCHG	Exchange *D* & *E*, *H* & *L* Registers	1	1	1	0	1	0	1	1	4	EB
XRA M	Exclusive Or memory with *A*	1	0	1	0	1	1	1	0	7	AE
XRA r	Exclusive Or register with *A*	1	0	1	0	1	*S*	*S*	*S*	4	
XRI	Exclusive Or immediate with *A*	1	1	1	0	1	1	1	0	7	EE
XTHL	Exchange top of stack, *H* & *L*	1	1	1	0	0	0	1	1	18	E3

Notes: 1. *DDD* or *SSS* 000 *B*-001 *C*-010 *D*-011 *E*-100 *H*-101 *L*-110 Memory-111 *A*.
2. Two possible cycle times. (5/11) indicate instruction cycles dependent on condition flags.

Step 2: device characteristics. The terminal characteristics of our printer are shown in Fig. 6 of Part 5 in the October issue.
Step 3: system design. The block diagram of our general solution was shown in Fig. 7 in the October issue. Its step-by-step operation is flowcharted here in Fig. 1. We shall use index addressing to retrieve each character from memory. Addressing modes have been discussed in Part 3 in the August issue.

6800 Solution

Step 4: hardware design. The i/o signals of the Motorola 6800 are shown in Figs. 2 and 3. Reference to these figures shows that our In signal in Fig. 7, October issue, is generated by Anding VMA and R/W, the outputs of pins 5 and 34 of the 6800 chip. Similarly our Out signal is generated by Anding VMA with the inverted form of R/W. Note that line R/W is high during a read operation and low during a write operation. The interface hardware consisting of two And gates and an inverter is shown in Fig. 4.
Step 5: software design. Our programming model is shown in Fig. 5. Memory location 10 on page 20 is used as a counter, and the first byte is stored in line 40 of the same page.

By direct reference to our programming model in Fig. 5 and to the M6800 instruction set, reproduced in the previous article, we derive the hex listing of our test-and-skip software – see Table 1.

8080 Solution

Step 4: hardware design. The i/o signals of the Intel 8080 are shown in Fig. 7. Reference to this figure shows that our In and Out signals in Fig. 7 of the October issue are generated by Anding INP with DBIN and WR with OUT. The interface hardware consisting of two And gates and an inverter is shown in Fig. 7 here.

Note the similarity between the 8080 and the 6800 hardware implementations. The almost-identical nature of our solutions applies to all present-day microprocessors and to all their modes of operation, as we shall be demonstrating in future articles.
Step 5: software design. Our programming model in the case of the Intel 8080 is shown in Fig. 8 Microprocessor register C is assumed to be available to be used as a counter. The first byte is stored in line 40 of page 20 in memory.

By direct reference to our programming model in Fig. 8 and to the Intel 8080 instruction set (shown in Table 2), we derive the hex listing of our test-and-skip software. It is shown in Table 3.

The next article will deal with wait/go systems.

Table 3: Hex listing of the PRINT problem when implemented using the test-and-skip mode and the Intel 8080.

	Hex address	Hex listing	Mnemonics	Comments
	1000	21	LXI HL	Set memory pointer to
	01	40		line 40 on page 20 – location
	02	20		of the first byte to be printed
	03	0E	MVI C	Load register C with block
	04	n		length (n)
	05	CA	JNZ	Jump to L1 if n=0
	06	16		
	07	10		
L2:	08	DB	IN	Read printer status
	09	60		
	0A	07	RLC	Rotate left through carry
	0B	D2	JC	Jump to L2 of carry
	0C	08		flag (printer not ready) is
	0D	10		set
	0E	7E	MOV, A, M	Move into A next byte to be printed
	0F	D3	OUT	PRINT
	10	61		
	11	23	INX HL	Point to next byte in the block
	12	0D	DCR C	Decrement byte count (held in C)
	13	C3	JMP	Jump to L2
	14	08		
	15	10		
L1:	16	76	HLT	Stop

Software wait

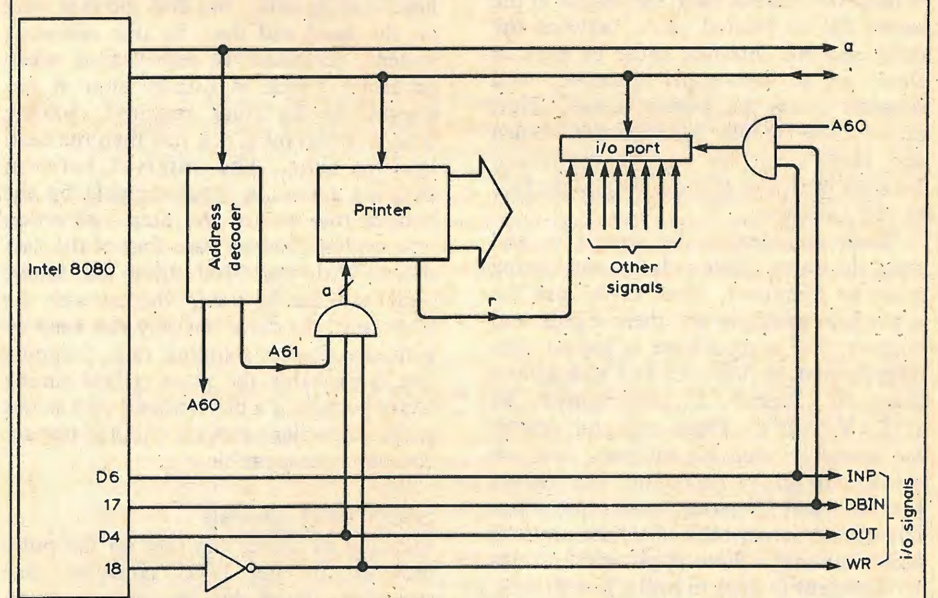


Fig. 7. Interface hardware of the PRINT problem using test-and-skip and the Intel 8080.

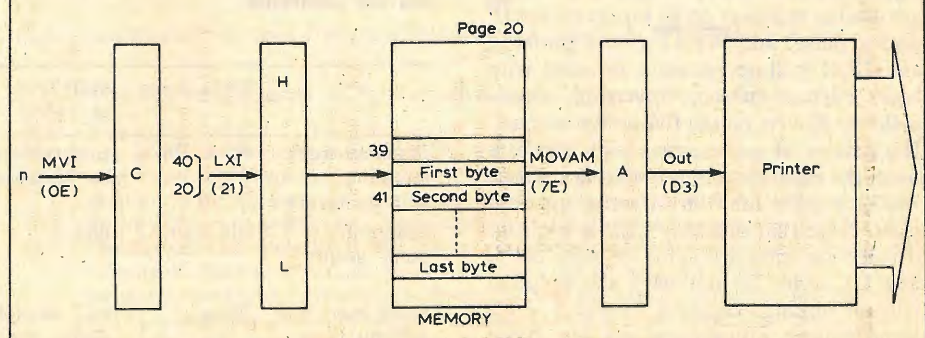


Fig. 8. Programming model for the PRINT problem using the Intel 8080.

Floppy disc system for the scientific computer — 2

Interfacing a disc drive to the controller

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

This interface has been designed to operate with the Data Recording Equipment model 7100 8in disc drive, but should be easily adapted to suit others. The main advantage of an 8in drive over a 5¼in system is its greater storage capacity, 77 tracks of 3¼Kbytes each using the IBM format described in part one, compared with 35 tracks of 2¼Kbytes each. The disadvantage is greater cost. This concluding article describes how the drive is matched to the floppy-disc controller, and illustrates the salient points to check when considering other drives.

Whichever drive is used, the length of the cable, flat or twisted pairs, between the drive and the interface must be kept as short as is reasonably possible, and separate from the power cables. Each power cable should have its own return and there must be a good connection between the frame of the drive and the case of the computer.

When considering the signals to and from the drive, their polarity and timing must be examined. Most drives use the active-low principle for their inputs and outputs, i.e. a true state is logical zero (represented by 0≤V≤0.4V) and a false input is logical 1 (represented by 2.5V<V<5.25V). Open collector drivers are generally used for outputs, and low value pull-up resistors on the inputs provide a full 5V swing and keep the line impedance down, both of which improve noise immunity. One implication of this arrangement is that, to pull a line to zero, the driving device will need to sink the current supplied by the receiving gate and by the pull-up resistor, typically 40mA. For a logical 1, no current is required from the driving device. The controller i.c. signals are mostly active-high, so inverters are used as receivers on all inputs except $\overline{IP}$ (index pulse) and $\overline{WPRT}$ (write protect), and 220Ω pull-up resistors are used with high current-sinking, inverting, open-collector drivers on the five active outputs. If a drive with some active-high inputs is used, the equivalent non-inverting buffers, 7407, or pairs of 7406 in series must be used. Note that ordinary t.t.l. is used for driving the interface cable because the L and LS series do not have the required current-sinking capacity. Table 3 gives some timing information for the 5¼in drive, the 7100 and the WD1771 controller.

When used with an 8in unit, the WD1771 must be clocked at 2MHz, whilst with a 5¼in disc 1MHz is used. This is necessary to meet the standard data rates used for the two sizes, and results in the doubling of all pulse timings for the i.c. when used with the smaller disc. There are other timing requirements connected with the application of power and selection of the drive, but these can be allowed for in the programming of the computer.

Stepping time

Most drives offer the option of keeping the head permanently loaded against the disc. This speeds operations by eliminating head-loading delay, but does increase wear on the head and disc. In this operating system, the head is only loaded when necessary which is usually after it has stepped to the track required. Settling time is irrelevant if it is less than the head loading time. The interval between stepping pulses is programmable by the bottom two bits of the Step instruction byte as described on page four of the data sheet. With the 7100 drive the fastest (6ms) rate can be used, whereas with the 5¼in unit, the drive can only just keep up with the slowest stepping rate. Stepping rate is probably the most critical timing factor because if a drive cannot step as fast as the controller's slowest rate, the two are virtually incompatible.

Stepping pulse

Virtually all drives can step on the pulse provided by the 1771. However, one exception found by the author is an obsolete version of the 7100. As this unit may still be available, the interface has been designed to operate with it and the current version.

The obsolete 7100 is most easily recognised by the absence of three d.i.l. sockets and header plugs next to the edge connector on the p.c.b., and the presence of two power resistors and three power transistors instead of one resistor and four transistors near the opposite corner to the edge connector. To allow compatibility, a monostable stretches the stepping pulse to 10µs.

Head-loading time

Ten milliseconds after the HLD (Head Load) output of the controller becomes active (20ms for the 5¼in disc), the HLT (Head loaded test) input is sampled and when it is low the controller proceeds. If the combined loading and settling time for the head is less than 10ms, this input can be wired low. If the disc-drive electronics provide a head-loaded and ready signal, this can be connected to HLT. If neither is true, as it is for both of these drives, HLD should trigger a monostable to produce the necessary delay before HLT becomes low. Because most drives will need this monostable if they are to be used with the head normally un-loaded, it is important to establish the total delay before the head is ready for use, i.e. the loading and settling time. Note that one value cannot be inferred from the other by comparing the stepping rate figures for the two drives.

Drive options

Most drives offer wiring options, and in this system one for direct control of head loading by the controller is used. To select this option on the current model, remove the link joining pins 13 and 14 on plug PP2 (the middle one of three referred to earlier) and join pins 3 and 14 together. On the obsolete version, remove the short wire link joining the points marked HL and SI and connect a wire from HL to the pad at the end of the p.c.b. track coming from the edge connector tab numbered 18.

This change allows the controller to drive the head-load circuit through the previously unused pin 18 on the edge connector. The current and obsolete units should now be interchangeable.

Table 3. Timing information for disc drivers and the controller.

	5¼in drive	WD1771 @ 1MHz	DRE 7100 8in drive	WD1771 @ 2MHz
Track to track stepping + settling times	40 + 10ms	programmable to 12, 20 or 40ms	4 + 14ms	programmable to 6, 10 or 20ms
Stepping pulse width	1µs min.	8µs	600ns (10µs on older units min.)	4µs
Head load and settling time	75ms	HLT sampled after 20ms, therefore monostable is required	30ms	HLT sampled after 10ms, therefore monostable is required

System software

The software in table 4 is not a full disc operating system, but it illustrates the basic functions required to position the head, read and write records of any length from 128bytes to 256Kbytes with error checking, and to re-format corrupted tracks. With the drive and interface connected to the computer, move the head towards the centre of the drive by turning the stepping motor by hand. Apply mains to the motor and then switch on the computer. Put a disc into the unit and close the door. If the system is working, the head should quickly step to the outermost track 00 because the charging delay, caused by the RC network on pin 19 of the controller i.c., holds that pin (master reset) momentarily low in a similar way to the circuit used on the Z80. One of the actions which takes place during the resetting sequence is a Restore command, which moves the head out in this way. If it doesn't, check that the wiring is correct. If it steps out but does not stop, check that the track 00 line from the drive to the controller functions. With the software loaded, RUN 1D00 and then READ space. In response to the prompts DESTINATION: TRACK: SECTOR: NUMBER OF SECTORS: type 8200 40 space 0 space 8 space respectively. The head should move in to track 40 and load 8 sectors (1Kbyte) of data from the disc, starting with sector 0 to computer locations 8200 to 85FF, i.e. onto the v.d.u. With the IBM formatted disc, these should appear as percentage or proportional symbols.

At the end of the read, which should take less than one second, the head should release from the disc and READY occur. If a reading error occurs, the computer will attempt to re-read the particular sector up to twenty times. A corruption should be evident by rubbish appearing on the v.d.u., the controller recognises it by computing the CRC from a permutation of the data from the sector and comparing it with the pre-recorded CRC. Each sector takes up two lines on the v.d.u. If the corruption begins in a line and keeps changing, the data is corrupted. If the reading process seems to stop at the end of a line, the controller is having trouble recognising the Ident Field for the track or sector and, therefore, the track needs to be re-formatted (described later). With an undamaged disc most reads are successful first time, but if the operation fails for the 20 times that it is attempted, the message ERROR AT TRACK XXX SECTOR XXX appears. To force an error into the system and observe this feature, try

1D00	ED	5E	3E	1D	ED	47	DD	21	E4	1D	DB	05	DE	1D	3E	FF
1D10	D3	A0	FB	76	76	08	76	FE	20	20	FE	08	CD	C6	03	FE
1D20	12	20	21	CD	61	02	04	05	13	14	09	0E	01	14	09	0F
1D30	0E	3A	20	1D	CD	DE	03	CD	C6	03	CD	FD	1D	3E	E7	CD
1D40	57	1E	18	F9	FE	17	20	33	CD	61	02	13	0F	15	12	03
1D50	05	3A	20	1D	CD	DE	03	CD	C6	03	CD	FD	1D	3E	71	32
1D60	F3	1D	3E	57	D3	A0	FB	76	3E	F5	C1	C1	CD	57	1E	18
1D70	EC	1A	2F	D3	B8	13	FB	F9	76	18	ED	FE	06	20	64	CD
1D80	C6	1E	79	32	A3	1D	21	00	C0	06	28	36	FF	23	10	FB
1D90	06	06	36	00	23	10	FB	36	FC	23	06	1A	36	FF	23	10
1DA0	FB	11	01	38	0E	1A	06	06	36	00	23	10	FB	36	FE	23
1DB0	72	23	36	00	23	73	23	36	00	23	36	F7	23	06	11	36
1DC0	00	23	10	FB	36	FB	23	06	80	36	E5	23	10	FE	36	F7
1DD0	23	06	1B	36	FF	23	10	FB	1C	0D	20	CA	06	00	36	FF
1DE0	23	10	FB	C7	FF	FF	FF	DB	1D	2F	12	13	FB	F9	76	18
1DF0	72	F9	1D	E7	1D	DB	1D	18	F3	DB	05	2F	C9	CD	61	02
1E00	14	12	01	03	0B	3A	20	1D	CD	C6	1E	DD	71	00	CD	C6
1E10	03	CD	61	02	13	05	03	14	0F	12	3A	20	1D	CD	C6	1E
1E20	DD	71	01	CD	C6	03	CD	61	02	0E	15	0D	02	05	12	20
1E30	0F	06	20	13	05	03	14	0F	12	13	3A	20	1D	CD	C6	1E
1E40	DD	71	02	CD	B9	1E	3E	EB	D3	A0	FB	76	E6	18	20	F6
1E50	E5	21	00	00	39	D1	C9	32	F3	1D	06	14	3E	77	D5	D3
1E60	A0	FB	76	E6	18	28	34	D1	3E	73	10	F2	11	80	82	CD
1E70	61	02	05	12	12	0F	12	20	01	14	20	14	12	01	03	0B
1E80	20	1D	DD	7E	00	CD	DA	1E	CD	61	02	20	13	05	03	14
1E90	0F	12	20	1D	DD	7E	01	CD	DA	1E	C7	C1	DD	35	02	CA
1EA0	00	00	DD	34	01	DD	7E	01	FE	1B	20	0D	DD	36	01	01
1EB0	DD	34	00	3E	A3	D3	A0	FB	76	DD	7E	00	2F	D3	B8	DD
1EC0	7E	01	2F	D3	E0	C9	76	E6	0F	4F	76	FE	20	C8	E6	0F
1ED0	47	79	07	4F	07	07	81	80	18	EF	C5	CD	EA	1E	C6	30
1EE0	EB	70	23	71	23	77	23	EB	C1	C9	06	30	48	FE	64	38
1EF0	05	04	D6	64	18	F7	FE	0A	38	05	0C	D6	0A	18	F7	C9

Table 4. System software.

Table 5. Software subroutines.

1DF9 Used in READ and WRITE to convert the typed in track number, sector number and number of sectors from decimal to binary, and then dump them into locations 1DE4 to 6 respectively using the index register. These bytes are then sent to the controller, which is then told to step into this track and, by reading an indent field, verify that the head is over the correct track. Also, by reading the CRC, verifies that the track number has been correctly read and does not match the track register's contents by chance. The data destination/source address is transferred from HL to DE and, by clearing HL and adding SP to it, the contents of the stack pointer register are loaded into HL.

1E57 Used in READ and WRITE. On entering this routine, the A register holds a byte which is dumped at 1DF3 to be used by a $\overline{DRQ}$ interrupt as the lower part of the interrupt routine address (1DE7 for READ, 1D71 for WRITE, 1DF5 for VERIFY WRITE). 20_{10} is loaded into B and DE, which holds the destination/source address, is saved on the computer stack in case a re-read or -write is necessary. The controller is then instructed to read a sector of data to that and succeeding locations. After the read, at 1E63, a check is made for the correct CRC and for the existence of the track and sector. If no faults have occurred, execution jumps to 1E9B where the saved DE is discarded from the stack into BC and, using indexed operations, the number of sectors byte is decremented. If this operation sets the byte to zero, an exit is made because the READ is complete. Otherwise, the sector and, if necessary, the track number are updated for the next sector to be read, the information is sent to the controller registers and another sector is read. If the operation to read the sector fails, the starting address of the data is popped back off the stack and B is decremented. If this does not reduce it to zero, a re-read is attempted and after 20 attempts execution passes to 1E6C et al and the error message appears.

1EC6 Loads decimal data from the keyboard and converts it to binary in register C.

1EDA Displays the contents of A, converted to decimal, on the v.d.u.

1DE7 The READ interrupt routine, called by a $\overline{DRQ}$. This routine transfers the byte in the controller's data register to the Z80, inverts it to its true form, stores it in the location pointed to by DE, and increments DE ready for the next byte. The interrupt system in the Z80 is automatically disabled when an interrupt is accepted so that the Z80 can service the interrupting device without interference from the interrupting device itself. Standard service routines usually finish with a re-enabling of the interrupt system and then a return. To ensure that the return will occur, the Z80 does not re-enable the interrupt until it has executed the instruction after the enabling instruction F3. This service routine does not have a return, but it uses this one protected instruction after the F3, F9, to load HL into the stack pointer, SP, register. SP is increased by two when the subroutine 1DF9, which loaded HL with the SP, ended and the return address was popped off the stack. When the DRQ interrupt was accepted, the current PC (program counter) contents were pushed onto the stack and SP decreased by two, as is normal at the calling of any subroutine. Therefore, for the first DRQ, HL and SP are the same and F9 has no effect. The next byte in the subroutine is a HALT, at which the Z80 stops and waits for the second DRQ which, when it arrives, jumps the execution back to the start of the subroutine and pushes another return address onto the stack. When the data byte is read and the F9 is executed, SP, which decremented when the second interrupt was accepted, is pulled back to where it was before the interrupt occurred. Therefore this, and all future DRQs are demoted from calls to being, effectively, simple jumps to 1DE7. Whilst each return address is written on top of the last as the DRQs progress, the first call from the main program remains unaltered one position further up the stack. When all 128 DRQs have passed and the SP has been pulled back again, the INTRQ interrupt occurs and this, having a conventional return at its end, returns execution to the first popped address, i.e. where the original "read a sector" command was given. This forms a neat method of writing the main program because it makes the controller appear as part of the main processor and, more important, it saves time. There are only 32μs during which data can be transferred from the controller to the memory, and the Z80 made ready for the next interrupt. If the sequence servicing the controller takes longer than this, data will be lost and the controller will halt the reading sequence. A conventional return takes 5½μs and the jump from this returning point to the "wait for a DRQ" point requires a further 6μs. The single F9 instruction only takes 3μs, which achieves the same purpose, but just within the 32μs limit.

1D71 The WRITE interrupt routine called by DRQ. This is similar to the previous routine in that the progress of the stack pointer is arrested by repetitive loading from HL. This routine differs because the first two DRQ-pushed addresses are saved, 1D68 and 1D79 respectively. When the 128 DRQs have occurred, INTRQ causes a jump to the status reading routine after which the return occurs to 1D79 at which a jump pushes execution on the 1D68. Here the other DRQ is popped off the stack and a new vector byte, F5, is placed into the A register ready for the third type of DRQ.

1DF5 When checking a written sector, 1E57 is used as the reading subroutine. Because we are interested in the CRC and not the data on the disc, 1DF5 acts like 1DE7 when handling DRQs, except that it makes no attempt to store the unwanted data and just waits for the INTRQ. When this arrives, 1DF5 returns to the point in the main program where the CRC can be checked to see if the track just written has verified itself.

reading any sector track 77, which does not exist! Note that spaces are required after decimal information – the track, sector and number of sectors, but not after the hexadecimal destination address.

If the Read has worked type RUN 1D00, which should cause the unloaded head to return to track 00. Next type WRITE space, and in response to SOURCE type 0000, for TRACK: 40 space, for SECTOR: 0 space, and for NUMBER OF SECTORS 32 space. The head should move in and write to track 40, step to track 41 and continue writing, so that the first 26 sectors fill track 40 and the final 6 fill sectors 0 to 5 track 41. The write operation is slower because after each sector is written it is read back and checked for errors. As before, up to 20 attempts are made before the operation terminates and the ERROR message occurs. Nevertheless, it should only take a few seconds to record the entire 4K monitor.

Explanations of the software subroutines are given in Table 5. To follow the main program 1D00 to 1DFC, a disassembler such as the one given in a recent computer newsletter is useful. The interrupt mode 2 is set and the I register, which is used (as described in part one) to form the top half of the interrupt addresses, is set at 1D and the IX index register is set at 1DE4. The index register is useful as a pointer to an area of memory because any indexed Z80 instructions, i.e. instructions prefixed by DD, will use a byte in the instruction to say which byte relative to 1DE4 is to be used in the instruction. In this case byte number 00 (i.e. 1DE4 itself) stores the required track number, byte number 01 (1DE5) stores the required sector number and byte 02 (1DE6) stores the number of sectors. The status and data registers are read next (not for their contents) to reset the INTRQ and DRQ interrupt lines if they are active due to the power-on sequence. Note that this unit is designed to operate with the mark III operating system, (see the scientific computer newsletter) which contains these same four bytes, DB,05, DB and 1D. They are executed in the high level so that the MM57109 interrupts are not upset by the disc controlled conditions. 1D0E-14 illustrates the way instructions are sent to the controller. The instruction byte loads into A, in this case a Restore instruction, it is sent to the command register, the interrupt is enabled and the Z80 is halted to wait for the interrupt. When it arrives, in this case a INTRQ, the computer reads the interrupt controller byte Fl, adds it to the 1D previously stored in the I register and then reads in the byte at 1DF1 and 1DF2 as the address of the INTRQ subroutine, which is 1DF9. Execution passes to this address when the status register is read and inverted back to a true state.

Re-formatting a disc

As well as reading and writing individual sectors, the controller can read and write whole tracks using the index pulse as the start and finish of the operation. As described in part one, even before use the disc is fully recorded with ident fields and dummy data. If the ident fields become magnetically corrupted, the entire track has to be re-recorded, or re-formatted, before it can be used in the sector mode again. To do this, a block of length 5¼K bytes must be set up in r.a.m. and then recorded en bloc. Assembley of this block requires extra r.a.m. over the basic computer's memory and, given this, the operating system can synthesise the track format. I used a 32Kbyte expansion (referred to in the computer newsletter) and assembled this block at C000. To accommodate other r.a.m. locations, the byte at 1D88 must be altered. After RUN 1D00, type FORMAT space and then the track number, in decimal, to be altered. As

continued on page 57

Table 6. Floppy-disc controller commands used. The asterisked addresses are where modifications to the software are made when a track is re-formatted.

Address	Byte	Command	Function
1D0F	FF	00	RESTORE the head to track 00 and clear the track register.
1D63	57	A8	Assuming the head is to be loaded against the disc, WRITE a single record of IBM format to the track and sector specified by the respective registers, using FB as the data mark.
1E47	EB	14	SEEK the track specified by the data register by stepping the difference between it and the contents of the track register. Then, by reading an Ident Field from the track, verify that it is the correct one.
*1E5D	77	88	Assuming that the head is loaded against the disc, READ a single record of IBM format from the track and sector specified by the respective registers.
1E69	73	8C	As above, but it begins by issuing the HLD, head load, signal and waiting for the HLT signal to become active before proceeding.
1EB4	A3	5C	Load the head against the disc and then STEP IN by one track, updating the track register. Perform a verify of the track as described above.
*1D63	0B	F4	WRITE TRACK. Starting at the index pulse, data is written continuously up to the next index pulse.
*1E47	EF	10	On a badly corrupted track, it is not possible to verify the head position after a SEEK, so this version of the command omits it.

The death of electric current

A contribution to electromagnetic theory

by **Ivor Catt** CAM Consultants

Conventionally a signal can be understood either in terms of electricity in conductors, with associated fields, or in terms of electric and magnetic fields terminating on those conductors. In this article the author steps outside the accepted dualism and proposes a mechanism of signal transmission based on Oliver Heaviside's 'energy current' without recourse to 'conductors' in their conventional role.

A major advance in electromagnetic theory, which I shall call the transition from Theory N to Theory H, was made by Oliver Heaviside a century ago. What is proposed here is a transition from Theory H to a third theory, Theory C. It is to be hoped that the response to Theory C will be more perceptive than was the general response to Theory H a century ago, as typified by Sprague, quoted in this article. Until it was revived recently by CAM Consultants, Theory H had been ignored and then suppressed for a century. It was revived because of its great value in digital electronic design.[1,2]

Theory C has major implications across a whole spectrum of subjects. It could trigger an exciting renaissance in many fields of endeavour.

Whereas the conventional approach to electromagnetic theory is to concentrate on the electric current in wires, with some additional consideration of voltages between wires, Heaviside concentrates primarily on what he calls 'energy current', this being the electromagnetic field which travels in the dielectric between the wires. It has an amplitude equal to the Poynting Vector, $E \times H$. Heaviside's phrase, "We reverse this"; points to the great watershed in the history of electromagnetic theory – between the 'ethereals', who with Heaviside believe that the signal is an 'energy current' which travels in the dielectric between the wires, and the 'practical electricians', who like Sprague believe that the signal is an electric current which travels down copper wires, and that if there *is* a 'field' in the space between the wires, this is only a result of what is happening in the conductors.

Oliver Heaviside announced Theory H a century ago[3]:

"Now in Maxwell's theory there is the potential energy of the displacement produced in the dielectric parts by the electric force, and there is the kinetic or magnetic energy of the magnetic induction due to the magnetic force in all parts of the field, including the conducting parts. They are supposed to be set up by the current in the wire. We reverse this; the current in the wire is set up by the energy transmitted through the medium around it . . ."

The importance of Heaviside's phrase, "We reverse this;" cannot be overstated. It points to the watershed between the 'practical electricians', who have held sway for the last half century, promulgating their theory – which we shall call 'Theory N', the Normal Theory: that the cause is electric currents in wires and electromagnetic fields are merely an effect – and the 'ethereals', who believe what we shall call 'Theory H': that the travelling field is the cause, and electric currents are merely an effect of these fields.

Opposition to any attempted change from the familiar Theory N to Theory H was forceful and successful for the next century. Sprague, a 'practical electrician' wedded to Theory N, with its retention of a phlogiston-like 'fluid'*, electricity, at the centre of the electromagnetic stage, wrote[4]:

"A new doctrine is becoming fashionable of late years, devised chiefly in order to bring the now important phenomena of alternating currents under the mathematical system. It is purely imaginery . . . based upon Clerk-Maxwell's electromagnetic theory of light, itself described by a favourable reviewer as 'a daring stroke of scientific speculation,' alleged to be proved by the very little understood experiments of Hertz, and supported by a host of assumptions and assertions for which no kind of evidence is offered; but its advocates now call it the 'orthodox' theory.

"This theory separates the two factors of electricity . . ., and declares that the 'current', the material action, is carried by the 'so-called conductor' (which according to Dr Lodge contains nothing, not even an impulse, and according to Mr O. Heaviside is to be regarded as an obstructor), but the energy leaves the 'source' (battery or dynamo) 'radiant in exactly the same sense as light is radiant', according to Professor Silvanus P. Thompson, and is carried in space by the ether: that it then 'swirls' round (cause for such swirling no one explains) and finds its way to the conductor in which it then produces the current which is apparently merely an agency for clearing the ether of energy which tends to 'choke' it, while the conductor serves no other purpose than that of a 'waste pipe' to get rid of this energy . . .

"This much, however, is certain; that if the 'ether' or medium, or di-electrics carry the energy, the practical electrician must not imagine he can get nature to do his work for him; the ether, &c., play no part whatever in the calculations he has to make; whether copper wire is a conductor or a waste pipe, that is what he has to provide in quantity and quality to do the work; if gutta percha, &c., really carry the energy, he need not trouble about providing *for that purpose;* he must see to it that he provides it according to the belief that it prevents loss of current. In other words, let theoretical mathematicians devise what new theories they please, the practical electrician must work upon the old theory that the conductor does his work and the insulation prevents its being wasted. Ohm's law (based on the old theory) is still his safe guide.

"For this reason I would urge all practical electricians, and all students who desire to gain a clear conception of the actual operations of electricity, to dismiss from their minds the new unproved hypotheses about the ether and the abstract theory of conduction, and to completely master the old, the practical, and common sense theory which links matter and energy together, . . . "

Sprague accurately described Theory N.

One of the few supporters of Theory H was J. A. Fleming, who wrote[5]:

"It is important that the student should bear in mind that, although we are accustomed to speak of the current as *flowing in the wire* in one direction or the other, this is a mere form of words. What we call *the current* in the wire is, to a very large extent, a process going on in the space or material outside the wire. Just as we familiarly speak of the sun rising and setting, when the effect is really due to the rotation of the earth, so the ordinary language we use in speaking about electric currents flowing in conductors retains the form impressed upon it by older and erroneous assumptions as to their nature."

Heaviside's view

As time went by, support for Theory H gradually died out. Let us end Theory H with a long discussion by its originator[6]:

"Consider the electric current, how it flows. From London to Manchester, Edinburgh, Glasgow, and hundreds of other places, day and night, are sent with great velocity, in rapid succession, backwards and forwards, electric currents, to effect mechanical motions at a distance, and thus serve the material interests of man.

* Phlogiston was a 'subtle fluid' postulated by the German chemist G. E. Stahl (1660-1734). It was thought to be combined with a 'calx' or ash in combustible materials and to be given off by these materials in the process of burning, leaving the ash behind. This hypothesis was strongly held in the 18th century but was eventually upset by Lavoisier's deductions leading to the theory of the conservation of mass. – Ed.

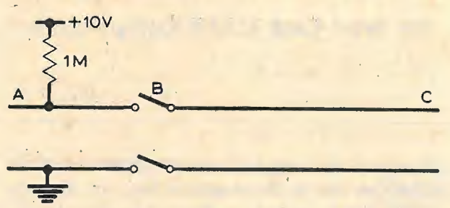
"By the way, is there such a thing as an electric current? Not that it is intended to cast any doubt upon the existence of a phenomenon so called; but is it a current – that is, something moving through a wire? Now, although nothing but very careful inculation at a tender age, continued unremittingly up to maturity, of the doctrine of the materiality of electricity, and its motion from place to place, would have made me believe it, still, there is so much in electric phenomena to support the idea of electricity being a distinct entity, and the force of habit is so great, that it is not easy to get rid of the idea when once it has been formed. In the historical development of science, static phenomena came first. In them the apparent individuality of electricity, in the form of charges upon conductors, is most distinctly indicated. The fluids may be childish notions, appropriate to the infancy of science; but still electric charges are easily imaginable to be quantities of a something, though not matter, which can be carried about from place to place. In the most natural manner possible, when dynamic electricity came under investigation, the static ideas were transferred to the electric current, which became the actual motion of electricity through a wire. This has reached its fullest development in the hands of the German philosophers, from Weber to Clausius, resulting in ingenious explanations of electric phenomena based upon forces acting at a distance between moving or fixed individual elements of electricity.

"Return to our wire from London to Edinburgh with a steady current from the battery in London. The energy is poured out of the battery *sideways* into the dielectric at a steady rate. Divide into tubes bounded by lines of energy-current. They pursue in general solenoidal paths in the dielectric, and terminate in the conductor. The amount of energy entering a given length of the conductor is the same wherever that length may be situated. The lines of energy-current are the intersections of the magnetic and electric equipotential surfaces. Most of the energy is transmitted parallel to the wire nearly, with a slight slant towards the wire in the direction of propagation; thus the lines of energy-current meet the wire very obliquely. But some of the outer tubes go out into space to an immense distance, especially those which terminate on the further end of the wire. Others pass between the wire and the earth, but none in the earth itself from London to Edinburgh, or vice versa, although there is a small amount of energy entering the earth straight downwards, especially at the earth "plates". If there is an instrument in circuit at Edinburgh, it is worked by energy that has travelled wholly through the dielectric, then finding its way into the instrument . . ."

If we keep to Theory H, the theory that the field $E \times H$, travelling along between the wires at the speed of light – what Heaviside called the 'energy current', is the cause, then electric charge and electric current are merely what define the *edge* of an energy current. If electric current is that which defines the side of an energy current, then we may with equal justification postulate 'displacement current' as that which defines the front face of a step of energy current[1].

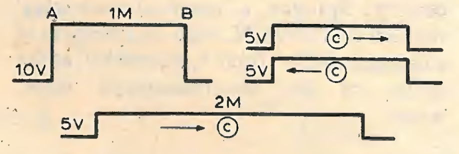
Now let us move on to Theory C, when we drop the dualism – circuit and field – that has until now been the foundation of electromagnetic theory. First we shall discuss the reed relay pulse generator, which illustrates some of the ideas underlying Theory C.

The reed relay pulse generator was a means of generating a fast pulse using rather primitive methods. A one-metre section of 50-ohm coaxial cable AB was charged up to a steady 10 volts (say) via a one megohm resistor, and then suddenly discharged into a long piece of coax BC by the closure of two switches.



A five-volt pulse two metres wide was found to travel off to the right at the speed of light for the dielectric on closure of the switches, leaving the section AB completely discharged. (The practical device lacked the second, lower switch at B, which is added in the diagram to simplify the argument).

The curious point is that the width of the pulse travelling off down BC is twice as much as the time delay for a signal between A and B. Also, the voltage is half of what one would expect. It appears that after the switch was closed, some energy current must have started off to the *left*, *away* from the now closed switch; bounced off the open circuit at A, and then returned all the way back to the switch at B and beyond.



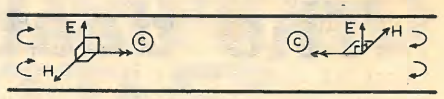
This paradox, that when the switches are closed, energy current promptly rushes *away* from the path suddenly made available, is understandable if one postulates that a steady charged capacitor is not steady at all; it contains energy current, half of it travelling to the right at the speed of light, and the other half travelling to the left at the speed of light.

Now it becomes obvious that when the switches are closed, the right-wards travelling energy current will exit down BC first, immediately followed by the leftwards travelling energy current after it has bounced off the open circuit at A.

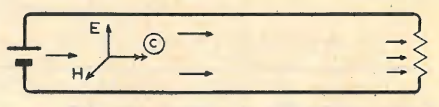
We are driving towards the principle that *energy (current) $E \times H$ cannot stand still; it can only travel at the speed of light.* Any apparently steady field is a combination of two energy currents travelling in opposite directions at the speed of light[7].

E and *H* always travel together in fixed proportion Z_0.

Electric charge does not exist according to Theory C. The so-called electric charge is merely the edge of two reciprocating energy currents. In the case of the so-called steady charged capacitor, the electric fields of the two energy currents add but the magnetic fields cancel, so that it has come to be thought that a charged capacitor is devoid of magnetic field.



Now let us consider a simple circuit with battery and resistor. Two conductors guide the energy current from battery to resistor. It enters the resistor *sideways*



(Kip 1962)[6]. 'Electric current' is merely the side of a wave of energy current. If a 'conductor' is perfect, the energy current has a sharp side; the so-called 'electric current' has infinite density in the outside surface of the 'electric conductor', which Heaviside called an obstructor.

Energy current penetrates an imperfect conductor in the same way as it enters a resistor, from the side. In this case, the region containing a variation in energy current density, the so-called 'electric current', widens and penetrates into the conductor; skin depth is no longer zero.

Nothing exists behind a mirror; nothing happens there. The velocity of the 'things' behind a mirror does not depend on the medium, or material, behind the mirror[8].

As Maxwell's equations show,[9] 'electric current' is always derivable as the gradient on the side of a wave of energy current. Unlike energy current (but like the immages in a mirror), electric current contains no energy, it has no function, and it explains nothing. Electric current does not exist.

Although a cloud cannot exist without edges, the *edges* of a cloud do not exist. They have no width, volume, or materiality. However, the *edges* of a cloud can be drawn. Their shapes can be manipulated graphically and mathematically. The same is true of the so-called 'electric current'.

In the following analogies, the sheep represent energy, the dogs electricity.

Theory N. The sheep are forced out of the pen by the sheep-dogs. The dogs then run alongside the sheep. There can only be a forward flow if sheep-dogs first advance on both sides of the flow of sheep, which the dogs direct and cause.

Theory H. The sheep rush out of the pen into the great open spaces. They will go forward regardless, but their direction is actively guided by the sheep-dogs running alongside, the front of the line of dogs always keeping level with the foremost sheep.

Theory C. There are no sheep-dogs. The sheep leave the pen and flow out into the great open spaces. Some of the space is rougher. (This rough space was previously thought to be the terrain preferred by the dogs.) Here fewer sheep go, and their rate of advance is slower. Some ground is very obstructive, nearly impassable for sheep.

Although it might appear that the sheep are actively guided by the rough terrain towards the smooth terrain, this is not so. Neither does a grease mark on blotting paper actively guide the ink towards the ungreasy areas. There is no active guidance mechanism; greasy paper is merely bad blotting paper with poor capillary action, passively guiding the ink.

The excision of sheep-dogs from the theory is a giant simplification. Nothing flows in the conductor; nothing happens therein. Heaviside was right to call it an obstructor. Half of the primitives in electromagnetic theory disappear, and it ceases to be a dualistic theory. ρ and *J* disappear, becoming merely the physically non-existent results of the mathematical manipulation of *E* and *H*, with no more significance than "circularity"' (Letters, June 1979 issue, p. 82).

The direct transition from Theory N to Theory C is similar to the change in combustion theory from phlogiston to oxidation, but is more difficult. Phlogiston is very similar to electricity, being a strange 'fluid' which permeates solids. But whereas the oxygen which 'replaced' phlogiston was still within the same body, the energy current which replaces electricity is not where the electricity was; it is where it was not. This is a very difficult transition. If the idea of replacing the well known phlogiston by oxygen caused mirth at High Table, we have to expect Theory C to generate widespread hilarity.

I would like to thank David Walton and Malcolm Davidson of CAM Consultants for their dogged support for six years. This article is taken from the book Electromagnetic Theory Vol 2, pub. CAM Publishing, 17 King Harry Lane, St. Albans, England.

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Appendix

Definition of a perfect conductor: $\epsilon = \infty$. It follows that velocity of energy current

$$= \frac{1}{\sqrt{\mu\epsilon}} = 0$$

Impedance $Z_0 = \sqrt{(\mu/\epsilon)} = 0$

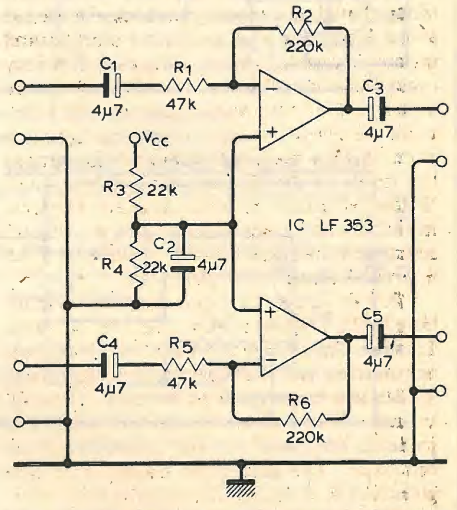
In an imperfect conductor, ϵ is very high.
Impedance $(= Z_0) \to 0$
Penetration velocity is very slow." □

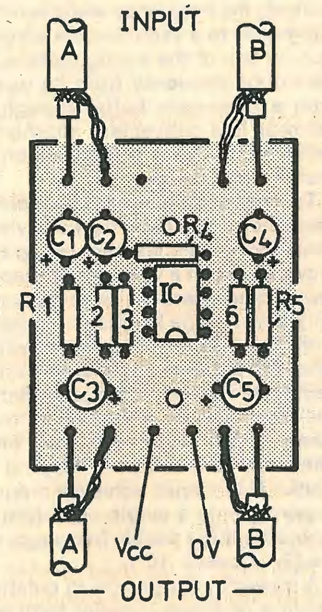
Solid-state level meter – further notes

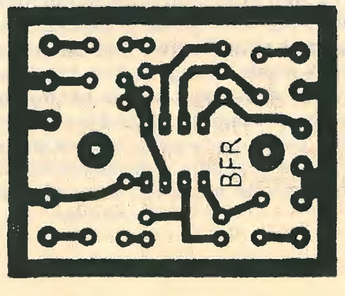
Several points were not fully explained in Quentin Rice's article on his level indicator in the August issue. The peak hold function was a late addition. Achieved by taking a terminal adjacent to R_4 to 0V, this effectively switches off the decay voltage and is extremely useful for peak detection. Although the unit has no graduations, the author says it is a linear and accurate piece of equipment, and the user can employ whatever scaling is required. The attack time of the circuit is about 2ms f.s.d., which is well within any p.p.m. specification, but if this is felt to be too fast, increase the value of R_9.

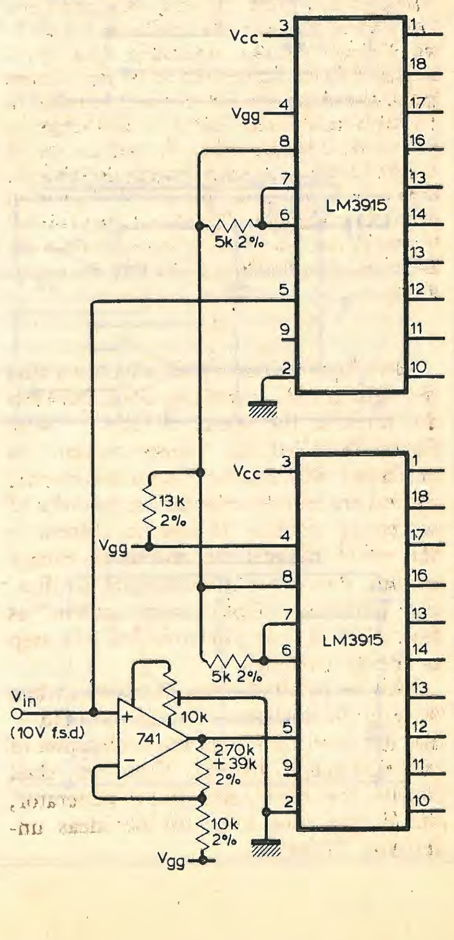
When the unit was used with an oriental cassette recorder of dubious electronic integrity (expensive but no input h.f. rolloff, and no monitoring facility), intermodulation occurred because the meter was taken directly from the medium-impedance record output. This is overcome in such cases by using a buffer to isolate the signal and to provide adequate gain to bring the signal up to a useable level. With low impedance lines, this presents no problems.

Mention was made of the LM3915 and 3916 devices. As the data are quite recent, no consideration for these was made in the original design. The LM3915 may be cascaded like the 3914, giving twenty steps of 3dB, but an extra op-amp is required to provide 30dB gain and offset. The regulator is changed for a 24V type, and D_6 is changed to 12V. It should be borne in mind that the decay is no longer linear as it follows the law of the display. The LM3916 is not cascadable, but it can be used with the LM3915 to give a mixed law display with a 40dB range, albeit with only 19 l.e.ds and without the linear decay. In this circuit, the dot/bar mode select is difficult to implement. For further information, consult the National Semiconductor literature. □







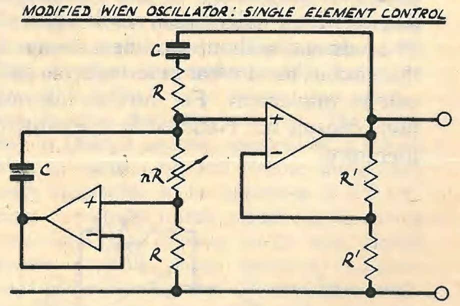


Circuit for 60dB display range, left, uses LW3915 V_{cc} 24V, V_{gg} 12V. Buffer circuit, above, and board patterns are for use with medium-impedance outputs. V_{cc} can be 15 to 30V, unregulated. In the p.c.b. pattern on page 32 (August issue), pins b & 7 of IC_3 should be linked to pins 4 & 8 of IC_4.

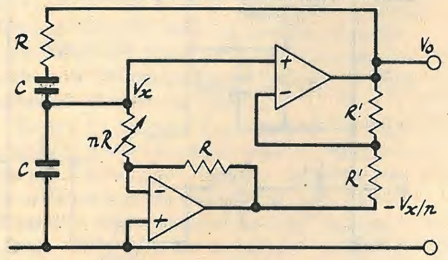
RC oscillators: single-element frequency control

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

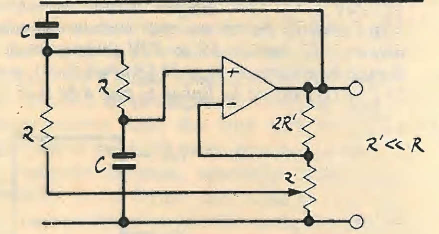
MODIFIED WIEN OSCILLATOR: SINGLE ELEMENT CONTROL



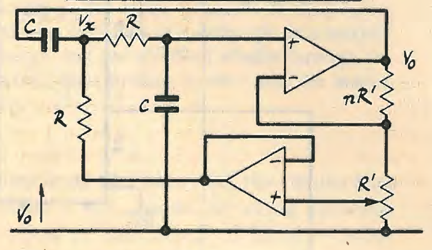
SINGLE RESISTOR CONTROL – MODIFIED WIEN



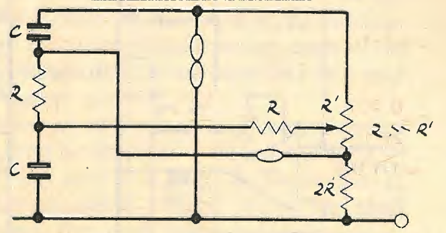
SINGLE AMPLIFIER SINGLE ELEMENT CONTROL



SINGLE ELEMENT CONTROL OSCILLATOR



NULLOR FORM: INVERTED



The best-known RC oscillator is based on the Wien network, usually in the form of a bridge activated by an operational amplifier or other high-gain equivalent. It shares with the related lead-lag and lag-lead circuits the need for simultaneous adjustment of two components if the frequency is to be varied without change in the loop gain. A number of elegant alternatives have been devised to overcome these limitations, usually at the expense of an additional amplifier. In this example the shunt capacitor of the Wien network is driven instead via a unity-gain buffer from a tapping on the resistor. By varying the resistor shown the frequency of oscillation is controlled over >100:1 range without change in the oscillatory condition (excepting second-order effects due to amplifier impedances, bandwidth etc.). This allows the amplitude to be controlled by a suitable amplitude sensing circuit with only minor shifts in the operating point of the sensing element. The ratio of resistors differs from that of the conventional bridge. At either extreme of the frequency range the distortion increases and the second-order effects shift the amplitude but good performance over a 10:1 range is readily achieved with the single variable resistance.

This circuit uses the current in the resistance path of the shunt CR network to provide a drive voltage for what would otherwise be the ground point on the feedback potential divider. Again variation of the single resistor changes the frequency of zero phase shift. At the same time the auxiliary amplifier injects a correcting signal into the potential divider to restore the gain condition. It is no coincidence that this and the previous circuit use the same components; this circuit was published first and the previous one derived from it by drawing in nullor form and manipulating the nullators and norators to produce new circuits, equivalent internally but differing for example in the point on the passive network is grounded. There are yet other practical forms but these two appear most useful each being tunable over a 100:1 range using a single variable resistor. Clearly the output of the auxiliary amplifier must vary with frequency of oscillation and the original output is the one that would normally be stabilized. Any of the stabilization methods applicable to the Wien bridge oscillators are equally applicable here.

The lead-lag and lag-lead oscillators are known to have identical transfer functions to Wien network for equal R and C values throughout. The impedance properties internal to the networks are different and there is no direct equivalent to the previous one. Another family of oscillators have been described using lag and lead networks with the addition of a second variable gain amplifier that, appropriately connected, again controls the frequency while leaving the oscillator gain condition unchanged. A simple alternative to a variable gain amplifier is a constant gain preceded by variable attenuation. In one of the configurations it is found that varying the gain from 0 to +1 gives control of frequency from its usual value of $f=1/2\pi CR$ toward zero. The amplifier is then a unity-gain buffer though a high input impedance stage such as a source follower is a convenient alternative. The useful frequency range in this circuit is of order 100:1 with a low distortion and stable amplitude readily achievable over more than a 10:1 range.

To reduce the number of variable components and achieve single-element control of frequency it has been necessary to introduce a second amplifier (or to permit the gain condition to vary widely placing a strain on the amplitude controlling circuitry). In the previous circuit a very simple step eliminates the extra amplifier. Because the variable-gain requirement has been reduced to variable attenuation the amplifier is being used only to buffer the lead-lag network from the potential divider. With modern operational amplifiers, particularly those with f.e.t. input stages, the ratio of the lead-lag resistances to the potential divider resistance can be large enough that the loading effect is negligible for the buffer amplifier to be omitted. In the final circuit shown, R<<R and oscillation can be extended to low frequencies using relatively low values of capacitance – both because R may be large and because the configuration reduces the frequency further as the tapping point on the potentiometer is increased from 0 to 100%. This circuit achieves frequency variation with a single potentiometer while requiring only a single operation amplifier. The loading effect cannot be completely ignored but the usable frequency range though less than for the two-amplifier circuits readily exceeds 10:1.

A powerful design tool in creating these variants is the nullor. If the single amplifier circuit is re-drawn in nullor form and inverted its internal behaviour remains the same. The shift in ground point to the other end of the norator then allows a new operational amplifier form to be produced. The same component values result in the same frequency of oscillation. The differences in performance may be significant as the common mode swing at the amplifier input terminals is ⅔ of the output instead of ⅓. An advantage of this configuration is that the resistance 2R' is grounded which makes it easier to control via an amplitude sensing network. It is such practical points that make it advisable to consider alternatives to known circuits – they will not often provide dramatic improvements but each new form may have particular advantage that can be exploited in particular circumstances.

RC oscillators: single-element frequency control

THEORY

● In each of the first two examples the resistor ratio to give the appropriate gain condition is assumed; the frequency condition then follows simply. In the third case the analysis is fuller with no prior assumption.

Oscillator frequency corresponds to network attenuation of 0.5. Impedance of series arm is $R+1/sC$

Admittance of shunt arm $\dfrac{1}{(n+1)R}+\dfrac{n\,.\,sC}{n+1}$

$$\therefore (n+1)R=(1+nsCR)(R+1/sC)$$

$$s=-\frac{1}{nC^2R^2}$$

$$\omega=\frac{1}{\sqrt{n}}\cdot\frac{1}{CR}=\frac{\omega_0}{\sqrt{n}}\quad\text{where }\omega_0=\frac{1}{CR}$$

● The impedance convertor interpretation is not appropriate to the second form of oscillator.

$$\frac{v_0}{v_x}=1+Z_sY_p$$

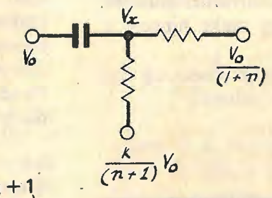
$$1+\left(R+\frac{1}{sC}\right)\left(sC+\frac{1}{nR}\right)=2+\frac{1}{n}+sCR+\frac{1}{nsCR}$$

$$\text{But }\frac{v_0-\frac{v_x}{n}}{2}=v_x\text{ or }v_0=v_x\left(2+\frac{1}{n}\right)$$

$$\therefore\frac{v_0}{v_x}=2+\frac{1}{n}=2+\frac{1}{n}+sCR+\frac{1}{nsCR}\quad\text{and}\quad\omega=\frac{1}{\sqrt{n}}\cdot\frac{1}{CR}$$

● If v_x is derived (i) from the RC potential divider driving the non-inverting input (ii) by applying Millman's theorem (or superposition) and the two results equated, an equation leading to the frequency and gain conditions is obtained.

$$\text{(i) } v_x=\frac{v_0}{1+n}(1+sCR)$$



$$\text{(ii) } v_x=\frac{v_0\left[sC+\frac{k}{(n+1)R}+\frac{1}{(n+1)R}\right]}{sC+1/R+1/R}$$

$$(1+sCR)(sC+2/R)=(1+n)\left(sC+\frac{1}{R}\cdot\frac{k+1}{n+1}\right)$$

$$(1+sCR)(2+sCR)=RsC(1+n)+k+1$$

$$2+3sCR+(sCR)^2-sCR(1+n)-(k+1)=o$$

Equating real and imaginary separately to zero

$$(1+n)=3$$

$$2-(k+1)=(\omega CR)^2$$

$$\omega=\frac{\sqrt{1-k}}{CR}\quad\text{where }\omega_0=\frac{1}{CR}$$

● As $k\rightarrow 1$ $\omega/\omega_0\rightarrow 0$ and low frequencies of oscillation are attained without the need for large time constants. The theory is applicable to the single-amplifier circuit provided $R'\ll R$ as then the loading effect on the potential divider remains negligible. The algebra is equally valid for the nullor equivalent circuit, its inverted form and any operational amplifier forms derived from them.

EXAMPLES

1. The first oscillator is required to have a frequency range from 100Hz to 3kHz. Choose suitable component values, given that the available variable resistors have a contact resistance of 10Ω and that the op amp input resistance with feedback is 10MΩ.

The constraints suggest that the variable resistor has to be ≫10Ω to avoid significant frequency shifts due to contact resistance variation. Similarly to avoid loading by the op amp the resistance should be ≪10MΩ. To meet the frequency range with a dependence on $1/\sqrt{n}$, the resistance has to change by $(3000/100)^2$ over the whole range i.e. 900:1. This is just possible while meeting the constraints if say R_{min} = 330Ω and R_{max} = 300kΩ. Then

$$R_{min}=33\times\text{contact resistance}$$

$$R_{max}=\frac{\text{op-amp input resistance}}{33}$$

with consequent errors of a few percent at the extreme ends of the range.

This example illustrates the difficulty of achieving wide frequency variation with a single control element — though possible it requires considerable attention to detailed design.

2. The single-amplifier single-element-control oscillator uses a thermistor for amplitude control. The thermistor has optimum performance when its p.d. is 1V rms and it is dissipating 2mW. Choosing an appropriate value for the potentiometer, select R, C values to give a frequency of oscillation of 1kHz when the potentiometer is set at its mid point.

The thermistor has to be placed at location 2R' to control the amplitude — as the amplitude increases the thermistor is heated causing its resistance to fall. This provides more negative feedback, reducing and then stabilizing the amplitude.

$$\text{Thus }P=\frac{v^2}{(2R')}$$

$$2R'=\frac{1^2}{2.10^{-3}}$$

$$R'=\frac{10^3}{4}=250\Omega$$

This is a standard potentiometer value and presents no problem. The R values of the lead-lag network must be ≫R' to avoid loading of the potentiometer, but should not be so high as to be loaded in turn by the op amp inputs. The latter constraint can be virtually removed by using f.e.t. input op amps, though increased susceptibility to hum pick-up can be a problem.

These considerations suggest R = 100kΩ as a suitable compromise (400 x R').

For k=0.5

$$\omega=2\pi10^3=\frac{\sqrt{1-0.5}}{C\,10^5}$$

$$\therefore C=\frac{0.707}{2\pi\,10^8}$$

$$=1.12\text{nF}$$

LETTERS TO THE EDITOR

DESIGNING WITH MICROPROCESSORS

I read the letter from R. M. O'Connor in the October issue with great dismay and I suspect that it has put off a few would-be micro system designers and made them think again.

I would like to describe, as briefly as possible, a microprocessor based system that I have designed and built in just two months. I was not put off by any fears of components becoming out of date overnight. The objective was to design and make a machine, and it was achieved with great success.

My business needed a machine to off-line direct mail letter production. We already have a Research Machine 380Z but this is in full time use doing other work. The machine needed: (a) the ability to read a serial keyboard and a cassette deck; (b) between 2 and 4 kilobytes of r.o.m. and about 4 kilobytes of r.a.m.; and (c) a driver for a fast daisywheel printer. (No screen was needed; the daisywheel provides the user-machine interface.)

After browsing through several back copies of your journal I realized that the Z80 is the best and most popular processor around; also, because our Research Machines 380Z uses a Z80A, then this could be used to assemble the program which would control the new machine.

Careful scrutiny of the *WW* articles on Z80 type systems (particularly those by John Adams on the Scientific Computer) showed that there are not many ways of putting the support logic around a Z80. I therefore 'learned' how to design a system by studying these articles.

A design was made, carefully checked and improved. A printed circuit was then designed (double sided) and this was etched by a local firm. The whole was then assembled and tested. To my absolute delight it worked more or less first time. The faults were in the printed circuit tracks being fractured; there was no design fault at all.

Next, software. A book on Z80 assembly programming was purchased and studied. The program to control the machine was written and assembled on the 380Z. It was not possible to test it on the 380Z because of the way input-output was implemented. Very careful desk checking was time well spent; there was no method of tracing the program once it was on the 'new' machine. The program (approx. 1500 bytes) was burnt into two 2708 e.p.r.o.ms and the machine was tested. It worked, although not quite properly – subsequent sorting out did not take long.

To summarise: *It does help a great deal* to understand how a particular microprocessor works. It is vital to understand the connections to the processor. It is futile to worry that a particular processor will become out-dated. If every designer held this view then nothing would be designed! The Z80 has been, and will be, around for many many years.

I now have a machine that does exactly what I require and if a 32-bit machine comes along that is 500 times faster than my Z80 I will not worry one bit. I have had the satisfaction of designing from scratch, and with help from the many contributors to *WW*, a simple yet very useful machine for very little cost (£150). I now have considerable confidence in tackling further microprocessor based systems. It really is not that difficult.

Finally, and in defence of ICL, Mr O'Connor has got it all wrong about the 2900 range of machines. The majority of these machines use 'microcode' rather than hard wired instructions. This enables them to 'pretend' to be any machine, not just the ICL machine models that they replace. It is not true that they are 'very inefficient indeed'. They run at the same speed regardless of the machine they are emulating and their performance is very high. Does Mr O'Connor seriously believe that users would accept performance of the kind he describes? No, the 2900 range is one of the best in the world – the sales figures clearly demonstrate that.

Charles Coultas
Reading
Berks

CRANKY VIEWS

I have news for S. Frost (October letters). The millibel, to use John Stuart Mill's own words, *is* an absolute certainty – a concept that is probably beyond the comprehension of most modern politicians, let alone one of the greatest of the nineteenth century.

So I still stand firmly by what I said in my original letter (May issue) – that in the context of its proposed *application*, it was rubbish; and if, in doing so, I was impolite, that too was intentional.

My second comment ought to have been read more carefully. I would never deny the right to a platform for cranky views; good heavens, there are plenty of those around already and they are freely available on any bookstall. But is it not reasonable to plead for one oasis where rational and carefully considered ideas can be discussed? Or is it the intention of *Wireless World* to go the way of the comic papers that masquerade as technical journals?

And since, sir, we are getting into a quoting match, may I parry with one from the same source: "The liberty of the individual must be this far limited; he must not make himself a nuisance to other people".

Can we now get back to good engineering and leave political philosophy to others?

Reg Williamson
Norwich

ENGINEERS IN THE ARMS RACE

It is a sad day for me, having studied *Wireless World* for more than 60 years, to be reading an editorial in it openly urging civil rebellion, thereby laying itself open to a charge of treason (November issue). And on a basis of untrue and libellous statements too.

You say, in effect, that our post-war governments – Labour and Conservative – and our military and industrial leaders consist of megalomaniacs and insane persons, not amenable to reason but only to force applied by popular insurrection. I comfort myself with the thought that such a rebellion is unlikely to result from your intemperate outburst.

There is certainly a case (to which during recent months you have not neglected to give prominence in what is supposed to be a technical journal) for suggesting to readers that they give conscientious thought to the morality of their vocations. There is also a case for asking them to take account of the fact that whereas world war II broke out 21 years after world war I, the latter ended 35 years ago and still there is no world war III in spite of the imperialistic aims of the Soviet 'Union,' and its many annexations effected by the mere threat of nuclear power. Have you in mind bringing present authority in the West to an end, thus introducing a state of chaos hitherto unknown here, and handing ourselves over to the mercies of the Soviets through the removal of the deterrent which (it is not unreasonable to argue) has extended the duration of general peace so much longer than last time in spite of at least as great aggressive intentions?

I realise that in saying this, and in failing to rally to the call to rebel, I have put myself among your demented class. Personally, instead of taking for granted that all who think, however reluctantly, that there is a case for the nuclear deterrent, are out of their minds and must be forcibly locked up, I would rather be charitable enough to give them credit for having given serious thought to the matter with the object of preventing any repetition of the dreadful scenes described in your quotation. It is very very difficult to know what to do. But of one thing I am sure, that your dogmatic and insulting attitude is unlikely to make matters any better.

M. G. Scroggie
Bexhill
Sussex

My son, who is a test engineer, bought a copy of the November issue of *Wireless World* yesterday and showed me the editorial on page 37 entitled "Microchips and megadeaths." My husband, son and I were all most impressed by the wording and presentation of this article. I would like to say how heartened I was to read your editorial as I sometimes get depressed by people who call me a traitor, especially as I am a perfectly ordinary middle-age woman with no strong political affiliations.

Mary Davies
Reading
Berks

Since the publication of my letter in November 1979, whether by coincidence or otherwise this subject has not been discussed in your magazine. I see in the September issue a letter by Peter G. M. Dawe who, in my opinion, is highly irresponsible. He says it is dangerous to have a nuclear capability. I submit that it would be suicide not to have one – and at best we would be puppets of the Russians. We need these brilliant people he suggests should be put on the dole – the designers, the constructors, the project leaders. We are also told they have serious gaps in their knowledge. As a technical person I know this to be rubbish, having known a few of these highly skilled people.

The freedoms we all enjoy today were fought for at a terrible price in the first and second world wars. Defence costs are part of the continuing price of freedom and we should therefore keep our heads out of the sand and refrain from making a third mistake.

Peter C. Gregory, G4HXV
Ashton-under-Lyne

Your November editorial "Microchips and megadeaths" made me very proud. Thank you for printing it.

I perceive two great threats to mankind: first is the use of the ultimate weapon, second is the passive acceptance of the idea that such a weapon will inevitably exist in all futures. The second frightens me more; we have to live with its paranoia.

If sanity is left in the hands of the engineers, then surely we can perfect the megachip and the microdeath?

Philip Atkin
Gonville and Caius College
Cambridge

Congratulations on your editorial "Microchips and megadeaths" in the November issue. You are so right. No arms race without the active co-operation of the technical world. We need a new style of conscientious objection.

Bruce Kent
Campaign for Nuclear Disarmament
London WC1

E MADE EASIER

I found Mr Finlay's three-part article on e (December, February, April issues), of absorbing interest. For me, he certainly succeeded in enlivening what I recall from my student days as a rather dull subject.

Perhaps I can make a contribution by outlining another method for evaluating e on a cheap pocket calculator: a method which I suggest is easier to memorise and more accurate than most cited by Mr Finlay.

Mr Finlay showed from first principles that $e \approx (1 + 1/n)^n$ when n is large, but this converges rather slowly. Faster convergence is obtained with the allied formula

$$e \approx \left[\frac{n+1}{n-1}\right]^{n/2}$$

Now translate this to binary form, viz.:

$$e \approx \left[\frac{2^n+1}{2^n-1}\right]^{2(n-1)}$$

This can be applied on an ordinary four-function calculator, even without memory – provided only that it will treat the display both as multiplicand and multiplier (as most do).

For instance, select $n = 8$. It requires little mental effort to find $2^8 = 256$. Enter 257 ÷ 255 =. Then press x = seven times. The result on my calculator is 2.7182703 – having an error, when rounded, of only one unit in the fifth decimal place.

ODDBALL IDEAS

"Mixer", writing in the August issue, is concerned about the shops which are closed to oddball ideas. Strangely enough, we academics (not my own choice of phrase, but more apposite than 'we scientists,' which I might reasonably claim to be in the view of the lay public) find ourselves on both sides of the counter in these shops. We are, it is true, sometimes bothered by 'flat earthers', if one might coin a phrase for the kind of people that have alternative ideas that are no more useful than one's own. But equally, we also send 'original' papers to unsuitable magazines, or the editor suggests that we have simply re-invented the wheel, or his referee has written the standard text book on the subject which is still selling well in its umpteenth paperback edition.

But what I think troubles me occasionally, and less reasonably, is the oddball letter that I find unintelligible. If a letter is couched in language that betrays an ignorance of the specific meanings of words and phrases that are commonly used in scientific and technical intercourse, then there is no way that I can be sure that I understand what the author means. Sometimes I can pass it to somebody with specialist knowledge and hope that he can discover its meaning or lack of it. Occasionally I have been referred to in my turn, and only once have I been able to say 'yes, this chap is not off his rocker, his proposal is feasible, and may be useful'. And what of the 'seeker after truth' person, who is difficult to convince of the pointless task of seeking right and wrong in physics? A physicist is more likely to 'borrow' a new idea if he thinks it useful, than to reject it on the grounds that Newton was always 'right'. But it has to be couched in standard scientific language or it doesn't even get to first base. As Heaviside discovered.

I am of course always fascinated by encounters of the Dingle-McCrea, Snow-Leavis, and now in *WW* the 'Displacement Current', kind, where the Gods are fighting it out way above my head, and cries of 'oddball' must disturb the calm of editorial offices almost daily. From the safety of my ivory tower, I can enjoy the wrangles of Tweedledum with Tweedledee for a mere 60p a month.

Desmond Thackeray
Department of Music
University of Surrey

INERTIA OF THE ELECTRON

In the article on the inertia of the electron by T. B. Tang in the May issue we find references to numerical coincidences which have been used to develop some possible models for the universe. Dr Tang's interesting article could also be a plausible one and it is suitable for further development.

Just to add to the number of models, I devised another one which can be summarized by the equation:

$$G = \frac{c}{\pi h}\left(\frac{c}{2\pi}\,\frac{e}{2\pi}\,\sqrt{\alpha(2-\alpha)}\right)^4$$

where G is the constant of gravitation, c the speed of light, e the charge of the electron, h is Planck's constant and α is the fine structure constant.

Of course there is a theory behind it where the electron is considered as a black hole with the result that both e and α take up new dimensions, thus rendering the equation dimensionally balanced. But its real interest is that the accuracy by which G can be computed is much higher than any experimental value so far found. In fact, G comes out to be $6{,}673019.10^{-11}$ N m^2 kg^{-2} with a precision better than 20 parts in a million.

It is still a coincidence?

D. Di Mario
Milan
Italy

The author replies:

The expression given by Mr Di Mario for the gravitational constant G may indeed be interesting because, as he has mentioned, G has been measured only to an accuracy of several parts per million whereas the four physical constants appearing in the l.h.s. of his expression are all known to better than several p.p.m. However, the resulting numerical coincidence can have no meaning when the expression is dimensionally incorrect; I fail to see how the dimension of the l.h.s. may match that of G, which is $(\text{length})^2$ (in the system $c = h/2\pi = 1$). The theory mentioned in which an electron is considered as a black hole would, to me, be considered as a dark alley.

T. B. Tang

ELECTRONIC ORGAN TONE FILTERS

Pipe organ technology is limited in its ability to imitate musical instruments but the sounds produced by combinations of organ stops are varied and pleasing. Electronic organs imitate pipe organs and current developments are concerned with perfecting this imitation (Dr Pykett's article in the October issue). Thus in general we have a good imitation of a poor imitation of a mixed bag of musical instruments – some obsolete (what were diapasons and cornopeans anyway?).

Surely it would be better to imitate electronically modern musical instruments and thus have the modern symphony orchestra sound available to the keyboard player – which was probably the goal of the original pipe organ builders in their time. (We could even see stops called "Galway Flute" or "Perlman Violin" etc.)

On a broader front, electronic musical instruments lack any way for human beings to express themselves as compared with what they can do on conventional musical instruments which can be bowed, blown or struck. This results in gimmicky and sterile music without warmth.

Perhaps the conventional forms of musical instrument expression input could be put into electronic instruments, which could then produce the sound of the best conventional instrument of that type, e.g. bowed input would give the sound of a Stradivarius violin. Of course it would also be possible to produce the best trumpet sound from a bowed input at the flick of a switch!

M. Robins
Rugby

The author replies:

Mr Robins's assertion that the pipe organ attempts to emulate a symphony orchestra is mistaken. The organ reached its pinnacle of development as a musical instrument in Northern Europe during the Baroque era as exemplified by the works of J. S. Bach, well before symphonies or symphony orchestras appeared! The tonal design of the better modern instruments is mainly based on Baroque principles, though the presence of a few stops with "orchestral" names is a legacy (not necessarily an unmusical one) from the romantic period around the turn of the century. Therefore the organ is an instrument in its own right, and its musical literature has little connection with that of the orchestra or any other ensemble of players. Consequently there are several reasons why a good imitation of the organ is a valid pursuit, not the least of them being that the electronic version is smaller and cheaper than the real thing and thus more suited to the domestic environment.

With regard to his query concerning the names of stops, "diapason" is derived from the Greek – it has no connection with any other instruments and is peculiar to the British organ.

"Cornopean" is probably a corruption of "cornet à pistons" and is of Victorian origin.

In widening the discussion to include other forms of electronic music we are going beyond the scope of my article, but Mr Robins's final comments call to mind the application of devices such as vocoders in modern music. His criticism that electronic instruments are unmusical is too generalised; any musical instrument is merely a machine for producing sound and the utmost in sophistication or craftsmanship cannot make good the inadequacies of an incompetent performer. A Stradivarius is indeed a wonderful instrument, but it would still sound appalling in the hands of many a beginner.
C. E. Pykett

The type of electronic organ Dr Pykett is describing in his current articles is basically identical with the Allen-Rockwell types which produced from r.o.m.-plus-d.a.c. approximations to waveforms collected from more than one organ. The largest of these belongs to the indefatigable Carlo Curley who nearly filled the Albert Hall with people, not to mention sound, in an event involving also the resident Fath Willis organ and three or four catehdral organists.

I want to suggest that there are about twenty difficulties confronting the designer of electronic organs and wish Dr Pykett every success with them. I think it was at the Great Exhibition of 1851 that an organ was powered by steam to the extent that housewives thought it was the Last Trump and knelt to pray in the streets. By the turn of the century some church organs roared very loudly indeed, nearly drowning the noise of the gas-engine driving the blower. It took Albert Schweitzer to stop people ripping out baroque organs which among other things worked at a very low pressure and had broad lines on the frequency analyser, or in other words they produced filtered noise.

Strange materials such as pure tin are used for some pipes, and the board they are set in functions as a soundboard. This all tends to the production of a very complex sound on organs. One electronic organ constructed for an English parish church used waveforms derived from bistables triggered by noise gated alternately to R and S at the fundamental frequency, to broaden the spectral lines.

Many amateur constructors seem convinced that each manual should have its own speaker system and Curley's organ has 400 speakers. This resembles the situation where rock music can be played through normal speakers but a bass electric guitar has to have a specially strong speaker. There is perhaps a problem here of occasional peaks building up. Thus if one is simulating 100 pipes at different pitches sounding at 1W each measured on the way to the speakers, with a single speaker system a 10kW capacity is needed to prevent overloading when all the peaks coincide, to provide 100 times the sound peak pressure arising from one "pipe".

I think there is room to doubt the validity of any approach which averages harmonic spectra right across the keyboard even though this is only four octaves. Piano design is based on systematic drooping of harmonic amplitudes as one ascends the keyboard; even then end-effects on the lowest strings give overtones which are not true harmonics and I would expect the same trouble with flue pipes. The point is important because it affects the choice between filtering out a tone and building it up from components, since a filter affects each note differently.

Of course organ pipes have different envelopes for the different partials and presumably this will be a residual difficulty for some time to come. But pipe organs can only get more expensive and electronic organs, *hoffentlich*, will get cheaper and better simultaneously. I recommend that readers building organs simulate some reverberation, in fact a good deal of it, and turn their loft into an organ loft lit only by a small lamp over the music rack, and pretend they're the cantor of Leipzig.
Bernard Jones
London W1

FAILURE OF DISTRESS SIGNALS AT SEA

With reference to Mr Wiseman's letter of June 1979, although the gist of his remarks is relevant, some of his letter may prove very misleading to non-seagoing readers.

It is true that all ships compulsorily fitted with wireless telegraphy (i.e., those of 1,600 gross registered tonnage and over) carry a battery powered W/T transmitter operating on 500 kHz. This is only an emergency installation and is a back-up to the ship's main m.f. transmitter which, today, has a p.e.p. output in the region of 1.5kW.

The supply for the main installation is taken from the vessel's main distribution board fitted in the engine room. This is also covered by an emergency supply consisting of a diesel driven generator set of sufficient output capacity to provide all essential supplies should the main generators fail. This supply is so connected as to cut in automatically when the main power fails. From this is will be seen that in most emergency situations the ship's radio officer has access to his main W/T transmitter, the emergency diesel set usually being installed outside the engine room and above the water line (mainly on the boat deck).

I should not like to take up Mr Wiseman's remarks about the aerial situation. It is my experience that the loss of radiation can only be blamed slightly on deck or bulkhead feed-through insulators. The fault must lie in the practice of designing modern ships with the bridge, accommodation and engine room casing all on top of each other, leaving little room to rig a realistic aerial system. One can add to this the lack of thought which is put into using it efficiently.

Recently, while serving on board a 250,000 deadweight tonnage supertanker, I had the very disturbing experience of not being able to raise any ship carrying a doctor in what should normally have been good m.f. range. An engineering officer was suffering from second-degree scald burns and, although I knew that within help range there were at least five Russian, Polish or East German freighters or fish factory vessels (having passed a couple earlier), I could not raise one in reply to my emergency signals. In fact, a nearby British tanker, whose emergency alarm was activated by my signals, advised me over v.h.f. that my signals were just about readable at under 15 miles.

Atmospherics were normal for the tropics, humidity was a little on the high side (but no more than had been experienced in past years) but the strain aerials were neutralised by a deposit of salt from spray and carbon from funnel gases. The particular aerial layout consisted of two horizontal nine-metre lengths connected in parallel to a 13-metre downlead. This arrangement was slung between the signal mast on top of the bridge house and a 60-ft high funnel casing to the top of which it was secured at the end of a 3-ft iron bracket and held up by a wire hallyard made fast at the base of the funnel casing.

Under normal conditions one could (with the transmitter in use) expect to register 10 amps on the aerial ammeter on 500kHz but as soon as any high humidity was experienced 1_{ae} dropped to 1 amp or less. Despite dropping the main aerial on as many occasions as possible (a practice frowned on by most ship's deck officers as it interferes with the essential work of painting) to wash off carbon and salt from the strain insulators, after a couple of days the old problems showed up again after dark.

When one's main aerial was rigged between two high masts and led into the radio room using an aerial of the inverted 'L' or a 'T' configuration the problem was practically non-existent. The writer remembers the many occasions when contact was established on m.f. with Capetown radio (ZSC) using an IMR M-100a half-wave rectified main transmitter at 2,500 nautical miles, or Auckland radio (ZLD) at 3,000 miles across the Pacific with the help of a Marconi type 380 ¼-watt full-wave set.

Okay! So it was at night, and in the tropics, and conditions were good, but normally one could work within 500 miles to a shore station and over 300 miles to another ship. Today, even with the most sophisticated 1.5kW synthesized transmitter one can get a better DX on the v.h.f.

It is felt that more care should be used in the siting of modern aerial installations, or more use (certainly in British ships, where the practice seems to be frowned on) made of the 'capacitance hat' type, or the folded unipole type, of free-standing radiators. Good examples of such installations can be observed on Norwegian, German or Swedish vessels (for the use of mast radiators) or Japanese ships for conventional types of aerials.

However, when these points were raised recently (after my emergency experience) with a ship's superintendent, he raised his hands in horror at the idea of the vessel's owners being asked to foot a bill of (his figures) $10,000 upwards for a newly designed aerial system. When tackled as to whether seafarers' lives were not considered to be worth an extra $10,000, he refused to commit himself. I wonder what his thoughts would have been if *he* had been chief engineer of my ship and *his* engineer officer had been the man to require medical aid. Probably he would have put it down to the P.B.R/O.

If this letter only makes some of your aerial design readers think, I shall be well rewarded. However, I must admit my remarks are going to be raised with my association for consideration by it, and all other seafarers' organisations. I've only one life; I don't want it to be jeopardised by a lousy bit of wire.
John J. Boyd (Radio Officer)
Birkenhead
Merseyside

LEVY ON BLANK TAPES

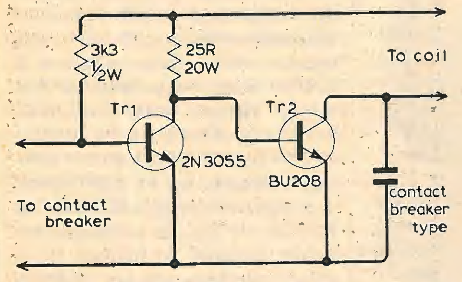
I learn with some misgivings that the Mechanical Copyright Protection Society is considering the promotion of a Bill to allow the levying of a surcharge on the price of blank magnetic tapes.

While I support the attempts of musicians and their agents to obtain a just reward for their labours, I do not think this is a suitable way to go about it. It sets a poor legal precedent, in that it attempts to penalise people for something they might do – akin to compulsorily levying the price of a dog licence from everyone in case they may get a dog.

Should the Society feel compelled to persist with this proposal, I would like to have their assurance that users of magnetic tape for purposes other than the duplication of copyright material will be exempted from this levy. As a reminder, these purposes include: dictation; word processing; information storage in both amateur and professional computing equipment; data logging; amateur recording of live music; tape 'letters'; recording of broadcast programmes for educational purposes; wildlife recording; recording of effects for amateur dramatics; recording of interviews and spoken pieces for local radio; telephone answering machines; and recording of messages transmitted by licensed amateur radio operators.
R. C. Simmons
Chipping Norton
Oxfordshire

ELECTRONIC IGNITION

I have been interested to read of the problems your correspondents have been having with their electronic ignition systems. I used to have starting troubles with my car and decided to do the main switching of the coil by transistors rather than using the contact breaker directly for this purpose. The circuit is very simple and costs less than £3 to make. It has now been in use for more than three years (40,000 miles), and the points themselves are still in perfect condition. The contacts still need adjusting every 12,000 miles or so because there will be wear on the cam follower causing the gap to narrow slightly with age.



The circuit is as shown. With the contacts closed, Tr_1 is off, and hence Tr_2 is hard on. So hard in fact that the voltage drop across it is in the order of 0.3 volts. Since it is passing a current of about 4 amps, it is only dissipating just over 1 watt and has worked perfectly well without extensive heatsinking.

The contact breaker is now switching just 4mA at the most, and this is purely resistive, hence the total lack of pitting etc.
D. J. Cope
Southport
Merseyside

ADVERTISEMENTS IN WIRELESS WORLD

As a regular *Wireless World* reader I think the number of full-page advertisements is excessive for the price of this otherwise interesting magazine. It would probably be true to say most readers would pay another 5p or so to reduce the full page ads that seem to increase in number every month.

The point is here that ads on ITV are free* but in this magazine and others you pay to see them. I realize this is a large source of income but it will not be if your readership is reduced because of them. I think a better idea is to cut down on some of the ads but increase those in the appointments section. With rising unemployment this would serve a more useful purpose to help the electronics community as a whole.
"Worried"
Haverhill
Suffolk

*See the current editorial on this subject – Ed.

TV VIEWING AIDS

Mr Fred Holloway (October letters) has suggested that television sets should be provided with headphone sockets for the benefit of viewers who are hard of hearing. May I suggest that there is also a strong case for the provision of this facility for another reason? In many homes there are conflicting simultaneous demands for television sound for one or more persons and quietness for others who may wish to read, do homework or listen to the radio on phones.

A related subject is that of room lighting. Use of the conventional room lighting reduces effective luminance contrast and colour saturation, while the absence of lighting produces eyestrain. At an early Television Society lecture a manufacturer demonstrated a receiver with an illuminated area surrounding the screen. Such an arrangement would not be appropriate with today's larger screens, but I find that a 13-watt fluorescent tube fitted at the rear of a receiver provides a good "halo". (An incandescent lamp of similar brightness would need to dissipate about 60 watts and would increase the ambient temperature undesirably.)

It would be more convenient if manufacturers would provide these facilities.
Roy C. Whitehead
Sutton
Surrey

TV SETS FOR THE HARD OF HEARING

In your October issue Fred Holloway of the Essex League of the Hard of Hearing recounted his difficulties in obtaining a television receiver with earphone facility. The implication of course was that British industry was once again seen to be behind its foreign competitors. Not so – Decca produce 14in, 20in, and 22in sets all with a choice of headphones only or both loudspeaker and headphones plus tape recording and with full remote control if required. To this will be added in the autumn of this year a new range of 30AX models each with the same facilities. According to our information at least three other **British** manufacturers also supply sets fitted with earphone sockets.

We shall be glad to send full details to anybody interested in this particular problem.
Ian C. Rule
Decca Radio & Television Ltd
Willenhall
West Midlands

Mr Holloway's letter in the October issue draws attention to the lack of headphone outputs on many tv sets, and the resultant problems for the hard of hearing. The following comments might be of interest to people in a similar position.

Several sets, mainly portable types, have a 3.5mm socket for use with a low impedance earpiece. This can be used with normal headphones and a suitable adaptor; the socket can be easily modified to stop switching of the speaker. If a socket is to be added to an existing set, an isolating output transformer is usually necessary due to the lack of an earthed chassis.

For those who do not wish to modify the set, the following are available: small battery amplifiers using a microphone placed near the speaker and a lightweight headset or phones; for those with a suitable hearing aid, similar microphone amplifiers to drive a simple inductive loop placed round the room. Several firms including ourselves make suitable models. The RNID also issue a leaflet on the various types of "aids" available.
P. Royall
Sarabec Electronics
Middlesborough
Cleveland

INDUSTRIAL ROBOTS

Granted that industrial robots have been successfully applied to routine repetitive tasks in the automotive industry, the question nevertheless first arises as to whether we want every motor car on the road to look and be like every other. If, as you say in September News, "the natural growth area lies in flexible manufacturing systems, where a large number of different product types will be demanded by an increasingly sophisticated market", the answer to the question seems to be definitely in the negative.

If that is so, we may not need robots to make motor cars, or indeed much else, for that matter. There might well come a time, for example, when I may not like to have my motor car designed or built by anyone or anything that cannot properly appreciate Beethoven's 4th symphony or Renoir's "Le Moulin de la Galette", i.e. that cannot clearly distinguish between good art and bad art. A high level of sophistication maybe, but one that is certainly conceivable to me.

The amount of "fast-acting tactile, visual and aural sensory devices" that you would have to build into a robot to enable it to meet this level of sophistication would certainly have to be pretty enormous. I would respectfully suggest, therefore, that one might have much better luck, or success, by endeavouring to employ some of the two million unemployed "fast-acting tactile, visual and aural sensory" individuals who are at present on the labour market.
Peter G. M. Dawe
Oxford

AERIAL INSULATORS AT SEA

John Wiseman, in his August letter on the subject of the distress frequency at sea, has clearly defined the necessity for thoughtful antenna design, with fewer (parallel) insulators, better shielding, and greater capacitance. Mr Wiseman also makes reference to the Admiralty Handbooks, and I would like to supplement his reference by quoting from the 1931 Edition as follows: "It is, therefore, the duty of the wireles staff to keep all these scrupulously clean, especially after heavy steaming, heavy rain or bad weather, since under these conditions the insulators will probably be covered with a semi-conducting layer of 'stokers', dirt, or dried salt."

It is the semi-conducting layer that spoils radiation, not so much a flushing of the insulators with rain or sea-water. Thus, if the insulators are cleaned regularly, as if their Lordships of Admiralty once instructed, it is almost a certainty that no difficulties will be experienced except in special circumstances such as arise in areas like the Persian Gulf, where sand and spray may combine.

With the modern base insulated medium frequency antennae, the cleaning of the insulator poses little difficulty, and there is no excuse at all for it to become salt, stokers, or dirt encrusted.

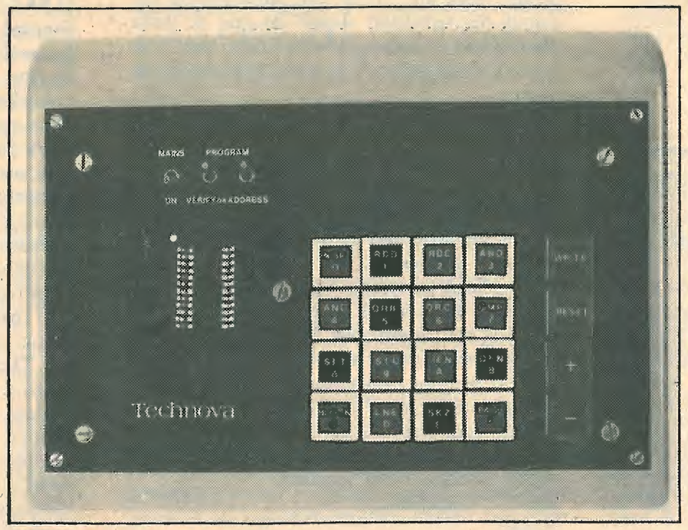
Mr Venekamp's low impedance antenna (August letters) may contribute to a solution, but I don't think we should avoid cleaning it.
P. J. W. Sawyer
Natal, Republic of South Africa

NEW PRODUCTS

E.p.r.o.m. programmer

A low-cost programmer for use with Intel 2716 e.p.r.o.ms has been introduced to the market by Technova Developments Ltd. After a sequence is written into the programmer, addresses can be incremented automatically. Also, addresses already entered can be selected for verification and/or alteration to allow possible errors to be corrected before the e.p.r.o.m. is programmed. Crystal control is used for the program pulse length to increase programming reliability and, at a one-off price of £475+v.a.t., the unit could be useful to development engineers who wish to program e.p.r.o.m.s for prototypes, or to modify existing programs. Technova Developments Ltd, Francis House, Blofield Heath, Norwich, Norfolk NR13 4SF.

WW 301



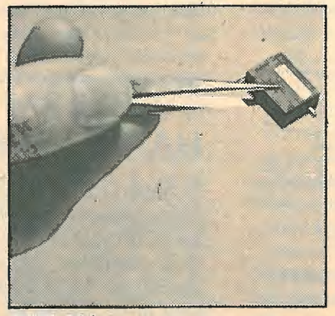
WW 301

Microwave detector

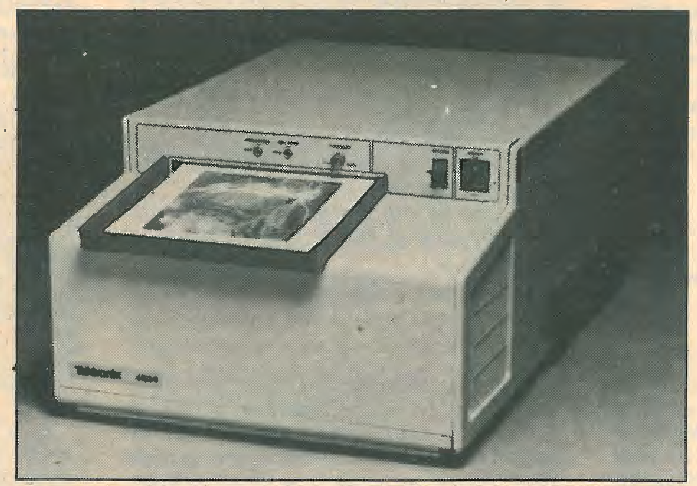
Now that microwave ovens used in hotels and restaurants must comply with the regulations of the Health and Safety at Work Act, the need for cheap, simple but effective methods of detecting microwave leakage has increased. This battery-powered "pocket" tester, the model TS256 from Bach-Simpson, gives both an audible and a visible alarm when r.f. leakage greater than 4.5mW/cm^2 is detected, and its only control is a combined on/off and "battery-test" switch. Designed for use in the ISM band, the TS256 is calibrated at 2450MHz and is said to be practically immune to failure caused by excessive field strength or physical abuse. Possible leakage is detected by simply switching the tester on and passing it around the seals of the oven, the only stipulations being that the oven is switched on at "high", and has been for a period of one minute prior to testing, and that the oven has in it a plastic vessel containing around 275ml of water. The price of the TS256 is £24.50. Bach-Simpson (UK) Ltd, Trenant Estate, Wadebridge, Cornwall PL27 6HD.

WW 302

WW 302



WW 304



WW 303

Hard-copy unit

High-resolution, continuous-tone copies can be produced in a matter of seconds from raster-scan video sources using the Tektronix 4364 imaging hard-copy unit. With an image of 15×20cm, the copier uses a fibre-optic cathode-ray tube to record onto dry-silver paper without the use of toners or developers. Front control panel and front paper load/exit allow the unit to be unobtrusively mounted into a video system. The 4634 is self-contained, usually requires only a single cable connection and can be interfaced to most video sources whether analogue or digital. An a.g.c. circuit is included which tracks the input signal to reduce the effects of variations at the input and a grey-scale range with twelve levels is also featured. The makers say that the unit was designed to provide photographic quality images and claim it is a cost-effective alternative to other display recording devices with a similar image quality. Tektronix UK Ltd, Beaverton House, P.O. Box 69, Harpenden, Herts.

WW 303

Miniature motor

With a supply potential of 1.2V, the 712L d.c. motor from Portescap can develop a mechanical power of 70mW although it measures only 7×12×16mm. These features, together with a starting torque of 2.5×10^{-4}Nm, a no-load speed of 11,000r.p.m. and low-inertia, are said to have been made possible by combining the use of new materials with established design techniques. Gold-alloy brushes, samarium-cobalt magnets, sintered-bronze bearings and the maker's ironless rotor are all included in the design. Portescap (UK) Ltd, 204 Elgar Rd, Reading RG2 ODD.

WW 304

Strain meter

Field measurements can be made with the DMD20 battery powered and portable strain meter with digital readout. Hottinger Baldwin Messtechnik GmbH, represented by Carl Schenk Ltd, manufacture the instrument which provides energizing for transducers, and operates with a carrier frequency of 225Hz. Strain-gauge half and full bridge circuits with resistances from 60 to 2000Ω can be used in conjunction with the meter to indicate strains of up to ±1999μm/m and gauge matching and balancing facilities are built in. Although primarily designed to indicate static values, the meter has an analogue output which allows the recording of low-frequency dynamic values also. The same manufacturers have also announced extensions of their range of strain gauges. Carl Schenk (UK) Ltd, Stonefield Way, Ruislip, Middx HA4 OJT.

WW 305

Continuous coverage receiver

Any frequency in a range from 50kHz to 29.7MHz can be tuned in, using the McKay DR 33C communications receiver, distributed by Lee Engineering Ltd, which makes use of phase-locked digital frequency synthesis, with crystal control, to enable continuous and accurate coverage of the full range, and a large, six-digit, display for frequency readout. Demodulation for either a.m., u.s.b., l.s.b. or c.w. (also r.t.t.y. with an external converter) is switch-selectable, as are r.f. filtering, which ranges from four to eight kHz, and noise limiting. A high-level r.f. front end, and a double-balanced diode ring-mixer are used for good i.m. rejection and sensitivity, whilst crystal filters in the first and second i.f. amplifiers, and a ceramic filter in the third, are provided for the rejection of all undesired frequencies and good selectivity. A.m. envelope detection is carried out using a class D configuration, which has the advantage of giving low-distortion, even at high modulation levels. Variations on the DR 33C model are available, as are an active all-wave antenna, and passive r.f. preselectors ranging from 0 to 30MHz in 9 bands. The DR 33C costs around £950. Lee Engineering Ltd, Napier House, Bridge St, Walton on Thames, Smurrey KT12 1AP.

WW 306

Keyboard protection

Moulded rubber covers to protect keyboards can be made to manufacturers' specifications by Kea Flex Ltd. These covers make possible the use of keyboards outdoors and in dusty, humid enviroments such as process plants and mills. One such cover already made by this manufacturer for Racal Datacom has individual raised keypads to improve tactile response, bonded white key symbols, and is made from silicone rubber to give it mechanical flexibility and resistance to high temperatures and chemical contamination. Kea Flex say that they can provide a complete design, development, toolmaking and moulding service specially geared to handle difficult customer requirements. Kea Flex Mouldings Ltd, Broxhead Works, Linford, Bordon, Hampshire.

WW 307

16k modem

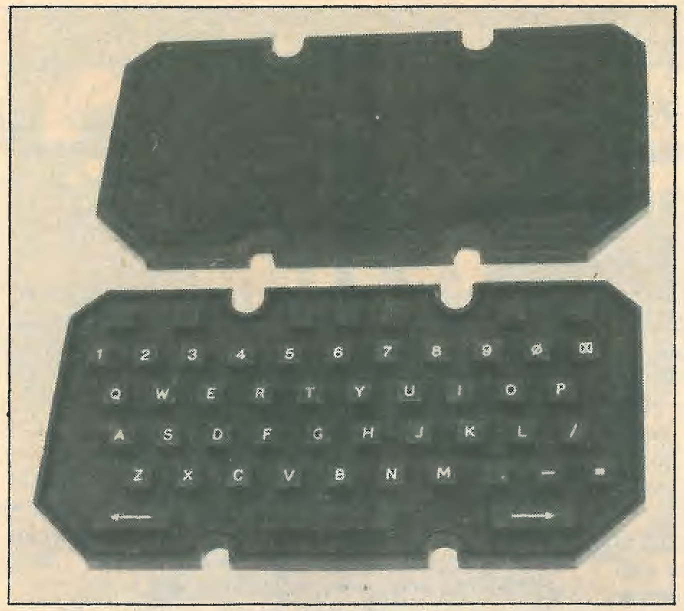
The world's first 16,000bit/s modems to be made available commercially is the claim made by Plessey for their 16000 series. An improvement on the 16001, the first design in the series, is expected to be available in January and is designated the 16002. The second version is suitable for data communication as well as digital speech transmission and also offers improved performance on poor lines. Quadrature amplitude modulation has been chosen as the means of carrying information over voice frequency lines as it offers high noise immunity. The two carriers in quadrature are at a frequency of 1700Hz and each can have eight possible amplitudes. In order to reduce the effects of line noise which would normally cause unacceptably high error rates, a forward correction module will also be available as an optional extra. Plessey Digital and Network Systems Ltd, Taplow Court, Taplow, Bucks.

WW 308

Humidity control switch

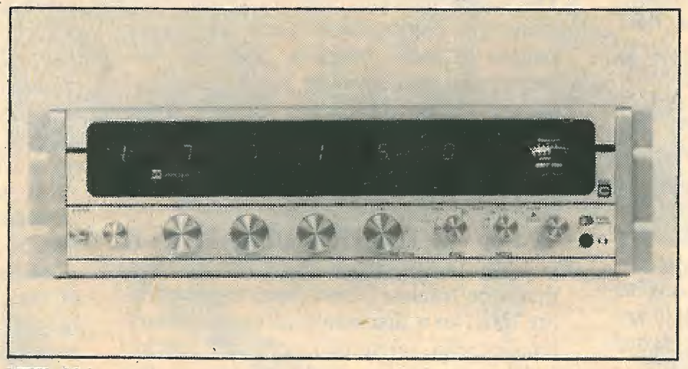
Natural hair is used as the sensing-element in this control unit, the Regin type-HR room humidistat from Appliance Components Ltd. Any desired relative humidity limit value from 30 up to 90% can be set using a dial on the front of the unit, and the hysteresis of the limit switching point is low at ±1.5% r.h. The taut hair of the sensor stretches as the humidity of the air around it increases. This means that if the sensing-element should break, become wet or not be recalibrated after a certain period of time, the humidity of the room will tend to decrease rather than increase, an inherent safety function not found in for example cotton-type sensors which shrink with increasing humidity. Calibration of the 165×60×38mm wall-mounting unit is simple, and its control microswitch has a contact-rating of 10A at 480V a.c. into a resistive load. Possible applications of the type-HR include the control of humidity in computer rooms, air-conditioning systems and laboratories. The 100-off price is around £17.34 per unit. Appliance Components Ltd, Cordwallis St, Maidenhead, Berks SL6 78Q.

WW 309



WW 307

WW 308



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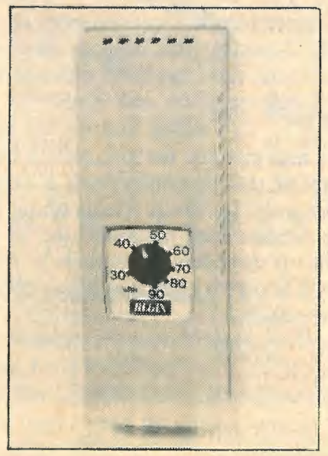

WW 309

C.r.t. controller

Design aims of this r.o.m. programmable c.r.t. controller were to reduce the manufacturing costs of intelligent c.r.t. terminals, word processors and information display equipment produced in large quantities. The S68045 from AMI Microsystems Ltd is pin compatible with existing software programmable devices and can directly replace those such as the MC6845 and SY6545 once character fonts and display formats have been established. Two complete character and display programs are stored in r.o.m. in the S68045, which makes use of the same power supplies and clocks as the devices it is to replace. This offers, the manufacturers say, cost savings of up to 40%. AMI Microsystems Ltd, Princes House, Princes St, Swindon, Wilts SN1 2HU.

WW 310

F-V converter

Low drift and high reliability are claimed for the Teledyne Philbrick 4736 hybrid frequency to voltage converter which is available through Technical Selling Services. With a guaranteed linearity error of less than 0.008%f.s., the 4736 can operate at frequencies of up to 1MHz and gives an output voltage which is linearly proportional to the input signal frequency regardless of the waveform used. Mounting onto a p.c.b. is simple as is the hybrid-type package used has a 24 pin d.i.l. layout. Minimum and maximum input potentials are 1.6V (threshold voltage) and 12V respectively, while the maximum output voltage is 11V, and the maximum output current is 20mA. Versions are available which have undergone 100% screening similar to MIL-STD 883, method 5008. Technical Selling Services, 80a High St, Camberley, Surrey GU15 3RS.

WW 311

SIDEBANDS By Mixer

All very well, but . . .

It isn't often I can report what seems to me a hopeful sign of renascent sanity, but it's all the more welcome for its rarity. If you can be bothered with the rest of the issue after reading this page, you may come across a piece by one of our hacks on air traffic control in which the said hopeful sign makes a brief appearance.

In a few year's time, it is the intention of the civil aviation people to provide air traffic controllers with all manner of computery, which it is hoped will enable them to see what is going to happen in about a quarter of an hour unless they tell the pilots to do something else. In this way, they will be able to tell whether everything will proceed in an orderly and thoroughly British manner, or whether there is going to be an almighty bang.

To the naive, this is just the ticket, and one might imagine that controllers would be absolutely delighted to exchange important parts of their anatomy for such equipment. But air traffic controllers are not noted for their naivete, and engineers rather less so, if anything, so they're all looking at the gear through noticeably narrowed eyes.

What they don't like much, they say (and the people developing the stuff quite see their point) is that the displays are so convincing that they find themselves taking the computer's word for Gospel, and they're realistic enough to insist that nothing is that perfect. Well, you can see what they mean – when a couple of airliner captains come on the air to point out that they haven't been trained for close-formation flying, and would you mind awfully making the other one go away, it is absolutely not on to explain that it's all right really, because the computer says so.

So, you see, there's hope. So long as there are some people left who can still say "Yes, but . . .", we can rest easier in our economy-class, battery-passenger cells.

". . . by any means make money"

"It is in the game for profit, and the service it provides is incidental, a means to that main purpose." Thus the editorial at the other end of this month's issue, independent television being the target.

It is just possible that there may be a couple of you out there who think the above remark is going a bit far. The programmes aren't that bad, you might think, and they have to show adverts to pay for the programmes, which are obviously the reason for broadcasting at all. They are, aren't they? Well, actually no, they're not. The programmes seem to be regarded by the companies as a rather time-wasting and expensive way of filling the time between adverts. Admittedly, with some of the stuff they put out, I wouldn't argue with them, but for a method of propagating information as prodigal of bandwidth as television to be used by a few people to make vast amounts of money by advertising seems to me obscene.

I can vouch for the prevalence of this view of television among the companies and will illustrate it by reference to a visit I once paid to Yorkshire Television. I'd gone there to see some new equipment they'd had installed, and arrived just after a breakdown lasting some hours. I commiserated and said "How awful" and "Dear, dear" and all the usual things and was a bit taken aback when the very senior engineer I was talking to said that it hadn't been all that disastrous, really, because they'd only lost about fifteen minutes.

Apparently the loss of several programmes didn't count: it was the fifteen minutes of adverts down the drain and the consequent loss of revenue that had caused them to hop around briskly mending fuses or whatever they do. So there you are – never mind the programmes; feel the ads!

The game of the name

The Dutch are a fine race, and I have often thought it was a crying shame they never learned to speak properly. Still, they do keep trying, and to prove it, a Dutch publisher recently sent a letter, couched in the unlikely combination of characters that I am reliably informed passes for a language over there. Words like 'wij' and 'mogelijk' abound.

Now, my adventures in foreign languages, apart from those that are dead and therefore 'useless', have been confined in the main to a discussion of extraordinary females who, for some inscrutable reason, insist on keeping a supply of pens in the garden. I am not, therefore, well prepared to decipher communications even in single Dutch. Luckily, the newest member of our editorial team has been exposed to the lingo for some years and is able to make sense of it. So I asked him to cast his eye over it and give me the gist, which he did.

It seems that two magazines, *Elektronica Hobbie* and *ELO* are to merge under a new name, which they have decided is to be Hobbit. It does have a hyphen – *Hob-bit* – but it is pretty clear that it has appeared in translation.

I have no quarrel with the name Hobbit. As names go, it is a perfectly good name. I am not sufficiently enthusiastic about it to want to read books on the subject, but it seems harmless enough. But to call an electronics magazine after a hairy-footed denizen of Middle Earth does indicate a certain self-imposed limitation in circulation figures. We shall see, but it's going to need some very explicit covers if confusion is to be avoided. Maybe they don't read Tolkien in Holland: or perhaps Hobbit is spelt with a lot of 'j's and 'k's in Dutch – I wouldn't be a bit surprised.

Best of luck to *Hob-bit*, anyway.

Real estate

As befits a journal with a readership of *Wireless World*, the standard of letters we receive is a cut above the normal run of 'letters to the press'. I have been terribly impressed by all the erudition displayed over displacement current and electrons, and only wish I could contribute myself. But I have always thought it important to know one's limitations, and displacement current, relativity and many other rarefied subjects are well on the 'no-go' side of mine.

I do feel, however, that all this about e ought not to be allowed to go unrecognized. You never know when you might be caught short without either guessing stick or calculator, and experience an urgent need to know the value of e. I've noticed several letters offering valuable advice here, and this is an area where I do think I could be of assistance. I doubt whether many folk would be able to remember those funny sentences, such as 'In Wapping, a quantity of penguins I glowered at grumpily fled', so I've come up with another idea.

My method could be used in any circumstance, but preferably while standing in a 54.365636568 acre tract of land – a wood, or moor or whatever is to hand: one of the Ordnance Survey plans should be helpful here. Stand there until you have managed to attract the attention of twenty passers-by – more or less could be used, but the arithmetic becomes inconvenient. Now get them to distribute themselves equally over the area you have chosen (offers of money or quantities of alcohol make this easier). This done, you mark out the land by drawing lines exactly midway between people, and then you can tell them all to go away. It should be possible to do this without causing offence, but if not, you might find it necessary to feign madness – this often averts aggression. It only remains to measure one of the small areas enclosed by the lines you have drawn, which will be found to be 2.7182818284 acres.

Alternately, you could try remembering 2.7 1828 1828 4.

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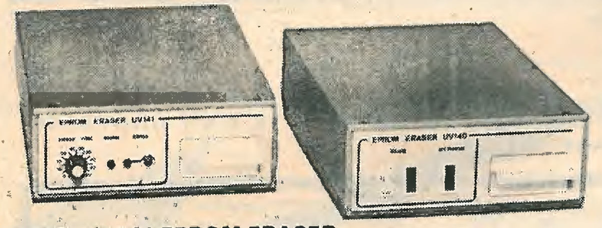

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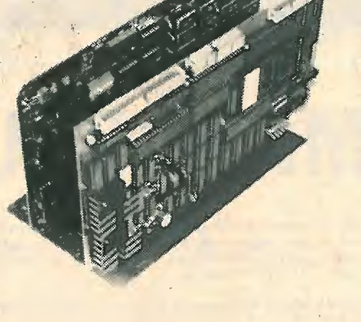

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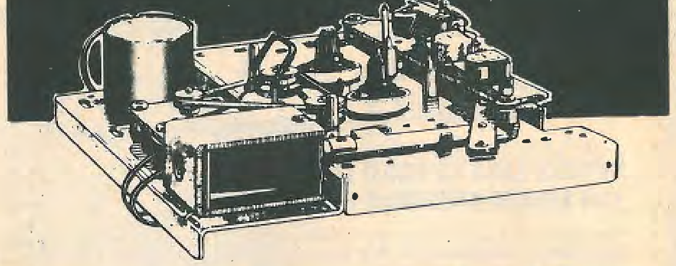

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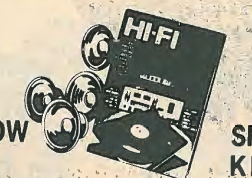

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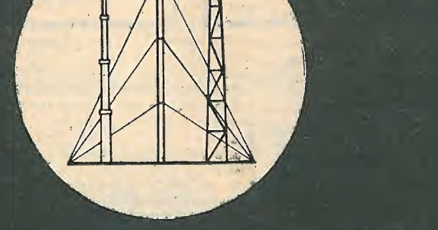

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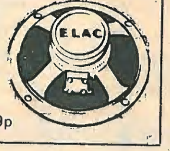

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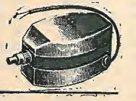

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Deluxe pocket size precision moving coil instrument, jewelled bearings — 2000 o.p.v. Battery included. 11 instant ranges measure: DC volts 10, 50, 250, 1000. AC volts 10, 50, 250, 1000. DC amps 0-100 mA. Continuity and resistance 0-1 meg ohms in two ranges. Complete with Test Prods and instruction book showing how to measure capacity and inductance.

£6.50

HIGH QUALITY

JVC DECK £28.50 Post £2

J.V.C. BELT DRIVE STEREO DECK

Detachable head, adjustable counter balance weight, hydraulic damped cueing platform, automatic pick-up arm return, 2 speeds, 33 and 45 rpm, suppression circuit to start stop switch, 240V AC motor, dynamic pendulous bias compensator. Teak veneered base, 19in. x 14½in **£9.** Plastic cover **£6,** post £2. Recommended stereo magnetic cartridge **£6.50** extra.

RCS SOUND TO LIGHT KIT Mk. 2

Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Suitable for home or disco. Easy to build. Full instructions supplied. Cabinet **£4.50** extra. Will operate from 200MV to 100 watt signal. **£18** Post 50p

200 Watt Rear Reflecting White Light Bulbs. Ideal for Disco Lights, Edison Screw. 6 for **£4,** or 12 for **£7.50.** Post 50p.

"MINOR" 10 watt AMPLIFIER KIT £14.00

This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£14.00;** 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 STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and PC Board. Can be ganged to make multi-way stereo mixers **£2.95** Post 35p

MAINS TRANSFORMERS ALL POST 99p.

250-0-250V 70mA, 6.5V, 2A	£3.45
250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A	£4.60
350-0-350V 250mA, 6.3V 4A CT, 5V 2A,	£12.50
300-0-300V 120mA, 2×6.3V 2A C.T.; 5V 2A	£10.00
220V 45mA, 6.3V 2A	£2.50

GENERAL PURPOSE LOW VOLTAGE.

Tapped outputs available

2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	£6.00
1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£6.00
2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£9.50
3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£12.50
5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£16.00

12V, 100mA	£1.30	20V, 40V, 60V, 1 amp	£4.00
12V, 750mA	£1.75	12V, 3 amp	£3.50
10-0-10V 2amp	£3.00	10V, 30V, 40V, 2 amp	£3.50
30V, 5 amp and 17V-0-17V, 2 amp	£4.00	2 of 28 volt 1 amp	£5.00
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9V, 3 amp	£3.50	20V-0-20V, 1 amp	£3.50
25-0-25V 2 amp	£4.50	9-0-9 volt 50ma	£1.50
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15-0-15V, 2 amp	£3.75	9V, ¼ amp	£1.50
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AUTO TRANSFORMERS. 115V to 240V 150W **£8.00** 500W **£10.00.**

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6-12 volt 3 amp	£4.00	6-12 volt 2 amp	£1.10
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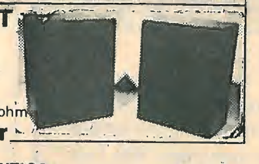
FLUTED WOOD FRONTS
TEAK VENEERED CABINET
11×8½×7in
50 to 14,000 cps 15 watts 8 ohm
Post £2 **£20 pair**



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1 mfd, 2 mfd, 4 mfd, 8 mfd, 10 mfd, 16 mfd, 25 mfd, 30 mfd, 50 mfd, 100 mfd, 250 mfd. All 15 vgts. 22 mfd/6v/10v; 25 mfd/6v/10v; 47 mfd/10v; 50 mfd/6v; 68 mfd/6v/10v/16v/25v; 100 mfd/10v; 150 mfd/6v/10v; 200 mfd/10v/16v; 220 mfd/4v/10v/16v; 330 mfd/4v/10v; 500 mfd/6v; 680 mfd/6v/10v/16v; 1000 mfd/2.5v/4v/10v; 1500 mfd/6v/10v/16v; 2200 mfd/6v/10v; 3330 mfd/6v; 4700 mfd/4v. **ALL 10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p.**
1000mF 12V **20p;** 25V **35p;** 50V **50p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 40V **60p;** 1200mF 76V **80p.**
2500mF 50V **70p;** 3000mF 50V **65p;** 2000mF 100V **£1.**
4500mF 64V **£2.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**
5000mF 35V **85p.**

HIGH VOLTAGE ELECTROLYTICS

8/350V	35p	8+8/450V	75p	50+50/300V	50p
16/350V	45p	8+16/450V	75p	32+32/450V	90p
32/500V	75p	16+16/450V	75p	100+100/275V	65p
50/500V	£1.20	32+32/350V	50p	150+200/275V	70p
8/800V	£1.20	50+50/500	£1.80	220/450V	95p
16/500V	65p			80+40/500V	£2

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NEON PANEL INDICATORS 250V 30p.
ILLUMINATED ROCKER SWITCH. single pole. Red **65p.**
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CASSETTE MOTOR. 6 volt **£1.00**
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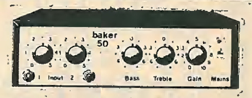
U.H.F. COAXIAL CABLE SUPER LOW LOSS. 25p yd.

BAKER LOUDSPEAKERS "SPECIAL PRICES"

Post £1.50 ea.

MODEL	INCHES	OHMS	WATTS	TYPE	PRICE
MAJOR	12	4-8-16	30	HI-FI	£12
DELUXE MK II	12	8-16	15	HI-FI	£14
SUPERB	12	8-16	30	HI-FI	£20
AUDITORIUM	12	8-16	45	HI-FI	£20
AUDITORIUM	15	8-16	60	HI-FI	£35
GROUP 35	12	4-8-16	40	PA	£12
GROUP 45	12	4-8-16	45	PA	£15
GROUP 50	12	4-8-16	60	PA	£20
GROUP 75	12	4-8-16	75	PA	£22
GROUP 100	12	8-16	100	PA	£26
GROUP 100	15	8-16	100	PA	£29
DISCO 100	12	8-16	100	DISCO	£26
DISCO 100	15	8-16	100	DISCO	£29

BAKER 50 WATT AMPLIFIER

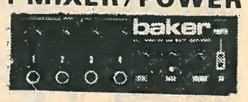


£69 Post £2.00

Ideal for Halls/PA systems, Discos and Groups. Two inputs. Mixer, Volume Controls, Master Bass, Treble and Gain Controls. 50 watts r.m.s. Three loudspeaker outlets 4, 8, 16 ohms.

BAKER 150 WATT MIXER/POWER AMPLIFIER

Professional 4 inputs with volume controls. Will mix mics, decks, musical instruments, etc. **£89**



Slave version available **£75**   100 Volt Line **£14** extra. Post £2.00

FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

Post £1.50 ea

MAKE	MODEL	SIZE	WATTS	OHMS	PRICE
SEAS	TWEETER	4in	50	8	£7.50
GOODMANS	TWEETER	3½in	25	8	£4.00
AUDAX	TWEETER	3¾in	60	8	£10.50
SEAS	MID-RANGE	4in	50	8	£7.50
SEAS	MID-RANGE	5in	80	8	£10.50
SEAS	MID-RANGE	4½in	100	8	£12.50
GOODMANS	FULL-RANGE	5½in	15	8	£6.50
GOODMANS	FULL-RANGE	8in	20	8	£5.50
SEAS	WOOFER	8in	30	8	£14.00
RIGONDA	FULL-RANGE	10in	20	8	£8.50
GOODMANS	AUDIOM	12PG	60	8/15	£20.00
GOODMANS	AUDIOM	12PD	60	8/15	£20.00
GOODMANS	AUDIOM	12P	50	8/15	£20.00

BATTERY ELIMINATOR MAINS to 9 VOLT D.C.

Stabilised output, 9 volt 400 m.a. UK made in plastic case with screw terminals. Safety overload cut out. Size 5 x 3¼ x 2½in. Transformer Rectifier Unit. Double insulated. Suitable Radios, Cassettes, models, **£4.50**

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LOUDSPEAKER CABINET WADDING 18in wide **25p** ft.

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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.. **£3.00;** 8x5in.. **£3.00;** 8in.. **£3.50.**
SPECIAL OFFER: 64 ohm, 2¾in., **35 ohm,** 3in., **25 ohm,** 3in., 5x3in., 7x4in., **8 ohm,** 2in., 2¾in., 3in., 3½in., 5in., **15 ohm,** 3½in. dia. 6x4in., 7x4in., 5x3in., **3 ohm,** 4in., 5in., 7x4in., **120 ohm,** 3¼in. dia. **£1.50 each.**
FAMOUS MAKE TWIN CONE LOUDSPEAKERS 8in. diameter 4W **£3.50.** 10in. diameter 5W **£3.50;** 12in. diameter 6W **£4.50.** 3/8 or 15 ohms, please state.
MOTOROLA PIEZO ELECTRIC HORN TWEETER **£6.50** 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**

GOODMANS RUBBER SURROUND BASS WOOFER

Standard 12in. diameter fixing with cut sides 12" x 10". 14,000 Gauss magnet. 20 watts RMS 4 ohm imp. Bass resonance = 30 c.p.s. Frequency response 20-8000 c.p.s. **BARGAIN, £8.50.** Post £2

ALUMINIUM HEAT SINKS. FINNED TYPE. Sizes 5"x4"x1" **95p.** 6½"x2"x2¼" **45p.**
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JACK PLUGS Stereo Plastic 30p; Metal 35p.
JACK SOCKETS. Mono Open 20p; Closed 25p.
JACK SOCKETS Stereo Open 25p; Closed 30p.
FREE SOCKETS — Cable end 30p.
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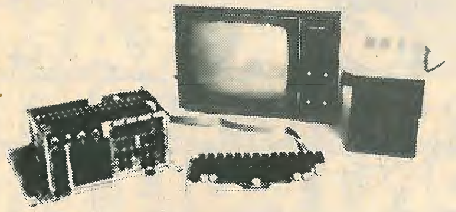
From Newtronics

THE NEW EXPLORER/85 SYSTEM

EXPLORER/85 PROFESSIONAL COMPUTER KIT



An inexpensive 8085, S100 Based Computer System designed for maximum flexibility Now available with 8″ Floppies

The EXPLORER/85 offers you real design flexibility — you can build the exact system you require. EXPLORER/85 can be your Beginners System, OEM Controller or IBM formatted 8″ Disc System. You don't buy more than you need. Prices start from £85.

Here's the line up:

Intel 8085 microprocessor. 8355 as a really powerful 2K Monitor system. 8155 RAM I/O all on one single Mother board with room for RAM/ROM/PROM/EPROM and two S-100 pads (expands to six), plus plenty of prototype space.

The 8085 is 100% compatible with the 8080 but 50% faster. The 8355 ROM 2K monitor system includes cassette interface with tape control. Two 8-bit programmable I/O ports, automatic baud rate selection, labelling of cassette files, etc. 8155 RAM I/O features ¼K 'scratch pad'. Two programmable 8-bit and One programmable 6-bit I/O ports plus progammable 14-bit binary counter-timer. Plus many other features which cannot be included due to lack of space.

You can purchase the EXPLORER/85 Mother board (level A) at this point for as little as £85 or we'll supply it with address decoding and data drives plus wait state generator and separate regulators (level B), 4K Workspace (level D), 8K Microsoft Basic in ROM for £233 in kit form or £293 assembled and tested.

If you don't possess a VDU you can add our Keyboard Terminal (less monitor) which features a full ASC11 keyboard with upper and lower case with cursor control, Video Display board which is microprocessor controlled giving 64 or 32 (on TV) Characters by 16 lines adding up to a full computer system having 4K workspace at a special price of £299 (less P.S.U. and monitor/TV).

Compare these prices carefully and you'll find you are actually getting more for your money.

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Like a Floppy Disc system? We now have an 8″ Drive system with CP/M. We will quote you for a complete system either in kit form or assembled ready to go.

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8″ Control Data Corp Professional Drive
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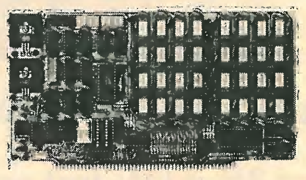
Let us quote you for other Software.

64K 'JAWS' S100 DYNAMIC RAM BOARD



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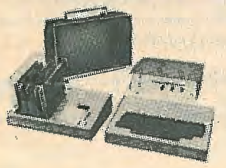
ELF II



SPECIFICATION
*RCA 1802 8-bit microprocessor with 256 byte RAM expandable to 64K bytes.
*RCA 1861 video IC to display program on TV screen via the RF Modulator Single Board with Professional hex keyboard — fully decoded to eliminate the waste of memory for keyboard decoding circuits. Load, run and memory protect swiches. 16 Registers, Interrupt, DMA and ALU. Stable crystal clock. Built-in power regulator 5-slot plug-in expansion bus (less connectors).

Christmas Special Offer

~~£50.95~~ **£39.95**

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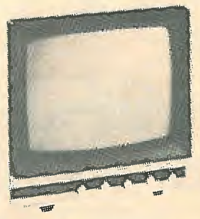

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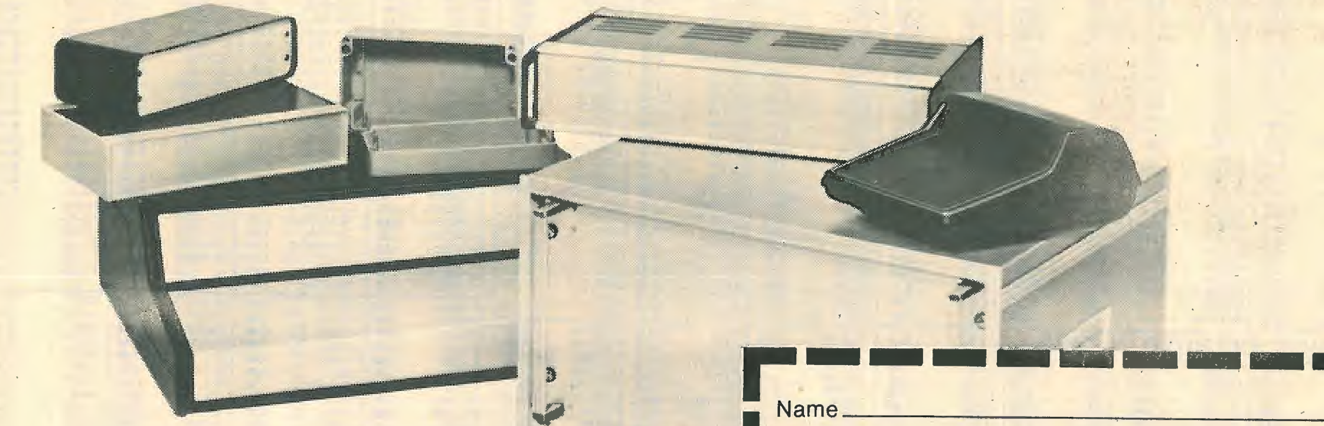

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PDP 11/23 SYSTEM comprising 11/23 card with memory management chip, MXV 11-A multifunction card with 8K bytes, 2 serial interface channels and 2 x 2716 EPROMs, 64K byte MSV11 card, XYLOGICS Model C510 disc controller with bootstrap, 2 x DIABLO Series 30 removable disc drives compatible with RK05, VT52 VDU (24 lines x 80 ch), DEC BA11-MF box with 4 spare slots. Apart from the terminal and disc drives the components of this system are NEW and dated 1980 . . . . . **£7,500.00**
TEXAS INSTRUMENTS Model 980A processor. With 16K x 16 MOS memory, battery backup and full console. A generous assortment of interface modules is included. Manufactured 1978 . . . . . **£450.00**
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K & N Model AC3500 acoustic coupler. AS NEW **£80.00**
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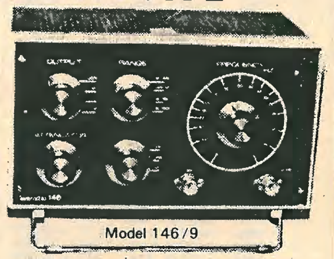

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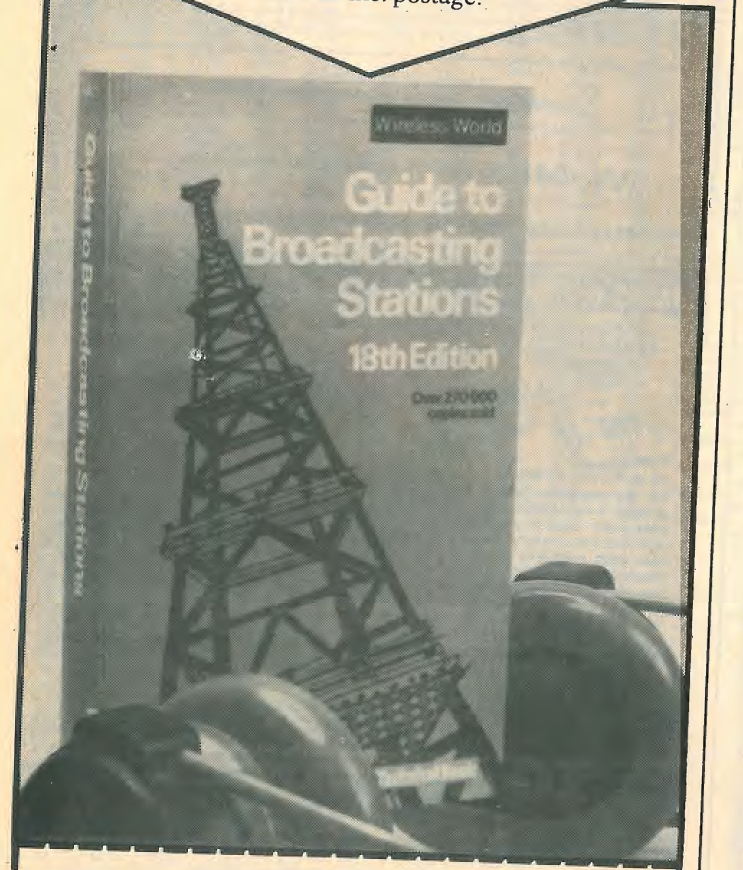

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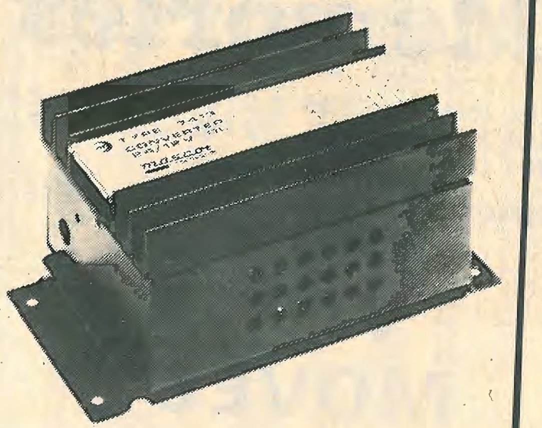

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B4, 61A moves to F3, 115

...or if you haven't got a pocket edition of the current Geographers' A to Z of London with you: Dorset House, Stamford Street, S.E.1. moves to Quadrant House in Sutton, Surrey.

This is the new headquarters of our parent company, IPC Business Press—and our new address as from 1st December.

It's a brand-new, purpose-built tower block of twenty storeys linked to a low-rise block of seven, and it's situated right by Sutton railway station. The environment is nice and the facilities are impressive: our new telephone system is one of the most modern in the country and callers will receive just about the fastest-answering service they've ever had.

This is only one way in which we hope our move will be of benefit, not simply to us, but to everyone who has been used to contacting us at Dorset House, Stamford Street, S.E.1.

We look forward to seeing or hearing from you at our new address, so please make a note in your diary now:

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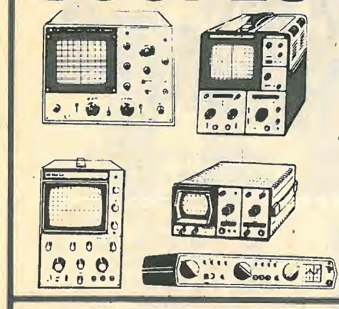

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SC110 10mHZ Battery portable, 10mV 3.2 × 2.6cm display (Optional case £8.80, Nicads £7.95, Mains unit £4.00) £149.95
LBO512A 10mHZ, 10mV, 5" display (plus FREE probe) £195.50
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CS1566A 20mHZ, 5mV, 5" display £323.15
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CS1577A 30mHZ, 2mV, 5" display £455.40
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*V302 30mHZ 5" display £447.35
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* Including free probe(s)

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LSG231 100m HZ± 1mHZ (adjustable) FM stereo generator and pilot and mod. £195.00

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LM100 3½ Digit LCD AC/DC 2 amp £86.50
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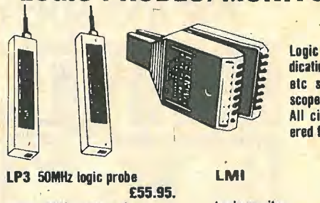
(DM series options. Carry case £8.50, NI-cads £7.95. Mains adaptor £4.00)

LOGIC PROBES/MONITORS



Logic probes indicating high/low etc states that scopes can miss. All circuit powered for all ICs.

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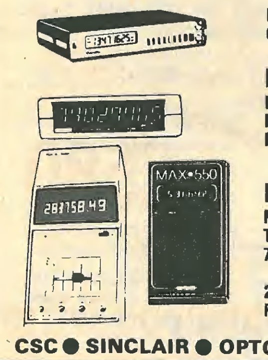

Portable and Bench LCD and LED Counters up to 600mHZ. Prices include batteries and leads.

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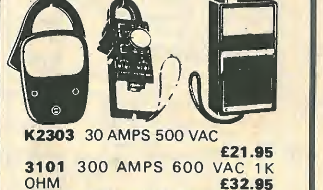

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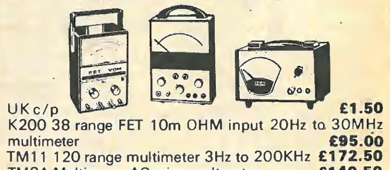
ELECTRONIC METERS



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Ref.	VA (Watts)	£	P&P
0/★	20	4.84	.91
149	60	7.37	1.10
150	100	8.38	1.31
151	200	12.28	1.31
152	250	14.61	1.73
153	350	18.07	2.12
154	500	22.52	2.47
155	750	32.08	OA
156	1000	40.92	OA
157	1500	56.52	OA
158	2000	67.99	OA
159	3000	95.33	OA

★115 or 240 sec only. State volts required. Pri. 0.220-240V.

VAT 15% 12 or 24-VOLT

Separate 12v windings Pri 220-240V

Ref	Amps 12v	Amps 24v	£	P&P
111	0.5	0.25	2.42	.52
213	1.0	0.5	2.90	.90
71	2	1	3.86	.90
18	4	2	4.46	1.10
85	5	2.5	6.16	1.10
70	6	3	6.99	1.10
108	8	4	8.16	1.31
72	10	5	8.93	1.31
116	12	6	9.89	1.52
17	16	8	11.79	1.52
115	20	10	15.38	2.39
187	30	15	19.72	2.39
226	60	30	40.41	OA

50 VOLT RANGE

Pri 220-240V. Sec. 0-20-25-33-40-50V. Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40 or 20V-0-20V and 25V-0-25V Screened

Ref.	Amps	£	P&P
102	0.5	3.75	.90
103	1.0	4.57	1.10
104	2.0	7.88	1.31
105	3.0	9.42	1.52
106	4.0	12.82	1.75
107	6.0	16.57	1.89
118	8.0	22.29	2.39
119	10.0	27.48	OA
109	12.0	31.79	OA

30 VOLT RANGE

Pri 220-240V Sec 0-12-15-20-24-30V. Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V and 15V-0-15V

Ref.	Amps	£	P&P
112	0.5	2.90	.90
79	1.0	3.93	1.10
3	2.0	6.35	1.10
20	3.0	6.82	1.31
21	4.0	8.79	1.31
51	5.0	10.86	1.52
117	6.0	12.29	1.67
88	8.0	16.45	1.89
89	10.0	18.98	1.89
90	12.0	21.09	2.24
91	15.0	24.16	2.39
92	20.0	32.40	OA

60 VOLT RANGE

Pri 220-240V
Sec 0-24-30-40-48-60V. Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V, or 24V-0-24V and 30V-0-30V

Ref.	Amps	£	P&P
124	0.5	4.27	1.10
126	1.0	6.50	1.10
127	2.0	8.36	1.31
125	3.0	12.10	1.39
123	4.0	13.77	2.12
40	5.0	17.42	1.89
120	6.0	19.87	2.12
121	8.0	27.92	OA
122	10.0	32.51	OA
189	12.0	37.47	OA

SCREENED MINIATURES Primary 240V

Ref.	mA	Volts	£	P&P
238	200	3-0-3	2.83	.63
212	1A, 1A	0-6, 0-6	3.14	.90
13	100	9-0-9	2.35	.44
235	330, 330	0-9, 0-9	2.19	.44
207	500, 500	0-8-9, 0-8-9	3.05	.85
208	1A, 1A	0-8-9, 0-8-9	3.88	.90
236	200, 200	0-15, 0-15	2.19	.44
239	50MA	12-0-12	2.88	.37
214	300, 300	0-20, 2-20	3.08	.90
221	700 (DC)	20-12-0-12-20	3.75	.90
206	1A, 1A	0-15-20, 0-15-20	5.09	1.10
203	500, 500	0-15-27, 0-15-27	4.39	1.10
204	1A, 1A	0-15-27, 0-15-27	6.64	1.10

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Pri 200/220 or 400/440
Sec 100/120 or 200/240

VA	Ref.	£	P&P
60	243	7.37	1.58
350	247	18.07	2.12
1000	250	45.94	OA

AUTO TRANSFORMERS

Ref.	VA (Watts)	TAPS	£	P&P
113	15	0-115-210-240V	2.73	.81
64	75	0-115-210-240V	4.41	1.10
4	150	0-115-200-220-240V	5.89	1.10
67	500	" "	12.09	1.91
84	1000	" "	20.64	2.39
93	1500	" "	25.61	OA
95	2000	" "	38.31	OA
73	3000	" "	65.13	OA
80s	4000	0-10-115-200-220-240	84.55	OA
57s	5000	" "	98.45	OA

Step Up or Step Down

BRIDGE RECTIFIERS

100v	25A+	£2.10
200v	2A	45p
400v	2A	55p
200v	4A	65p
400v	4A	85p
400v	6A	£1.40
500v	12A	£2.85

P&P 17p. VAT 15%

CASED AUTO TRANSFORMERS

240V cable input USA 115V Flat pin outlets

VA	£	P&P	Ref.
20VA	£6.55	1.03	56W
75VA	£8.50	1.31	64W
150VA	£11.00	1.31	4W
200VA	£12.02	1.67	65W
250VA	£13.38	1.67	69W
500VA	£20.13	1.89	67W
1000VA	£30.67	2.65	84W
1500VA	£42.82	OA	93W
2000VA	£54.87	OA	95W

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DC-100mA. Res — 150K
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Ref.	Amp	Price	P&P
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172	1A	3.26	.90
173	2A	3.95	.90
174	3A	4.13	.99
175	4A	6.30	1.10

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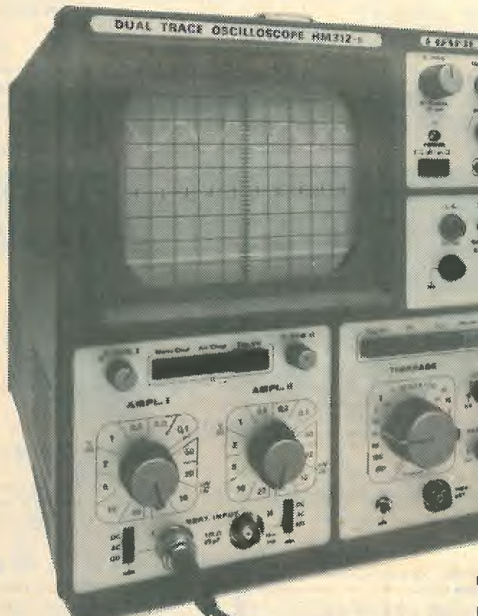
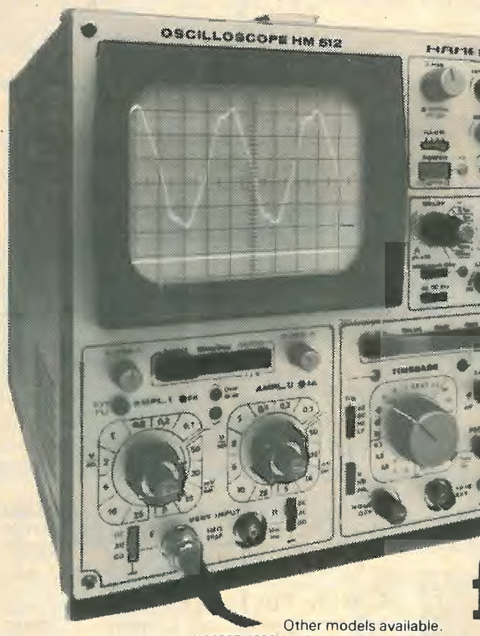


HM312 Dual Trace Oscilloscope.
DC-20MHz. Sensitivity 5mV-20V/cm. Time base range 0.5uS-0.2S/cm with x5 horiz mag to 100nS/cm, with variable control uncalibrated to 40nS/cm. CRT screen 8 x 10cm. Full XY using chII as X input. Bandwidth 2.3MHz. TV trigger.

NOW BETTER VALUE THAN EVER AT

£220



HM512 Dual Trace Oscilloscope with delayed sweep.
DC-50MHz. Sensitivity 5mV-20V/cm Time base range 0.1uS-2.0S/cm with x5 horiz mag to 20nS/cm. Delay ranges 7 decade steps 100ns-1S with fine control CRT screen 8 x 10cm. Full XY using ch II as x input, bandwidth 4 MHz. Z input. Delay line allows viewing of leading edge. Vertical overscan indicated by 2 LED's.

£580

Other models available.
HM307 10MHz plus component tester. £138.00
HM412 20 MHz with sweep delay. £350.00
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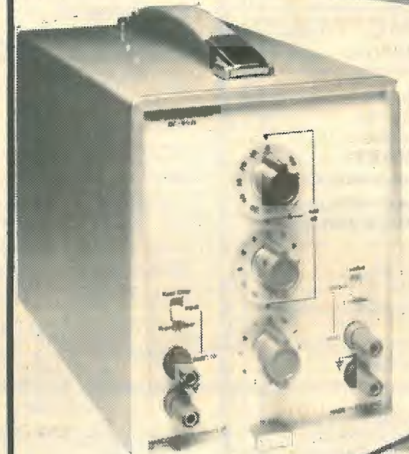
Autoranging D.M.M. PM 2514 **£125**
4 digit D.M.M. PM 2524 **£225**
Autoranging D.M.M. PM 2527 **£400**
SCHLUMBERGER
5½ digit D.M.M. A243 **£425**
Microprocessor D.M.M. 7065 **£950**
As above with processor option **£1250**
Microprocessor D.M.M. 7055 **£850**
As above with processor option **£1150**

FREQUENCY COUNTERS

ADVANCE
500MHz Counter TC 15 & TC 15 P1 **£495**
FLUKE
250MHz Multifunction Counter 1911A-01 **£325**

HEWLETT PACKARD
Generator/Sweeper 8601A c/w Marker Generator 8600A 100KHz-110MHz 5 Marker Freqs

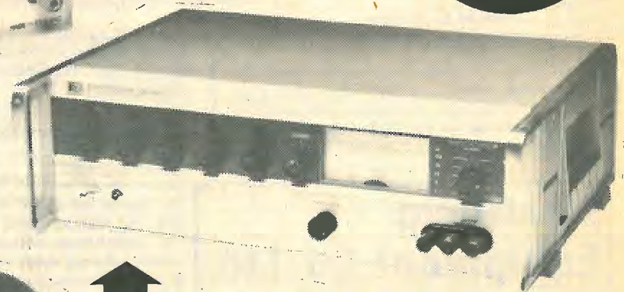
OUR PRICE **£1,500**



MARCONI INSTRUMENTS
M.F. Attenuator TF 2162 DC-1MHz 0-111 dB 600Ω

QUICK DELIVERY— QUANTITIES AVAILABLE FULL WARRANTY

NEW PRICE £300 OUR PRICE **£115**



HEWLETT PACKARD
Digital Oscillator 4204A 10Hz-1MHz 0.2% Freq. accuracy. Accurate 80 db output attenuator Flat freq. response. Provides accurate stable test signals for laboratory or production use

NEW PRICE £1018 OUR PRICE **£715**

AVO
Multimeter Model 8 Mk V superb condition and fully calibrated (Supplied without leads) QUANTITIES AVAILABLE — EX-STOCK DELIVERY

NEW PRICE £104 OUR PRICE **£70**

500MHz Multifunction Counter 1912A **£395**
125MHz Multifunction Counter 1925A **£350**
PHILIPS
520MHz Univ. Counter/Timer PM6614 **£395**
80MHz. Freq. Counter PM6664 **£250**

OSCILLOSCOPES

COSSOR
4100 75MHz Portable Dual Trace, Delayed Sweep. 30-day warranty. **Only £450**
HAMEG
HM 312-7 DC — 10MHz Dual Trace (New) **£200**
HEWLETT PACKARD
75 MHz Dual Trace 1707A **£600**
High Sensitivity Single Trace 130C **£250**
1707B 75MHz Portable Dual Trace, Delayed Sweep, 30-day warranty **Only £650**
MARCONI INSTRUMENTS
X-Y Display TF 2213/1 c/w Memory Unit TK 2214 **£790**
PHILIPS
25MHz Dual Trace PM 3212 **£625**
PM3260E 120MHz Dual Trace, Delayed Sweep **1 Only £975**
S.E. LABS
6 Channel Monitor SM121 **£395**
TEKTRONIX
465 100MHz. Spec. similar to 465B but no alternate sweep. **£1195**
35MHz Dual Trace T932 **£550**
W. Diff. Plug In **£295**
1A6 Plug In **£199**
TELEQUIPMENT
D75 50MHz Portable Dual Trace, Delayed Sweep **2 Only £715**

RECORDERS

BRYANS SOUTHEERNN
40000 12 channel UV Recorder plus 2 Off 40501 galvo amps. 6" chart width. Grid and timing lines. Superb condition **£950**
PHILIPS
Single Channel Recorder PM 8110 **£195**
RACAL
Store 4 FM Tape Recorder, 4 tracks DC-20KHz, 7 speeds. **£1950**
S.E. LABS
3006 12 channel UV Recorder. 6" chart width. Grid and timing lines **£550**
6012 50 channel UV Recorder 12" chart width. Servo paper drive up to 5 Mtr/Sec. Two event markers. Trace identification **1 Only £1100**
WATANABE
6 Channel Chart Recorder MC 641 **£2250**
YOKOGAWA
Chart Recorder 3047 **£450**

SIGNAL SOURCES

HEWLETT PACKARD
H.F. Signal Generator 606B **£1500**
AM/FM Signal Signal Generator 8640B (Opt. 002) 0.5-1024MHz **£3650**
Variable Phase, Sine and Signal Generator 203a **£495**
Oscillator 10Hz-10MHz 651B **£415**
V.H.F. Oscillator 3200B **£400**
U.H.F. Signal Generator 612A **£850**
V.H.F. Signal Generator 608F **£450**
Phase Lock Synchroniser 8709A **£475**
RF Sweeper/Marker Generator 8600A+8601A, 100KHz-110MHz. 5 marker frequencies. **£1500**
MARCONI INSTRUMENTS
AM/FM Signal Generator TF 995B/2 (0.2 to 220MHz) **£675**
A.F. Oscillator TF 2000 **£325**
A.F. Oscillator TF 2100 **£150**
A.M. Signal Generator. TF801D/8S **£550**
L.F. Oscillator TF 2102/1M1 **£195**
U.H.F. Signal Generator TF1060/3 **£650**
Two Tone Source TF 2005R **£295**
H.F. Generator TF 144H/4 **£750**
TF2002B AM/FM Signal Generator. 10KHz-82MHz. **1 Only £1200**
PHILIPS
Function Generator PM 5108 **£250**
Function Generator PM 5127 **£395**
Function Generator PM 5167 **£500**

TELONIC

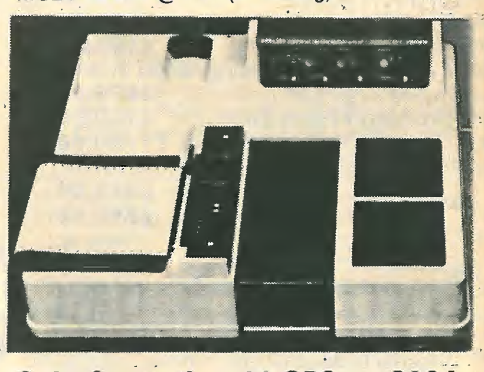
R.F. Sweeper 2003 c/w 3302, 3331, 3341, 3351, 3360, 3370 (1-300MHz) **£1150**

MISCELLANEOUS

ADVANCE
Constant Voltage Transformer CVN 1000A **£65**
Off Air Frequency Standard OFS 2B **£95**
AVO
Valve Tester VCM 163 **£475**
BRADLEY
AC Calibrator 125B **£475**
DC Calibrator 126B **£250**
BRUEL KJAER
Sound Level meter 2203 & Microphone 4145 **£395**
DATALABS
Power Line Disturbance Monitor DL019 **£175**
FLUKE
DC Differential Voltmeter 895A **£950**
332A DC Voltage Calibrator 0.003% Calibration Accuracy 0.1PPm resolution **£1750**
GENERAL RADIO
Sound Level Meter 1933 **£1000**
Cassette Recorder 1935
Recording Sound and Vibration Analyser 1911A **£1250**
HEWLETT PACKARD
DC Microvolt-ammeter 425A **£250**
AC/DC Differential Voltmeter 741B **£695**
Vector Impedance Meter 4815A **£1950**
S Parameter Test Set. 8745A **£2750**
Insulation Resistance Meter 4329A **£500**
MARCONI
A.F. Power Meter TF 893A **£185**
Transmission Test Set TF 2332 **£425**
Transmission Test Set TF 2333 **£600**
P.C.M. Regenerator Test Set OA 2805A **£2700**
P.C.M. Multiplex Tester TF 2807A **£1500**
RHODE AND SCHWARZ
Stereocoder MSC **£850**
S.E.I.
Super 50 Selectest **£77**
SIEMENS
Carrier-Freq. 'L.M.S. D2021/W2021/G2021 10KHz-25MHz **£1700**
Level Measuring System. D2074/W2074/G2006 **£2600**
Carrier Frequency Level Test Set W2007+D2007, 6KHz-18.6MHz. **£1750**
TEKTRONIX
Pulse Generator 2101 **£420**
TM515 Main Frame c/w FG504 0.001Hz-40MHz function generator. 2 Off PS503A Triple Power Supplies. **£1250**
TM515 Main Frame c/w SC502 15MHz Oscilloscope. FG503 1.0Hz-3MHz Function Generator. DM502 3½ digit DMM. DC503 100MHz Counter **£1495**
WANDEL & GOLTERMAN
Andimat (2MHz system) **£9500**
Pattern generator PFG-1 **£995**
Digital Error Detector PFM-1 **£1495**
WAVETEK
Sweep Generator 135 **£275**
Programmable Phase Meter 755 **£550**

POWER SUPPLIES

ADVANCE
PMA47. 0-15V @ 3A (Presetable). **£37**
PMA 50. 0-15V @ 5A (Presetable). **£45**
PMA 53. 0-15V @ 10A (Presetable). **£65**
MG 5-60 5V @ 60A (Switching). **£160**
MG 5-20 5V @ 20A (Switching). **£120**
MG 5-10 5V @ 10A (Switching). **£95**
MG24-12 24V @ 12A (Switching). **£130**



Only 9 months old SP3 — 200A Infrared Spectrophotometer.

Pye Unicam. Ratio Recording Type. Still under warranty. Current List Price £5150.

ONLY £3950

Also available 15 ton hydraulic Press with Safety Guard S.

ONLY SMALL SELECTION OF OUR VAST STOCKS SHOWN HERE

12-MONTH WARRANTY

All Second User Test Equipment is fully guaranteed for 12 months unless otherwise stated.

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Add 15% VAT to ALL PRICES

A copy of our trading conditions is available on request.
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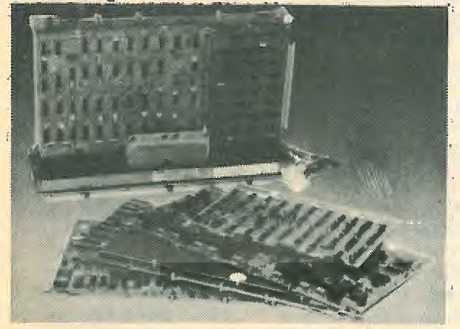
ELECTRONIC BROKERS

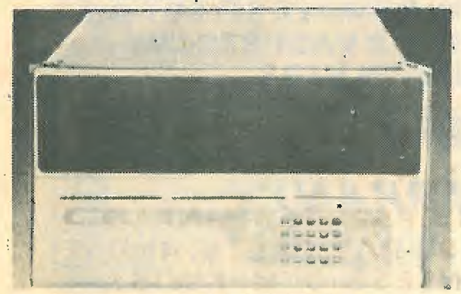
GILT-EDGED USED COMPUTER EQUIP

DEC EQUIPMENT



DEC MEMORY — BARGAIN OFFER

MM11DP 16KW core (ex DEC-maintained 11 34 systems) ONLY **£395.00**
DD11-CK 4-slot backplane (11/34) . . . **£175.00**
H775-C8 Battery Back-up . . . **£525.00**
KA8E Positive I/O (8E) . . . **£95.00**
KD8E Databreak (8E) . . . **£145.00**
KL8JA Asynchronous I/O (8E) **£275.00**
KL8E Asynchronous I/O (8E) . **£250.00**
KP8E Power Fail (8E) . . . **£95.00**
LAII-PD 180 cps matrix printer **£1250.00**
M7850 Parity Controllers . . . **£185.00**
MF11L 8KW Core including 9-slot system unit . . . **£975.00**
MM11LP 8KW Parity Core . . **£750.00**
MM11YP 32KW Core Memory **£1750.00**
MSV11C 16KW MOS Memory (LSI11) . . . **£495.00**
MS11JP 16KW MOS Memory **£895.00**
PDP11/34 Processor, 10½" chassis, 128KW MOS, DL11W, KY11B **£6950.00**
PDP11/40 Processor with 32KW parity core, KT11D Memory Management, DL11 Interface 6ft cabinet . . . **£4950.00**
PR11 High speed reader & control . . . **£925.00**
REV11 Bootstrap (LSI11) . . . **£75.00**
RK05F Add-on disk drive . . . **£2250.00**
VT55-FB Graphics Terminal with integral hard copy . . . **£1850.00**
PDP8E Series modules — large stocks of option modules, add-on core, CPU boards etc. all at reduced prices.



PDP11/04 PROCESSOR

10½in chassis. 16KW MOS DL11W. BRAND NEW **£4,500.00** (Can be enhanced to 28KW).

SCOOP BULK PURCHASE OF HAZELTINE VDUs

HAZELTINE H1000 VDU

12 x 80 Display Upper Case ASCII RS232 Interface Choice of Baud Rates
SUPER VALUE

£199 + VAT 30-day warranty

HAZELTINE H2000 VDU

Superb spec including full XY Cursor Addressing and edit facility, 27 x 74 Display.
Upper Case ASCII RS232 Interface Switch-Selectable Baud Rates

£299 + VAT 90-day warranty

HAZELTINE MODULAR ONE VDU

Now with Upper/lower case, XY Cursor Addressing
24 x 80 line display. Upper/Lower Case ASCII. Detachable Keyboard. RS232 Interface. XY Cursor addressing.

£399 + VAT 90-day warranty

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PRINTERS

CENTRONICS 101A

Heavy Duty Matrix Printer with 64 ASCII upper case character set. 165 cps operation. 132 print positions with adjustable tractor feed. 7 x 9 dot matrix, parallel input.
£750.00

ASR 33 TELETYPE

Input/Output terminal incorporating paper tape punch and reader. 64 ASCII upper case character set. 110 baud operation, even parity keyboard choice of RS232 or 20mA interface. **NOW ONLY £595.00.** Options: ICL-type keyboard £50.00. 8th level marking £25.00. Remote reader control £50.00. Reader step £20.00. Auto reader £25.00. Pedestal £30.00.

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

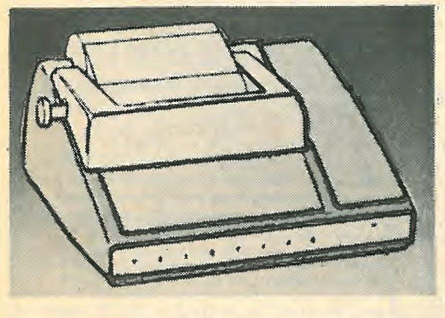
HAZELTINE THERMAL PRINTER, 80 column 30 cps silent RO printer with parallel TTL input **£395.00**

TALLY 1602 MATRIX PRINTER, Parallel Input, Upper/lower case, Tractor feed, as new **£995.00**

TERMIPRINTER 7075 RO Impact Printer, Upper/lower case, pin-feed, RS232 **£275.00**

TEXAS 725 Portable Terminal with acoustic coupler **£625.00**

TEXAS 733 ASR Terminal **£1375.00**



LOW COST PRINTER OFFER

Teletype 33 printer mechanism including case but no keyboard or electronics, 64 upper case ASCII 10 cps Pinfeed platen, ideal for the electronic hobbyist. . . . only **£85.00**

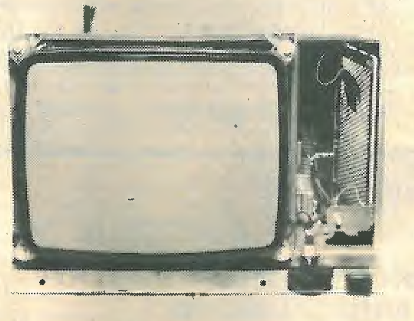
MISCELLANEOUS

DIGITRONICS P135 paper tape punches. 35 cps. Solenoid device with 27VDC coil **£95.00**
FACIT 4070 Paper Tape Punch **£675.00**

HEWLETT PACKARD PROGRAMMABLE CALCULATOR MODEL 9830A

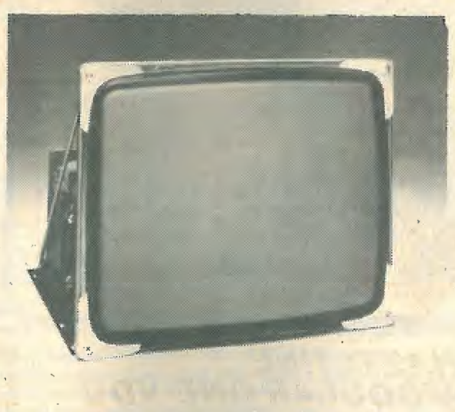
8K Memory. Extended I/O ROM. String Variables ROM 4. Peripheral interfaces (1 serial, 3 parallel). . . . **PRICE £1995.00**

MONITORS



EMI MONITOR

15in Diagonal Tube Integral Power Supplies accepts composite or separate video input. **BRAND NEW SURPLUS.** Price **£100.00.**



BALL MIRATEL TTL15

15in Diagonal green phospher tube. Integral power supply. Requires separate horizontal and vertical video input. **BRAND NEW SURPLUS** . . . **£75.00**

NEW CATALOGUE JUST OUT
Send for FREE COPY

NEW ASCII KEYBOARDS — NEW LOW PRICES

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

Mail Order Total

KB756 56-station ASCII Keyboard mounted on P.C.B. . . . £45.00 **£53.48**
KB756MF As above, fitted with metal mounting frame for extra rigidity . . . £49.50 **£58.65**
KB710 10-key numeric pad, supplied with connecting cable . . . £8.00 **£9.78**
KB701 Plastic enclosure for KB756 or KB756MF . . . £12.50 **£15.24**
KB702 Steel enclosure for KB756 or KB756MF £18.00 **£23.00**
KB2376 Spare ROM Encoder £12.50 **£15.24**
KB15P Edge connector for KB756 or KB756MF £3.25 **£4.31**
DC-512 DC convertor to allow operation at 5V only (plugs in to P.C.B.) . . . £7.50 **£9.20**
DB25S Mating connector for KB771 £4.25 **£5.46**
PERK 56-station ASCII Keyboard for PET complete with PET interface, built-in power supply and steel enclosure . . . £145.00 **£172.50**

Discounts available for quantities

90-DAY WARRANTY

SECOND-USER PRINTERS AND TERMINALS ARE COVERED BY FULL 90-DAY PARTS AND LABOUR WARRANTY UNLESS OTHERWISE STATED.

All Prices subject to carriage and VAT

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Add 15% VAT to ALL PRICES

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AUDIO LEADS

No.	Type	Price
107	FM indoor Ribbon Aerial	£0·69
113	3·5mm Jack plug to 3·5mm Jack plug length 1·5m	£0·86
114	5 pin DIN plug to 3·5mm Jack connected to pins 3 & 5 length 1·5m	£0·98
115	5 pin DIN plug to 3·5mm Jack connected to pins 1 & 4 length 1·5m	£0·98
116	Car aerial extension screened insulated lead. Fitted plug and socket	£1·44
117	AC mains connecting lead for cassette recorders and radios 2 metres	£0·78
18	5 pin DIN phono plug to stereo headphone. Jack socket	£1·21
19	2 · 2 pin DIN plugs to stereo Jack socket with attenuation network for stereo headphones. Length 0·2m	£1·04
0	Car stereo connector. Variable geometry plug to fit most car cassettes. 8-track cartridge and combination units. Supplied with inlined fuse power lead and instructions	£0·69
3	6·6m Coiled Guitar Lead Mono Jack plug to Mono Jack plug Black	£1·72
	3 pin DIN plug to 3 pin DIN plug. Length 1·5m	£0·85
	5 pin DIN plug to 5 pin DIN plug. Length 1·5m	£0·85
	5 pin DIN plug to Tinned open end. Length 1·5m	£0·85
	5 pin DIN plug to 4 Phono Plugs. All colour coded. Length 1·5m	£1·49
	5 pin DIN plug to 5 pin DIN socket. Length ·5m	£0·92
	pin DIN plug to 5 pin DIN plug mirror image. ength 1·5m	£1·21
	pin DIN plug to 2 pin DIN inline socket. ngth 5m	£0·78
	pin DIN plug to 3 pin DIN plug 1 & 4 and 3 & 5 ngth 1·5m	£0·95
	pin DIN plug to 2 pin DIN socket. Length 10m	£1·13
	pin DIN plug to 2 Phono plugs. Connected s 3 & 5. Length 1·5m	£0·86
	in DIN plug to 2 Phono sockets. Connected 3 & 5. Length 23cm	£0·78
	n DIN socket to 2 Phono plugs. Connected pins 3 & 5. Length 23cm	£0·78
136	Coiled stereo headphone extension lead. Black, length 6m	£2·01
178	AC mains lead for calculators, etc	£0·52

O/NO. 1495 £0·29

No.	Title	Price
		£1·15
		£1·15
	…State Proj. for Home	£1·95
224	110 Int. Circ. Proj. for Home	£2·95
231	Beginners Guide to Transistors	£2·25
232	Beginners Guide to Electric Wiring	£2·25
233	Beginners Guide to Radio	£2·75
234	Guide to Colour TV	£2·25
235	Electronic Diagrams	£1·80
236	Electronic Components	£1·80
237	Printed Circuit Assembly	£1·80
238	Transistor Pocket Book	£3·90
240	Semiconductor Handbook Part 1	£5·25
241	Semiconductor Handbook Part 2	£4·28
242	Electronics Pocket Book	£3·90
244	Beginners Guide to Integrated Circuits	£2·75
	BI-PAK CMOS Data Book	50p

SWITCHES

Description	No.	Price
DPDT miniature slide	1973	£0·16
DPDT standard slide	1974	£0·17
Toggle switch SPST 12 amp 250V ac	1975	£0·38
Toggle switch DPDT 1 amp 250V ac	1976	£0·48
Rotary on-off mains switch	1977	£0·58
Push switch–Push to make	1978	£0·16
Push switch–Push to break	1979	£0·21

ROCKER SWITCH A range of rocker switches SPST–moulded in high insulation material available in a choice of colours ideal for small apparatus

Colour	No.	Price
RED	1980	£0·35
BLACK	1981	£0·35
WHITE	1982	£0·35
BLUE	1983	£0·35
YELLOW	1984	£0·35
LUMINOUS	1985	£0·35

Description	No.	Price
Miniature SPST toggle 2 amp 250V ac	1958	£0·81
Miniature SPST toggle 2 amp 250V ac	1959	£0·86
Miniature DPDT toggle 2 amp 250V ac	1960	£0·91
Miniature DPDT toggle centre off 2 amp 250V ac	1961	£1·07
Push-button SPST 2 amp 250V ac	1962	£1·04
Push-button SPST 2 amp 250V ac	1963	£1·09
Push-button DPDY 2 amp 250V ac	1964	£1·34

MIDGET WAFER SWITCHES
Single bank wafer type–suitable for switching at 250V ac 100mA or 150V dc non-reactive loads make-before-break contacts. These switches have a spindle 0·25 in dia. and 30 indexing.

Description		No.	Price
1 pole	12 way	1965	£0·55
2 pole	6 way	1966	£0·55
3 pole	4 way	1967	£0·55
4 pole	3 way	1968	£0·55

MICRO SWITCHES No. Price
Plastic button gives simple 1 pole change over action £0·29
Rating 10 amp 250V ac 1970

FUSE HOLDERS AND FUSES

Description	No.	Price
20mm · 5mm chassis mounting	506	£0·18
1¼in. · ¼in. chassis mounting	507	£0·14
1¼in. car inline type	508	£0·18
Panel mounting 20mm	509	£0·23
Panel mounting 1¼in.	510	£0·37

QUICK BLOW 20mm

Type	No.		Type	No.		Type	No.	
150mA	611	7p	1A	615	6p	3A	619	6p
250mA	612	6p	1·5A	616	7p	4A	620	10p
550mA	613	6p	2A	617	6p	5A	621	6p
800mA	614	8p	2·5A	618	7p			

ANTI-SURGE 20mm

Type	No.	Type	No.	Type	No.
100mA	622	1A	625	2·5A	628
250mA	623	2A	626	3·15A	629
500mA	624	1/6A	627	5A	630

All **8p** each

QUICK-BLOW 1¼in.

Type	No.	Type	No.	Type	No.
250mA	631	500mA	632	800mA	634

All **8p** each

Type	No.	Type	No.	Type	No.
1A	635	2/5A	638	4A	641
2A	637	3A	639	5A	642

All **60** each

NUTS AND BOLTS

BA BOLTS-packs of BA threaded cadmium plated screws slotted cheese head. Supplied in multiples of 50

Type	No.	Price	Type	No.	Price
1in. OBA	839	£1·38	½in. 4BA	846	£0·37
½in. OBA	840	£0·86	¼in. 4BA	847	£0·29
1in. 2BA	842	£0·75	1in. 6BA	848	£0·46
½in 2BA	843	£0·52	½in. 6BA	849	£0·24
¼in. 2BA	844	£0·60	¼in. 6BA	850	£0·20
1in. 4BA	845	£0·51			

BA NUTS–packs of cadmium plated full nuts in multiples of 50.

Type	No.	Price	Type	No.	Price
OBA	855	£0·83	4BA	857	£0·35
2BA	856	£0·55	6BA	858	£0·28

BA WASHERS–flat cadmium plated plain stamped washers supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
OBA	859	£0·16	4BA	861	£0·14
OBA	860	£0·14	6BA	862	£0·14

SOLDER TAGS–Hot tinned supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
OBA	851	£0·46	4BA	853	£0·25
2BA	852	£0·32	6BA	854	£0·25

TANTALUM CAPACITORS

3137	1MFD	35V	£0·13	3142	4.4MFD	35V	£0·21
3138	22MFD	35V	£0·13	3157	3.3MFD	25V	£0·21
3139	47MFD	35V	£0·13	3143	10MFD	35V	£0·25
3140	1.0MFD	35V	£0·13	3144	22MFD	16V	£0·25
3141	2.2MFD	35V	£0·14	3156	33MFD	35V	£0·13

REGULATORS

Positive	Price		Price
uA7805 TO220	£0·75	uA7912 TO220	£0·85
uA7812 TO220	£0·75	uA7915 TO220	£0·85
uA7815 TO220	£0·75	uA7924 TO220	£0·85
uA7824 TO220	£0·75	uA7818 TO220	£0·85
uA7818 TO220	£0·75	72723 14 pin DN	£0·52
Negative		uA723C TO99	£0·52
uA7905 TO220	£0·85	LM309K TO3	£1·72

SUPER SOUND
SAVING!
DINDY
LOW NOISE CASSETTES

O/no. 3193	30 min lettertape	£0·38 each
O/no. 301	Dindy C60 tape	£0·41 each
O/no. 302	Dindy C90 tape	£0·52 each
O/no. 303	Dindy C120 tape	£0·75 each

TRANSFORMERS

MINIATURE MAINS Primary 240V

No.	Secondary	Price
2021	6V–0–6V 100mA	£1·04
2022	9V–0–9V 100mA	£1·04
2023	12V–0–12V 100mA	£1·29

MINIATURE MAINS Primary 240V with two independent secondary windings

No.	Type	Price
2024	MT280–0–6V 0–6V RMS	£1·84
2025	MT150–0–12V 0–12V RMS	£1·84

1 AMP MAINS Primary 240V

No.	Secondary	Price	
2026	6V–0–6V 1 amp	£2·88	P & P 45p
2027	9V–0–9V 1 amp	£2·30	P & P 45p
2028	12V–0–12V 1 amp	£2·00	P & P 55p
2029	15V–0–15V 1 amp	£3·16	P & P 66p
2030	30V–0–30V 1 amp	£3·97	P & P 86p

STANDARD MAINS Primary 240V
Multi-tapped secondary mains transformers available in ½ amp, 1 amp and 2 amp current rating. Secondary taps are 0–19–25–33–40–50V. Voltages available by use of taps. 4, 7, 8, 10, 14, 15, 17, 19, 25, 31, 33, 40, 25–0–25V

No.	Rating	Price	
2031	½ amp	£3·91	P & P 85p
2032	1 amp	£5·06	P & P 85p
2033	2 amp	£6·27	P & P £1
2035	240V Primary 0–55V · 2A Secondary	£7·30	P & P £1

SPECIAL OFFER
2042 240V Primary 0–20V · 2A Secondary. By removing 5 turns for each volt from the secondary winding any voltage up to 20V · 2A is easily obtainable ideal for the experimenter.
£1·50 P & P 86p

HEATSINKS

Type	No	Price
TO3 – single heat sink	873	£0·31
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Double sided heat sink	875	£1·67
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TO1 – heat sink	878	£0·09

All prices include VAT: Add 50p post per order — Just quote your Access or Barclaycard number
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BARCLAYCARD VISA

Appointments

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A challenging and full career in Government Service.
Minimum qualification — HNC.
Starting salary up to £6,737 (under review).
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H.M. Government Communications Centre, Hanslope Park, Milton Keynes MK19 7BH.

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ITN

SENIOR ENGINEER

Radio Links Maintenance

Salary £11,406

Independent Television News Limited has a vacancy for a Senior Engineer in their new ENG Maintenance Section.

The successful applicant would be a member of the small team responsible for the maintenance of our Radio Link Equipment and extensive R/T Networks. This is a rapidly expanding field, following the introduction of Electronic News Gathering to ITN. Previous maintenance experience with RF systems is essential.

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SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING

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Reference No. NT/80/81/35

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BP6	Engineers & Machinists Ref. Tables	£0·50
BP14	2nd Book Transistor Equivs. & Subs	£1·10
BP24	52 Projects Using IC741 (or Equiv.)	£0·95
BP26	Radio Antenna Book Long Distance Reception & Transmission	£0·85
BP27	Giant Chart of Radio Electronic Semiconductor & Logic Symbols	£0·68
BP32	Build Metal & Treasure Locators	£1·00
BP35	Handbook of IC Audio Preamplifier & Power Amplifier Construction	£1·25
BP36	50 Cicts use Germ/S11/Zener Diodes	£0·75
BP39	50 Field Effect Trans Projects	£1·25
BP40	Digital IC Equivs. & Pin Connection	£2·50
BP41	Linear IC Equivs. & Pin Connection	£2·75
BP42	50 Simple LED Circuits	£0·75
BP43	How to make Walkie-Talkies	£1·25
BP45	Projects on Opto-electronics	£1·25
BP46	Radio Circuits Using IC's	£1·35
BP47	Mobile Discotheque Handbook	£1·35
BP48	Electronics Projects for Beginners	£1·35
BP49	Popular Electronic Projects	£1·45
BP50	IC LM3900 Projects	£1·35
BP55	Radio Stations Guide	£1·45
BP160	Coil Design & Construction Manual	£0·75
BP202	Handbook of Integrated Circuits Equivalents & Substitutes	£1.00
BP205	1st Book HI-FI Speaker Enclosures	£0·75
BP213	Circuits for Model Railways	£1·00
BP215	Shortwave Circuits & Gear for Experimenters & Radio Hams	£0·85
BP217	Solid State Power Supply Handbook	£0·85
BP221	28 Tested Transistor Projects	£1·25
BP222	Short-wave Receivers for Beginners	£0·95
BP223	50 Projects using IC CA3130	£0·95
BP224	50 CMOS IC Projects	£0·95
BP225	A Practical Intro to Digital IC's	£0·95
BP225	Build Advanced Short-wave Receivers	£1·20
BP227	Beginners Guide to Building Electronic Projects	£1·25

NEWNES BOOKS

216	Transistors 3rd Ed.	£1·00
218	Radio & Television	£1·25
219	Electronics	£1·15
220	Colour TV 2nd Ed.	£1·15
221	Hi-Fi	£1·15
223	20 Solid State Proj. for Home	£1·95
224	110 Int. Circ. Proj. for Home	£2·95
231	Beginners Guide to Transistors	£2·25
232	Beginners Guide to Electric Wiring	£2·25
233	Beginners Guide to Radio	£2·75
234	Guide to Colour TV	£2·25
235	Electronic Diagrams	£1·80
236	Electronic Components	£1·80
237	Printed Circuit Assembly	£1·80
238	Transistor Pocket Book	£3·90
240	Semiconductor Handbook Part 1	£5·25
241	Semiconductor Handbook Part 2	£4.28
242	Electronics Pocket Book	£3·90
244	Beginners Guide to Integrated Circuits	£2·75
	BI-PAK CMOS Data Book	50p

SWITCHES

Description	No.	Price
DPDT miniature slide	1973	£0·16
DPDT standard slide	1974	£0·17
Toggle switch SPST 12 amp 250V ac	1975	£0·38
Toggle switch DPDT 1 amp 250V ac	1976	£0·48
Rotary on-off mains switch	1977	£0·58
Push switch–Push to make	1978	£0·16
Push switch–Push to break	1979	£0·21

ROCKER SWITCH

A range of rocker switches SPST–moulded in high insulation material available in a choice of colours ideal for small apparatus

Colour	No.	Price
RED	1980	£0·35
BLACK	1981	£0·35
WHITE	1982	£0·35
BLUE	1983	£0·35
YELLOW	1984	£0·35
LUMINOUS	1985	£0·35

Description	No.	Price
Miniature SPST toggle 2 amp 250V ac	1958	£0·81
Miniature SPST toggle 2 amp 250V ac	1959	£0·86
Miniature DPDT toggle 2 amp 250V ac	1960	£0·91
Miniature DPDT toggle centre off 2 amp 250V ac	1961	£1·07
Push-button SPST 2 amp 250V ac	1962	£1·04
Push-button SPST 2 amp 250V ac	1963	£1·09
Push-button DPDT 2 amp 250V ac	1964	£1·34

MIDGET WAFER SWITCHES

Single bank wafer type–suitable for switching at 250V ac 100mA or 150V dc non-reactive loads make-before-break contacts. These switches have a spindle 0.25 in dia. and 30 indexing.

Description		No.	Price
1 pole	12 way	1965	£0·55
2 pole	6 way	1966	£0·55
3 pole	4 way	1967	£0·55
4 pole	3 way	1968	£0·55

MICRO SWITCHES

	No.	Price
Plastic button gives simple 1 pole change over action Rating 10 amp 250V ac	1970	£0·29

OPTOELECTRONICS

NEW INCREASED RANGE—ALL 1ST QUALITY

LEDS (diffused)

O/No.	Type	Size	Colour	Price
1501	ARL209 (TIL209)	3mm (·125)	RED	£0·12
1502	MIL3232 (TIL211)	3mm (·125)	GREEN	£0·22
1503	MIL3331 (OPL212A)	3mm (·125)	YELLOW	£0·22
1504	ARL4850 (FLV117)	5mm (·2)	RED	£0·12
1505	MIL5251 (TIL222)	5mm (·2)	GREEN	£0·22
1506	MIL5351 (MV5353)	5mm (·2)	YELLOW	£0·22
1509	FLV111	5mm (·2)	CLEAR (ill. Red)	£0·13

SUPER 'HI BRITE' TYPE

1521	MIL32	3mm (·125)	RED	£0·12
1522	MIL52	5mm (·2)	RED	£0·12
1514	ORP12 Light dependent resistor			£0·63
1520	OCP71 Photo transistor			£0·40

LED CLIPS

1508/125	pack of 5	125 clips	£0·17
1508/2	pack of 5	2 clips	£0·21

DISPLAYS

DL703 7 segment D P left (30" height) Common Anode RED Single Digit O/NO 1523 £0·85
DL707 7 segment D P left (30" height) Common Anode RED Single Digit O/NO. 1510 £0·92
DL527 7 segment D P left (50" height) Common Anode RED Two-Digit Reflector O/NO. 1524 £2·08
DL727 7 segment D P right (·10" height) Common Anode RED Two-Digit Light Pipe O/NO. 1512 £2·07
DL747 7 segment D P left (630" height) Common Anode RED Single Digit Light Pipe O/NO. 1511 £1·73

OPTO-ISOLATORS

Isolation Breakdown–Voltage 1500–continuous fwd. current 100 mA

CIL74 Single Channel 6 pin DIP standard type–optically coupled pair with infra-red LED Emitter and NPN Silicon Photo Transistor O/NO. 1497 £0·61

CILD74 Multi-Channel 8 pin DIP Two Isolated Channels O/NO. 1498 £1·22

CILQ74 Multi-Channel 16 pin DIP Four Isolated Channels O/NO. 1499 £2·69

MELL II (TIL81) NPN LIGHT DETECTOR

Silicon Photo Darlington Amplifier–VCBO 30V VECO 10V 1c 100mA Ptot 300mW IL Min. 0·5 Typ 2mA 1D 100mA nA O/NO. 1495 £0·29

FUSE HOLDERS AND FUSES

Description	No.	Price
20mm · 5mm chassis mounting	506	£0·18
1¼in. · ¼in. chassis mounting	507	£0·14
1¼in. car inline type	508	£0·18
Panel mounting 20mm	509	£0·23
Panel mounting 1¼in.	510	£0·37

QUICK BLOW 20mm

Type	No.		Type	No.		Type	No.	
150mA	611	7p	1A	615	6p	3A	619	6p
250mA	612	6p	1·5A	616	7p	4A	620	10p
550mA	613	6p	2A	617	6p	5A	621	6p
800mA	614	8p	2·5A	618	7p			

ANTI-SURGE 20mm

Type	No.	Type	No.	Type	No.
100mA	622	1A	625	2·5A	628
250mA	623	2A	626	3·15A	629
500mA	624	1/6A	627	5A	630

All 8p each

QUICK-BLOW 1¼in.

Type	No.	Type	No.	Type	No.
250mA	631	500mA	632	800mA	634

All 8p each

Type	No.	Type	No.	Type	No.
1A	635	2/5A	638	4A	641
2A	637	3A	639	5A	642

All 60 each

NUTS AND BOLTS

BA BOLTS-packs of BA threaded cadmium plated screws slotted cheese head. Supplied in multiples of 50

Type	No.	Price	Type	No.	Price
1in. OBA	839	£1·38	½in. 4BA	846	£0·37
½in. OBA	840	£0·86	¼in. 4BA	847	£0·29
1in. 2BA	842	£0·75	1in. 6BA	848	£0·46
½in 2BA	843	£0·52	½in. 6BA	849	£0·24
¼in. 2BA	844	£0·60	¼in. 6BA	850	£0·20
1in. 4BA	845	£0·51			

BA NUTS–packs of cadmium plated full nuts in multiples of 50.

Type	No.	Price	Type	No.	Price
OBA	855	£0·83	4BA	857	£0·35
2BA	856	£0·55	6BA	858	£0·28

BA WASHERS–flat cadmium plated plain stamped washers supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
OBA	859	£0·16	4BA	861	£0·14
OBA	860	£0·14	6BA	862	£0·14

SOLDER TAGS–Hot tinned supplied in multiples of 50.

Type	No.	Price	Type	No.	Price
OBA	851	£0·46	4BA	853	£0·25
2BA	852	£0·32	6BA	854	£0·25

TANTALUM CAPACITORS

3137	1MFD	35V	£0·13	3142	4.4MFD	35V	£0·21
3138	22MFD	35V	£0·13	3157	3.3MFD	25V	£0·21
3139	47MFD	35V	£0·13	3143	10MFD	35V	£0·25
3140	1.0MFD	35V	£0·13	3144	22MFD	16V	£0·25
3141	2.2MFD	35V	£0·14	3156	33MFD	35V	£0·13

AUDIO LEADS

No.	Type	Price
107	FM indoor Ribbon Aerial	£0·69
113	3·5mm Jack plug to 3·5mm Jack plug length 1·5m	£0·86
114	5 pin DIN plug to 3·5mm Jack connected to pins 3 & 5 length 1·5m	£0·98
115	5 pin DIN plug to 3·5mm Jack connected to pins 1 & 4 length 1·5m	£0·98
116	Car aerial extension screened insulated lead. Fitted plug and socket	£1·44
117	AC mains connecting lead for cassette recorders and radios 2 metres	£0·78
118	5 pin DIN phono plug to stereo headphone. Jack socket	£1·21
119	2 · 2 pin DIN plugs to stereo Jack socket with attenuation network for stereo headphones. Length 0·2m	£1·04
120	Car stereo connector. Variable geometry plug to fit most car cassettes. 8-track cartridge and combination units. Supplied with inlined fuse power lead and instructions	£0·69
123	6·6m Coiled Guitar Lead Mono Jack plug to Mono Jack plug Black	£1·72
124	3 pin DIN plug to 3 pin DIN plug. Length 1·5m	£0·85
125	5 pin DIN plug to 5 pin DIN plug. Length 1·5m	£0·85
126	5 pin DIN plug to Tinned open end. Length 1·5m	£0·85
127	5 pin DIN plug to 4 Phono Plugs. All colour coded Length 1·5m	£1·49
128	5 pin DIN plug to 5 pin DIN socket. Length 1·5m	£0·92
129	5 pin DIN plug to 5 pin DIN plug mirror image. Length 1·5m	£1·21
130	2 pin DIN plug to 2 pin DIN inline socket. Length 5m	£0·78
131	5 pin DIN plug to 3 pin DIN plug 1 & 4 and 3 & 5 Length 1·5m	£0·95
132	2 pin DIN plug to 2 pin DIN socket. Length 10m	£1·13
133	5 pin DIN plug to 2 Phono plugs. Connected pins 3 & 5. Length 1·5m	£0·86
134	5 pin DIN plug to 2 Phono sockets. Connected pins 3 & 5. Length 23cm	£0·78
135	5 pin DIN socket to 2 Phono plugs. Connected pins 3 & 5. Length 23cm	£0·78
136	Coiled stereo headphone extension lead. Black, length 6m	£2·01
178	AC mains lead for calculators, etc	£0·52

REGULATORS

Positive	Price		Price
uA7805 TO220	£0·75	uA7912 TO220	£0·85
uA7812 TO220	£0·75	uA7915 TO220	£0·85
uA7815 TO220	£0·75	uA7924 TO220	£0·85
uA7824 TO220	£0·75	uA7818 TO220	£0·85
uA7818 TO220	£0·75	72723 14 pin DN	£0·52
Negative		uA723C TO99	£0·52
uA7905 TO220	£0·85	LM309K TO3	£1·72

SUPER SOUND SAVING!
DINDY LOW NOISE CASSETTES

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Take your pick

**HF-VHF-UHF-
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A challenging and full career in Government Service.
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**From Bahrain . . .
. . . to Bognor**

Use Your
Mini-Micro-Digital Hardware/Software Ability

100s of interesting and progressive opportunities at all levels in
Design - Test - Sales Service - Support

Most UK areas — some overseas

**Ring MIKE GERNAT
076-384 676 (24 hours)**

**ELECTRONIC COMPUTER AND MANAGEMENT APPOINTMENTS LTD.
148/150 High Street
Barkway, Royston, Herts
SG8 8EG**

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ENGINEERING OPPORTUNITIES

Telemotive uk Ltd is a Company in association with a major U.S.A. manufacturer with world leadership in the radio control of industrial machines, systems and processes, in collision prevention, and in other industrial electronics activities.

Our principal products are founded on the Near Field Induction Effect and on other inductive techniques in the 300kHz band. No other U.K. company has a comparable product line and our business therefore offers engineering experience of unusual interest. Training in our techniques is provided.

COMMISSIONING ENGINEER

We currently require an engineer with the ability to work independently, commissioning, servicing and testing systems on customer's sites. In addition, the engineer would at times work on systems requiring service at base (Hersham).

The position involves travelling within the U.K. and will take the engineer into a wide variety of industries. A company car is provided.

ELECTRONICS TECHNICIAN

We also require a technician whose duties would include assembly, wiring and test of complete equipment as well as testing small batches of PCBs. He or she would work with a small team of engineers but must be able to work unsupervised.

Previous experience of wiring is essential, preferably to military standards. Previous production testing experience would be an advantage.

Telemotive is a good employer. We look only for above average personnel, and this is reflected in the conditions of employment offered.

Please apply in writing, giving details of previous experience and training, to:—

765

telemotive uk ltd

Riverdene Industrial Estate, Molesey Road, Hersham, Walton-on-Thames, Surrey
Telephone Walton-on-Thames (09322) 47511

INNER LONDON EDUCATION AUTHORITY
LEARNING MATERIALS SERVICE TELEVISION CENTRE
Thackery Road, Battersea, S.W.8

VIDEOTAPE ENGINEER (ST3)

The Learning Materials Service produces teaching programmes in colour for ILEA schools and colleges, many of which are marketed throughout the U.K. and abroad. There is a Television Studio and mobile unit and a film unit. The programmes are recorded in the master control section on broadcast standard videotape (CCIR formats A and C). This section carries out all editing and post-production work, and provides large scale duplication on a variety of helical videocassette formats.

A vacancy has arisen in this section, which consists of four senior engineers. Applicants will be expected to have good operational experience of videotape, with a thorough understanding of the technical features, and to have appropriate technical qualifications. A general grounding in colour television theory is essential. The successful candidate will be expected to undertake maintenance of the broadcasting and tape machines and associated equipment, as well as the operational functions. Some overtime is required.

Salary within the scale £7904 to £8498.

Application forms from EO/Estab., 1C Room 365, The County Hall, S.E.1. Telephone No. 633 7456/8848.

(808)

WE'VE MOVED

NOTICE TO CLASSIFIED ADVERTISERS RE-CHANCE OF ADDRESS

Please note that Wireless World has now moved to Sutton, Surrey and all classified advertisements should be sent to the following address:

Classified Department
WIRELESS WORLD
Quadrant House, The Quadrant
Sutton, Surrey SM2 5AS
Tel. 01-661 3500, Ext. 8158
Telex: 892084 BISPRS G

wireless world

(794)

Radio Communications Electronics Engineers and Software Designers

Mid-Sussex—S.W. London **Salaries up to £8,000**

To join our expanding R&D Laboratories covering a wide range of R.F. spectrum, from L.F. to V.H.F. Equipments include transmitters and receivers for marine- and land-based use, radio navaids and radio monitoring remote computer-controlled systems.

Electronics Engineers should have experience in transmitter or receiver design, analogue or digital circuit design, microprocessor applications. Software Designers should be experienced Programmers with an interest in control, signal processing or navigational software.

Attractive salaries are complemented by excellent prospects and generous benefits.

Contact: **David Bird, Redifon Telecommunications Limited, Broomhill Road, Wandsworth, London, S.W.18. Phone: 01-874 7281** (reverse charges).

(9938)

COMPUTER TECHNICIAN—T2

A new post in our Computer Centre for maintenance of terminal and peripheral equipment of all kinds, clearing faults wherever possible, etc.

Salary: T2 £3990 to £4476

For further details contact: **'Personnel,' The Polytechnic Wolverhampton, The Molineux, Molineux Street, Wolverhampton, WV1 1SB. Tel. W'ton 710654** — 24-hour ansaphone.

(823)

STRATHCLYDE REGIONAL COUNCIL

GLASGOW Sub-Region
EDUCATION DEPARTMENT

ELECTRONICS TECHNICIAN

Glasgow College of Nautical Studies

Salary Scale - Tech. 'A/C' - £3,618 - £5,130. Placing according to experience and qualifications.

The successful applicant will be required to maintain the electronic and associated systems of the ship simulator after a period of specialised training. Typical qualifications required: C.G.L.I. Marine Radio and Radar Certificate or Technician Certificate in Electronics.
Ex-Service personnel with equivalent training and/or qualifications would seem to be particularly suitable for this post.

Application forms may be obtained from the **Assistant Director of Manpower Services, Glasgow Sub-Region, Strathclyde House, 8 India Street, Glasgow,** to whom completed forms, quoting Ref. G2939, should be returned by 3rd December, 1980.

R. M. O. McCulloch
Director of Manpower Services
(799)

Advanced Broadcasting Equipment

Increased home and export orders for our broadcast TV products mean that we are looking widely to recruit staff to fill new vacancies and others created by promotion of engineers who have been with us some time.

SYSTEMS ENGINEERS — TELEVISION

Experienced engineers are needed to work on design and project management of Outside Broadcast vehicles and television studios. This is an opportunity for engineers to become involved in projects from their initial design concept, through manufacturing to delivery and installation.

Our custom built systems require a high degree of customer contact at engineering level, from the initial design stage to the necessary training of operational staff on completion of the contract, both within the UK and overseas.

You should have a knowledge of TV studio engineering gained from experience in this type of work or from experience in the operational side of television.

DESIGN AND DEVELOPMENT ENGINEERS — VIDEO

An experienced engineer who will be involved in the design of studio products, including a new range of colour cameras, using the very latest analogue and digital techniques. You will have the opportunity to see your designs made in volume production, fulfilling the high technology requirements of the '80s.

We are looking for engineers who are qualified to degree or HND level and who have at least four years' experience in the design of electronic equipment, with some knowledge of video engineering and microprocessor techniques.

TEST ENGINEERS

We require engineers at intermediate level to assist in the manufacture of our new range of products for the Broadcast studio television market.

You need to have an up-to-date knowledge of digital and linear circuit techniques gained from experience working on broadcast television, or similar sophisticated products, and be capable of faultfinding down to component level.

We are a young, successful Company, well known in international television circles, operating from our modern purpose-built factory in Andover. Salaries offered are very competitive, and supplemented by generous holidays, free life and health insurance, pension scheme, subsidised meals and relocation expenses.

PLEASE WRITE GIVING FULL DETAILS OR PHONE JEAN SMITH AT THE ADDRESS BELOW FOR AN APPLICATION FORM.

LINK ELECTRONICS

Link Electronics Limited,
North Way, Andover,
Hants, SP10 5AJ.
Telephone: (0264) 61345

(800)

Technicians in Communications

GCHQ We are the Government Communications Headquarters, based at Cheltenham. Our interest is R & D in all types of modern radio communications – HF to satellite – and their security.

THE JOB All aspects of technician support to an unparalleled range of communications equipment, much of it at the forefront of current technology.

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PAY Competitive rates, reviewed regularly. Relevant experience may count towards increased starting pay. Promotion prospects.

TRAINING We encourage you to acquire new skills and experience.

QUALIFICATIONS You should have a TEC Certificate in Telecommunications, or acceptable equivalent, plus practical experience.

HOW TO APPLY For full details on this and information on our special scheme for those lacking practical experience, write now to **Robby Robinson, Recruitment Office, GCHQ, Oakley, Priors Road, Cheltenham, Glos. GL52 5AJ,** or ring 0242-21491 ext 2269.

GCHQ

PIONEER

require

FIELD SERVICE ENGINEER CAR AUDIO

c. £7,000 + Car

Applicants should hold a C. & G. qualification in Radio and T.V. Electronics or Telecommunications or an H.N.C. in Electronics. It is envisaged that the applicant should have up to 5 years' experience, the specialist knowledge required to analyse and solve car suppression problems and have a wide, general knowledge of car audio equipment, together with a methodical approach to work and the ability to deal in a friendly, polite way with people. You should hold a clean driving licence.

BENCH SERVICE ENGINEERS

Applicants should hold C. & G. Radio and T.V., 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 up to £7,500 per annum, according to age and experience.

Luncheon vouchers, four weeks' annual holiday and pension scheme.

For further information, do not hesitate to contact:

Mrs. C. A. Burridge
PIONEER HIGH FIDELITY (GB) LTD.
Pioneer House, The Ridgeway, Iver, Bucks.
Tel. Iver (0753) 652222

(776)

ELECTRONIC TECHNICIANS

FOR PRODUCTION RESEARCH AND DEVELOPMENT SERVICING

OXFORD c. £5,500

Research Machines is a young, successful company, being the leading U.K. manufacturers of micro-computer systems for research and education.

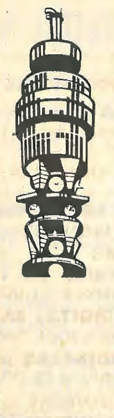
We are offering the opportunity of varied and satisfying work on technically advanced equipment. Applicants should be capable of prototype construction, testing and updating drawings. Experience in working with complex TTL logic boards essential.

You should be educated to A-level or ONC/HNC standard, or have relevant experience. Knowledge of microprocessors is not necessarily required, but applicants must be eager to acquire expertise in this field.

On appointment you will be assigned to either production, servicing or research and development. A starting salary of £5,500 for a 35-hour week is being offered together with good company benefits and the opportunity to acquire a 380Z computer at low cost.

Please write, giving full details of your experience, to: Mrs. Diane Hinton, Research Machines Ltd., P.O. Box 75, Oxford OX2 OBW.

(821)



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THE UK's No. 1 ELECTRONICS AGENCY

Design, Dev. and Test to £9,000
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SALES to £12,000 plus car
Ask for Ken Sykes

FIELD SERVICE to £8,000 plus car
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We have vacancies in ALL AREAS of the UK

Telephone: 01-637 5551 (3 lines)

UNIVERSITY OF PAPUA NEW GUINEA

Applications are invited for the post of

SENIOR TECHNICAL OFFICER IN THE DEPARTMENT OF HUMAN BIOLOGY

Applicants should have a Diploma in Medical Technology or Science Laboratory Techniques or equivalent. Those with experience in the field of physiology will be given preference. A substantial part of the duties will consist of supervision and on-the-job training of junior technical staff, with emphasis on training in handling instrumentation. Salary: K14,050 p.a. (£1 sterling = K1.58). Three year contract; gratuity; rent-free accommodation; family passages; baggage allowance; leave fares after 18 months service; education allowance; salary continuation scheme for extended illness or disability.

Detailed applications (2 copies), including a curriculum vitae, a recent small photograph and naming 3 referees should be sent to the Secretary, Box 4820, University P.O., Papua New Guinea, to arrive no later than 19 December 1980. Applicants resident in U.K. should also send 1 copy to Inter-University Council, 90/91 Tottenham Court Road, London, W1P ODT. Further details are available from either address.

(801)

THE POLYTECHNIC WOLVERHAMPTON

TV SERVICING TECHNICIAN (T3/4)

To maintain and repair video recorders, monitors, TV cameras and control gear. Good environment with potential to further development. Additional training may be available.

Previous applicants still under consideration.

Salary: £4581 to £5784.

Details from:

'Personnel'
The Polytechnic
Wolverhampton
(Tel: Wolverhampton 710654

24-hour ansaphone (831)

Inner London Education Authority
GARNETT COLLEGE
Downshire House, Roehampton Lane, London, SW15 4HR
01-789 6533

Electrical Engineering Resource Centre Technician (Grade 4)

Technician in the college's Resource Centre and electrical/electronic section; opportunity to develop a wide range of technical skills. Some experience in servicing electrical equipment desirable.

Salary: £4,756-£5,422 including London Weighting.

Applicants should possess an ONC or an Ordinary City and Guilds, or have done a recognised apprenticeship and should have at least 7 years' relevant experience.

Further details and application forms, returnable within 10 days, from the Acting Chief Technician at the college. (Ref. WW) (825)

TOP JOBS IN ELECTRONICS

Posts in Computers, Medical, Comms, etc. ONC to Ph.D. Free service.

Phone or write: **BUREAUTECH, AGY, 46 SELVAGE LANE, LONDON, NW7. 01-906 0251.**

(8994)

Communications Engineers and Technicians. Have you considered a career in Technical Publicity?

Our Central Publicity Department, based in the pleasant Berkshire town of Wokingham, has opportunities for Communications Engineers & Technicians (Male or Female) who wish to move into technical publicity by joining a team involved in the production of written copy for a wide range of sales literature and technical articles.

Even if you have never considered writing as a career, providing you have experience in communications, either data or radio, and an ability to express yourself clearly, we would very much like to hear from you.

Those people currently employed in telecommunications services or the electronics industry or those about to leave the HM forces would find the work varied, stimulating and creative. A certain amount of travelling will be involved for which a generous mileage allowance is payable. Excellent prospects exist for promotion to more senior positions.

We can offer staff excellent salaries, Group pension scheme, free life assurance, five weeks' annual holiday and relocation expenses where applicable.

This is your chance to join the most successful electronics Company in the U.K. Apply in writing, or telephone, giving brief details of age, experience and qualifications to:
Manager Group Personnel Services,
Racal Group Services Ltd.,
Western Road, Bracknell, Berks.
Tel: Bracknell (0344) 3244 Ext. 149

(814)

Britain's fastest growing electronics group RACAL

ENGINEERING OPPORTUNITIES

Samuelson Sight & Sound Ltd. is a well established firm, which in the past few months has found, due to increasing business the need to take on both Video and Audio engineers.

VIDEO ENGINEERS

Well proven service background in all aspects of video, including television, television camera, video tape recorder both VHS and U-Matic formats.

Salary negotiable dependent on experience.

AUDIO ENGINEERS

Experience in all forms of audio equipment including sound mixing consoles, amplifiers, talk back systems etc. However if you have a good electronics background this would be considered.

Salary negotiable dependent on experience.

Please apply in writing, giving details of previous experience and training to:-

Mr. R.T.Morgan (Service Manager)
Samuelson Sight & Sound Ltd.
303/315 Cricklewood Broadway,
London NW2 6PQ

SAMUELSON SIGHT SOUND LIMITED

SALARIES UP TO £13,000

can be obtained despite the recession

CURRENT VACANCIES INCLUDE:

DESIGN ENGINEERS to work on counter measures for secure computers i.e. equipt to detect interference from voice radio telex etc., up to 1:3GHz. Surrey to £13,000.

VERSATILE YOUNG ENGINEERS to join high flying design team engaged on new industrial instruments including: chart and data recorders, data acquisition and display products. Exp. low frequency instrumentation and mpu controls essential. South Coast to £10,000.

DESIGN ENGINEERS Digital video systems for security and document transmission over satellite and viewphone. Experience in digital signal processing essential. Berks to £1,000.

RF ENGINEERS & DIGITAL ENGINEERS for very advanced emergency services communication system. Berks to £10,000.

DEVELOPMENT ENGINEERS pcb's for control of mechanical peripheral equipment. Rural Cheshire to £8,000.

DEVELOPMENT ENGINEERS to work on a wide range of video cameras, video processing equipment — and sonar. South West Coast to £8,000.

PROJECT ENGINEER with drive and enthusiasm to develop analogue and digital modules for automotive industry. Rural Gloucs. c£9,000.

COMPUTER ENGINEERS Vacancies throughout U.K. in tech, support, field service, permanent site and systems test. Salaries range from exceptionally good to diabolical — but according to location and type of equipment.

WANTED URGENTLY — ANY HARDWARE OR SOFTWARE ENGINEERS, TEST ENGINEERS, SERVICE ENGINEERS, TRIALS ENGINEERS.

For further details, please contact:

Charles Airey Associates

8 Hammersmith Grove, London W6 ONA. Tel: 01-741 4011

PROBABLY THE BEST KNOWN SUPPLIER OF ELECTRONIC ENGINEERS IN THE COUNTRY

(532)

GOVERNMENT OF DUBAI
DUBAI RADIO AND COLOUR TELEVISION
TELEVISION ENGINEERING DEPARTMENT

TRANSMITTER ENGINEER

A vacancy exists for one Television Engineer to augment an existing team which is responsible for the maintenance of VHF and UHF medium and high power transmitters.

Candidates should be experienced in the broadcast field and be familiar with routine testing procedures to ensure the continued good performance of equipments under their control. Extensive use is made of SHF microwave links and candidates should be familiar with the operation, testing and setting up of such equipment. The maintenance of a medium power FM stereo transmitter is also involved.

Only candidates with some years of proven experience in broadcast engineering need apply.

The contract will be for two years and full details of conditions of service may be obtained from Falcon Television, 7a Grafton Street, London W1X 4HB, Telephone 01-629 6203.

The salary scale for this post will be £12000-£14000 Sterling per annum tax free depending on experience.

Applications, which will be treated in strictest confidence should be sent accompanied by C.V. and UK telephone contact to:—

Chief Engineer,
Dubai Radio and Colour Television,
c/o Falcon Television Productions,
7a Grafton Street,
London,
W1X 4HB

It is expected that interviews will be held in London in December.

(787)

St. Bartholomew's Hospital/
St. Leonard's Hospital
Medical Electronics Department

FIELD SERVICE ENGINEER

We have a vacancy for a technician to join a small team maintaining Renal Dialysis equipment. The work involves servicing electronic and mechanical equipment in both the Dialysis Centre and in the patient's homes. Rostered on call duties and overtime working are normally required. A current driving licence is essential. Applicants must hold a recognised technical qualification.

Salary scale (MPT III/IV) in range £4409-£6479 per annum inclusive of London Weighting.

Job description and application form from **Personnel Department, St Bartholomew's Hospital, London EC1A 7BE. Telephone: 01-600 9000 extension 2271.**

Reference number PTB/100

(775)

UNIVERSITY OF EXETER
DEPARTMENT OF PSYCHOLOGY

TECHNICIAN

Applications are invited for the post of (Audio Visual) Technician (Grade 4) in the Department of Psychology. Candidates should have experience in the use of Video cameras V.T.R. and associated equipment; photographic skills and/or an interest in microprocessor interfacing would be an advantage.

Salary will be on the scale £4431-£5097 p.a., with initial placement according to qualifications and experience.

Letters of application, stating full personal details and the names of two referees, should be sent to **Mrs. Doreen Birch, Northcote House, Queen's Drive, Exeter, EX4 4QJ,** from whom further particulars are available, by 2 December 1980. Please quote reference No. 5153.

(774)

Surrey Education Committee

Brooklands Technical College
Heath Road, Weybridge, Surrey

DEPARTMENT OF TECHNOLOGY

Lecturer I— Telecommunications/ Electronics

to teach TEC Certificate Courses and C & G 224. Industrial experience and qualifications to HNC/FTC preferred. Ability to offer Telephony-based subjects an advantage.

Salary Scale: Lecturer I—£4683-£8055 plus £213 per annum London Fringe Area Allowance

Commencing salary dependent upon qualifications and experience. General relocation expenses in approved cases.

Further details and application forms from the Principal to be returned within 10 days after publication date.

(819)

Dolby

ELECTRONIC TEST ENGINEERS

We manufacture and market audio noise reduction equipment which is used by major recording companies, recording studios, the film industry and broadcasting authorities throughout the world.

We need experienced Test Engineers to join a dedicated team who are proud to be world leaders in the manufacture of professional noise reduction equipment.

Those with practical knowledge of electronic testing and rapid trouble-shooting ability can enjoy varied and interesting work and high rates of pay.

Telephone TONY HILL 01-720 1111

DOLBY LABORATORIES INC.
346 Clapham Road, London, SW9 9AP

(817)

Experienced T.V. aerial

SYSTEMS ENGINEER

required to work from S.E. London.

Apply to:

Greenwich Cablevision Limited, 307 Plumstead High Street, London SE18 1JX
Tel: 311-3466

(778)

AUDIO ENGINEER. Small company requires Audio Engineer. The applicant should be familiar with construction and servicing of a wide range of audio equipment and should be capable of working without supervision, prototype, R&D work imminent. Applicants should be 21-35 years of age. Salary £3,500-£5,000 per annum according to qualifications. Kelsey Acoustics, 01-727 1046. (829

BROADCAST ENGINEERS, £16,000 neg. Permanent positions overseas. Tax free salaries, first class accommodation and conditions. Apply: SPS EXECUTIVES (Ref 1726), Recruitment Consultants, Delme Court, West Street, Fareham, Hampshire or better still telephone (0392) 235611/236857. (597

ROYAL FREE HOSPITAL, Hampstead, NW3 Medical Physics Technicians II and III. Salary on scale £5,132-£7,445. For well equipped Electronics Laboratory for maintenance of Radiotherapy machines, Physics equipment. CT scanners and Ulstrasound apparatus. Equipment includes Linear accelerator, two Cobalt units, 300 kv and superficial machines. Also development work on computerised Cobalt treatment unit film badge, reader, etc. Qualifications — ONC, HND or equivalent specialising in electronics plus 3 years experience. For details and application form — Personnel Dept, tel. 01-794 0500 ext. 4286. Quote ref: 1487. (821

COMPUTER & DIGITAL FIELD ENGINEERS

A Place on our specialist register ensures wide exposure to the right opportunities with the minimum of time-wasting.

We provide —

- ★ Expertise of ex Field Engineer/Manager
- ★ Continuous update of your circumstances — we don't file and forget!
- ★ Genuine 24-hour service — no answering machines.
- ★ No promises we can't keep.
- ★ Countrywide contacts.

Ring now for a free Registration form—

01-464 7714, ext. 502

LOGEX

ELECTRONICS RECRUITMENT SERVICE
HIGH ROAD, LOUGHTON, ESSEX
01-502 1589/01-464 7714, EXT. 502

(824)

UNIVERSITY OF PAPUA NEW GUINEA

Applications are invited for the post of

SENIOR TECHNICAL OFFICER IN THE DEPARTMENT OF CLINICAL SCIENCES

Faculty of Medicine.

Applicants should have a Diploma in Medical Technology or equivalent with several years' experience, preferably in a teaching institution. Those with experience, in the field of Immunology will be given preference. Appointee will be responsible to the Chairman of the Department (through the Laboratory Manager) for the co-ordination of all technical services. Duties include supervision and on-the-job training of junior technical staff. Salary: K14,050 p.a. (£1 sterling = K1.58). Three-year contract; gratuity; rent-free accommodation; family passages; baggage allowance; leave fares after 18 months' service; education allowance; salary continuation scheme for extended illness or disability.

Detailed applications (2 copies), including a curriculum vitae, a recent small photograph, photo-copy of educational qualifications and naming 3 referees, should be sent to the Secretary, Box 4820, University P.O., Papua New Guinea, to arrive no later than 19 December 1980. Applicants resident in the U.K. should also send 1 copy to Inter-University Council, 90/91 Tottenham Court Road, London W1P 0DT. Further details are available from either address.

(802)

APPOINTMENTS IN ELECTRONICS

£5 – £10,000

Take your pick of the permanent posts in:

MISSILES — MEDICAL
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RADAR — COMMS
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HARDWARE — SOFTWARE

For free expert advice and immediate action on salary and career improvement, 'phone or **write to GRANT WILSON**

Technomark

Engineering and Technical Recruitment

11 Westbourne Grove
London W2. 01-229 9239

(9257)

We have the following vacancies in our Network and Service Planning Department based at our Engineering Headquarters near Winchester:-

Engineer
Network Planning
(Ref: WW/524cc)

Under the general supervision of a Senior Engineer you will be required to progress modifications and extensions to the IBA vision, sound and telemetry networks. The work includes the installation and testing of microwave links.

You should have a degree in electronic engineering and at least two years' experience in microwave systems planning and commissioning. Alternatively, experience of Post Office practice or communication methods in either broadcasting or private industry may be acceptable.

Senior Engineer
Network Planning
(Ref: WW/523cc)

You would be required to plan and supervise the implementation of communication facilities for the current and future needs of the Authority. The work will involve the control and provision of Post Office Services and the planning, installation and commissioning of private radio systems within a given budget.

You should be qualified to degree level with several years' experience of transmission systems both line and radio. Familiarity with current video and audio transmission techniques is essential and applicants should have practical experience of microwave link design and operation.

Both posts will involve travelling with periods away from base, therefore, a current driving licence is essential. Applicants (male or female) will be required to climb and work on tall structures.

Depending upon qualification and experience, the commencing salary will be on a range which rises to £9,603 per annum for the Engineer post and to £11,040 per annum for the Senior Engineer post.

Relocation expenses will be paid where appropriate.

IBA — INDEPENDENT BROADCASTING AUTHORITY

Please write or telephone for an application form, quoting the appropriate reference number, to Christine Gossling, IBA, Crawley Court, Winchester, Hampshire SO21 2QA. Telephone Winchester 822270.

(772)

Broadcasting Engineers
Saudi Arabia up to £6,000 to £16,000

EDOK-ETER are a major international civil, telecommunications and defence engineering company with rapidly developing worldwide interests. Our headquarters is in Athens.

One of our more important undertakings is the construction, commissioning and long-term operation of the new Saudi Arabian HF and MF broadcasting network based on multi-megawatt MF transmitters and HF or microwave programme and telecommunication links.

We require several grades of Broadcasting Engineers to take full responsibility for the operation and maintenance of all the radio and electronic equipment of a new station. Successful candidates aged up to 50 must have a relevant Degree and radio engineering experience, preferably in broadcasting, or alternatively in manufacture and installation, or in Armed Services communication.

Salary is up to £16,000 p.a. tax free, depending on qualifications and experience. Benefits are comprehensive covering single furnished accommodation, medical treatment, generous home leave and air fares and accident insurance cover.

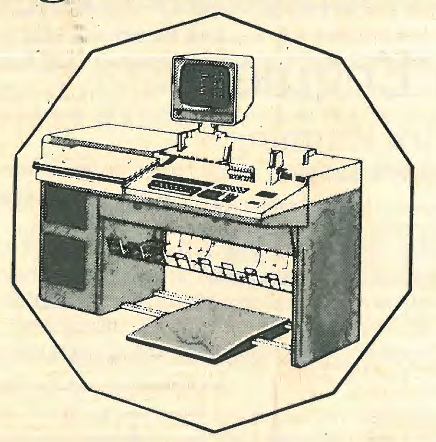
Please write, quoting reference 903, giving full details of previous experience, employment and professional qualifications and enclose a recent photograph to: **The Personnel Manager, EDOK-ETER Group, 83 Buckingham Palace Road, London SW1W 0QJ. Tel: 01-828 6814.**

EDOK·S.A.-ETER·S.A.

(789)

ELECTRONIC ENGINEERS

looking for a different image?



Competitive Salary + Car

In the field of Electronics, few areas offer such growth opportunities as that of Computing. Philips Data Systems is a division of Philips Business Systems, the pacesetting group that manufactures and markets one of the widest ranges of advanced business systems and equipment. We are looking throughout the UK for **Customer Engineers,** male or female, who wish to be part of that growth.

If you are experienced in dealing with customers' problems, skilled in electronics/electro-mechanics, then **Philips will provide you with the training necessary to enter this technically exciting and challenging field.**

We offer excellent conditions of employment, a competitive initial salary, which will be reviewed on completion of your first 6 months training period. Naturally, a company vehicle will be provided.

If you believe you have the ability/experience needed to take on this image, then why not telephone Alan Bowden, Senior Personnel Officer, on 0206 5115 or write to him at Philips Data Systems, Elektra House, 2 Bergholt Road, Colchester, Essex CO4 5BE.

PHILIPS Business Systems Simply years ahead **PHILIPS**

(809)

JUNIOR DEVELOPMENT ENGINEERS

ELECTRONICS

John Player and Sons, a leading manufacturer of tobacco products, offer the opportunity to young electronics engineers to gain valuable practical experience in industrial electronics.

Vacancies exist for work in the Machinery Evaluation Section where new generation cigarette making and packing machines are undergoing pre-production trials. These machines are equipped with increasing numbers of modern electronic control circuits using the latest technological advances including microprocessors.

The successful applicants will undergo a period of familiarisation, look after specific machines during the evaluation period, be involved in the development of special features as well as devising evaluation aids and ultimately in the training of others in the maintenance of these machines on the production floor.

We are looking for men or women who are qualified to HNC or equivalent, and who have two years' experience in one or more of the following areas:

a) electronic control and logic circuits
b) process control systems
c) microprocessors

A knowledge of the tobacco industry is not essential.

We offer a starting salary of £6,500 per annum together with other benefits associated with a large progressive company including relocation assistance where applicable.

Application forms cab be obtained by telephoning Nottingham (STD 0602) 787711, Extension 345 or writing to:

Lorna Blayney

JOHN PLAYER & SONS
NOTTINGHAM NG7 5PY

(790)

ELECTRONICS ENGINEER

CENTRAL SCOTLAND

A vacancy exists in our engineering design and development deparment for an Electronics Engineer.
Applicants should be qualified to HNC level or have the depth of industrial experience and ability to work on new designs with the minimum of supervision.

Apply for application form to:

Administration Manager
G R INTERNATIONAL ELECTRONICS LTD.
Inveralmond Industrial Estate, Perth PH1 3NY
Telephone: Perth 34771

(796)

When the ship comes home, why not settle down?

We're British Telecom Maritime Service and we have everything in a job that you'd want: the kind of work you're trained to do, good pay, job security and all the comforts of home where they really count – at home!

Radio Officers

Vacancies exist at several coast stations for qualified Radio Officers to carry out a variety of duties that range from Morse and teleprinter operating to traffic circulation and radio telephone operating. And for those with ambition, the prospects of promotion to senior management are excellent.

You must have a United Kingdom Maritime Radio Communication Operator's General Certificate or First Class Certificate of proficiency in Radio-telegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic. Preferably you should have some sea-going experience.

The starting pay at 25 or over will be about £5,381; after 3 years service this figure rises to around £7,087. (If you are between 19 and 24 your pay on entry will vary between approximately £4,229 and £4,937). Overtime is additional, and there is a good pension scheme, sick-pay benefits and at least 4 weeks' holiday a year.

For further information, please telephone Kathleen Watson on Freefone 2281 or write to her at the following address:
IE Maritime Radio Services Division (WWA), IS8.1.1.2, Room 304, Landsec House, 23 New Fetter Lane, London EC4A 1AE.

British TELECOM PART OF THE POST OFFICE

(524)

SITUATIONS VACANT

CHIEF ENGINEER
RADIO AVONSIDE LIMITED

Applications are invited for the post of Chief Engineer at the Bristol-based Independent Local Radio station due to come on air in the autumn of 1981. The appointment should be made before the end of this year and the successful applicant will begin his or her duties next spring.

The contract offered to Radio Avonside by the Independent Broadcasting Authority covers Bristol, Bath and surrounding areas with a possible adult audience in excess of 800,000. It will be one of the most exciting and challenging engineering appointments within the ILR network and a high standard of administrative ability and technical experience is required.

The person appointed will be concerned with the planning and setting up of the station and will thereafter be responsible to the Managing Director for all aspects of Radio Avonside's technical operation and maintenance procedures. A salary of around £10,000 p.a. is envisaged, subject to qualifications and experience.

Applicants should write to the Chairman, Professor Glynne Wickham, at Radio Avonside Limited, 4th Floor, Bush House, 72 Prince Street, Bristol BS1 4NU. The closing date is 1st December 1980.

(804)

PICCADILLY RADIO 261

serving a population of four million from the heart of Manchester seeks a

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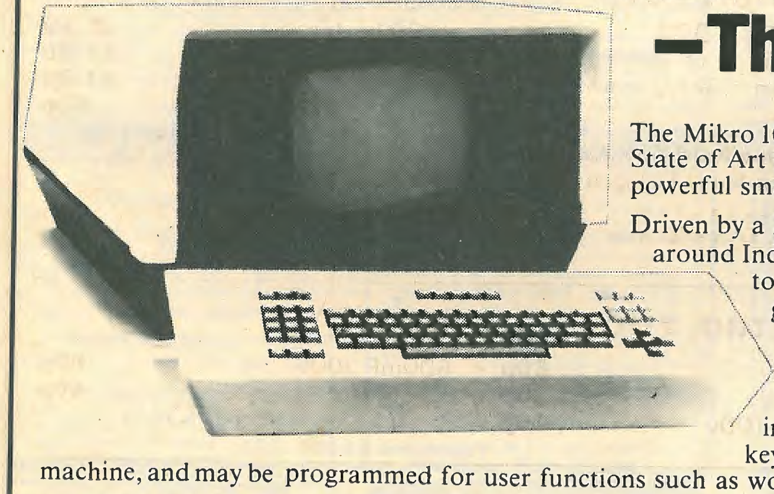

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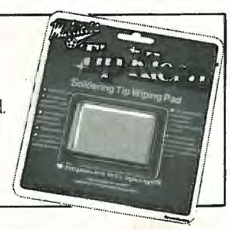

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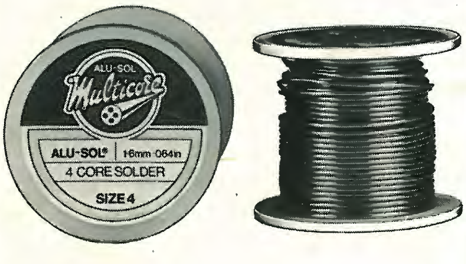

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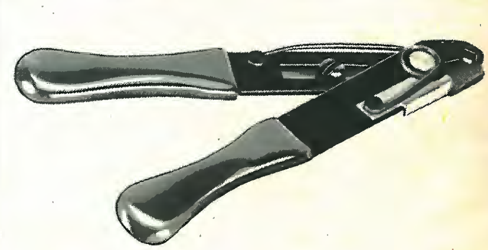

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