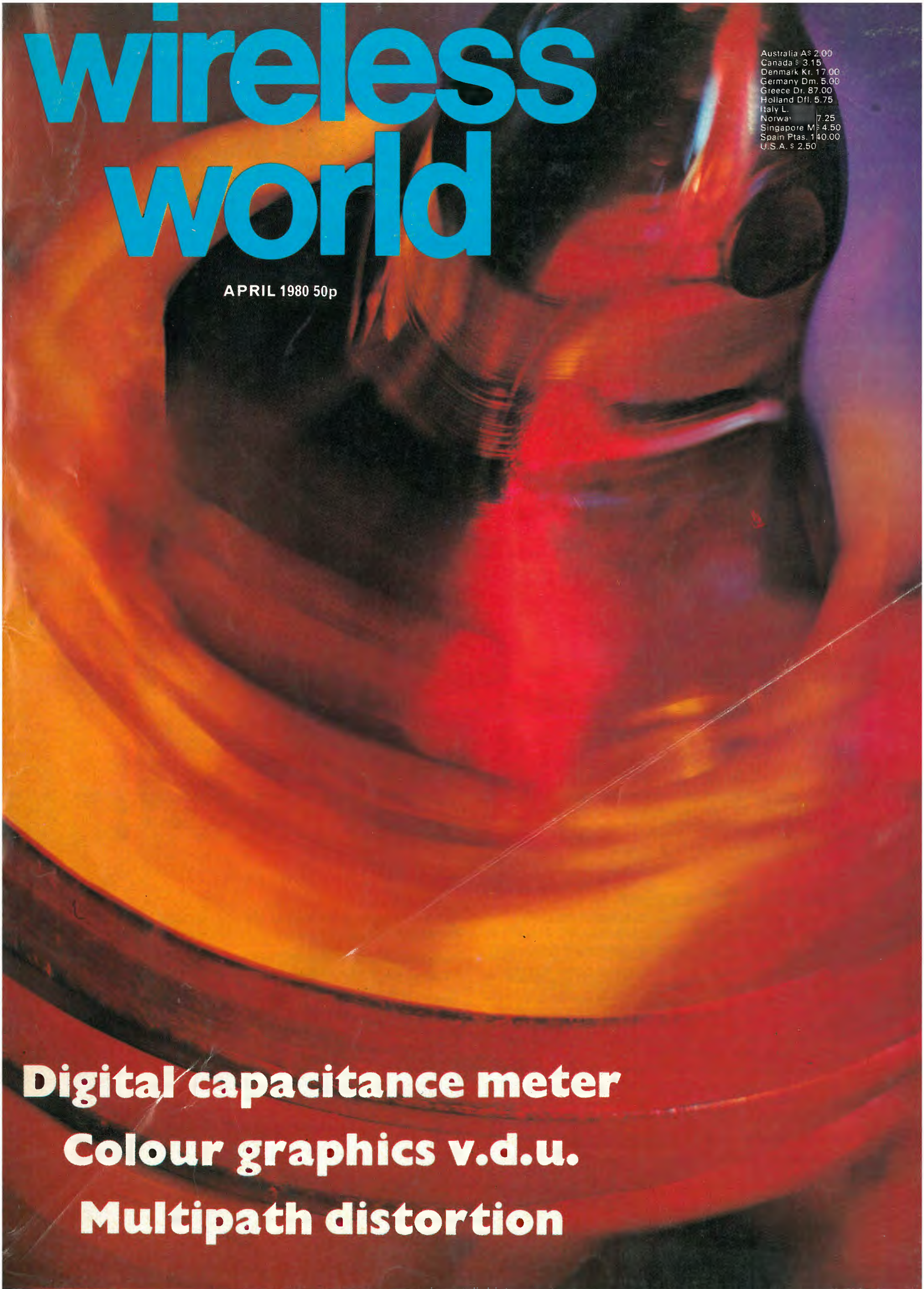


wireless world

APRIL 1980 50p

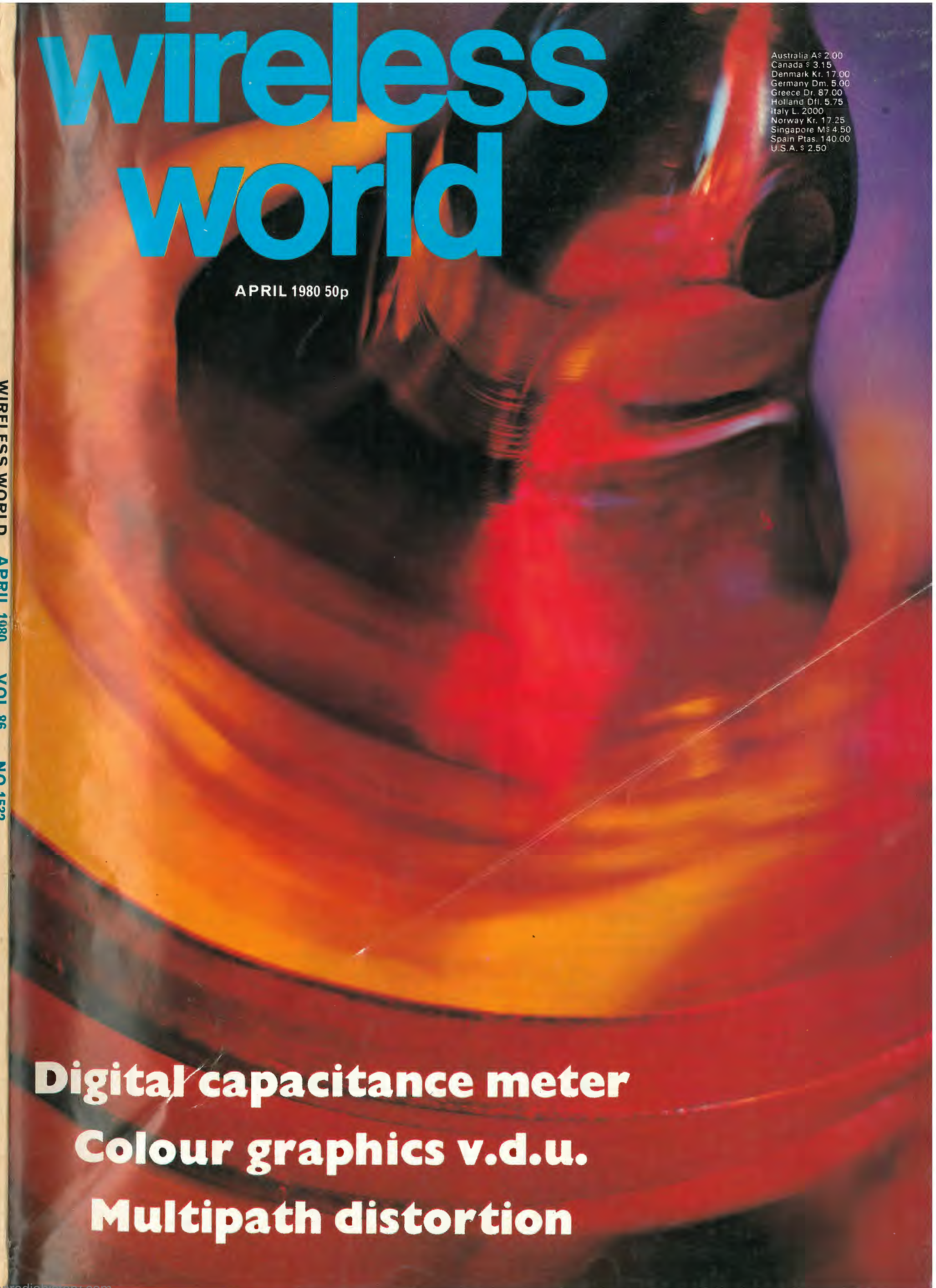
Australia A$ 2.00
Canada $ 3.15
Denmark Kr. 17.00
Germany Dm. 5.00
Greece Dr. 87.00
Holland Dfl. 5.75
Italy L. [illegible]
Norwa[illegible] 7.25
Singapore M$ 4.50
Spain Ptas. 140.00
U.S.A. $ 2.50

Digital capacitance meter

Colour graphics v.d.u.

Multipath distortion

WIRELESS WORLD APRIL 1980 VOL 86 NO 1532



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Spain Ptas. 140.00
U.S.A. $ 2.50

Digital capacitance meter

Colour graphics v.d.u.

Multipath distortion

Front cover shows the process of growing a silicon crystal, from which semiconductor devices will be made. Photographer Paul Brierley.

IN OUR NEXT ISSUE

Weather satellite picture processor. **Constructing a device to display side by side visible-light and infra-red pictures from TIROS-N satellites.**

Designing with microprocessors. **Start of a series to help designers use the micro as a component in electronic systems.**

Audio spectrum analyser. **Constructing an instrument with manual or automatic sweep and digital frequency display to use with a c.r.o.**

Current issue price 50p, back issue (if available) £1.00, at Retail and Trade Counter, Paris Garden, London SE1. Available on microfilm: please contact editor.
By post, current issue 86p, back issues (if available) £1.00, order and payments to Room CP34, Dorset House, London SE1 9LU.
Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.
Telephones: Editorial 01-261 8620. Advertising 01-261 8339.
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Subscription rates: 1 year £9.00 UK and $31 outside UK.
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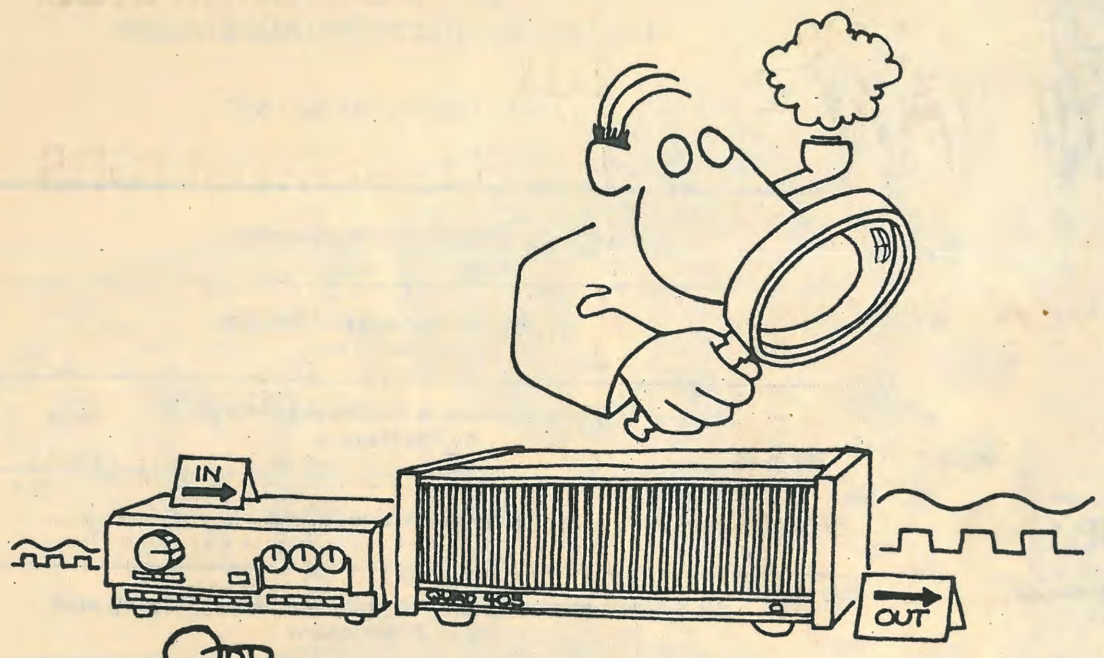
ISSN 0043 6062

wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

APRIL 1980 Vol 86 No 1532



"Comparisons are odorous"

We are often asked by audio enthusiasts how our amplifier compares with so and so's product, and they are surprised when we reply "we don't know, we have never tried."

It is not that we are unwilling to learn from other people's mistakes, it is simply that at Quad we recognise only one standard for comparison, namely the original.

What we wish to know is how the output of the equipment under investigation compares with the original signal fed into it.

Over the years we have developed experimental techniques which enable us to investigate the audible contribution of a piece of equipment to a music signal, and as a result we can say with complete confidence that a Quad 405* contributes absolutely no audible degradation to the signal fed through it, and that's as close to the original as you need to get.

For further details on the full range of QUAD products write to:

The Acoustical Manufacturing Co. Ltd., Huntingdon, Cambs. PE18 7DB. Telephone: (0480) 52561.

*or 303 or 33. When operated within specified input and output levels and at specified loads.

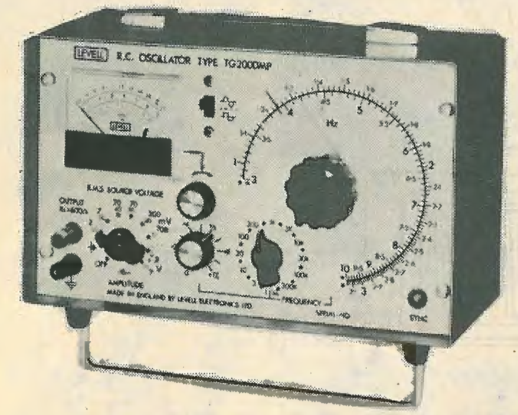
QUAD

for the closest approach to the original sound

QUAD is a registered Trade Mark

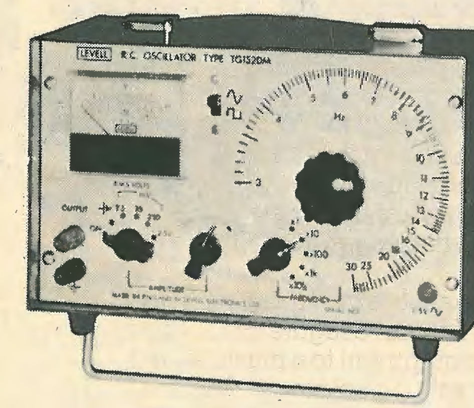
WW—074 FOR FURTHER DETAILS

DON'T GAMBLE WITH PERFORMANCE BUY LEVELL OSCILLATORS



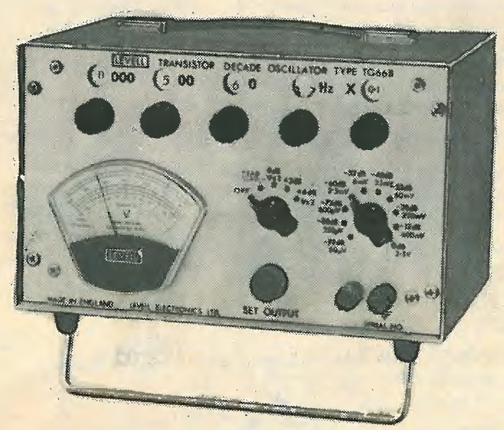
FREQUENCY	1Hz to 1MHz in 12 ranges. 0 to 1% fine control on TG200DMP.
ACCURACY	±1.5% ±0.01Hz up to 100kHz. ±2% up to 1MHz.
SINE OUTPUT	7V r.m.s. down to <200μV with Rs = 600Ω.
DISTORTION	<0.05% from 50Hz to 15kHz, <0.1% from 10Hz to 50kHz, <0.2% from 5Hz to 150kHz, <1% at 1Hz and 1MHz.
SQUARE OUTPUT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

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



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

TG152D Without meter **£80** — **TG152DM** With meter **£99**



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

TG66B Battery model **£265** — **TG66A** Mains & battery model **£280**

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

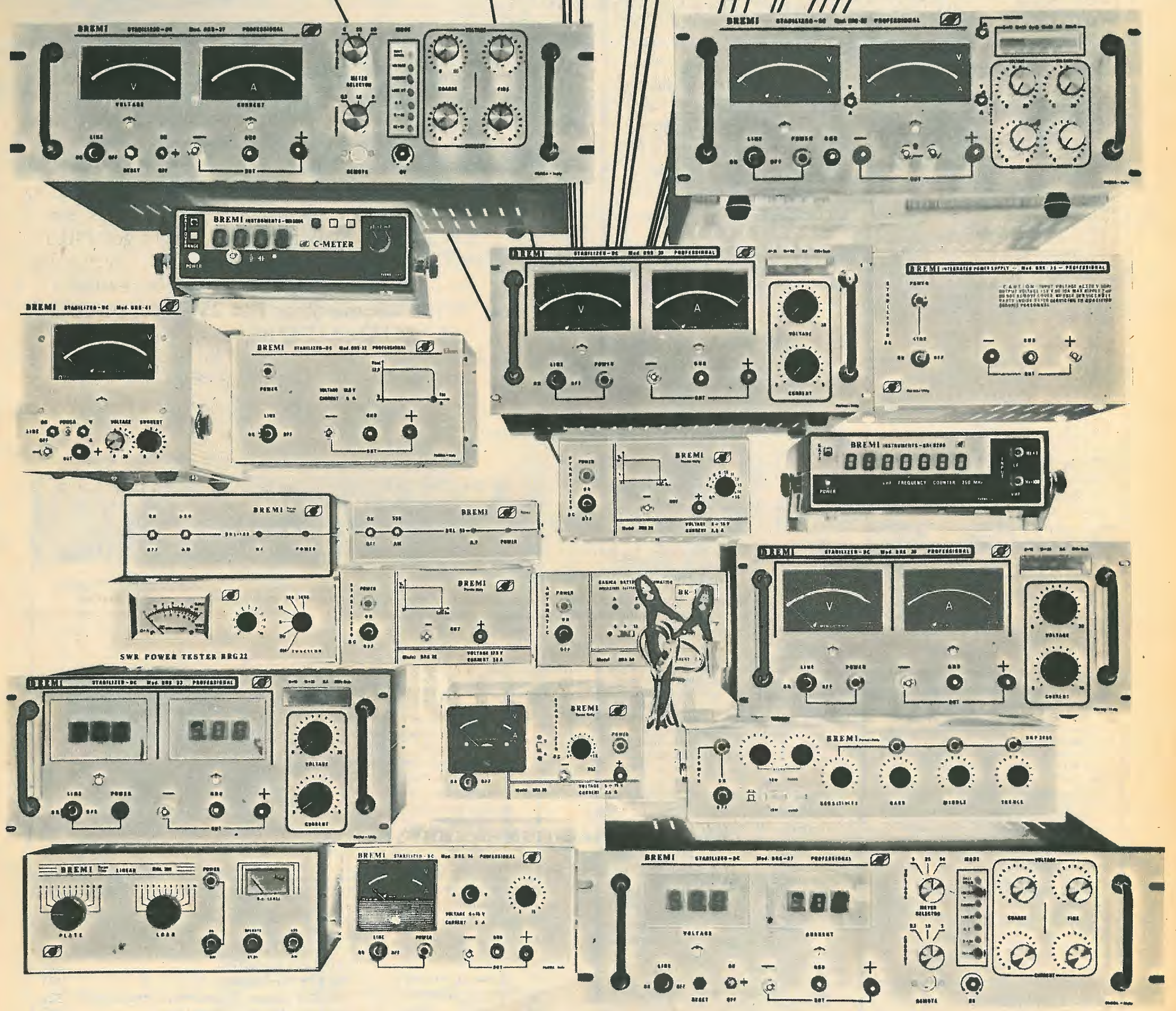
LEVELL ELECTRONICS LTD.

MOXON STREET, BARNET, HERTS., EN5 5SD. TEL: 01-449 5028/440 8686

WW—016 FOR FURTHER DETAILS

BREMI

BREMI ELETTRONICA
Via Pasubio 3/C
43100 Parma - Italy
Tel. 0521/72209 - 771533
Telex: 530259 ccia pr I for BREMI



DC POWER SUPPLIES a vast range suited to meeting both amateur and professional requirements
MEASURING INSTRUMENTS Digital frequency meter, digital capacity meter

PSICHEDELIC LIGHTS EQUIPMENT various models of light modulators, with/without microphone, stroboscope, spot lights etc.
EQUIPMENT FOR CB linear amplifiers, S.W.R. meter, wattmeters

METAL DETECTOR

AUTOMATIC BATTERY CHARGER

Our articles, which are of top quality, are known and exported worldwide.

WE ARE LOOKING FOR AN EXCLUSIVE IMPORTER

well introduced on the English market for all our articles and for some lines of our product.

WW — 018 FOR FURTHER DETAILS

INPUT FROM PHILIPS TEST & MEASURING INSTRUMENTS

NO WAITING FOR THESE TOP PRODUCTS

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

Reader inquiry number 222

Some other Philips audio and video service instruments:
PM 5326 RF SIGNAL GENERATOR
- 100 kHz-125 MHz in 9 overlapping ranges
- Built-in 5 digit counter
- 50mV RF output at 75Ω can be attenuated to over 100dB
- Electronically stabilised output level
- Wobbulator facility

Reader inquiry number 223

PM 6307 WOW AND FLUTTER METER
- X-tal controlled oscillator
- High accuracy and frequency stability
- 3150 Hz or 3000 Hz switchable
- Separate 'Drift' and 'Flutter' indication

Reader inquiry number 224

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.

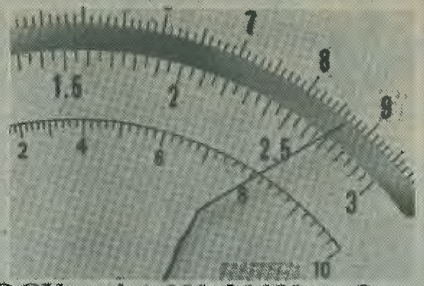
	Inquiry no.	
PM 2517 multimeter	220	☐
PM 3207 oscilloscope	221	☐
PM 5519 colour TV pattern generator	222	☐
PM 5326 RF signal generator	223	☐
PM 6307 wow and flutter meter	224	☐

PHILIPS **Test & Measuring Instruments**

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

PHILIPS

Finally, you can have all the advantages of DMMs and none of the disadvantages of analogues for about the same price.



Our new 169 is a tough, lightweight, battery-powered digital multimeter for use in the field or on the bench. It is a 3½-digit, full 5-function DMM with respectable .25% DC accuracy.

Its low-parts-count, high-efficiency design keeps power consumption to a minimum for longer component life and fewer failures. MTBF is 20,000 hrs. or about 10 years.

All 5 functions are fully protected – 1400V peak on DCV and ACV, 300V on Ω, 2A (250V) on DCA and ACA. The fuse is externally accessible for quick replacement. Extensive vibration stress-testing assures the 169 will stand up to all the mechanical shock and abuse normally associated with tough applications.

Is this the end for Analogue meters?

Cost-conscious ease of maintenance is so thoroughly designed into the 169 that only one calibration adjustment a year is required. That adds up to a cost-of-ownership no other competitive DMM can touch. For example, the 169 needs only one battery change per year at a cost of about £1.50.

When you factor in features like function and range annunciation right on the display, auto-zero, auto polarity, 60% larger display than other DMMs and the easy-to-read, colour coded front panel, we think you'll get the point. No analogue meter or DMM can match the price/performance of the new 169. It costs £99 (plus VAT)

For information on the 169 or any Keithley DMM call (0734) 861287
Telex: 847047

Ex stock

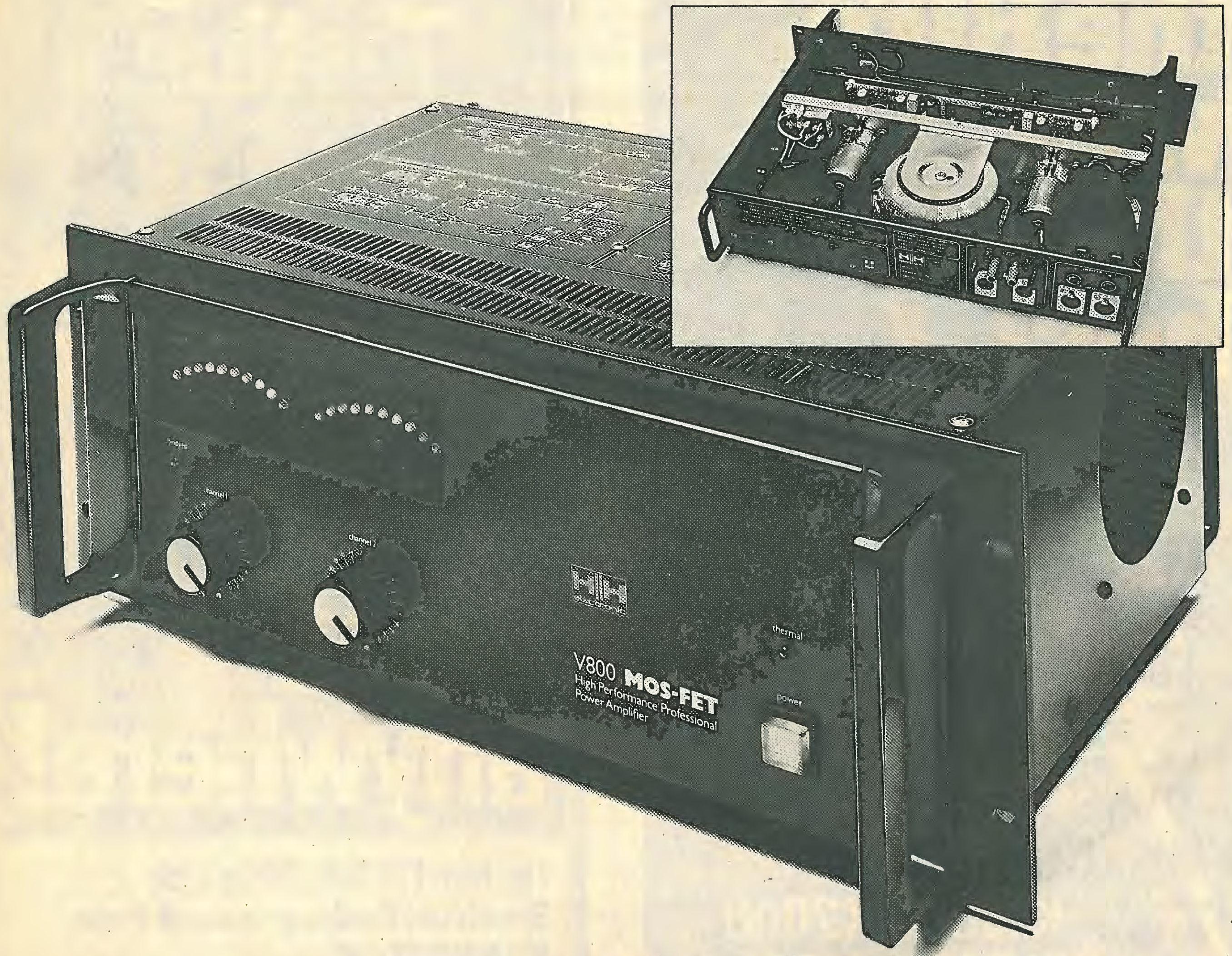
WW 034 FOR FURTHER DETAILS

KEITHLEY

Keithley Instruments Ltd.
1, Boulton Road
GB-Reading, Berkshire RG2 0NL
UNITED KINGDOM
(0734) 861287 Telex: (851) 847047

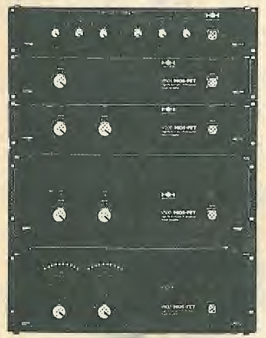
Keithley Instruments GmbH
Heiglhofstrasse 5
D-8000 München 70
(089) 714-40-65
Telex: 521 21 60

Keithley Instruments SARL
44, Rue Anatole France
F-91121 Palaiseau Cedex
01-014-22-06.
Telex: (842) 204188



Lateral Thinking

"The perfect definitive power amplifier should run absolutely stable and completely undistorted across a full frequency range up to the highest power level with total dependability," we said. Our resolve was to make that ideal a reality.

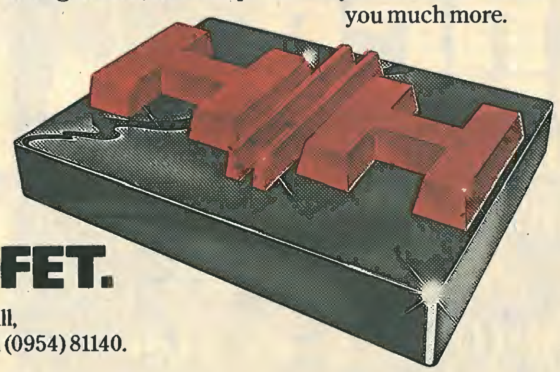


Thus, our boffins at Cambridge donned their thinking caps and with typical panache sliced across convention with a radical new solution: MOS-FET technology.

And the result? No thermal runaway. No secondary breakdown. Simpler circuits. Fewer components. Therefore, greater reliability under tough conditions. Whatever your application; variable frequency power supplies, servo motor systems, vibrator driving, or superior audio installations, our new MOS-FET amplifiers will deliver perfect waveforms right up to 50kHz at full power.

Now this technology is available to you, in 19" rackmount format with models from 150 to 800 Watts... and upwards in multiples, using the X300 frequency dividing network.

So if you're thinking that our thinking was along the right lines, then drop us a line yourself and we'll tell you much more.



Graduate to the 80's. MOS-FET.

HH Electronic, Dept. A5, Viking Way, Bar Hill, Cambridge CB3 8EL. Telephone: Crafts Hill (0954) 81140. Telex: 817515 HH Elec G.

WW—029 FOR FURTHER DETAILS

Plan the 80's with the best

K1000 & K2000 SOLDERING IRONS

- 16w Producing 420°c (Helping the Save-it campaign)
- PUSH-IN TIPS
- 6 MONTHS GUARANTEE

ADCOLA

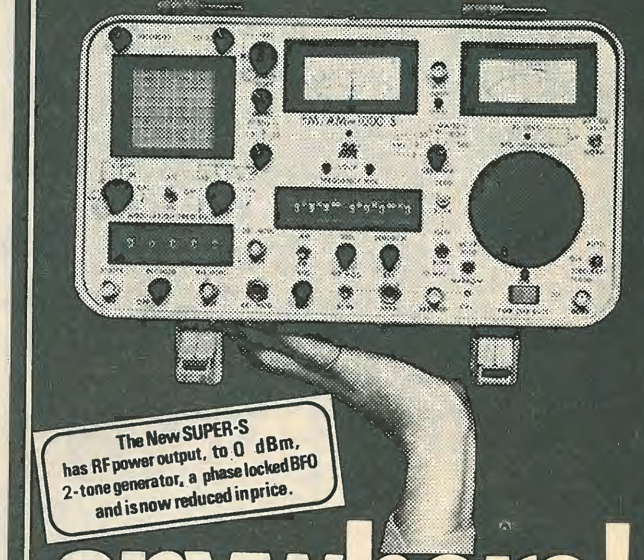
United Kingdoms Leading Soldering Instrument Manufacturers

Tel. 01-622-0291/4

ADCOLA PRODUCTS LIMITED
GAUDEN ROAD, LONDON SW4 6LH

WW — 027 FOR FURTHER DETAILS

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



anywhere!

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

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

For further information contact Mike Taylor

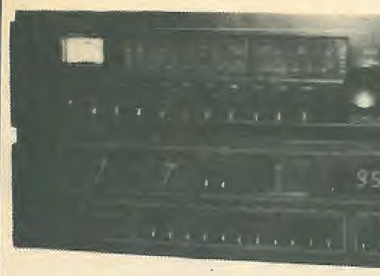
Hunting **FieldTech**

IFR precision simulators

FieldTech Ltd
Heathrow Airport-London Hounslow
TW6 3AF
Tel: 01-759 2811
Telex: 23734
FLDTEC G

WW — 061 FOR FURTHER DETAILS

BEWARE! RADIO ACTIVITY



The new MK III FM tuner sitting under the Dorchester multiband AM/FM tuner

Revisions to the Mark III include a centre zero tuning indicator meter and silent preset switching

New 944378-2, the last word in stereo decoders with the KB4437/4438.

Choosing the products to advertise each month can be quite a task at AMBIT, since we tend to introduce at least one new line per week. So it is nearly impossible to say all we would like in this space - other than to bring you as far up to date as possible with current events. The major medium for finding out about what we have to offer is our unique catalogue system, and we ask that you invest in a copy of parts 1,2 & 3 since many questions we are asked can be readily answered by reference to these.

Each part costs 60p, or £1.60 for all three current editions.

We are also launching a new and greatly elongated version of our PRICE LIST, which now includes a large number of quantity listings, and many items not previously listed. The new style price list is a quick reference short form to our general catalogues - available FOC with a large (A4) SAE please.

As a result of the soaring price of oil - and the subsequent huge increases in the cost of wax for Mr Tom Jackson's famous moustache, the Post Office have increased their charges (Feb. 4th). Accordingly, our standard cover charge has been increased to 35p per order (CWO).

MODULE NEWS

We are at last able to quote for quantities of our modules, following a program of standardization and revision to speed manufacture and test. The following types are the results of the standardization program:

UM1181	5 varicap MOSFET input VHF band 2 tunerhead	£12.00 nc
911225 A	High Performance FM IF system, with switched BW	£23.95 nc
911225 B	Single BW filters, single tuned detector	£14.95 nc
91072 A	DC tuned and single pole switched MW LW tuner	£14.43 nc
91072 B	As type 'A' but with either SW1 or SW2 band	£15.90 nc
92242 A	Combined LW/MW tuner, with FM IF detector section	£29.00 nc
92242 B	As 92242A but with 5-10MHz SW section	£34.00 nc

All are supplied housed in screened metal cases 97x56x24mm, with all connections along a single edge, suitable for verticle or horizontal mounting.

Previously advertized units are still available - although there may have been some price changes in the latest edition of the Price List (Date Feb.80). A separate leaflet covering the new range of modules is available from April 80, with an A4 SAE please

COMPONENTS

DIGITAL FREQUENCY READOUTS / SYNTHESISER SYSTEMS

Ambit has the biggest range of digital frequency readout systems for various applications in Broadcast and Communications. Prices range from £18.50 for a complete AM/FM broadcast frequency display (kit of DFM2). Most are detailed in the latest catalogue.

TUNING SYNTHESIZERS are also heavily featured, and we offer our first complete system covering MW/ LW/ SW2 and FM based on Hitachi parts. The unit is retrofittable to voltage tuned radio systems - and will shortly be incorporated in a complete tuner project. Cost for the synthesiser will be circa £40

A versatile communications system based on the new Mullard 2 IC system is nearing completion, together with 16 station CMOS memory and optical shaft encoder system with fast tune facility. Synthesiser circa £70, memory £50.

Latest semiconductor news:

CMOS, TTL and LPSN TTL are in stock (ask for our OSTS price leaflet). Some of the very popular types are still "difficult" but we have things like 4011s, 4017s at the time of writing.

RADIO ICs - - -interesting developments here, we now have the Hitachi HA11225 and the HA12412 ultra high specification members of the CA3089E family. The PLESSEY SL1600 range now includes the SL6600 high performance PLL NBFM IF and detector.

CA3089E	2.11	HA1197	1.61	SD6000	4.31	SL1610	1.84	SL1626	2.80
CA3189E	2.53	CA3123E	1.61	TDA4420	2.59	SL1611	1.84	SL1630	1.86
HA1137W	1.95	TDA1072	3.09	MC1330P	1.38	SL1612	1.84	SL1640	2.17
HA11225	2.47	TBA651	2.53	MC1350P	1.38	SL1613	2.17	SL1641	2.17
HA12412	2.81	TDA1090	3.51	KB4412	2.24	SL1620	2.50	SL6600	4.31
KB4420	1.95	TDA1220	1.61	KB4413	2.24	SL1623	2.80	SL6640	3.16
TBA120S	1.15	TDA1083	2.24	KB4417	2.53	SL1624	3.77	SL6690	3.68
KB4406	0.80	TDA1062	2.24	MC3357P	3.16	SL1625	2.50	MC1496	1.44

TRANSISTORS : New lower prices, wider range, large stocks. Also the world's lowest noise audio devices (2SC2546E and 2SA1084E) first from AMBIT of course. Power MOSFETs & all sorts of other devices. Our 3SK51 MOSFET replaces the 408XX and 40673 families.

BC237-8-9	0.092	2SC1775	0.207	2SA1084E	0.368	BF256	0.437	BFY90	1.03
BC307-8-9	0.092	2SA872A	0.207	2SC2547E	0.391	2SK55	0.368	BF224	0.253
BC413-5	0.115	2SD666A	0.345	2SA1085E	0.391	2SK168	0.402	BF274	0.207
BD414-6	0.126	2SB646A	0.345	2SK133	6.32	3SK51	0.62	BFT95	1.138
BC546-556	0.138	2SD760	0.52	2SJ48	6.32	3SK60	0.667	VN66AF	1.092
BC550-560	0.138	2SB720	0.52	2SK135	7.29	BF960	1.426	2N4427	0.977
BC639-640	0.265	2SC2546E	0.368	2SJ50	7.29	3SK48	1.426	J176	0.747

RADIO CONTROL: A special section for all RC fans. New and exciting stuff:
KB4445/KB4446 : complete 4 channel RX/TX dig.prop IC pair RF&control in one 4.75pr
MSL9362/MSL9363 : logic section of a four channel dig.prop link, with switch opt. 3.75pr
NE5044 : Signetics versatile 7 channel encoder, suitable for mixing etc. £2.14 ea
NE544 Signetics famous servo driver IC £2.07 MC3357P as used in RCME design £3.16 ea
AMBIT RCRX4 - RCME FM system compatible, complete RX kit with box/connector and AMBIT design screened front end with 27MHz ceramic filter £16.10 (kit)
XTALS: FM pairs £3.74 (no splits) TX is fund. ½ op frequency, RX 3rd OT- 455kHz
AM pairs £3.57 (no splits. Both 3rd OT types, again RX IF at 455kHz

NEW LINE : ALPS switches and rotary potentiometers. With a general catalogue that's over 3 inches thick, we cannot begin to offer a comprehensive list of what we can offer - but we are already stocking the keyboard switches, keyswitches, pushbutton switches etc. In particular, the pushbutton switches really put all others in the shade (schadow?) when it comes to quality and price. A special new shortform is being prepared (and may be ready when you read this). All the potentiometers and switches you could ever need from a single source. Keypad switches cost as little as 15p ea (1 off), with a range of two part caps for easy ledgending. You must see the shortform catalogue (30p) and our new pricelist for full details of this huge range of components

AMBIT SHOP NOW OPEN

We are gradually getting our caller sales area sorted out, with displays of the products on offer and a browsers corner to sit and study data/catalogues. Call in next time you are in the area - parking outside the door.

COMPUTER CAPABILITIES

Ambit has been keeping a low profile on the subject of the MPU and its applications. Interestingly enough, the first project we offer with MPU content does rather more in the way of processing than simply playing a daft game, or looking like an enormous calculator. Our MPU facility and expertise is now for hire on a fully commercial basis. Z80, 6800, 6809, 2650 etc.

Keyboard switch
SCK41505
typ 6m ops
23p each (1-24)

NEW LINE : DC/DC+AC converters for fluorescent displays. TOKO CPS series 12v IN, −20 and 3v AC out at 65mA. Thick film design £2.34 ea Qty. prices OA

GENERAL INFORMATION

Ambit stocks the following ranges of components for ex-stock volume delivery: SIGNAL COILS, CERAMIC, MECHANICAL and CRYSTAL FILTERS. RADIO ICs for AM/ FM/SSB , TOROID CORES FOR RADIO and EMI FILTER CIRCUITS, INDICATING AND PANEL METERS, AUDIO ICs, RF TRANSISTORS, FETS, MOSFETS, DIODES (PIN,VARICAP,SCHOTTKY), PASSIVE DBMs (like MD108 etc), IC SOCKETS, LEDS, TRIMMER CAPS, SWITCHES, KEYBOARD SWITCHES, TUNERHEADS, IF AMPS, AM RADIO MODULES, etc etc

NEW LINE : DVM176 - the definitive ICM7106 LCD DVM module. 3½ digit £22.37 ea.

CM161: LCD 12/24hr alarm clock/day/date/backlight (eq.RS308-499) 7mm digits £11.44 each
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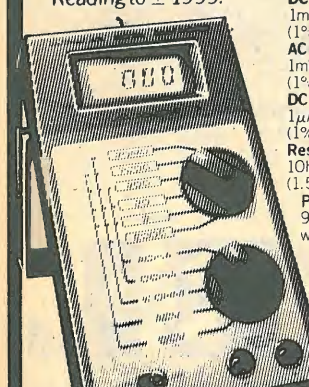

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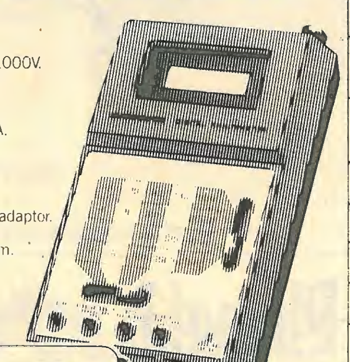

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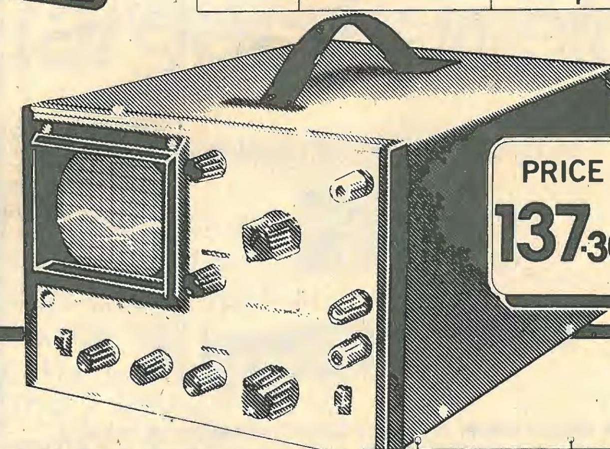

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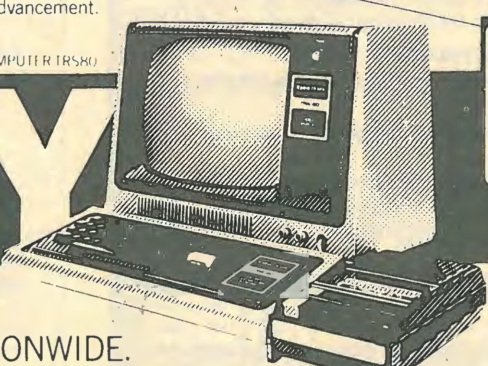

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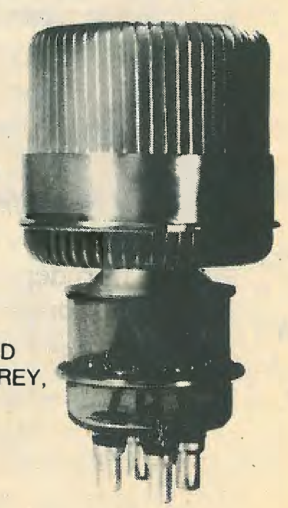

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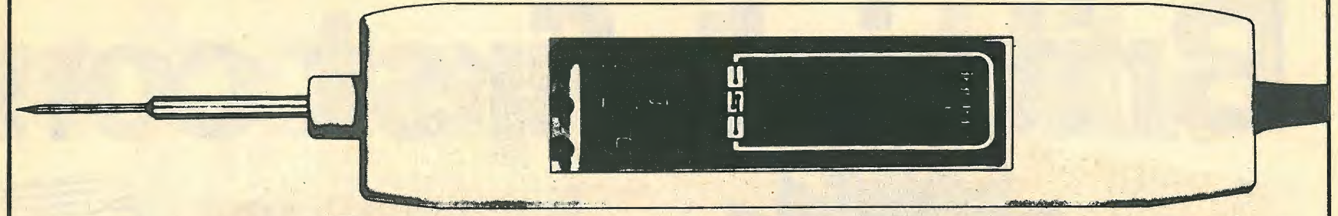

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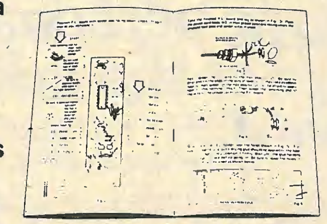

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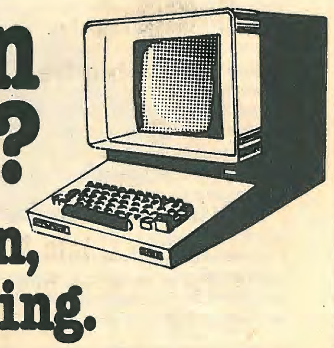

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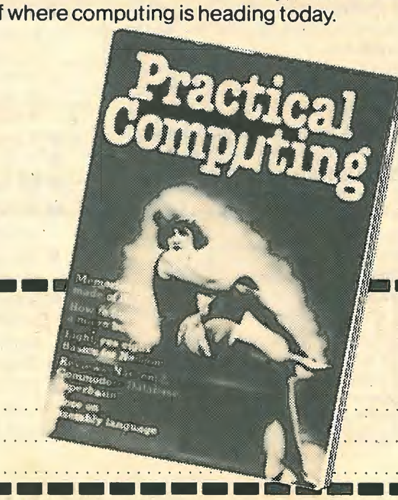

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And yet the ZX80 really is a complete, powerful, full-facility computer, matching or surpassing other personal computers on the market at several times the price. The ZX80 is programmed in BASIC, and you could use it to do quite literally anything from playing chess to running a power station.

The ZX80 is pleasantly straightforward to assemble, using a fine-tipped soldering iron. Once assembled, it immediately proves what a good job you've done. Connect it to your TV set...link it to an appropriate power source*... and you're ready to go.

Your ZX80 kit contains...

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- FREE course in BASIC programming and user manual.

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- Mains adaptor of 600 mA at 9 V DC nominal unregulated (available separately – see coupon).
- Additional memory expansion boards allowing up to 16K bytes RAM. (Extra RAM chips also available – see coupon.)

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

Two unique and valuable components of the Sinclair ZX80.

The Sinclair ZX80 is not just another personal computer. Quite apart from its exceptionally low price, the ZX80 has two uniquely advanced components: the Sinclair BASIC interpreter; and the Sinclair teach-yourself BASIC manual.

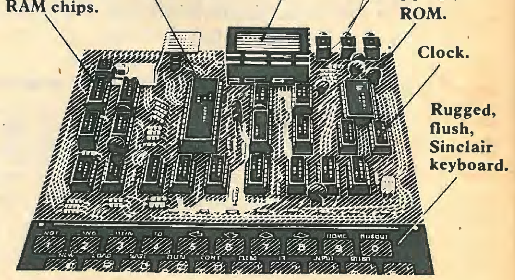
The unique Sinclair BASIC interpreter... offers remarkable programming advantages:

- **Unique 'one-touch' key word entry: the ZX80 eliminates a great deal of tiresome typing. Key words (RUN, PRINT, LIST, etc.) have their own single-key entry.**
- Unique syntax check. Only lines with correct syntax are accepted into programs. A cursor identifies errors immediately. This prevents entry of long and complicated programs with faults only discovered when you try to run them.
- Excellent string-handling capability – takes up to 26 string variables of any length. All strings can undergo all relational tests (e.g. comparison). The ZX80 also has string input – to request a line of text when necessary. Strings do *not* need to be dimensioned.
- Up to 26 single dimension arrays.
- FOR/NEXT loops nested up 26.
- Variable names of any length.
- BASIC language also handles full Boolean arithmetic, conditional expressions, etc.
- Exceptionally powerful edit facilities, allows modification of existing program lines.
- Randomise function, useful for games and secret codes, as well as more serious applications.
- Timer under program control.
- PEEK and POKE enable entry of machine code instructions, USR causes jump to a user's machine language sub-routine.
- High-resolution graphics with 22 standard graphic symbols.
- All characters printable in reverse under program control.
- Lines of unlimited length.

...and the Sinclair teach-yourself BASIC manual.

If the features of the Sinclair interpreter listed alongside mean little to you – don't worry. They're all explained in the specially-written 128-page book *free* with every kit! The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming – from first principles to complex programs. (Available separately – purchase price refunded if you buy a ZX80 later.)

A hardware manual is also included with every kit or built machine.



Fewer chips, compact design, volume production – more power per pound!

The ZX80 owes its remarkable low price to its remarkable design: the whole system is packed on to fewer, newer, more powerful and advanced LSI chips. A single SUPER ROM, for instance, contains the BASIC interpreter, the character set, operating system, and monitor. And the ZX80's 1K byte RAM is roughly equivalent to 4K bytes in a conventional computer – typically storing 100 lines of BASIC. (Key words occupy only a single byte.)

The display shows 32 characters by 24 lines.

And Benchmark tests show that the ZX80 is faster than all other personal computers.

No other personal computer offers this unique combination of high capability and low price.

The Sinclair ZX80. Kit: £79.95. Assembled: £99.95. Complete!

The ZX80 kit costs a mere £79.95. Can't wait to have a ZX80 up and running? No problem! It's also available, ready assembled, for only £99.95.

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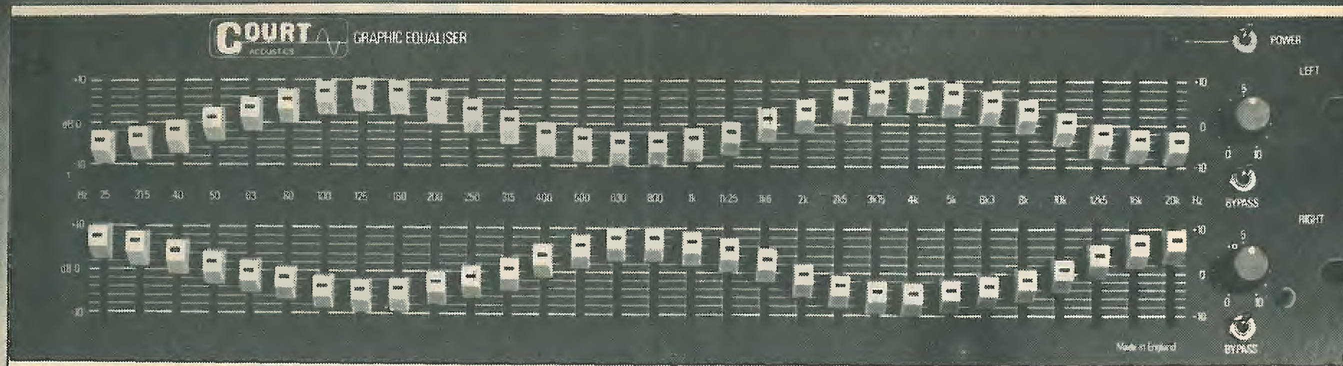

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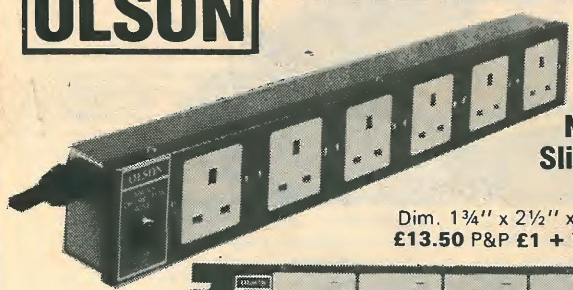

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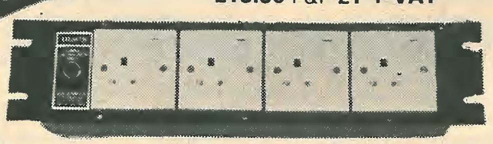

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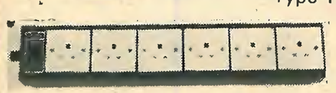

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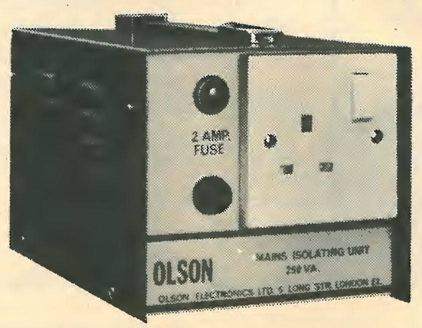

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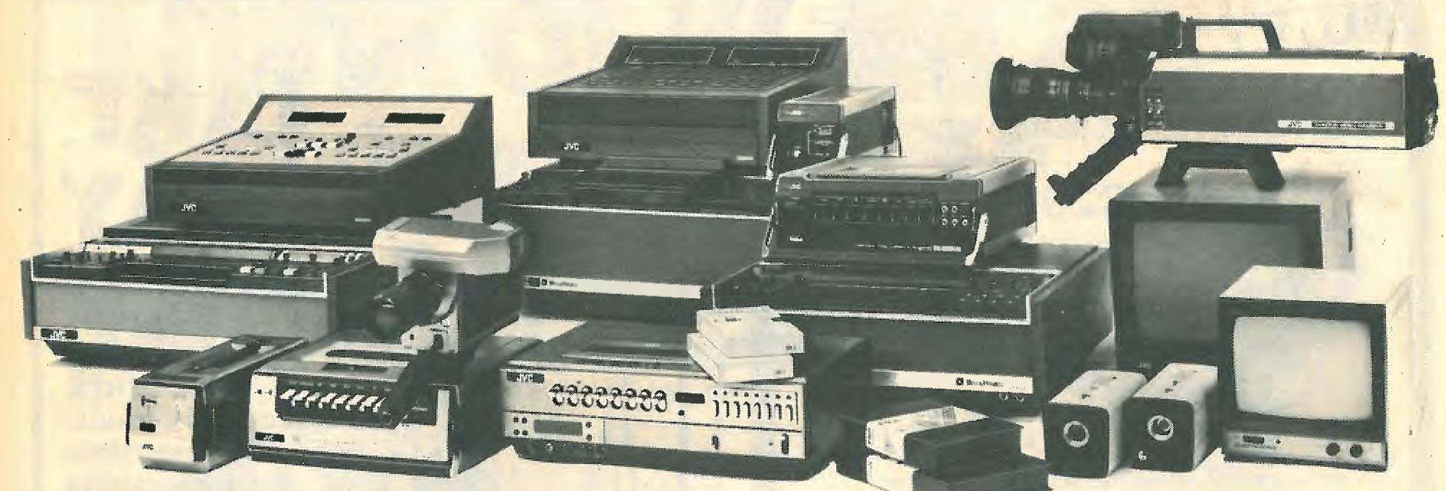

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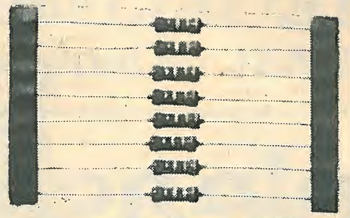

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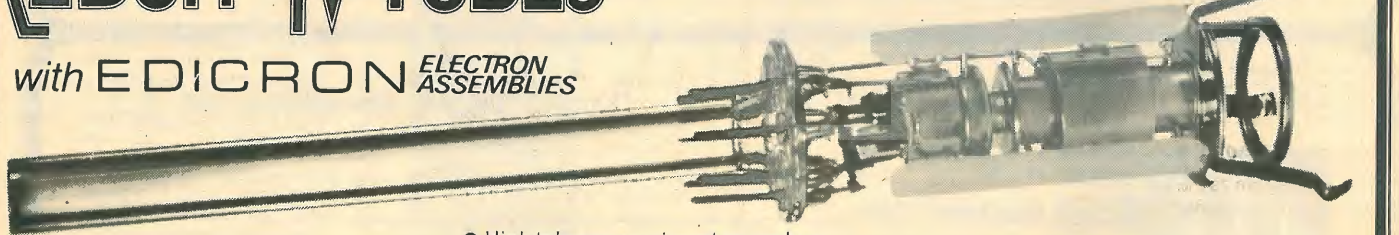

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SOFTY Software Development System

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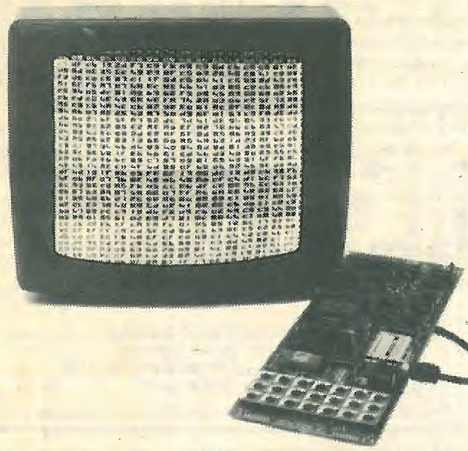

MICROSYSTEM DEVELOPMENT USING SOFTY

SOFTY is intended for the development of programs which will eventually become software residing in ROM and forming part of a microsystem. During the development stage of a microsystem, SOFTY will be connected in place of the firmware ROM via a ribbon cable, terminated in a 24 pin DIL plug.
Data may be entered into the SOFTY RAM via the **serial port, parallel port, direct memory access, or the keypad,** and manipulated using the **assembler key-functions.** When the program has been entered, the internal microprocessor can be 'turned off', and the external m crosystem and its resident microprocessor allowed to access and run the program in SOFTY's RAM and/or programming socket. In this way modification can be made until the required program is complete — **the contents of the RAM being clearly visible as a 'page' on TV or monitor.** 4 pages are available, 2 of the Data RAM an 2 of the programming socket.

In the end, when the program is complete and working, the DIL plug is removed and replaced by an EPROM device programmed by SOFTY. **SOFTY is able to program the 2704/2708/2716 family** which have 3 voltage rails — we supply with each SOFTY details of a simple modification which allows SOFTY to program the single rail 2716/2732, etc.
(If you want to program EPROMs/PROMs other than the 2704/2708/2716 family, we may be able to help you — our range of add-on Programming Modules is currently under development.)
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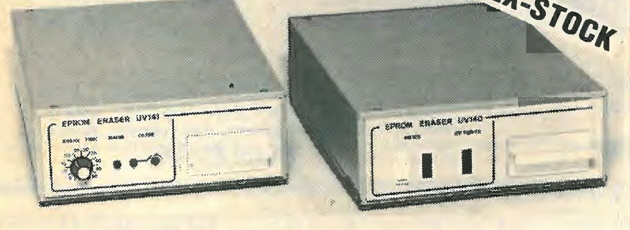

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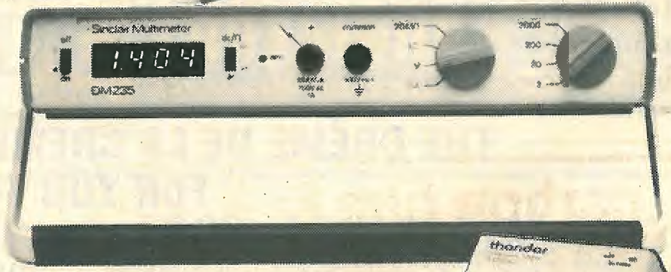

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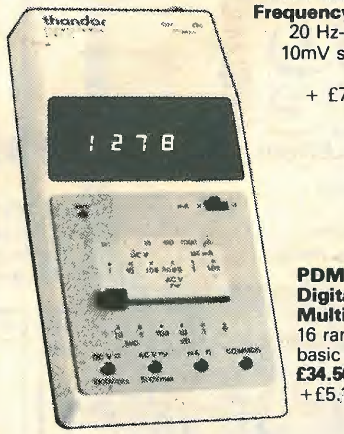

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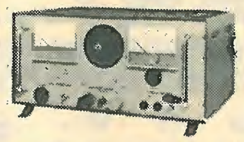

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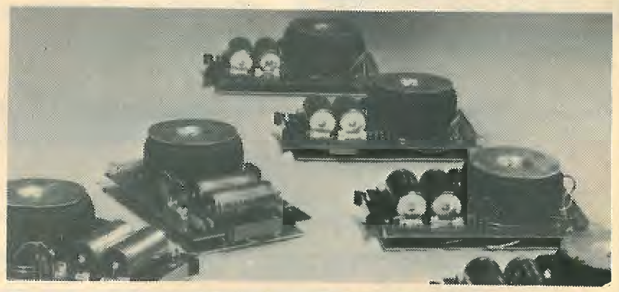

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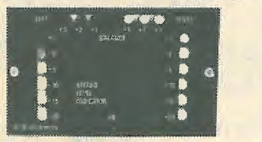

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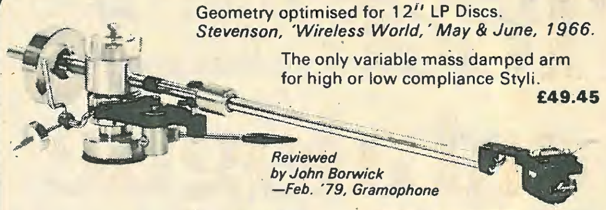

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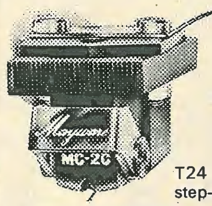

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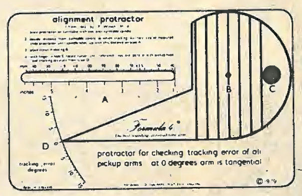

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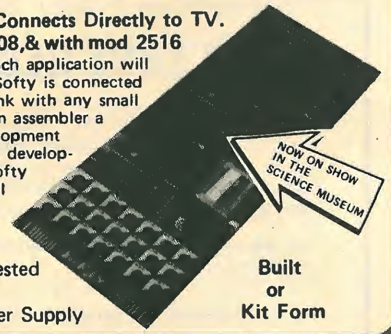

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Science of the whole

The study of all creation and man's place in it was the only kind of science worthy of consideration, in Tolstoy's view. A school curriculum of sufficiently wide scope for such a purpose would take a little time to construct and a good deal more to practise, but at the conclusion of such a course of instruction a child would be well on the way to becoming a whole person, if not several. Nearer to the modern scene, and considerably less ambitious in his requirements, was A. N. Whitehead, who remarked that wisdom is the fruit of a balanced development. In this context, the balance is not between the two specialisations in science or the arts, but between education and training.

One must recognise that, to a greater degree now than ever before, specialisation is necessary if potential engineers and scientists are to have a reasonably stable platform on which post-school training can be built. Merciless economics dictates that scientifically-aware youngsters are needed to enable this country to earn its living — even to stand still, let alone to grow. In the sixth form at school, and even earlier in some schools, the specialisation in science has been promoted for many years, with the result that universities and technical colleges have received a steady stream of entrants, well grounded in the relevant disciplines. It is true that there is now a shortage of science teachers of the required level of competence, but that is a separate and more recent issue.

That is all as it should be. But while a pupil should be given a sound base of knowledge for his professional training (and there is no sexist meaning intended in that pronoun or succeeding ones) the 'balanced development' is unlikely to be obtained by an exclusive study of maths, chemistry, physics and a useful language, even though a token 'art' (in the wider sense) may be tacked on for the sake of appearances. If one's entire two years of sixth-form experience is devoted to analysis rather than appreciation in less precise terms of the natural and human condition, the soulless future which many fear and of which some already see the first signs becomes more probable. If a sixth-former has no freedom to view the world in a less calculating way in his last two years of education, there will be even less possibility of his doing so during a professional training at college or university.

Those whose business it is to make recommendations on education are aware of the need for 'breadth', but allow it only a symbolic presence in courses of study. For example, a recent article on secondary education, written on behalf of the Council of Engineering Institutions, recognizes the concept of "study in breadth", but goes on to propose a list of five subjects to be taken in a new examination for young people intent on a science or engineering career: the five subjects are maths, English language, physical science, a European language and at least one other "relevant to career choice". The breadth is taken care of by "other supplementary subjects as desired". The whole of human experience outside the sciences is thus lumped together and labelled "supplementary subjects".

A tendency to segregate 16-plus pupils, and even younger ones in some cases, into science and arts groups has been evident for many years. C. P. Snow's Two Cultures are discernible long before the Second Law of Thermodynamics becomes a matter for discussion, with A-level students encouraged to view those whose interests lie in French literature or History as woolly-minded aesthetes. One might have hoped that a broader view could now be admissible, but when a friendly science teacher with public school experience was asked for his opinion, he said, "Well, they are, aren't they?"

School is surely not meant to be a training ground for either tradesmen or professionals, but for people. The first aim of 16-plus schooling must obviously be a preparation for a university training, but a sixteen-year-old ought not to have his sensitivity so blocked with a mass of analysis that he cannot also perceive the pleasures of learning about life. Nor should he be allowed to finish his education on a diet of arts alone; no-one should be excluded from the excitement of science. But the balance must be preserved.

If H. G. Wells is to be believed, human history becomes more and more a race between education and catastrophe.

Digital capacitance meter

Six ranges of 200pF to 20μF full-scale

by Adrian Ryan, (G3VJN)

The article describes the design and construction of a 3½ digit capacitance meter having six ranges of 199.9pF to 19.99μF full-scale. The maximum error of the instrument is ±1%, determined by the accuracy of the two calibration standards used. Accuracy is largely unaffected by voltage or temperature variations, making battery power practicable. No precision components are used in the design, maximum advantage being taken of digital c.m.o.s. integrated circuits to render the use of precision components unnecessary.

A recent project required the selection of numerous values of resistance and capacitance, and it was whilst performing this chore that the contrast was made between the ease and simplicity of selecting resistors with the aid of a 3½-digit digital multimeter, and the tedium of using an LCR bridge to select capacitors. I therefore investigated the possibility of designing an instrument to measure capacitance with comparable accuracy and ease of operation to that of my d.m.m.

Design considerations

The heart of the instrument is shown in Fig. 1. If a positive-going edge is applied simultaneously to one input of a 2-input NAND gate, and, via a series CR network to an inverting Schmitt trigger whose output is connected to the other input of the gate, then the output from the gate will be a negative-going pulse whose width is directly proportional to the time constant R_{RANGE} $(C_x + C_{stray})$. If this pulse is used to gate the input of a counter, then, by choosing the appropriate values for R_{RANGE} and the counter input frequency, the final accumulated count can be made to exactly represent the numerical value of $C_x + C_{stray}$. To avoid having to use separate precision resistors for each range, only two range resistors are used, the intermediate steps being effected by successively dividing the gated output of the master clock by 10 for ranges 2 and 5, and by 100 for ranges 3 and 6. With the sample period chosen (approximately 1 second) this arrangement will suffice for capacitors up to about 5μF. However, for larger values there is insufficient time to discharge the capacitor completely before the arrival of the next sample edge, so Tr_3 is included to discharge the capacitor rapidly via the current-limiting resistor R_7. The transistor is turned on by the inverted SAMPLE CLK obtained from the output of IC_{2d}. The transistor used must have a very low leakage current, a BC108B being suitable.

The above scheme will be satisfactory for all values of capacitors for which C_{stray} can be neglected, but the offset produced by the presence of this stray capacitance will become increasingly inconvenient as C_x is reduced. I chose to eliminate the effects of C_{stray} by the arrangement shown in Fig. 2. Here, much the same circuit used to generate the gate pulse is used, the difference being that the output of IC_{2a} is used to inhibit a certain number of periods of the master clock. By varying the 'set zero' potentiometer, the offset suppression pulse can be made to cancel the zero error produced by the stray capacitance.

The success of the instrument will greatly depend on its stability in the face of varying supply voltages and temperature, and in this regard, the Schmitt trigger i.c. chosen, the NS 74C14 or RCA CD40106 is ideal. The threshold voltages at which switching occurs are defined by the ratio of the on-chip resistors. Thus, these switching thresholds will always be a fixed percentage of the supply voltage. Similarly, since the resistors are fabricated at the same time, whilst their own absolute temperature coefficient may be large, the temperature coefficient of their ratio will be very small [1, 2]. The other major influence on stability is the master oscillator, and the design chosen is that of a conventional Hartley oscillator, using a re-wound 455kHz transistor radio i.f. transformer. With the feedback ratio chosen, no problems should be encountered with any normal production 2N3819 f.e.t. It is a characteristic of well designed LC oscillators that the output frequency is relatively insensitive to supply voltage changes, and with my unit, varying the supply voltage from 7 to 13V caused the frequency to change from 898.990 kHz at 7V to 898.630 kHz at 13V. Over the nominal voltage range for my device, 7-9.6V, the frequency change amounted to 0.25%. Temperature compensation of the oscillator is achieved by using a polystyrene capacitor, since with the usual ferrite cores used for i.f. transformers, this type of capacitor provides a complementary effect, resulting in a low nett temperature coefficient. For my oscillator, the frequency changed from 881.752kHz at +36°C to 880.466kHz at +3°C, giving a change of ±0.073%, referred to 20°C.

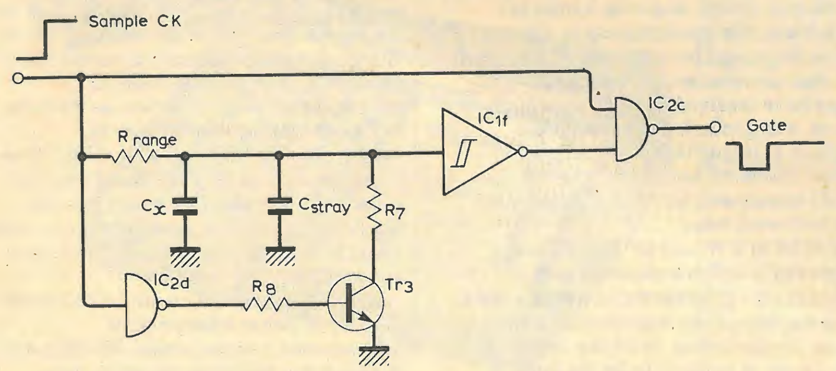


Fig. 1. Outline of the method of measurement. Gate width is proportional to the capacitance.

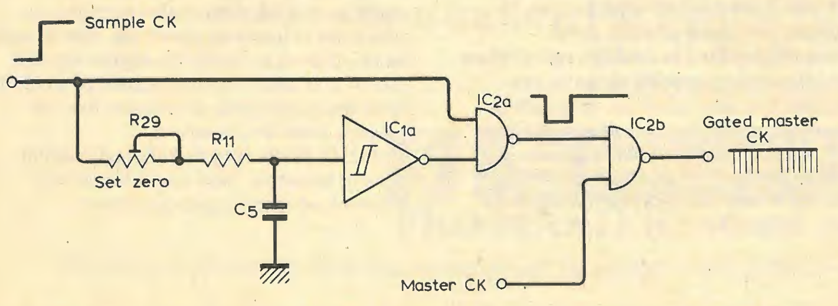


Fig. 2. Circuit to eliminate the effects of stray capacitance. Clock pulses are inhibited for a time corresponding to the value of the strays.

Circuit operation

Turning now to the complete circuit diagram in Fig. 3, it will be seen that the counter used is the Motorola MC14553. This 16-pin, 3-digit b.c.d. counter with an internal digit multiplexer is an excellent choice for straightforward counting applications. The counter b.c.d. output is decoded by IC_6 to provide a 7-segment display format. The requisite current limiting resistors are included in IC_9, but normal 470Ω discrete components may be substituted. Digits 1, 2, and 3 are multiplexed, the appropriate digit being turned on via Tr_6, Tr_5, and Tr_4 in response to the digit-selection pulses from IC_5. Digit 4 is continuously driven, since it is only required to display either a blank or 1.

To explain the operation, assume that the unit is switched to Range 2 which has a full scale reading of 1999 pF. In addition, assume that only a small capacitor is connected to the measurement terminals, for example, 500 pF. The last overflow/clear (OF-CLR) pulse will have reset IC_{7a}, and at the end of the gate period, only 500 periods of the master clock will have been counted, thus no carry out (CO) pulse will have been generated and IC_{7a} will remain in the reset state. The termination of the gate pulse will generate the latch-enable (LE) pulse, which will transfer the contents of the decade counters to the output latches within IC_5. The positive edge of LE will, in turn, generate a 10μsec strobe pulse from IC_{7b} which will store the current state of IC_{7a} in the digit 4 latch, IC_{8a}. In this example, therefore, the contents of IC_{8a} will be a 0, consequently Tr_7 will be turned off and digit 4 will be blank.

Assume now that the capacitor connected to the input terminals is increased to 1200 pF. The negative going edge of gate will enable the input to the counter, and after 1000 periods of the master clock a CO pulse will occur. This pulse will set IC_{7a}, and after a further 200 periods of the master clock, the gate period will terminate, generating LE, which will transfer the contents of the decade counters to the output latches. The positive edge of LE will generate the transfer strobe, and the state of IC_{8a} will become 1. Transistor Tr_7 will turn on and digit 4 will display the figure 1.

If the capacitor on the measurement terminals is too large, the first CO from IC_5 will set IC_{7a} as before, but the second CO will cause IC_{8b} to be set. The resulting 1 level on its Q output is used to hold IC_{8a} in the reset state, and the 0 on the Q output is used to inhibit the display driver IC_6 via its blanking input (BI) terminal. Thus the over-range indication is provided by the display blinking on for 2, 20, or 200 msec, depending upon the range selected.

Power requirements

The choice of supply voltage for the unit was not entirely arbitrary, but was dictated by maximum count-rate considerations of the MC14553. I have used this device for a number of counting applications, and have obtained samples from many sources. The majority of these i.cs, whilst meeting their guaranteed specifications, have had maximum counting rates which were somewhat lower than the "typical" figures given in the data sheet[3]. Accordingly, to avoid the need to select devices, a supply voltage was chosen that would ensure sufficient speed margin, even with both a worst-case counter and a worst-case threshold voltage for the Schmitt trigger. In my instrument, I used a re-chargeable nickel-cadmium battery pack, simply because it was available. However, this would be difficult to justify in general, since both the current drain and the duty cycle are low in normal use. Consideration should therefore be given to using a normal 9V dry battery, such as the PP9. Whilst on the subject of power supplies, it is worth noting that certain problems are likely to be encountered if the unit is mains powered. The input impedance on ranges 1 to 3 is very high – 10MΩ – making the instrument sensitive to hum pick-up. The effect is mainly to be observed on Range 1, as jitter of the displayed value. With battery power, since hum pick-up affects both input terminals equally, it appears as a common-mode voltage and is rejected. Therefore, unless one is prepared to go to the trouble of providing a well-shielded and isolated supply battery power is recommended. In my case, since the mains transformer had insufficient capacity to re-charge the battery pack and power the unit, a mains socket was chosen with an integral switch that automatically disconnects the electronics module during recharging.

Construction

The unit is constructed on two 8cm × 10cm printed-circuit boards with a shielding plate interposed. The plate was included only as a precautionary measure, and may not be required in all cases. It will be noted that no precision components are called for in the design,

Components List

Integrated circuits

IC_1 National Semiconductor 74C14 or RCA CD40106.
IC_2 CD4011.
IC_3 IC_4 CD4017.
IC_5 Motorola MC14553.
IC_6 CD4511.
IC_7 IC_8 CD4013.
IC_9 integrated resistor package; Beckman 899-3-R470.

Resistors

R_1 R_{14} 1M.
R_2 R_3 R_9 R_{10} R_{21} R_{22} 100k.
R_4 3.3M high stability.
R_5 5.6M high stability.
R_6 10k high stability.
R_7 R_{19} R_{20} R_{25} 2.2k.
R_8 150k.
R_{11} 180k high stability.
R_{12} 3.3k.
R_{13} 560k.
R_{15} R_{16} R_{17} 8.2k.
R_{18} R_{26} 1.2k.
R_{23} R_{24} 470.
R_{27} 220, 2W.
R_{28} 2.2M, 15 turn cermet. Sternice type T93YA.
R_{29} 1M, 15 turn cermet. Sternice type T93YA.

Capacitors

C_1 C_7 0.47μF 16V tantalum.
C_2 C_3 C_2 C_{10} 100pF polystyrene.
C_5 470pF polystyrene.
C_6 C_9 10pF ceramic.
C_8 390pF polystyrene.
C_{11} C_{12} 150μF 16V tantalum.
C_{13} 1.8nF disc ceramic.

Diodes and displays

D_1 D_2 D_3 1N4148, or equivalent.
D_4 Red l.e.d.
Displays, 4 off, Hewlett-Packard HP-5082-7740 common-cathode.

Transistors

Tr_1 2N3819.
Tr_2 Tr_3 Tr_7 BC108B or similar. β_{min} 180.
Tr_4 Tr_5 Tr_6 2N2907 or similar. β_{min} 120at I_c 160mA.

Inductor

L_1 83.5μH, 100 turns, tapped 30 turns from ground end, wound on stripped 455kHz ex-transistor radio i.f. transformer core, with internal tuning capacitor removed.

Switches

Sw_1 4-pole, 6-way, make-before-break.
Sw_2 power switch. See text.
Sw_3 single-pole, integral with mains power socket. See text.

Transformer

Tr_1 12-0-12V, 100mA, 220V primary.

only good quality, high-stability, metal-film resistors for R_4, R_5, R_6, and R_{11}, and cermet potentiometers for R_{28} and R_{29}. It should be noted that the connexion from the input terminals to the p.c. board should be screened, and not laced in with the wiring loom. Otherwise, construction is uncritical.

Calibration and use

The unit may be calibrated as follows. Apply power, short TP_1 to ground, and observe that the display shows 888. Set R_{28} to mid-travel, and R_{29} to minimum resistance. Select Range 4, and with a 0.1μF, 1% capacitor connected to the input terminals, carefully adjust the slug in L_1 for a display of 100.0. Without removing the capacitor, select Range 3 and observe that the display blinks, signifying that an over-range condition exists. Remove the capacitor, select Range 1, and verify that zero error exists. Increase R_{29} from its initial minimum setting, observing that the displayed count reduces, until a small residual error remains (approximately 1-2 pF is suitable). Select Range 2, connect a 1000 pF, 1% capacitor to the input, and adjust R_{28} until the display reads 1000. Disconnect the capacitor, select Range 1, and re-check that a small residual error remains. If necessary, re-adjust R_{29} and reset Range 2 calibration so that finally, with no capacitor connected on Range 1, the instrument reads 00.0, 00.1 or 00.2, and also displays correctly on Range 2. This completes calibration and adjustment.

In use, it is only necessary to connect the unknown, switch on and adjust the range switch for the desired resolution. Certain points should be borne in mind. In order for an accurate reading to be obtained, it is essential that the equivalent leakage resistance of the device under test is much higher than the range resistor. For ranges 1-3, this means that the leakage resistance must be in the order of 100MΩ, and for ranges 4-6, at least 100kΩ. Both of these requirements are readily met by normal quality components. If the instrument displays anomalous readings between ranges 3 and 4, this would indicate a very leaky component. For example, if a nominal 1800pF capacitor displays correctly on Range 4, but shows as over-range on Range 3, this would be cause for regarding the component with considerable suspicion.

Modifications

After the instrument had been in use for some time, it was noted that it would always stabilize within about a second. This prompted me to replace the power switch with a three-position, centre-off

Fig. 4. General timing diagram. ▶

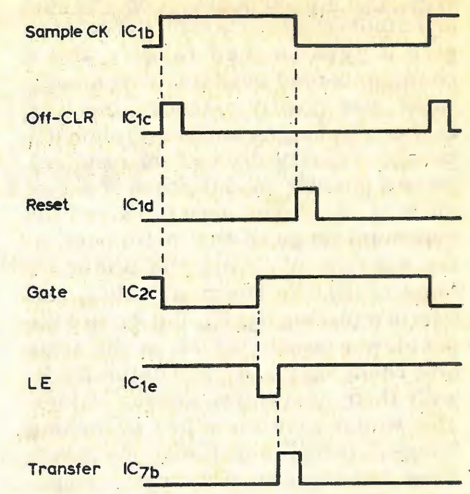
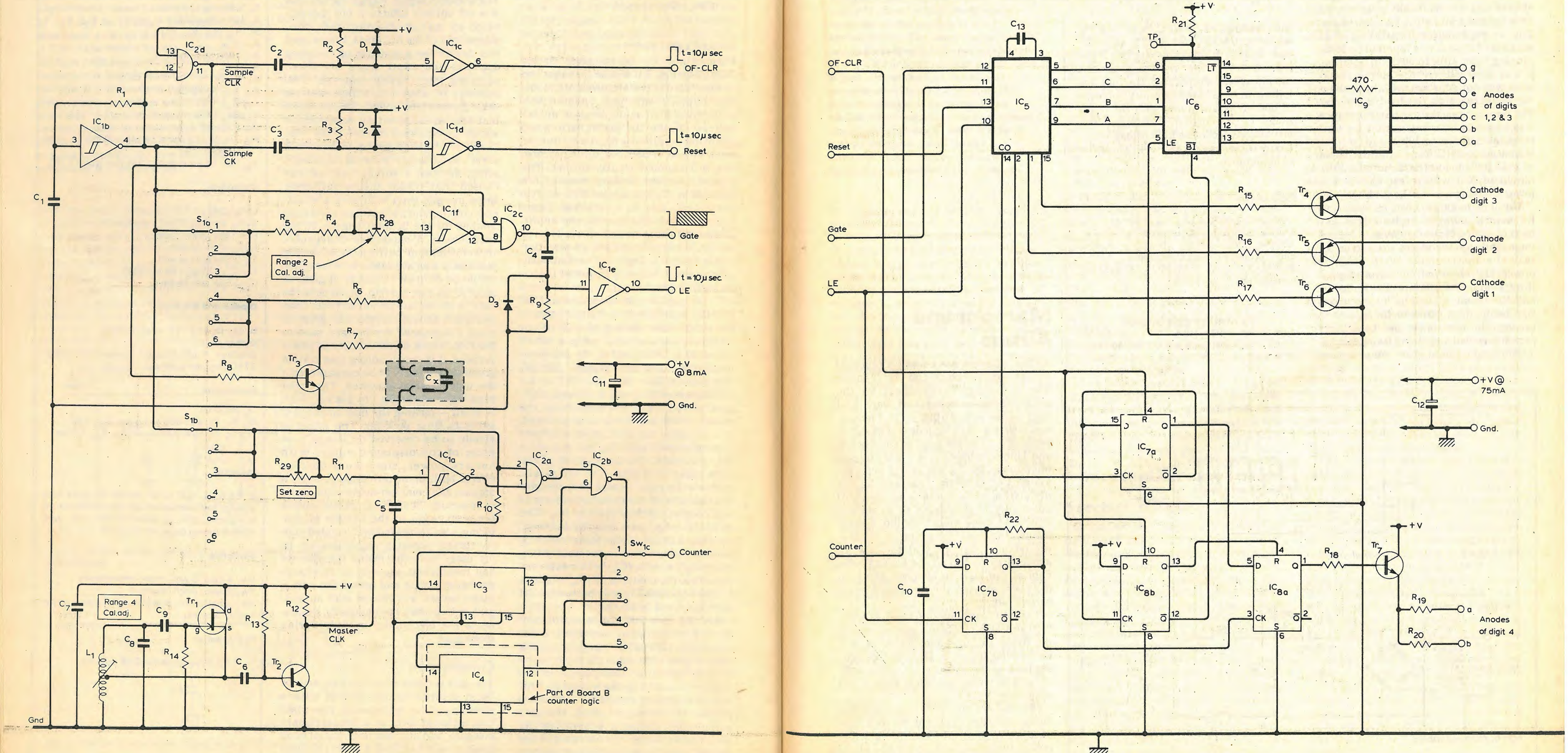


Fig. 3. Complete circuit diagram of the meter. The instrument is built in two boards, equivalent to left and right-hand halves of the diagram. ▼



type, with a locking action on one side and a momentary action on the other to give a push-to-read facility and a continuous-read position. This modification has greatly extended the time between recharges, and would similarly benefit ordinary dry-cell operation. A second possible modification could be made by those who need to extend the maximum range of the instrument, at the expense of losing the minimum range of 199.9pF. The modification consists of replacing R_{28}, R_4, and R_5 with the next-lower-decade values, at the same time changing R_{29}, R_{11} and naturally, R_6 with their next-lower decade values. This would have the effect of making Range 1 1999pF and Range 6 199.9μF. Note that the non-zero output resistance of IC_{1b} will artificially lengthen the time constant and must be allowed for. The average output resistance of 15 samples of this i.c. was found to be 260Ω, ranging from 210Ω to 303Ω. In addition, it was observed that the output resistance was not constant with load, tending to increase as the load increased. For one sample the output resistance was found to remain constant for load resistances down to 10kΩ, and to have increased to 281Ω from its initial value of 244Ω for a load of 1kΩ. Buffering the output of IC_{1b} with a fast voltage follower would eliminate the problem.

The unit has now been in operation for several months, and no drift has been observed in the displayed values of the calibration standards used to calibrate the instrument. With battery power, the observed values of display jitter amount to ±0.7 pF for Range 1, and the usual ±1 count in the least-significant digit position for all other ranges. The instrument has been temperature cycled and, using Range 4 with a 100nF capacitor at room temperature, the reading at +40°C was −0.7%, whilst at 0%C it was +0.7%, thus demonstrating the inherent stability of the instrument. With the push-to-read modification incorporated, the unit has indeed demonstrated its utility and ease of operation, and along with the ohms range of my digital multimeter has virtually replaced the LCR bridge. Now, fi only there was a convenient analogue of inductance . . .

The author

Adrian Ryan was educated at the College of Electronics, which was part of the Royal Radar Establishment, Malvern. He then went to the Government Communication Headquarters, Cheltenham, where he spent 11 years in research and development. He has been a design consultant for an electronic organ company, and at present is with the North Atlantic Treaty Organisation in Brussels, Belgium. He is married with two small daughters, and amongst his many interests is an active radio amateur, holding the call signs of ON8WV and G3VJN, a hi-fi enthusiast, a poor organist, and an enthusiastic motorcyclist.

References

1. MM54C14/MM74C14 Data sheet.
2. National Semiconductor Application Note AN-140 "CMOS Schmitt Trigger – A Uniquely Versatile Design Component."
3. Vol. 5, Series A.McMOS Integrated Circuits, pps. 7-288/7-293.

Printed circuit boards

A set of two single-sided p.c.bs is available for £7.50 inclusive of v.a.t. and UK postage from M. R. Sagin at 23 Keyes Road, London NW2.

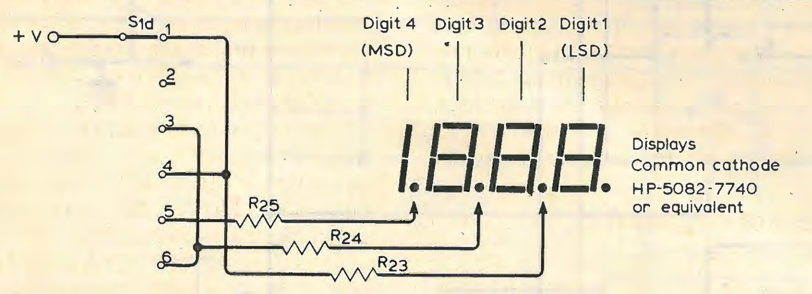


Fig. 5. Switching for the decimal point.

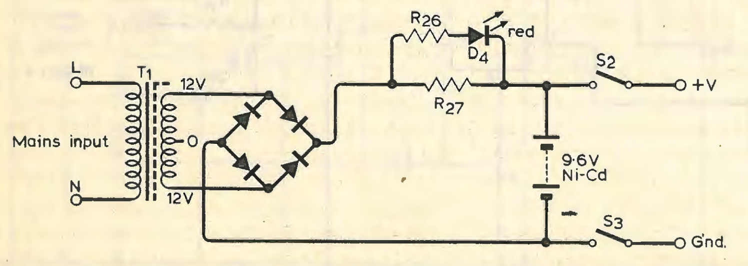


Fig. 6. Power supply.

Marconi and Airbus

Airbus Industrie has chosen a proposal by Marconi Avionics and the German firm of Liebherr Aerotechnik for the microprocessor control of flaps and slats on the new Airbus A310. The system is to provide a high degree of safety (slats and flaps are used in the takeoff and landing phases of a flight) by self monitoring, by the use of two separate systems of different type and by the provision of a certain amount of autonomy in operation to avoid the effects of crew error. Should a crew member attempt, for example, to close the leading-edge slats at too low an airspeed, or to extend the trailing-edge flaps at too high an airspeed, the controls will prevent the command being carried out.

The microprocessors used are the 6800 and 8085, one being used to control the flying surfaces and the other in a monitoring function. Different designs are used in the expectation that a software fault would not affect each in the same way.

Marconi are now very experienced in automatic flight control, having supplied the system for Concorde and the highly-automatic system for the abandoned Boeing YC-14 military transport.

How serious is multipath distortion?

Effect on sound quality and bit-streams in broadcast reception

by Pat Hawker, Independent Broadcasting Authority

According to one broadcaster, multipath distortion is "one of the major factors" which deteriorate received sound quality in v.h.f./f.m. broadcasting. Yet, says the author, it has had relatively little investigation in the UK for over twenty years. This article discusses its effects and prevalence in both conventional broadcasting and systems using digital information; outlines a recent Japanese analysis of how it affects stereo reception; and finally considers what can be done, if anything, to minimise the problem.

In introducing his article "Audible amplifier distortion is not a mystery" (*Wireless World*, November 1977) Peter Baxandall quoted Bertrand Russell: "Some things are believed because people feel as if they must be true, and in such cases an immense weight of evidence is necessary to dispel the belief." He showed that much of the advice given to would-be high-fidelity enthusiasts was (still is?) misleading; that popular "reviews" of consumer equipment sought to perpetuate myths of supposed subtleties by evolving "a series of wilder and yet wilder pseudo-scientific hypotheses", and that the public is being encouraged to "detect" forms of subjective distortion that defy (and sometimes contradict) objective engineering measurements; with some magazine reviewers showing much concern about levels of distortion that can be detected (if at all) only by the most musically-sophisticated listeners.

But is there not another anomaly in what is sometimes referred to as the great hi-fi-con? Serious and detectable forms of distortion go unmentioned, either because they are difficult to relate to particular equipments or because the whole subject may still be surrounded by uncertainty, may differ according to particular circumstances, or may be contrary to what, otherwise, may be highly desirable trends.

Multipath distortion of v.h.f./f.m. sound broadcasting, mono, stereo and (potentially) 'surround sound' is a notable example.

Broadcast engineers for over a quarter-century have recognised that, for good quality reproduction, v.h.f./f.m. offers great advantages over m.f./a.m. in terms of full audio bandwidth (up to 15kHz), in much increased dynamic range (and consequent reduced need for compression) and in reduction of the co-channel interference that plagues European m.f. broadcast reception. It has been a major disappointment that the public continues to rely so much on m.f. transmissions: a BBC survey only a few years ago indicated that at any given time 86 per cent of the audience were listening on m.f./l.f. compared with 14 per cent on v.h.f./f.m. – even although a far higher percentage were equipped with v.h.f./f.m. receivers.

Public bodies, including the Crawford Committee (1974) and the Annan Committee (1978), have repeatedly stressed that listeners should be encouraged to use v.h.f./f.m.; the IBA in setting up independent local radio services puts into the contracts that m.f. is provided "as a back-up service", implying that the day is anticipated when the vast majority of listeners will use v.h.f./f.m.; rather more cynically (or realistically?), the programme companies tend to concentrate their promotion on their medium wavelengths.

The broadcasters have thus felt obliged to attempt to induce the public to make more use of v.h.f./f.m. The many advantages, rather than the few disadvantages, have been stressed: little emphasis has been put on multipath distortion, although the problem has been recognised for more than 20 years.

Effects of multipath

For the listener multipath distortion may pass unnoticed on receivers of limited audio bandwidth but on high-quality installations may vary from just perceptible to severe breaking up of the higher audio notes. While often comparatively difficult to detect subjectively on orchestral music, it can be observed on sustained notes and solo instruments; notably on solo piano or classical guitar. It has been likened to a "tissue paper" effect produced by an off-centre loudspeaker speech coil; it can also cause distortion of sibilants and indeed any loud high-frequency audio components. The Japanese broadcasting organisation, NHK, has recently stated categorically that for v.h.f./f.m. stereo it is *one of the major factors which deteriorate the received sound quality*, though noting that for many years its characteristics were not determined precisely because of the difficulty of analysis by conventional methods.

How common is multipath?

There is very little doubt that multipath conditions are responsible for a very significant share of the degradation of broadcast transmissions received on high quality equipment. Multipath distortion is due to the simultaneous pick-up of direct and reflected signals, and is the counterpart of the well-known "ghosting" on television; however, unlike tv ghosting its effect may not be readily observed by the listener, nor can its effects be readily mitigated by adjusting the aerial while watching the picture.

It is brought about by reflections from tall buildings, hills, mountains, gas holders, towers and masts, cranes and similar high structures and may vary seasonally or over a period by changes in foliage, new building work and the like. Generally long-term multipath 'echoes' are more likely to be prevalent on Band II (88-97.5MHz) than on u.h.f. television Bands IV, V. Over the years, there has been an increase rather than a decrease in multipath conditions, particularly in urban areas, due to the amount of high-rise building.

There appears to have been relatively little investigation into multipath distortion in the UK for over twenty years. Soon after the BBC began regular v.h.f./f.m. broadcasting from Wrotham in May 1955, unexpected reports of poor quality began to arrive and engineers at the BBC's research centre at Kingswood Warren began an investigation[1,2]. It was soon discovered that the problem stemmed from multipath propagation and a special measuring technique was developed using an oscilloscope display as in Fig. 1. In the absence of a reflected signal a horizontal trace is obtained. When reflected signals are present, the phase difference and hence the resultant amplitude varies with instantaneous frequency; such a display provides an indication not only of the ratio of the amplitudes of the two signals but also the path difference between the signals.

The investigations, at a large number

of sites, showed that even on standard receivers there were few sites where at least "just noticeable distortion" was not observed when using indoor aerials; distortion could be minimised by ensuring that the a.m. suppression characteristics of the receivers were good and by the use of outside aerials.

It was also shown that distortion becomes more serious as the difference in path length (long-term echoes) increases. The amplitude of reflected signal compared with the direct signal needed to produce "slightly disturbing" distortion on solo piano was found to be about 35 per cent for a path difference of five miles, but only 6 per cent for a path difference of 18 miles. These investigations (before the advent of stereo) were of course confined to monophonic transmissions.

While the results of these investigations were released to set makers and the technical press, the work appears to have been allowed to lapse; perhaps on the traditional broadcasters' argument that "the signals were all right leaving us".

Recently NHK have released some details of an analysis made of multipath distortion in stereophonic reception[3]. It is suggested that although distortion due to multipath propagation is one of the major factors causing degradation of broadcast sound, its characteristics have not previously been determined because of the difficulty of analysis by conventional methods.

The NHK engineers have analysed the relationship between the audio distortion and the relevant multipath parameters using electronic computation to which fast Fourier transform processing was applied. "In this way," the report states, "the complicated computation was easily performed and extensive analysis of the distortion was made possible, providing a clear understanding of the nature of the distortion."

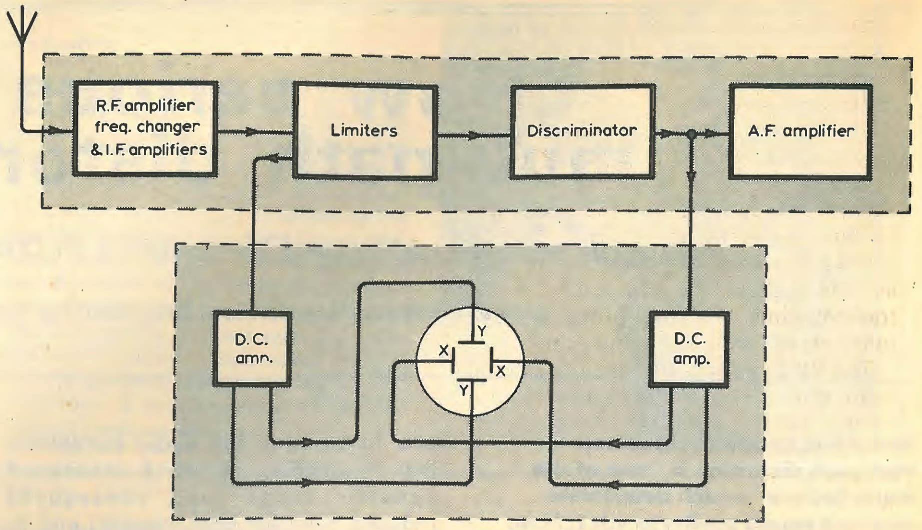


Fig. 1. Measuring equipment used by BBC in 1950s for investigating the extent of multipath reception of v.h.f./f.m. transmissions.

Some of the results obtained for stereo reception are that:

1. The distortion tends to be pronounced if the delay time of the reflected undesired signal (U) with respect to the direct desired signal (D) is comparatively long (thus confirming the BBC experience).

2. The distortion is almost inversely proportional to the D/U ratio if this ratio exceeds 10dB.

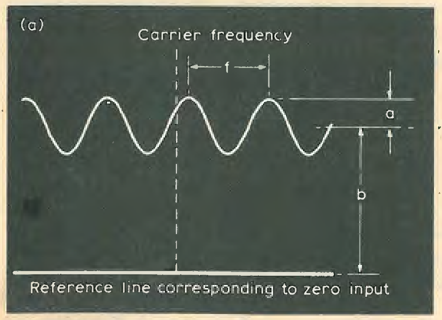
3. The phase difference which gives maximum or minimum distortion is not constant but varies with such parameters as delay time, modulation frequency and depth of modulation.

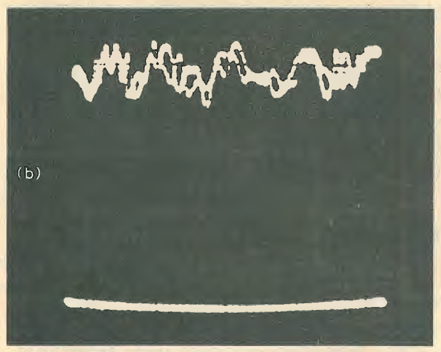
4. Maximum distortion at 15kHz is greater than at lower audio frequencies, and is several times greater than that at 1kHz.

Fig. 3 shows a computed example of the spectrum distribution of the distorted output signals at 15kHz modulation. Fig. 4 shows the relationship between the required D/U ratio and delay time for various parameters of maximum distortion (at 15kHz). This shows clearly that high values of D/U ratio are needed to ensure good sound quality in situations where multipath propagation exist. Indeed the 20-year-old BBC investigation, and more recent IBA investigations of multipath on u.h.f. signals in relation to teletext reception, suggest that such high D/U ratios are seldom found unless great care is taken in aerial installation.

Work on digital systems, which are susceptible to both short-term and long-term echoes, has underlined the unsuspected extent of multipath, even on u.h.f. where highly directional aerials can be used. For example IBA surveys showed that 86 per cent of pictures checked in homes in the Hebden Bridge service area and 79 per cent in the Abergavenny service area had visible ghosting; perhaps more significantly it showed that in those situations where multipath was sufficiently bad to cause teletext failures, it was not possible to recover the situation simply by swinging or re-adjusting the aerial within the limitations imposed by the space available on a chimney stack[4].

BBC experiments on multiplexed digital sound carried out at Pontop Pike in 1977-78 indicated that while reception quality was very good in many areas, there were a disturbing number of 'black spots' where the bit-stream was seriously corrupted by multipath. The extent of this problem seems to have surprised those broadcast engineers who have come to have enormous faith in digital techniques, although less





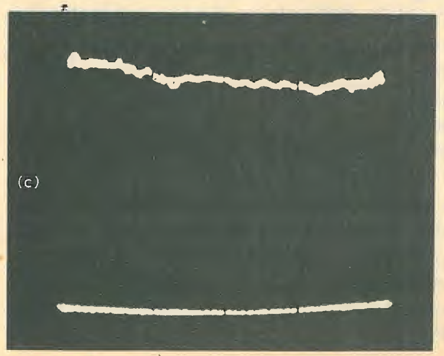


Fig. 2. Type of display obtained using the equipment of Fig. 1 (a) Idealised display in which the ratio of the amplitudes of the direct (D) and indirect (U) signals is represented by a/b and their path difference in km by 300/f where f is the frequency separation in kHz between adjacent maxima of the trace. (b) Display obtained at a typical site using a correctly oriented dipole. (c) Trace at the same site using a 4-element Yagi aerial indicating considerable reduction in the amplitude of the reflected signal compared with the direct signal.

surprising to those who have long been concerned with the low bit rates that, primarily because of multipath, can be reliably achieved on h.f. radio circuits.

Sir James Redmond, when BBC Director of Engineering, is on record[6] as saying of the p.c.m. work: "Our initial experiments have shown that, in heavily built-up areas, there are reception problems due to multipath propagation as indeed there are with existing f.m. transmissions. We shall probably have to try other forms of modulation."

The BBC appears to have considered using multiplexed radio channels on a wideband f.m. bearer as a further alternative means of carrying a stream of separate radio network transmissions within a single v.h.f. television channel.

Such systems, it is claimed, would offer a unique opportunity to make radio reception simple and reliable. While this may well be the case, we should surely think very carefully before committing the UK to a third system of radio while still having to maintain m.f./a.m. and v.h.f./f.m. systems.

The investigation by the IBA of the effect of multipath on teletext errors led Peter Hutt to express the opinion[5] that the conventional theoretical model is not a satisfactory one for reasons that are not clearly understood. Whereas the accepted "model" indicates that a u.h.f. signal might be expected to have equal probability of gain or loss (due to the additive or subtractive effect of the reflected signal) across the bandwidth of the vision signal, in fact there appears to exist a strong propensity for colour subcarrier loss in typical built-up areas.

A similar puzzle has arisen in American investigations into the use of circular polarisation for television as well as sound transmissions. Circular polarisation provides an effective method of discriminating against reflected signals, since, on reflection, the sense of polarisation is changed. In other words the transmitted 'left-hand' (anti-clockwise) signals become, on a single reflection, 'right-hand' circular. Clearly circular-polarised transmitting *and* receiving aerials provide an effective method of reducing multipath distortion. However, very few listeners have circularly-polarised aerials but receive the signals on linear-polarised aerials (losing a potential 3dB in the process).

The American tv investigations, such as that carried out by Jampro at KLOC-TV, California,[7] suggest that ghosting is reduced on circularly polarised signals, *regardless of the mode of reception.* While circular polarisation is used on virtually all of the IBA's ILR transmitters, no investigations have been made to ascertain whether or not multipath distortion is reduced in a similar manner. While it is difficult to see any theoretical basis for the American findings, it may well be because of the rotation of the plane of polarisation of v.h.f. signals in built-up areas and where the signals are received indoors:

Table 1. Investigations by BBC in 1950s
(Typical sites — indoor aerials — private houses)

Distance from transmitter (km)	Mean long-path reflection (%)	Maximum long-path reflection (%)
35	16	50
34	5	12
29	1.5	12
36	7.5	15
24	6.5	7.5
60	10	20
35	9	25
34	7.5	14
41	5	8
61	11	13

Notes: Long-path reflections are defined as those where there is a path-difference greater than 3km. At each site a dipole aerial was placed at picture-rail level on two adjacent walls and at table level parallel to the walls (positions of very low signal strength disregarded). At one site measurements made over 13 days showed variation in relative amplitude of reflected wave varying from 13.3% to 17.5% but relative phase remained within ±13° showing that path difference (18km) remained virtually constant. Using indoor aerials just-perceptible distortion could be anticipated at all 45 sites tested.

direct circular polarised signals could be expected to be received on average better, and this may be more important than any corresponding improvement in reception of the unwanted, reflected signals, though there appears to be no experimental evidence to support this. Surveys of the advantages of circularly polarised aerials for v.h.f./f.m. transmission[8] appear, like so much else written on v.h.f./f.m. broadcasting, to overlook this question.

When the BBC set up its national networks of v.h.f./f.m. transmitters, the upper limit of audio frequencies was normally set by the "music lines" of the Post Office distribution circuits; this meant that audio frequencies much above 7kHz could not be guaranteed. These circuits also presented problems in handling stereo over distances exceeding about 50-75 miles. However, in recent years the BBC has introduced its p.c.m. digital transmission system which provides high-quality stereo up to about 15kHz throughout the UK. At the same time, the ILR stations are able to provide good quality stereo since the transmitters are seldom more than a few miles from the originating studios.

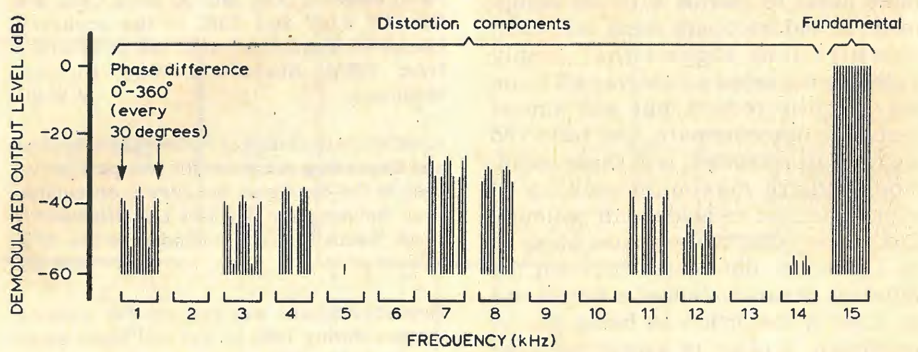
These developments have increased rather than decreased the importance of multipath distortion.

The current work by both IBA and BBC, to evaluate various matrix systems of 'surround-sound' such as MSC and HJ, using "2", "2½" or "3" transmission channels does not appear so far to have included any practical assessment of the effects of multipath on the different systems, although IBA engineers are hoping to undertake a study shortly in connection with the MSC (Mono-Stereo-Compatible) system.

The possibility of using charge-coupled-device delay lines to reduce ghosting on television pictures has been reported[9] but little thought appears to have been given to whether similar techniques could be usefully applied to v.h.f./f.m. reception.

Minimising multipath distortion

Multipath propagation of v.h.f. signals is a fact of life: it would appear that even by installing good outdoor aerials of reasonable directivity the listener would often be unlikely to reduce long-



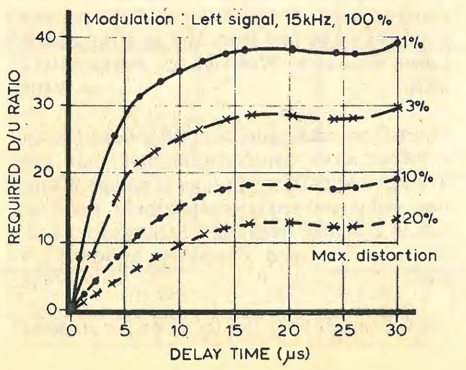


Fig. 3. NHK-computed example of spectrum distribution. The D/U ratio is 20dB; delay time 10μs; modulation — left signal, 15kHz, 100%; maximum distortion 5.6% (when 180°); and minimum distortion 4% (when 90° or 270°).

Fig. 4 (left). Relation between required D/U ratio (desired signal/undesired signal) and delay time (path difference) as calculated by NHK.

path echoes to the extent suggested as desirable by the NHK calculations. There are severe practical problems even in attempting to reduce the strength of reflected signals by physical adjustment of the aerial.

The BBC in its otherwise very useful booklet "How to get the best out of stereo radio" (July 1977) has a paragraph devoted to multipath ("distortion of sibilants or other high-pitched loud signals" page 10) which suggests: "The directional properties of a carefully positioned multi-element aerial can often be used to reduce the pick-up of the reflected signals and thus reduce or eliminate the distortion. The best position of the aerial will normally be the one giving the best ratio between the wanted and the reflected signal – this is not necessarily the position giving maximum pick-up. The optimum position can be found by moving the aerial in an arc of about 30 degrees either side of the maximum signal position and selecting the position within this arc which gives the best listening result."

This, if with respect one may say so, is not so helpful as it may appear. One has the image of a quality conscious listener nipping up to his roof to adjust his possibly large directional outdoor aerial, carefully waiting before doing so for the broadcast of a long piano solo with plenty of high-frequency notes. Life is just not like that. The aerial will almost certainly have been installed (carefully perhaps if not by a rooftop cowboy) and checked to ensure that it provides sufficient signal on all channels to overcome stereo noise. I cannot imagine the installer being in any position to cope with multipath distortion except of the most gross kind. Unlike television he has no visible 'ghosts' or even test cards to guide him. If he tests the installation and detects distortion there is no guarantee that he will identify it as multipath distortion but is more likely to ascribe it to the equipment. In bad multipath areas, television investigations suggest that simply swinging the aerial a little way off beam may slightly reduce, but will almost certainly not eliminate, the reflected signal. Furthermore it is in those conditions (where maximum pick-up of signal does not coincide with optimum D/U ratios) that there is most likely to be significant differences between the different channels. Indeed a simple test to identify distortion as being due to multipath is often to switch between channels and note whether the distortion disappears!

The original BBC investigations highlighted the importance of the a.m. suppression characteristics of the receiver/tuner and the need to have a "balance" or "a.m. rejection" adjustment with a typical ratio detector. However even this may prove unsatisfactory, particularly as such adjustments and measurements are most likely to be carried out with a signal generator modulated with 400Hz tone which in conjunction with the time-constants of the receiver limiters may indicate a degree of a.m. suppression that differs significantly from that at 15kHz.

What then can be done? Clearly good high, outdoor aerials and good a.m. suppression can result in a very worthwhile improvement. We could try to convince town-planners that high structures should be discouraged (unless needed to support the transmitting aerials!) but even that will not remove mountains. Multipath is going to remain a problem – but do we not need more awareness of its impact, more knowledge of its practical effects, more thought on whether it could be reduced by more use of circular polarisation? Or shall we just continue to sweep it under the carpet and pretend that v.h.f./f.m. can always or usually provide high fidelity reception? Or regard the present system as obsolescent and direct our thoughts to alternative modes of transmission such as multiplexed wide-band f.m., or digital systems, or direct broadcasting from satellite at frequencies of the order of 1-2GHz?

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3. "Analysis of Multipath Distortion in FM Sound Broadcasting," NHK Technical Research Laboratories, June 1979.
4. L. A. Sherry. "A summary of ORACLE field trials", Teletext Transmission Working Group Note 51, IBA 78.
5. P. R. Hutt. "The Fundamentals of Teletext Transmission", IBA 1977.
6. J. Redmond. "Broadcasting: the developing technology", *Proc IEE*, Vol 126, No 1, January 1979. See also *Wireless World* December 1978, p. 52.
7. "Test results comparing circular with horizontal polarisation in u.h.f. tv broadcasting", Jampro Antenna Company, 1976.
8. J. Ryan. "A new circularly polarised f.m. broadcasting aerial for Band II", IBC 1968, IEE Conference Publication No 46, Part 1.
9. Syunichi Ohnishi and Masaharu Obara. "Application of charge-coupled device for cancellation of tv ghost signals", NHK Laboratories Note No 226, May 1978.

Literature Received

Course book and cassette with several programs contain a training programme for complete beginners to **computing.** It is based on Strathclyde BASIC and the Commodore PET microcomputer. The course book was written by Andrew Colin and is well organized. Course costs £12 from Commodore Business Machines (UK) Ltd, 818 Leigh Road Trading Estate, Slough, Berks.

Load cells made by Hottinger Baldwin are for use in tension and compression and are rated between 500g and 20 tons. Cells are the U1; U1-V and Z3H, in the accuracy classes 0.1 and 0.3. A leaflet can be obtained from HBM, Stonefield Way, Ruislip, Middlesex. WW401

A leaflet on the range of Robnorganic **mixing and dispensing** machines for two-part resins used in the electronic industry is obtainable from Robnorganic Systems Ltd, Highworth Road, South Marston, Swindon, Wilts. SN3 4TE. WW402

Hewlett-Packard will run several training courses during 1980 on gas and liquid **chromatography,** Winnersh being one of the centres used. A brochure describing the courses can be had from H-P at King Street Lane, Winnersh, Wokingham, Berks. RG11 5AR. WW403

Short-form catalogue from B&K describes in a rather more complete manner than the average 'short-form' a range of **sound, vibration and signal analysis** equipment. Publication is available from B&K Laboratories Ltd, Cross Lances Road, Hounslow, Middx, TW3 2AE. WW404

Leaflets specifying the facilities for making graticules, diffraction gratings, grids and other **precision photographic products** are obtainable from Opsec Ltd, Holywell Hill, St Albans, Herts. WW405

A supplement to the ITT **instrument catalogue** is available, containing information on, among others, the Texas TM990/189 microcomputer learning aid and Iwatsu oscilloscopes. It can be obtained from ITT Instrument Services, Edinburgh Way, Harlow, Essex. WW406

Bibliographies on the application of **microprocessors** in engineering, in home and office, in science and medicine and in electrical engineering are published by the IEE at prices ranging from £6.50 to £10.00. They are obtainable from the Marketing Department, The Institution of Electrical Engineers, Station House, Nightingale Road, Hitchin, Herts. SG5 1RJ.

Products for the home constructor in the Vero range of **prototype building aids** are selected for inclusion in the new Hobbyist catalogue, which is available at 40p by post from Vero Electronics Ltd, Industrial Estate, Chandler's Ford, Eastleigh, Hants, SO5 3ZR.

Theory and application of **mixers** is described in practical terms in a booklet which is obtainable free of charge from Hatfield Instruments, Burrington Way, Plymouth, Devon PL5 3LZ. WW407

Two publications from Plessey. Professional Radio Applications covers design and application using the range of **Plessey radio linear i.cs,** including synthesizers. Also an abridged catalogue of **all Plessey i.cs.** Both obtainable from Publicity Office, Plessey Semiconductors, Cheney Manor, Swindon, Wilts. SN2 2QW. WW408

Shared-memory colour-graphics visual display system

Teletext/Prestel-compatible unit interfaces with Z80 computer and colour TV set

by **S. J. Marchant,** B.Sc., University of Nottingham

This article describes a design for a memory-mapped, colour-graphics visual display unit for use with a microprocessor and a modified colour TV set. Although the unit was designed to operate with a Z80 and a modified 14-in Sony portable TV, interface requirements are simple and can easily be modified for use with other processors and television receivers.

The unit operates with a supply of 5V at 1A and a 16-bit address, eight-bit data, MREQ, RD and WR signals. It generates R, G, B, black/white and sync. signals. The system appears to the processor as 4K × 8 bits of static r.a.m. and presents one l.s. t.t.l. load to each input. Address selection is achieved on-board and the r.a.m. can be placed anywhere within a 64K memory map. The circuit to modify the Sony TV, used as an interface between the TV and the main unit, is also described.

A memory-mapped display system is one in which the read/write memory for the display is shared with a microprocessor; the memory is mapped into a particular slot of the microcomputer's address bus. The reasons for using memory-mapped visual displays stem from three main advantages

simple hardware requirements; scroll or cursor control logic elements are not required

maximum display flexibility

high-speed updating.

Offsetting these are two important disadvantages

driving software is required to make the memory map appear as a terminal device to the microprocessor

c.p.u./v.d.u. memory access competition causes glitches unless complex double buffering or cycle-stealing logic is included.

I overcame the first by writing a suitable package for the Z80 which makes the display appear as a terminal device. The software supports a cursor along with all the usual ASCII control codes. Full cursor control is included plus many graphics and colour facilities which use 31 of the available 32 control codes. This software can be placed in 2K p.r.o.m. and used just like an I/O device driver routine. Table 1 lists the facilities included.

The problem of glitches has been resolved by blanking the display outputs for a few microseconds while the processor takes control, the processor having highest priority. In this way up-dating results in a certain amount of flicker which is normally found acceptable under most conditions. The problem can be eliminated if writing to the display is restricted to line and frame blanking periods. This can be achieved by using the blanking output as a strobe to the processor. Each line can be sensed via an I/O port and updating can only occur when this signal is active. Such polling can be built into the display software if required.

The principal features of the unit, described in detail in the following sections, are

— simple, flexible, low-cost, standard components
— microprocessor-compatible memory-mapped design appears as 4K × 8 bit static r.a.m.
— 64 × 26 character display
— 128 × 104 graphics elements
— eight foreground colours
— eight background colours

Functional block diagram of v.d.u. circuit board which operates with 16-bit address, eight-bit data, MREQ, RD and WR signals from microprocessor.

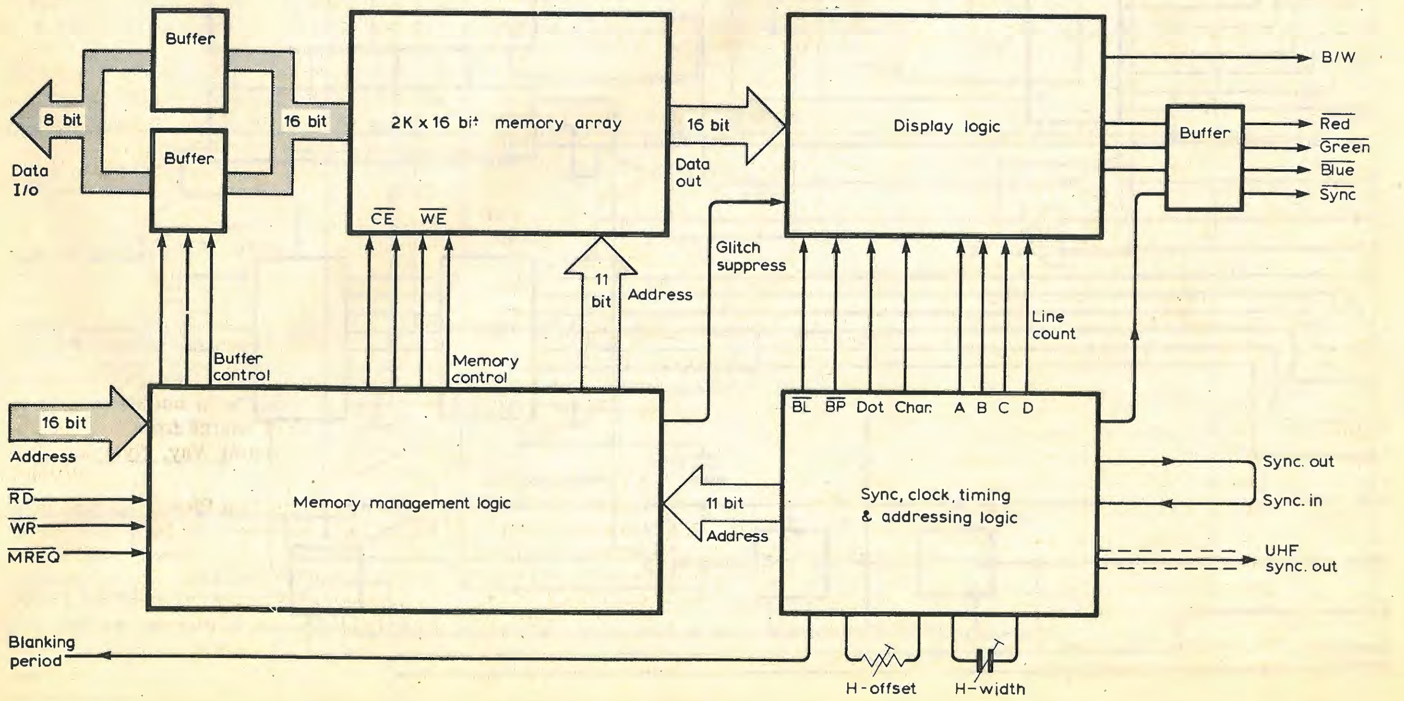
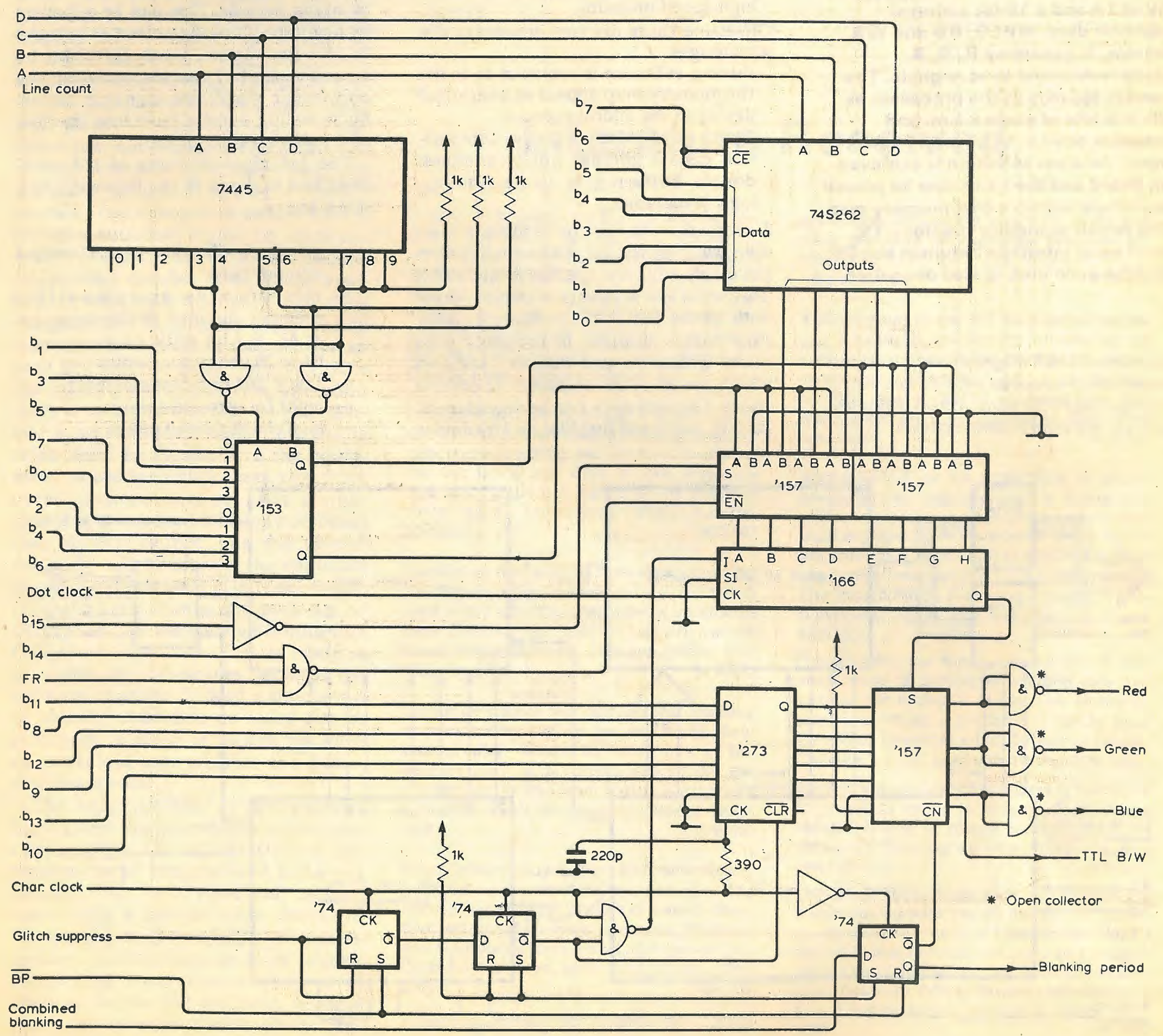


Table 1. Facilities included in driving software

Control Code	Char.	Function Description		Control Code	Char.	Function Description		
0	@	NULL	— routine returns carry set	16	P	BLA	— black	
1	A	DOT	— graphic dot at X, Y (next two characters)	17	Q	RED	— red	
2	B	VCT	— vector from X, Y, to X1, Y1 (next 4 chars)	18	R	GRN	— green	
3	C	CXY	— positions cursor to X, Y (next 2 chars)	19	S	YEL	— yellow	colour
4	D	BKG	— next colour control sets background	20	T	BLU	— blue	control
5	E	EOL	— erase to end of line	21	U	MAG	— magenta	
6	F	STS	— define colour status byte (next char)	22	V	CYN	— cyan	
7	G	BELL	— externally generated tone	23	W	WHT	— white	
8	H	BS	— cursor left	24	X	PRT	— print page to list device	
9	I	TAB	— tabulate 8 cols	25	Y	RGT	— cursor right	
10	J	LF	— cursor down	26	Z	HOME	— cursor to home position	
11	K	VT	— cursor up	27		ESC	— routine returns cursor off, carry set	
12	L	CLR	— clear screen	28		INI	— re-initialize	
13	M	CR	— cursor to left-hand side	29				
14	N	BL	— blink	30		CON	— cursor on	
15	O	BLO	— blink off	31		COFF	— cursor off	

Fig. 1. Display logic converts 16-bit data from memory array into colour signals.



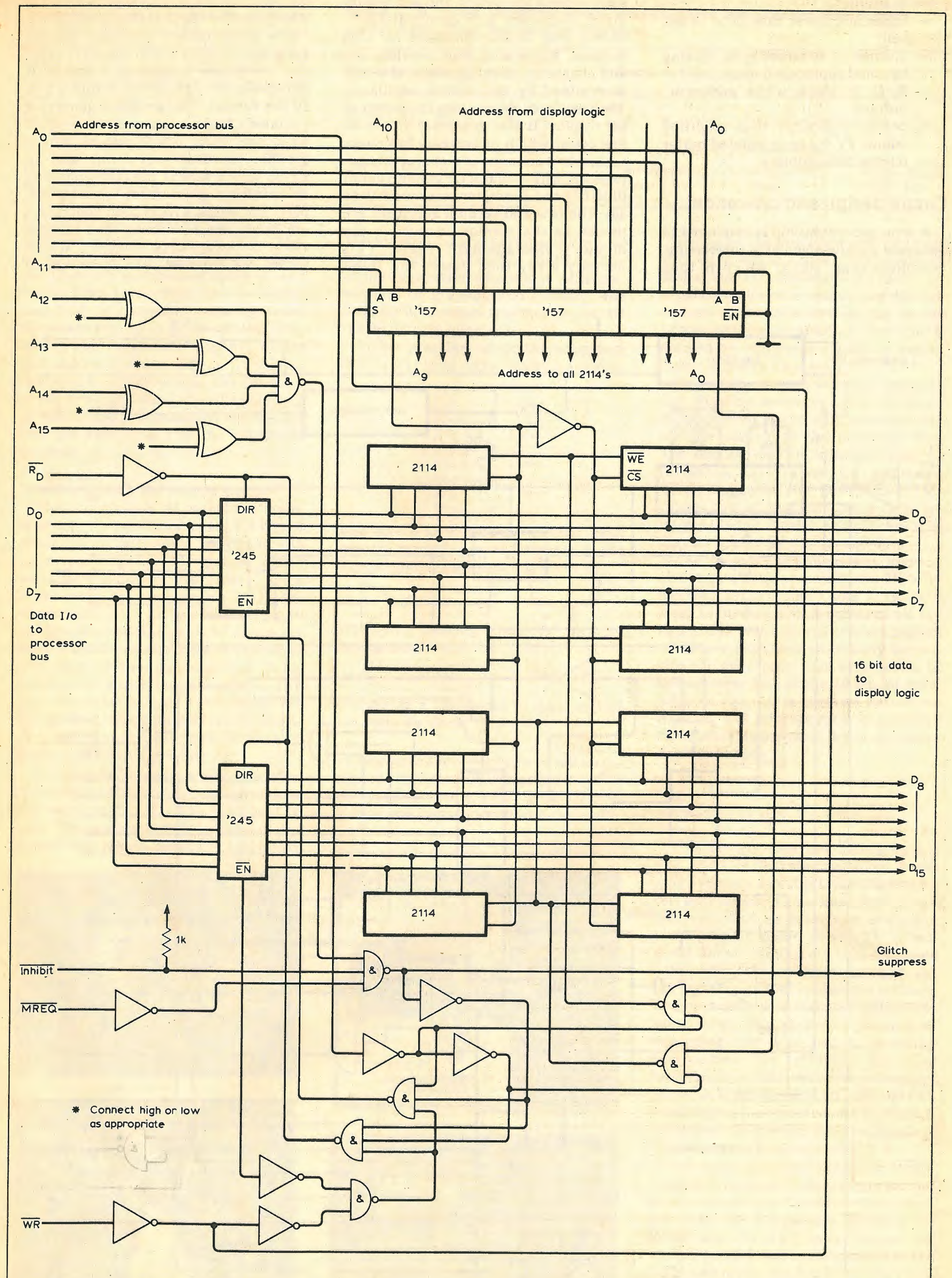


Fig. 2. Memory array and management logic to interface array with microcomputer bus and display logic.

- flashing
- upper and lower case (5 × 10 dot cell)
- internal or external sync. (giving optional superposed displays)
- R, G, B, black/white and sync. outputs
- connects directly to a modified colour TV via opto-isolated buffer
- teletex compatibility

Circuit design and operation

A sync-generator chip is employed to generate a convenient fully interlacing, combined sync. signal which is then used to drive the timing and addressing logic, although any external sync. source may equally be used for this purpose. Addressing logic provides dot and character clocking pulses at a rate determined by the astable oscillator. The frequency determines the width of the display. It also generates a four-bit line count which increments from zero to nine in the course of a character row, together with a character column count (0 to 63) and character row count (0 to 25). The row and column addresses are passed to the memory array via the memory management logic. This memory array then passes the 16-bit data word to the display logic where it is interpreted by the character generators.

The alphanumeric character generator is the 74S262N which supports upper and lower-case English-style ASCII. It also caters for descenders within a 5 × 10 dot format. The graphics generator contains a 7445 i.c. to decode the four-bit b.c.d. line count into a two-bit binary graphic character cell count, and an LS153 which selects the corresponding bit-pair from the memory word for display. The outputs from both generators are fed to the serializing shift register via a two-way data selector, which passes the required data according to

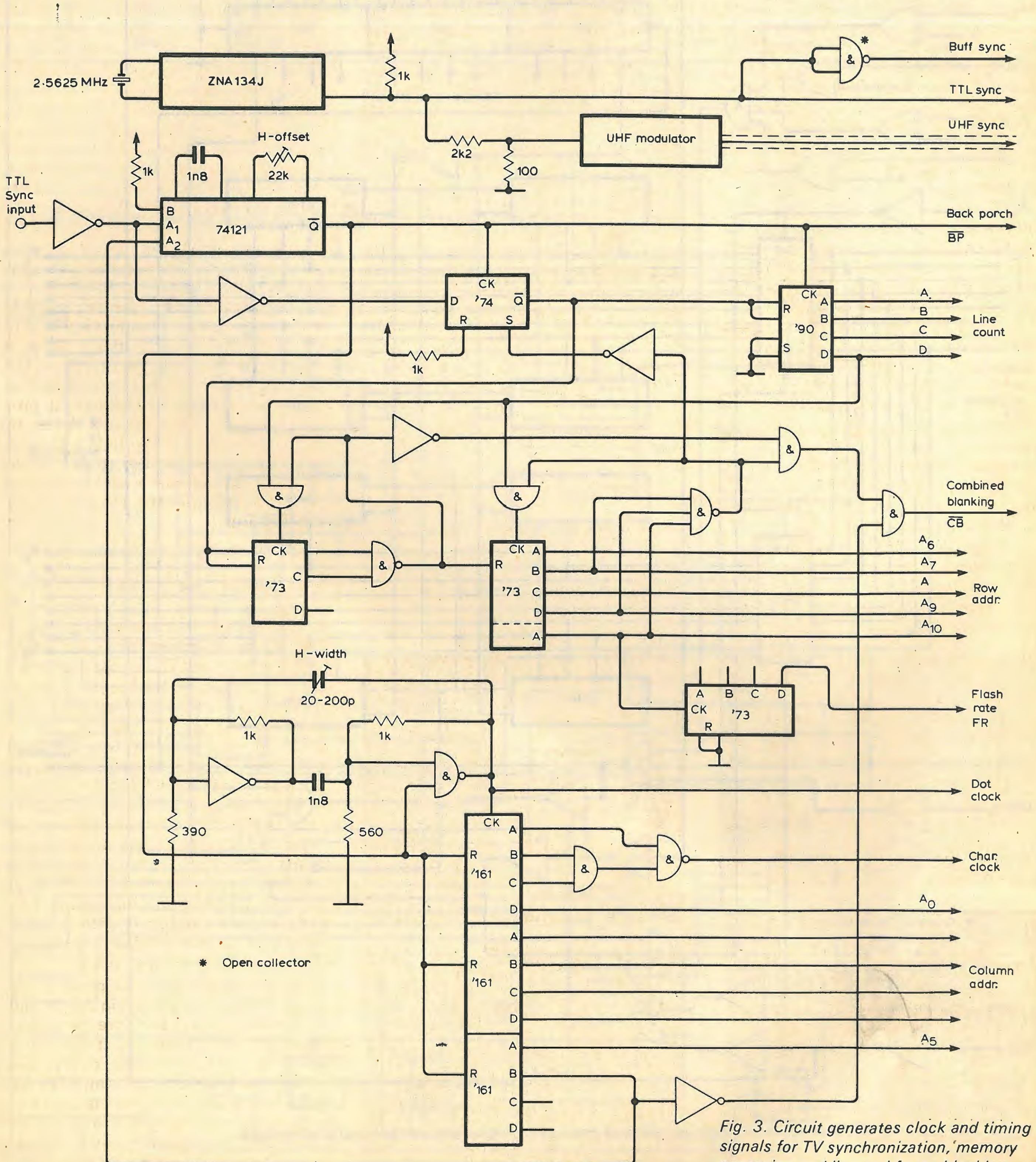


Fig. 3. Circuit generates clock and timing signals for TV synchronization, memory accessing and line and frame blanking.

the state of the graphic flag bit 15. Bit 14, the flash flag, has the capability of overriding the selection in favour of a black cell if it is set. This depends on the state of the flash rate low frequency clock which determines the flash frequency.

The output from the serializer is used to select either foreground or background colour bits from a six-bit latch loaded from the six remaining data bits 8 to 13. The R, G and B signals thus produced are buffered by an open-collector inverter ready for line transmission to the modified TV set where the lines are terminated, buffered and fed to high bandwidth opto-isolators. Isolation is necessary because most television sets have a live chassis. Following the isolators is another buffer and a high-voltage driver transistor operated in common base, the collector of which is parallelled onto the collector of the TV set's internal driver transistors. See Figs 1, 2 & 3 for the full circuit diagram.

Interfacing with the microprocessor

The objective is to make the v.d.u. appear to the processor as 4K × 8 bits of static r.a.m., although internally the r.a.m. is arranged as 2K words of 16 bits with each character represented by a 16-bit word. Of the possible 2048 characters only 64 × 26 are used owing to the practical limitation of 26 character rows in a 625-line raster (each character row takes 10 lines per frame). A 16-bit character word length stores the graphic/ASCII code, the three-bit foreground colour field, three-bit background colour field, the flash and graphic flag bits, see Table 2.

The display incorporates two character generators, one alphanumeric and one graphic. Bits 0 to 7 are sent to both generators but the value of b_{15} determines which output is displayed.

Table 2. A 16-bit character word length stores the graphic/ASCII code, colour fields, flash and graphic flag bits.

Character code								Status byte							
b_0	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8 R	b_9 G	b_{10} B	b_{11} R	b_{12} G	b_{13} B	b_{14} F 1	b_{15} G 1
ASCII code or graphic code								Foreground colour			Background colour			Flash flag	Graphic bits

The foreground and background colour bits determine the colour configuration of that character whether it be alphanumeric or graphic, and similarly the flash bit determines whether or not the character is to blink.

In the graphics mode the character cell is divided into eight sections

b_0	b_1	3 lines
b_2	b_3	2 lines
b_4	b_5	2 lines
b_6	b_7	3 lines

and bits 0 to 7 dictate whether each picture sub-cell is to be displayed in the foreground or background colour e.g.

10001000 111 001 10

represents flashing white "A" on blue background

and 10011001 101 000 01

represents a checkered graphic cell of magenta on black.

Photographs show examples of teletext displays (including 24 characters reserved for system program), plotting facility from a Basic program, and authors Basic game "shoot".

Photographs by University photographic unit.

However, the processor can only cope with eight bits at a time, so the memory management logic maps all even addresses to character codes and odd addresses to status codes. As far as the processor is concerned each character is defined by two bytes of data in consecutive memory locations.

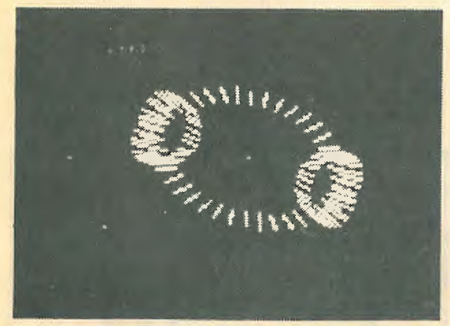
When the microprocessor accesses the display memory, the memory management logic will immediately transfer control to the processor bus. The display logic is informed that its incoming data is invalid when the "glitch suppress" line goes active. This causes a small blanking pulse to be set up and used to squelch any glitches that may be caused by this invalid data.

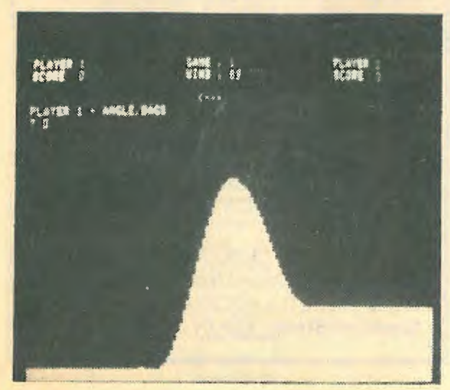
The memory management logic is also responsible for making the 2K × 16 memory array appear like a 4K × 8 array to the bus. This is achieved via the two LS245 bidirectional tristate buffers which are activated alternately to provide the microprocessor with access to one or other half of the 16 bits of data. Address line A0 is used to determine whether the microprocessor accesses the most significant byte or least significant byte.

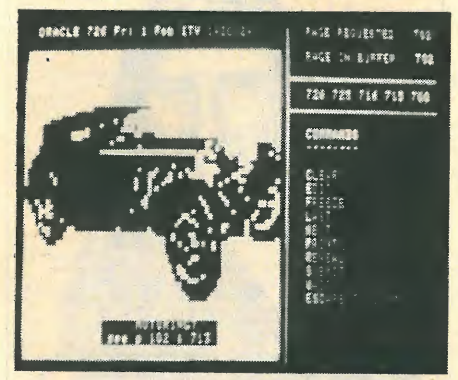
Interfacing the TV set

This design does not incorporate a PAL encoder because the colour bandwidth of such a device is insufficient for this application. Consequently a personality circuit to interface the main visual display board to the TV is required. Direct interfacing to a TV, used with most teletext systems, improves the legibility of the text but the problem of live-chassis sets makes it difficult to implement. The common method of achieving this is to use an isolating transformer. The technique described here employs opto-isolation to connect the R, G, B signals (and an optional t.t.l. sync signal) combined with a v.h.f. modulator to provide synchronization. The scheme is illustrated in Fig. 4.

The technique does not require any track or links to be broken in the set and video output can therefore be superposed on the TV picture. If the set is tuned into the u.h.f. sync. output the picture is blank but synchronized to the v.d.u. and hence the display. If the v.d.u. is externally synchronized to an off-air transmission the display may be superposed over that picture. A t.t.l. opto-isolated sync channel is provided along







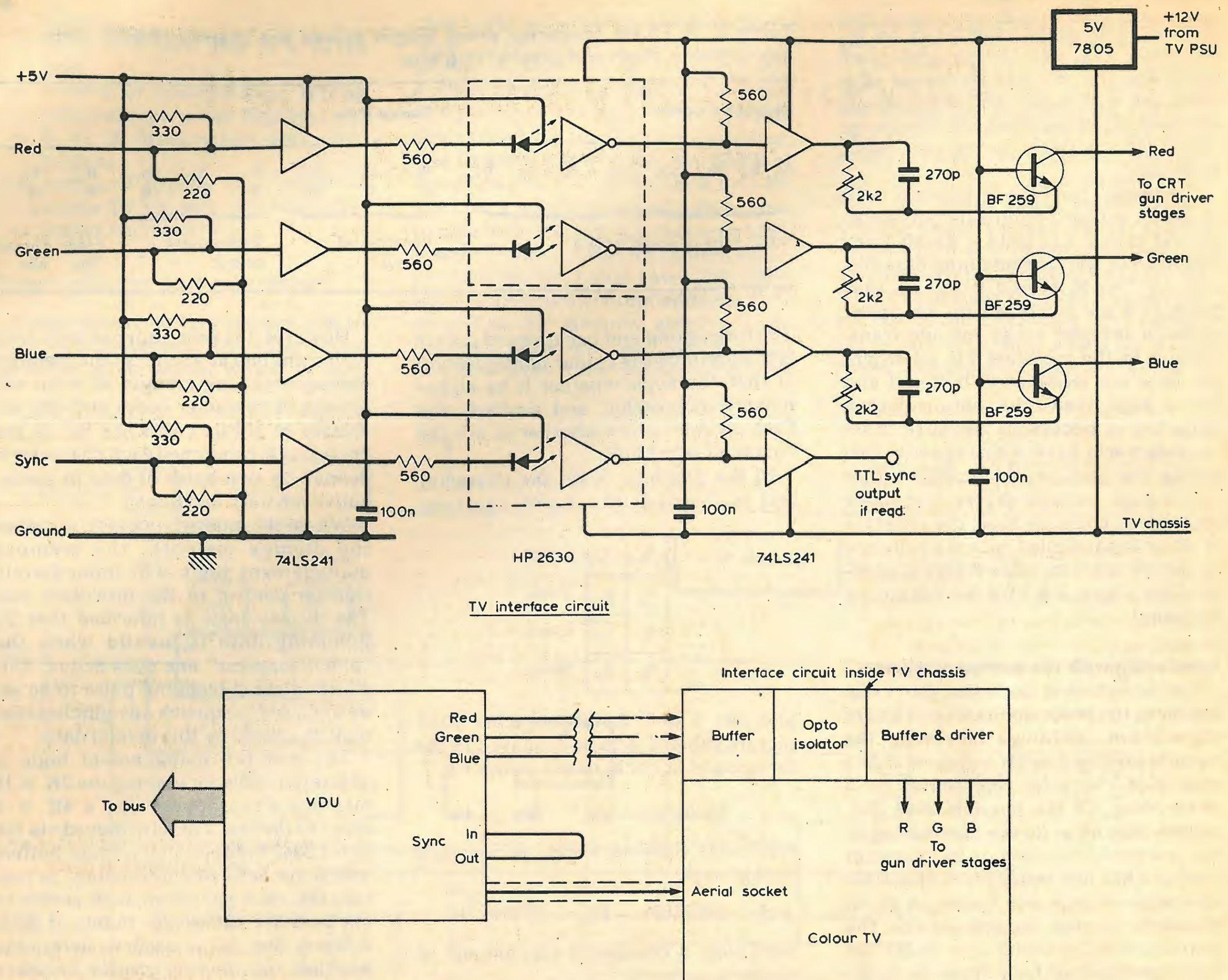


Fig. 4.

with the RGB isolation to provide extra flexibility should the u.h.f. link not be favoured.

Teletext and Prestel compatability

Although the display format is not identical to that specified for Prestel/teletext use, it is compatible. Under the control of a microprocessor, the display can be made to support most teletext/Prestel specifications, certainly the important ones. I have built a compact teletext interface for a Z80 computer system which uses the display system most effectively with a 2K-byte software package to complete this teletext facility. □

A double-sided glass-fibre p.c.b. for the colour graphics circuit will be available from M. R. Sagin at 23 Keyes Road, London NW2 for £18.50 inclusive of v.a.t. and UK postage. Roller tinned and drilled board measures 235 × 305mm.

Stephen Marchant, at 25, is joining Nottingham University as manager of a new microprocessor applications laboratory in the electronics department. Currently studying for a Ph.D. in the business application of microcomputers, he has designed and constructed many microprocessor-based projects which — he assures us — will form the basis of future articles.

Guide to Broadcasting Stations

Many of our readers have been impatiently awaiting publication of the new edition of this long-established book and will consequently be glad to learn that it is now available. This 18th edition is in the familiar format, listing stations in the long, medium, shortwave and v.h.f. bands, in alphabetical order, by location and by frequency. There are also sections on receivers, aerials, signal propagation, station identification and reception reports.
The book costs £3.25, including postage, and can be obtained from General Sales Department, Room CP34, Dorset House, Stamford Street, VDON SE1 9LU.

Circuit analysis by small computer — 2

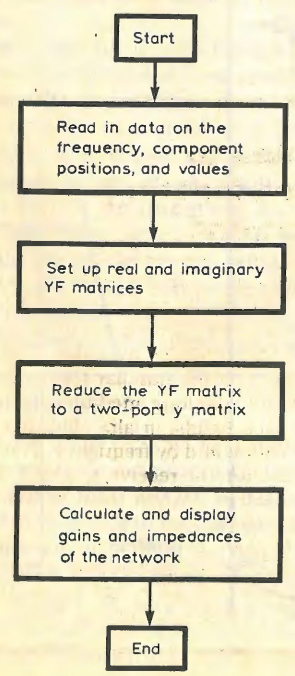
Programming and modelling techniques for common passive and active circuits

by **A. S. Beasley,** B.Sc. McMichael Ltd

The previous article (February issue) showed how an n-port analysis technique using the YF matrix could be translated into a simple rote procedure, which is ideal for small computer circuit analysis.

This article briefly outlines a program based on the YF matrix and then goes on to show the modelling techniques required for accurate analysis of common active and passive circuits. Examples and case studies, including microwave oscillators, power amplifiers and hybrid-π models, show that computer breadboarding of circuits represents a useful and versatile tool for those engaged in electronics, industry, education and at home.

The computer program used throughout this article for circuit analysis is called Dirac. Dirac runs a Commodore Pet, which uses Basic, and occupies 14K bytes of memory. (Earlier versions of Dirac could perform adequate circuit analysis for under 5K bytes. The current Dirac program is considerably more versatile than shown here.) The essence of the procedure that Dirac follows is shown below. Methodology for setting up the YF matrix, the equations for its reduction and the equations for the calculation of the gains and impedances of a circuit were discussed in the previous article, so this article is confined to examining the way Dirac manipulates the YF matrix.



Dirac sets up two matrices, one is used to store the real part of the YF matrix and the other the imaginary part i.e.

$$YF=\begin{pmatrix} YR(0,0),YR(0,1),YR(0,2), \ldots \\ YR(1,0),YR(1,1),YR(1,2), \ldots \\ YR(2,0),YR(2,1),YR(2,2), \ldots \\ \ldots\ldots, \ldots, \quad \ldots, \quad \ldots \end{pmatrix} + j\begin{pmatrix} YI(0,0),YI(0,1),YI(0,2), \ldots \\ YI(1,0),YI(1,1),YI(1,2), \ldots \\ YI(2,0),YI(2,1)YI(2,2), \ldots \\ \ldots\ldots, \ldots, \quad \ldots, \quad \ldots \end{pmatrix}$$

In setting up the YF matrix Dirac makes good use of the symmetry it possesses, this being greatest for passive components. By splitting the YF matrix into real and imaginary parts and by always choosing that mode 0 represents the input and that node 1 represents the output and node 2 the common rail, the reduction of the YF matrix becomes a few simple FOR NEXT loops i.e.

```
FOR X=N TO 3 STEP —1
FOR P =O TO X—1
FOR Q=O TO X—1
A=YR(X,X) ↑ 2+YI(X,X) ↑ 2
B=YR(P,X)*YR(X,Q)—
    YI(P,X)*YI(X,Q)
C=YR(X,Q)*YI(P,X)+YI(X,Q)*YR(P,X)
YR(P,Q)=YR(P,Q)—(B*YR(X,X)+
         C*YI(X,X) )/A
YI(P,Q)=YI(P,Q)—(C*YR(X,X)—
         B*YI(X,X) )/A
NEXT Q,P,X
```

This will leave the two-port y-parameters as

$$\begin{pmatrix} YR(0,0)+jYI(0,0), & YR(0,1)+jYI(0,1) \\ YR(1,0)+jYI(1,0), & YR(1,1)+jYI(1,1) \end{pmatrix}$$

Application of Table 1 of the previous article, now gives the gains and impedances of the circuit.

Modelling technique

Passive circuits are, by and large, straightforward to analyse, as are most narrow-band active circuits. However many common circuits require a more subtle approach. Consider the variation of transistor parameters, oscillator and v.c.o. design and large signal design.

Table 1. Hybrid-> circuit elements

Parameter	Equation	Units
g_m	$35 \times 10^{-3} I_E(A)$	A/V
$r_{b'b}$	$h_{ie}-h_{fe}/g_m$	Ω
$r_{b'e}$	h_{fe}/g_m	Ω
r_{ce}	$1/ch_{oe}-g_m h_{re})$	Ω
$C_{b'e}$	$g_m/2\pi f_T$	F
$C_{b'e}$	$C_{cb}(V_{CE}/V_{CE})^3$	F

where f_T is the gain-bandwidth product and V_{CE} is the voltage at which C_{ob} was measured.

The h parameters are low frequency h parameters, and so are purely real numbers.

Hybrid-π model

The simple approach of using the y or h-parameters of a transistor as given on a data sheet, ignores the fact that these parameters themselves vary with frequency and bias conditions. The hybrid-π model of a bipolar transistor, Fig. 1, provides a way of predicting the variation of these parameters, with the minimum of information, see Table 1. What a hybrid-π model does is trade accuracy for complexity of calculation, which is an excellent exchange for computer analysis. Curves of Fig. 2 show a comparison of measured two-port values as a function of frequency, as compared with the hybrid-π predicted values. Generally, the hybrid-π model of the bipolar transistor is good from dc to 10MHz, although variations do exist which are good up to 120MHz.

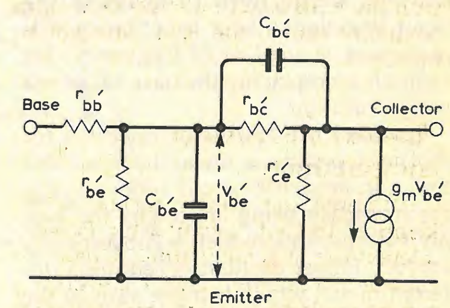
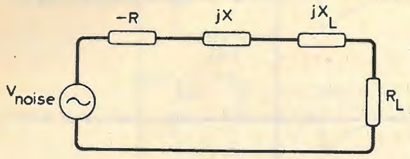


Fig. 1. Hybrid-π transistor model can be used to advantage with computer analysis.

Small-signal oscillator and v.c.o. analysis

Using the YF matrix, from which we ultimately derive gains and impedances, the criterion for oscillation is best viewed in terms of negative resistance. Referring to the diagram below oscillation occurs when $jX + X_L = 0$ and $R \geq R_L$



As a more concrete example consider the upper inset diagram in Fig. 3. At 1400MHz the circuit exhibits negative resistance. At lower frequencies the circuit would require positive feedback, but at 1400MHz the feedback is internal to this transistor. The base capacitor has been chosen to maximise the negative resistance. To produce oscillation across a 50ohm load one requires a network which transforms the input resistance such that $R \leq -50$ohms, at the same time as tuning out the reactance jX. By choosing a high-Q network, that is one with a rapid change of reactance with frequency, the oscillation frequency will be well-defined. The lower inset of Fig. 3 shows such a network. The curve shows the predicted values of R and X, before and after the transforming network is added. From it one would predict oscillation at 1402MHz. The circuit based on this design in fact produced 300 milliwatts at 1350MHz, an error of 3%, but could be tuned from 1100 to 1400MHz via the base capacitor.

A v.c.o. design would proceed along similar lines, except that some parameter would be voltage controlled, and one would need to examine the input impedance as a function of this parameter as well as of frequency, for example by replacing the base capacitor with a varactor.

Provided the transistor operates for the most part in a linear fashion, and that non-linearities occur suddenly, e.g. the transistor being limited by the supply voltage, this model is substantially correct. Power oscillators require a different model which is more akin to the power amplifier design dealt with next.

Power amplifier design

Large-signal design usually involves non-linear operation, e.g. classes AB,B,C. When this is the case there is no simple YF matrix to describe the circuit. For power amplifiers we have to limit the analysis to considering only how to get the drive power into the transistor, and the resulting amplified signal out into a load.

As an example take a v.m.o.s. power f.e.t. operated at 100W at 145MHz. To use it one must power-match its output to 50 ohms, see below. The input matching network does much the same job, but the output match is the more important of the two, as the higher power levels on the output can more easily destroy the £100 f.e.t. by mismatching. The model adopted assumes the output impedance of the f.e.t. is described by

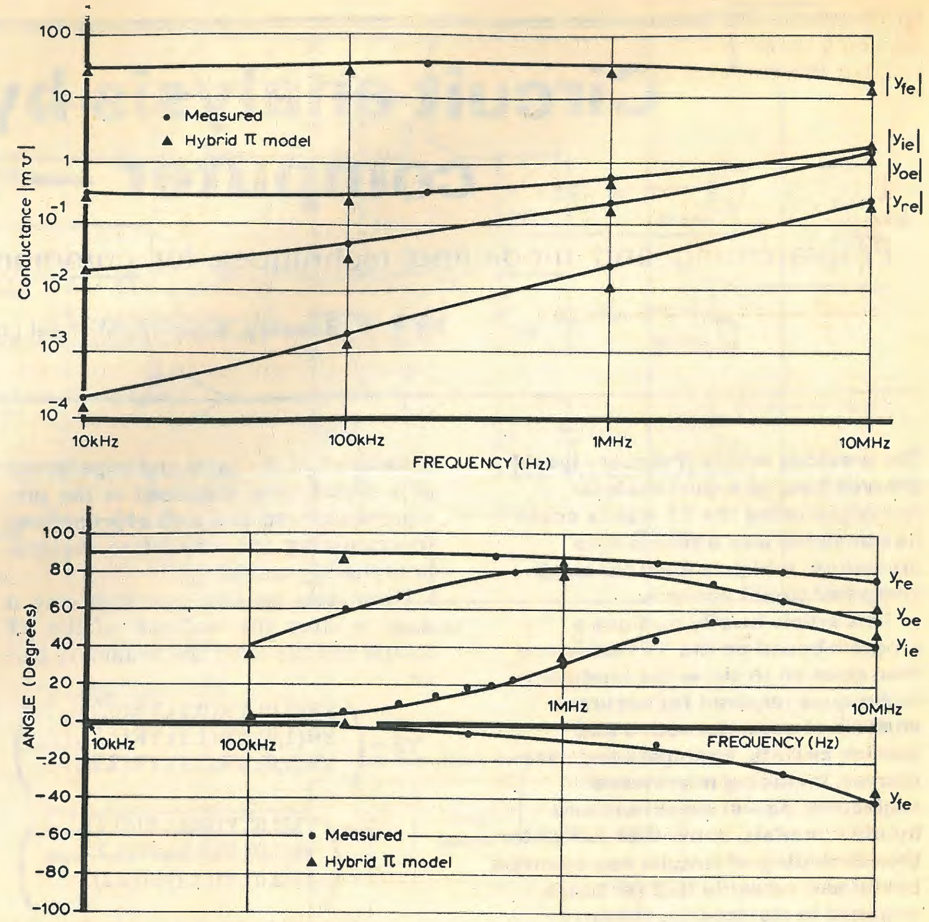


Fig. 2. Comparison of measured two-part parameters with valves predicted from hybrid π model of Fig. 1.

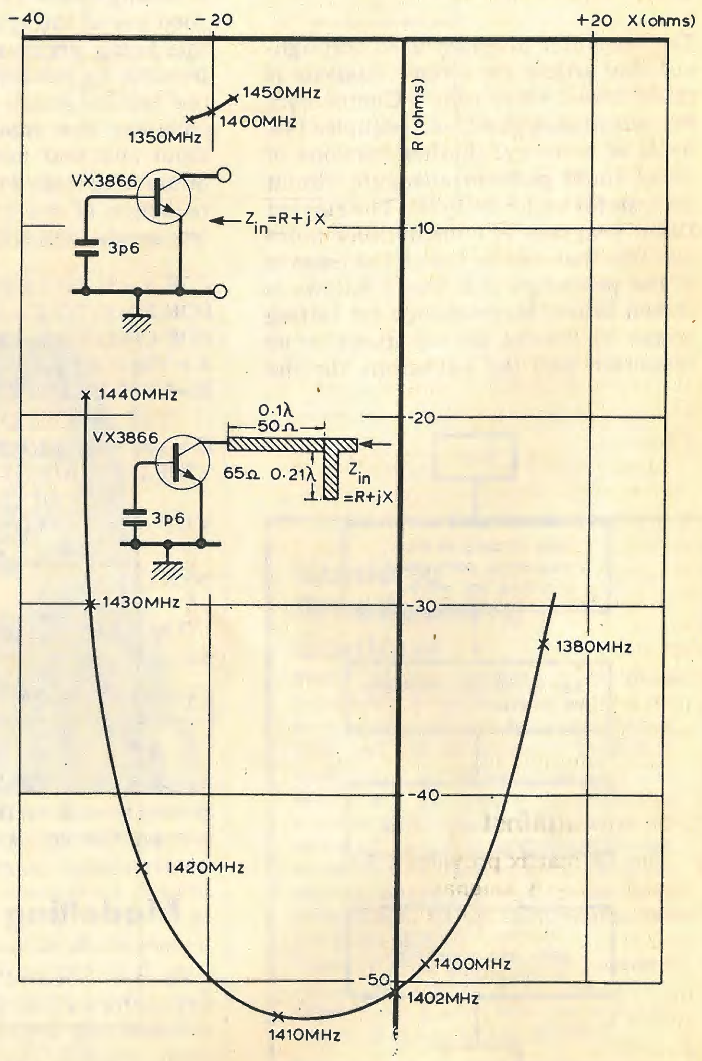
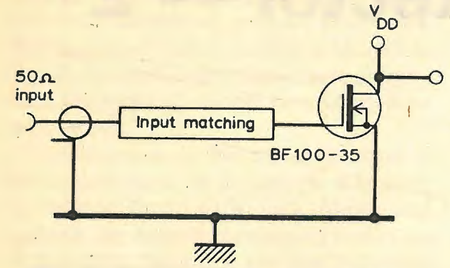
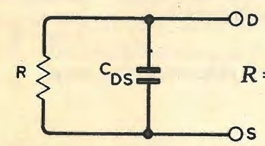


Fig. 3. Predicted series input impedance of oscillator circuits, shown inset.





$$R = V^2_{DD}/2P_{out}.$$

where P_{out} is the rated output power of the f.e.t. and C_{DS} the drain-to-source capacitance. (The f.e.t. input impedance is given on the data sheet.) Fig. 4 shows a network breadboarded on Dirac and the network finally used, the amplifier having 10dB gain when run in class AB.

Economics of small computer analysis

The circuit in Fig. 5 shows a 3rd-order active filter, used as part of a subsystem in a satellite communication system. The filter was designed and checked using Dirac. Having verified the designed circuit would give the required response, the program was re-run using practical resistor and capacitor values. Various practical values had to be tried until an acceptable response was obtained. The exercise in itself gives the engineer a feel for the network, and the relative sensitivity of cut-off frequency etc, to component values.

Finally the filter was breadboarded, and the filter response measured. Figure 6 shows the comparison with the predicted and the measured response. The response was judged close enough to the optimum not to need any adjustment. Hence engineering time and effort had been saved, not to mention possible burnt out components. Rental of the main frame computer the Company has access to would have cost £30 for the same amount of computing time.

For and against

The YF matrix provides a method of circuit analysis amenable to the computer. Other methods exist, but after a year of experience in industrial R&D the YF matrix has proved superior for all but passive ladder networks. For versatile usage of analysis programs modelling techniques become essential, although modelling ultimately is synonymous with a sound understanding of circuitry.

A small computer analysis does have some drawbacks; bad designs will remain bad designs although confidence in them may grow if the computer says they will work. A similar trap exists regarding computer accuracy — the predicted response of a circuit using n% tolerance components is rarely better than n%. As the reliability of the desktop machine determines its running cost, i.e. the service and repair costs, this should be carefully looked at before investing in a machine. Finally, the speed of operation of a desk-top machine is often disappointing to those used to a large main frame; this arises from the use of an interpreter instead of a compiler. Nearly all these drawbacks stem from the cheap desktop machine being a first-generation machine used by first-generation engineers, and so it must be expected that as experience grows the cheap desktop machine will become more established as a common piece of lab equipment.

Acknowledgements. My thanks to the management of McMichael Limited for encouragement in writing these articles, and colleagues in Advanced Projects Division for help in obtaining the material, though any errors are my own.

Correction to part 1. The author regrets a row was omitted from matrix YF, in the example on page 40, February issue. The fourth row should read 0,0, $-Y_{23}$,Y_{23},0, the row shown being the fifth. We regret the misprints on page 39; under Fig. 4 the term in I_0 should read $-Y_{01}V_1$ and not $-Y_{02}Y_1$, and in the matrix form the 1st column, 3rd row term is of course $-Y_{02}$. The second row of the ideal transformer matrix (Table 2) should be deleted. □

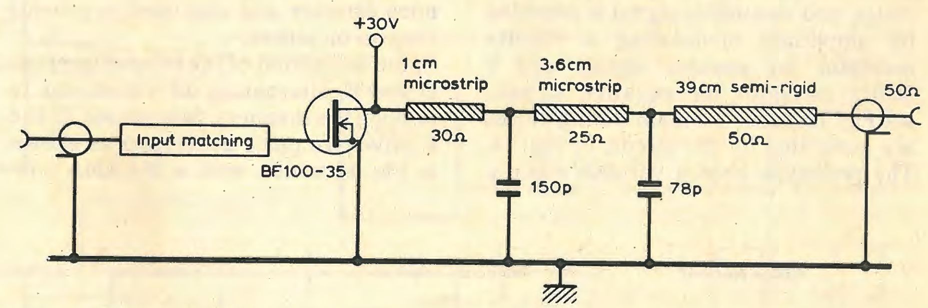


Fig. 4. Final modelled output circuit differed only in using 94pF instead of 78pF capacitor.

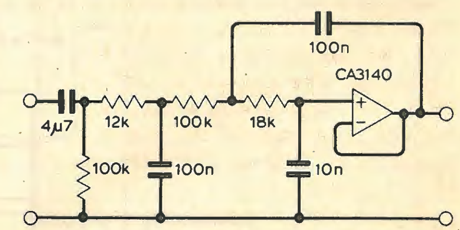
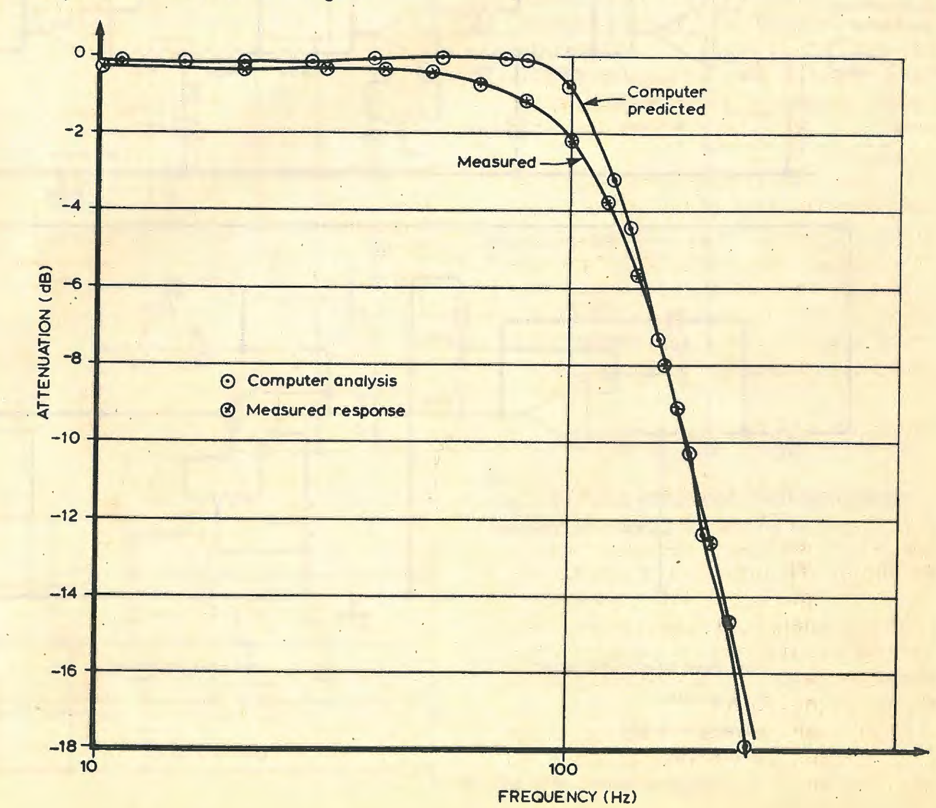


Fig. 5. After verifying that active filter circuit would give required response, program was re-run using practical values.

Fig. 6. Predicted and measured amplitude response of active filter in Fig. 5.



Pulse induction metal detector — 2

by J. A. Corbyn.

The bandpass amplifier in Fig. 11 extracts possible signals from background noise caused mainly by transients in the circuits. To permit a gain of up to 8000, a narrow pass-band from 0.2 to 0.6Hz is used with a high-order filter for sharp roll-off. The circuit also has a limited overshoot with a step function as shown in Fig. 12.

The output is displayed by a voltmeter, and an audible signal is provided by amplitude modulating a 1400Hz oscillator for positive signals and a 900Hz oscillator for negative signals, see Fig. 13. All of the main timing pulses are generated by the circuit in Fig. 14. The prototype used a variable c.m.o.s. RC oscillator with four switched ranges of 40 to 175μs, 160 to 700μs, 640 to 2800 μs and 2.56 to 11.2ms for Δt. The oscillator drives a counter and decoder which provide a division of 32 and produce the following waveforms.

A, the receive interval with a duration of 6×Δt and separated from the on pulse by Δt.

B, a reversing signal for the synchronous detector and also used to provide the two on pulses.

C, the last period of the receive interval.

D and E, alternating on waveforms to provide the magnetic field pulses. D and E drive two pulse generators as shown in Fig. 15 which, with a BU 326A non-saturating common emitter output, can supply up to 1.5A. Two transmit coils were used in the prototype because a rugged high-voltage p-n-p transistor was not available at a reasonable price. The regulated power supply is shown in Fig. 16. As well as the capacitors shown, extra decoupling should be provided on each circuit.

Construction of the metal detector is not critical and the prototype was built in module form with jack plugs and sockets for interconnexions. Selection of damping resistors for the transmit and receive coils is best carried out with an oscilloscope, although I found that the values chosen were generally in agreement with the theoretical values.

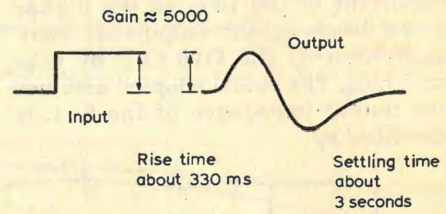
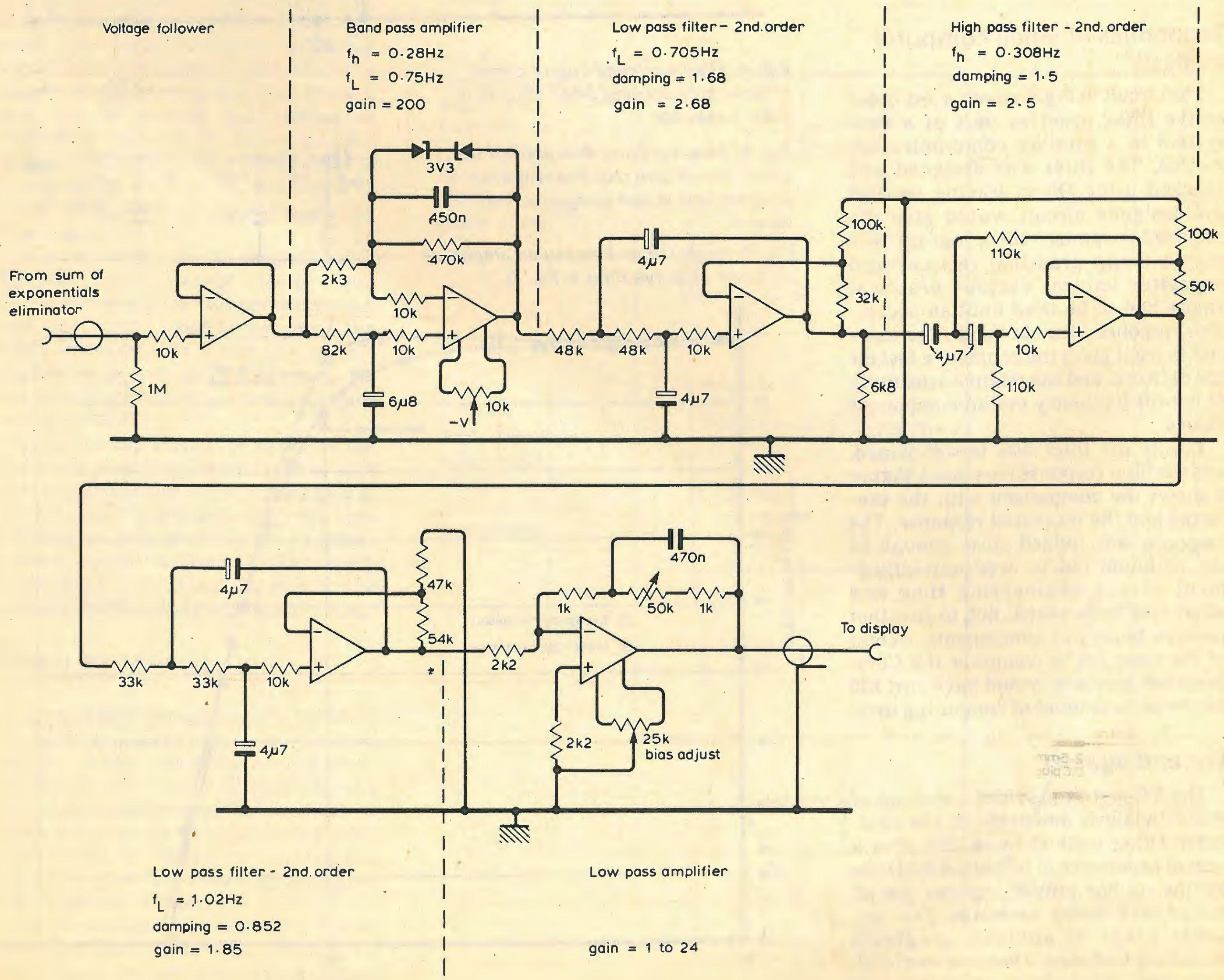


Fig. 12. System response to a step function.

Fig. 11. Bandpass amplifier. All op-amps are LM351 or similar and all capacitors are polyester. Offset voltage for the first amplifier is set to 0V with a supply of ±8V.



Conclusion

This metal detector is essentially dynamic because it only responds to a target when it is moving in relation to it.

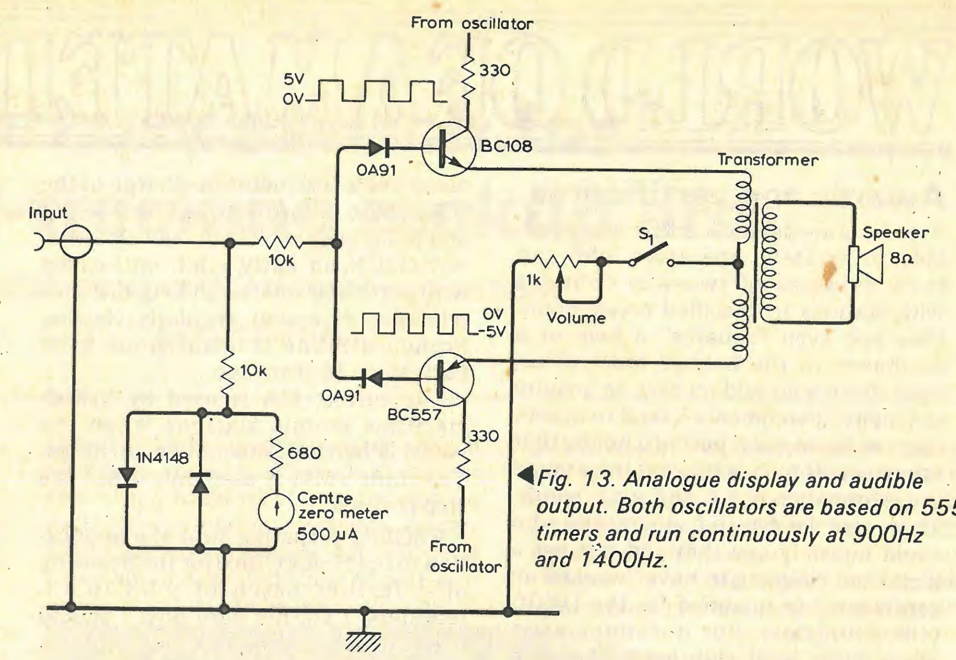
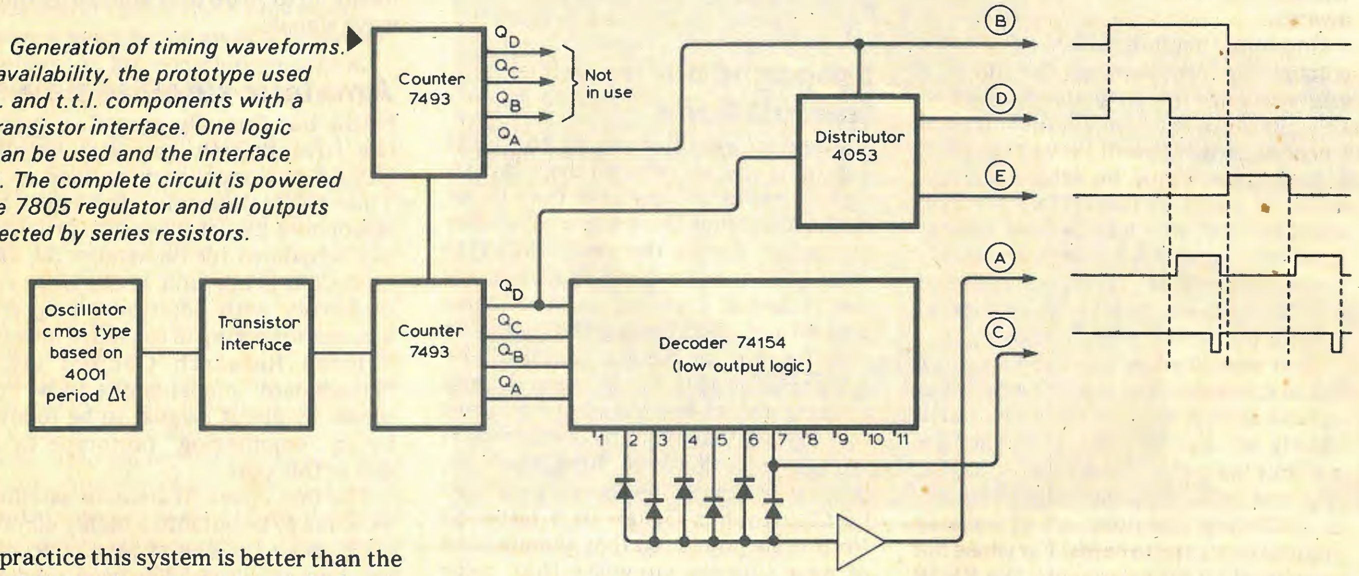


Fig. 13. Analogue display and audible output. Both oscillators are based on 555 timers and run continuously at 900Hz and 1400Hz.

Fig. 14. Generation of timing waveforms. Due to availability, the prototype used c.m.o.s. and t.t.l. components with a single transistor interface. One logic family can be used and the interface omitted. The complete circuit is powered from the 7805 regulator and all outputs are protected by series resistors.



In practice this system is better than the static type because any maladjustments, in connection with the magnetic viscosity effects, are not important with a reasonably uniform ground. Slow variations of amplifier offsets are also unimportant.

Due to magnetic viscosity effects and possible feedback loops, metal detectors need to be tested in operation to determine their sensitivity. A 600 mm radius coil assembly, as shown in Fig. 5, satisfactorily detected a piece of brass 50 mm in diameter at a depth of 750 mm, and a 15 mm diameter brass target at a depth of 50 mm. In both cases a peak transmit current of 1A was used with a Δt of 250 μs and a ground speed of 1 m/s. □

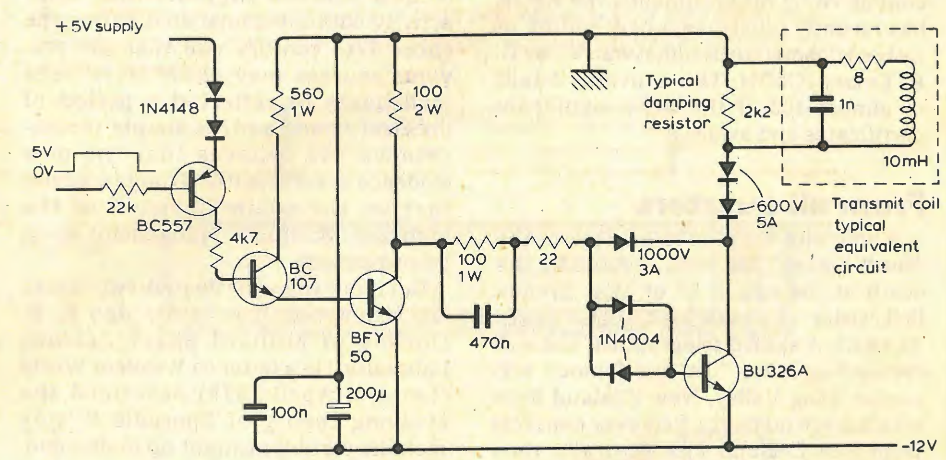


Fig. 15. Pulse generator. Two circuits are needed, one for each polarity input.

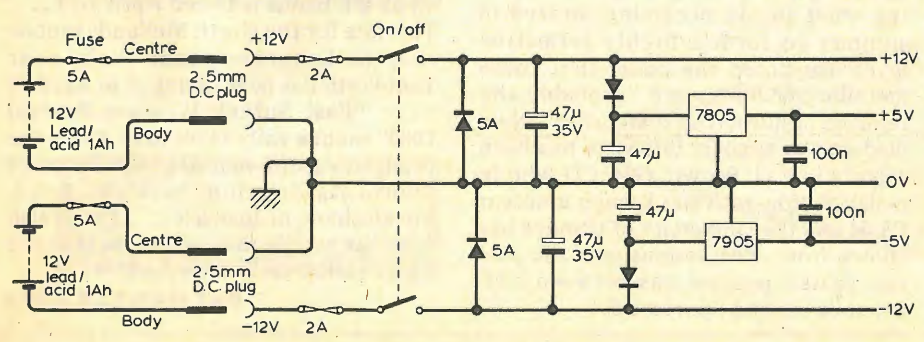


Fig. 16. Power supply.

WORLD OF AMATEUR RADIO

Awards and certificates

Are the awards and certificates available to amateur operators who can show evidence of two-way contacts with stations in specified areas, countries and even "squares" a help or a hindrance to the hobby? Most of us, even those who seldom seek to acquire the many "parchments", tend to accept them as an inherent part of a hobby that sets great store in achieving the utmost in performance in h.f. and v.h.f. bands. There can be few h.f. operators who could honestly say they did not get a kick from claiming to have "worked all continents" or qualified for the DXCC (100 countries). But questions arise when every local club begins to issue awards.

One long-time critic of the furiously competitive "dx-chasing" that may be encouraged by awards has been Bill Scarr, G2WS. In his presidential address to the RSGB in 1950 he claimed: "Much more would be achieved if the amateur could shake off his feverish thirst for "dx" which in its most sinister form can transform him into a scarcely human animal devoid of all sense of time and utterly lacking in consideration for his family or his fellows".

That was 30 years ago but I see from *Radio Communication* that he is still as critical as ever of such practices, particularly of what he refers to as the new parlour game of "working squares" (squares on a map) which he compares to collecting the numbers of railway engines or cigarette cards! For those not convinced by his arguments, the RSGB has recently published a new edition of its book "Amateur Radio Awards" by C. R. Emary, G5GH. This provides details of almost 100 of the more significant certificates and awards.

From all quarters

A link with the pioneering says of the "short waves" has been severed by the death at the age of 87 of Miss Brenda Bell, sister of Frank Bell, Z4AA (later ZL4AA). A skilled telegraphist, she was "second operator" at this famous station at Shag Valley, New Zealand from which were made the first ever contacts from New Zealand with Australia, then North America and then in 1923 with Cecil Goyder at the Mill Hill school station. She was in sole charge of Z4AA when in 1927 contact was made with South Africa, considered the most difficult "dx" feat from New Zealand. In 1979 she received the Queen's Service Medal.

Deaths of two other well-known "old-timers" have been reported: Edward Redington, W4ZM who built his first equipment in 1911 and was for many years Instructor-in-Charge of the U.S. Coast Guard Radio Engineering and Maintenance School; and Dr Bensley, G2UN, an early v.h.f. enthusiast with particular interest in long-distance television reception, regularly viewing French 819-line transmissions from Paris some 30 years ago.

The suffix /MA is used by British maritime mobile stations when the vessel is berthed, moored or anchored. The suffix /MM is used only when the ship is at sea.

RSGB is preparing to make application to the Home Office for the licensing of a further batch of v.h.f./u.h.f. repeaters. I am not sure how I should react to the rumour that one group is applying for the callsign "GB3VA".

Propagation speculations

For several years, many of the most intriguing speculations on the forecasting of sunspot activity have been based on the belief that there was a "Maunder Minimum" during the years 1645-1715 when little or no visible sunspot activity was recorded; a period, as many have pointed out, which coincided with the mini Ice Age in Britain. Much of the evidence for this has stemmed from examination of the naked-eye sunspot records kept over many centuries in China and the Far East. Now, however, this whole concept has been challenged by Christopher Cullen in a letter to *Nature*. He points out that examination of new sources suggests that solar activity continued unabated during the entire 17th century and that the previous sources may either have been inadequate or reflected a period of political chaos and/or simple incompetence. He believes that the new evidence is sufficiently strong to advise that on the whole question of the Maunder Minimum "judgement must be suspended".

But if one theory is dented, two others are reinforced. Two years ago E. B. Dorling of Mullard Space Science Laboratory in a letter to *Wireless World* (Letters, April 1978) described the evolving theory of Sporadic E: tiny metallic particles caught up in descending wind shears becoming ionized in summer to form a highly reflective layer. He noted the belief that these metallic particles were "probably the remains of burned up meteorites". New evidence to support this view has been reported by G. Brown, GJ41CD who in collaboration with the French amateur F8SH and the University of Dundee has shown from observations over the past two years a positive link between meteor showers and Sporadic E.

Again, many years ago Dennis Heightman, G6DH, noted the enhancement of signals on frequencies as low as 3.5MHz arriving in Clacton along sea paths during those weather conditions which gave rise to tropospheric ducting on v.h.f. But the possibility that h.f. signals are subject to super-refraction and ducting seems to have attracted the attention of professional researchers only within the past few years. Now however in *Radio Science*, R. A. Pappert and C. L. Goodhard provide convincing evidence that super-refraction ducting occurs on sea paths on frequencies from 20MHz upwards. Experimental work by P. Hansen on a 235km sea path off the coast of California has shown enhancements up to 20 dB over standard ground wave signals.

Amateur satellite news

NASA has formally agreed to include the first British amateur satellite UOSAT as a secondary payload on the Thor-Delta launcher for the Solar Mesophere Explorer project, provisionally scheduled for September 30, 1981. UOSAT is being built at the University of Surrey with additional help from amateurs working in the space industry, Science Research Council etc. A "breadboard" model is due to be completed by about August to be followed by an "engineering" prototype by the end of this year.

The first Phase III amateur satellite is now due to be put into a highly elliptical orbit about the end of May. A Russian amateur satellite(s) has been predicted for early this year, possibly by the time these notes appear.

In brief

Transatlantic 50MHz signals continued to be well received in the UK during the first half of January .... An Australian 50MHz two-way record has been confirmed between VK5KK and XE1GE, Mexico, a distance of over 14,000km .... George Cole, G4AWI who lost his sight on active service in Italy during 1943 has been made a member of the First-class Operators Club .... The GB2RN station on board HMS Belfast, moored near the Tower of London, will be active on all h.f. bands between April 4-13 .... The date for the North Midlands mobile rally at Drayton Manor Park, near Tamworth has been changed to April 13 .... "East Suffolk Wireless Revival 1980" mobile rally is on May 25 on the usual site at Ipswich Area Civil Service Sports Association, Straight Road, Bucklesham, nr Ipswich .... The Welsh amateur mobile rally will be held at the Barry Memorial Hall on April 20.

PAT HAWKER G3VA

Mercury switch for parallel-tracking pickup arm

Switch detects 0.2 degree movement

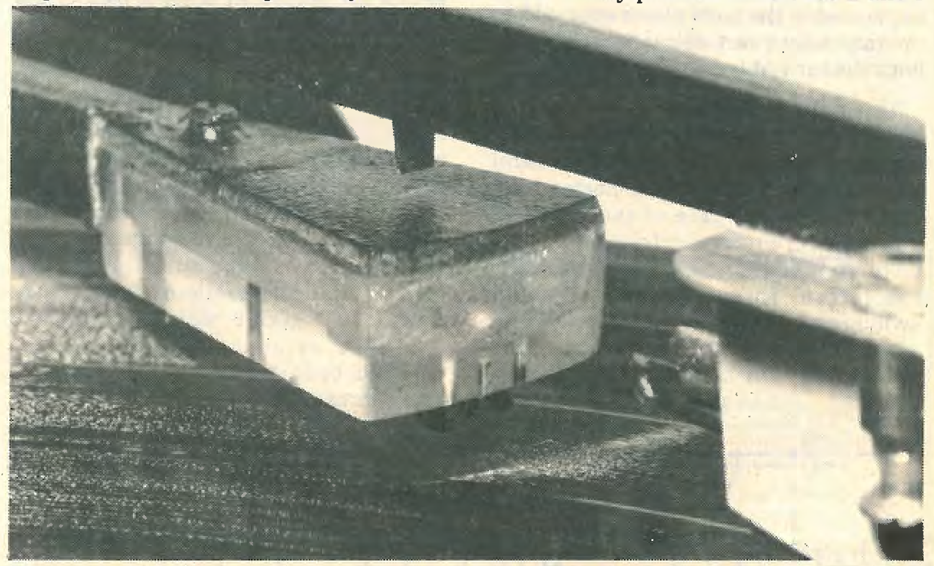
by Rod Cooper

The parallel-tracking pickup described in the January issue was originally designed to be operated by a mechanical switch. The author thought that a mechanical switch could solve some of the problems which beset opto-electronic parallel-tracking pickups, namely complexity and lack of reliability. A successful record deck was built using a mechanical switch based on mercury as the switching medium, used in a novel configuration.

The design problem was that a switch didn't exist that could detect a movement of 0.2 degrees, that was free of hysteresis, and imposed no appreciable load on the tracking arm. The criterion of 0.2 degrees was chosen after consideration of record eccentricity, as discussed in the earlier article. The ready availability of a p.t.f.e. coating material, Vydax, which is described later, provided the means of realising a very accurate mercury switch.

The principle behind the switch is as follows. Due to its high surface tension, a ball of mercury of about 0.1in diameter is an almost perfect sphere. This makes it an excellent target for a horizontally-moving electrode, provided the highly mobile mercury can be held in a stable position. Fortunately this is easy to do without sacrificing its properties as a target electrode. A mercury spheroid of this size will easily roll down a p.t.f.e.-coated slope of only two degrees, and so can be precisely located at the bottom of a shallow V-shaped trough. A pivoted pair of electrodes can now touch either side of the spheroid, and this is the basis for a s.p.d.t. switch with centre-off position.

Fig. 1 shows the layout in diagram form. Freely pivoted electrodes E and F



Mercury switch fitted to tracking arm as an alternative to the opto-electronic sensor in the parallel-tracking arm.

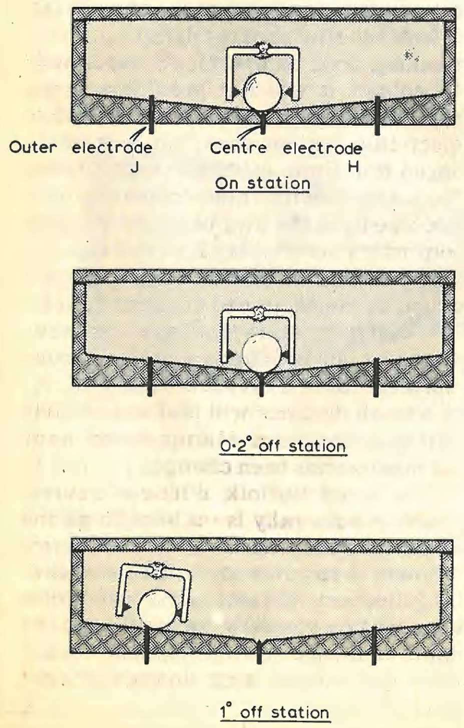
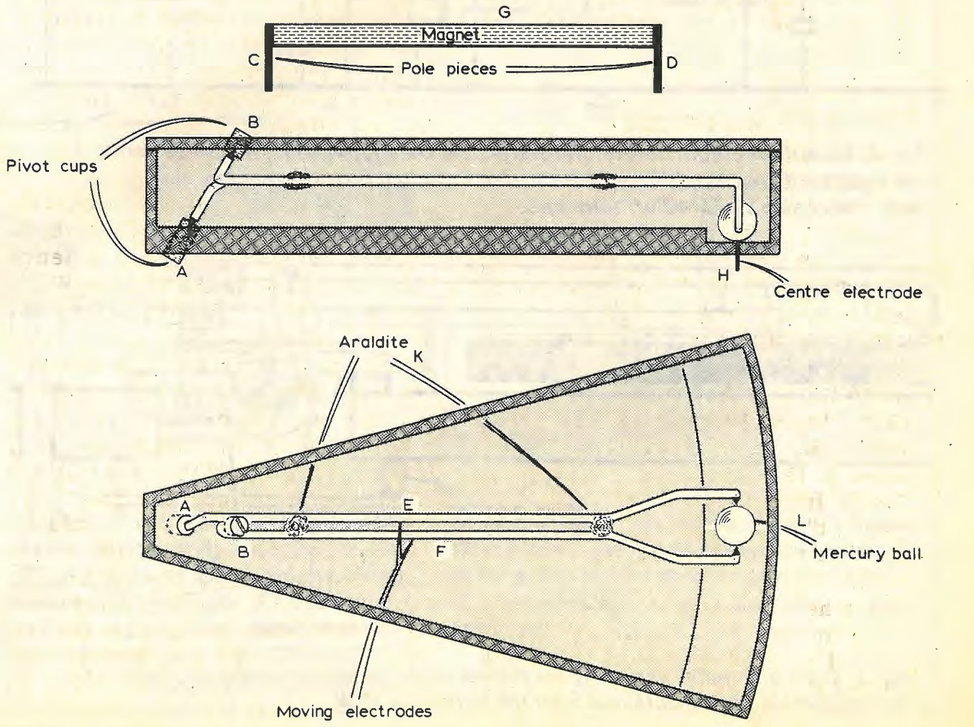


Fig. 1. Magnet G is located within pickup arm. Movement of the polepieces, shown protruding in the photograph, causes nickel electrodes to contact mercury spheroid.



are held in exact position by a small magnet G which is attached to the tracking arm so that in the central position neither electrode touches the mercury spheroid. A small displacement of the electrodes caused by movement of the magnet to either left or right causes contact with the mercury and completes a circuit via electrode H. It is worth noting at this point that small vertical movements of the magnet do not affect the electrodes E and F, neither do small fore-and-aft movements. This is all to the good, as movement in these directions can only arise from play in the suspension of the arms.

If the tracking arm over-runs the proper position, i.e. the servo-motor does not correct the displacement quickly enough, then the electrodes E and F will roll the spheroid up the inclined plance. Further electrodes J are implanted in the path of the spheroid to operate a cut-out relay which stops both the turntable and the servo-motor.

The only forces acting on the cartridge with the switch in or near the central position are the minute lateral forces required to press the electrodes E and F into the surface of the mercury, and to overcome the friction of the pivots at A and B. For practical switches the lateral force needed for clean switching is of the order of 10 mg. This is a truly negligible force when one considers that on a conventional arm needing anti-skating compensation, which is in the region of 200 mg per 1 gm of tracking force, optimal correction to within 10 mg is seldom achieved. Furthermore, the dynamic variation in skating force can be around 50 mg depending on stylus tip geometry, recording modulation level, etc. Besides this there are other adverse dynamic forces due to record warp, and groove eccentricity, plus frictional forces from the arm pivot, all of which are probably larger at some stage during the playing of a record than the mere 10 mg needed to work the switch. So this small force can be ignored for all practical purposes.

The force needed to make the switch operate in the over-run position is larger — about 50 mg — but this presents no problem for either cartridge or record surface, and in any case is only encountered on the run-out groove at the end of the record, or if some part of the servo-system malfunctions.

The presence of p.t.f.e. to form a running surface for the mercury is essential, as the high surface tension mentioned earlier would make the spheroid stick to the sides and bottom of the trough. Switches constructed without p.t.f.e. have proved worthless for this application. The Dupont company manufacture a type of p.t.f.e. called Vydax which is particularly suitable. Vydax is a stable wax-like polymer available as an aerosol, and when sprayed onto most surfaces forms a semi-transparent, dry, adherent film with an exceptionally low coefficient of friction. The long-term chemical properties are good — it does not decompose or turn gummy, and is unaffected by mercury.

Surface tension also poses problems where the electrodes come into contact with the mercury, and for this reason the electrode tips are sharply pointed.

The electrodes are made of nickel as this is the only commonly available metal with the necessary properties i.e. low solubility in mercury (only 2 × 10-6 wt %), strongly magnetic, resistant to oxidation, and easily worked into the required shape. Iron may be a satisfactory material, but has not been tried in practice.

As the regions where the electrodes touch the surface of the mercury are essentially point contacts, with low current-carrying capability, the servo motor cannot be driven directly. A simple circuit for controlling the motor is shown in Fig. 2. In this system, the servo motor runs at the usual pre-set speed (as discussed in the earlier article) until the tracking arm is 0.2 degrees off-station, when the mercury switch will operate and either raise the voltage to the motor or reduce it to zero, depending on which side of the switch the tracking arm is in error.

To prevent oxidation of the mercury, the switch capsule was filled with gas (Propane works quite well and is easy to obtain).

Regarding the mechanical layout, this is very similar to that of the opto-electronic system already described, except that the reference arm is now attached to the lower part of the gimbal ring, and carries the mercury switch, Fig. 3. The tracking arm carries a miniature magnet over the top of the switch. The reference arm inertia is added to that of the tracking arm in the vertical plane. However, the position is no worse from this aspect than that of the conventional arm, as the extra mass offset by the shorter length of the tracking arm, as previously explained. Of course, it will not provide a large reduction in inertia as the opto-electronic system does, but it is envisaged that there are other applications for a switch with these properties, not necessarily in the field of record-players — proximity switching for example.

The switch is not difficult to construct, as the captioned diagrams show. It is not necessary to have inclined pivots as shown in the diagramatic representation, as vertical pivots offset by a small distance will perform just as well over small angles of operation, and are much easier to construct.

Care is needed in handling mercury, which is poisonous by skin absorption and when the vapour is breathed in. Mercury is surprisingly volatile and the lungs are very efficient extractors of the vapour. Work should be done out of doors and any spillage cleared up at once and dusted with flowers of sulphur. □

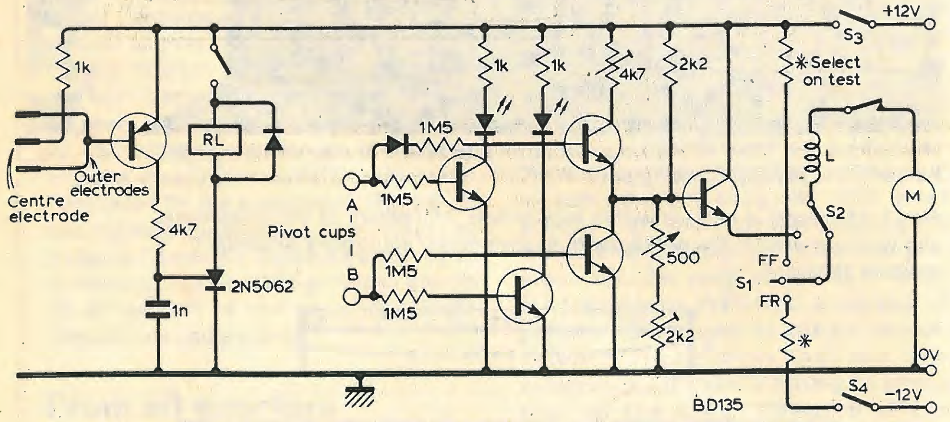


Fig. 2. Except for output device, transistors are Darlington pairs, MPSA65 for the thyristor driver, and MPSA12 for the rest. Switch S_2 is operated by cueing lever. Relay also switches off turntable.

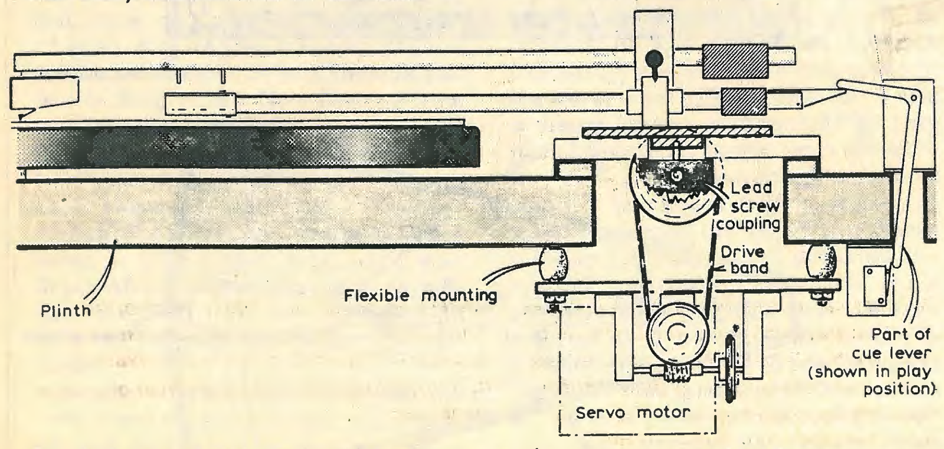
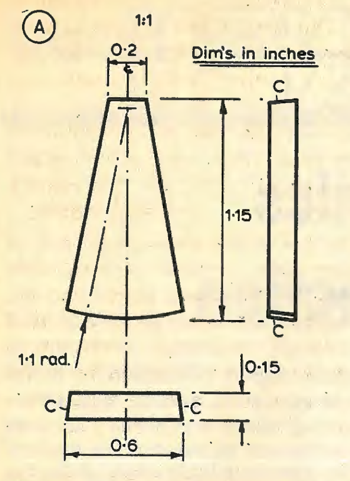
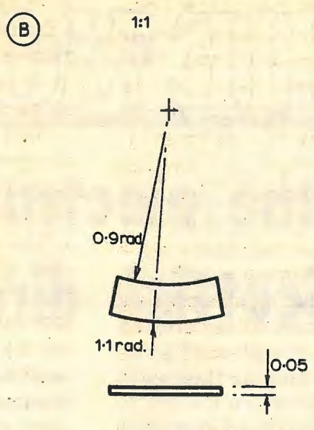


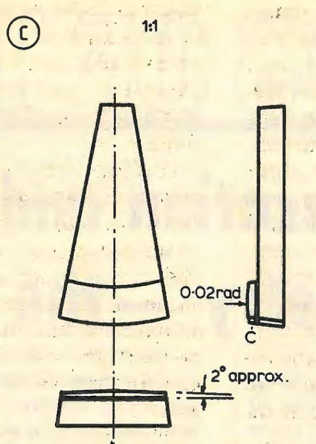
Fig. 3. Track and motor assembly are similar to opto-electronic version. Pivot and arm details can be obtained from the author via WW.



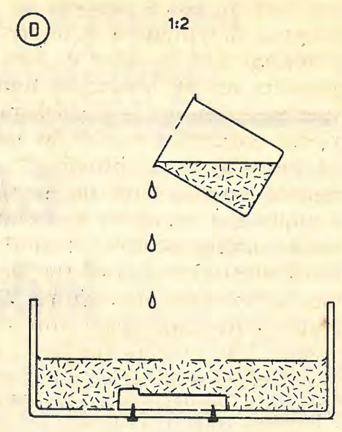
Cut and shape brass plate 0.15in. (approx. 5/32in.) thick to shape. Chamfer sides at places marked C to facilitate release from mould later.



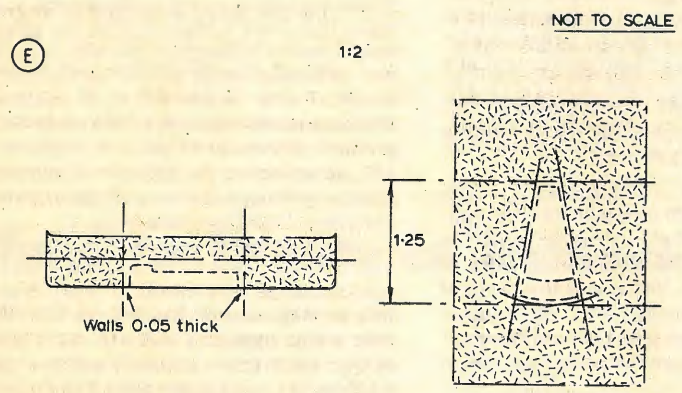
Cut and shape brass plate 0.05in. thick to shape.



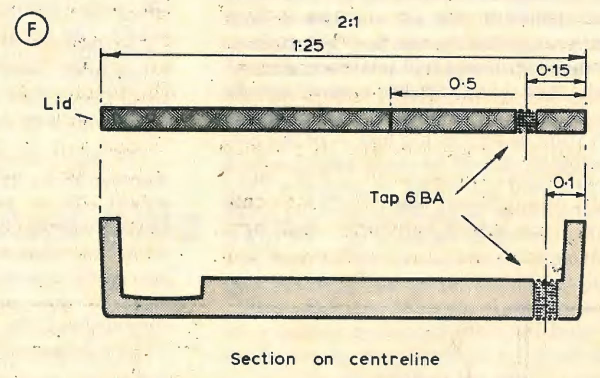
Solder B to A in position indicated. File two-degree slope on top side of B. Polish to mirror finish overall.



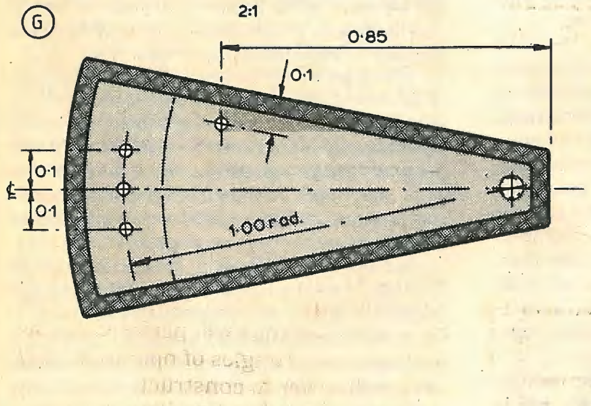
Coat brass pattern with p.v.a. release agent and allow to dry. Fix to bottom of Strand Glass mould tray with self-tap screws and washers. Pour in catalyzed resin C, prepared as detailed in Strand data sheet 4.



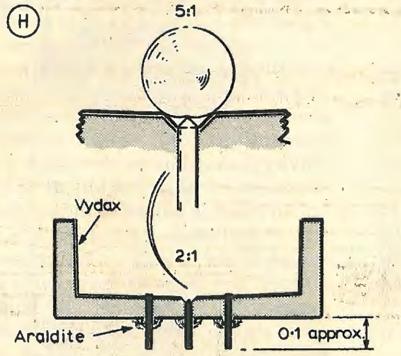
When resin has solidified, knock out brass pattern. File off excess resin to shape shown. A "grizzly disc" attached to an electric drill does this in a few minutes.



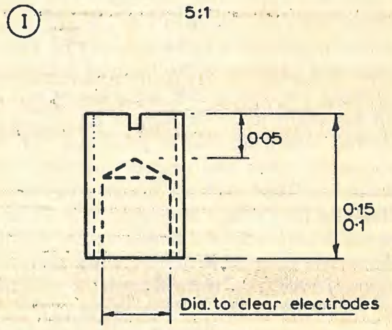
Drill and tap a 6BA thread as shown. Make a two-piece lid for the switch case from a piece of incudled fibreglass p.c.b., and drill and tap this 6BA also. Pivots are not slanted as shown in Fig. 1. but vertical and off-set instead.



Drill three holes to suit guage of nickel being used. A filler hole 8BA is also made in approximate position shown. Polish switch case with grade 600 wet and dry and then Strand glassfibre compound. Plastic should then be transparent.



Countersink centre electrode hole. Mask off areas except channel and spray with light, even coat of Vydax aerosol. Allow to dry, insert electrodes. Adjust centre electrode to give mercury ball a stable 3-point suspension. Adjust outer electrodes so that they only just project above surface. Araldite all three in place.



Make two pivot cups from a piece of 6BA steel screw. Sizes given are approximate as cups will be filed down to give exact fit. It is therefore best to start with an over-size pivot cup.

Continued on page 88

NEWS OF THE MONTH

Education and the electronics industry — the Scottish direction

In his inaugural lecture as Professor of Electrical Engineering at the University of Edinburgh recently Professor Jeffrey Collins called for a co-operative partnership between universities, colleges, industry and government. This would produce more skilled manpower, he said, and result in improved products employing microelectronics techniques, regenerating Scottish industry and improving employment prospects. This would be done by building on the established base of Scotland's central belt, "the major chip manufacturing area in the UK."

The new technologies of the 1980s and particularly the confluence of microelectronics, communications and computing could, he believed, offer a lifeline to economic prosperity over the decade, but "solutions to our present problems will not come easily." To make sure that the public understand the economic potential as well as the threats — job creation as well as job loss — of the new technologies, it will be necessary for both engineers and scientists to improve their communications skills and to join the battle for public understanding.

"Further educational resources are needed," he said, "resources which can ultimately only be paid for out of the profits generated by manufacturing industry, to which we in the universities must contribute through creative engineering."

The Scottish electronics industry grew mainly in the immediately post-war years as major American firms such as Honeywell and I.B.M. established factories, initially to manufacture products developed elsewhere but later making use of local research expertise in product development.

Firms also started on local initiatives such as the Edinburgh-based Nuclear Enterprises (now part of Thorn/E.M.I.) and some of the founders, having sold out to larger combines, had now become "second phase" entrepreneurs in different markets. There is now a group of some 60 small firms ...... "significantly, they are predominantly run by electronics engineers," which are very successfully exploiting new or limited sectors of the market overlooked by the larger corporations. This group is actually and potentially very important because American experience between 1960 and 1976 showed that small firms were responsible for generating two thirds of all the new jobs.

The Scottish electronics industry, which employs about 35,000 people in all (the equivalent of one Texas Instrument plant in Dallas) contributes £500 million in sales to the British economy. Yet despite this range of successful developments, Scottish industry as a whole has not yet taken full advantage of the excellent chip manufacturing facilities on its own doorstep.

Turning to the responsibilities of government and the central agencies, Professor Collins observed that the 1979 Booz, Allen and Hamilton Report, commissioned by the Scottish development agency, had shown quite clearly that, as lower-level jobs were lost, there was an increasing "up market" demand for those with higher-level skills. Yet the government was now cutting the level of funding to the universities. As a result, in Edinburgh University the engineering intake is not being allowed to expand. However, the number of well-qualified schoolchildren applying for electrical engineering and computer science courses continues to expand — 30% up on the 1979 figure.

The attitude of the British Government stands in sharp contrast to the prompt action taken in Ireland where, in 1979, the government created more than 150 new academic and technician posts in the universities. In contrast, the recent U.G.C. initiative in microprocessor education in Britain would produce only about 80 posts throughout the UK, as opposed to the 200 posts which would have to be funded in Scotland alone to match the scale of the Irish initiative.

Professor Collins went on to emphasise the valuable link between universities and manufacturers as a means of ready transfer of staff expertise based upon a workforce with a high degree of skill. Hewlett Packard at Queensferry for example, have 90 r. and d. staff out of a total of 800 and a 50% growth in sales of new products.

As the 1980s progressed, he said, the effect of microelectronics would spread more widely. "Authors will write via word processors, artists, will draw by means of interactive graphics and composers will use frequency synthesisers." Electronic mail and money transfer will largely replace currency forms and Texas Instruments, a company successful in producing innovatory products (stylophones and speak and spell machines, etc) have recently established a new breed of "chip shop", which concentrates on selling products based on microelectronics.

This type of expansion into retailing is, in Professor Collins' view, another example of the "vertical integration" which is becoming necessary in electronics both in industry and education. In industry, the creative and effective applications of microelectronics to particular products could not be achieved simply by incorporating standard chips.

In summing up he said, "Nothing could be further from the truth .... than that the UK does not need a microelectronics industry or that the commonly held position, 'give me a microprocessor, apply it and the products fall like apples from the trees' is necessarily valid. As in industry, so in education .... "our philosophy at Edinburgh is entirely based on vertical integration, from basic materials right through to "systems on a chip". Edinburgh appears to be the only university doing this and simultaneously tackling teaching, training, long-term research, consultancy and the generation of microelectronics products for manufacturing industry."

Digital telecine by 1985

According to a paper presented at the Society of Motion Picture and Television Engineers' 14th annual conference in Toronto, all-digital telecine machines may be a reality by 1985.

Richard Sanders is the head of the Image Scanning Section in the department and he and his team have developed an all-digital telecine which he claims produces "an exceptionally clear and uniform picture." The sensor is a 1024 element linear array which scans the film image in sequence at 24 or 25 frames/s to produce a single 625 or 525-line sequential output which is then stored in digital form. The information in the field store is then modified and read out to provide the conventional 625-line, 50 fields/s or 525-line, 60 fields/s interlaced video signal.

The processing stages in a telecine machine include matrix colour correction, gamma correction and aperture correction. In order to carry out these processing activities by digital means the dark areas of the picture must be coded to 11-bit sample accuracy. The BBC research team has devised a practical alternative to a full 11-bit analogue-to-digital converter by providing an 8-bit a-d.c. with its signal pre-amplified by a factor of eight. This second a-d.c. contributes three additional bits whenever the signal falls below 12.5% of peak white.

A further contribution to the "clear and uniform" pictures arises from the correction process needed for the linear sensor array. Corrections for element-to-element sensitivity variations in the linear sensor, unevenness in illumination at the gate and colour shading can all be entered into a single line digital store each time the telecine is reloaded; the correction coefficients are then simply applied as part of the digital processing run. Stability and simple adjustment should made the digital telecine very attractive.

Richard Sanders claims that the current trend in camera design for lightweight heads using economical analogue l.s.i. signal processing cannot yet be matched by digital circuits which need more space and consume more power. However, his paper also takes a look at the fully digital studio and foresees a "period of steady expansion of digital techniques into what is at present regarded as undisputed analogue territory."

Racal gets Decca

After several weeks of speculation about which of the two "giants", Racal or G.E.C., would finally win the battle for Decca, an equity offer by Racal worth £103 million secured the deal for Racal on Valentine's Day, Feb. 14th. The equity offer was backed by a cash alternative of £100.7 million, which was less than G.E.C.'s best offer at £106 million but the issue was decided by Racal Electronics' claim that it had had irrevocable acceptances from enough Decca shareholders to give it voting control.

The speculation about Decca began in the early part of January 1980 after the company's attributable profits had fallen from £10 million in 1976 to £1.4 million in 1979. By contrast, Racal's pre-tax profits had rocketed from £9.56 million in 1975 to £226 million in 1979. Observers have seen the source of Decca's ills as bad management linked to a not-large-enough tv business and a too-classical record division tagged on to its radar, navigator and electronics warfare sections. Increasing competition from the US and Japan, added to the fall in markets for world shipping also had their effect.

The City's response to Racal and Decca, personified in Racal's Ernest Harrison and Decca's Sir Edward Lewis, who, sadly, died in his sleep on 29th January before any of the issues were decided, could hardly be more diverse. How much of Decca's failing fortunes could be attributed to the City's lack of confidence in Sir Edward's patrician chairmanship is of course debatable, but there is no doubt at all about the widespread confidence in Racal itself.

Decca had been born 50 years ago when Sir Edward Lewis's finance company (he was a non-technical chairman) floated the new company in January 1929. Under his leadership the company went from strength to strength, surviving the depression and expanding into electronics. Its record company's heyday was in the 1960s and early seventies, when its catalogue included stars such as the Rolling Stones, Engelbert Humperdinck and Tom Jones and in the early 'sixties Decca and E.M.I. dominated both classical and hit-parade record sales.

Today, the only Decca record in the hit parade is a re-issue of "Knights in White Satin", by the Moody Blues, first recorded in the early sixties.

The competitors' view of Decca's "problem" is that it had a good range of products on which it made too small returns. It will be interesting to note exactly how Racal's more dynamic approach will modify these "good" products, in the light of the fact that Ernest Harrison is on record as having said that it is his intention to take over his competitors and create a "second force" to rival G.E.C.

First ITU regional administrative conference opens

Some 250 delegates from 28 member countries are attending the first regional administrative medium frequency conference of the International Telecommunication Union (ITU) in Buenos Aires. This session will deal with technical and operating criteria and planning methods which will serve as the basis for the second session of a frequency assignment plan for the m.f. broadcast band in region 2 (the Americas — 535 to 1605kHz). The session began on 10th March and the next will begin in November 1981.

Change of address

Suppliers of a wide range of semiconductor devices to both the trade and consumer markets, Semiconductor Supplies International are now the official Teledyne Semiconductor stockists in the London area. The company, which was formed in 1968 and previously traded in Wallington, is now situated in Dawson House, Carshalton Rd, Sutton, Surrey. A full stock list and catalogue are available on request.

World conference on transnational data flow policies

The repercussions of the growth of data networks operated by transnational companies, time sharing services, carriers, governments and other international organizations, are being felt in both industrial and developing countries.

A world conference is being held in Rome from 23rd to 27th June 1980 to discuss the technical, regulatory, economic and social implications of transborder data flow. This will be the first opportunity for representatives of governments, business users, carriers, suppliers and services to participate in an informal forum which it is hoped will realistically assess the status of data flow developments and look at the legal and social implications, the regulatory environment and interdependence caused by the global nature of modern communications systems.

The conference has been set up in response to a resolution adopted by the intergovernmental Conference on Strategies and Policies in Torremolinos, Spain, in 1978, which was attended by 78 national delegates.

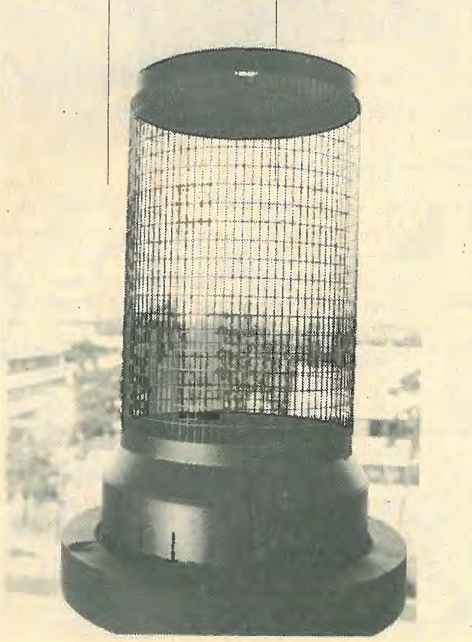
Individuals or organizations wishing to participate or present papers should write to the IBI, PO Box 10253, 00144 Rome, Italy.

Methane yields improved transmitting valve grids

A form of graphite known as "pyrographite", formed by the decomposition of methane at very high temperature (1900°K) is being used by Siemens as the constructional material for grids in high power transmitting tetrodes. The process involves deposition of graphite on the surface of a cylinder, the final cutting of the grid structure being carried out by a laser beam.

Siemens say that the method yields grids of very smooth contour when compared with sand-blasted control grids. Pyrographite has proved to have great dimensional stability in continuous operation and in addition graphite already exhibits neutral emission characteristics, emitting few electrons as a result of thermal excitation. Similarly, its low secondary emission properties make it preferable to wire or sheet metal grids, which have to be specially treated if their secondary emission features are to be controlled. Graphite remains free of grid currents even at high transmitter power.

At the moment these graphite grids are being used in tetrodes made by Siemens for short, medium and long wave transmissions.



The smallest in the range is the RS2054 (100kW) which has grid dimensions of 90mm diameter by 170mm high, while the largest has a continuous power rating of 1,200kW (the RS2084 SK). The grid developed for this model has dimensions of 21cm diameter by 45cm high.

The small external dimensions of these tetrodes, minimal stray capacitance and the advantages related to secondary emission performance combine to make them highly efficient. Although methane is being used by Siemens, other hydrocarbons may be employed for this process.

A Siemens pyrographite grid for a power tetrode. During normal working the valve may have to dissipate 100kW or more, with the cathode and grid operating at a temperature of 2000° K. The actual grid filaments are only a few tenths of a millimetre in diameter.

Citizens' Band moves

The lobby for citizens' band radio in the UK has been regrouping in the hope of putting stronger pressure on the government. One important move has been the formation of a National Committee for the Legalization of Citizens' Band. This combines the efforts of all the smaller bodies (such as the Citizens' Band Association) to make one large pressure group for the whole of the UK. Chairman is Theo Yard, a councillor at Lewisham, and treasurer is James Bryant, president of the CBA. C.b. clubs with at least 100 members are encouraged to join. A meeting of the National Committee was held in Cheltenham on 16th March.

In addition, the Citizens' Band Association has applied to the Radio Regulatory Department of the Home Office for a licence for a private mobile radio (p.m.r.) communication system — the kind of licence issued to taxi firms, etc. Ostensibly it is for a self-help group of motorists, the principle being that it will help to save fuel, but the CBA sees it really as a "foot in the door" from which a larger system may grow. Initially it is intended for about 50,000 users, but the Association says it hopes to get about a million users in 2½ years. According to James Bryant, lawyers have advised the CBA that the Home Office cannot refuse to give such a licence, but at the time of going to press the Association had not even received an acknowledgement of its application.

Finally, the CBA has written to the Home Secretary, telling him that the government need not worry about appointing extra civil servants to administer a citizens' band radio service. The Association is willing to provide the staff to do this. Their accountants have told them they would have no difficulty in raising the money to form a limited company to take on such a staff.

Noogami Electric announce unique device

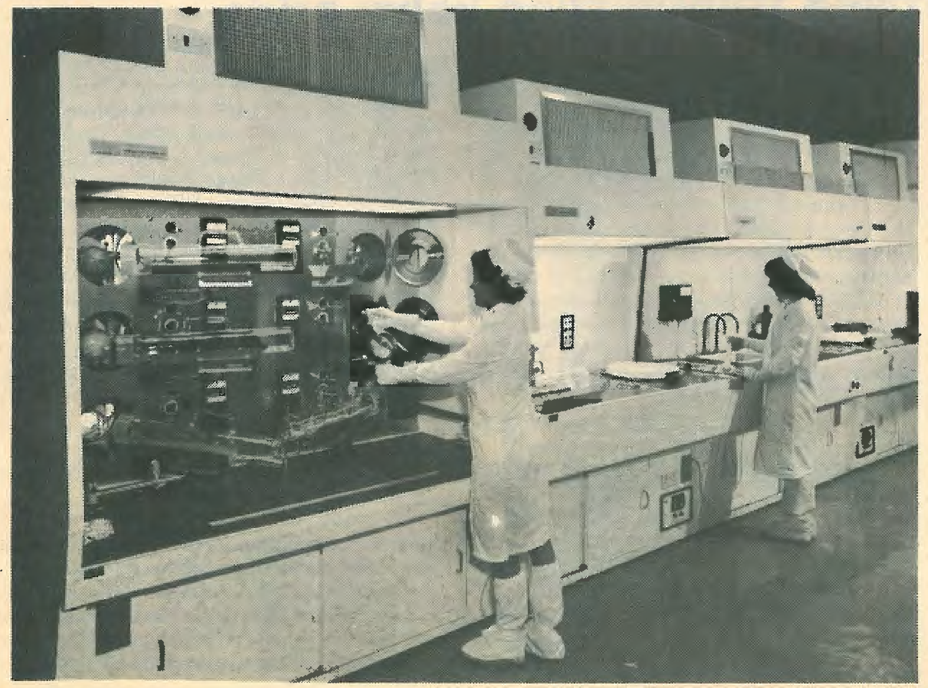
THE British subsidiary of the Japanese Noogami Electric Corporation has recently announced the introduction of a "first" in the linear device field. The item results from a ten-year test programme which enquired into base conducting materials and takes the form of a current-controlled, bi-directional circuit element of outstanding electrical properties.

Although the full method has not yet been revealed, *Wireless World* believes that the heart of the forming process is the mechanical extrusion of a medium-weight element. A significant advance in this device is the coating of the extrusion with a second non-oxidizing alloy which prevents the progressive degradation of the primary (host) extrusion. This symbiotic amalgam overcomes traditional short, medium and long-term "life" problems associated with earlier primitive forms.

The device is claimed to exhibit extraordinary electrical properties such as a totally flat frequency response from d.c. to 100GHz (ignoring skin effect losses), good thermal tracking, fast rise time and virtually no propagation delay. No distortion is introduced by the device.

Packaging consists of the now-standardized axial, horizontally-opposed terminations. Designated ERIW-FO-1in, the new device can be used in conjunction with a resistance and load to form a simple voltage dropping circuit; it is claimed to be ideally suited to applications where virtually unimpeded current flow is required.

The new conducting device undergoing extensive environmental tests in the manufacturer's "clean" room at Yokohama by English workers in training. Staff are checked for stray capacitance before entering the area.



NEWS IN BRIEF

A display of early wireless equipment, under the general title of "Broadcasting in the Twenties and Thirties", will be held at the Admiral Blake Museum, Bridgwater, Somerset, starting on 8th April 1980. The display is intended to provide a view of some of the hardware of pioneering days in broadcasting.

The IEETE has a series of lectures and other events planned for March and April 1980. On 27th March the Finniston Report will be discussed at a meeting in the Ariel Suite, Royal Angus Hotel, St. Chads, Queensway, Birmingham, starting at 7.30 pm.

On 2nd April, **"Electric Vehicles, Present and Future Technology,"** will be presented by M. Appleyard, manager of the vehicles Eng.motive power group, at the Polygon Hotel, Southampton at 7.30 p.m.

On 10th April, P. Kimber, senior engineer GADEC project, Seaboard, will present **"Computer Assisted Distribution Engineering Control,"** at the Sussex County Cricket Club, County Ground, Hove at 7.30 p.m.

On 11th April Professor A. J. Ellison will present **"Extra Sensory Perception — Fact or Fallacy?"** at Swansea University starting at 6.30 p.m.

On 17th April, **"Electrical and Electronic Engineering Design — Education and Training for Tomorrow,"** (speaker to be confirmed) to be given at the IEE building, Savoy Place, London WC2 at 10.15 a.m.

On 21st April **"Electrical Safety at Work"** will be presented by P. E. Whitby, senior inspector of factories, at the MANWEB headquarters, Sealand Rd, Chester at 7.30 p.m.

On 23rd April, the **Plessey PDX System** will be introduced by S. J. Gracie of Plessey Communications and Data Systems Ltd, at the Barry College of Further Education, Barry, at 7.30p.m.

On 24th April, **The Jet Project** will be discussed by the director of the Jet Joint Undertaking, Dr H. O. Wuster, at the Oxford College of Further Education, Oxpens Rd, Oxford, at 7.30 p.m.

The Department of Electrical Engineering Science at the University of Essex will be running its annual electronics **Summer School for teachers** between 7th and 11th July 1980. Three courses will be run simultaneously; the linear circuit design course is concerned with the use of transistors and operational amplifiers in analogue applications and the basic elements of the hi-fi amplifier are considered in detail. The digital circuit design course looks at the use of the transistor as a switch and develops design using integrated logic circuits. The Electronics systems course is related to the A.E.B. "A" level in electronic systems. Topics are varied and are fully supported by laboratory sessions based upon the "A" level experimental boards and special emphasis is placed on communications systems.

NEWS IN BRIEF

As the author and commentator of the tv series "The Mighty Micro," Dr. Christopher Evans brought the chip to the attention of the "masses". Sadly, he died before the series was completed and in commemoration of his contribution as a communicator of the vital interactions of society and technology, a seminar on the subject of "Microprocessors and the Future" will be held in the Fyvie Hall, Polytechnic of Central London, 309 Regent St, London W1, on 29th May 1980 starting at 2 p.m. Tom Stonier will be introducing the seminar and he will be accompanied by a member of the National Physical Laboratory staff, where Chris Evans had held a senior post. Applications should be made to the London Regional Management Centre for free tickets for the session.

The Byte Shop assets have been acquired by Comart (Computer Mail Order and Retail) Ltd, and the original premises in Tottenham Court Rd, Ilford, Nottingham, Birmingham, Manchester and Glasgow are to re-open fully staffed by the personnel running them before the Official Receiver became concerned with the original company. The new company is to be called "The Byte Shop" and all branches are currently being re-stocked with microcomputers and systems for off-the-shelf delivery. The Byte Shop will operate as an entirely separate business within the Comart group and the company intends to retain its independent dealer network.

A new company, called Monolog Systems, has been set up in Guildford, Surrey. The company is interested in the application of microelectronics to industrial projects and will be offering turnkey microprocessor systems for industrial applications.

The **10th European Solid State Device Research** conference will be held at the University of York from 15th to 18th September 1980. The main aim of this conference is that of bringing together scientists and engineers working in the broad field of solid-state devices and to provide a European forum for the presentation and discussion of the latest research and technology.

A conference on **low-frequency noise and hearing** is to be held from the 7th to the 9th May 1980 in Aalborg, Denmark, under the sponsorship of the Federation of Acoustical Societies of Europe, The (British) Institute of Acoustics, the Danish Acoustical Society, the Danish IEEE, the EEC and Aalborg University Centre. The conference fee is 500Dkr and further imformation can be obtained from Henrik Moller, Aalborg University Centre, Box 159, 9100 Aalborg, Denmark.

Portsmouth Polytechnic is running a series of **courses on microprocessors** from 24th March to 18th July 1980. Details can be obtained from Mrs A. P. Sizer, Department of Electrical and Electronic Engineering, Portsmouth Polytechnic, Anglesea Rd, Portsmouth PO1 3DJ

Plessey and Anderson form "Signal Technology Ltd"

Two well known electronics giants, one well known in the UK, the other in the USA, have founded a joint venture company, to be known as "Signal Technology Ltd", based in Swindon, Wiltshire. The two companies involved are Plessey and Anderson Laboratories Inc., and the main expertise of the new company will be the design, applications and production of surface acoustic wave filters.

The company will concentrate on the market for military applications such as weapons and weapon systems, radar, cable tv, land-based and satellite communication equipment, plus land mobile radio installations. Signal Technology's production unit in Swindon contains facilities for dedicated computer-aided design and a full range of test and measurement equipment.

Both Signal Technology and Anderson will offer the same complement of products with Signal Technology serving UK and European markets and Anderson serving US and Japanese markets.

As a result of the pooling of Plessey and Anderson resources, the new company will commence business with a catalogue of over 200 products.

Obituary— Cecil Goyder

The death has occured in Princeton, New Jersey, USA, of Cecil Goyder who, until his retirement, was concerned with the United Nations communications and broadcast radio services. Previously he was engineer-in-charge of All India Radio but it was as a young engineering student at the City and Guilds Institute, Imperial College that, in 1924, he made an indelible mark on the history of short-wave radio.

As the operator of the Mill Hill Scoool wireless society's amateur transmitter, 2SZ, he succeeded at 6.15 a.m. on October 19th of that year in making the first direct two-way contact on low power with Australasia. The transmission wavelength was 80m and *Wireless World* reported the event under the headline, "Amateurs girdle the world – American papers please copy."

This contact and others over the next few weeks are regarded as a significant achievement in amateur long-distance working. There can be little doubt that Cecil Goyder's youthful success was bitterly resented by some of the leading amateur operators of the day, who had organized the trans-oceanic tests, including E. J. Simmonds, 20D, whose signals had been heard in New Zealand the previous day.

Cecil Goyder's contact was Frank Dillon Bell, Z4AA, of Shag Valley station Waihemo where, in 1964, a commemorative cairn was erected. Cecil Goyder was also responsible for the design of an early form of phase-locked variable oscillator known as the "Goyder lock".

Solar power study group meets

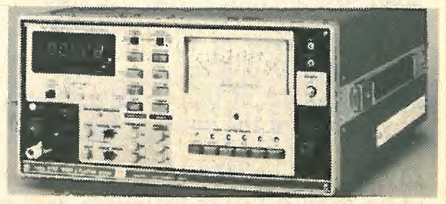
A study group which is to look at the implications of solar power satellites for British industry met at the Leatherhead base of Era Technology recently. This was the latest in a series of meetings bringing together specialists from Marconi Space and Defence Systems, Era Technology and British Aerospace. Also present were representatives from the RAE, Farnborough, which is funding the six-month study.

The proposed solar power satellite would convert solar energy into electrical energy and beam it by microwave to the Earth's surface where it would be collected at a ground station and then fed into the national grid.

Era's part in the activity is that of assessment of the transmitting and receiving antennas as well as the ground power conversion, control and national grid interface problems.

Kikusui—new in UK

Measuring instruments made by the Japanese firm of Kikusui are now sold and serviced in the UK by Telonic Berkeley UK, of Castle Hill Terrace, Maidenhead, a subsidiary of the American company Berkeley Controls, Inc. Kikusui is a relatively small firm, with a staff of about 200 and a turnover of £5.6 million, but the range of instruments it produces is surprisingly large. Telonic will hold in stock only a small part of the range, concentrating on oscilloscopes, function generators and several audio or l.f. test instruments, including an automatic distortion meter and wow-and-flutter meters. The 6702 wow and flutter meter shown indicates JIS, NAB, CCIR and DIN weighted readings, with separate wow and flutter indication. Sensitivity is sufficient to accept signals directly from a tape head. Both digital and analogue displays are provided and a memory function of up to 10s eliminates jitter, the digital indicator reading tape speed, frequency and frequency ratio, as well as tape speed fluctuation.



Kikusui wow and flutter meter

A.m. detectors

A survey of amplitude-modulation detectors, with a classification of types

by **S. W. Amos,** B.Sc., M.I.E.E.

Circuits used for the detection of amplitude-modulated signals are grouped into four main types, individual circuits in each group being examined in detail.

The word detector has been in use since the early days of radio and it was an unfortunate choice of term because it is by no means clear what a detector detects. It doesn't detect the presence of a radio signal because the aerial and/or first tuned circuit of a receiver do that. It doesn't detect the presence of modulation because an a.g.c. detector is designed to ignore modulation and to give an output related to unmodulated carrier amplitude. According to B.S. 4727 the job of a detector is to abstract information from a radio wave: the information may be the modulation waveform as in a demodulator or it may be the value of the unmodulated carrier amplitude as in the a.g.c. detector. Thus a demodulator is an example of a detector but a detector isn't necessarily a demodulator.

Since those early days the number of different types of detector has apparently grown enormously. It is possible to name 30 or 40 a.m. types without great effort. Terms such as diode detector, square-law detector, envelope detector and product detector are constantly encountered in electronics literature and examination of the various terms shows that the qualifying word may describe a number of different features of the detector. For example it may describe:

(a) a component used in the detector e.g. diode detector, grid-leak detector,
(b) a property of the detector e.g. infinite-impedance detector,
(c) the shape of the transfer characteristic of the detector e.g. square-law detector,
(d) the originators' names e.g. Foster-Seeley detector (to quote an f.m. example)

or, or course, the word detector may be used in its general (non-electronics) sense as a device which responds to the presence of a particular condition e.g. overload detector.

It follows that a given detector circuit may be known under a number of different names. For example a diode detector may be described as a linear detector, an anode-bend detector as a square-law detector and the infinite-impedance detector is sometimes called a reflex detector. There are, therefore, not so many different types of detector as the multiplicity of terms might suggest and it is the purpose of this article to illustrate this by surveying the various circuits and attempting to classify them.

If the mode of operation of the various a.m. detectors is considered in detail it is found that each conforms to one of four basic modes. There are minor variations in the details of operation but all a.m. detectors conform to one of the following four types:

1. those in which the detector output is made up of samples of the peak value of the modulated r.f. input,
2. those in which the detector clamps the peaks of the modulated r.f. input at a constant potential so that the mean value of the signal varies at modulation frequency,
3. those in which the output stems from the interaction between the side frequencies and the carrier of the modulated r.f. input, the interaction being caused by the non-linearity of the transfer characteristic,
4. those in which the output results from the effective multiplication of the modulated r.f. input and a second input at the carrier frequency.

We shall now examine this classification in detail.

Sampling detectors

Series-diode circuit

The simplest example of a sampling detector is the series-diode circuit shown in Fig. 1. It is similar to a half-wave rectifier circuit and the capacitor C_1 can be called a reservoir capacitor. Operation of the circuit relies on the rapid charging of C_1 through the low-value forward resistance and the subsequent discharge through the high-value diode load resistor R_1.

Diode D_1 conducts during positive half-cycles of r.f. input and charges C_1 to the peak value of the input signal. During negative half-cycles the diode is cut off and C_1 begins to discharge through R_1. The ratio of the time constant R_1C_1 to the period of the carrier is, however, so chosen that very little of the charge on C_1 is lost before D_1 begins to conduct on the next positive half-cycle of input and C_1 is again charged to the peak value. Thus C_1 maintains a positive voltage which keeps D_1 cut off except for the instants when the input signal passes through its positive peaks. In practice the period of conduction is only a small fraction of the positive half cycle.

Thus the load circuit R_1C_1 is connected to the modulated r.f. source by the low forward resistance of the diode for only a brief fraction of each input cycle and during this time the capacitor voltage is "topped up" to the peak value of the r.f. input. For the remainder of each cycle the diode is cut off, isolating the load circuits from the r.f. input so that the voltage across R_1C_1 begins a small exponential fall. Thus the diode acts as a switch which is turned on and off by the carrier component of the input signal. This is an example of a sampling process in which the modulated r.f. input signal is sampled once per cycle when it is passing through its positive peak. As the peak value changes as a result of modulation, the voltage across R_1C_1 changes to give a simulation of the modulating signal waveform made up of a number of "topping up" increases separated by exponential falls. These constitute an r.f. ripple of small amplitude superposed on the modulating-frequency waveform and which is easily removed by an r.f. filter to make the output waveform a good approximation to the modulating signal.

This type of detector is widely used in a.m. receivers and gives a good performance provided that the input signal is large enough to switch the diode effectively, i.e. so that it has a low forward resistance and a high reverse resistance. For an r.f. input of small amplitude the forward resistance is higher and the reverse resistance lower than could be wished and thus detection of small-amplitude signals is inefficient. Better results could be obtained for small inputs if the diode could be switched by a large-amplitude signal synchronised with the carrier component. This is possible using a synchronous detector of the type normally used for the demodulation of suppressed-carrier a.m. signals: such detectors are described later. The switching signal can be obtained from a local oscillator as in synchrodyne receivers or from the received signal by removing the modulation as in the homodyne receiver. I.cs are available with limiter stages suitable for use in a homodyne receiver.*

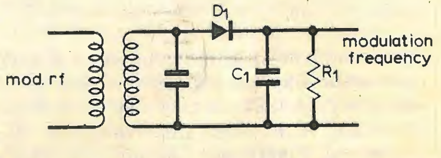


Fig. 1. The simple series-diode detector circuit is an example of a sampling detector.

Infinite-impedance detector. The diode in the circuit of Fig. 1 can be replaced by a triode, the reservoir capacitor being connected in the cathode circuit as shown in Fig. 2. The valve is turned on by positive swings of the signal applied to the grid and is cut off by negative swings. Thus the capacitor C_k is charged through the low internal cathode impedance of the valve during positive half-cycles and discharged through R_k on negative half-cycles. This is another example of a sampling detector, the cathode capacitor so biasing the valve that it conducts for only a small fraction of the positive half-cycle during which, by cathode-follower action, C_k is charged to the positive peak value.

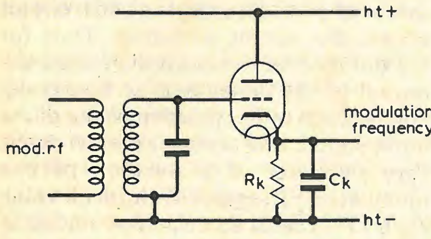


Fig. 2. Infinite-impedance detector.

This is, of course, the so-called infinite-impedance detector — another unfortunate term because the grid-cathode capacitance of the valve, in conjunction with C_k, gives the circuit some of the properties of one form of Colpitts oscillator and the input impedance can be negative, as many enthusiasts discovered in trying to cure such detectors of r.f. instability.

Anode-bend detector. The infinite-impedance detector can be made capable of amplification. All that is necessary is to include a resistor R_a in the anode circuit and an amplified version of the detected signal is available from the anode. The circuit is shown in Fig. 3 and is known, of course, as the anode-bend detector.

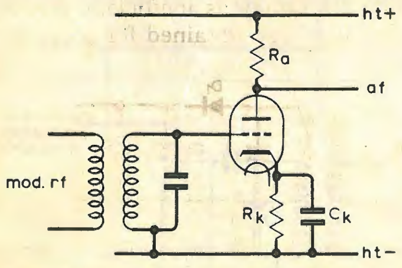


Fig. 3. Anode-bend detector with automatic cathode bias.

The cathode circuit is not decoupled at a.f. and the resulting negative feedback reduces the voltage gain of the a.f. amplifier to approximately R_a/R_k so that R_a must be large compared with R_k to achieve worthwhile gain. If R_k = 47 kΩ, a commonly-used value, then R_a could be 470 kΩ, giving a gain of approximately 10. This detector operates by sampling the positive peaks of the r.f. input and the anode (and cathode) current consists of a succession of carrier-frequency pulses. These are smoothed to give an approximation of the modulation waveform by the reservoir capacitor C_k. To obtain a similar waveform from the anode circuit this also requires a shunt capacitance C_a and the time constant R_aC_a should equal R_kC_k. If $R_a = 10R_k$ then C_a should be $C_k/10$. C_k is commonly 100pF, so C_a should be 10 pF. Stray capacitance is probably of this value so it may not be necessary to add a physical component to provide it. If the equality of time constants is maintained there is no difference in audio quality between the outputs at anode and cathode. This is an interesting conclusion because in the days when a.m. transmissions were the only source of broadcast music the audio quality from the infinite-impedance detector was assessed as good by hi-fi enthusiasts whereas that from the anode-bend detector was regarded as poor! Perhaps the time constants weren't equal.

If the value of C_k is increased sufficiently to give effective decoupling at audio frequencies the gain of the valve is considerably increased by the elimination of negative feedback. The capacitor, once charged on the positive half-cycle of the r.f. signal at the valve grid, now discharges very slowly, the time contant being of the order of 1 second. This does not matter when the amplitude of the r.f. carrier is constant or increasing but it can be important when it is decreasing. If, as a result of modulation, the carrier amplitude falls more rapidly than the cathode-capacitor voltage then the valve is cut off until the capacitor voltage has fallen or the carrier amplitude has increased sufficiently for conduction to be possible again. Thus there are momentary periods of non-conduction when the rate of fall of r.f. amplitude is a maximum i.e. when the modulation frequency is high and the modulation deep. It is fortunate that in sound signals deep modulation rarely occurs at the highest frequencies and thus the distortion caused by these gaps in conducted is not as serious as might be supposed: indeed many of the harmonics introduced as a result of this effect are outside the passband of the amplifier, the loudspeaker or the ears of the listener. Although this type of detector was never used in receivers intended for high-quality reproduction it was commonly employed in cheaper models where its high gain was considered to outweigh its limitations.

Synchronous detectors. Circuits of the type so far considered are used to detect modulated signals in which the carrier is present. They take samples of the positive peaks of the modulated r.f. input and are not affected by variations in the timing or phase of the peaks. To detect carrier-suppressed a.m. signals the detector must be sensitive to the phase as well as the amplitude of the peaks of the input signal: the reason for this will be made clear in the discussion of Fig. 5. Thus the detector must have a reference signal of constant frequency against which it can compare the phase of the modulated r.f. input. To this end the detector is provided with a second input in the form of a constant-amplitude sinusoidal signal synchronised with the (suppressed) carrier frequency of the modulated r.f. signal to be detected.

Synchronous sampling detector. One possible circuit for a synchronous sampling detector is given in Fig. 4. The single series diode of the prototype a.m. detector is replaced by two diodes and a centre-tapped transformer. Both diodes conduct together to produce the low-impedance path which connects the source of modulated r.f. to the capacitor C_4. When the diodes are non-conductive the path is open-circuited and C_4 retains its charge. The diodes must be driven into conduction and non-conduction by the carrier input and not by the modulated r.f. input and thus the carrier input must be large compared with the other input signal. The balanced form of the carrier circuit is adopted to minimise any carrier component which may reach C_4. The time-constant circuits R_1C_1 and R_2C_2 are included as diode loads to ensure that the diodes conduct for only a small fraction of each cycle i.e. when sampling is required.

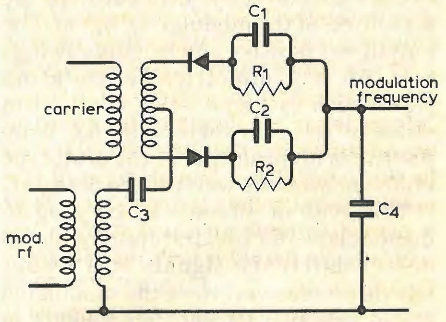


Fig. 4. Synchronous sampling detector using a diode bridge.

The way in which such a detector demodulates a double-sideband suppressed-carrier signal is illustrated in Fig. 5, in which the vertical dashed lines indicate the sampling periods. A non-synchronous a.m. detector, being insensitive to phase, would sample all the positive peaks and would thus pro-

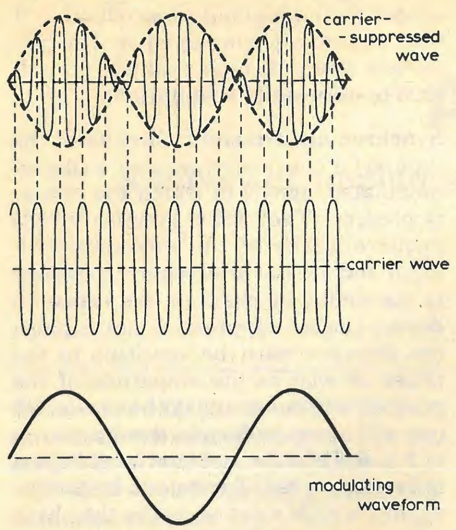


Fig. 5. Action of a synchronous sampling detector in detecting carrier-suppressed signal. The dashed lines indicate the sampling periods.

duce a grossly-distorted output. The synchronous detector operates strictly at carrier-frequency intervals and samples the positive peaks during one half-cycle of the modulating signal and negative peaks during the other half-cycle, thus correctly reconstituting the waveform of the modulating signal. The output has positive and negative swings and, for a symmetrical modulating signal such as a sine wave, has a mean value of zero, i.e. there is no d.c. component as in the output of the prototype non-synchronous series-diode detector.

This type of circuit can be used to demodulate the quadrature-modulated colour-difference signals in a colour television receiver. Here the modulated signal has two carrier components in quadrature, each amplitude modulated by a different signal. The circuit of Fig. 4 can demodulate one of these signals without interference from the other, because, during the time it is sampling the peaks of one signal, the other is passing through zero and so has no effect on the detector output. A second detector with its carrier input in quadrature with that of the first is required to demodulate the second colour-difference signal.

For some applications the components R_1C_1 and R_2C_2 can be omitted.

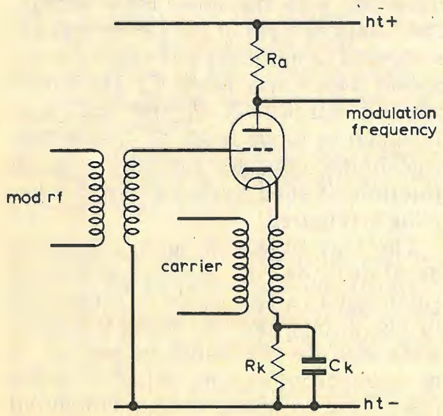


Fig. 6. Synchronous anode-bend detector.

The diodes then connect C_4 to the source of modulated r.f. for the whole of one carrier half-cycle.

Synchronous anode-bend detector. The anode-bend detector with a short time constant *RC* combination in the cathode circuit is an example of a sampling detector, the valve being switched to conduction once per carrier cycle by the positive peak of the r.f. input applied to the grid. The valve could alternatively be switched on and off by a carrier-frequency signal applied to the cathode circuit and one type of synchronous sampling detector operates on this principle. It is sometimes called a gated amplifier.

A typical circuit is shown in Fig. 6. The modulated r.f. signal is applied to the grid and the carrier signal, suitably phased with respect to the grid signal and of much greater amplitude, is applied to the cathode. The components R_kC_k act as a diode load circuit and hold the valve cut off except during the negative peaks of the half-cycles of the signals applied to the cathode. When the valve is conductive the anode current takes up a value determined by the amplitude of the signal at the grid at that instant. As the valve is provided with an anode load, corresponding magnified signals can be obtained from the anode.

Clamping detectors

Shunt-diode circuit. In the circuit of Fig. 1 the output of the detector is taken from the reservoir capacitor, but it could alternatively be taken from the diode, the circuit being re-arranged as shown in Fig. 7 to enable one leg of the

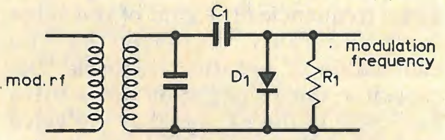


Fig. 7. The simple shunt-diode detector circuit is an example of a clamping detector.

output to be earthed. In this version of the circuit, known as the shunt-diode detector, the reservoir capacitor is series-connected, which makes the circuit convenient when d.c. isolation is required between the output terminals and the source of modulated r.f. input.

There is, however, no r.f. isolation between r.f. input and the output as in the series-diode circuit. The reservoir capacitor provides a low-reactance path at r.f. and transfers the modulated-r.f. input signal with little attenuation to the detector output terminals. The output is, in fact, made up of the modulation-frequency signal generated across the reservoir capacitor in series with the modulated-r.f. signal transferred from the input. Thus the output of the shunt-diode detector has a much greater r.f. ripple content than that of the series-diode circuit. The waveform of the output from the shunt-diode circuit can be deduced in the following way.

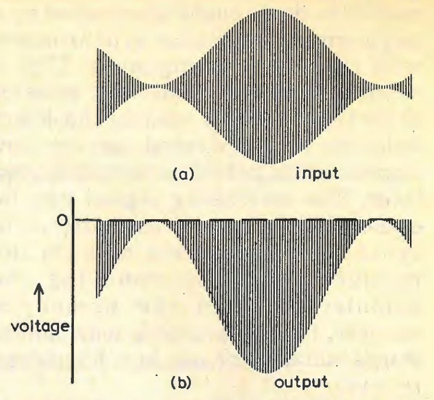


Fig. 8. Input (a) and output (b) waveforms for shunt-diode detector.

The diode conducts during a small fraction of each r.f. input cycle to charge the reservoir capacitor and for this brief period it acts as a short circuit across the output terminals. Thus for the duration of the charging period the output of the detector is zero: this occurs at each of the positive peaks of the input signal. The detector output therefore consists of a version of the modulated-r.f. input waveform in which each r.f. cycle is so displaced vertically that all positive peaks touch the zero-volts line as shown in Fig. 8. The mean value of such a signal varies with modulation and, if the r.f. ripple is suppressed, consists of the modulation waveform superposed on a negative zero-frequency component proportional to the amplitude of the unmodulated r.f. input.

The action of this form of detector is an example of clamping in which positive peaks of the input signal are clamped at zero volts. The circuit is often used in television to clamp the sync tips of a video waveform at a particular voltage: in this application the circuit is known as a d.c. restorer.

Grid-leak detector. One well-known example of a clamping detector which provides amplification is the grid-leak detector alternatively known as the leaky-grid or cumulative-grid detector, the circuit diagram of which is shown in Fig. 9. The grid and cathode of a triode or pentode are used as a shunt-diode detector the output of which, being generated between control grid and anode, is amplified by the valve to give a magnified output from the anode. Fig. 10 shows the waveform of the grid voltage for a sinusoidally-modulated r.f. input signal (positive peaks being

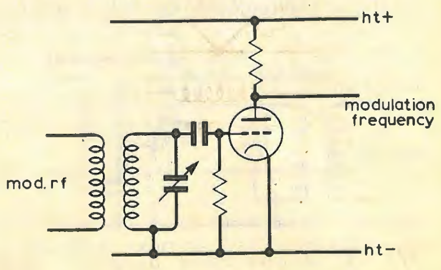


Fig. 9. A grid-leak detector.

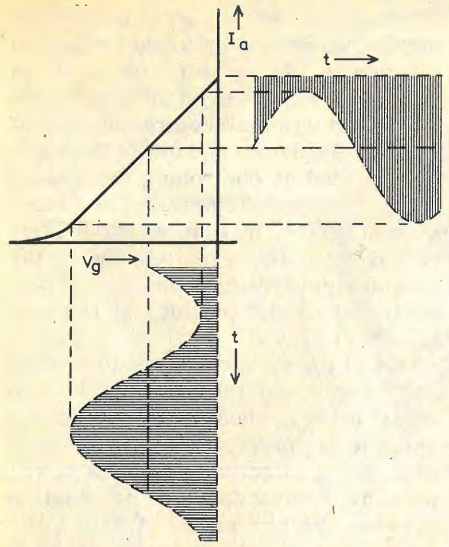


Fig. 10. Anode current/grid voltage relationship for a grid-leak detector.

clamped at zero volts) and the corresponding anode-current waveform.

The detector has the disadvantage that the control grid does not make an ideal diode anode and detection efficiency is therefore not high. The diode output contains, in addition to the wanted a.f. component, a d.c. component and a large r.f. ripple. The d.c. component provides the valve with grid bias and its value depends on the amplitude of the input signal, the bias becoming more negative (so decreasing mean anode current) as input-signal amplitude increases. The bias is suitable for class-A amplification only for a limited range of input-signal amplitudes. When it is unsuitable the curvature of the I_a-V_g characteristic causes anode-bend detection (in which the mean anode current increases with increase in input-signal amplitude) and the resulting audio signal is in antiphase with that due to grid-leak detection, causing a loss of audio output and distortion.

The r.f. component of the anode current can readily be suppressed by a decoupling capacitor across the anode circuit but it was common practice to make use of this component to provide positive feedback (called reaction) which greatly increased detector sensitivity.

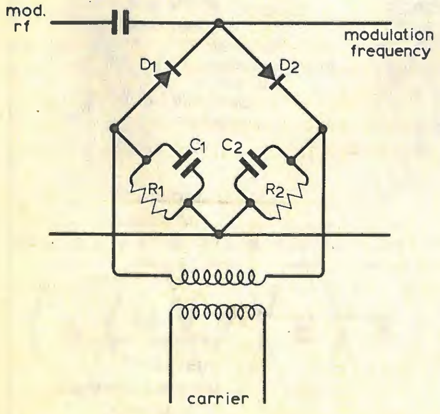


Fig. 11. A synchronous clamping detector using a diode-bridge.

In an effort to improve the performance of the grid-leak detector it was recommended that a valve with a long grid base should be used and that the anode voltage should be high to further increase the grid base. This made location of the operating point on the characteristic less critical and the a.f. component resulting from anode-bend detection less important. This variant of the grid-leak detector was known as a power-grid detector.

Synchronous clamping detector. Figure 11 gives the circuit diagram of a synchronous clamping detector. It has much in common with the synchronous sampling detector of Fig. 4 except, of course, that the diodes are arranged to produce a shunt short circuit once per carrier cycle. The diodes and their load circuits form a balanced circuit chosen to minimise carrier content in the detector output and the time constant of

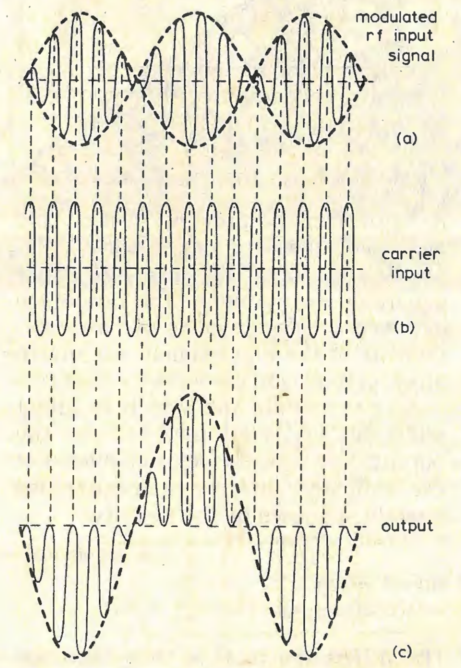


Fig. 12. The action of a synchronous clamping detector is demodulating a suppressed-carrier, amplitude-modulated input signal.

the load circuits R_1C_1 and R_2C_2 is made long compared with the carrier period so that the diodes conduct for only a small fraction of each cycle. At each conduction period that part of the modulated-r.f. input waveform which coincides in time with it is clamped at zero volts.

The way in which the detector demodulates a suppressed-carrier signal is illustrated in Fig. 12, in which the vertical dashed lines indicate the conduction periods. For a correctly-synchronised carrier these coincide with positive peaks of the modulated-r.f. signal during one half-cycle of the modulating signal and with negative peaks during the other half-cycle. Thus the output signal has positive and negative swings as shown in Fig. 12(c). As for the prototype non-synchronous shunt-diode detector there is a very large r.f. ripple

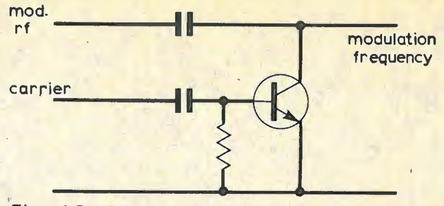


Fig. 13. A simple synchronous clamping detector using a symmetrical bipolar transistor.

content in the output but, for a symmetrical modulating signal such as a sine wave, there is no d.c. component.

The diodes can be replaced by a shunt-connected bipolar transistor which is switched on and off by the carrier signal applied to the base. The circuit diagram (Fig. 13) includes an *RC* combination in the base circuit which determines the duration of each clamping period. If the transistor is a symmetrical type transmission of the carrier signal to the detector output can be minimised.

Additive (non-linear) detectors

In all the detectors so far considered, a reservoir capacitor has played an essential part: it is charged during part of each cycle of carrier component and discharges during the remaining part of the cycle. Thus the shape of the input-output characteristic of the charging device has only a second-order effect.

There is, however, a type of detector in which the shape of the input-output characteristic is all-important because it is in use for most if not the whole of each cycle of input signal. One example of this type is the anode-bend detector in which the valve is biased by a battery as shown in Fig. 14.

Detection is achieved because of the unequal response to positive and negative half-cycles of the input signal and this is a consequence of the non-linearity of the I_a-V_g characteristic as shown in Fig. 15. Clearly the mean value of the anode current varies with the modulation and the magnitude of the modulation-frequency output depends on the severity of the non-linearity of the characteristic. The mean current also varies with the magnitude of the input signal.

There is an alternative method of explaining the operation of this type of detector. When two sinusoidal signals with different frequencies are applied to

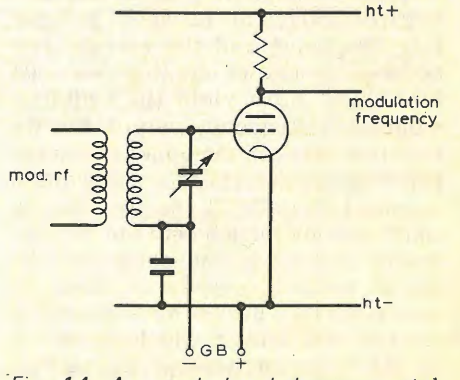
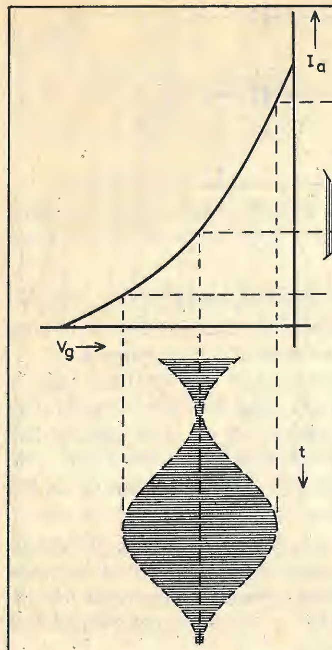
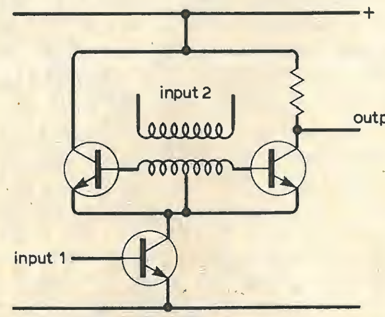


Fig. 14. An anode-bend detector using battery bias.



◄*Fig. 15. Anode current/grid voltage relationship for an anode-bend detector with battery bias.*

Fig. 16. A product detector using bipolar transistors (simplified circuit diagram). ▼



a device with a linear characteristic, the output has only two components and these are at the frequencies of the two input signals. If, however, two such signals are applied to a device with a non-linear characteristic, the output contains components not only at the frequencies of the two input signals but also at multiples of these two frequencies (harmonics) and at the sums and differences of the various harmonics. The last mentioned are known as combination frequencies and are given by $(mf_1 \pm nf_2)$ where f_1 and f_2 are the frequencies of the two input signals, m and n being integers. Perhaps the most interesting of the combination frequencies is $(f_1 - f_2)$ — the difference frequency. Non-linear devices are often used as r.f. mixers in superheterodyne receivers, the inputs from oscillator and the r.f. circuit being connected in parallel or series and applied to the single input terminal: it is the difference term which is selected from the output of the mixer for amplification in the i.f. amplifier. In an anode-bend detector the input, assumed amplitude-modulated by a single sinusoidal signal, has three components — the carrier, the upper side frequency and the lower side frequency. The difference term resulting from interaction between the upper side frequency and the carrier, and between the carrier and the lower side frequency, both yield the required modulation-frequency output. But interaction between the upper and lower side frequencies yields an unwanted second harmonic of the modulating signal and interaction between the harmonics of the side frequencies and the carrier yields a complex of other unwanted terms. Thus the non-linearity of the characteristic on which the action of the detector depends inevitably causes considerable harmonic and intermodulation distortion.

Multiplicative (Product) Detectors

As shown in the previous section one method of achieving a.m. detection is by use of a non-linear device which generates an output at the difference between the frequencies of two components of the input signal. An alternative method is to use a device with two output terminals and which in effect multiplies the two inputs to form the output. This process yields an output at the sum and difference frequencies directly as shown by the identity:

$$\sin \omega_1 t.\sin \omega_2 t = \tfrac{1}{2}[\cos(\omega_1 - \omega_2)t - \cos(\omega_1 + \omega_2)t]$$

The difference term is thus obtained without need of non-linearity.

There are a number of r.f. mixers and synchronous detectors which use this principle in which, as the identity implies, current is assumed to flow in the device throughout each cycle of both input signals. In all these examples both input terminals control the current through the device and one of them can be regarded as controlling the mutual conductance of the device. The output current is given by $g_m v_{in}$ approximately (where v_{in} is the signal applied to the second input terminal) and is thus proportional to the product of the two inputs.

One of the earliest devices to be used in this way was the pentode, the two inputs being applied to the control grid and the suppressor grid. The screen grid, being effectively earthed at r.f., prevented any capacitive interaction between the two inputs. A better performance was achieved in the hexode which had an additional screen grid between suppressor grid and anode.

An alternative method of producing a circuit in which two inputs control the same current is by connecting two transistors in series across the supply as indicated in Fig. 16. A number of circuits of this type are in common use, particularly in integrated circuits, and frequently the upper transistor is replaced by a parallel push-pull pair, the input being applied to their bases in push-pull, the output being taken from only one of the transistors. The advantage of using push pull is that the currents of the paralleled transistors are in antiphase so that alternating currents at the frequency of the push-pull input are confined to the push-pull stage and do not stray into the supply circuits or to the lower transistor which controls the current to the push-pull pair.

A third type of multiplicative device is the dual-gate, field-effect transistor. Both gates control the channel current and thus if two signals are applied to the two gates, sum and difference signals are available in the drain current.

To conclude this article the classification of a.m. detectors surveyed is summarized in the table. □

Classification of a.m. detectors

Type	Non-synchronous	Synchronous
sampling detector	series-diode infinite-impedance anode-bend with cathode bias (amplifying)	diode bridge anode-bend (gated amplifier)
clamping detector	shunt-diode (d.c. restorer) grid-leak, power-grid (amplifying)	diode bridge symmetrical transistor
additive (non-linear)	anode-bend with battery bias	
multiplicative (product)		pentode, hexode dual-gate f.e.t. bipolar transistors in series

*See, for example, J. W. Herbert: "A Homodyne Receiver" *Wireless World* Sept. 1973.

LETTERS TO THE EDITOR

PROGRAMMABLE NOTES FOR KEYBOARD INSTRUMENTS

Regarding M. Robins's letter in the November 1979 issue, one way of overcoming the problems with key changes while allowing a "natural" scale is to redefine the function of the keyboard. The following is a suggestion to overcome the limitations of current keyboard instruments, which are tuned to an "equal-tempered" scale. The latter is really a compromise, basically due to the fixed number of physical notes available.* If we had a much larger number, true musical intervals (i.e. subjectively correct) could be played in any key; in fact early keyboard instruments had "split" notes to reduce this problem. For example, A♭ and G♯ should strictly be different frequencies, depending on the scale/key being played, but have now been "tempered" to give the same frequency (i.e. they are the same physical note), which has become acceptable in modern music.

However, if we consider a keyboard generating "intervals" as opposed to absolute frequencies, this situation should not arise. Imagine a keyboard where notes to the right represent positive intervals relative to the last note played, and notes to the left represent negative intervals (the middle note representing no change). This is shown in Fig. 1. If a piece of music is now reinterpreted as a set of intervals (e.g. major/minor tones, thirds, fifths, octaves, etc.) the instrument will generate the exact frequencies required. For example, intervals of a fifth from any note will always be the exact ratio of 3 to 2.

In practice, frequencies have to be generated which are proportions of the previous frequency. This could be done using multiplier circuits or digital techniques, but a simple method which springs to mind is to use a basic synthesizer concept. In these instruments a keyboard generates a linear range of voltages which control logarithmic voltage-controlled oscillators. Using this idea, the frequency multiplication/division we require is easily obtained by adding/subtracting d.c. voltages. Operational amplifiers can be used for this, as well as for storing the last note played in a sample-and-hold arrangement.

The circuit in Fig. 2 (albeit crude) illustrates the basic idea, but has not been tested as it is only a suggestion for those readers with more time and patience to try a feasibility study. It may not in fact be practical due to drifting unless highly stable circuits are used. It is analogous to an inertia based navigation system which is reset once only, and from then on everything is calculated relatively, thus accumulating errors. The instrument may be physically difficult to play and certainly a rethink would be required for musical notation. It is also monophonic, as chords have not yet been considered.

But for those who are undeterred, the operation is as follows: The key contacts are labelled $S_{1,2,3\&4}$ and must operate in that sequence. $IC_{1\ \text{and}\ 3}$ hold the current note in their "hold" capacitors. When a key is pressed, S_1 opens and isolates IC_1. S_2 closes, selecting the interval required (plus/minus or zero) which is added to the previous note from IC_1 using the summing amplifier IC_2. S_3 closes, thus storing this new note on IC_3 which produces the required frequency from the oscillator. S_4 triggers the note envelope shaper. S_5 is the reset required at switch-on.

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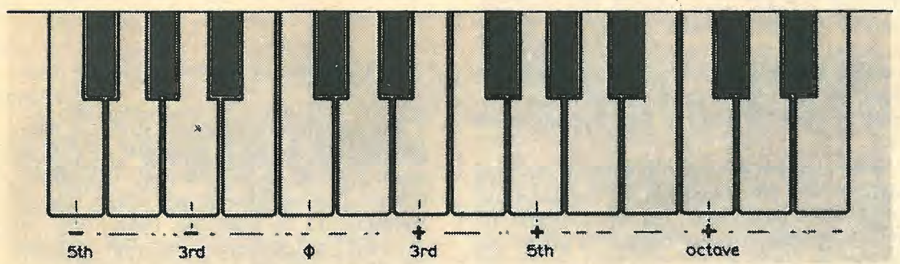


Fig. 1.

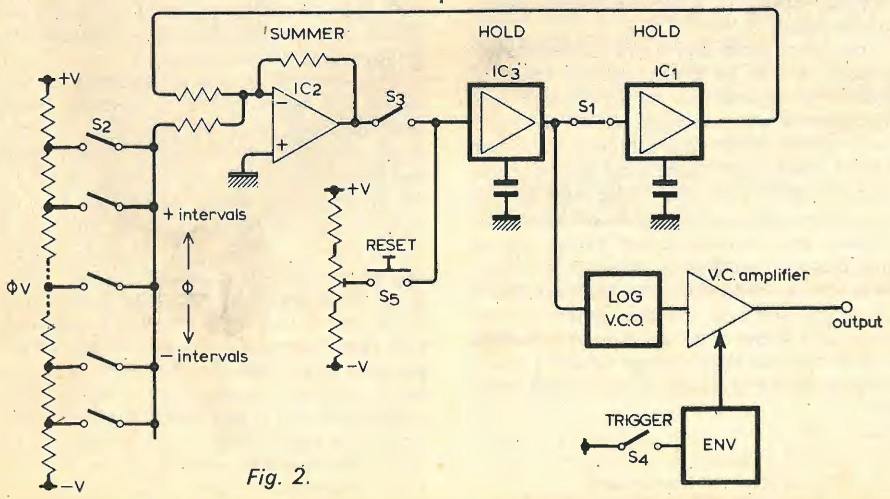


Fig. 2.

* In the equal-tempered scale, each of the twelve semitones differs in frequency from its neighbours by a constant ratio which is the twelfth root of 2(=1.059463094). This constant derives from the fact that in the scale there are 12 frequencies, of which the highest note, an octave above the lowest, is of course 2× the frequency of the lowest. — Ed.

C.B. RADIO AND POPULATION DENSITY

R. B. Hooper's letter in your February issue is interesting. He's perhaps forgotten about the density of population here. England comes second, after the Netherlands, with 900 people per square mile. Scotland, from where I write, is No.22 on the world's list, with 170; but even that is heavily concentrated, in its central area. A lot of the rest is mountainous.

Victoria, Mr Hooper's home-state, is Australia's most densely crowded! This happy region has 37 people per square mile, almost the same as Finland! His island-continent is itself at the end of the world's list. As it's roughly the same area as the continent of Europe it can well afford the 'luxury' of citizens' radio, without 'mutual interference'.

With these facts in front of him, Mr Hooper must realise that the authorities here, with a population of around 55 million, view with some foreboding just how many thousands will apply for this 'privilege'! When was he last here? If so, did he ever have the experience of driving a car through the English Midlands? All the towns merge into one another!

The USA, which he quotes, is No. 27 on the list, with 50 people per square mile! Like Australia, its vast area has undoubtedly made c.b. radio both feasible and necessary.

In most of the UK one is within easy reach of a telephone. Our communications system has, fairly recently, been extensively modernised and is quick and effective.

King Canute would have been gratified!

W. C. Ritson
Stromness
Orkney

THE INTELLIGENT PLUG

Two points regarding The Intelligent Plug mains communication system described in your December 1979 issue: (a) it could be lethal; (b) it would need a licence, which would not be granted.

The danger arises from the 1μF capacitor in the transmitter circuit, practically between the neutral and earth lines (ironically the authors state "for maximum safety"). However, if the neutral and earth connections at the wall socket were dirty and not making very good contact, the live mains would pass through the primary of the mains transformer at least, making the neutral wire also live, and then pass through the 1μF, making the earth and hence the case and microprocessor live!

B.S.415, the radio and tv safety spec. (para. 9.1.1 etc.) says that a part is deemed to be live if more than 0.7mA (peak) a.c. can be drawn between it and either pole of the supply. At 240V, 50Hz this works out to be about 6.6nF maximum value between either pole and earth. In any case the specification goes on to state a maximum value of 0.1μF. This is no doubt one reason why commercial units inject signals between the poles, and not with respect to earth.

Secondly, regarding the licence, I have always been led to believe that a system such as this is considered as a straightforward transmitter, which requires licensing, but the frequency used would probably rule this out. After all, inductive loop paging systems and metal detectors require licences. Just because mains-intercoms are sold does not mean they are legal to use (cf walkie-talkies).

David Williams
London SE12

The authors reply:
We would like to thank David Williams for pointing out the possible hazard in the circuitry of The Intelligent Plug. Our first reaction was to change the project name to "The Intelligent Socket!" – if the circuitry is mounted in a p.v.c. box as part of the mains socket the problem does not arise.

As this would make the project less accessible to the home constructor, however, we recommend that the 1μF capacitor in the transmitter circuit is reduced as Mr Williams suggests. Reduction to 0.1μF should not incur a significant loss of signal to noise ratio: beyond this the gain of the amplifier may need to be increased or redundant transmission techniques used to combat the accompanying degradation of the channel.

The letter raises the difficult question of whether we have chosen the best pair of wires for transmission. After carefully reconsidering the issue, we still feel that neutral and earth is a good choice: a disadvantage of live and neutral of which we have recently been made aware is that transmission can interfere with certain test equipment which does not filter the power input.

Regarding the point about licensing, we must emphasize that the system does not rely on radiated signals as do the loop paging systems and metal detectors that Mr Williams mentions. Signals are instead transmitted along mains wiring. No licence is needed to send signals along one's own wires in one's own property; indeed if it were, every piece of electronic and electrical equipment would need a licence!

Neil McArthur, Andy Wingfield, Ian Witten.

POLITICS AND ELECTRONICS

How interesting and encouraging to find a fellow reader and critic of the remorselessly centralising bureaucracy that is supposed to run our social system (S. Frost, January letters).

His letter is a very good contribution to why such developments as c.b. radio should be supported – whatever the 'difficulties' to bureaucrats, and however large the 'technical' problems appear to be. The question is one of politics and philosophy; the politics of access to resources and uses, and the philosophy of freedom. We are told that freedom also brings with it responsibilities, but no responsibility can be exercised until freedom has been gained and experienced. Most important of all, freedom is never 'granted' (that would be like looking for the dark with a torch), it must be taken by struggling for it. That is one of the most vital messages of a political nature we can help young people in our society to perceive, and I am delighted to see *Wireless World* making a small contribution to this end.

Mr Frost could have added words from Gerrard Winstanley to his list of those that have seen what it takes to struggle for freedom. Also people interested could very well re-read Henry Thoreau's "On the Duty of Civil Disobedience". Finally on this point, one should remember that Christ said a lot of nasty things about lawyers and doctors – and the state, but you would not think so after centuries of oppressive and professionalised religion.

Directly after Mr Frost's letter you printed the flaccid letter by Mr Greenwood. It is an excellent contrast to see that an intelligent man like him could still offer the old 'politics is dirty' argument. Notice how he tries to imply that *Wireless World* should be 'above' such mess, or by the same token that to allow political rhetoric to enter the pages of a technical journal somehow besmirches it. His letter sounds just like a Victorian lady arguing that sex has reared its ugly head in her 'pure' journal! And that kind of aloof puritanism is not far away in Mr Greenwood's letter.

I would ask how can a person who has worked in technology think that such a subject is not political – some of the most critical political questions of all time will mightily involve technology as we are developing it. Mr Greenwood could profitably read the book by Jacques Ellul entitled "The Technological Society", or some of Ivan Illich's works, although I admit it would be like asking the Victorian lady to read Havelock Ellis or Kinsey. Nonetheless turning away from what might be unpalatable scientific facts should be the last thing a technician or engineer should do, especially as it is now impossible to hide behind the fallacy that science is somehow 'pure' or 'beyond politics'. That science, and by implication its relative, technology, is a highly political and messy human activity like any other is hardly disputed any more – and one does not have to acquire a deep understanding of Thomas Kuhn or Karl Popper to see it.

Any awareness that the coming political struggle will not centre around the bankrupt 'Right-Left' dichotomy, but will concern the Centralist-Decentralist debate, is all to the good. C.b. radio is a *networking* use of technology, self-determined, and exercises peoples' ability to generate these spontaneous forms.

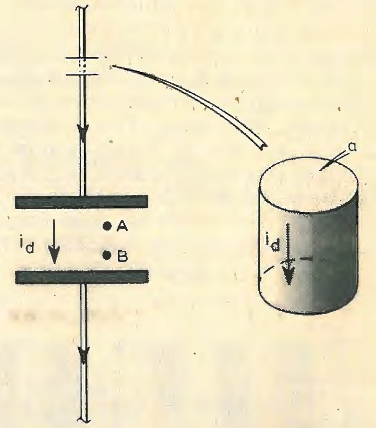
The word processors and disseminated micros, as well as a vast proliferation of cybernetic approaches to production and management will transform social forms and work habits within our lifetimes. It is our subject, electronic engineering that is in the vanguard of all this. One of the most decentralised and self-organising social structures we have ever known should evolve out of this. But hierarchically minded politico-bureaucrats – who think that they are God's gift to the universe and that power should reside with them – will have to be watched, or it is possible that George Orwell's voice will echo from the clouds, "I hate to say I told you so".

Ken Smith
Electronics Laboratories
University of Kent at Canterbury

DISPLACEMENT CURRENT

In the articles on displacement current by Catt, Davidson, and Walton (Dec 1978, March 1979) two important concepts are brought out. One is the limitations of Maxwell's lumped capacitance model, the other the transmission-line model the authors have contributed. However, the authors' claim with reference to Maxwell's capacitor that the displacement current is "an artefact of this faulty model" should be taken with a grain of salt. Maxwell's displacement current occurs at many places and in many forms, one of which is inside a capacitor, another in free space. Whether or not the authors replace Maxwell's capacitor with a transmission line has nothing to do with dD/dt in space, which will forever continue to make electromagnetic wave propagation possible, whatever is the source.

It is stated repeatedly that charge flows, which is correct, but also that current "flows". Current is a time-rate quantity that *exists* or *is*; it does not flow. *It reflects a point observation*, how much charge that passes that point. If no charge is passing there is no current. It is particularly hard to consider current "flowing" when it is a displacement current, appearing where there are no moving charges. In the accompanying diagram no charges move between points A and B, or anywhere between the two capacitor plates.



The displacement current is no current at all, because we have robbed it of the very agent it needs to be a current – the flow of charge. Is it sensible to talk about "flowing currents" in vacuum? So, both "flow" and "current" are objectionable terms, notwithstanding the fact that i_d is a current, equal to the conduction current i both to quantity and unit. It is unfortunate that Maxwell did not call his displacement current something else, such as "displacement entity".

Some experts on electromagnetic theory do not use the historically inherited terms "displacement" and "displacement current" at all, while they do employ Maxwell's math and give proper credit to Maxwell[1]. Why are we so disturbed about names we can do without, holding on to the math? The title of the authors' first article was "Displacement Current – and how to get rid of it". If someone really succeeds to get rid of displacement current in Maxwell's capacitor, and then opens up the plates so that it becomes an antenna, how comforting it must be to this person to learn that wireless communication is just a fiction of the mind. And to the authors who succeed in getting rid of the displacement current at the input to their transmission line, what a setback it must be to have to accept displacement current *inside* the transmission line. In their Fig. 3 in the second article, the quantity D is shown four times inside the transmission line. The moment the transmission line is put to use, D becomes dD/dt. The authors seem to imply that when displacement current occurs inside a transmission line, it need not be explained. The truth in the matter is that dD/dt in a transmission line requires the same amount of explanation as that in a capacitor, if not more, ie to the one who feels that he does not understand displacement current. To him, if Maxwell's displacement current in a capacitor begs for an explanation, so does the same thing when occurring in a transmission line. But the "paradox" of the capacitor is today a paradox for the layman only. Particularly with the extended theory the authors offer, the math of electromagnetism is clear and to the point. One cannot escape the impression that the author effort to get rid of the displacement current is not only futile, it is also misdirected!

If we accept the fact that electromagnetic waves are generated from an antenna, and if we get a number of wavelengths away from it, then

$$\nabla \times H = \nabla \times (B/\mu_\nu) = dD/dt = \epsilon_\nu\, dE/dt \qquad (1)$$

(partial derivations intended). This is a more crucial case to tackle for those who set out to get rid of Maxwell's displacement current. Just to mention another case of the omnipresence of this current, see the right-hand side of my diagram. There exists displacement current already in the wire that goes to the capacitor, such as a copper wire, because it has an E-field. Quite apart from the immensely much greater conduction current in the wire, it is likewise dependent on the area a. The point is that it is there. If we more or less successfully do away with displacement current in one place, should we not do away with it in all places? And the most important place of them all is that depicted by (1).

Certainly the authors are right in placing the electromagnetic energy in the fields, and they are justified in dressing up the capacitor as a transmission line, to which the old Maxwell capacitor presents a conditional approximation. But, what kind of a transmission line? In Maxwell's equation (1) in its general form

$$\Sigma(B/\mu_\nu)s = i_c + i_d = i_c + d\Phi/dt \qquad (2)$$

here written symbolically and simplified, s is the magnetic field-line path, i_c the conduction current, and ϕ the electric flux. The equation shows that i_d has magnetic field, too. Nevertheless, the authors promote only a TEM magnetic field, turned 90° with reference to Maxwell's. The field situation is quite a complex one, with the boundaries extending to right-angle bends, and the entire capacitor with standing waves on the plates located inside the demarcation line of the Fresnel zone. Thus the vectors E and B are not necessarily normal to each other, nor does the E-field necessarily convey the same energy as the B-field. Theoretically at least, as a limit consideration, a certain magnetic field can be approximated out of existence because almost all the energy is in the E-field. From the authors' illustrations, it is hard to figure out how the magnetic field lines are supposed to go. Whatever TEM there is, it surely is not alone.

(1) is an interesting way of writing one of Maxwell's equations for free space. If we don't like D, we can use E. (And, if we don't like H, we can use B.) Perhaps the fact that D is not as important as it is made out to be should be brought out here. We might say that Maxwell put D and H on a pedestal, and that history has given both quantities a lot of significance, while the really important quantities are E and B, at least to the engineer. Specifically, the two historically inherited equations are shown in (3),

$$D = \epsilon_\nu E, \quad B = \mu_\nu H \qquad (3) \qquad\qquad E = (1/\epsilon_\nu)D, \quad B = \mu_\nu H \qquad (4)$$

We may claim that (3) is an anomaly since it tends to convey the general idea that there exists an important relationship, on one side between D and B, on the other between E and H. If so, (3) is deceiving, while (4) conveys the right idea. This is that E goes with B, and D with H. Perhaps also that D and H are less important (and thus explanations of D and dD/dt less important). Although we cannot do without them, we may consider D and H merely as aids in the unwinding of electromagnetic theory, stepping stones in the classroom teaching leading to E and B. We may look upon D and H as auxiliary quantities, with D tying q and E together (the electric tie, so that we can proceed from charge to field), and similarly H tying i and B together. Then dD/dt is simply the "tie rate". If we can make D and dD/dt less important, on a relative scale, and give the engineer more appropriate names and concepts, it seems that the entire issue of the displacement current may have lost its edge.

H. E. Stockman
Sercolab
Arlington
Mass. USA

Reference

1. King, R. W. P. "Fundamental Electromagnetic Theory", Dover, 1962.

The authors reply:
With regard to para 1, neither Maxwell nor anyone else except Dr Stockman has identified more than one form of Maxwell's displacement current, or asserted that dD/dt behaves in some way differently inside a capacitor and in free space. We anxiously await amplification of this important preliminary disclosure. We thought that, like the Cheshire Cat's grin, displacement current was always the same.

As to para. 2, where Dr Stockman suggests that "displacement current" should be renamed "displacement entity", we would prefer "displacement nonentity".

With regard to para. 3, we object to Maxwell's math quite as much as we object to his names. Further, the quantity D is *not* displacement current, as Dr Stockman avers. We do not object to the quantity D, which equals ϵE. In our Fig. 3, D does *not* imply the existence of a dD/dt. Quite the contrary, dD/dt is zero at three of the four points where D is written, although at each of those points an electromagnetic signal is successfully travelling along without the benefit of a non-zero dD/dt.

Now for para. 4. Let us tackle equation (1) in a world devoid of displacement current but containing TEM waves as defined in *Wireless World*, July 1979, page 73.

$$\text{LHS} = \nabla \times H = \text{curl}\, H = -\frac{\partial H}{\partial x} \qquad (1)$$

$$\text{RHS} = \epsilon\frac{dE}{dt} \qquad (2)$$

From definitions in the July 1979 issue, page 73

$$-\frac{\partial H}{\partial x} = \frac{1}{c}\frac{\partial H}{\partial t} \qquad (3)$$

by definition
(see *W.W.* July Appendix 1)

$$\text{Now since } \frac{E}{H} = \sqrt{\frac{\mu}{\epsilon}}, \quad D = \epsilon E, \qquad (4)$$

$$\frac{D}{\epsilon H} = \sqrt{\frac{\mu}{\epsilon}} \qquad (5)$$

$$\therefore D = \frac{H}{c} \qquad (6)$$

$$\therefore \frac{\partial D}{\partial t} = \frac{1}{c}\frac{\partial H}{\partial t} \qquad (7)$$

Therefore substituting in (3),

$$-\frac{\partial H}{\partial x} = \frac{\partial D}{\partial t} = \epsilon\frac{dE}{dt} \qquad (8)$$

Returning to (1),

$$\nabla \times H = \epsilon\frac{dE}{dt}$$

See, no displacement current!

Of course, these mathematical arpeggios, the likes of which have for so long masqueraded as electromagnetic theory, are quite meaningless and futile. We might as well be asked to demonstrate how our skill at basket weaving (or at computing large prime numbers) in order to establish our credibility as experts in electromagnetic theory

Continuing with Dr Stockman's para. 4, there certainly does not exist displacement current or an E-field inside a perfect conductor. It is confusing the issue to discuss imperfect (copper) conductors when we are talking about the rudimentary fundamentals. The conduction current, as Dr Stockman knows, is only in the surface of the conductor (i.e. skin depth is zero).

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

SEVEN-SEGMENT / B.C.D. ENCODER

While applauding the attempt by Mr D. D. Clegg in your December 1979 issue to instruct us in the use of Karnaugh maps, I cannot help feeling that the particular problem discussed is more easily solved using National Semiconductor's integrated circuit DM86L25 which accepts both positive and negative logic. Although more expensive than the sum of the four packages used in the article, the reduction in space and p.c.b. layout time is usually worth while.

P. W. Small
Haverhill
Suffolk

The author replies:
In answer to Mr Small's comments I should point out that this circuit was originally designed several years before the appearance of National's DM86L25. Despite the availability of this device now, I recently used my design again to satisfy the requirements of a customer whose equipment had to incorporate qualified Mil-Spec. components available from more than one manufacturer.

I think you will agree with me when I say that the publication of such an article is not to claim the solution as being perfect or unique, but rather to demonstrate how such a solution was arrived at, and in so doing inform the reader and possibly stimulate the birth of new ideas! In electronic engineering the solution to a particular problem is

important but it is the approach to that solution which creates the interest and excitement.
David D. Clegg

WHAT'S SO NATURAL ABOUT e?

In Mr Finlay's interesting article "What's so natural about e?" (December, 1979) graphs of $y=4^x$, $y=3^x$, and $y=2^x$ are drawn and it is shown that for each curve $(dy/dx)/y$ is equal to a constant, k ($y=4^x$: $k=1.4$; $y=3^x$: $k=1.1$; $y=2^x$: $k=0.7$). Let the general form be $y=a^x$. The problem then is to find a value, a, such that $k=1$.

In Mr Finlay's Fig. 6 a graph of k is plotted against a. The value of a which makes k equal to 1 is found; this value of a is e. This method is easy to understand, but another method avoids drawing the interpolation graph; it gives the result from the graphs drawn in Fig 5.

Expressing it baldly, the procedure is to draw a tangent from the origin to one of the graphs – any graph. Find the distance of the point of contact from the x-axis. This distance is e. Though this is simple to do, the justification may not be obvious, and since we are trying to explain the importance of e, it is better to suggest drawing tangents from the origin to each of the curves. We note that the line drawn through the points of contact is parallel to the x-axis. The different curves have this property: the distance of the point of contact is the same for all the curves.

We now want to calculate this distance. The normal procedure would involve differentation, but since, quite reasonably in his approach, Mr Finlay wants to avoid this, let us use his values of k. Let us take the graph $y=3^x$, for which $k=1.1$. At the point of contact for this curve (P in my diagram) $dy/dx=PQ/OQ$. We know that $(dy/dx)/y=1.1$. At P, $y=PQ$. This gives $PQ=(dy/dx)/1.1=(PQ/OQ)/1.1$. Dividing each side by PQ, we have

$$1=\frac{1}{OQ\times 1.1} \text{ and}$$

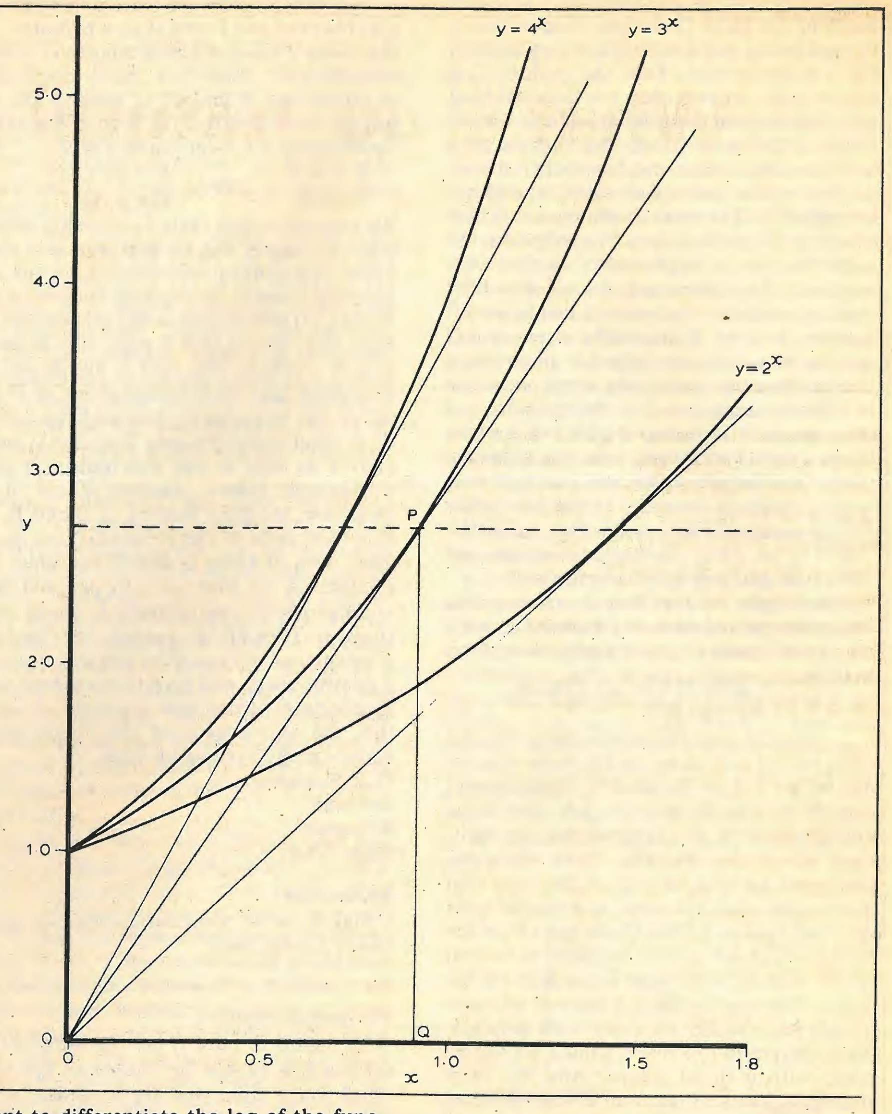
$$OQ=\frac{1}{1.1}$$

The relation between y and x is $y=3^x$ and x is 1/1.1. Thus $y=3^{(1/1.1)}=2.715$. This is our value for e. (Using Mr Finlay's other values for k (0.7 for $y=2^x$; 1.4 for $y=4^x$) we find a value of 2.69; of course, it is not pretended that Mr Finlay's values for k are accurate).

The advantage of this method is that students should realise from this approach that all curves of the form $y=a^x$ are associated with e. A by-product of this method is that it can be used to show that $OQ/\log_a e$ or that $OQ=1/\log_e a$).

This seems an appropriate context to mention an occasion on which he took me by surprise. I wanted to compare the accuracy (or resolution?) of different calculators. It is known that the limiting value of $x^{1/x}$ as x tends to infinity is 1. Using a scientific calculator, I wanted to find how large x could be before $x^{1/x}$ became 1. Then I started to explore the function $y=x^{1/x}$. It is 1 when $x=1$ and when $x\rightarrow$ infinity. When $x=2$, $y=1.414$. For what value of x is y a maximum? Trials on the calculator soon showed that the required value of x is between 2.5 and 3.0. More trials soon showed that the value was e.

Evaluating $dy/dx=0$ confirmed that it had to be e. (In the differentiation, it is convenient to differentiate the log of the function rather than the function itself.)



Classical mathematics could confirm that the result should be e, but my experience of classical maths did not suggest that it might be e until I had played with the calculator. I suspect that Euler would have known it all the time. Mr Finlay has written a valuable article which suggests a wide knowledge of the literature on e. I wonder whether he would have guessed it? Anyhow, I thank him for his article.
T. Palmer
Kew
Surrey

The author replies:
I thank Mr Palmer for his kind remarks and am greatly indebted to him for contributing to my museum of e-forcing graphical methods (by no means finished yet!) a simple and elegant one of drawing tangents from the origin against any number of a^x curves, as well as showing that $e=a^{1/k}$. As he rightly says, my k values for $a=2$, 3, 4 were approximate, and e will emerge more accurately from that formula when k is more accurate (e.g. by using the values I gave to the 'pure mathematician' on p.70).

The $y=x^{1/x}$ function is a curious one in several ways, including its y/x graph. This is virtually zero up to $x\approx0.4$, then rises suddenly and climbs smoothly, flattening out to a maximum value of ≈1.445, for $x=e$ as Mr Palmer states, and finally falls very slowly to a value of unity at x = infinity. I wonder how many other functions there are which show a similar maximum or minimum related to e?
John C. Finlay

STAGGERED LOUDSPEAKER UNITS

Without wishing to add to the highly analytical and sometimes controversial literature and correspondence under the general heading of "linear phase loudspeakers", I feel the following account, based on recent practical experience may be of interest.

During the development of a mid-range and treble "satellite" loudspeaker based on a line-source of three 7 × 4 in elliptical units side-by-side with a line-source of eight 2in diameter round cone tweeters, it was arranged that the degree of stagger between these two sources could be easily varied during listening tests. Subjectively there was a very critical physical spacing which gave optimum clarity to high frequency detail in the programme material. Indeed, the adjustment was as conclusive as "peaking-up" a high-Q tuned circuit. The interesting points that came out of this exercise were: (a) it is worthwhile allowing adjustment of the individual acoustical planes; and (b) the optimum degree of stagger is that which places the front edge of the speech coils approximately in line.

It should be mentioned that the full a.f. range above 100Hz was fed to the larger units and the a.f. range above 2.5kHz fed to the smaller units, the only cross-over components being series capacitors.
G. T. Edwards
Finesse Electronics
Reading, Berks.

What's so natural about e?

3 — Uses of e, including some in electrical science

by John C. Finlay

After discussing natural growth and decay and many of the phenomena in which they can be seen, the author passes on to second-order differential equations in natural vibrations. He continues with the operator j and series, looks at Euler's Trigonometrical Identity and de Moivre's Theorem, and ends this three-part series with the history of the a + jb type of representation.

The laws of natural growth and decay have been neatly summarized as 'The rate of growth is proportional to the state of growth'[20]. They are, mathematically speaking, examples of solving first-order differential equations. We have already worked out that for natural growth,

$$\text{where } \frac{dy}{dx}=y,$$

$$\text{the solution is } y=e^x$$

and for natural decay,

$$\text{where } \frac{dy}{dx}=-y,$$

$$\text{we have } y=e^{-x}.$$

A closely related kind of natural growth, not explosive like e^x and therefore (fortunately!) more common, is expressed by $y=1-e^{-x}$. To see what this looks like we'll sketch out a set of useful exponential curves in the region around values of +1 and −1 for x and y, as shown in Fig. 17. These include our old friends e^x and e^{-x} from Fig. 7, and making mirror images of them on the underside of the x axis, $-e^x$ and $-e^{-x}$. Then to produce $1-e^{-x}$ we lift the $-e^{-x}$ curve bodily by 1 unit. This transfers the crossover point on the y axis from −1 for $-e^{-x}$ to the origin, so that for $1-e^{-x}$, $y=0$ if $x=0$. Also we note that $1-e^{-x}$ can never exceed a value of +1 and in fact never quite reaches it, no matter how large x is. The important bit (for positive values of x) is solidly lined in, and we now have a curve whose rate of growth becomes *smaller* instead of greater as x increases, and gradually dies away to nothing, so putting a definite limit on the final value reached. We can look upon it as a sort of wise natural restrainer of sudden, exuberant and dangerous changes, and you will recognize it as showing the rate at which the lounge temperature climbs after you switch on the electric fire (or the current builds up in an electromagnet connected across a battery). e^{-x}, also lined in for positive values of x, has its virtues, too. When you switch off the fire, it stops the temperature from falling drastically, even though the fall is depressingly faster than the original rise!

Most of us probably think of growth and decay in terms of a *time span*, like life itself. It may be short-lived (or transient) like a flash of lightning, or almost eternal, like some radioactive decay. Cases governed by the exponential curves of Fig. 17 abound in all the sciences, material and immaterial.

In physics, Newton's law of cooling (as in the lounge we have just left unheated!) is familiar in heat studies. Mechanical examples include the rate of fall of a flywheel speed, the build-up of aircraft speed against air resistance, the free decay of vibrations in a musical instrument or an unmusical machine and the damping of unwanted vibrations in mechanical instruments. The last two remind us of analogous behaviour in electrical circuits with damped oscillations in spark transmitters, car ignition systems, tv e.h.t. generators, electronic flash guns and much else. Then of course there is the rise and fall of current in the series RL d.c. circuit and of capacitive voltage in the series RC equivalent, and the build-up of current in a gas-discharge due to the ionizing electrons.

The speed of growth of chemical reactions and its relation to temperature, and the rate of change of solution concentrations due to diffusion are both governed by e. So also is radioactive disintegration, as recently mentioned.

You can easily see the influence of e in botany by the manner of growth of vegetable life such as trees or plants and even more remarkably by the formation of daisy blossoms (florets), pinecones, pineapple bumps and tree leaves, all examples of the equiangular spiral[1], whose radius steadily increases as it grows, like e^x. In the first article I mentioned the topic of population explosions, an important preoccupation in biology (and medicine) and the infants have come across it in the prolification of their school rabbits! The famous Malthusian curve of population/production is of the same (depressing) shape[1]. The equiangular spiral enters again in the shapes of various animal objects such as the nautilus shell (a mollusc) already mentioned, and various surface appendages such as horns, nails, hairs, tusks and claws.

In the world of business and economics we have already met the Compound Interest Law. Another financial one deals with the depreciation of plant. Then there is the growth of multiple factories or shops and of mass-produced articles of a given kind, and industrial growth and decline in general. e may even control the price of a house building plot, where this depends upon how many have been sold already! Psychologists are convinced that rates of learning (in psychology, education and management) are exponentially controlled. So too are the rates of growth of religious and political beliefs, which you can easily see if you assume that every fervent devotee converts two others to his views, and that they in turn do the same (which could also be said of adherents to the chain-letter scheme, or of fanatics in hi-fi, punk rock or whatever!).

Perhaps the greatest of all the time-related phenomena is our concept of time itself[1]. In recalling past events, whether in your own lifetime or from ages ago, you will surely tend to remember more facts in a given year, decade or century, the nearer it is to your own present day. This exponential growth is curiously paralleled by the spread of dates allocated to various geological periods.

Natural growth and decay control many affairs which have *no* direct relation with time, especially in physics. That weird factor entropy, which terrifies so many students and is beloved of heat engineers, governs the processes of expansion and compression in gases and vapours, the work done and the pressures obtained. Heat transmission is another customer for e, as in the mean temperatures acquired by heat exchangers and bearings. Talking of pressure, the atmospheric pressure at any named height above sea level drops off exponentially as you go further up (Halley's Law). Earnest mechanical students know that the tensions on the two sides of a hard-driven pulley-belt pay homage to e, and that there are diabolical relations involved in the stresses found in thick cylinders and shells. Every husband who has been nagged into the impossible task of straightening his wife's clothes line may have been tempted to ask her why the CEGB isn't any more successful with its Grid cables between the pylons, and yet both of them, like the rest of us, have no doubt admired the graceful lines of a suspension bridge over the Forth, the Severn or the Thames.

The first two cases are examples of the curve naturally produced by gravity pulling an evenly-formed line out of horizontal shape – a catenary (from the Latin 'catena' = chain) – and the others, which have the added complication of an almost horizontal roadway slung below, are pretty near it in shape. The catenary is formed by *adding* two exponential curves from Fig. 17, namely e^x and e^{-x}, and halving the result, i.e.

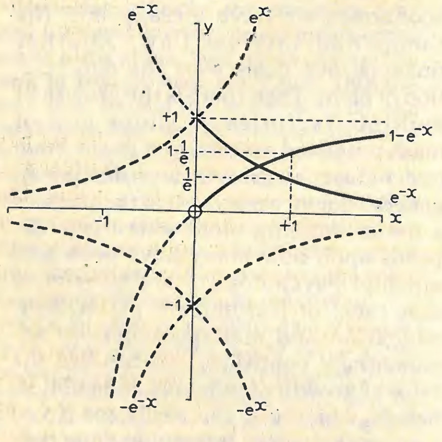


Fig. 17. Some useful exponential curves.

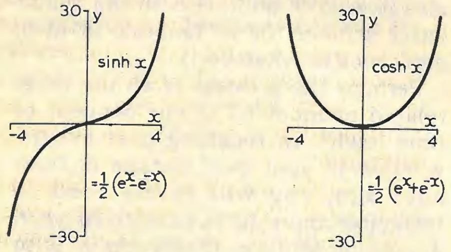


Fig. 18. More exponential curves, y=sinhx (left) and y=coshx (the catenary).

$\frac{1}{2}(e^x + e^{-x})$. This curve, shown in Fig. 18, is termed 'cosh*x*', implying 'cos hyperbolic', because it can be defined using a trigonometric ratio from the angle made with a rectangular hyperbola (Fig. 16), in the same way that a cosine can be defined from the angle made with a circle. Similarly 'sinh*x*' (pronounced 'shine'), also shown in Fig. 18, is made up from half the *difference* between e^x and e^{-x} and is the hyperbolic equivalent of sin*x*.

Electrically, sinh and cosh loom large (not to mention tanh!) whenever we have a much-repeated (iterative) chain or ladder of identical 3- or 4-terminal networks, as in transmission lines (d.c. or a.c., power or communication) with evenly distributed leakage or inductance and capacitance, and in wave filters[22] and attenuators (and we mustn't forget that attenuation can be measured in nepers – yes, the Baron rules OK! – as the natural log equivalent of decibels, often handier[22]). The simpler exponentials appear in the average magnetic field strength within a solenoid, the inductance of a short coil, the inductances and capacitances of both parallel and concentric conductors, the dielectric stress gradient across a circular cable, the saturation current in a valve diode and the forward current in a semiconductor diode.

When light is obscured by passing it through a filter of some kind its intensity is reduced exponentially as the filter thickness increases steadily. Astronomers have long known that the brighter a star is, the bigger is its magnitude, and today the brightness can be accurately measured and the magnitude calculated from a logarithmic formula[1]. Keen photographers also know all about the brightness of light, and that while it waxes or wanes in steps that seem even to the eye or in their exposure effect on a film, the brightness is in fact increasing or decreasing exponentially. Two 'stops' doubles or halves the light, just like the very first series we looked at (to check this, look at your camera iris and compare the hole areas at various *f no.* settings).

The last two examples are just one case of the human sense responses, in which the eye responds to brightness and the ear to sound volume and to pitch (frequency), all in a logarithmic manner, making it possible for us to distinguish very weak sensations and to be mercifully protected against extremely strong ones. The same law, discovered by the 19th century psychologists Weber and Fechner, applies to other senses, too, as of touch or pressure in comparing weights in the two hands.

Earlier I mentioned the shape of a grand piano, determined by the varying lengths of its strings (Land[1] makes an interesting comparison between it and the FA Cup rounds as a knock-out competition). The uneven spacing of the frets in fingering a guitar follows an exponential curve, as does the corresponding way in which a fiddler handles his strings or a trombonist moves his slide[1]. And what about the exponential horn, beloved of ageing hi-fi purists? In the somewhat colder world of statistics, e governs such matters as the Poisson distribution and normal distribution curves and various aspects of probability.

Another class of differential equations, the second order, such as

$$\frac{d^2y}{dx^2} + a\frac{dy}{dx} + by = 0$$

is of great importance to engineers. We meet them most commonly in dealing with natural vibrations, whether mechanical or electrical, and x is then a time variable. The general solution is

$$y = k_1 e^{\lambda_1 x} + k_2 e^{\lambda_2 x}$$

which looks very simple after what we did earlier, until you realize the complexity of the relationships between λ_1, λ_2 and *a*, *b*, and the three well-known cases that can result (overdamped, critically damped, underdamped). The last one is especially diabolical, and therefore likely to be interesting, because it lands us with new type of exponent for e, involving the square root of a negative number.

Now that last factor alone is not unfamiliar to electrical engineers since we represent it by *j* and use it a lot in a.c. circuit analysis. But what about $e^{j\theta}$? This quantity is very important to students of a.c. theory and to electrical engineers who work with rotating machinery. Now why should this be so? Of what possible practical value is an imaginary power of a transcendental number? As usual, it is generally introduced as a mathemagician's trick, a sorcerer's device that will unlock the door to several mysteries. And so it does.

Let's make use of the series we found earlier for e^x by fitting it to $e^{j\theta}$, replacing x by $j\theta$.

$$\text{Then } e^{j\theta} = 1 + j\theta + j^2\frac{\theta^2}{2!} + j^3\frac{\theta^3}{3!} + j^4\frac{\theta^4}{4!} + j^5\frac{\theta^5}{5!} + j^6\frac{\theta^6}{6!} + \ldots$$

Now all of you know from your a.c. theory, as well as by simply multiplying a few $(\sqrt{-1})$s together, that

$$j^2=-1 \quad j^3=-j \quad j^4=1 \quad j^5=j \quad j^6=-1$$

so that we can sort out the series and divide it into two neat rows

$$e^{j0} = \quad -\frac{\theta^2}{2!} \quad +\frac{\theta^4}{4!} \quad -\frac{\theta^6}{6!}$$

$$+j\theta \quad -j\frac{\theta^3}{3!} \quad +j\frac{\theta^5}{5!}$$

Now the first line turns out to be the series for calculating cosθ, and the second line for *j* times sinθ (θ in radians), which I would like to have known all those years ago!

$$\text{so } e^{j\theta} = \cos\theta + j\sin\theta$$

This is usually credited to Euler, that master-builder of series, and so is known as Euler's Trigonometric Identity. Interestingly, though, this formula (1748) was anticipated by an Englishman, Roger Cotes, who in 1714 published a theorem on complex numbers[23] which would appear in modern form as

$$j\theta = \log_e(\cos\theta + j\sin\theta)$$

All this was long before a.c. or even a commercial electric power supply of any kind had been thought of, so what does it mean today? Let's multiply all through by *r*, for a good reason that will appear in a moment, so that

$$re^{j\theta} = r\cos\theta + jr\sin\theta$$

The trig. side shouldn't bother anyone because it is a clear instruction to build up a phasor diagram from *r*cosθ

horizontally to the right followed by *r*sinθ vertically upwards, as in Fig. 19.

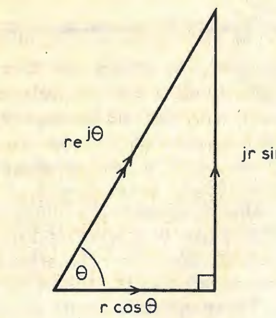


Fig. 19. The meaning of $re^{j\theta} = r\cos\theta = jr\sin\theta$.

Then it is obvious that we have a right-angled triangle with angle θ in the position shown and a hypotenuse of length *r*. So what about $re^{j\theta}$? It is now clear that $e^{j\theta}$ is an 'operator', giving us an instruction about the direction in which *r*, thought of as a radius arm revolving about a pivot at its lower end, is to point, namely at a positive angle θ above the horizontal reference direction. In brief, it is a *polar operator*.

If you're still not convinced, and think that I glided too neatly over the problem by merely *saying* that the series adding up to $e^{j\theta}$ comprised the two series for cosθ and *j*sinθ, I can do no better than refer you again to that prince of problem-solvers, Marcus Scroggie[24], who first demonstrated in this journal many years ago that the series we derived for $e^{j\theta}$ can be literally plotted out in a phasor diagram. He makes θ=1 (radian) so that

$$e^{j\theta} = 1 + j1 - \frac{1}{2} - j\frac{1}{6} + \frac{1}{24}$$

(which is about as far as it is worth going) and then plots out these values in turn, giving a spiralling path which homes in on a point at unity distance from the origin and making a positive angle of 1 radian (about 57°) to the *x*-axis! In further confirmation he takes θ as 2 and shows that $e^{j\theta}$ still has its unity radius value but now makes 2 radians (about 115°) to the reference axis. Long live the graphical solution!

You probably know that Euler (and all mathematicians following) used *i* where electrical people (for obvious reasons!) prefer *j*, and the full identity covers + *and* – terms and appears usually as

$$e^{\pm ix} = \cos x \pm i\sin x$$

Here x is the angle, and if we make it π radians (=180°) we get

$$e^{i\pi} = -1 + 0$$

$$\text{or } e^{\pi i} + 1 = 0$$

which is that marvellous mystical relation between the three weirdos e, π and *i* that I mentioned earlier. How wonderfully clear it looks now! It also serves to show us that since e, by definition, is non-algebraic or transcendental, so also must π be (as we said earlier), since $e^{i\pi} = -1$ and $i\pi$ cannot therefore be algebraic. Now *i* is algebraic, so that π is not[25].

Many of you will know another identity entitled de Moivre's theorem:

$$(\cos\theta + i\sin\theta)^n = \cos n\theta + i\sin n\theta$$

De Moivre was a Huegenot refugee from France who came to England as a young man in 1685, taught mathematics, became a close friend of Sir Isaac Newton and a member of the Royal Society and its French and German equivalents, worked for a firm of insurers and pioneered the actuarian profession in the calculations he carried out for them. Not surprisingly, he made important contributions to the theory of probability. His theorem was published in 1722[26] and has been described as the 'keystone of analytic geometry'[27]. It is very useful if you want to work out half-forgotten trig. identities for multiple angles, such as $\cos 2\theta = 2\cos^2\theta - 1$ and $\sin 2\theta = 2\cos\theta\sin\theta$[24], by separating the in-phase and quadrature components (as we would say in phasor diagrams). These are also somewhat quaintly termed the real and imaginary parts by mathematicians, originally as long ago as 1637 by Descartes[28] (to whom we also owe the idea of Cartesian co-ordinates). Let's use the theorem to express cos 3θ and sin 3θ in terms of cosθ and sinθ respectively.

Then, using the electrical engineer's more familiar *j* notation,

$$(\cos\theta + j\sin\theta)^3 = \cos 3\theta + j\sin 3\theta$$

$$= (\cos^2\theta - \sin^2\theta + 2j\sin\theta\cos\theta)(\cos\theta + j\sin\theta)$$

$$= \cos^3\theta - \sin^2\theta\cos\theta - 2\sin^2\theta\cos\theta + j(2\sin\theta\cos^2\theta + \sin\theta\cos^2\theta - \sin^3\theta)$$

Hence, equating in-phase parts,

$$\cos 3\theta = \cos^3\theta - 3\sin^2\theta\cos\theta$$

$$= \cos^3\theta - 3(1 - \cos^2\theta)\cos\theta$$

$$\text{or } \cos 3\theta = 4\cos^3\theta - 3\cos\theta$$

and, equating quadrature parts,

$$\sin 3\theta = 3\sin\theta\cos^2\theta - \sin^3\theta$$

$$= 3\sin\theta(1 - \sin^2\theta) - \sin^3\theta$$

$$\text{or } \sin 3\theta = 3\sin\theta - 4\sin^3\theta$$

both of these are standard results, and you get two for the price of one!

De Moivre himself stated his formula for *n* positive (and was probably only aware of it in that form; it was Euler who proved that it was also true for negative and fractional powers[29] and equated it to the e power already mentioned, so that in full

$$(\cos\theta \pm i\sin\theta)^n = e^{\pm ni\theta}$$

$$= \cos n\theta \pm i\sin n\theta$$

and Euler's Identity, already mentioned, is just the special case where $n=1$. At the same simple level it is very handy for deriving identities of the sum or difference type, since the polar operator $e^{j\theta}$ (as we will now call it again) can be easily split into two single-angle operators when θ is changed into a sum or difference angle. For example, suppose we want to obtain cos(*A*–*B*) and sin(*A*–*B*) in terms of *A* and *B* functions,

$$\text{then } e^{j(A-b)} = e^{jA}.e^{-jb}$$

$$\text{Now } e^{jA} = \cos A + j\sin A$$

$$\text{and } e^{-jB} = \cos B - j\sin B$$

$$\text{so that } e^{j(A-B)} = e^{jA}e^{-jB} = (\cos A + j\sin A)(\cos B - j\sin B)$$

$$= \cos A\cos B + \sin A\sin B + j(\sin A\cos B - \cos A\sin B)$$

but $e^{j(A-B)} = \cos(A-B) + j\sin(A-B)$ from Euler's Identity

Hence, equating the in-phase parts, $\cos(A-B) = \cos A\cos B + \sin A\sin B$ and, equating quadrature parts, $\sin(A-B) = \sin A\cos B = \cos A\sin B$ which are again standard results.

Many other sine and cosine problems can be sorted out by turning them into exponentials[30]. There are, of course, many more advanced uses of the formula such as finding the powers or roots or complex numbers, phasors or position vectors (call them what you will!) and of real or non-complex numbers[31], or deriving series for accurate calculation of sines and cosines of any angle[32]. Jon M. Smith quotes many useful formulas and Hewlett-Packard procedures for handling complex functions on a pocket calculator[33], recognizing that the more advanced scientific calculators all simplify conversion between rectangular and polar co-ordinates, which eases this sort of analysis.

In a final fling of history, let us pay credit for the *geometrical* representations of $a+jb$ (etc.) where it is due. The earliest useful attempt was published in 1685 by Englishman John Wallis, which used what we would now call the *x*-axis for the *a* part and drew perpendicular lines to it as required to erect the *b* part, but failed to use the idea of a *y*-axis[34]. It was not until much later that real progress was made by Wessel, Argand and Gauss[35]. Wessel was a Norwegian surveyor who in 1797 published a paper in a Danish academic journal which represented 'directed line segments' (vectors), for the first time, by reference to two axes, one for 'real' numbers (*x*) and one for the 'imaginaries' (*y*), written in the form $a+h\sqrt{-1}$. Summing and multiplication of vectors was correctly described.

No doubt because of its obscure publication, Wessel's work was overlooked until a full century later, when it was republished in French. In the meantime Argand, a Swiss bookkeeper who, like Wessel, was self-taught, had in effect rediscovered the principle, described in a book in 1806, but added to it the idea that multiplying by $\sqrt{-1}$ turned a vector through 90° counter-clockwise, whereas a $-\sqrt{-1}$ product produced a similar clockwise rotation. He also represented his directed line by the form $r(\cos\theta + i\sin\theta)$ where *r* is the length, and by $r = a + bi$ where *a* and *bi* are mutually at right angles in the so-called Argand diagram. It wasn't however until Gauss, the great German mathematician, physicist and astronomer, took a hand in the matter, actually coining the term 'complex number' and using it in several papers published up to 1831, that the idea became generally accepted. He dispelled the unnecessary mystery about 'negative' and 'imaginary' numbers by saying that they would have been better termed 'inverse' and 'lateral'. He was also the first to represent $a+bi$ as a point and not necessarily as a vector, and introduced some basics in complex function theory.

Finale

Have you, like me, ever had a hangup about e? Maybe you refused to believe in the existence of this peculiar number, or even took an active dislike to every formula in which it appeared? If so, I hope that by now your feelings towards e will have mellowed and indeed warmed, much as they may do in real life towards an old enemy whom you haven't seen for many years and whom you never really understood. The next time you meet e, perhaps indeed you will look upon it as a friend whose acquaintance is well worth cultivating and, if the thought is not too fanciful, with the encouragement of Euler, Napier and all the others who have contributed to its understanding, smiling from their golden clouds in Paradise.

Could I make a special plea to any teacher of (or lecturer in) mathematics who has taken the trouble to read through these articles? *Please* try to enliven your subject and give your students an incentive by revealing to them some of the glories of Nature and the practicalities of man, as I have tried to do here, and as the very greatest of mathematicians have always done.

Finally, a request. Does anyone know of a simple mechanical model which brings out the value of e? I have looked far and wide, in vain, for something which the infants could use (in place of their ubiquitous tin cans for finding π). The search is probably hopeless because, as I said at the beginning, e does not so readily reveal its secrets, and some pundit will probably prove (at least to his own satisfaction) that no such model could ever be made. However, hope is eternal and progress lives upon it, and perhaps just one person's imagination will be fired to provide this missing link, as has so often happened in the story of science and technology.

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35. Ref. 23, pp. 628-632. □

BOOKS

Two-metre Antenna Handbook, by F. C. Judd (G2BCX), is a mainly practical book for amateurs using the 145MHz band for the first time. A chapter on basic aerial theory is followed by sections on omnidirectional and directional designs, with notes on construction. A chapter on cables includes details of matching devices, connectors and rotators, and the final chapter on measuring the performance of aerials includes some confidence-inspiring photographs of displays from the author's polar plotting equipment, using model aerials. The 157 page book is published at £3.95 in paperback by Butterworth and Company Ltd, 88 Kingsway, London WC2B 6AB.

The Theory and Servicing of A.M., F.M. and F.M. Stereo Receivers, by Clarence R. Green and Robert M. Bourque, is well explained by its title. It contains a great deal of non-mathematical information on the operation of all sections of the equipment under discussion, and goes on to suggest general and specific methods of fault-finding in typical equipment, describing both semiconductor and valve techniques. While the book is American and the language a little unfamiliar in places, it will be found easy to read by British service technicians. Circuit diagrams may be a bit more difficult, since they are drawn in the 'upside down' transatlantic manner. The book contains 583 pages, costs £16.20 and is published in hardback by Prentice-Hall International, 66 Wood Lane End, Hemel Hempstead, Herts. HP2 4RG.

Complex Digital Control Systems, by Guthikonda V. Rao, is weighty in both senses of the word. It is concerned in the main with data-sampling digital control systems, in particular those used in video tape and disc recording equipment, on which Dr Rao is an authority. The book is not as mathematical as its subject might lead one to suppose, most algebra being concentrated in an early chapter which surveys both analogue and digital control theory. Several sections on the control of video equipment are followed by a chapter on the use of microcomputer systems with which, the author remarks, digital control systems are about to take a new turn altogether. Three appendices are concerned with frequency synthesis of oscillators, high-speed phase-locked loops, and the basic concepts of feedback control systems. There is a useful bibliography. This beautifully-produced book contains 516 pages, costs £27.40 and is published by Van Nostrand Reinhold Ltd, Molly Millars Lane, Wokingham, Berks.

The American Radio Relay League has sent us their two most recent publications, the first being the prestigious **Radio Amateur's Handbook** for 1980. This one is in a larger format than before, and several of its chapters have been revised. It is impossible to give a list of its contents; it is enough to say that any amateur radio enthusiast would be ill-advised to pursue his hobby without it.

The second offering from ARRL, **Weekend Projects,** is a collection of reprinted constructional articles from *QST*, selected for their cheapness and simplicity. As the editor remarks, there is a decline in the home-building of amateur radio equipment due to the high cost of components and lack of time. The answer seems to lie in quick, simple and cheap 'quickies' for the shack, and this is the reason for the book. Handbook: $12.50 ($18 clothbound). Weekend Projects: $3.50. The American Radio Relay League, Inc., Newington, Connecticut 06111, USA.

SIXTY YEARS AGO

Senatore Marconi was in trouble with the newspapers and popular science publications in the early part of 1920. Many operators were at a loss to explain 'X's' or atmospherics and Marconi expressed the view that, since identical 'signals' were received at widely separated points on the earth, the most likely sources were at a great distance and possibly well outside the earth, meaning natural sources, of course. This remark was joyfully seized on by Fleet Street, who interpreted it as meaning that playful Martians were transmitting to us. Marconi denied that he meant anything like that, but it was too late — the controversy was well under way and its initial head of steam was maintained by the press, who found the story too good to worry much about the facts.

A succession of articles appeared, and the one in our April 3, 1920 issue (we were then fortnightly) contained a piece by Philip Coursey and the report of the presidential address to the Wireless Society of London by A.A. Campbell Swinton, F.R.S. His remarks on the subject went as follows:

"Perhaps it might with advantage be pointed out that the intensity of received wireless signals varies inversely more or less as the square of the distance between the source and the point of reception; so if we suppose the mysterious signals in question originate on the planet Mars, the power of the sending apparatus must be of prodigious dimensions. For instance, if the signals in question are received in London as loudly as those from Paris, the power employed in Mars must be greater than what is used in Paris in the proportion of the square of 200 — the rough distance in miles from Paris — to the square of 49,000,000, the distance in miles from Mars.

The power employed in Paris is about 200 HP; so that unless the inhabitants of Mars have improved methods of directional sending greatly surpassing our own, the power used on Mars to give equal effects in London must be about 60,000,000,000 times great as in Paris or say, 12,000,000,000,000 HP.

This certainly seems a fairly large amount for even Martians to employ for purely signalling purposes and would entail the use of a Morse key of ample dimensions.

Surely a much more reasonable supposition is that the so-called signals originate in the sun where natural outbursts of electro-magnetic activity exceeding in amount even this stupendous horse-power are, it is known, of not infrequent occurrence. Indeed, our great luminary is continually radiating into space some ten thousand horse-power per square foot of its surface, and as its diameter is 865,000 miles there are a great many square feet, and the total horse-power it radiates in toto is something altogether enormous. It is thus evident that even comparatively small ebullitions on the sun's surface may well cause disturbances on the earth amply sufficient to account for the so-called signals".

Improving photodiode camera signals

Shading correction for array scanner used in chromosome analysis

by **Daryll K. Green** MRC Clinical and Population Cytogenetics Unit, Edinburgh

The circuit described corrects signals for the shading effects which occur in a photodiode array camera used for detecting stained chromosomes in dividing blood cells. Correction is needed because both the differences in photodiode sensitivity in the array and the illumination shading are greater than the chromosome image contrast. Cost of components is a fraction of the cost of the photodiode array camera.

Most photodiode array scanners show some non-uniformity of diode sensitivity. Quite often subjects which are imaged onto any type of scanner are non-uniformly illuminated. Where the illuminating light level is high, giving rise to a high signal-to-noise ratio, and the image contrast is greater than either diode or illumination shading effects, the detection and measurement of subject features with a photodiode scanner presents no problem. The difficulty which prompted the building of the shading corrector described here is the detection of stained chromosomes imaged through a microscope where both the differential diode sensitivity and the illumination shading are for the most part greater than the chromosome image contrast. A circuit for correcting the photodiode signals for these shading effects is explained. The corrected photodiode scanner forms part of a machine used for automatically detecting dividing blood cells on a microscope slide preparation.

Fig. 1 shows a photograph of a typical field of view from a microscope slide preparation intended for chromosome analysis. The cells of primary interest are similar to the one which is circled in the figure. There the chromosomes are well separated and randomly distributed in an approximately 50μm diameter circle. On average there are about 10 cells of interest, together with about 10,000 undividing cell nuclei similar to the plain circular objects seen in Fig. 1, on each square centimetre of slide.

The scanner signal from a 1-inch Integrated Photomatrix Ltd 256 linear diode array and signal processor is shown in Fig 2. The cost effectiveness of the microscope depends in part on the speed at which the cells of interest can be found. It is therefore important to work as close as possible to the limits of acceptable geometric resolution and signal-to-noise ratio of the microscope and scanner combination. Extensive experiments have led to a scanner speed of one scan per 300 μs and a scanned field width of 384

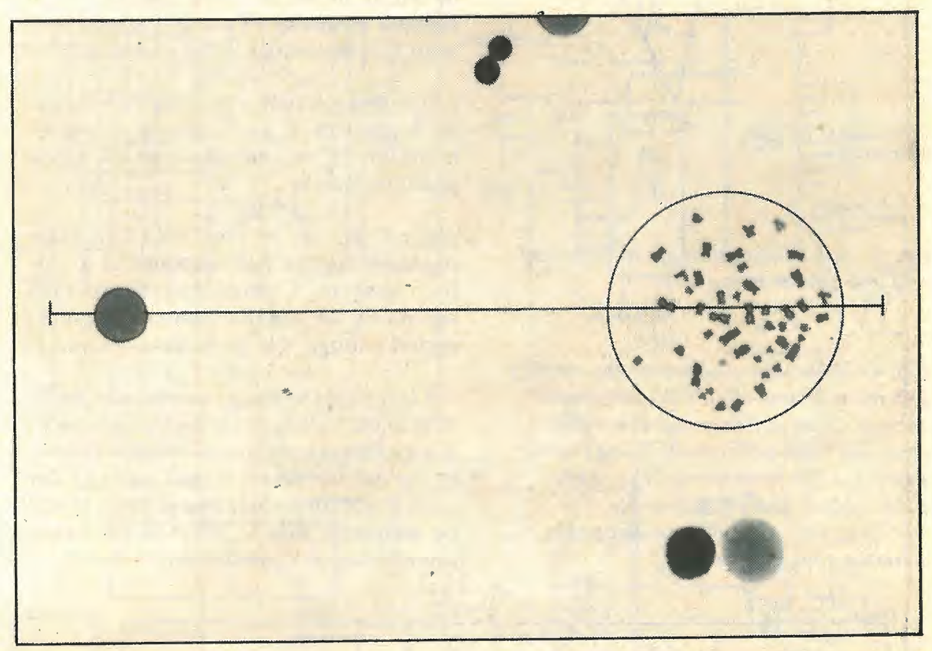


Fig. 1. Chromosomes in a blood cell are shown on this microscope slide in the circled area, which has a diameter of about 50μm. The drawn horizontal line represents a scan traversing the image on the photodiode array. Large dark objects in this field of view are nuclei of blood cells which are not dividing.

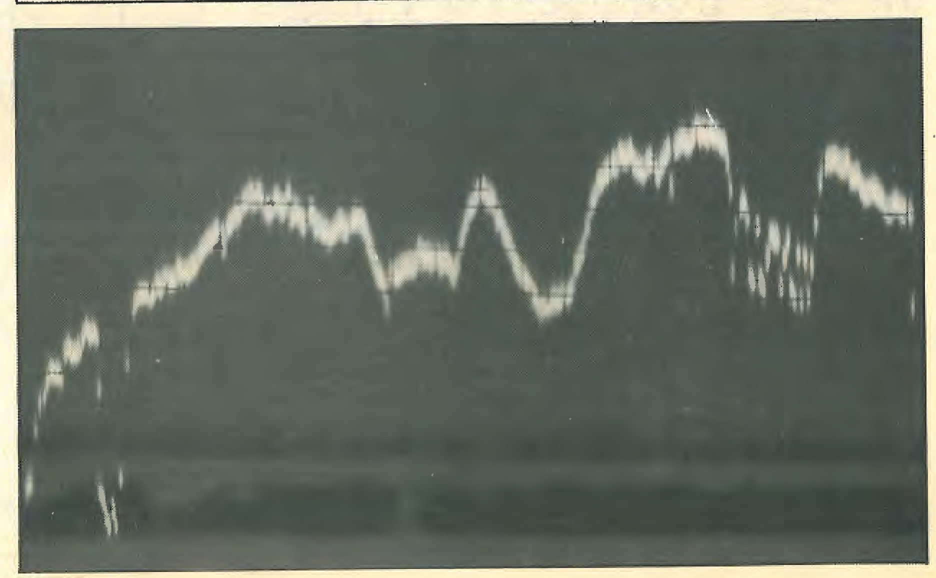


Fig. 2. Oscilloscope trace of the 256-diode array scanner signal corresponding to the scan line marked in Fig. 1. Vertical scale is 200mV/cm; horizontal scale is 30μs/cm.

microns. The microscope slide is at the same time driven back and forth under the control of a stepping motor at 90° to the scanner direction and at a speed of 5,000 microns per second.

The major component of the non-uniformity of diode array signal voltages arises out of the slide illumination and imaging system (Fig. 3) which comprises a 100W quartz iodine microscope lamp with the usual condenser, objective and projection eyepiece optics. At each stage in the microscope light path there is a loss of intensity due to the imperfect transmission of the optical components across the whole field of view. Maximum transmission is usually along the optical axis. A lesser component of signal non-uniformity is the differential photodiode sensitivity, which is specified as 5% by the manufacturers, though in practice only one or two diodes differ in sensitivity from their neighbours by this amount.

The magnitude of signals from large chromosomes exceeds the 5% sensitivity variation of the diodes but is much less than the observed 2:1 illumination variation. Small chromosome signals are obscured by both. In the absence of shading correction, therefore, detection of chromosomes and the measurement of their transmissivity is very nearly impossible.

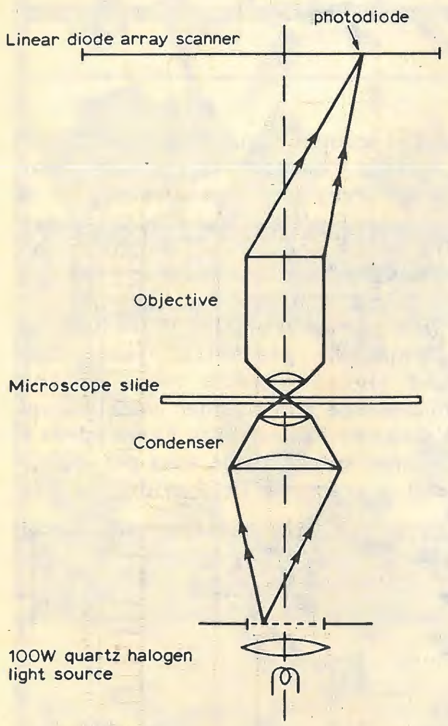
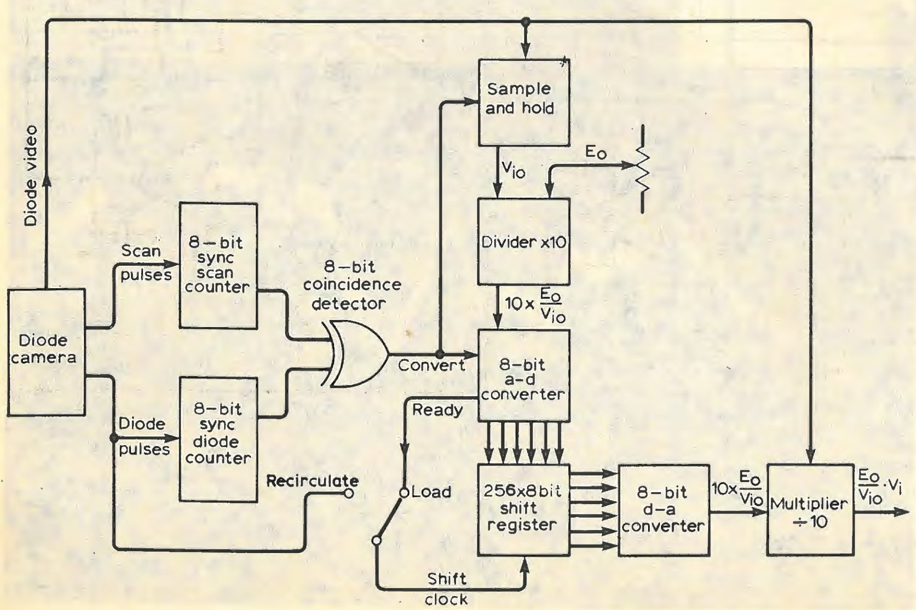


Fig. 3. Path of light through microscope to a photodiode in the array.

Fig. 4. Schematic diagram of the loading and recirculating circuit for correction factors. Scan pulses occur every 300 microseconds; photodiode pulses occur every 1.17 microseconds. The ready pulse occurs approximately 20 microseconds after the convert pulse initiates a conversion.



Shading correction theory

When there is no object on the microscope slide imaged onto the i^{th} diode a signal voltage V_{io} is measured. When an object of transmissivity "t" is imaged onto the i^{th} diode a signal voltage V_i is measured. It follows that

$$t = V_i/V_{io}$$

It is desired that a shading correction be applied to V_i such that a measurement of "t" is independent of diode position, that is

$$t = V_i/V_o$$

where V_o is a constant voltage representing the flat response of a perfect system. Comparing these two equations we see that the shading corrected voltage V is given by

$$V = V_i(V_o/V_{io})$$

Each diode voltage therefore must be multiplied by a factor (V_o/V_{io}) where V_o is an arbitrary constant voltage and V_{io} is the uncorrected signal voltage for each diode for a clear image field. It will be seen later that V_o is set to the maximum value of V_{io} and is relabelled E_o.

Implementing shading correction

The correction factors (E_o/V_{io}) are held in digital form in a 256-element shift register which is synchronously recirculated with the diode array signals. The number of bits required in each of the shift register elements is roughly determined by the average signal-to-noise characteristic of the diodes. This amounts to about 25 millivolts in a full saturation voltage of 5 volts, which is one part in 200. An 8-bit binary correction factor is therefore more than adequate and fits in well with a wide range of 8-bit commercial analogue-digital and digital-analogue converters. The value of (E_o/V_{io}) for each diode is loaded into a 256×8-bit static shift resister which is then recycled synchronously with the original diode signals. The circuit for loading and recycling the correction factors is schematically shown in Fig. 4. Loading the shift register in one scan of the array camera, which in this example occurs in 300 microseconds, would require an approximately 1 microsecond analogue-to-digital conversion for each diode correction factor. Though this is possible it is expensive. For this reason a simple timing circuit is used, such that during a whole scan time of 300 microseconds only one diode correction factor is sampled, converted and loaded into the shift register. Each diode is taken in sequence and an extra scan time is allowed at the end to give the final diode in adequate conversion time. The total correction set-up time is therefore 300 × (256 + 1) microseconds, which is approximately 77 milliseconds.

Detailed circuit

In practice the correction factors E_o/V_{io} will always be greater than or equal to unity, which would cause most analogue divider circuits to overflow. There are several ways of overcoming this problem such as the following:

1. Reduce E_o by a fraction "f", store correction factors (fE_o/V_{io}), then multiply the corrected diode signals with a factor $1/f$ to form:

$$V_i\ (1/f)\ (fE_o/V_{io} = V_i\cdot(E_o/V_{io}).$$

2. Store correction factors (V_{io}/E_o), then *divide* diode dignals with these factors to form: $V_i\ /\ (V_{io}\ /\ E_o) = V_i\ (E_o\ /\ V_{io})$.

3. Store correction factors $(E_o - V_{io})\ /\ V_{io}$, then multiply diode signals with these factors and add V_i, to form

$$V_i(E_o - V_{io})\ /\ V_{io} + V_i = V_i(E_o\ /\ V_{io}).$$

The actual method adopted is the last of these options. Fig. 5 shows the complete shading correction circuit. Diode zero timing signals occur at the start of each scan and the diode clock signals occur each time a diode video signal is ready for processing. Both pulses are approximately 500ns which is half the duration of each diode signal. The start circuit is designed to begin accumulation of correction factors at the second

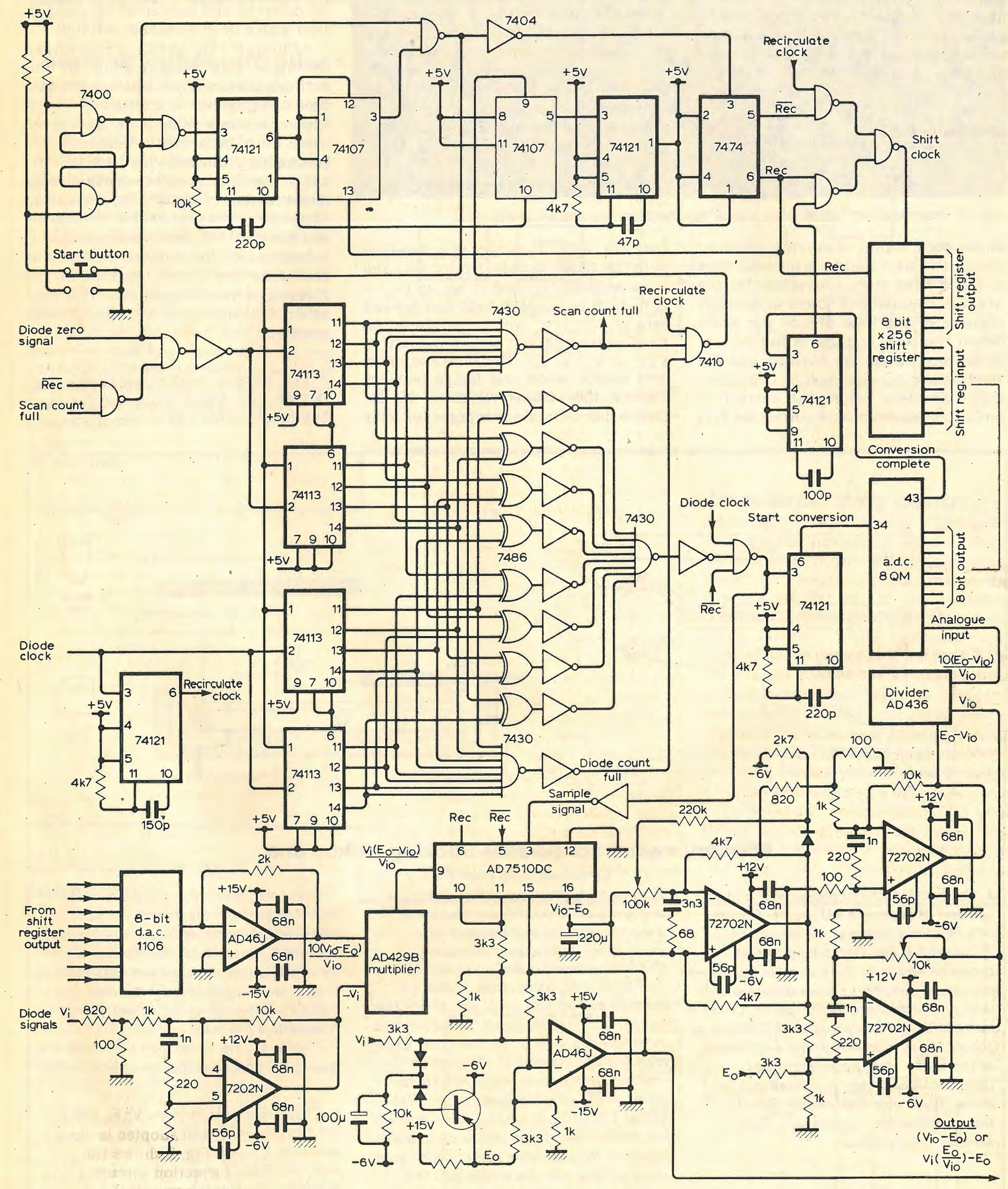


Fig. 5. Complete circuit of the shading correction system

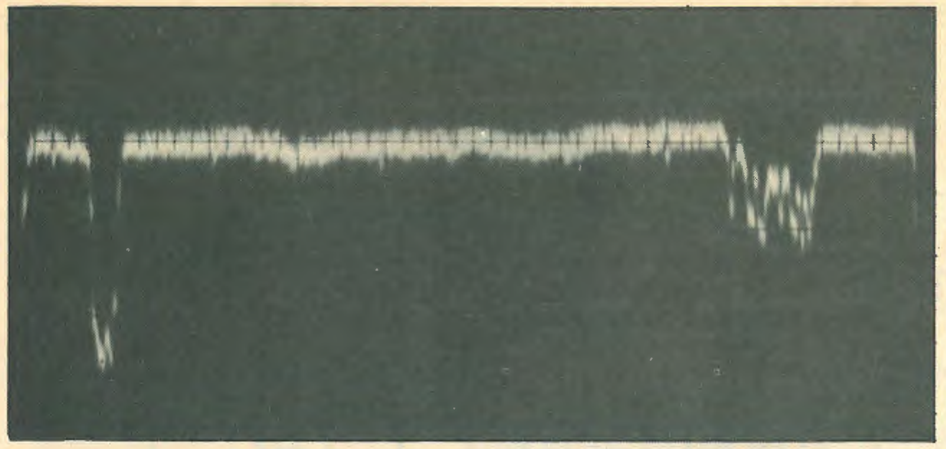


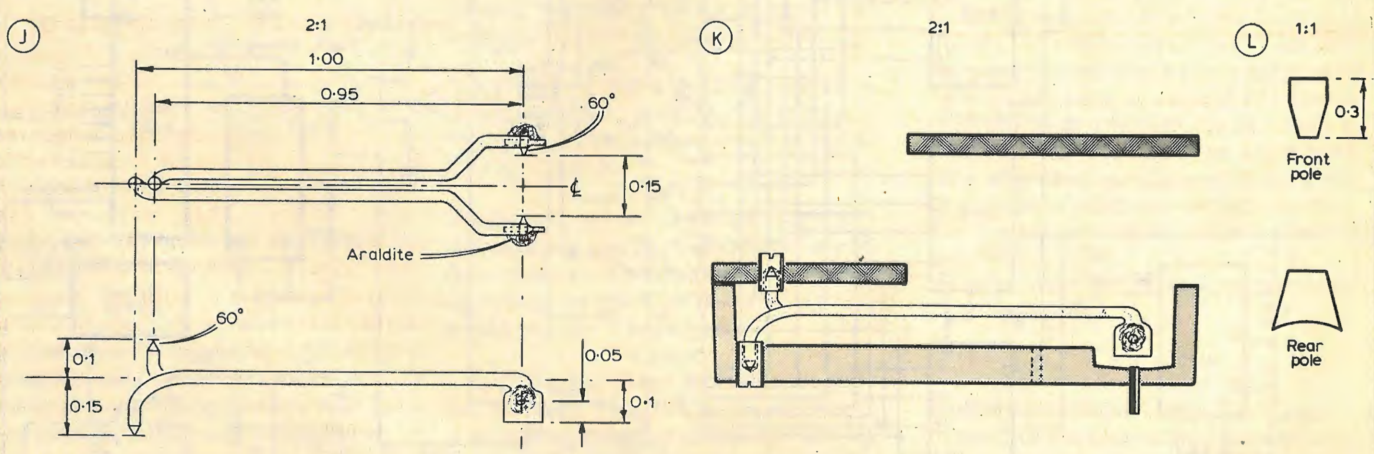
Fig. 6. The corrected diode array signal for the scan line shown in Fig. 1.

diode zero signal occurring after or during the start button is pressed, thus giving a clean start. Correction factors are then counted and stored in the shift register at the rate of one per scan. When the scan counter is full further diode zero pulses are blocked and the diode clock counter must be coincidentally full twice before the correction circuit closes down and correction factors are recirculated in synchronism with the diode signals. Notice that the same amplifier is used to set up ($V_{io} - E_o$) which is sampled, held and formed into $(E_o - V_{io})/V_{io}$ and to produce the final corrected and offset output of $V_i(E_o / V_{io}) - E_o$. The final output is zero except when real image features traverse the scanner which in this instance has certain advantages for later signal processing.

Fig. 6 shows the array scanner signal of Fig 2 after multiplication with recirculating correction factors which were previously set up from a clear image field. The chromosome signals can now be detected and measured by comparison with a fixed threshold voltage.

Although this shading correction technique was brought about by the author's own need to squeeze the last drop of signal out of a relatively cheap form of scanner using a low light level, there must be a host of other image processing problems where it is important to obtain an accurate densitometric measurement of the scanned material. The component cost of this refinement to a standard IPL linear array camera is a fraction of the camera cost and is falling by the month, and all of the foregoing remarks apply equally well to other conventional or c.c.d. linear array scanners.

The author wishes to thank Roy Bayley and Denis Rutovitz for their helpful contributions to this article. □



Mercury switch for parallel-tracking pickup arm

Continued from page 63

J. *Cut two lengths of nickel wire and turn one end of each to a 60° point. Flatten other end in a vice and file square to 1.2in. and 1.3in. Drill a hole to suit guage of wire (e.g. 22 s.w.g.) in flattened portion. Insert short pieces of nickel wire with one end turned to 60° point. Crimp into place, and apply a spot of Alraldite to secure. Bend the ends of the electrodes as indicated. Hold both electrodes together side by side in a small vice or pliers. Twist into final shape. Glue temporarily with "superglue". Test for electrical isolation.*

K. *Assemble pivot cups in switch case and rear part of lid. Try out electrode assembly for size and freedom of movement. If necessary dismantle electrode assembly and pivot cups and file/bend until acceptable. Introduce mercury ball on trial basis and check that correct action takes place. The electrode assembly can then be permanently fixed with Araldite instead of "Superglue."*

Now remove pivot cupts and solder 12in. length of Litz wire to them. Also solder 12in. of Litz wire to three-channel electrodes taking care not to disturb their position. Re-assemble switch, with some rapid-setting Araldite on the lid. This gives you about 3min to manoeuvre the lid. Give a final mechanical and electrical check before glueing on the front part of the lid, using Araldite.

Inject the mercury ball via filler hole with 1ml syringe. Flush with propane gas and plug filler hole with 8BA steel screw.

Switch is now ready for testing. If too sensitive, shake mercury out until there is larger clearance between electrode tips and ball. Extra mercury can be injected to reverse this process.

Finally, fix the completed switch to the lower arm with liberal amount of Araldite.

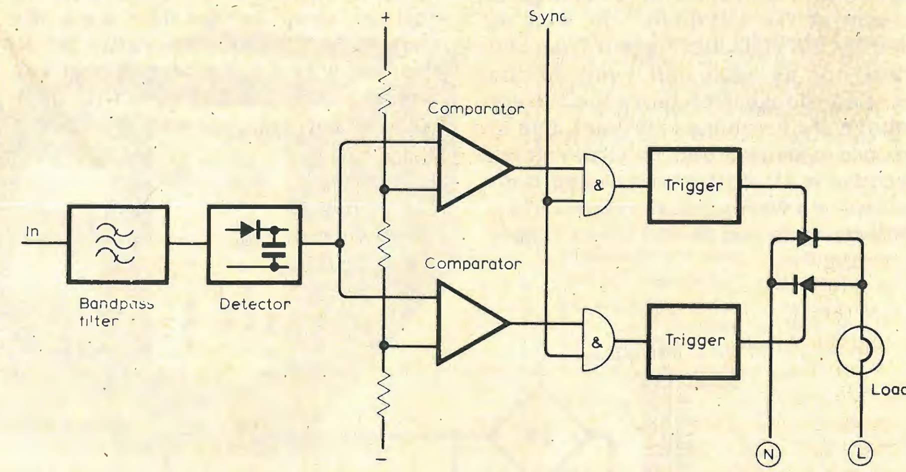
L. *Shape rear pole for magnet by trial and error to give no lateral force on tracking arm over 1° each side of the central position. Radius shown is nominal. Material: mu-metal transformer lamination.*

CIRCUIT IDEAS

Thyristor light controller

Designs for sound-activated light controls often use zero-voltage switching to reduce r.f.i., but this technique reduces the lamp illumination to on or off. The lighting effect can be improved by providing a level control with a pair of back-to-back thyristors as shown. If the rectified output from a bandpass filter is between the thresholds of the comparators, only one thyristor is triggered and the lamp operates at a reduced brightness. When the output is greater than the upper threshold, both thyristors are triggered and the lamp operates at full brightness. Sync. pulses are derived from the mains input and ensure that the thyristors are triggered only at the mains zero-crossings.

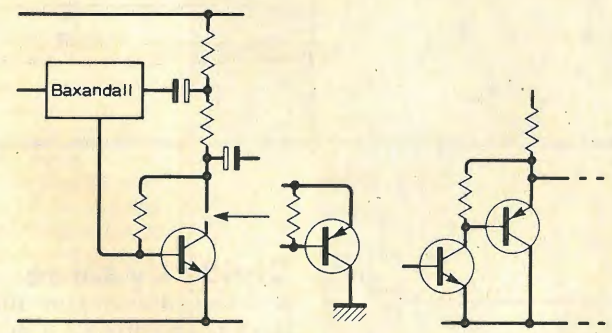
P. M. Jessop
Solihull
W. Midlands



Improved tone control

Many audio amplifiers use a Baxandall tone control network around a single transistor as shown. With this arrangement the gain is adequate when the controls are flat but, if bass or treble boost is required, noticeable distortion often arises. This problem can frequently be overcome by providing the original transistor with a bootstrapped collector load. With an inverted emitter follower, the increase in gain is around 25dB. The base-emitter resistor should be 2k2 and the bias resistors must be adjusted to restore the original d.c. conditions.

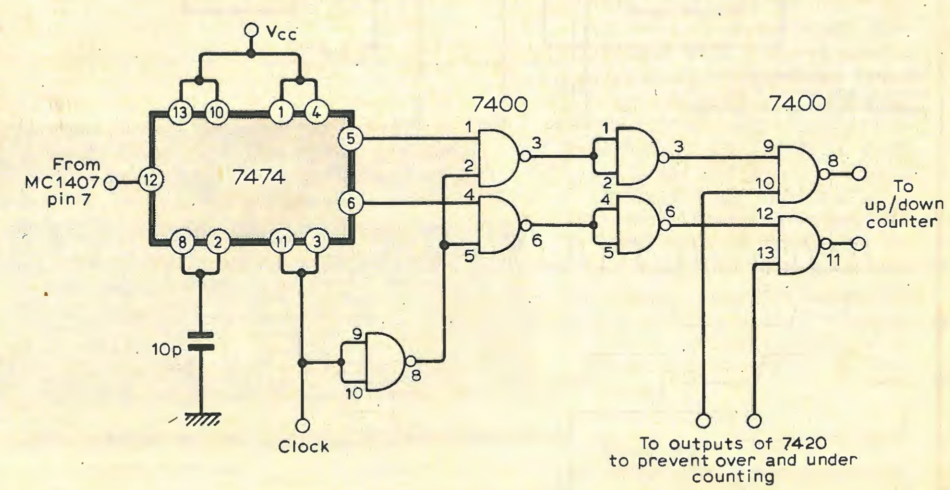
G. Hibbert
Blackfriars
Oxford



Continuous a-to-d converter

After several months experience with the a-to-d converter published in March 1979, we have found that timing is less critical if only one output of the MC1407 is used and clocked through two multivibrators in series rather than both outputs each clocked through one multivibrator. The circuit shows a modification from the output of the MC1407 to the counter inputs. Data appearing at the output of the counter is only correct near a specific phase of the clock. For recording the data under certain conditions, such as maximum amplitude, or at specified times, always AND the clock through a variable delay with the sampling pulse, so that correct data is recorded.

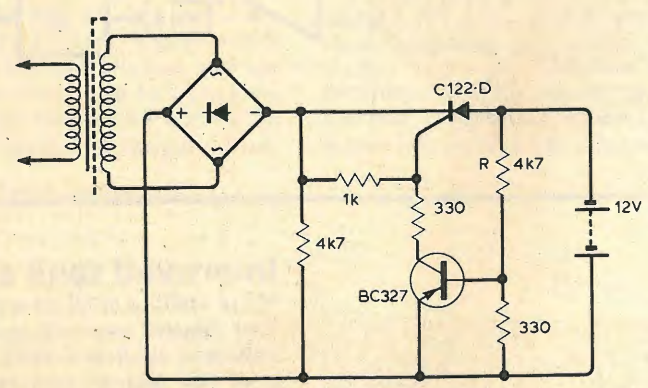
J. E. Dahl and
J. D. Whitehead
University of Queensland
Australia



Battery charger protection

The rectifiers in an unprotected battery charger can be destroyed by shorting the connecting clips or incorrectly connecting them to the battery. Although a fuse is effective it has to be replaced to restore protection. This circuit prevents current flow unless a correct voltage is present at the terminals. The s.c.r. is fired by the collector current from the transistor as each half cycle of the rectified voltage rises above the battery voltage. If no voltage is present, due to an open or short circuit, or a low voltage because a 6V battery has been connected, or a wrong polarity, the transistor is not switched on and the s.c.r. does not conduct. Reasonable overvoltages will not cause damage because the base current is well below the maximum rating, and the s.c.r. will become reverse biased. The circuit can be added to an existing charger but the transformer needs an extra 1V to compensate for the voltage drop across the s.c.r. By switching to a lower value of R, together with a lower transformer voltage, the circuit can be used with dual-voltage chargers.

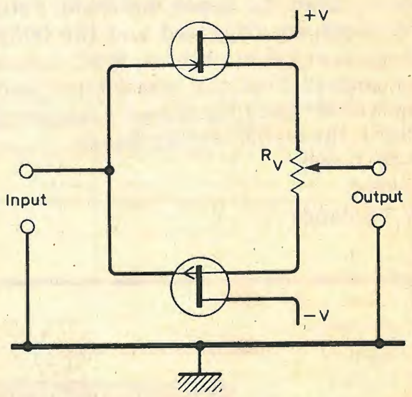
R. H. Bennett
Christchurch
New Zealand



Voltage follower with adjustable zero-offset

In the circuit, R_v is bootstrapped by the complementary j.f.e.t. source-followers, so that signal amplitude and waveform are preserved along the track. Therefore, any d.c. level can be selected between the gate-source voltages. Voltage gain is virtually unity and the distortion is negligible. Large-signal bandwidth is several megaHertz, which makes the circuit superior to conventional op-amp voltage-followers. Output impedance is high, but this can be reduced by adding a bipolar emitter-follower.

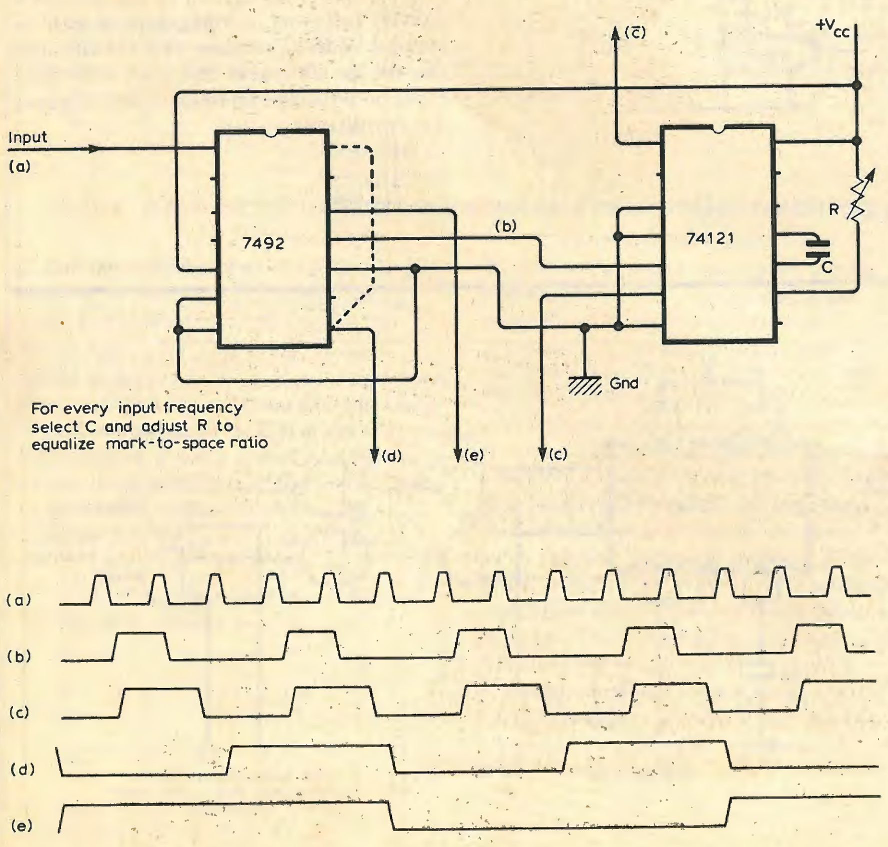
R. D. Smith
Gallowgate
Aberdeen



Divide by three

A circuit idea in June 1978 uses only three i.cs to provide a divide-by-three circuit. This number can be reduced still further with the circuit shown. A divide-by-six output with an equal mark-to-space ratio is also available at (d) and, by connecting this output to the first flip-flop in the 7492, a divide-by-twelve output at (e) is obtained.

M. Rocha
University of Porto
Portugal

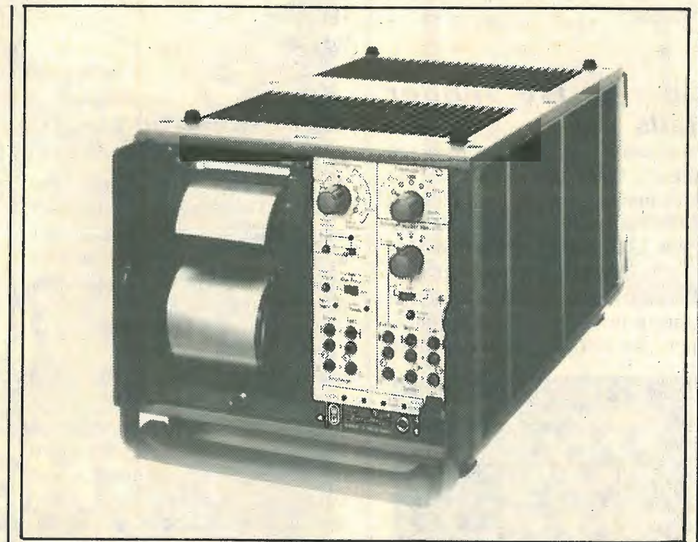


NEW PRODUCTS

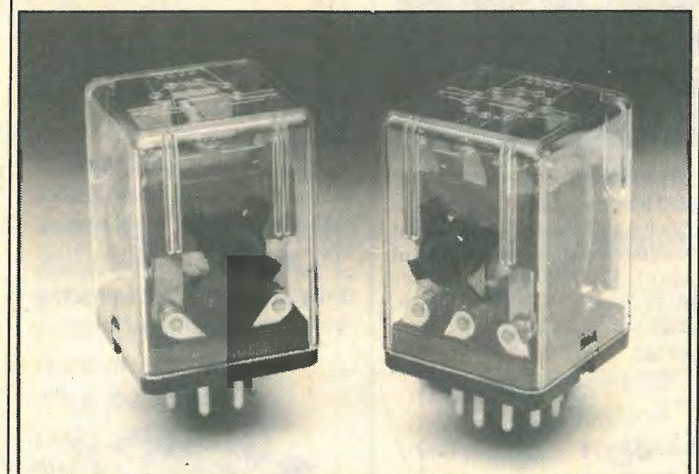
Data channel error recorder

Measurement of bit and block error rates on data communication systems, such as those employed by the Post Office and private service users, is the central function of the DF-64 measuring set made by Wandel and Goltermann. The set features a real-time printer which permanently records error rates in a 20 column tabulated print-out, which includes symbols for "no signal" and "out of sync." as well as the identification number for the signal-pulse pattern and error evaluation. Where an optional plug-in timer is used, the date and time in hours and minutes may be recorded and the timer allows print-out intervals to be preset for automatic operation. The equipment also incorporates a sender and receiver section, the send side being crystal-controlled. After the receive section has synchronized to the correct frequency, the data-channel pulse pattern under test is compared bit-by-bit with the reference sequence to enable bit and block error rates to be derived. Fault tracing on sub-assemblies of data communication equipment is also possible with the DF-64, making use of additional digital and timing signal inputs and outputs located on the back panel; a further connector on the back panel provides positive and negative supplies of 12V d.c. and a 5V d.c. supply. Wandel and Goltermann (UK) Ltd, 40-48 High St, London W3.

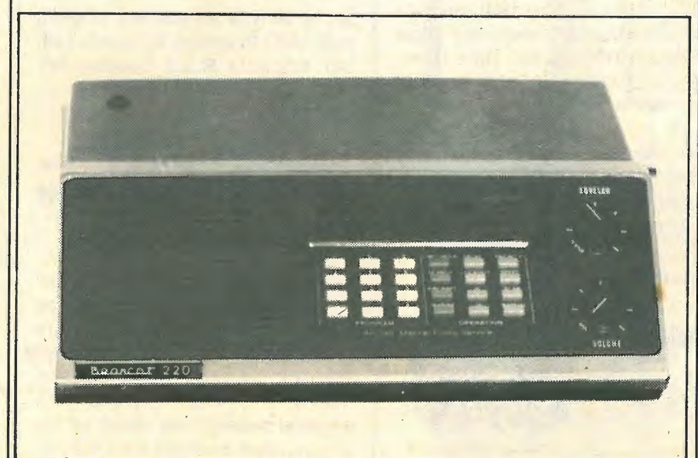
WW301



WW301



WW303



WW304

V.h.f. automatic d.f. set

A portable receiver, indicator unit and antenna array constitute the ADFS-320 v.h.f. automatic direction finder, intended for the location of narrow-band f.m. or a.m. signals in the 148 to 174MHz range. The unit is manufactured by the American O.A.R. Company and is distributed in the UK by Techmation Ltd; the receiver/indicator unit consists of a c.r.t., signal strength meter, internal loudspeaker and 10 plug-in crystal points. A standard Adcock antenna array is fitted for shipboard or fixed-location installations and comprises four vertical dipole elements, a central whip section for sense reference and signal pre-processing circuits, all contained in one integrated assembly. A signal is instantaneously displayed as a relative compass bearing on the circular c.r.t., where it is shown as a thin line trace running from the centre to a calibrated compass bezel at the outer edge. The makers say that information displayed in this way is easily interpreted, even by inexperienced operators. The circuit technique employed eliminates the need for a manual "sense" function to resolve 180° ambiguity and results in automatic readout of bearings. Techmation Ltd, 58 Edgware Way, Edgware, Middlesex.

WW302

Relay with push-button actuator

Push-button actuation, permitting manual operation of the relay without the need for an energizing voltage to be applied, is the main improvement which Pye Electro-Devices Ltd, quotes for its new range of Series 12 relays. These are general purpose two and three-pole changeover types for both a.c. and d.c. operation; they have octal base connexions and contact ratings of 10A maximum. Options include tropicalization and neon indicators for coil energization. Mounting sockets complete with retaining clip are also available. Pye Electro-Devices Ltd, Exning Road, Newmarket, Suffolk.

WW303

Programmable v.h.f. receivers

The Bearcat range of programmable receivers, made in the USA by Electra, are now available in the UK from Com-Tek. The receivers are programmable synthesized v.h.f. units permitting monitoring of frequencies in the ranges 66-88MHz, 118-136MHz, 146-148MHz, 148-174MHz, 420-470MHz and 470-512MHz. Bearcat model 220F permits up to 20 channels in any combination of the stated frequency ranges to be keyed in and monitored continuously. Power supplies required are either 240V a.c. or 12V d.c. and prices start at £280. Com-Tek (Mids) Ltd, 506, Alum Rock Road, Birmingham B8 3HX.

WW304

Tool kit

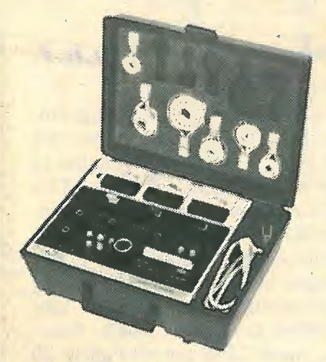
One of the largest manufacturers of tools for use in electronics applications in the USA, Vaco, are now offering a comprehens-

ive tool kit in the UK through their agents, Toolrange Ltd. The 70260 "super case" contains an assortment of tools, 48 in all, including screwdrivers, nut-drivers, pliers, etc., and special tools on two fitted pallets. Storage space is provided in the bottom of the moulded case for meters, power tools and larger items of equipment. The case can be locked and the overall weight, including a full tool complement, is 20 pounds. The tool kit costs £200 plus v.a.t. Toolrange, Ltd, Upton Road, Reading RG3 4JA.

WW305

Display tube analyser/restorer

The model 467 c.r.t. analyser manufactured by the American company B and K/Dynascan Corporation, is intended for the field testing of computer terminal c.r.ts and for general tests on all types of colour and monochrome display tubes. A "restore" facility is also included which permits the reactivation of tubes which have deteriorated in efficiency due to cathode "poisoning", and

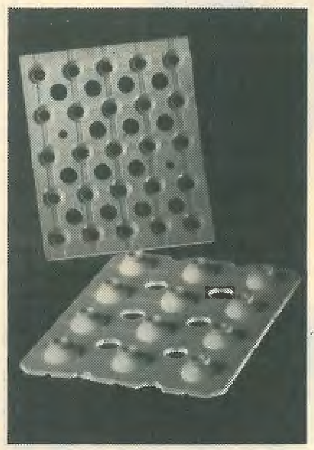


this process is timed automatically in order to prevent cathode stripping. The complete tester is fully equipped with adaptors for various pin configurations as well as a comprehensive set-up chart which the makers say makes the unit virtually obsolescence-proof. A further feature is that of a multiplex testing technique called "tridynamic" testing, where all three guns of a colour c.r.t. are tested simultaneously under actual operating conditions. Focus electrode continuity can also be tested. The complete unit is housed in a rugged carrying case with internal storage compartments and is priced at $360 off-the-shelf. B and K Precision, Sales Dept, 6460 W. Cortland, Chicago, IL 60635.

WW306

Conductive rubber pads

Semi-conductive rubber pads are already used extensively on the continent of Europe in keyboard applications, according to G. English Electronics Ltd, and this company is now producing a fully conducting form which it asserts is suitable as a replacement for normal metal contacts.



The same tactile feedback is provided by these silicon conductive rubber pads and they can be cut to requirements using a pair of scissors. G. English Electronics Ltd, 27 Warspite Rd, Woolwich, London SE18 5NU.

WW307

8 digit counter/timer

Frequencies from 0 to 10 MHz and periods from 0.5μs to 10s can be measured and displayed by a new Lascar Electronics 8 digit counter/timer module. Further capabilities of the unit include measurement of frequency ratio between two inputs, time intervals in increments of 0.1μs and operation as a conventional 8 digit totalizer. There are four switched ranges and the display consists of 4in characters made up from red l.e.ds. The counter operates from a supply of +5V

d.c. and controls include store, hold, and reset, while various outputs enable all functions to be monitored externally. A 10MHz quartz crystal controls the timebase, with a temperature stability error of ±10 p.p.m. Lascar Electronics Ltd, Unit 1, Thomasin Rd, Burnt Mills, Basildon, Essex SS13 1LH.

WW308

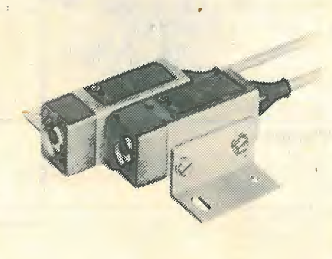
Flush mounting proximity switch

A proximity switch which the makers, Hamlin Electronics, say is designed for use in intruder alarms, counting, "batching" and warning equipment, can be flush-mounted in a hole drilled in a door frame. The RP113 is a reed-switch device and the operating magnet can be similarly fitted to the door. Four options are available, the lower cost form A (normally open), standard form A, higher power form A and standard form C (single pole/double throw). The switch measures 28 × 7.62mm and is supplied with two pairs of leads, one being provided for looping back into the circuit. Hamlin Electronics Europe Ltd, Diss, Norfolk IP22 3AY.

WW309

Miniature photoswitch

The E3S photoswitch is claimed by the makers, IMO Precision Controls, to be the world's smallest. The unit has a sensing range of 3m (max.) and can switch 80mA when operating from a 24V d.c. supply. Mains operation is



achieved via an add-on control unit. IMO Precision Controls Ltd, 349, Edgware Road, London W2 1BS.

WW310

Shrink-on tubing and terminals

A range of materials manufactured in p.v.e. or polyolefin for use as shrunk-on tubing or as shrunk-on terminals and covers is available from Suhner Electronics. Each item, when warmed, will shrink to approximately one third of its original size, creating a secure, oil resistant seal suitable for continuous temperatures up to

120°C. Tubing is available in a range of sizes from 8 to 80mm, shrinking to bore diameters of between 3 and 30mm with wall thicknesses of 1 to 4mm. Moulded cable terminals and caps are offered in five sizes of sealing cap, from 15 to 90mm, three sizes of three-way junction from 35 to 90mm and four sizes of four-way junction from 22 to 90mm. All products are available with or without internal adhesive. Measurements stated are for pre-shrinking bore diameters. A minimum order of 5,000 units is required by the makers. Suhner Electronics Ltd, Telford Road, Bicester, Oxon.

WW311

Flat l.e.ds

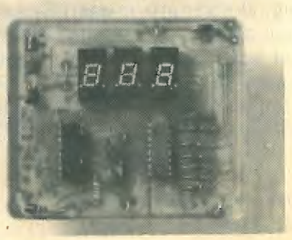
Designed as an answer to the problems of high density component packing, the ED10 range of flat-bodied l.e.ds, manufactured by Rastra Electronics, measure 0.1in or 0.2in centre to centre. They are available in the standard colours of red, green, orange and yellow. Rastra Electronics, Ltd, 275-281 King St, Hammersmith, London W6 9NF.

WW312

Digital readout for antenna rotator

Claimed by the makers, Monitor, of Canada, as "accurate to one degree", the DX-3 digital readout module, which is supplied in kit form, can be used to provide visual information on the orientation of a rotatable antenna. The makers also say that the unit may be used as a workbench digital voltmeter and the price is £19 (money order) from Monitor, Box 55, Agincourt, Ontario, Canada MIS 3B4.

WW313



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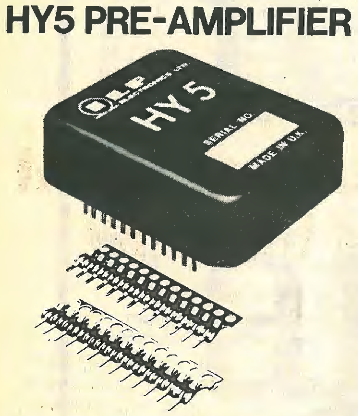

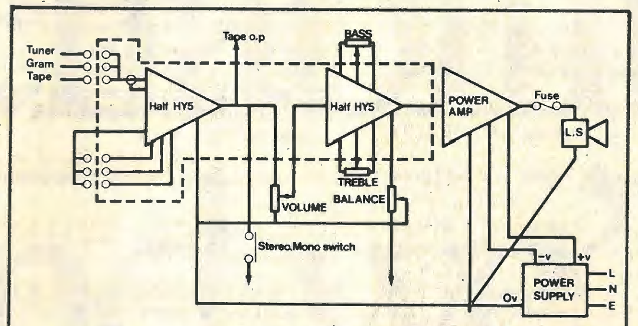

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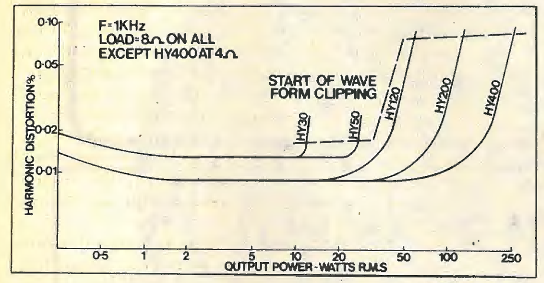
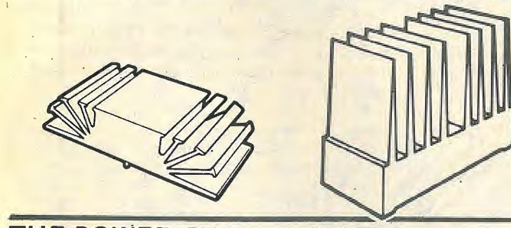
The HY5 pre-amp is compatible with all I.L.P. amplifiers and P.S.U.'s. It is contained within a single pack 50 x 40 x 15 mm. and provides multi-function equalisation for Magnetic/Ceramic/Tuner/Mic and Aux (Tape) inputs, all with high overload margins. Active tone control circuits; 500 mV out. Distortion at 1KHz–0.01%. Special strips are provided for connecting external pots and switching systems as required. Two HY5's connect easily in stereo. With easy to follow instructions.

£4.64 + 74p VAT

THE POWER AMPLIFIERS

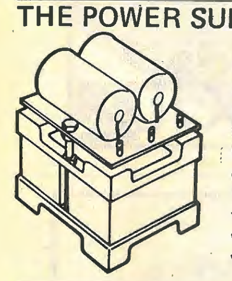


Model	Output Power R.M.S.	Distortion Typical at 1KHz	Minimum Signal/Noise Ratio	Power Supply Voltage	Size in mm	Weight in gms	Price + V.A.T.
HY30	15 W into 8 Ω	0.02%	80dB	-20 -0- +20	105x50x25	155	£6.34 + 95p
HY50	30 W into 8 Ω	0.02%	90dB	-25 -0 +25	105x50x25	155	£7.24 + £1.09
HY120	60 W into 8 Ω	0.01%	100dB	-35 -0- +35	114x50x85	575	£15.20 + £2.28
HY200	120 W into 8 Ω	0.01%	100dB	-45 -0- +45	114x50x85	575	£18.44 + £2.77
HY400	240 W into 4 Ω	0.01%	100dB	-45 -0- +45	114x100x85	1.15Kg	£27.68 + £4.15



Load impedance – all models 4 - 16Ω
Input sensitivity – all models 500 mV
Input impedance – all models 100KΩ
Frequency response – all models 10Hz - 45KHz - 3dB

THE POWER SUPPLY UNITS



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PSU 36	for 1 or 2 HY30's	£8.10 + £1.22 VAT
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PSU 70	with toroidal transformer for 1 or 2 HY120's	£13.61 + £2.04 VAT
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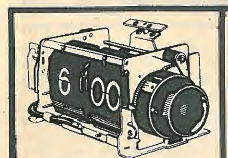

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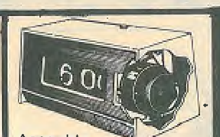

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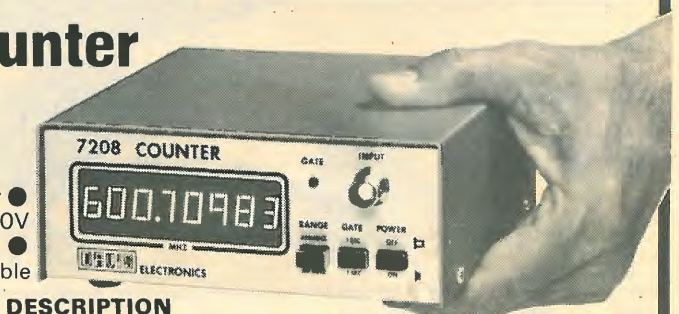

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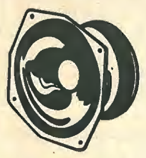

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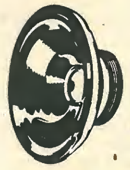

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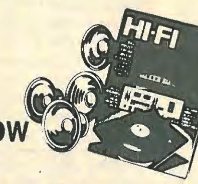

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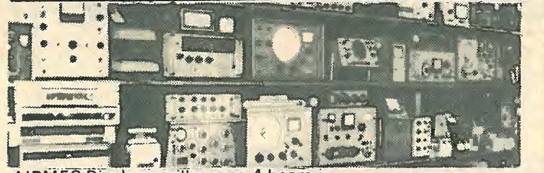

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AC187	0.23
AC188	0.23
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AD162	0.52
AF106	0.52
AF114	0.86
AF115	0.86
AF116	0.86
AF117	0.86
AF139	0.46
AF186	1.38
AF239	0.52
AFZ11	3.16
AFZ12	3.16
ASY26	0.46
ASY27	0.46

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

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

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

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

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

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

OC203	2.02
OC204	2.88
OC205	2.88
OC206	2.88
OC207	2.02
OCP71	1.44
ORP12	1.15
R2008B	2.02
R2009	2.59
R2010B	2.02
T1C44	0.35
T1C226D	1.38
T1L209	0.23
T1P29A	0.47
T1P30A	0.48
T1P31A	0.51
T1P32A	0.55
T1P33A	0.79
T1P34A	0.84
T1P41A	0.72
T1P42A	0.81
T1P2955	0.77
T1P3055	0.64
T1S43	0.52
ZS140	0.29
ZS170	0.24
ZS178	0.62
ZS271	0.26
ZS278	0.65
ZTX107	0.13
ZTX108	0.12
ZTX109	0.14
ZTX300	0.14
ZTX301	0.15
ZTX302	0.17
ZTX303	0.20
ZTX304	0.22
ZTX311	0.14
ZTX314	0.23
ZTX500	0.15
ZTX501	0.16

ZTX502	0.18
ZTX503	0.20
ZTX504	0.23
ZTX531	0.23
ZTX550	0.18
1N914	0.06
1N916	0.08
1N4001	0.07
1N4002	0.07
1N4003	0.08
1N4004	0.08
1N4005	0.09
1N4006	0.09
1N4007	0.10
1N4009	0.07
1N4148	0.07
1N5400	0.15
1N5401	0.15
1S44	0.05
1S920	0.08
1S921	0.08
2G301	1.15
2G302	1.15
2G306	1.27
2N404	1.15
2N696	0.29
2N697	0.29
2N698	0.35
2N705	1.38
2N706	0.17
2N708	0.23
2N930	0.23
2N1131	0.30
2N1132	0.30
2N1302	0.40
2N1303	0.40
2N1304	0.52
2N1305	0.52
2N1306	0.58
2N1307	0.58
2N1308	0.63

2N1309	0.63
2N1613	0.29
2N1671	1.73
2N1893	0.29
2N2147	2.02
2N2148	1.89
2N2218	0.29
2N2219	0.28
2N2220	0.21
2N2221	0.21
2N2222	0.21
2N2223	3.16
2N2368	0.20
2N2369A	0.24
2N2484	0.23
2N2646	0.63
2N2904	0.29
2N2905	0.29
2N2906	0.24
2N2907	0.24
2N2924	0.24
2N2925	0.25
2N2926	0.16
2N3053	0.29
2N3054	0.58
2N3055	0.81
2N3440	0.69
2N3441	0.92
2N3442	1.26
2N3614	1.73
2N3702	0.13
2N3703	0.15
2N3704	0.15
2N3705	0.15
2N3706	0.15
2N3707	0.15
2N3708	0.12
2N3709	0.15
2N3710	0.12
2N3711	0.12

2N3771	2.02
2N3772	2.30
2N3773	3.45
2N3819	0.41
2N3820	0.52
2N3823	0.63
2N3866	0.83
2N3904	0.15
2N3905	0.15
2N3906	0.15
2N4058	0.16
2N4059	0.12
2N4060	0.14
2N4061	0.14
2N4062	0.15
2N4124	0.17
2N4126	0.17
2N4286	0.23
2N4288	0.25
2N4289	0.28
2N5457	0.40
2N5458	0.40
2N5459	0.40
2S017	7.48
2S019	7.48
2S026	13.80
2S103	1.73
2S302	0.86
2S303	0.86
2S322	0.92
2S324	1.44
2S701	1.73
2S745A	0.40
2S746A	0.40

VALVES

A1834	10.35
A2087	13.58
A2134	10.06
A2293	8.62
A2426	13.50
A2521	11.62
A2900	10.98
A3343	25.56
AZ31	1.26
AZ41	1.32
BK448	88.43
BK484	119.54
BS90	31.33
BS810	35.24
BT5	43.47
BT17	79.29
BT19	27.08
BT29	242.93
BT69	247.30
BT75	102.46
BT95	95.16
CBL31	2.30
CL33	2.30
CY31	1.15
C1K	11.50
C3A	11.50
C3JA	23.23
DA41	21.50
DA42	12.30
DA100	52.90
DAF91	0.46
DAF96	1.15
DET22	24.15
DET24	52.90
DF91	0.46
DF96	1.15
DK91	1.21
DK92	1.44
DK96	1.26
DL92	1.26
DL94	1.38
DL96	1.26
DLS10	9.48
DLS15	12.37
DLS16	12.37
DLS19	12.37
DM70	1.44
DM71	1.44
DM160	3.86
DY86/7	0.73
DY802	0.96
E55L	25.17
E80CC	9.27
E80CF	11.96
E80F	9.75
E80L	9.51
E81CC	6.62
E81L	10.28
E82CC	7.03
E83CC	7.16
E86C	12.48
E88C	6.71
E88CC	3.86
E90CC	9.34
E90F	9.71
E91H	5.34
E92CC	8.86
E99F	9.39

E130L	19.39
E180CC	8.86
E180F	7.83
E182CC	9.34
E186F	11.62
E188CC	7.36
E280F	25.88
E283CC	9.02
E288CC	17.25
EA52	19.43
EA76	2.02
EABC80	1.38
EAC91	0.92
EAF42	1.44
EAF801	2.02
EB41	2.30
EB91	1.01
EBC33	2.02
EBC41	1.44
EBC81	1.26
EBC90	0.97
EBF80	0.58
EBF83	1.44
EBF89	0.97
EBL31	4.60
EC90	1.28
EC91	8.35
EC92	1.44
EC157	276.92
ECC33	4.02
ECC35	4.02
ECC40	1.44
ECC81	1.01
ECC82	0.82
ECC83	1.01
ECC84	1.36
ECC85	1.38
ECC86	2.30
ECC88	2.07
ECC89	1.88
ECC91	8.72
ECC189	1.90
ECC807	2.02
ECC808	2.59
ECF80	1.24
ECF82	1.38
ECF86	1.73
ECH35	2.30
ECH42	1.32
ECH81	1.38
ECH83	1.44
ECH84	1.47
ECL80	1.15
ECL81	1.73
ECL82	1.15
ECL83	1.73
ECL84	1.61
ECL85	1.28
ECL86	1.38
EF37A	4.02
EF39	3.16
EF40	1.32
EF41	1.38
EF42	2.30
EF50	1.73
EF54	5.75
EF55	2.88
EF80	0.92
EF83	2.02
EF85	0.92

EF86	1.74
EF89	1.84
EF91	2.07
EF92	6.03
EF93	1.15
EF94	1.24
EF95	5.25
EF98	1.44
EF183	0.92
EF184	0.96
EF804S	7.47
EF805S	8.05
EH90	1.61
EK90	1.24
EL32	1.73
EL33	4.02
EL34TH	2.53
EL34M	2.57
EL36	1.84
EL41	1.44
EL42	2.02
EL81	1.26
EL83	1.44
EL84	1.15
EL86	2.48
EL90	1.10
EL91	7.44
EL95	1.51
EL156	18.68
EL360	6.32
EL500/504	2.16
EL509	3.63
EL821	11.06
EL822	11.38
EM34	5.75
EM80	1.28
EM81	1.15
EM84	1.15
EM85	1.44
EM87	1.73
EN32	14.80
EN91	2.94
EN92	5.61
EY51	2.02
EY81	1.80
EY83	2.02
EY84	9.75
EY86	0.96
EY88	2.02
EY500A	2.23
EY802	94
EZ35	97
EZ40	1.44
EZ41	1.44
EZ80	0.96
EZ81	0.96
EZ90	1.38
FW4-500	2.88
FW4-800	2.88
G1.371K	23.23
G551K	12.65
G180.2M	18.42
G240.2D	12.85
G400.1K	19.28
GN4	8.62
GN4A	8.62
GS16	10.35
GT1C	14.38
GU50	14.31
GU51	13.62

GXU1	16.10
GXU2	28.43
GXU3	30.49
GXU4	32.77
GXU50	12.80
GY501	2.95
GZ32	1.44
GZ33	4.60
GZ34	2.18
GZ37	4.60
KT61	4.02
KT66	11.50
KT88	13.80
KTW61	2.02
KTW62	2.02
KTW63	2.02
M8079	11.59
M8080	7.68
M8081	9.95
M8082	6.41
M8083	7.59
M8091	10.85
M8096	4.31
M8097	4.09
M8098	4.37
M8099	5.98
M8100	8.23
M8136	8.46
M8137	8.72
M8140	5.17
M8141	5.52
M8142	6.15
M8144	4.31
M8149	5.86
M8161	7.87
M8162	7.59
M8163	5.17
M8190	5.29
M8195	4.25
M8196	7.47
M8204	6.57
M8212	11.76
M8223	3.16
M8224	3.85
M8225	2.99
M8248	11.55
MU14	1.73
MX119	53.82
MX123	63.25
MX145	50.40
MX151	15.18
MX152	115.00
MX161	129.72
MX163	19.55
MX164	21.14
MX166	126.50
MX168	40.25
N78	10.35
OA2	1.96
OA3	5.69
OA4	4.02
OB2	1.44
OB3	2.20
OC2	3.04
OC3	2.20
OD3	2.20
OZ4	1.84
PC86	1.61
PC88	1.61
PC95	1.49

PC97	1.38
PC900	1.38
PCC84	1.15
PCC85	1.38
PCC88	1.38
PCC89	1.56
PCC189	1.61
PCC805	1.51
PCC806	2.07
PCE82	2.07
PCF80	1.15
PCF82	1.15
PCF86	1.84
PCF87	1.84
PCF200	2.82
PCF201	2.45
PCF801	1.84
PCF802	1.82
PCF805	1.84
PCF806	1.84
PCF808	1.84
PCL82	1.15
PCL83	2.30
PCL84	1.15
PCL85	1.24
PCL86	1.24
PCL805/85	1.24
PD500	4.14
PE06-40N	31.40
PFL200	2.07
PL36	1.38
PL81	1.38
PL81A	1.38
PL82	1.38
PL83	2.55
PL84	1.24
PL504/5	1.61
PL508	2.07
PL509	3.45
PL519	3.73
PL801	1.27
PL802	3.40
PY33	1.27
PY81	0.97
PY82	0.92
PY83	0.81
PY88	1.01
PY500A	2.07
PY800	0.97
PY801	0.97
QQV02-6	13.16
QQV03-6	5.44
QQV03-20A	20.13
QQV06-40A	40.25
QQV07-50	53.13
QQZ03-20A	59.80
QQZ06-40A	55.10
QU37	14.38
QV03-12	4.31
QV04-7	2.88
QV08-100	118.45
QY3-65	53.74
QY3-125	56.78
QY4-250	65.93
QY4-400	75.67
QY5-500	59.39

QY5-3000A	82.56
QZ06-20	27.72
R10	5.75
R17	1.89
R18	4.89
R19	1.38
R20	1.66
RG3-250	32.49
RG3-250A	34.09
RG3-1250	29.56
RG4-1250	13.13
RG4-3000	75.44
RR3-250	48.68
RR3-1250	86.20
S11E12	30.48
S130	2.30
S130P	2.88
STV280-40	11.50
STV280-80	24.15
SU41	2.88
SU42	10.35
TD03-10	24.73
TD03-10E	26.16
TD03-10F	27.60
TT15	34.50
TT21	14.16
TT22	14.16
TT100	59.51
TY2-125	65.33
TW4-400	71.61
TY4-500	95.40
TY5-500	147.20
TY6-800	165.70
TY6-5000A	263.05
TY6-5000B	236.90
TY6-5000W	236.44
TY7-6000A	286.93
TY7-6000W	232.47
TZ40	17.25
U18-20	2.88
U19	10.33
U25	1.33
U26	1.66
U37	10.35
UABC80	1.44
UAF42	1.44
UB41	1.44
UBC41	1.73
UBF89	1.38
UCC84	1.26
UCC85	1.38
UCF80	1.32
UCH42	1.38
UCH81	2.67
UCL82	1.20
UCL83	1.66
UF41	1.15
UF42	1.44
UF80	1.66
UF85	1.66
UF89	1.66
UL41	2.88
UL84	1.38
UM80	1.15

UY41	1.44
UY85	1.20
VLS631	15.24
XG1-2500	32.37
XG2-6400	92.98
XG5-500	19.32
XGQ2-6400	106.15
XR1-1600A	27.54
XR1-3200	76.94
XR1-3200A	76.94
XR1-6400	84.24
XR1-6400A	149.30
YD1120	226.60
YD1240	241.50
Z759	11.04
ZM1000	6.03
ZM1001	6.19
ZM1020	10.83
ZM1021	10.17
ZM1022	10.00
ZM1023	8.81
ZM1040	22.26
ZM1041	19.16
ZM1042	20.44
ZM1051	100.05
1B3GT	2.58
1B24	11.50
1B35A	28.75
1B63	57.50
1R5	1.21
1S5	0.46
1T4	0.46
2AS15	11.50
2C39A	21.85
2C43	20.70
2D21	2.94
2E26	7.82
2J42	89.70
2J55	201.25
2J70A	270.25
2J70B	287.50
2K25	40.25
3-400Z	51.75
3-500Z	63.25
3A5	1.55
3B24	9.20
3B28	5.18
3B29	11.50
3B240M	17.25
3B241M	17.25
3C23	13.89
3C45	22.77
3CX100A5	23.00
3E29	29.67
3S4	1.26
3V4	1.38
465A	29.15
4-125A	41.98
4-250A	41.98
4-400A	52.05
4B32	29.16
4C35	46.00
4CX250B	28.53
4CX350A	48.88
4X150A	24.41
4X150D	28.75

5B254M	23.12
5B255M	23.12
5C22	46.00
5J180E	851.00
5R7GY	2.30
5U4G	4.35
5U4GB	2.60
5V4G	1.75
5Y3GT	0.98
5Z3	1.73
5Z4G	1.75
5Z4G7	1.75
6-30L2	1.79
6AB4	1.44
6AB7	1.73
6AC7	1.61
6AF4A	1.84
6AG7	2.30
6AH6	5.52
6AK5	3.98
6AK6	2.81
6AL5	1.01
6AM4	2.65
6AM5	4.43
6AM6	2.07
6AN5	6.12
6AN8A	3.80
6AQ5	1.10
6AR5	1.84
6AS6	6.42
6AS7G	7.76
6AT6	0.98
6AU5GT	4.81
6AU6	1.24
6AV5GT	4.36
6AV6	0.98
6AX5GT	3.57
6B7	1.73
6B8	2.02
6BA6	1.15
6BA7	5.89
6BA8A	4.31
6BC4	4.27
6BE6	1.24
6BH6	1.75
6BJ6	1.24
6BK4	4.84
6BL6	97.75
6BL7GT	4.44
6BM6	97.75
6BN6	1.89
6BQ7A	4.14
6BR7	4.60
6BR8	2.02
6BS7	4.60
6BW6	4.60
6BW7	1.75
6BX7GT	5.70
6BZ6	2.62
6C4	1.01
6CB6A	2.86
6CD6GA	5.64
6CG7	2.55
6CH6	7.48
6CL6	4.12
6CW4	8.33
6D2	1.01
6DK6	2.59
6DQ6B	4.49
6EA8	3.31

6EB8	2.44
6EW6	1.73
6F6	2.02
6F23	1.84
6F28	1.33
6F33	22.08
6H1	14.38
6H2N	1.21
6H3N	1.21
6H6	1.73
6J4	6.10
6J6	6.21
6J7	9.04
6K4N	1.44
6K6GT	1.50
6K7	1.73
6K8	2.02
6KD6	7.08
6L6G	2.88
6L6GA	1.73
6L6GT	2.24
6L6GC	2.88
6L7	2.30
6N2P	1.21
6N3P	1.21
6N7	1.73
6P25	4.14
6Q7	2.53
6R7	2.07
6SA7	1.67
6SC7	1.73
6SF7	1.84
6SH7	1.73
6SJ7	1.84
6SK7	1.50
6SK7GT	3.08
6SN7GT	1.84
6SQ7	1.50
6SR7	1.73
6SS7	2.07
6U5G	2.30
6U8	0.92
6U8A	3.24
6V6GT	1.84
6X4	1.38
6X5GT	0.97
7B7	1.96
7C5	2.02
7C6	1.44
7H7	2.30
7R7	1.73
7S7	2.59
7Y4	1.84
7Z4	2.13
11E3	60.82
12AT6	1.38
12AT7	1.01
12AU6	2.83
12AU7	0.83
12AV6	2.30
12AV7	3.98
12AX7	1.01
12AY7	5.24
12B4A	3.50
12BA6	2.42
12BE6	2.55
12BH7	1.29
12BY7	3.01
12E1	8.17
12E11TT	19.26

12E14	34.50
13E1	62.20
19H4	28.75
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30C17	1.84
30C18	1.84
30F5	1.93
30FL1/2	1.28
30FL12	2.07
30FL14	1.84
30L1	1.15
30L15	2.07
30L17	2.07
30P4	1.06
30P19	1.38
30PL13	2.07
30PL14	1.93
30PL15	2.07
35W4	0.69
50C5	0.81
75B1	4.26
75C1	2.24
85A1	8.63
85A2	2.19
90AG	9.15
90AV	9.15
90C1	2.24
90CG	15.73
90CV	15.30
92AG	9.15
92AV	9.15
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150C4	2.19
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1625	1.96
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5651	2.07
5670	5.29
5675	14.03
5687	7.08
5696	4.53
5718	7.36

5725	6.28
5726	4.05
5727	5.52
5749	5.73
5751	5.36
5763	4.14
5814A	4.81
5840	5.06
5842	15.59
5876A	13.06
5879	5.57
5886	12.08
5963	3.45
5965	4.07
6005	6.33
6021	5.13
6057	4.02
6058	10.40
6059	4.60
6061	4.89
6062	4.31
6063	4.20
6064	6.50
6067	4.02
6072	6.53
6080	7.88
6097A×B×C	46.00
6146A	5.89
6146B	6.42
6159	9.18
6189	9.25
6201	5.93
6442	17.25
6883B	6.81
6973	4.05
7025	2.62
7551	6.83
7586	13.09
7587	22.54
7609	36.57
7868	4.53
7895	14.84
8005	34.50
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18042	6.92
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7401	0.18
7402	0.18
7403	0.18
7404	0.20
7405	0.18
7406	0.46
7407	0.46
7408	0.23
7409	0.23
7410	0.18
7412	0.30
7413	0.37
7416	0.37
7417	0.37
7420	0.20
7422	0.23
7423	0.37
7425	0.35
7427	0.35
7428	0.49
7430	0.20
7432	0.35
7433	0.41
7437	0.37
7438	0.37
7440	0.21
7441	0.97
7442	0.83
7447AN	1.04
7450	0.21
7451	0.21
7453	0.21
7454	0.21
7460	0.21
7470	0.40
7472	0.38
7473	0.41
7474	0.46
7475	0.62
7476	0.46
7480	0.63
7482	0.86
7483	1.04
7484	1.15
7486	0.40
7490	0.60
7491	0.92
7492	0.69
7493	0.69
7494	0.92
7495	0.83
7496	0.92
7497	3.45
74100	1.73
74107	0.52
74109	0.81
74110	0.58
74111	0.81
74116	2.02
74118	1.15
74119	1.73
74120	0.95
74121	0.46
74122	0.69
74123	1.15
74125	0.63
74126	0.63
74128	0.69
74132	0.81
74136	0.63
74141	0.92
74142	2.65
74143	2.88
74144	2.88
74145	1.04
74147	2.30
74148	2.02
74150	1.84
74151	0.97
74154	2.02
74155	0.97
74156	0.97
74157	0.86
74159	2.42
74170	2.65
74172	5.06
74173	1.61
74174	1.73
74175	1.04
74176	1.26
74178	1.44
74179	1.44
74180	1.32
74190	1.73
74191	1.73
74192	1.55
74193	1.55
74194	1.44
74195	1.15
74196	1.38
74197	1.26
74198	2.59
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TBA520Q	2.65
TBA530	2.28
TBA540Q	2.65
TBA550Q	3.70
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IA1110	8K Static RAM 450nS	£ 99.00	£15.00
IA1030	Prototype	N/A	£15.00
IA2010	16K Static RAM 250nS	£295.00	N/A
IA2010	16K Static RAM 450nS	£275.00	N/A
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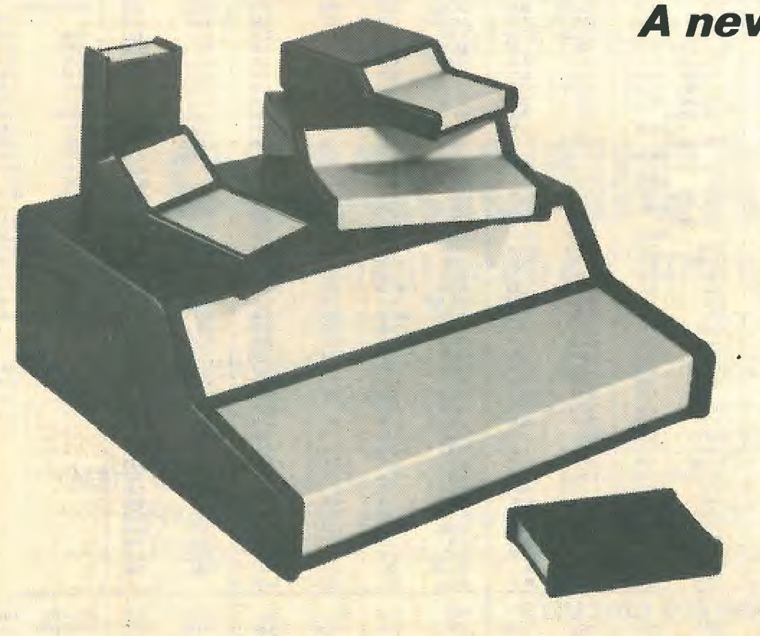
A new generation of cases . . .



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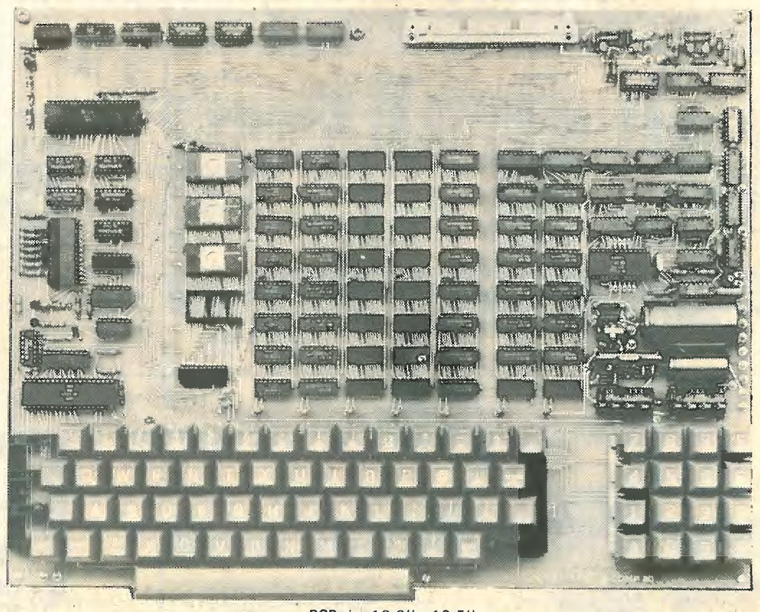

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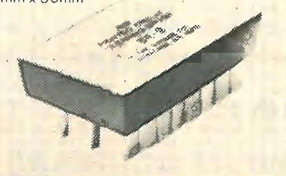
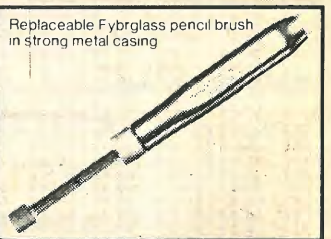


Fybrglass PCB brush approx size 76mm x 50mm



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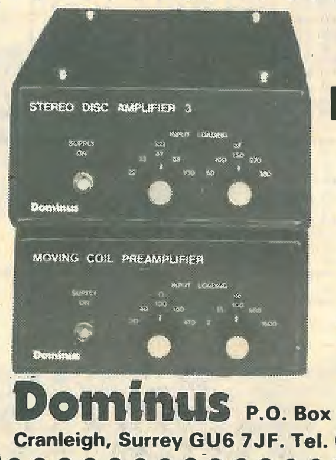

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A well-researched mains powered preamplifier offering optimum performance from all low impedance cartridges. It has switchable cartridge load capacitance and resistance and unrivalled distortion and noise performance. The unit is pictured here with the high quality RIAA equalisation amplifier **Stereo Disc Amplifier 3.**

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S-2020TA STEREO TUNER/AMPLIFIER KIT

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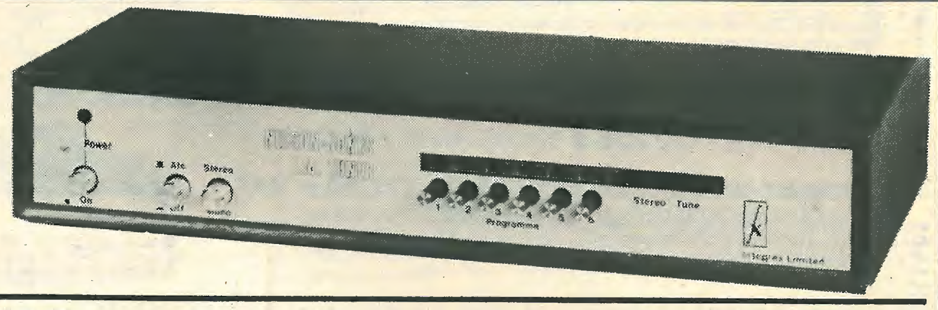
A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc.) THD less than 0-1% at 20W into 8 ohms. **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 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder, LED tuning and stereo indicators. Tuning range 88-104MHz, 30dB mono S/N @ 1.2µV. THD 0.3%. Pre-coder 'birdy' filter.

PRICE: £59.95 + 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.

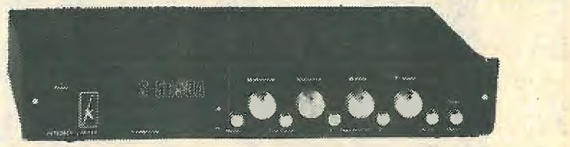
PRICE: £69.95 + VAT

NRDC-AMBISONIC UHJ SURROUND SOUND DECODER

The **first ever** kit specially produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug., '77.
The unit is designed to decode not only UHJ but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC HJ. 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 2 input signals and 4 or 6 output signals are provided in this most versatile unit.
Complete with mains power supply, wooden cabinet, panel, knobs, etc.
Complete kit, including licence fee **£49.50** + VAT or ready built and tested **£67.50** + VAT

S5050A STEREO AMP

Very high performance kit



50 watts rms-channel. 0.015% THD. S/N 90 dB, Mags/n 80 dB. Output device rating 360w per channel.
Tone cancel switch. 2 tape monitor switches. Metal case — comprehensive heatsinks.

Complete kit only **£63.90** + VAT

(Also available our 20w/ch BIFET SZ020 Amp)

INTRUDER 1 Mk. 2 RADAR ALARM

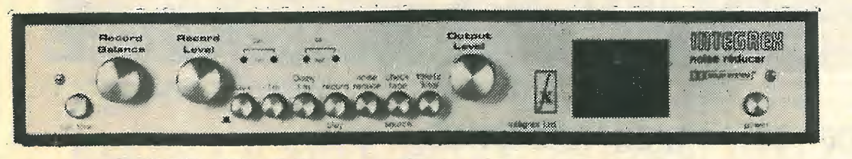
With Home Office Type approval

The original "Wireless World" published Intruder 1 has been re-designed by Integrex to incorporate several new features, along with improved performance. The kit is even easier to build. The internal audible alarm turns off after approximately 40 seconds and the unit re-arms. 240V ac mains or 12V battery operated. Disguised as a hard-backed book. Detection range up to 45 feet. Internal mains rated voltage free contacts for external bells etc.

Complete kit **£49.50** plus VAT, or ready built and tested **£64.50** plus VAT.

Wireless World Dolby noise reducer

Trademark of Dolby Laboratories Inc.



Typical performance
Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)
Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%
Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output
Dynamic range >90dB
30mV sensitivity

Complete Kit **PRICE: £43.90** + VAT (3 head model available)

Also available ready built and tested	**Price £59.40** + VAT
Calibration tapes are available for open-reel use and for cassette (specify which)	**Price £2.40** + VAT
Single channel plug-in Dolby (TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts and all components	**Price £9.00** + VAT

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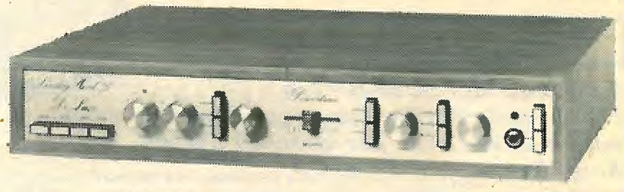
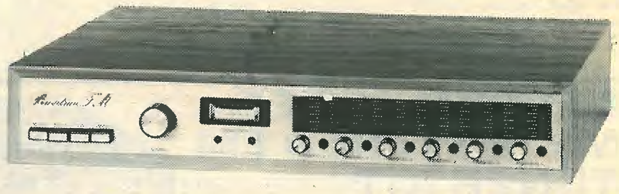
DE LUXE EASY TO BUILD LINSLEY-HOOD 75W STEREO AMPLIFIER £99.30 + VAT



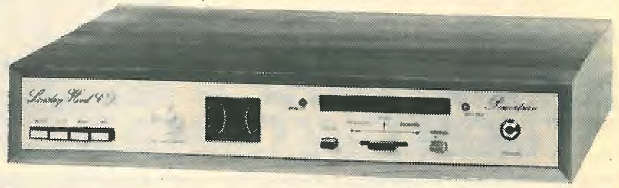
This easy to build version of our world-wide acclaimed 75W amplifier kit based upon circuit boards interconnected with gold plated contacts resulting in minimal wiring and construction delightfully straightforward. The design was published in Hi-Fi News and Record Review and features include rumble filter,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

WIRELESS WORLD FM TUNER £70.20 + VAT



A pre-aligned front-end module makes this Wireless World published design very simple to construct and adjust without special instruments. Features include an excellent a.m. rejection push-button station selection as well as infinitely variable tuning and a phase locked loop stereo decoder, incorporating active filters for "birdy" suppression.

LINSLEY-HOOD CASSETTE DECK £79.60 + VAT



This design, published in Wireless World, although straightforward and relatively low cost provides a very high standard of performance. There are separate record and replay amplifiers and switchable equalisation together with a choice of bias levels are also provided. The mechanism is the Goldring-Lenco CRV with electronic speed control.

TRANSCENDENT 2000

SINGLE BOARD SYNTHESIZER

As featured in Electronics Today International

Cabinet size 24.6"x15.7"x4.8" (rear) 3.4" (front)

The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or ½% metal film!) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibre glass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £700!

COMPLETE KIT ONLY £168.50 + VAT!

Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more than a multi-meter and a pair of ears!

CHROMATHEQUE 5000 5-CHANNEL LIGHTING EFFECTS SYSTEM

This versatile system featured as a constructional article in ELECTRONICS TODAY INTERNATIONAL has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound-to-light or have it strobe all the lights at a speed dependent upon music level or front panel control setting or use the internal digital circuitry which produces some superb random and sequencing effects. Each channel handles up to 500W and as the kit is a single board design wiring is minimal and construction very straightforward.

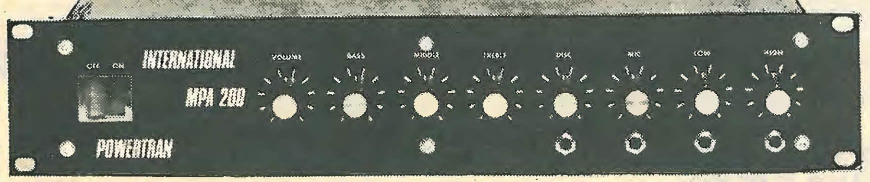
Kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. — Complete right down to the last nut and bolt!

COMPLETE KIT ONLY £49.50 + VAT

Panel size 19.0"x3.5". Depth 7.3"

MPA200 100W MIXER/AMPLIFIER

Featured as a constructional article in Electronics Today International the MPA 200 is an exceptionally low-priced but professionally finished general purpose, rugged, high-power amplifier which has an adaptable range of inputs such as disc, microphone, guitar, etc. There are 3 wide range tone controls and a master volume control. Mechanically the design is simplicity in the extreme with minimal wiring making construction very straightforward. Kit includes fully finished metalwork, fibreglass PCB's, controls, wire, etc. — Complete right down to the last nut and bolt!



Panel size 19.0"x3.5". Depth 7.3"

COMPLETE KIT ONLY £49.90 + VAT

Most kits also available as separate packs (e.g. P.C.B. component sets, hardware sets, etc.). Prices in FREE CATALOGUE.

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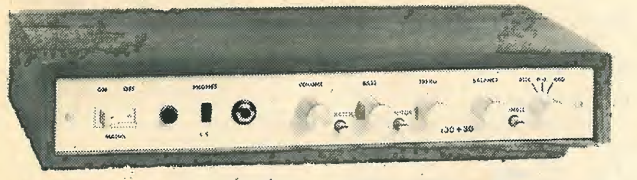
T20+20 AND T30+30 20W, 30W AMPLIFIERS



Designed by Texas engineers and described in Practical Wireless, the Texan was an immediate success. Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20+20 delivers 20W rms per channel of true Hi-Fi at exceptionally low cost. The **easy to build** design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers including scratch and rumble filters, adaptable input selector and headphones socket. In a follow-up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30+30. These include RF interference filters and a tape monitor facility. Power output of this model is 30W rms per channel.

SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE £33.10 + VAT

T30+30 KIT PRICE £38.40 + VAT

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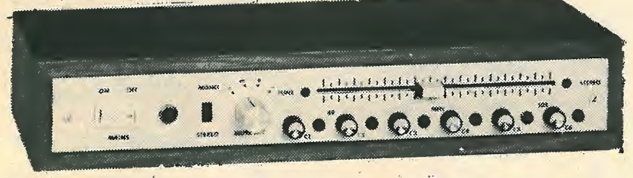
WWII TUNER

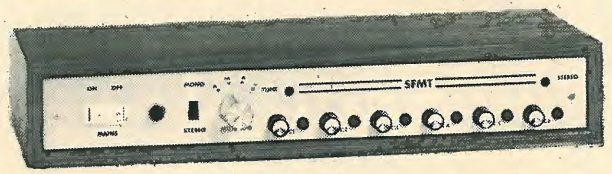


SPECIAL PRICE FOR COMPLETE KIT £47.70 + VAT

PRICES IN OUR FREE CATALOGUE

Following the success of our **Wireless World FM Tuner Kit** this cost reduced model was designed to complement the **T20+20** and **T30+30** amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with either.

POWERTRAN SFMT TUNER



PRICE FOR COMPLETE KIT £35.90 + VAT

AVAILABLE AS COMPLETE KIT ONLY

This is a simple, low cost design which can be constructed easily without special alignment equipment but which still gives a first-class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the **T20+20** and **T30+30** amplifiers.

WE'VE MOVED! NEW FACTORY UP! PRICES DOWN!

INCREASED CAPACITY AT OUR BIG NEW FACTORY MEANS MANY PRICES DOWN! ALL OTHER FROZEN!

Another superb design by synthesizer expert Tim Orr!

TRANSCENDENT DPX

As featured in Electronics Today International August, September October, 1979 issues

DIGITALLY CONTROLLED, TOUCH SENSITIVE, POLYPHONIC, MULTI-VOICE SYNTHESIZER

The Transcendent PDX is a really versatile new 5 octave keyboard instrument. There are two audio outputs which can be used simultaneously. On the first there is a beautiful harpsichord or reed sound — fully polyphonic i.e. you can play chords with as many notes as you like. On the second output there is a wide range of different voices, still fully polyphonic. It can be a straightforward piano or a honky tonk piano or even a mixture of the two! Alternatively you can play strings over the whole range of the keyboard or brass over the whole range of the keyboard or should you prefer — strings on the top of the keyboard and brass at the lower end (the keyboard is electronically split after the first two octaves) or vice versa or even a combination of strings and brass sounds simultaneously. And on all voices you can switch in circuitry to make the keyboard touch sensitive? The harder you press down a key the louder it sounds — just like an acoustic piano. The digitally controlled multiplexed system makes practical sensitivity with the complex dynamics law necessary for a high degree of realism. There is a master volume and tone control, a separate control for the brass sounds and also a vibrato circuit with variable depth control together with a variable delay control so that the vibrato comes in only after waiting a short time after the note is struck for even more realistic string sounds.

Cabinet size 36.3"x15.0"x5.0" (rear) 3.3" (front)
Also available as separate packs — prices in free catalgoue

COMPLETE KIT ONLY £299.00 + VAT!

To add interest to the sounds and make them more natural there is a chorus/ensemble unit which is a complex phasing system using CCD (charge coupled device) analogue delay lines. The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble circuitry can be switched in with either strong or mild effects.
As the system is based on digital circuitry data can be easily taken to and from a computer (for storing and playing back accompaniment with or without pitch or key change, computer composing etc., etc.) and an interface socket (25 way D type) is provided for this purpose.
Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophisticated, the kit is mechanically extremely simple with excellent access to all the circuit boards which interconnect with multiway connectors, just four of which are removed to separate the keyboard circuitry and the panel circuitry from the main circuitry in the cabinet.
The kit includes fully finished metalwork, solid teak cabinet, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc., even a 13A plug — you need buy absolutely no more parts before plugging in and making great music! When finished you will possess an instrument comparable in performance and quality with ready-built units selling for over £1200!

EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits. This will be sent free on request, by airmail, together with our "Export Postal Guide" which gives current postage prices. There is no minimum order charge. Prices same as for U.K. customers but no Value Added Tax charged. Postage charged at actual cost plus £1 documentation and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U.K. Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London.

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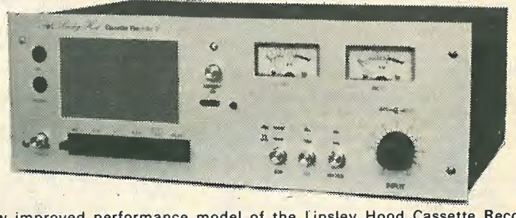
HART

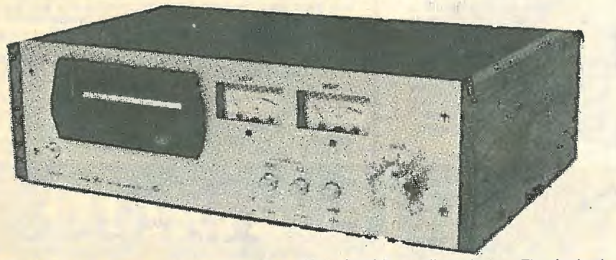
J. L. Linsley Hood High Quality Cassette Recorders

LINSLEY HOOD CASSETTE RECORDER 2

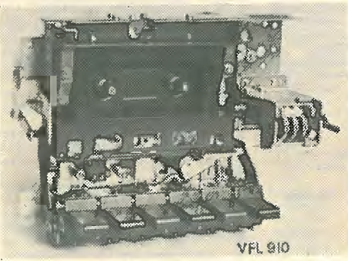


Our new improved performance model of the Linsley Hood Cassette Recorder incorporates our VFL 910 vertical front mechanism and circuit modifications to increase dynamic range. Board layouts have been altered and improved but retain the outstandingly successful mother and daughter arrangement used on our Linsley Hood Cassette Recorder 1.
This latest version has the following extra features. Ultra low wow-and-flutter of .09% — easily meets DIN Hi-fi spec. Deck controls latch in rewind modes and do not have to be held. Full Auto stop on all modes. Tape counter with memory rewind. Oil damped cassette door. Latching record button for level setting. Dual concentric input level controls. Phone output. Microphone input facility if required. Record interlock prevents re-recording on valued cassettes. Frequency generating feedback servo drive motor with built-in speed control for thermal stability. All these desirable and useful features added to the excellent design of the Linsley-Hood circuits and the quality of the components used makes this new kit comparable with built-up units of much higher cost than the modest **£94.90** + VAT we ask for the complete kit.

LINSLEY HOOD CASSETTE RECORDER 1



We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy aseembly and test. Sophisticated modular PCB system gives a spacious, easily built and tested layout. All these features added to the high quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our new HS15 Sendust Alloy record/play head, available separately at **£7.60** plus VAT, but included FREE as part of the complete kit at **£81.50** plus VAT.
REPRINTS of the 3 articles describing this design **45p** No VAT.
REPRINT of Postcript article **30p** No VAT.



VFL 910. Vertical front loading Super Hi-fi deck, as used in our new Linsley-Hood Cassette Recorder 2. **£31.99** + VAT. Set of knobs **£1.46** + VAT.

SUPER BARGAIN OFFER
LENCO FFR CASSETTE DECK

For those who missed our recent bargain CT4s we now are delighted to be able to offer Brand New Lenco FFR Decks complete with motor speed and auto-stop control board fitted and tested. These will operate with any supply between 9 and 16 volts. This deck can be used for both record and playback applications and is fitted with an erase head. A mono record/play head is fitted and we can supply an extra stereo head, if ordered with the deck at the very special price of £2 plus VAT. We also supply, with each deck and completely FREE, one of our specially moulded escutcheons. This deck would normally cost about £25 but we are able to offer them, while they last, at only £9.99 plus VAT.

BAILEY 30 WATT AMPLIFIER

We have now completed our redesign of this popular amplifier to make it as easy to build as our latest kits. The power amplifiers are complete modules plugging into a power supply master board, all possible wiring has been eliminated but faith has been maintained with the existing metal work to enable owners to update if they wish. Send for full details in our list.

LINSLEY HOOD 30-WATT AMPLIFIER

Advanced new cost-effective amplifier of impeccable specification from the 'master'. Published in the January and February issues of Hi-Fi News. We are supplying full kits to our usual professional standard.

STUART TAPE CIRCUITS

(For reel-to-reel decks)

These circuits are just the thing for converting that old valve tape deck into a useful transistorised recorder. Total system is a full three head recorder with separate record and replay sections for simultaneous off tape monitoring. We also stock the heads. This kit is well engineered but does not have the detailed instructions that we give with our more recent designs. We would not therefore recommend it to beginners. Reprints of the original three articles 45p. Post free. No VAT.

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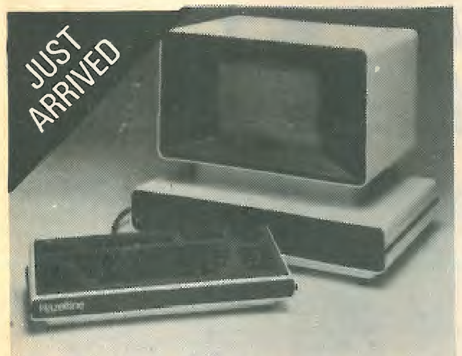

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BASIC Model from **£425.00**
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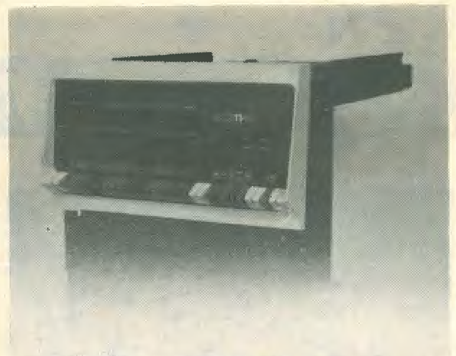

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Superb 48kW parity core processor with KT11D Memory Management and DL11 Asynchronous Interface. **Only £5250.00** including cabinet.

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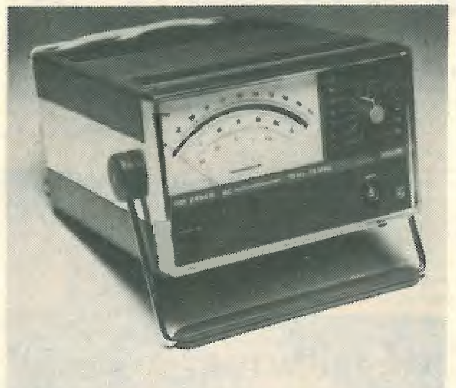

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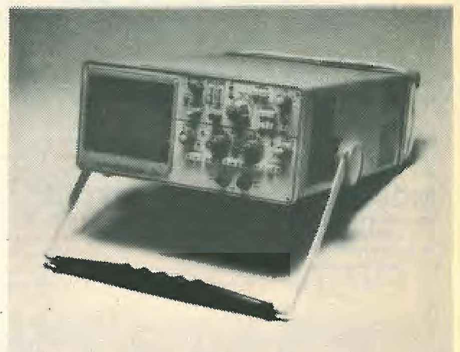
Millivoltmeter PM 2454B **£299**



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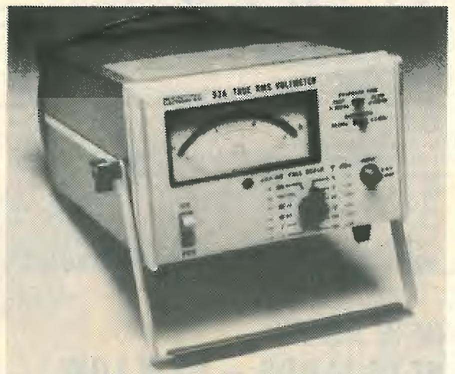

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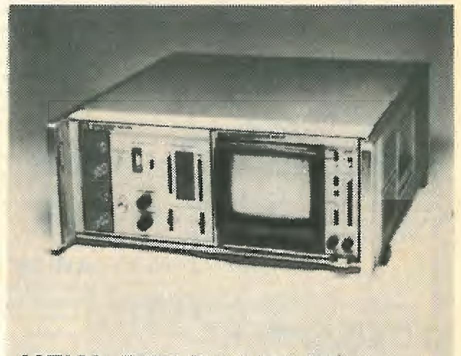

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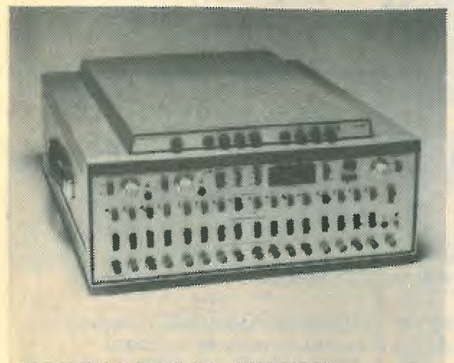

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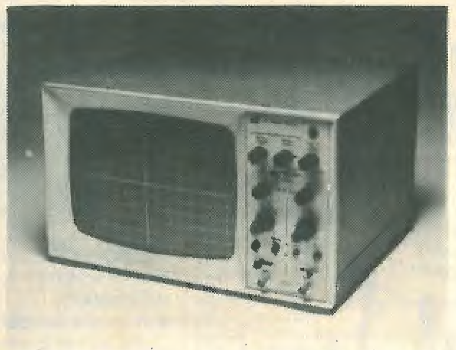

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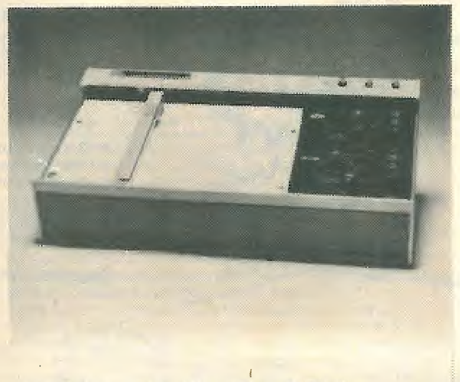

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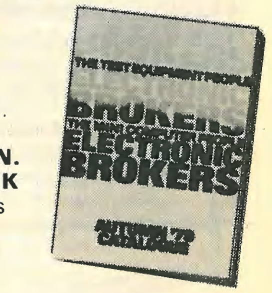

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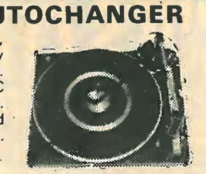

Plays 12", 10" or 7" records, Auto or Manual. A high quality unit backed by BSR reliability. Stereo Ceramic Cartridge. AC 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¼in. Below motor board 2½in. with Ceramic Stereo cartridge. **£20** Post £2

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Tinted Cover for above **£6.00**

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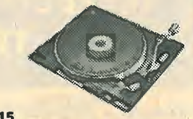
BSR SINGLE PLAYER



BSR P182 3 speeds flared aluminium turntable "S" shape arm, cueing device, ceramic cartridge **£24** Post £2

BSR TWO-SPEED BUDGET MODEL £15

GARRARD MINI CHANGER CC10A

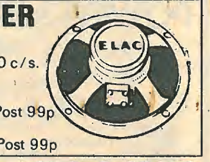
3-speed stereo cartridge. Plays all size records. 7in turntable **£6.95** Post £1.60

BSR P163 BELT DRIVE QUALITY DECK

Manual or automatic play. Two speeds. Precision balanced arm. Slide in head, cueing device. Bargain price **£30** Post £2

Suitable magnetic cartridge **£6.50.**

ELAC HI-FI SPEAKER 8in. TWIN CONE



Large ceramic magnet. 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance. 10 watts. RMS. **£5.95** Post 99p

20 watt woofer bass unit only **£7.95** Post 99p

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80 Ohm Coax

FRINGE LOW LOSS **15p** yd. PLUGS **20p.** SOCKETS **25p.** LINE SOCKETS **45p.** OUTLET BOXES **85p.** 300 ohm FEEDER **5p** yd.

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With tweeter and crossover. 10 watt. 3 or 8 ohm. **£9.95** Post 99p

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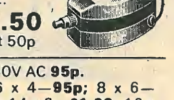
Bass woofer only 15 ohm. 20 watt. **£10.95** Post 99p

Suitable Bookshelf Cabinet Teak finish. For EMI 13 x 8 speakers. Size 16 x 11 x 8 inches approximately. **£9.50** Post £1.60

THE "INSTANT" BULK TAPE ERASER



Suitable for cassettes, and all sizes of tape reels. AC mains 200/250V. Leaflet SAE. Will also demagnetise small tools **£7.50**

Head Demagnetiser only £5.00. Post 50p

RELAYS. 12V DC **95p.** 6V DC **85p.** 240V AC **95p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**95p;** 8 x 6—**£1.40;** 10 x 7—**£1.55;** 12 x 8—**£1.70;** 14 x 9—**£1.90;** 16 x 6—**£1.85;** 16 x 10—**£2.20. ANGLE ALI.** 6 x ¾ x ¾in—**20p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
PLASTIC AND ALI BOXES IN STOCK. MANY SIZES

TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type, **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.** 8 amp **£2.50.**
TOGGLE SWITCHES SP **30p.** DPST **40p.** DPDT **50p.**
MANY OTHER TOGGLES IN STOCK. Please enquire.
PICK-UP CARTRIDGES ACOS, GP91 **£2.00.** GP94 **£2.50.**
SONOTONE 9TAHC Diamond **£3.75.** V100 Magnetic **£6.50.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, 20% **1p;** 2W **10p.**
HIGH STABILITY. ½W 2% 10 ohms to 1 meg. **8p.** Ditto 5%. Preferred values, 10 ohms to 10 meg, **3p.**

HIGH QUALITY

JVC DECK £35

Post £2

J.V.C. BELT DRIVE STEREO DECK With magnetic pick-up detachable head CN2316R 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 veneer base 19in. x 14½in. **£9.** Post £2, plastic cover **£6,** post £2.

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

"MINOR" 10 watt AMPLIFIER KIT £12.50

This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available: Mono, **£12.50;** Stereo, **£20.** Post 45p. Specification 10W per channel; input 100mV; size 9½ x 3 x 2in. approx. SAE details. Full instructions supplied. AC mains powered. Input can be modified to suit guitar.

RCS 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 **£2.95** Post 35p

Can be ganged to make multi-way stereo mixers

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
350-0-300V 100mA, 6.3V 3.5 amp	£5.80
300-0-300V 120mA, 2×6.3V 2A C.T.; 5V 2A	£10.00
220V 45mA, 6.3V 2A	£2.50
HEATER TRANSFORMER. 6.3V ½ amp £2.00 3 amp	£2.20

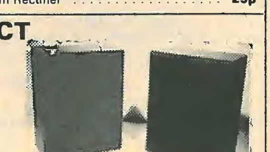
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs available

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	15-0-15V, 2 amp.	£3.75
12V, 750mA	£1.75	20V, 40V, 60V, 1 amp	£4.00
10-0-10V, 2 amp	£3.00	12V, 3 amp	£3.50
30V, 5 amp and 17V-0-17V, 2 amp.	£4.00	10V, 30V, 40V, 2 amp	£3.50
0, 5, 8, 10, 16V, ½ amp.	£2.50	40V, 2 amp	£3.50
9V, 3 amp	£3.50	20V, 1 amp	£3.00
25-0-25V, 2 amp.	£4.50	20V-0-20V, 1 amp	£3.50
30V, 2 amp.	£3.50	30V-0-30V, 2 amp	£8.00
30V, 1½ amp.	£3.30	2 of 18V, 6 amp, each	£11.00
		12-0-12V, 2 amp	£3.50
		9V, ¼ amp	£1.50

AUTO TRANSFORMERS 115V to 230V or 230V to 115V 150W **£7.00** 250W......**£8.00.** 400W......**£9.00** 500W......**£10.00**
FULL WAVE BRIDGE CHARGER RECTIFIERS. 6 or 12V outputs, 2 amp.....**75p.** 4 amp.....**£1.60**
CHARGER TRANSFORMERS 1½ amp. **£1.60.** 3 amp. **£4.00.** 4 amp. **£6.50.**
12V, 1½ amp Half Wave Selenium Rectifier **25p**

OPUS COMPACT SPEAKERS



TEAK VENEERED CABINET 11×8½×7in 50 to 14,000 cps. 15 watts 8 ohm **£20 pair** Post £2

LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p.**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 40V **60p;** 1200mF 76V **80p.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
4500mF 64V **£2.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**
5000mF 35V **85p.** 5600mF/76V **£1.75**

HIGH VOLTAGE ELECTROLYTICS

8/350V **22p**	8+8/450V **50p**	50+50/300V **50p**
16/350V **30p**	8+16/450V **50p**	32+32/450V **75p**
32/500V **75p**	16+16/450V **50p**	100+100/275V **65p**
50/500V **£1.20**	32+32/350V **50p**	150+200/275V **70p**

MANY OTHER ELECTROLYTICS IN STOCK

SHORT WAVE 100pf air spaced gangable tuner, **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0.01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0.1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0.001 to 0.05 **12p;** 0.1 **15p;** 0.25 **25p;** 0.47 **35p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over.
TWIN GANG, 385 + 385pF **80p;** 500pF slow motion **75p.** 365 + 365 + 25 + 25pF, Slow motion drive **85p.** 120pF **50p.**
TRANSISTOR TWIN GANG, 50p.
NEON PANEL INDICATORS 250V. Amber or red **30p.**
ILLUMINATED ROCKER SWITCH. single pole. Red **65p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **15p**
CASSETTE MOTOR. 6 volt **£1.00**
CASSETTE MECHANISM. Mono heads, no motor **£3.00**

"VALVES" special offer subject to being unsold £1 ea. Post Free

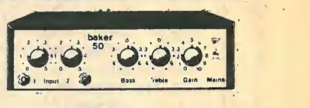
6AM6	12K7GT	PCF82	PL84	EBF80	EF80
6K8G	35L6GT	PCF86	PY33		EM84
6Q7G	954	PCL82	PY80	ECC84	EM85
6V6G		PCL84	PY82	ECF80	EM87
12Q7GT	35Z4GT	PL81	PY83	ECL80	EY51
12K8M	PCC84	PL82	E891	ECL82	EY86
25Y5G	PCC89	PL83	EBC81	EF41	EZ40

BAKER LOUDSPEAKERS "SPECIAL PRICES"

Post £1.50 ea.

MODEL	SIZE INCHES	OHMS	POWER WATTS	TYPE	OUR 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	£22
AUDITORIUM	12	8-16	45	HI-FI	£20
AUDITORIUM	15	8-16	60	HI-FI	£30
GROUP 35	12	4-8-16	40	PA	£12
GROUP 45	12	4-8-16	45	PA	£15
GROUP 25	12	4-8-16	60	PA	£20
GROUP 50	15	8-16	75	PA	£30
GROUP 75	12	4-8-16	75	PA	£24
GROUP 100	12	8-16	100	PA	£29
GROUP 100	15	8-16	100	PA	£35
DISCO 100	12	8-16	100	DISCO	£29
DISCO 100	15	8-16	100	DISCO	£35

BAKER 50 WATT AMPLIFIER



£65 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/AMPLIFIER

Professional 4 inputs with volume controls. Will mix mics, decks, musical instruments, etc. **£85** Post £2.00

Slave version available **£69**

FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

Post £1.50 ea.

MAKE	MODEL	SIZE	WATTS POWER	OHMS	OUR PRICE
SEAS	TWEETER	4in round	50	8	£7.50
GOODMANS	TWEETER	3½in square	25	8	£4.00
AUDAX	TWEETER	3½in square	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	8in	20	8	£5.50
SEAS	WOOFER	8in	30	8	£14.00
K.G.B.	GENERAL	10in	30	8	£10.50
McKENZIE	DISCO-GROUP	15in	150	8+16	£56.00
CELESTION	DISCO-GROUP	18in	100	8+16	£59.00
CELESTION	DISCO-GROUP	18in	200	8+16	£69.00

TEAK VENEERED HI-FI SPEAKER CABINETS
For 13x8in. or 8in. speaker **£9.50** Post £1.60
For 6½in. speaker and tweeter **£8.50** Post £1.00
Many other cabinets in stock. Phone your requirements.
SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.

GOODMANS TWIN AXIOM 8 inch dual cone loudspeaker. 8 ohm. 15 watt hi-fi unit **£10.50.** **CROSSOVERS. TWO-WAY** 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS PM 3 ohm 7x4in. **£1.50;** 6½in., **£1.95;** 8x5in., **£1.90;** 8in., **£2.50.**
SPECIAL OFFER: 64 ohm, 2¾in., **35 ohm,** 3in., **25 ohm,** 2½in., 3in., 5x3in., 7x4in., **8 ohm,** 2½in., 3in., 3½in., 5in., **15 ohm,** 3½in. dia., 6x4in., 7x4in., 5x3in., **3 ohm,** 2½in., 2¾in., 3½in., 5in. dia. **£1.50 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, **£2.50.**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS 8in. diameter 4W **£2.50.** 10in. diameter 5W **£3.50;** 12in. diameter 6W **£4.50.** 3/8/15 ohms, please state.
MOTOROLA PIEZO ELECTRIC HORN TWEETER £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 30-8000 c.p.s. **£5.95 each** Post £2

ALUMINIUM HEAT SINKS. FINNED TYPE. Sizes 5"x4"x1" **95p.** 6½"x2"x2¼" **45p.**
JACK PLUGS Mono Plastic 25p; Metal 30p.
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.
2.5mm and 3.5mm JACK SOCKETS 15p.
2.5mm and 3.5mm JACK PLUGS 15p.
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin 10p. Free Sockets 3-pin, 5-pin 25p.
Plugs 3-pin 20p; 5-pin 25p.
PHONO PLUGS and SOCKETS ea. 10p.
Free Socket for cable end ea. 15p.
Screened Phono Plugs ea. 15p.
TV CONVERGENCE POTS 15p each
Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms.

MONO PRE-AMPLIFIER. Mains operated solid state pre-amplifier unit designed to complement amplifiers without low level phono and tape input stages. R.I.A.A. equalisation on magnetic phono-input and N.A.B. equalisation for tape heads. Phono sockets. **£5** Post 50p.

RADIO COMPONENT SPECIALISTS

337 WHITEHORSE ROAD, CROYDON
Open 9-6. Closed all day Wed. Open Sat. 9-5.

Radio Books and Components Lists 20p. (Minimum posting charge 30p.) Access or Barclaycard please telephone: 01-684 1665 for same day despatch. Cash prices include VAT.

TTLs by TEXAS

7400 11p, 74S00 10p, 7401 12p, 7402 12p, 7403 14p, 7404 14p, 74S04 90p, 7405 18p, 7406 30p, 7407 32p, 7408 17p, 7409 17p, 7410 15p, 7411 24p, 7412 20p, 7413 30p, 7414 50p, 74C14 90p, 7416 27p, 7417 27p, 7420 17p, 7421 40p, 7422 20p, 7423 35p, 7425 27p, 7426 40p, 7427 30p, 7428 36p, 7430 17p, 7432 30p, 7433 40p, 7437 35p, 7438 35p, 7440 17p, 7441 70p, 7442A 60p, 7443 112p, 7444 112p, 7445 100p, 7446A 93p, 7447A 82p, 7448 80p, 7450 17p, 7451 17p, 7453 17p, 7454 17p, 7460 17p, 7470 36p, 7472 30p, 7473 34p, 7474 30p, 7475 38p, 7476 35p, 7480 50p, 7481 100p, 7482 84p, 7483A 90p, 7484 100p, 7485 110p, 7486 34p, 7489 175p, 7490A 30p, 7491 80p, 7492A 45p, 7493A 45p, 7494 84p, 7495A 65p, 7496 65p, 7497 185p, 74100 130p, 74104 65p, 74105 65p, 74107 34p, 74109 60p, 74110 54p, 74111 68p, 74116 200p, 74118 130p, 74119 210p, 74120 110p, 74121 34p, 74122 48p, 74123 73p, 74125 60p, 74126 60p, 74128 75p, 74132 75p, 74136 75p, 74141 80p, 74142 200p, 74143 312p, 74144 312p, 74145 90p, 74147 180p, 74148 150p, 74150 100p, 74151A 70p, 74153 70p, 74154 96p, 74155 80p, 74156 80p, 74157 70p, 74159 150p, 74160 100p, 74161 100p, 74162 100p, 74163 100p, 74164 120p, 74165 130p, 74166 130p, 74167 200p, 74170 240p, 74172 450p, 74173 120p, 74174 90p, 74175 90p, 74176 90p, 74177 90p, 74178 160p, 74180 90p, 74181 200p, 74182 90p, 74184A 150p, 74185 150p, 74186 500p, 74188 325p, 74190 120p, 74191 100p, 74192 100p, 74193 100p, 74194 100p, 74195 95p, 74196 90p, 74197 90p, 74198 150p, 74199 150p, 74221 160p, 74251 140p, 74259 200p, 74278 290p, 74279 110p, 74283 160p, 74290 150p, 74293 160p, 74298 200p, 74365 150p, 74366 150p, 74367 100p, 74368 150p, 74390 200p, 74393 200p, 74490 225p

74LS SERIES

74LS00 14p, 74LS01 16p, 74LS02 16p, 74LS03 18p, 74LS04 16p, 74LS05 22p, 74LS08 22p, 74LS10 20p, 74LS11 40p, 74LS12 35p, 74LS13 72p, 74LS14 90p, 74LS15 40p, 74LS20 20p, 74LS21 40p, 74LS22 25p, 74LS26 40p, 74LS27 40p, 74LS28 40p, 74LS30 20p, 74LS32 27p, 74LS37 40p, 74LS38 30p, 74LS40 25p, 74LS42 90p, 74LS47 90p, 74LS51 24p, 74LS55 30p, 74LS73 45p, 74LS74 72p, 74LS75 60p, 74LS76 45p, 74LS78 45p, 74LS83 90p, 74LS85 100p, 74LS86 40p, 74LS90 60p, 74LS92 70p, 74LS93 60p, 74LS96 110p, 74LS107 45p, 74LS109 45p, 74LS112 100p, 74LS113 45p, 74LS114 45p, 74LS122 80p, 74LS123 70p, 74LS124 180p, 74LS125 50p, 74LS126 50p, 74LS132 90p, 74LS133 30p, 74LS136 50p, 74LS138 75p, 74LS139 75p, 74LS145 120p, 74LS147 220p, 74LS148 200p, 74LS151 100p, 74LS153 80p, 74LS154 200p, 74LS155 90p, 74LS156 90p, 74LS157 80p, 74LS158 90p, 74LS160 100p, 74LS161 100p, 74LS162 100p, 74LS163 100p, 74LS164 120p, 74LS165 130p, 74LS166 130p, 74LS170 200p, 74LS173 130p, 74LS174 140p, 74LS175 120p, 74LS181 320p, 74LS183 200p, 74LS190 100p, 74LS191 100p, 74LS192 100p, 74LS193 100p, 74LS194 100p, 74LS195 100p, 74LS196 120p, 74LS197 120p, 74LS221 150p, 74LS240 170p, 74LS241 175p, 74LS242 170p, 74LS243 170p, 74LS244 160p, 74LS245 250p, 74LS247 130p, 74LS248 140p, 74LS249 140p, 74LS251 150p, 74LS253 140p, 74LS257 150p, 74LS258 160p, 74LS259 120p, 74LS266 100p, 74LS273 195p, 74LS279 80p, 74LS298 240p, 74LS324 150p, 74LS325 250p, 74LS326 250p, 74LS327 250p, 74LS365 75p, 74LS367 100p, 74LS368 100p, 74LS373 195p, 74LS374 195p, 74LS377 200p, 74LS393 200p, 74LS445 140p, 74LS668 100p, 74LS669 100p, 74LS670 400p

4000 SERIES

4000 15p, 4001 25p, 4002 20p, 4006 95p, 4007 25p, 4008 80p, 4009 60p, 4010 60p, 4011 25p, 4012 20p, 4013 50p, 4014 84p, 4015 84p, 4016 45p, 4017 80p, 4018 89p, 4019 45p, 4020 100p, 4021 110p, 4022 100p, 4023 27p, 4024 50p, 4025 20p, 4026 130p, 4027 50p, 4028 84p, 4029 100p, 4030 55p, 4031 200p, 4033 180p, 4034 200p, 4035 110p, 4036 295p, 4037 115p, 4038 105p, 4039 120p, 4040 100p, 4041 80p, 4042 80p, 4043 90p, 4044 90p, 4045 110p, 4046 110p, 4047 100p, 4048 55p, 4049 30p, 4050 48p, 4051 80p, 4052 80p, 4053 80p, 4054 150p, 4055 125p, 4056 135p, 4059 800p, 4060 115p, 4063 120p, 4066 56p, 4067 350p, 4068 27p, 4069 20p, 4070 30p, 4071 25p, 4072 25p, 4073 25p, 4075 25p, 4076 107p, 4077 27p, 4078 25p, 4081 27p, 4082 25p, 4085 72p, 4086 72p, 4089 150p, 4093 80p, 4094 250p, 4095 95p, 4096 95p, 4097 340p, 4098 120p, 4099 200p, 40100 220p, 40101 180p, 40102 180p, 40103 180p, 40104 99p, 40105 99p, 40106 80p, 40107 60p, 40108 470p, 40109 100p, 40110 300p, 40114 250p, 4411 1100p, 4412 1300p, 4502 120p, 4503 70p, 4507 55p, 4508 290p, 4510 99p, 4511 150p, 4512 98p, 4514 285p, 4515 300p, 4516 110p, 4518 100p, 4520 100p, 4521 250p, 4526 108p, 4527 150p, 4528 110p, 4532 125p, 4538 120p, 4543 180p, 4553 450p, 4556 72p, 4560 250p, 4569 250p, 4572 40p, 4583 90p, 4584 80p, 4585 100p, 4724 250p, 14411 1100p, 14412 1100p, 14433 1100p, 14500 700p, 14599 290p, CD22100 350p, CD22101 700p, CD22102 700p

93 SERIES

9301 160p, 9302 175p, 9308 316p, 9310 275p, 9311 275p, 9312 160p, 9314 165p, 9316 225p, 9321 225p, 9322 150p, 9334 380p, 9368 250p, 9370 200p, 9374 200p

VEROBOARDS 0.1 / 0.15 (copper clad)
2.5×3.75" 48p 43p; 2.5×5" 57p 51p; 3.75×3.75" 57p —; 3.75×5" 64p 64p; 3.75×17" 222p 194p; 4.75×17.9" 290p —; Pkt of 100 pins 50p; Spot face cutter 86p; Pin insertion tool 118p; Vero Wiring Pen + 2 wire spools + combs 370p; Combs 7p

LINEAR ICs

AY1-0212 600p, AY1-1313 668p, AY1-1320 325p, AY1-5050 140p, AY3-1270 810p, AY5-1224A 240p, AY5-1315 600p, AY5-1317A 725p, CA3019 80p, CA3046 70p, CA3048 225p, CA3080 72p, CA3080E, CA3086 48p, CA3089E 225p, CA3090AQ 375p, CA3130E 90p, CA3140E 50p, CA3160E 100p, CA3161E 140p, CA3162E 450p, CA3189E 300p, DAC1408-8 200p, FX209 750p, ICL7106 850p, ICL8038 340p, LF356P 100p, LM10C 425p, LM301A 30p, LM311 120p, LM318 200p, LM319 225p, LM324 70p, LM339 95p, LM348 95p, LM358 90p, LM377 175p, LM380 75p, LM381AN 160p, LM382 120p, LM710 50p, LM725 350p, LM733 100p, LM741 18p, LM747 70p, LM748 35p, LM3900 70p, LM3909 70p, LM3911 130p, LM3914 250p, LM3915 250p, LM13600 100p, MC1310P 150p, MC1458 40p, MC1495L 350p, MC1496 70p, MC3340P 120p, MC3360P 120p, MK50398 750p, MM57160 620p, NE531 150p, NE555 22p, NE556 70p, NE5618 425p, NE5628 425p, NE565 130p, NE566 155p, NE567 175p, NE571 425p, RC4151 400p, SAD1024A 1250p, SFF96364 £11, SN76003N 175p, SN76013N 140p, SN76013ND 120p, SN76023N 140p, SN76023ND 120p, SN76477 200p, SP8515 750p, TAA621 275p, TBA641B11 225p, TBA651 180p, TBA800 90p, TBA810 100p, TBA820 80p, TCA940 175p, TDA1004 300p, TDA1008 320p, TDA1010 225p, TDA1022 600p, TDA1024 120p, TDA1034B 250p, TDA1170 300p, TDA2002V 325p, TDA2020 320p, TL071, TL072 95p, TL074, TL081 45p, TL082 95p, TL084 130p, TL170 50p, UAA170 200p, UDN6118 320p, UDN6184 320p, ULN2003 100p, XR2206 400p, XR2207 400p, XR2211 600p, XR2216 675p, XR2240 400p, ZN414 90p, ZN419C POA, ZN424E 135p, ZN425E 400p, ZN1034E 200p, 95H90 800p, 11C90 1400p

TRANSISTORS

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We are looking for young people with a good general education – 'O' Levels in English, Maths and Physics essential, 'A' Levels in the latter two subjects preferred, alternatively an O.N.C. in Electronics, OR Part I C & G Telecommunications Course (No. 271). In addition you should be able to relate your theoretical knowledge to practical application. You must be at least 18 years old and have normal hearing and colour vision.

Minimum starting salary £4080 p.a. (including London Weighting). May be higher for candidates with exceptional qualifications. Extra payments for weekend and shift working.

For full details and an application form, please complete and return the coupon below, enclosing a self addressed envelope at least 9" x 4," to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting reference 80.E.4016/WW.

BBC

The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA (reference 80.E.4016/WW).

Name ______ Address ______

Tel. No ______

Age ______ Qualifications/Exam Results ______

(231)

Installation and Maintenance Engineers

for shipborne electronics equipment

Marconi Avionics at Welwyn Garden City are leading the world in the development of complex shipborne digital signal processing equipment and we now require additional electronics engineers, men and women, to join teams in the following specialist areas of our Project Services Department.

Ship Fitting

In this area responsibilities will cover all aspects of shipfitting from an early stage in design, including definition of the interfaces between the signal processor and other on-board equipment; installation specifications; connector schedules; participation in installation; setting to work and acceptance testing to customer satisfaction.

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While these positions are based at Welwyn Garden City, travel will be necessary throughout the UK and possibly overseas.

A high level of practical skill is required together with experience of working on computer-based equipment, possibly as an electronics Technician/Fitter in the Services. An ONC/HNC qualification or equivalent in-service training would be preferred.

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Write with details of experience to Rod Cook, Marconi Avionics Limited, 26–28 The Hydeway, Welwyn Garden City, Herts. Telephone Welwyn Garden 28511 extn. 15. Please quote reference MAW 8002.

(194)

MARCONI AVIONICS
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UNIVERSITY OF ST. ANDREWS

CHIEF TECHNICIAN

DEPARTMENT OF PSYCHOLOGY

Applications are invited for the above post in the Department of Psychology. The person appointed will be responsible to the head of department for the supervision of technical staff and the provision of technical services covering research and teaching laboratories, workshops and stores.

The department's laboratories have eight computing systems used for on-line control of experimental procedures and a considerable amount of television equipment, together with other specialised electronic apparatus and instruments.

It is expected that the person appointed would have not less than ten years' relevant experience of digital and analogue equipment design and maintenance procedures, be qualified to HNC level and have supervisory experience. Some knowledge of computer programming would be an advantage but is not essential.

Salary at appropriate point on Technician Grade 7 salary scale currently £5337-£5994 (from April 1980 £5685-£6384, under review).

Applications, with the names of two referees, should be sent by 4th April, 1980, to the Establishments Officer, The University, College Gate, St. Andrews, Fife KY16 9AJ.

(250)

UNIVERSITY OF OXFORD
DEPARTMENT OF PSYCHIATRY

ELECTRONICS TECHNICIAN

required for Medical Research Council supported research team. Duties include the design, construction, maintenance and repair of equipment used in psychological and physiological experimentation. Microprocessor experience an advantage.

Appointment would be for 3 years with the possibility of an extension.

Salary scale: Whitley Council Medical Physics Technician III or II, £4805-£5952 or £5547-£6918.

Applications in writing stating qualifications, age and present salary to Dr. D. Johnston, Psychological Treatment Research Unit, The Warneford Hospital, Oxford OX3 7JX.

(244)

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Great West Road, Brentford
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or telephone: 01-568 3273
quoting reference T102

(221)

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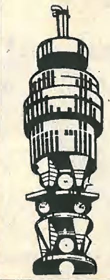

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(246)

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Fringe benefits include pension and life assurance plans, assistance with relocation where appropriate and, for the London vacancies only, local housing may be available and flexible working hours.

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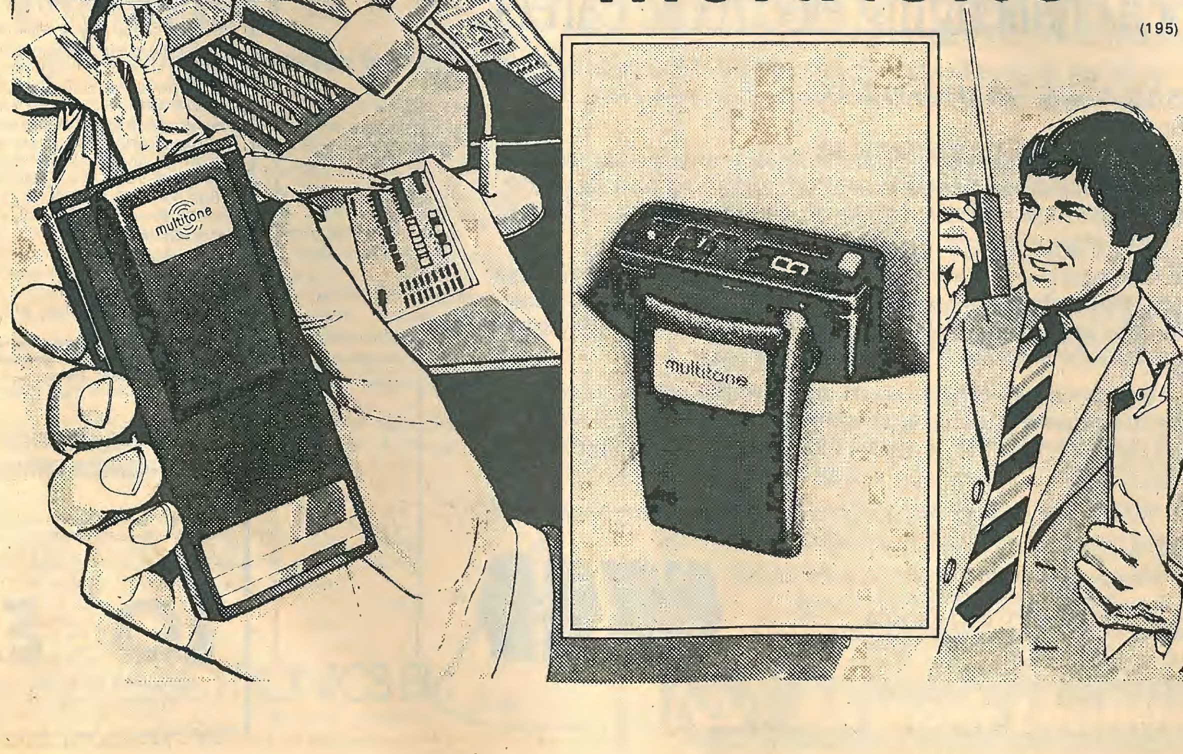
Please write to, or better still telephone, Brian Young at the address below.

Personnel Department
Multitone Electric Co. Ltd.,
6-28, Underwood Street, London, N1 7JT. Tel: 01-253 7611

multitone

(195)



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You should be educated to degree/HND level, and have at least 3 years relevant design experience.

Benefits include 25 days holiday, first class Pension and Sick Pay Scheme, and generous relocation assistance where appropriate.

Salaries will depend upon experience, and will range from c.£6,000 to c.£8,200 per annum.

These positions are open to both men and women.

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(212)

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Please write with brief personal and career details to: Lesley Buckland, Kelvin Hughes, New North Road, Hainault, Ilford, Essex. Or phone 01-500 1020.

KH

(217)

UNIVERSITY OF YORK DEPARTMENT OF CHEMISTRY

Chief Electronics Technician (Grade 7)

A vacancy exists for the post of Chief Electronics Technician. The person appointed will have general overall responsibility for all tasks carried out by two other technicians in the electronic workshop, but his main responsibility will be the maintenance of sophisticated computer-controlled instrumentation and electronic equipment. He will also be responsible, in consultation with academic and other technical staff, for the design and construction of new equipment, modifications to existing equipment and liaison with service engineers. A background in laboratory instrumentation will be an advantage but is not essential.

Salary on Grade 7 (£5,337-£5,994 under review)

Applications including curriculum vitae and the names of two professional referees should be sent for the attention of The Laboratory Superintendent, at the address below, from whom further details are available.

Department of Chemistry
University of York, Heslington, YORK, YO1 5DD. Tel: 0904 59861 ext 310.

Closing date for applications is 18th April, 1980. (220)

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ELECTRONICS TECHNICIAN

(Grade 5) required in a research group developing microprocessor-controlled optical instrumentation for atmospheric research using balloons and satellites, 37½ hour week, five weeks' paid annual holiday plus statutory and customary days at Christmas and Easter amounting to two weeks. Pension scheme. Salary in range £4,776-£5,448 inclusive of London Weighting depending on experience (further increase April 1, 1980). Application forms and further details from: The Personnel Officer (Technical Staff CJ25), University College London, Gower Street, London WC1E 6BT. (192)

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(247)

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Digital Computertechnics for Holland

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We are constantly looking for new products for the initial market for consumer and industry.

Applicants must have a thorough technical education, speak English, French and German fluently, they must be very flexible and be willing to travel widely when it's necessary. Of course he must have good communicative skills. Experience in an equal job would be pleasant, but is not essential.

We offer an attractive salary plus the usual fringe benefits you may expect for this job. A house in Holland will be available.

If you are challenged by this offer, please apply in writing giving details of age, education, experience and qualifications to:

(193)

WOLFSEN ELECTRONICS BV
Ged. Nieuwesloot 111-115, 1811 KR Alkmaar, Holland.
Tel. 072-124216*/128055. Telex 57572 Wolfs NL.

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Applications are invited from suitably qualified former British Armed Services NCOs to fill the following contract appointments in the Oman Army.

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Uniformed appointments, 3 year contracts, unaccompanied, starting emoluments equivalent to approx. £6850 (WOI), £6650 (WOII) or £5650 (Sgts) p.a. at current exchange rate tax free, terminal gratuity approx. £4000, mess accommodation and services free, three 20-day periods of UK leave annually with air passages paid.

For further details write, giving brief details of qualifications and experience, quoting the appropriate reference, eto:

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Airwork Limited

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Our continuing expansion has created opportunities for applicants with a good knowledge of hardware and software, and preferably with an active interest in microprocessors. Using these skills you will develop diagnostic routines and programmes for our Systems Support Personnel and Evaluation and Quality Assurance Departments.

Ideally you will be qualified to HND/degree level in electronics, or you should have considerable related experience. In either case we offer a progressive environment with good future prospects.

Salary will relate to individual experience and circumstances but will not be a limiting factor. Relocation expenses will be given where necessary.

For further details please contact:

Don Buckland,
Product Reliability Manager,
Burroughs Machines Ltd.,
512, Purley Way, Croydon,
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Burroughs

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Occidental, one of today's most progressive and rapidly expanding international oil companies, require communications experts to supervise the installation, maintenance and repair of communications equipment in the field production areas in Libya, including VHF/AM/FM equipment, HF-SSB Transceivers, LF radio beacons, TDM alarm systems, teleprinters etc.

Candidates must have at least five years' experience in installing, maintaining and repairing radio, telephone and microwave systems, some of which should be at supervisory level.

These desert based positions are on single status with a continuous work schedule of 33 days working, 21 days leave and airfare paid to point of origin for each fieldbreak. Other benefits include BUPA cover for employee and eligible family members, laundry and meals on site plus the usual benefits associated with a large established company.

Please send your resume with full personal and work experience to Patricia Conneely, Occidental of Libya Recruiting, 16 Palace Street, London SW1E 5BQ. Tel: 01-828 5600.

(243)

OXYLIBYA

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DEPARTMENT OF PHYSICS

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To assist with developing equipment and systems for collecting and processing data. The successful applicant will work in one of several areas: logic or analogue circuitry, application of minicomputers, development of special instruments, etc. Degree or equivalent qualifications necessary. Recent graduates will be considered. Salary according to age and experience on the scale for Experimental Officer (up to £6991 p.a. or Senior Experimental Officer (up to £8273 p.a.).

Application forms may be obtained from the Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote ref. RV/919/WW.

Inner London Education Authority
GARNETT COLLEGE
Downshire House, Roehampton Lane, London SW15 4HR 01-789 6533

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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: £3,757-£4,276, including London Weighting.

Applicants should possess an ONC or an Ordinary City & Guilds, or have recognised apprenticeship, and have at least 4 years' relevant experience.

Further details and application forms, returnable within 10 days, from the Acting Chief Technician at the college. (★Ref:)

(223)

HAMPSHIRE EDUCATION COMMITTEE
THE COLLEGE OF NAUTICAL STUDIES, WARSASH
Required immediately

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Scale Technical Grade 3. Salary £4,080-£4,533 according to qualifications and experience.

It is essential that the person appointed shall have knowledge of maintenance for complex electronic equipment in the field of digital computers and C.R.T. displays. Relevant qualifications would be City and Guilds or O.N.C. (electronics).

Application forms and full details from the Chief Administrative Officer, The College of Nautical Studies, Warsash, Southampton SO3 6ZL. (206)

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(248)

ELECTRONICS TECHNICIAN (Grade 5) required in the Department of Psychology, University of Reading, to take charge of electronics workshop, advise staff and students on electronics problems, and design and construct wide range of specialised equipment. The research programme already depends heavily on advanced digital and analogue techniques. Recognised qualification or apprenticeship and at least 7 years of varied experience in electronics are essential. Salary in scale £3996-£4668 p.a. (under review). Apply, with names of two referees, to Assistant Bursar (Personnel), University of Reading, Whiteknights, Reading RG6 2AH, quoting Ref. T.Z.Z.11A. (215)

Radio Technicians

Work in Communications R&D and add to your skills

At the Government Communications Headquarters we carry out research and development in radio communications and their security, including related computer applications. Practically every type of system is under investigation, including long-range radio, satellite, microwave and telephony.

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You should be at least 19 years of age, hold or expect to obtain shortly the City and Guilds Telecommunications Technician Certificate Part I (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are, or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

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GCHQ

Recruitment Office
Government Communications Headquarters
Oakley, Priors Road, Cheltenham GL52 5AJ

(9813)

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Application forms available from Miss J. A. Jenks, Personnel Manager, Brompton Hospital, Fulham Road, London SW3 6HP. Tel: as above, Ext. 4357.

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(218)

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IS8.1.1.2, Room 643, Union House,
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Post Office Telecommunications (198)

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SERVOTEST (254)

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For further details etc. (173)

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(239)

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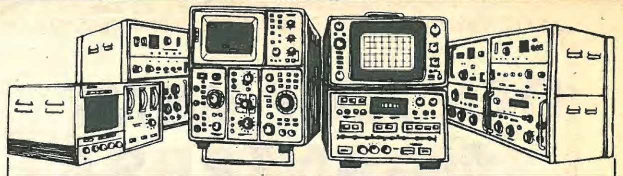

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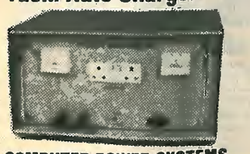

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