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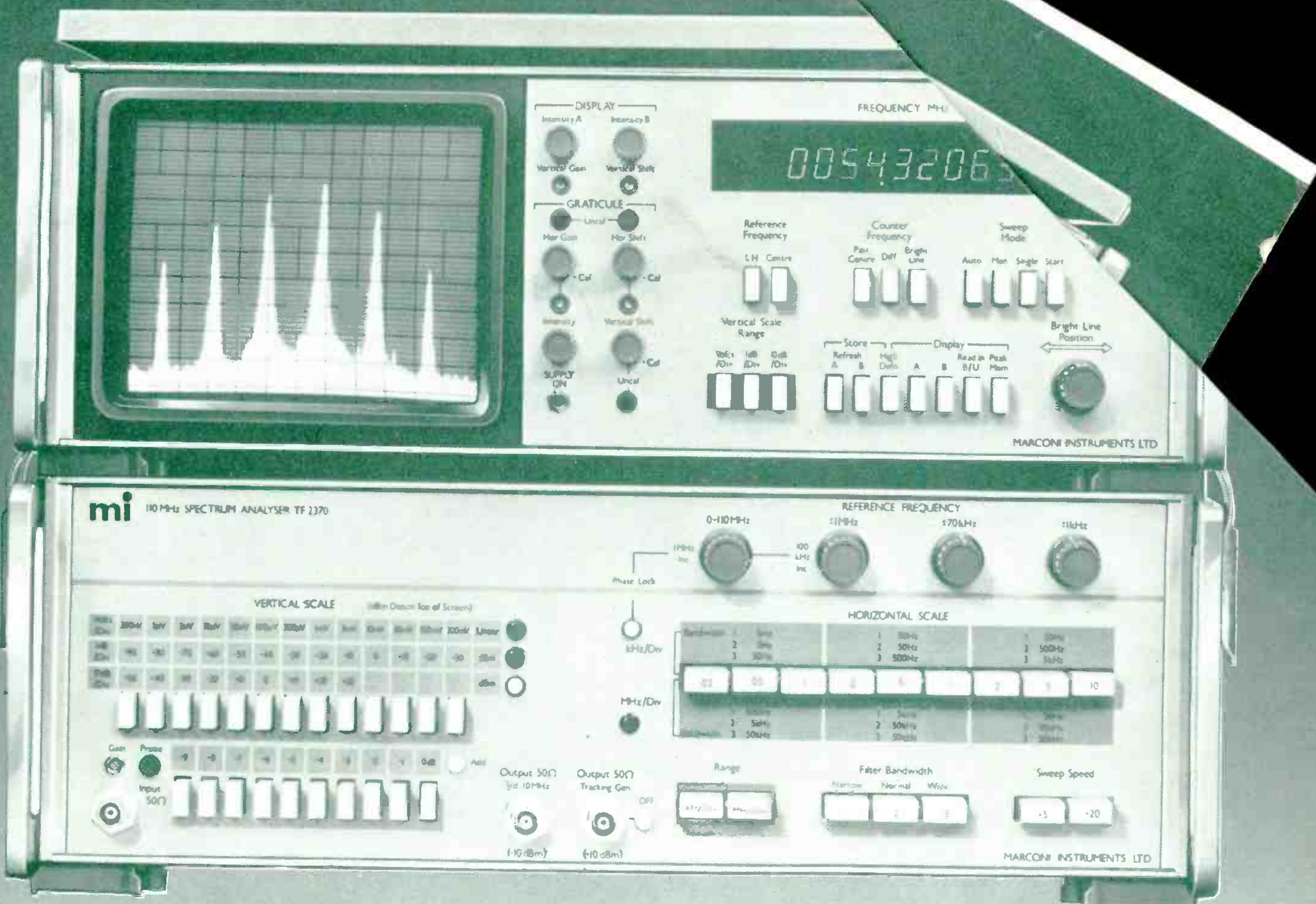

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You've never seen a faster, more accurate way of measuring frequency response from 30Hz to 110MHz

The TF 2370 Spectrum Analyser employs advanced technology to provide a complete system for measuring response, level, frequency, signal purity, modulation and much more, with a speed and degree of accuracy previously unobtainable. A digital memory permits the use of a standard monitor tube and internal logic selects gain ratios and sweep speeds for optimum performance. The specification speaks for itself:

* Flicker-free 100 dB display of frequency response from 30 Hz to 110 MHz on a high brightness c.r.t.
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* 9-digit electronic counter automatically gives centre frequency, reads any other frequency corresponding to manually-adjusted 'bright line' position on display, or the difference frequency between the two, at the press of a button. All to an accuracy of ±2Hz ± reference frequency accuracy on high resolution and manual. Internal reference frequency provided with setting accuracy of 1 in 10^7.
* Internal generator supplies synchronous signal source for measuring such items as networks and filters.
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* Automatic selection of optimum sweep speed.
* With the 5 Hz filter, signals 100 Hz from a response at 0 dB can be measured to −70 dB.

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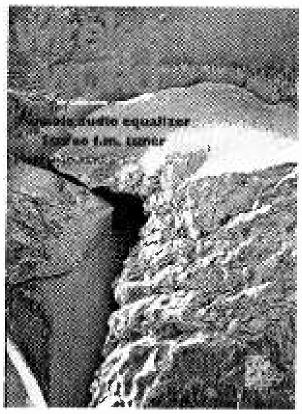

Scanning electron microscope photo of amorphous selenium as used for charge carrier layer in photocopying machines. Photo by Manfred P. Kage, made available by SEL, Stuttgart.

IN OUR NEXT ISSUE

***Digital storage* for oscilloscopes, allows waveforms to be stored for later examination. Pre-trigger and step elimination are provided in an add-on unit.**

***Capacitance meter* gives direct reading of capacitance in the range 1pF-100μF, using the diode-pump technique.**

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Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.

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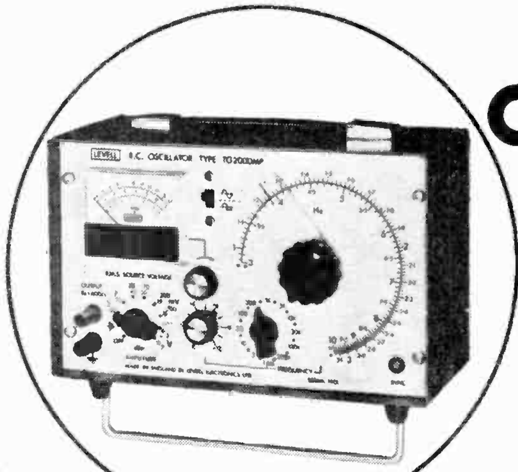
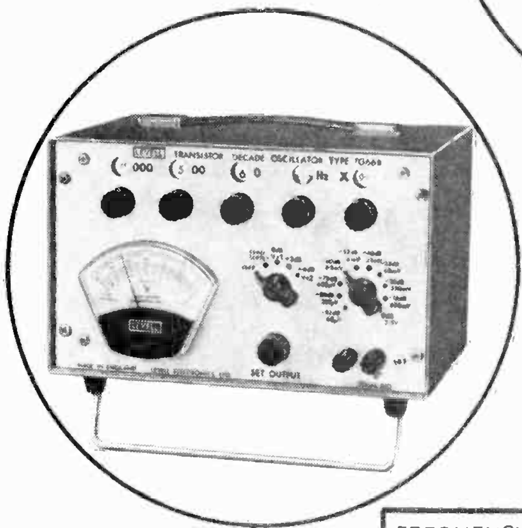
ELECTRONICS/TELEVISION/RADIO/AUDIO

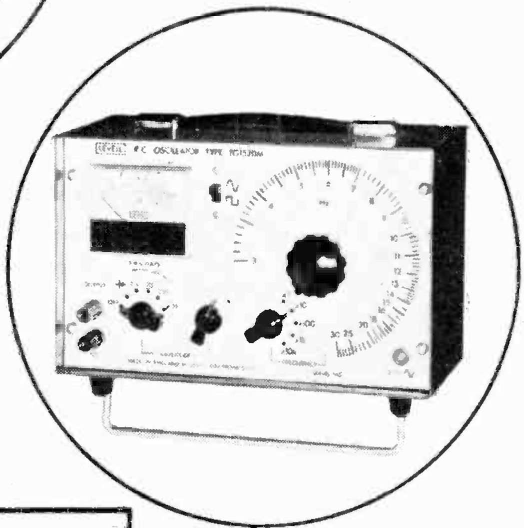
SEPTEMBER 1978 vol 84 No 1513

LEVELL
PORTABLE INSTRUMENTS

LOW COST 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 & DPM only. 0/2V, 0/7V & −14/+6dBm.
SIZE & WEIGHT	260 x 130 x 180mm. 4.3kg with batteries.

TG200	TG200D	TG200M	TG200DM	TG200DMP
£75	£79	£91	£95	£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 300 kHz. ±3% above 300 kHz.
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 &−2/+4dBm.
SIZE & WEIGHT	260mm x 190mm x 180mm. 5.6kg.

TG66B Battery model **£195**

TG66A Mains & battery model **£210**

FREQUENCY	3Hz to 300kHz in 5 decade ranges.
ACCURACY	±2% ±0.1 Hz up to 100kHz, increasing to ±3% at 300kHz.
SINE OUTPUT	2.5V r.m.s. down to <200μV.
DISTORTION	<0.2% from 50 Hz to 50kHz.
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.
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TG152D Without meter **£59**

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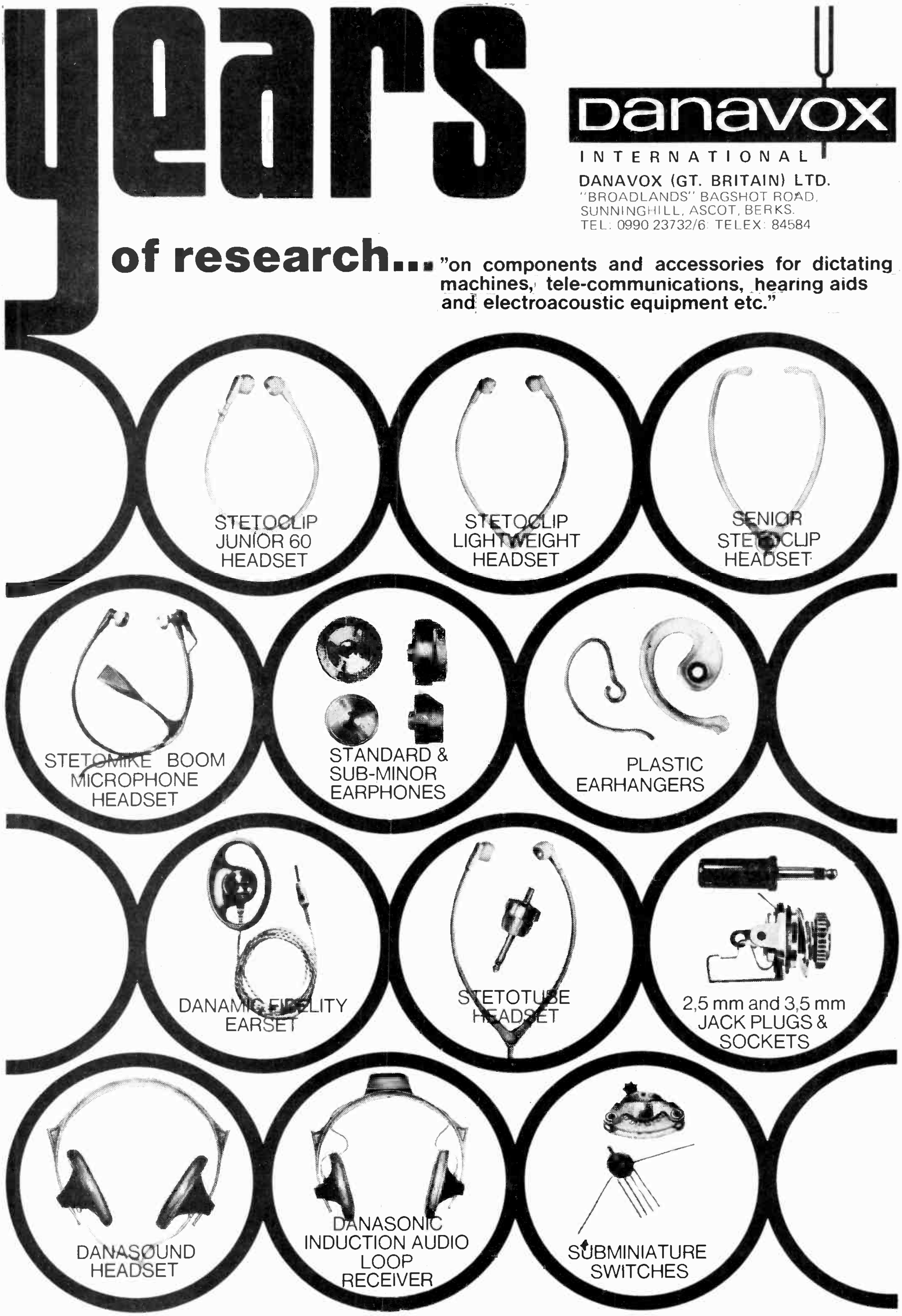
Prices are ex-works with batteries. Carriage and packing extra. VAT extra in U.K. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.

WW—079 FOR FURTHER DETAILS



WW—027 FOR FURTHER DETAILS

The Ultimate Multi-mate

What other DMM offers all this for £127?

It's easy to see why Philips new PM 2517 digital multimeter is called The Ultimate Multi-mate. No other DMM comes anywhere near its combination of laboratory performance and handy form - for such a handy price. Take a look at some of the features it packs in.

Full 4-digit display giving higher resolution than 3½ digits for 80% of measurements. Parameter readout, too.

Choice of LED or LCD display - choose the one that suits you, the price is the same. Mains unit supplied free with LED version.

Autoranging with manual override. Average auto response time less than two seconds.

True RMS rather than "average" detection. The Ultimate Multi-mate measures non-sinewave AC signals more accurately.

High accuracy - necessary to make full use of those four digits. An impressive 0.2% of reading ±0.05% of scale on d.c. volts.

Current to 10A via a separate input is standard, not optional, on the PM 2517.

Overload protection that is so comprehensive you have to try very hard to do any damage, even with mains and TV booster voltages.

Small and sturdy construction makes this DMM ideal for bench or field work.

Ergonomic design allows it to work in any position without fuss or fumble.

Low-cost temperature option makes possible measurement from —60 to +200°C.

Data hold option means that in tricky situations you can "freeze" measurements for increased operator safety and convenience.

Built to international standards - you name them and the PM 2517 meets them. But what else would you expect from an international company like Philips?

The no-compromise 4-digit instrument

The Ultimate Multi-mate is available from Wessex Electronics Ltd., 114 - 116 North Street, Downend, Bristol BS16 5SE. Tel: (0272) 571404; Rank Radio International, Watton Road, Ware, Herts. (Tel: Ware 3966); and Philips Service Centres ('phone 01-686-0505 for the address of your nearest branch).

It can also be purchased from the U.K. marketing organisation

Pye Unicam Ltd
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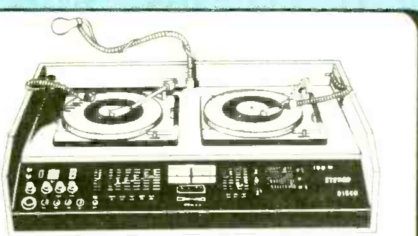
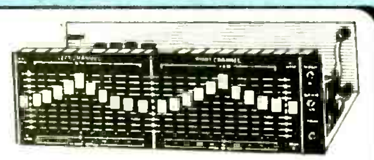


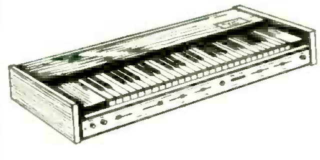
100W RMS STEREO DISCO

A genuine 100W RMS per channel (both channels driven) stereo disco with auto fade on microphone, VU meters, full monitoring and cueing facilities and a very high quality light show. Complete construction booklet MES41 price 25p. Cabinet comes complete with lid and carrying handles.



10 CHANNEL STEREO GRAPHIC EQUALISER

A new design with no difficult coils to wind, but a specification that puts it in the top-flight hi-fi class. All this for around £70 including fully punched and printed metalwork and woodwork. Send for our component schedule now. Full construction details price 25p. (All prices include V.A.T. and p & p.)



'PE' STRING ENSEMBLE

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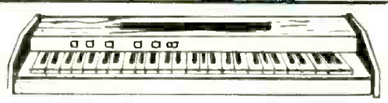
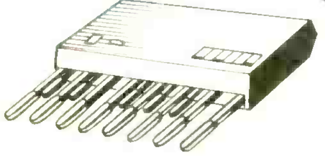
VERY LOW-DISTORTION AUDIO OSCILLATOR

The very low distortion sine wave (< 0·01%) output is suitable for testing very high quality hi-fi audio equipment. Also includes square wave output. Range 20Hz to 26kHz. Output 0V to 1V in three continuously variable steps. Total cost around £21. Full construction details in our catalogue. Send the coupon below, now! (all prices include V.A.T. and p & p).



TOUCH-SENSITIVE PIANO

The revolutionary new IC AY-1-1320 first seen on 'Tomorrow's World' is now available. Complete kit of IC's to build a 60-note piano (18 × IC's) order as HQ53H price £36·86. Preliminary circuit details in our October newsletter. Complete design, pcb's attractive veneered wooden cabinet available soon. It's the most realistic-sounding electronic piano we've ever heard and includes simulated damping, loud and soft pedals. Full details in our newsletters. (All prices include V.A.T. and p & p.)



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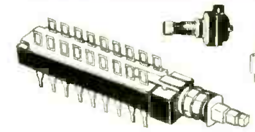
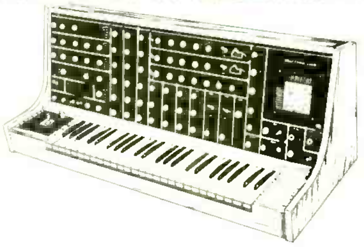
A completely self-contained pedal unit. 13-note. 2-Octave range. 4 organ stops. It can be added to any organ. A really unusual extra is the bass guitar stop which uses four envelope shapers to give a real bass guitar sound. A must for the solo guitarist. Full construction details in our catalogue—post the coupon below, now!



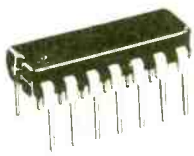
SWITCHES

We stock a wide range of switches including a really low-priced high quality interlocking push-button switch system which is extremely versatile. We've got toggle switches, slide switches, push switches, rotary switches—there are dozens to choose from, but it's only a tiny part of our fantastic range.



SYNTHESISER

The International 4600 Synthesiser. A very comprehensive unit. Over 400 sold. We stock all the parts costing less than £500 including fully punched and printed metalwork and a smart teak cabinet. Far less than half what you'd pay for a ready made synthesiser of equal quality. Specification on request. Full construction details in our construction book £1·50. (All prices include V.A.T. and p & p.)



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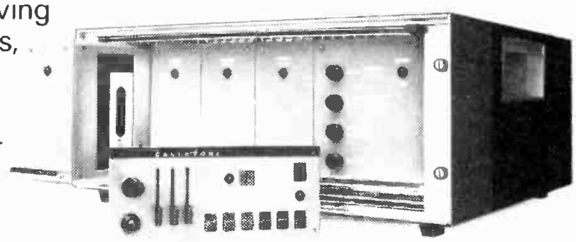
When police, ambulance, fire, local ATC and other services are called upon, either by radio or telephone, they often receive hasty, garbled messages – sometimes several at a time. In such instances a positive need for communications recording arises – a need for a system with instant message trace and replay – at the touch of a button – and at any speed to assist intelligibility.

All these facilities, and more, are available in the Racal-Thermionic 'Callstore' cassette recorder/reproducer. Actuated either by incoming audio signals or by local or remote control, Callstore uses four cassette transports, each giving up to four separate channels, including a search control track which is cued at the beginning of each message.

For details write to:

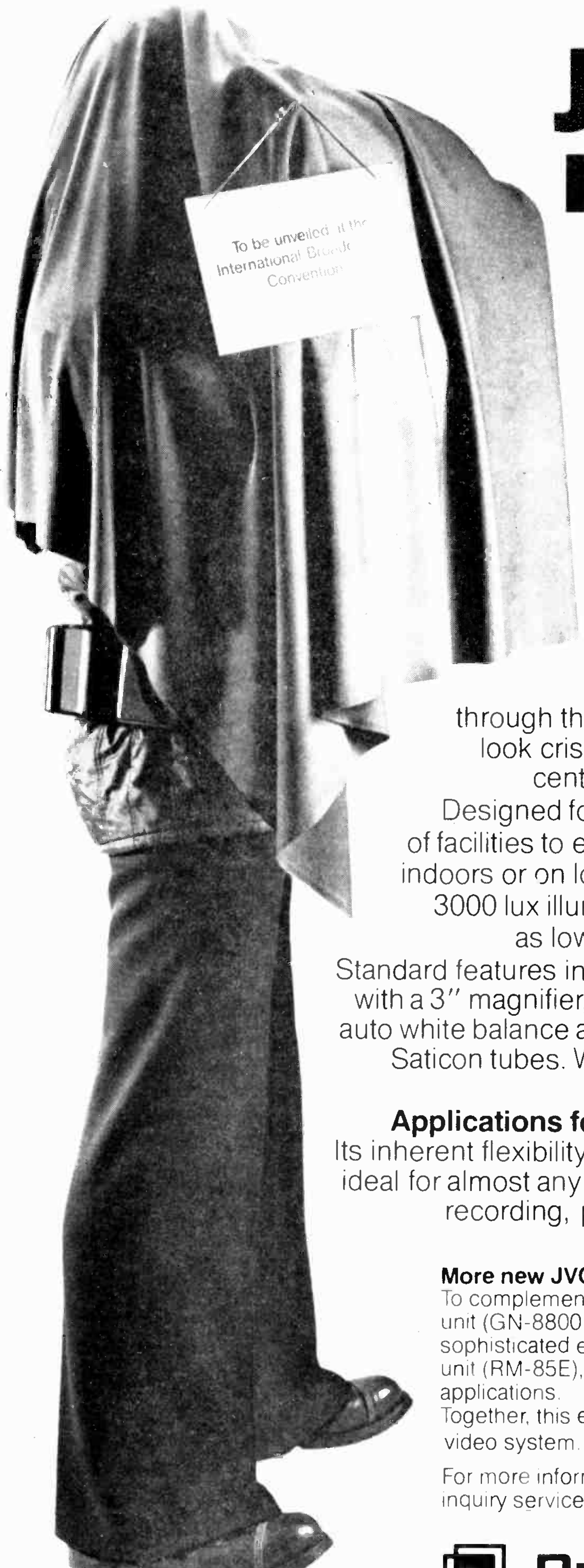
Racal-Thermionic Limited
Hardley Industrial Estate
Hythe, Southampton,
SO4 6ZH England.
Telephone: 0703 843265.
Telex: 47600.

RACAL



Callstore, from Racal-Thermionic, answers all the questions.

WW—013 FOR FURTHER DETAILS



JVC's new portable 3-tube CY-8800E camera

Featuring a choice of 2/3" Plumbicon or Saticon tubes, the new JVC portable 3-tube camera is one of the latest products of the company's 21 years' involvement in video systems. Pictures through the 10:1 f/1.9 C mount zoom lens, fitted as standard, look crisp and clean with better than 500 lines horizontal centre resolution.

Designed for Europe, the new PAL CY8800E has a wide range of facilities to enable operators to record virtually any scene – indoors or on location. With a 49dB S/N ratio at f/4 and only 3000 lux illumination, the camera can be used in light levels as low as 300 lux.

Standard features include built-in colour bar generator, 1½" viewfinder with a 3" magnifier, 3 way sensitivity switch (normal, +6dB, +12dB), auto white balance and bias lighting when the camera is fitted with Saticon tubes. Weight is only 9.6kg including lens, and viewfinder.

Applications for this superb camera

Its inherent flexibility and sensitivity make this JVC portable camera ideal for almost any situation, including training, news-gathering, event recording, pilot commercial preparations and sport.

More new JVC units

To complement the CY-8800E camera, JVC is also introducing a gen-lock unit (GN-8800E), 3" high-resolution viewfinder (VF-8300E), a more sophisticated electronic editing suite (CR-8500E), an automatic editing control unit (RM-85E), and a remote and sync unit (RS-8800E) for CY8800E studio applications.

Together, this equipment adds up to the world's finest ¾" U-format video system.

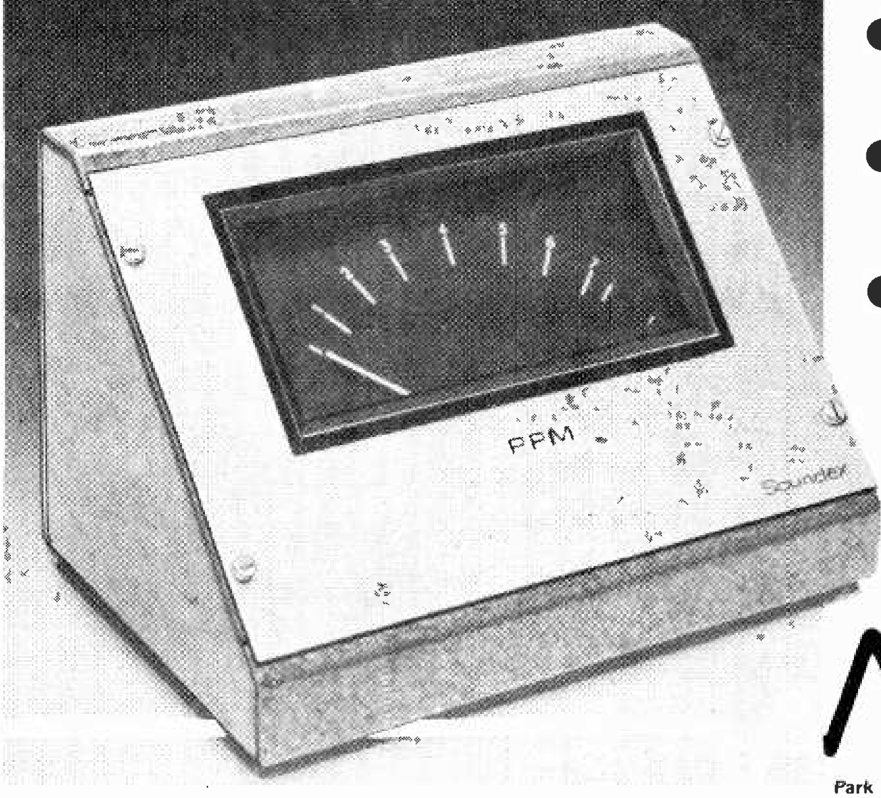
For more information about all this new JVC video equipment, use the inquiry service to obtain literature and a list of Bell & Howell video dealers.

BELL & HOWELL

Bell & Howell A-V Ltd.,
Alperton House, Bridgewater Road,
Wembley, Middlesex HA0 1EG.

WW—090 FOR FURTHER DETAILS

The Soundex PPM
COMPLIES WITH B.S. 4297 AND IEC 468



- ROBUST, FREE-STANDING UNIT
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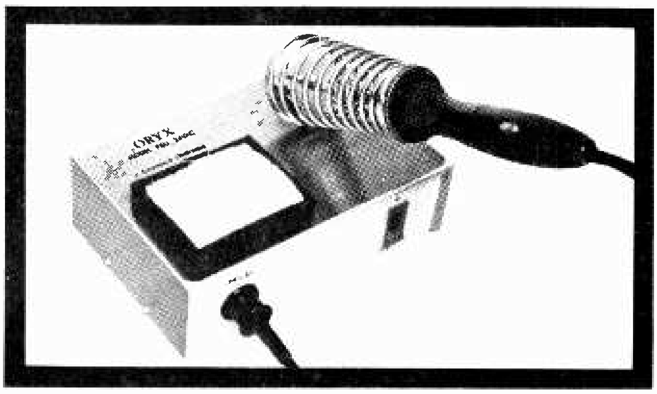


Introducing the ORYX PSU 24

a new compact self-contained 24 volt power supply unit
for ORYX temperature controlled soldering irons.

Styled in tough plastic, the ORYX PSU 24 is a smart new supply unit that is self-contained and small enough for the smallest of benches. Designed to meet BSS 3456 the ORYX has all the features you need - and more:- ON/OFF illuminated rocker switch; 3 pin non-reversible socket supplying 24 volts; a BSS 3535 transformer; an outside primary fuse; 1.5 metre white cable to BSS 6500 and fuse protection for transformer secondary wiring.

A unique feature is the facility to modify a 3 wire power system to a 2 wire fully isolated unit and vice versa.

A new product from Greenwood Electronics

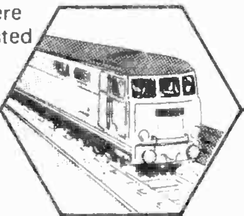
For full technical data write for information to Greenwood Electronics, Portman Road, Reading, RG3 1NE Telephone. Reading (0734) 595844 Telex 848659

WW—075 FOR FURTHER DETAILS

THE JAMES SCOTT INDUSTRIAL MICROWAVE RANGE OF EQUIPMENT

The James Scott range of Microwave equipment offers industrial users a greater choice of alternative systems in robust, industrial, cast aluminium housings, for a wide variety of applications.

The range is made up of standard sub-assemblies which can be permutated to suit individual application requirements. Here are some suggested applications for these units.



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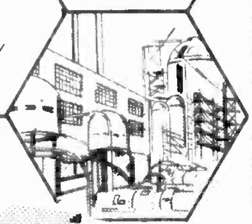

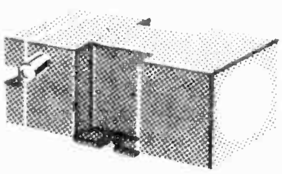

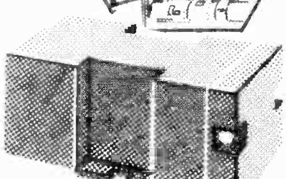

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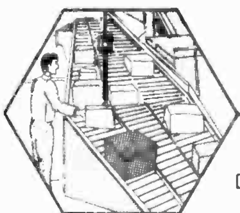

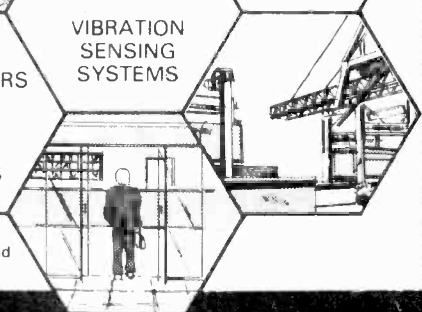

Please write or telephone for further information and technical literature to

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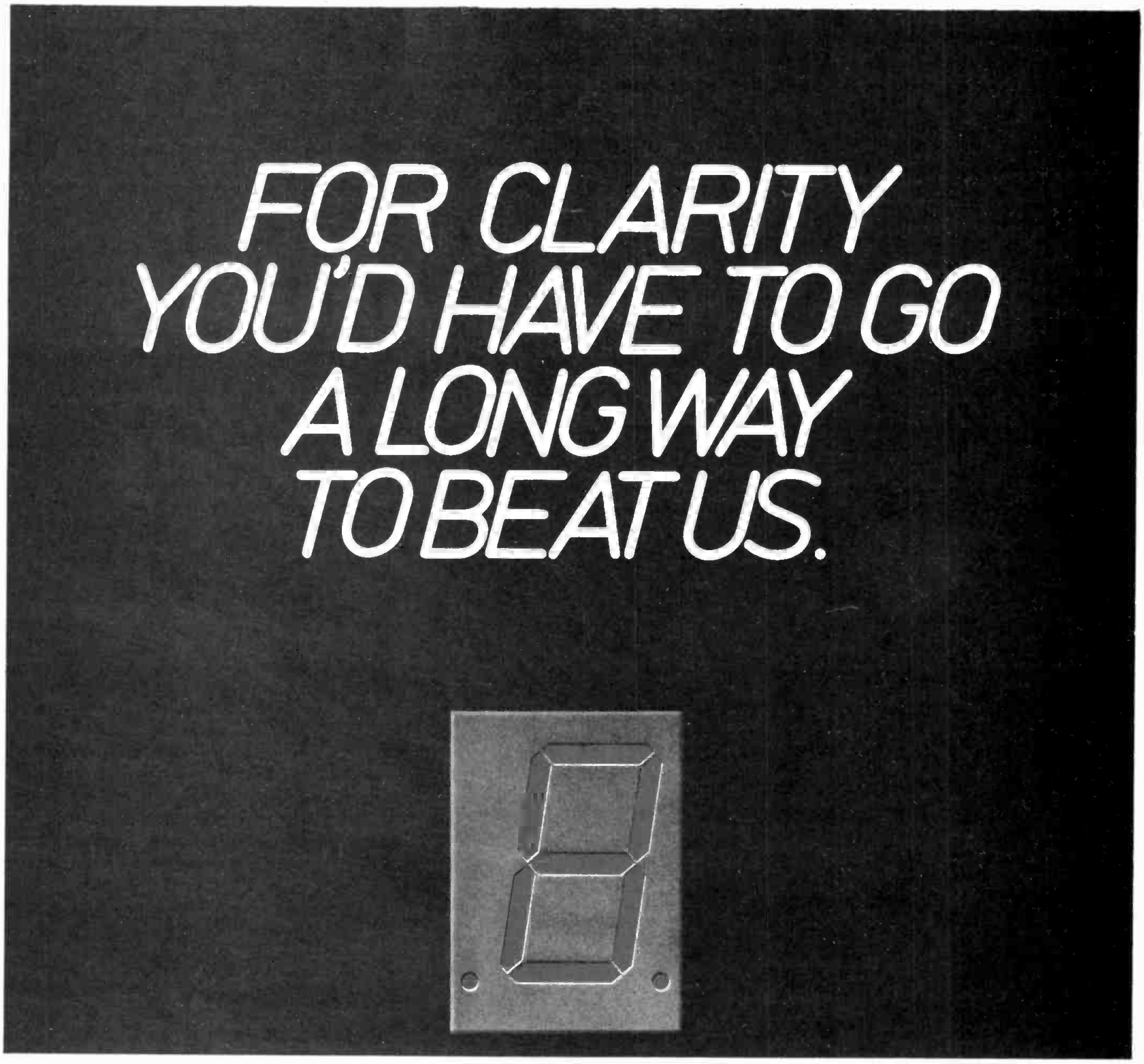
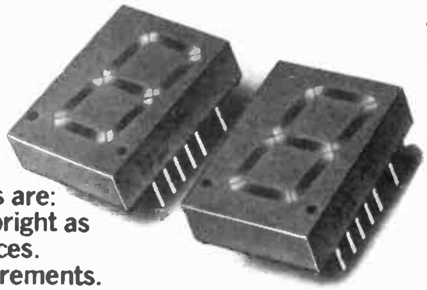


Hewlett-Packard's HDSP-3400 series display.

The readability of the HDSP-3400 series is excellent—designed for viewing distances of up to 33 feet. Even in bright ambients the clarity is remarkable. They replace existing 0.6" and 0.8" displays and are fully compatible with them.



Significant features are:
* **Nearly twice as bright as competitive devices.**
* **Low power requirements. Single Ga AsP chip per segment.**
* **Categorised for luminous intensity, assuring uniformity of light output.**
* **Grey packaging for optimum contrast.**
* **Overflow digit device available.**
* **Low cost. 100 + £1.36.**

For full details of why you'd have to go a long way to beat the HDSP-3400 series return the coupon.

HEWLETT hp PACKARD

To Crellon Electronics Ltd., 380 Bath Road, Slough, Berks. SL1 6JE.
Tel: Burnham (06286) 4434. Telex: 847 571.

Please send me full data
on the Hewlett-Packard HDSP-3400 Series

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WW9

WW—009 FOR FURTHER DETAILS

Artistic licence?

We at QUAD go to a very great deal of trouble to ensure that with a QUAD 33 in the Cancel position, the voltage delivered to your loudspeakers is a virtually exact RIAA transfer of the voltage the pickup will produce into a stated passive load. Nothing added – nothing taken away.

A visiting journalist recently suggested that we should not do this. Final adjustment should be done by ear, he said.

What an opportunity!

After all we know that if we add a little warmth with a subtle boost in the lower middle and balance this with an ever so gentle hump in the quack region (2-3kHz), we can make most programmes sound superficially more impressive. Come to that, why not change the 3180μS to 5000μS adding a little more 'heft' that most people will fall for. We could even make a special model for the boom and tizz brigade.

Been to any live concerts recently ?

For further details on the full range of QUAD products write to:
The Acoustical Manufacturing Co. Ltd.,
Huntingdon, Cambs. PE18 7DB
Telephone: (0480) 52561

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for the closest approach to the original sound

QUAD is a Registered Trade Mark


Haltron

SME SERIES III

The best pick-up arm in the world

Write to Dept 0649A · SME Limited · Steyning · Sussex · BN4 3GY

'This new pick-up arm is the result of in-depth study of disc reproduction requirements and reflects the audio perfectionist's attitude to design which we have come to associate with SME.

What really matters is that the manufacturer has anticipated cartridge developments and this alone puts the component well ahead of most others.'

What Hi-Fi?

'. . . judging by the results obtained from the moving-coils I would say that with damping, this arm is very good and gives a high performance. Certainly it is well in advance of the S2 and now, in the eyes of the establishment will presumably become the best pick-up arm in the world.'

Hi-Fi Answers

'There is no doubt that this is an exciting arm well in the avant garde of today's audio electronics. It will certainly have an irresistible attraction for the enthusiast: its precision engineering and its conspicuous aid to music listening will extend this appeal to music lovers.'

Financial Review (Australia)

'The law of diminishing returns says the Series II Improved is a better buy: the law of perfection says that the Series III is a better engineered and more universal arm. For many people that will settle the argument.'

Electronics Today, International (Australia)

'. . . the SME Series III must surely rank with the top few arms, having as an overwhelming benefit tremendous flexibility of use.'

Hi-Fi Review (Australia)

'For our examples we chose the new SME Series III arm. It could hardly be more appropriate, for SME – a British firm with an enviable reputation for getting things right – are noted for attention to the finer points which we advocate to hi-fi buyers.'

Popular Hi-Fi

'Starting from scratch, or if you are obsessed with perfection, the SME Series III meticulously set up must have the edge, probably not only over their earlier design but also over that of any other.'

The Gramophone

'. . . the new SME arm fulfils a lot more of the criteria mentioned than most arms, it was gratifying to hear the results achieved with Pioneer's PLC 590 and the Ortofon SL 20E. The best way of quickly describing the improvement is to say that all the strengths of a moving-coil cartridge were further emphasised, or in other words bass out-put became even more solid and realistic than ever, that incredible open clarity of a good moving-coil design was heightened and importantly, treble quality gained both better definition and sweetness.'

Practical Hi-Fi & Audio

'Standards of engineering in the execution of an SME arm reflects the sort of clear-sighted production competence which caused the British Empire to survive for so long and which continues to earn respect for British high technology overseas. While it takes a true enthusiast to appreciate the finer design points, an SME Series III arm is not only a technological feat it is also a function of a craftsman's love and a work of art. To someone interested more in music than machines and whose aims are high, it should suffice to say that an SME Series III arm is all you could possibly need. It's as simple as that.'

Men Only

'. . . the new Shure V-15 IV associates for the best with this exceptional arm. In this particular case, this new listening is at the same time more accurate and more human. . . . from the cartridges tested the most surprising differences come from Technics and from Ortofon MC20 and it is probable that you will have other surprises of the same kind with other cartridges. The arm adapts to every case, but for all the models it brings an improvement of quality, which may vary in proportion, but which always exists.'

Son Hi-Fi Magazine (France)

WW — 014 FOR FURTHER DETAILS

LOW COST · MULTI-CHANNEL · HIGHLY VERSATILE

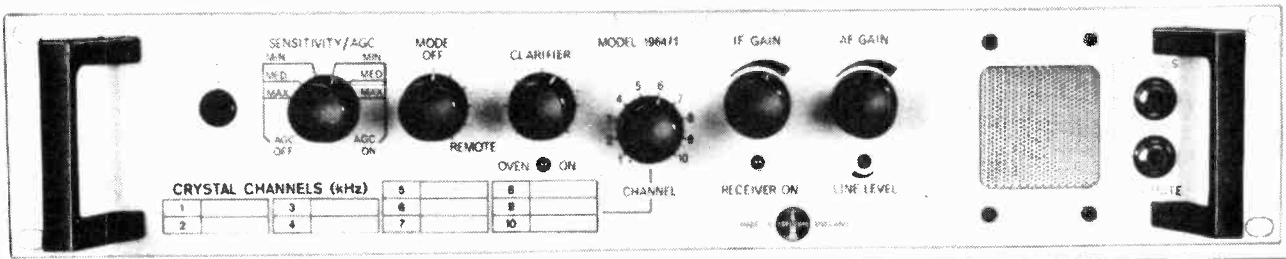
NEW Model 1964 from Eddystone

Eddystone's Model 964 is already in worldwide use for high-performance single channel working. The new multi-channel Model 1964 fulfils a whole new range of communication requirements.

- Pre-determined fixed frequencies
- Standard range 1.6MHz – 27.5MHz
- Versions available 100kHz – 50MHz
- Broadband or tuned RF amplifiers
- Dual diversity operation
- Remotable
- USB: LSB: DSB: F1 telegraphy

Please ask for illustrated brochures giving details of complete range.

483mm panel to suit standard racking



Eddystone Radio Limited

Member of Marconi Communication Systems Limited

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Eddystone

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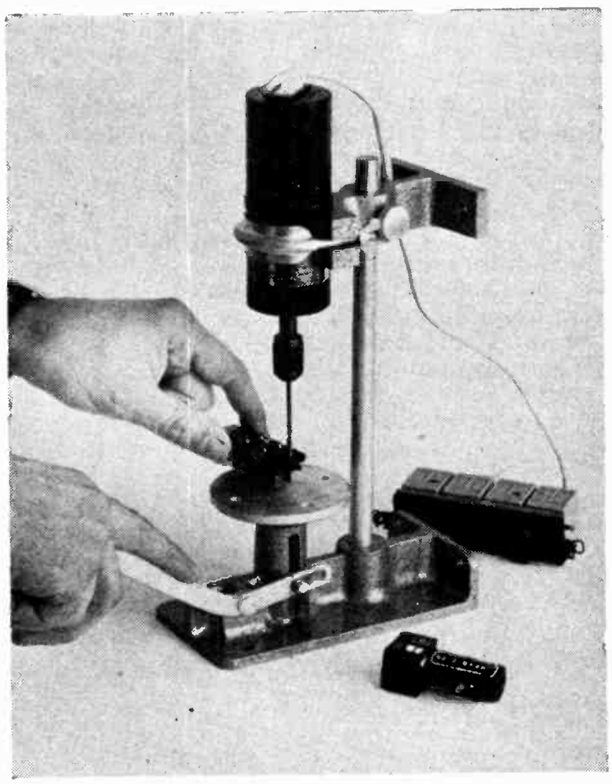
A. D. BAYLISS & SON LTD.

Behind this name there's a lot of real POWER!



Illustrated right is a **TITAN DRILL**

Mounted in a multi-purpose stand. This drill is a powerful tool running on 12v DC at approx 9000 rpm with a torque of 350 grm. cm. Chuck capacity 3.00 m/m.
The multi-purpose stand is robustly constructed of steel and aluminium. The base and bracket are finished in hammer blue.
Also available for use in the stand is the RELIANT DRILL which is a smaller version of the Titan. Approx. speed 9000 rpm, 12v DC, torque 35 grm. cm. Capacity 2.4 m/m.

TITAN DRILL & STAND — **£21.45**
+ 8% VAT = £23.17 + £1 P&P

TITAN DRILL ONLY — **£9.79** + 8% VAT = £10.57 + 35p P&P

RELIANT DRILL & STAND — **£18.44**
+ 8% VAT = £19.92 + £1 P&P

RELIANT DRILL ONLY — **£6.34** + 8% VAT = £6.85 + 35p P&P

TITAN MINI DRILL KIT — **£16.25**
Drill Plus 20 Tools
+ 8% VAT = £17.55 + 50p P&P

RELIANT MINI DRILL KIT — **£13.20**
Drill Plus 20 Tools
+ 8% VAT = £14.26 + 50p P&P

TRANSFORMER UNIT — **£9.40**
+ 8% VAT = £10.15 + 75p P&P

These are examples of the extensive range of power tools designed to meet the needs of development engineers, laboratory workers, model makers and others requiring small precision production aids.
To back up the power tools, Expo offer a comprehensive selection of Drills, Grinding Points and other tools.
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Stockists Richards Electric, Gloucester; Hoopers of Ledbury; Hobbs of Ledbury; D&D Models, Hereford; Bertella, Gloucester; J. Power Services & Co. Ltd., Worcester

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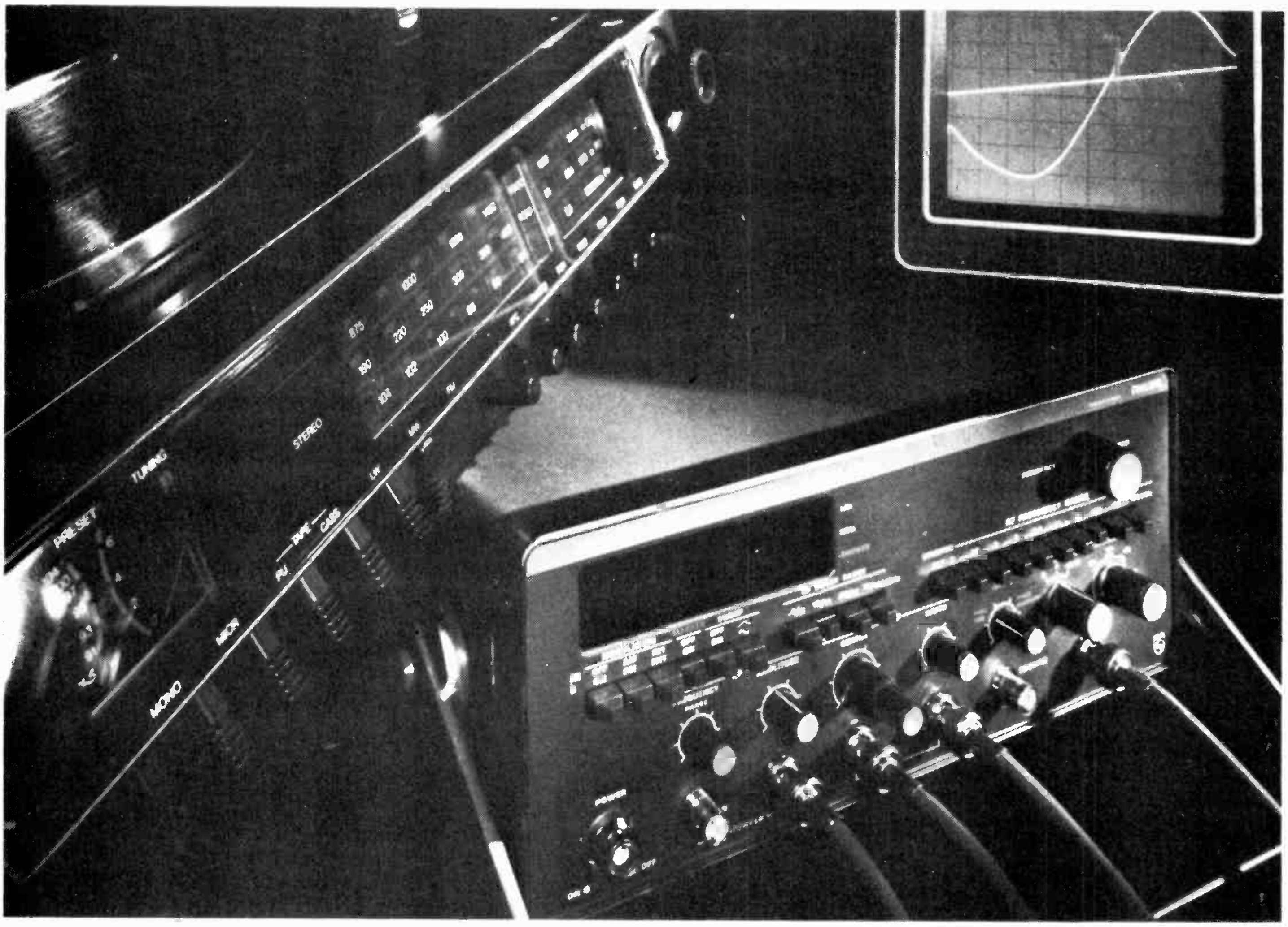

All round performance you can trust

This is the R.F. generator for you

It really is a pleasure to use our R.F. generator PM 5326. Frequency setting must be the easiest yet, press the range button and tune-in over 0.1-125 MHz to one part in 10.000 with the 5-digit LED display. You have to see this to realise how it beats all those dials and multipliers that have been around for some time. Output level is stabilized over all ranges at 50 mV into 75Ω and can be attenuated right down to more than 100 dB!

That means output levels of 0.5 µV are easily available and then only via the RF OUT connector.
A "double-box" construction keeps RF radiation very low, enabling you to make accurate sensitivity measurements with full confidence. To these fundamental qualities of precise and stable frequency setting, wide range attenuation and excellent RFI, this generator also has:

- **Frequency range 0.1 to 125 MHz**
- **Internal and external AM/FM modulation facilities**
- **Four RF sweep ranges for AM/FM IF's, Band II and Video IF's**
- **Variable and fixed markers**
- **COUNTER IN connector for checking external oscillators**

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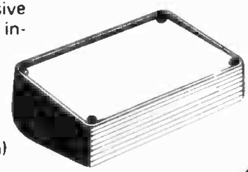
BIMCONSOLES
BIMBOXES
BIMBOARDS
BIMDRILLS
BIMDICATORS

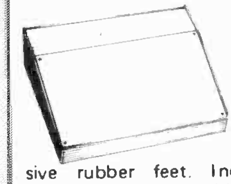
MINI DESK BIMCONSOLES

Moulded in Orange, Blue, Black or Grey ABS and incorporating guides on all sides for holding 1.5mm thick pcb's. 1mm Grey Aluminium panel sits recessed into front of console and held by screws running into integral brass bushes. Stand-off bosses in base for supporting small sub-assemblies etc. 4 self adhesive rubber feet also included.

BIM1005 (161x96x58mm) £2.12*
BIM1006 (215x130x75mm) £2.94*



LOW PROFILE BIMCONSOLES

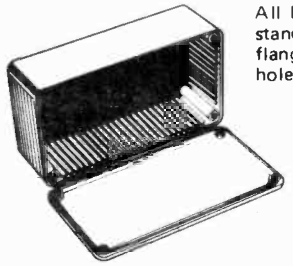


1mm Grey Aluminium panel sits recessed into front of console base, which is moulded in Orange, Blue, Black or Grey ABS and sits on 4 self adhesive rubber feet. Incorporating guides for holding 1.5mm thick pcb, the base also has stand-off bosses for supporting small sub-assemblies etc. and ventilation slots. Front panel is held by 4 screws which run into integral brass bushes.

BIM6005 (143x105x55.5[31.5] mm) £2.32*
BIM6006 (143x170x55.5[31.5] mm) £3.08*
BIM6007 (214x170x82[31.5] mm) £4.12*

ABS & DIECAST BIMBOXES

5 sizes, in either ABS or Diecast Aluminium
ABS moulded in Orange, Blue, Grey or Black
Diecast Aluminium available in Grey Hammertone or Natural



All boxes incorporate guides on all sides for holding 1.5mm thick pcb's and stand-off bosses in base for supporting small sub-assemblies etc. Close fitting flanged lids held by screws running into integral brass bushes (ABS) or tapped holes (Diecast).

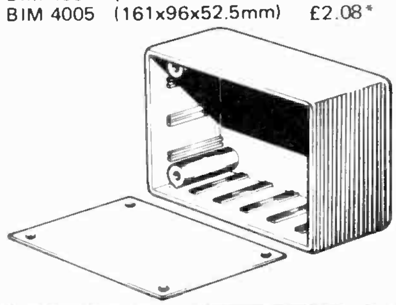
	ABS		Diecast	Hammertone	Natural
(100x50x25mm)	BIM2002/12	£0.95*	BIM5002/12	£1.20*	£0.97*
(112x62x31mm)	BIM2003/13	£1.05*	BIM5003/13	£1.50*	£1.20*
(120x65x40mm)	BIM2004/14	£1.15*	BIM5004/14	£1.86*	£1.49*
(150x80x50mm)	BIM2005/15	£1.30*	BIM5005/15	£2.38*	£1.91*
(190x110x60mm)	BIM2006/16	£2.04*	BIM5006/16	£3.41*	£2.85*

Also available in Grey Polystyrene (112x61x31mm) with no slots and self tapping screws BIM2007/17 £0.88*

MULTI-PURPOSE BIMBOXES

Moulded in Orange, Blue, Black or Grey ABS with 1mm thick Grey aluminium recessed front cover which is retained by 4 screws running into integral brass bushes. 1.5mm pcb guides are incorporated on all sides and as with all ABS boxes they are 85°C rated. 4 self adhesive rubber feet also included.

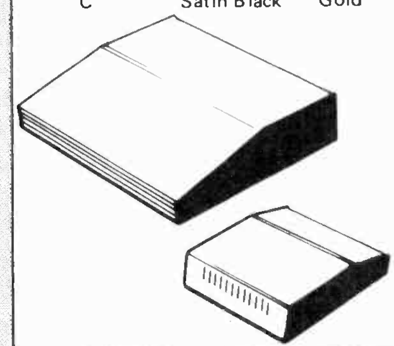
BIM 4003	(85x56x28.5mm)	£1.24*
BIM 4004	(111x71x41.5mm)	£1.56*
BIM 4005	(161x96x52.5mm)	£2.08*



ALL METAL BIMCONSOLES

All aluminium, 2 piece desk consoles with either 15° or 30° sloping fronts, sit on 4 self-adhesive non slip rubber feet. Ventilation slots in base and rear panels permit efficient cooling.

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



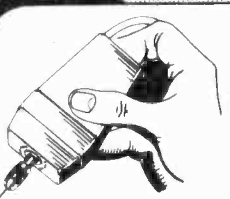
15° Sloping Panel

BIM7151	(102x140x51[28] mm)	£ 9.43*
BIM7152	(165x140x51[28] mm)	£10.43*
BIM7153	(165x216x51[28] mm)	£11.42*
BIM7154	(165x211x76[33] mm)	£12.39*
BIM7155	(254x211x76[33] mm)	£13.66*
BIM7156	(254x287x76[33] mm)	£14.65*
BIM7157	(356x211x76[33] mm)	£15.80*
BIM7158	(356x287x76[33] mm)	£16.78*

30° Sloping Panel

BIM7301	(102x140x76[28] mm)	£ 9.43*
BIM7302	(165x140x76[28] mm)	£10.43*
BIM7303	(165x183x102[28] mm)	£11.42*
BIM7304	(254x140x76[28] mm)	£12.39*
BIM7305	(254x183x102[28] mm)	£13.66*
BIM7306	(254x259x102[28] mm)	£14.65*
BIM7307	(356x183x102[28] mm)	£15.80*
BIM7308	(356x259x102[28] mm)	£16.78*

MAINS BIMDRILL

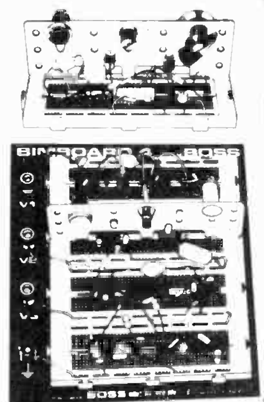


Operates directly from 220-240Vac and supplied with 2 metres long cable fitted with 2 pin DIN plug. Will drill brass, steel and aluminium as well as pcb's etc. Has integral biased-off switch and accepts tools with 1,2 and 3.2mm dia shanks £9.72*
Accessory Kit including 1mm, 2mm, .125" twist drills, 5 burrs and 2.4mm collet £2.20*

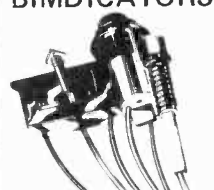
DIL COMPATIBLE BIMBOARDS

Bimboards accept all sizes of DIL packages as well as resistors, diodes, capacitors and LED's etc. They have integral Bus Strips running up each side for carrying Vcc and ground as well as Component Support Brackets for holding lamps, fuses and switches etc. Available as either single or multiple units, the latter mounted on 1.5mm thick, matt black aluminium back plates which stand on non slip rubber feet and have 4 screw terminals for incoming power.
Bimboard 1 contains 500 individual sockets whereas the multiple units containing 2, 3 or 4 Bimboards incorporate 1,100, 1,650 or 2,200 individual sockets, all arranged on a 2.5mm(0.1") matrix.

Bimboard 1 £ 9.72* Bimboard 2 £22.68*
Bimboard 3 £32.40* Bimboard 4 £42.12*



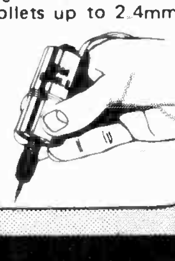
BIMDICATORS



Remember we are also one of Europe's largest manufacturers of Filament, Neon and LED indicators. Send for our BIMDICATOR DATA

12 VOLT BIMDRILLS

2 small but powerful 12V dc drills, easily held in hand or used with lathe/stand adaptor. Both drills have integral on/off switches and 1 metre long cable.
Mini Bimdrill with 2 collets up to 2.4mm capacity £7.56*
Major Bimdrill with 3 collets up to 3mm capacity £12.96*
Mains to 12 Volts adaptor, lathe, stand and accessory kits also available, details on request.



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THE BENEFITS OF A TEST SET

– for the price of a signal generator!

If you're servicing or manufacturing mobile communications receivers then look closely at Farnell's new synthesized 10 to 520MHz signal generator, the SSG520. It outperforms other units in many respects, and, with its remarkable ease of setting, repeatability and SINAD facility gives you most of the advantages of a receiver test set costing much more.

Typical tests the SSG520 does with speed and simplicity are:—
checking and aligning channel frequency and bandwidth
i.f. and filter alignment
sensitivity tests (so easy with SINAD)
mute/squelch performance
adjacent channel rejection (using two units) and
signal to noise and a.f. distortion tests are made easier using the SSG520.

R.F. leakage is remarkably low, permittting totally unambiguous sensitivity measurements down to 0.2μV (0.05μV if you like,using a 20dB pad). There's no leakage from counter display holes—there isn't one; you don't need a counter with our thumbwheel setting/readout. The SSG520 can be tuned in 100Hz steps under locked conditions with maximum stability over the entire frequency range.

Contrast this with competitive instruments which have either a mere 2% tuning range before re-lock or will only fast synthesize in 100kHz steps! Stability and accuracy are excellent and an optional ovened crystal version is available. Sideband phase noise is better than −100dB/Hz and harmonics better than −25dB. Any combination of a.m. and f.m. modulation, internal or external is possible. Output is calibrated and automatically levelled over the whole frequency range and the attenuator is set by adjacent 10 and 1dB click stop controls giving direct reading of dBm and volts—quicker to operate and enabling accurate mute/squelch settings.

Farnell

So if you want to improve service or production throughput of mobile radio telephones, fixed receivers, handportables, public correspondence radiophone and paging systems without spending as much as you would have thought, use this magazine's reply system now to obtain full details and price.

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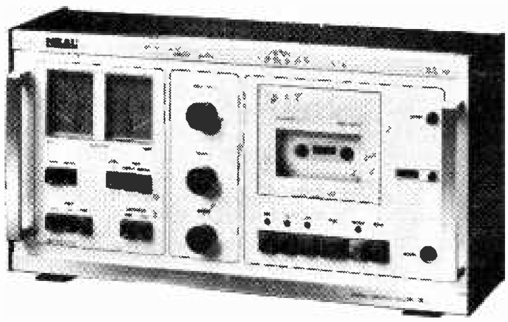
You always perform better with the right equipment

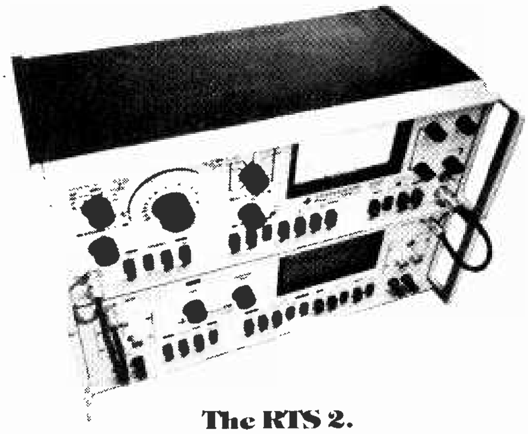
With Neal Ferrograph you get the right equipment for the job, and the best in its class. A good formula for success, of which you can be assured every time you choose from the fully - integrated range of specialist recording and ancillary equipment in the NEAL FERROGRAPH range.



The NEAL 302.
Incorporating a 3-motor mechanism, controlled by a full solid state logic system actuated by ultra light touch buttons, this is the machine used by top recording studios and broadcasting stations, for quality cassette copies and for in - cassette duplication masters.

The Ferrograph Logic 7.
A transportable tape recorder of unrivalled facilities; taking all spool sizes up to 27 cm, and providing three speeds, plus positive action push buttons in association with logic circuits . . . for fast, safe tape handling under all conditions.

Studio 8
A professional studio tape recorder logic controlled for superb tape handling characteristics, offering a choice of stereo, twin track and full or half track mono heads, PPM or VU meters, IEC (CCIR) or NAB equalisation, console or transportable models.



The RTS 2.
Combines in one easy to use compact instrument the measurement of gain, noise, frequency response, input sensitivity, output power, distortion and the parameters relating to recording equipment, such as wow and flutter, crosstalk, drift and erasure. Its range of application can be extended even further by the addition of the Auxiliary Test Unit **ATU 1.**

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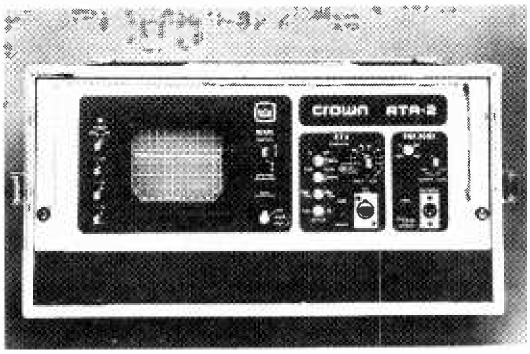
New from AMCRON

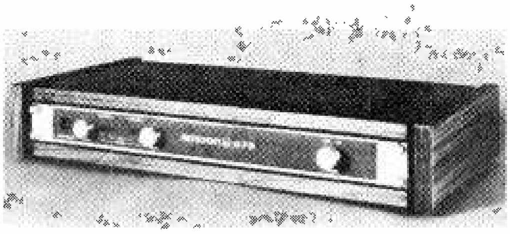
Real Time Analyser RTA2



The Amcron RTA2 Real Time Analyser is designed as much for use as a production tool as it is for on-site audio analysis of theatres, and recording studios. A flight case is available.

- ★ 5" CRT Display
- ★ Internal Pink Noise Source
- ★ ⅓ or 1 octave Display
- ★ Frequency range 20 - 20kHz
- ★ Outputs for X-Y Recorders
- ★ Compatible with any microphone
- ★ Price £1,960 ex. VAT

POWER AMPLIFIER D75



The AMCRON D75 power amplifier replaces the previous model D60. Employing completely new type circuitry it offers also many new features but without any increase in the price.

- ★ New Amcron IOC comparator.
- ★ Balanced XLR input connectors.
- ★ Signal Presence indicators.
- ★ Separate Signal/chassis earth.
- ★ 45 watts into 8 ohms per channel.
- ★ Price £230 ex. VAT.

Other AMCRON products include:

DC300A amplifier 500 watts/chan.	£550
D150A amplifier 200 watts/chan.	£350
VFX2A Electronic Variable Filter	£270
EQ2 Equaliser	£599
IC150A Pre-amplifier	£260
IMA Intermodulation Distortion Analyser unit	£610

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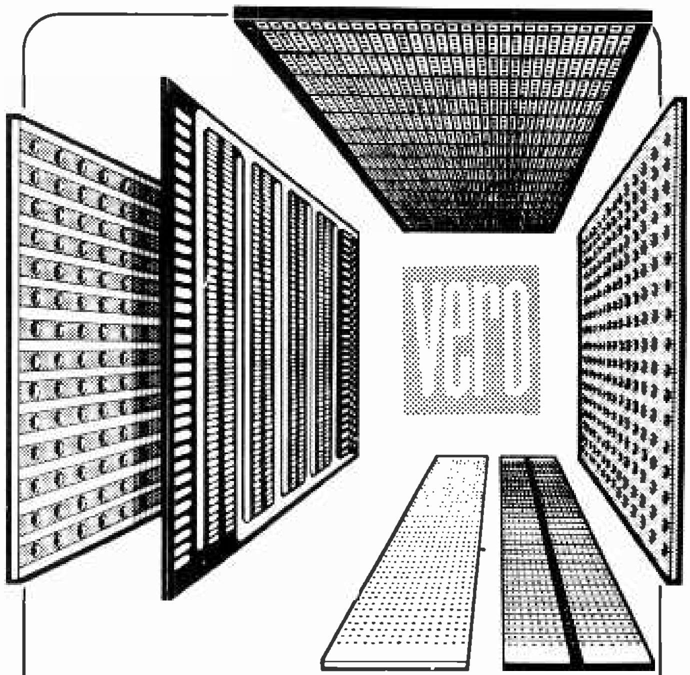

Our new 1978 catalogue lists circuit boards for all your projects, from good old Veroboard through to specialised boards for ICs. And we've got accessories, module systems, cases and boxes — everything you need to give your equipment the quality you demand. Send 25p to cover post and packing, and the catalogue's yours.

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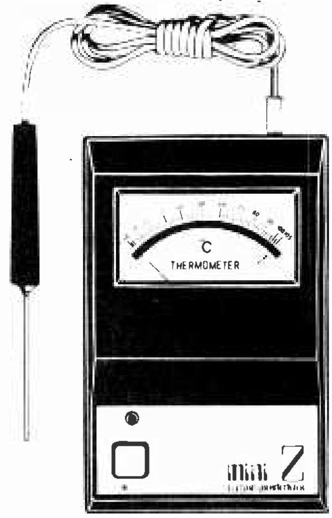
ELECTRONIC INDUSTRIAL THERMOMETER



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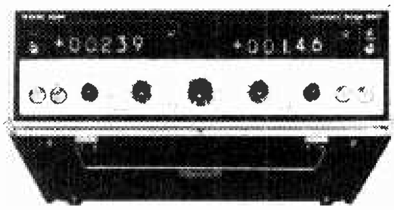

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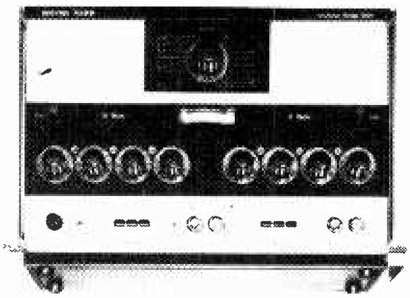

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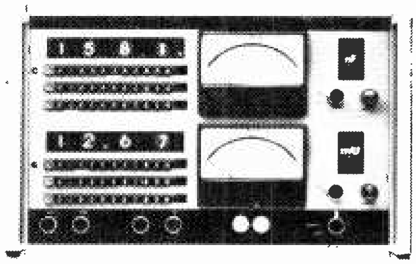

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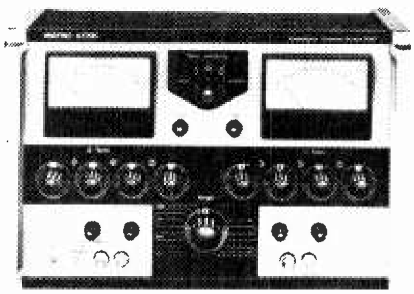

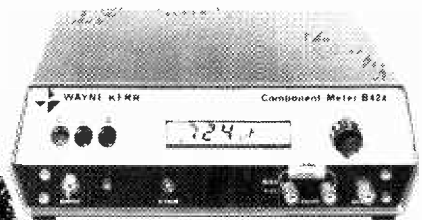

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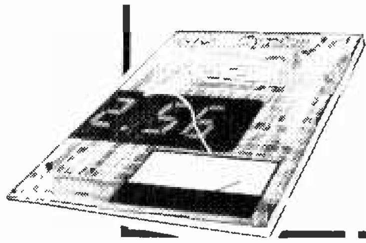

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IT IS UNLIKELY that many engineers have hitherto seen themselves as technological Renoirs or Gainsboroughs, or even prophets. But painters and practitioners in engineering suffer from the same barriers to full expression — they are often dependent on patronage and, in common with prophets, though most of them are not without honour, it is often not recognized in their own country.

We have recently seen examples of engineers who have originated quite remarkable inventions, but who, not having enough capital to put their ideas into practice, have hawked their wares round all the more obvious sources of finance — government establishments, manufacturers, financiers — with no success at all. No one, it appears, is in the risk business — at least, in the UK. As a result of this frustration, people are beginning to look overseas for their backing, which is fine for the inventor and his backer — not so good for this country.

Several British organizations exist for this very purpose, although if our correspondence pages are anything to go by, many bright ideas go unrecognized. A common complaint among engineers who do manage to sell their ideas and are assisted by, for example, the NRDC, is that the amount of money advanced is insufficient for an efficient operation. It may be said that half the amount needed is better than nothing, but if a cramped financial position leads to excessive caution and inhibits the broad view, it could well be worse than nothing.

Reasons for the directors of companies not wishing to risk venture capital on inventions with which they are unfamiliar hinge to a large extent on the very fact of their unfamiliarity. Company directors, as a class, are not noted for their engineering knowledge, being recruited in the main from accountants, economists and arts graduates. Their field of interest is in marketing, finance and sales; the products of the companies over which they preside need not have much influence on their work at all, except insofar as they determine the people they rub shoulders with in business.

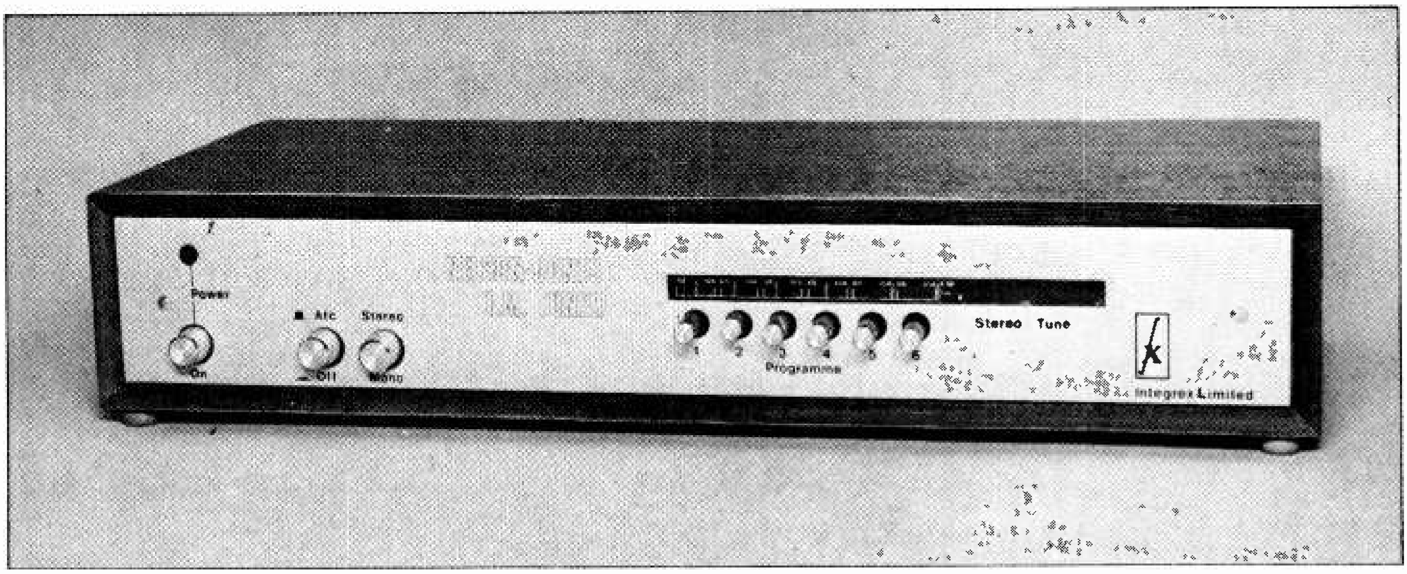
While they are reasonably adept in their own sphere of activity it seems unlikely that a financier is best able to judge the worth of even a simple piece of engineering, and if the project put forward for evaluation is even 'moderately recondite,' then a degree of relevant knowledge is essential. And yet only around 30% of UK directors have any such knowledge. In contrast with this, Germany has about 70% of knowledgeable directors and the US 85%. Taken in conjunction with our fairly dismal performance in recent years, these figures are significant, although it is impossible to say that this is the real reason.

It does appear, though, that there is a need for more university and college students to be given a chance to read their chosen engineering subjects, with a background support of 'business' training. Admittedly, this does fly directly in the face of the university tradition which insists that universities are not there to train people, but to educate them. Times are hard, however, and it should be recognized that some students, at least, are going to have to soil their hands and engage in vulgar commerce.

Stereo f.m. tuner — Mk II

Improved design uses new i.cs — 1

by **L. Nelson-Jones,** F.I.E.R.E.



This tuner is based on the author's highly successful design first published in the April, 1971 issue. The circuit has been modified to use two recently introduced and improved i.cs, together with a pre-aligned f.e.t. front-end module designed by the author. The circuit features an improved a.f.c. system which operates directly on the varicap tuning and allows simultaneous tuning of all the r.f. stages. Circuit options include the use of either a six-pole LC filter or ceramic resonator i.f. units.

WITH THE LARGE SIGNAL LEVELS that can occur from high-gain aerial arrays it is possible for an f.e.t. front-end to malfunction. This is due to oscillator-pulling by the signal at g_1 of the mixer which has capacitive coupling to g_2 and therefore the oscillator. In extreme cases the oscillator may be pulled completely into lock with the signal, which results in a zero-frequency i.f. To overcome this a diode limiter has been used to damp the second tuned circuit so that the oscillator cannot be pulled-in. The diode limiter does, however, lower the image-frequency rejection performance but this only occurs at very high signal levels. With this modification, and by applying around 20dB of a.g.c. to the r.f. stage at high signal levels, the front end can handle signals of around 600mV.

This front-end circuit, shown in Fig. 1, also differs from the Mk I design because it does not have a separate a.f.c. system. The tuning supply voltage is now modulated by the a.f.c. voltage, and controls all three tuned circuits together. Even with a high level of a.f.c., there will be no loss or gain within the holding range.

Choke coupling is used in the r.f. stage so that all tuned circuits are at d.c. ground potential. Because Mk II design is for varicap tuning only, a more compact layout has been possible. Decoupling has been improved by shorter lead lengths and a reduction in value of the decoupling capacitors to 470pF. This ensures that the capacitors do not come near to resonance. The complete front-end is now housed in a screened case to reduce oscillator radiation and pick-up from sources such as the i.f. strip, stereo decoder, and the demodulator.

An isolated coupling loop on the oscillator coil is brought out via two terminals on the main i.f. board. The loop provides a level of around 50mV and is designed to feed a digital counter at 50Ω impedance. This level will not cause excessive oscillator radiation, and can be interfaced to a counter via a buffer stage. The second gate of the r.f. stage is brought out through a decoupling RC network for a.g.c. A suitable biasing network is provided if a.g.c. is not required (a.g.c. ref).

I.f. amplifier

The first i.f. amplifier stage is in the front-end already described, and provides a broadly tuned output at 330Ω impedance. Fig. 2 shows the main i.f. ciricuit. The block filter can be the Toko six-pole LC filter, as shown in Fig. 3(a). In this case the additional series resistor R_2 has to be used to raise the source impedance to 1kΩ, and C_2 is placed at the filter input to provide the design source capacitance. Correct loading is provided by the input biasing resistor R_8.

A second option, shown in Fig. 3(b), is to use a pair of Toko i.f. ceramic resonators, type CFSE-10.7, which have a design source impedance of 330Ω. In this case R_2 and C_2 are not needed. As there is no d.c. path through these filters, C_4 is also redundant and is replaced with a link. Because the gain with these resonators is too high, a 10dB attenuator is placed between the two filter sections (this does not impair the noise performance of the tuner).

A third choice is to use two Vernitron FM4 i.f. ceramic resonators as in the Mk I design. These filters cannot normally be directly cascaded, but the 10dB attenuator section between them provides a satisfactory performance. Whichever type of ceramic resonator is used, it is essential that both have the same colour coding.

The main i.f. gain is supplied by the multi-stage limiting amplifier contained within IC_1. The circuit has been designed around the recently introduced CA3189E, which is an improved and

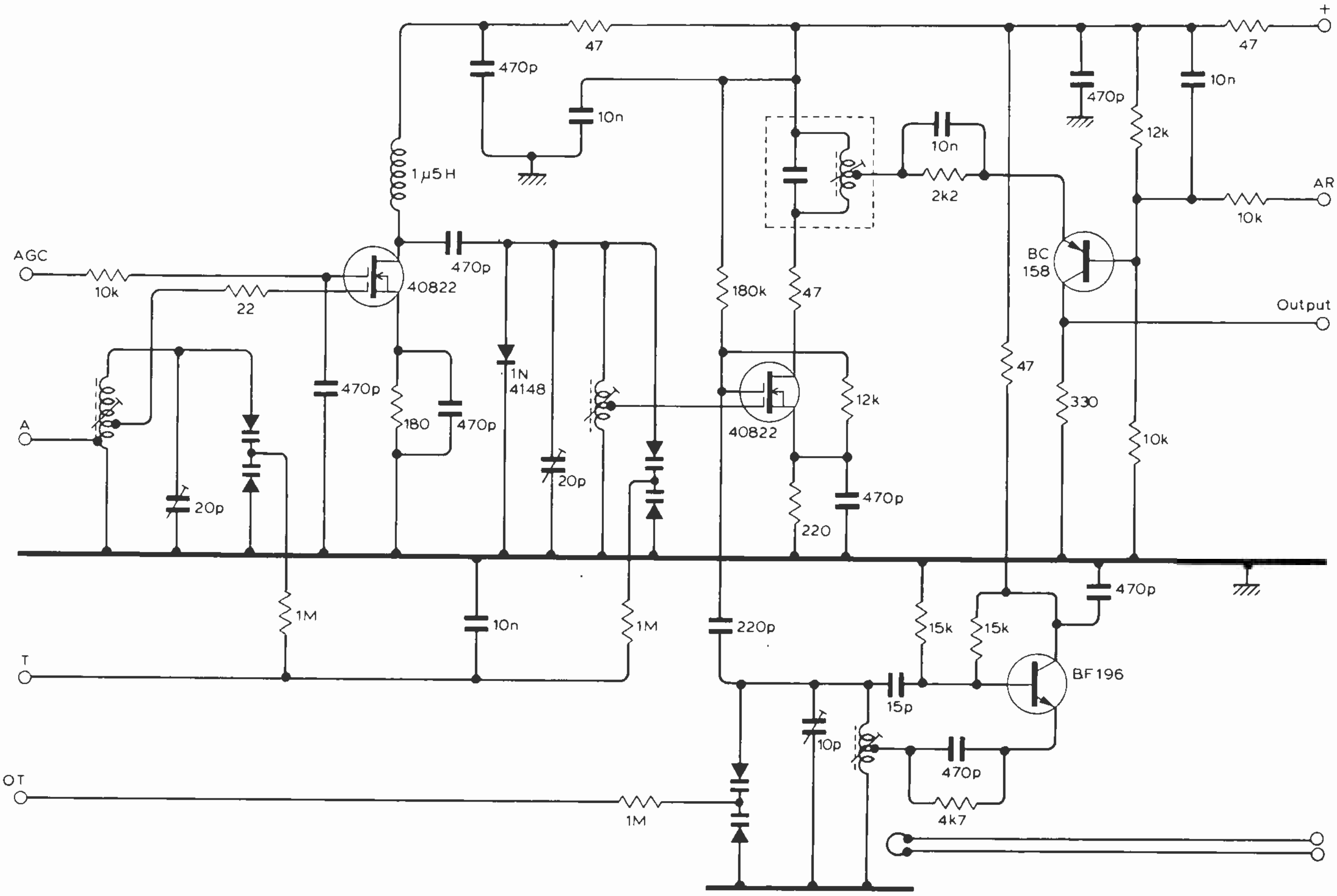


Fig.1. *Front-end module. Damping the second tuned circuit with a diode improves signal handling capacity.*

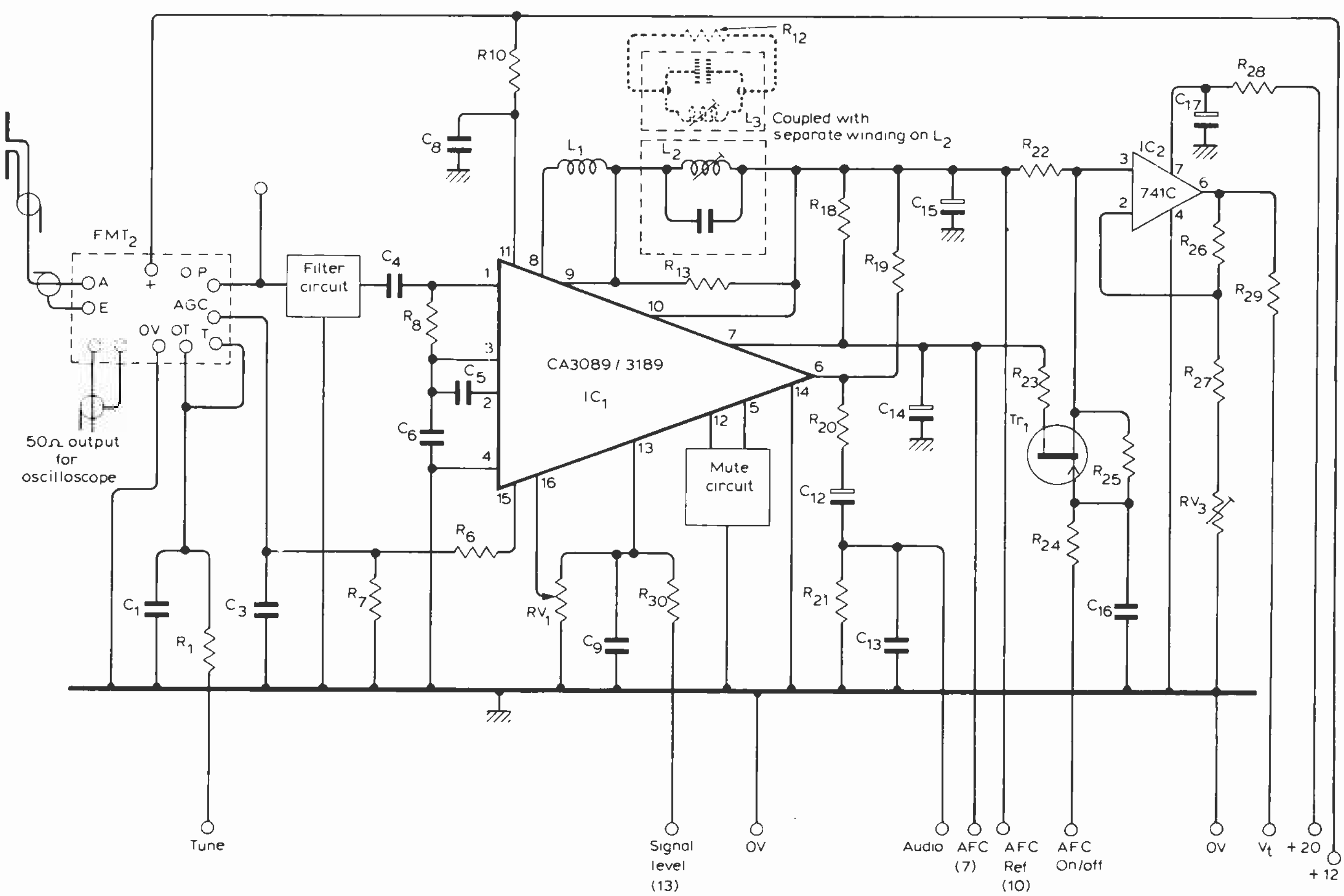


Fig.2. *Main i.f. circuit can use either the CA3089E or the newer CA3189E.*

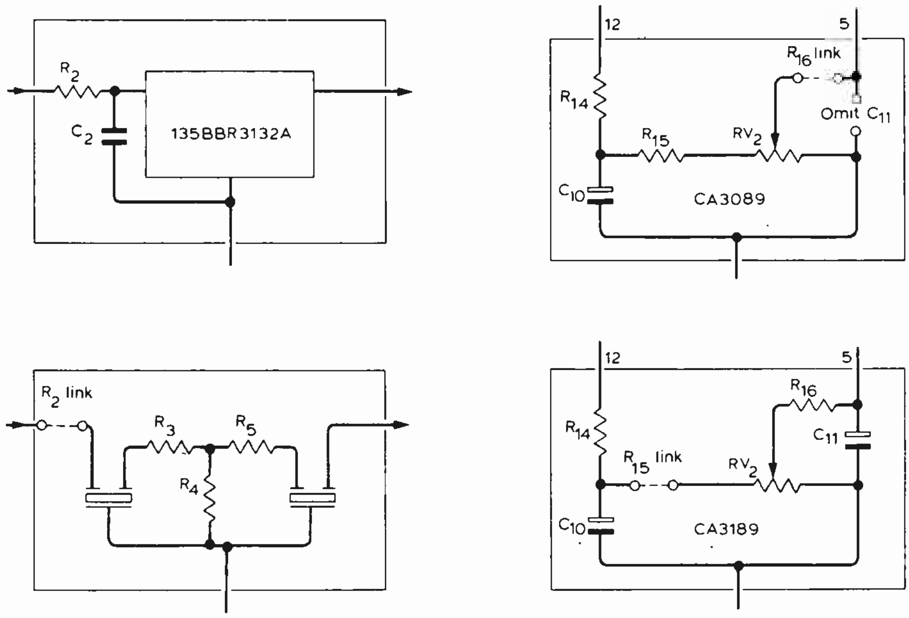


Fig.3. *(a) Six-pole LC filter. (b) Two ceramic resonators. (c) Muting circuit for CA3089 and (d) CA3189.*

somewhat altered version of the CA3089E. The printed circuit board can be used with either of these i.cs by making suitable component changes. However, in my experience the performance of the CA3089E is rather inferior to the CA3189E. The audio output of the CA3189E is adjustable and the values used give a level of 490mV for each of the options.

A further option is available for the CA3089E and CA3189E because both can be used with single or double-tuned quadrature coils, L_2 and L_3. The double-tuned arrangement can give very low demodulation distortion if correctly adjusted, but this requires a low distortion f.m. signal generator, and distortion measuring equipment. With a single-tuned circuit both i.cs will still give low distortion compared to earlier integrated circuits such as the TAA661B. Both devices provide an a.g.c. feed for the front-end module, but because the level is not the same for the two devices the a.g.c. voltage is fed through potentiometer R_6, R_7. The a.g.c. threshold is adjustable with the CA3189E. I have found this particularly useful in setting up the signal strength output, from pin 13 of IC_1, to give a steady and progressive increase of level with signal input voltage. The potentiometer concerned is usually set around midway.

The external muting circuit components for the two i.c.s differ and are shown in Fig. 3(c) and 3(d). The newer CA3189E operates on deviation as well as signal level, and the value of R_{18} sets the deviation at which muting begins. This may be varied if required from about 2.7kΩ for a large deviation before muting, to 22kΩ for a very small deviation before muting. In both circuits the setting of RV_2 determines the signal level at which muting takes place. With RV_2 set to 0V, the muting action is stopped.

Tuning voltage supply and a.f.c.

The a.f.c. output from IC_1 is not applied directly to the front-end, but is used together with the a.f.c. reference output from IC_1 to derive a 12V tuning supply which is modulated by the a.f.c. output

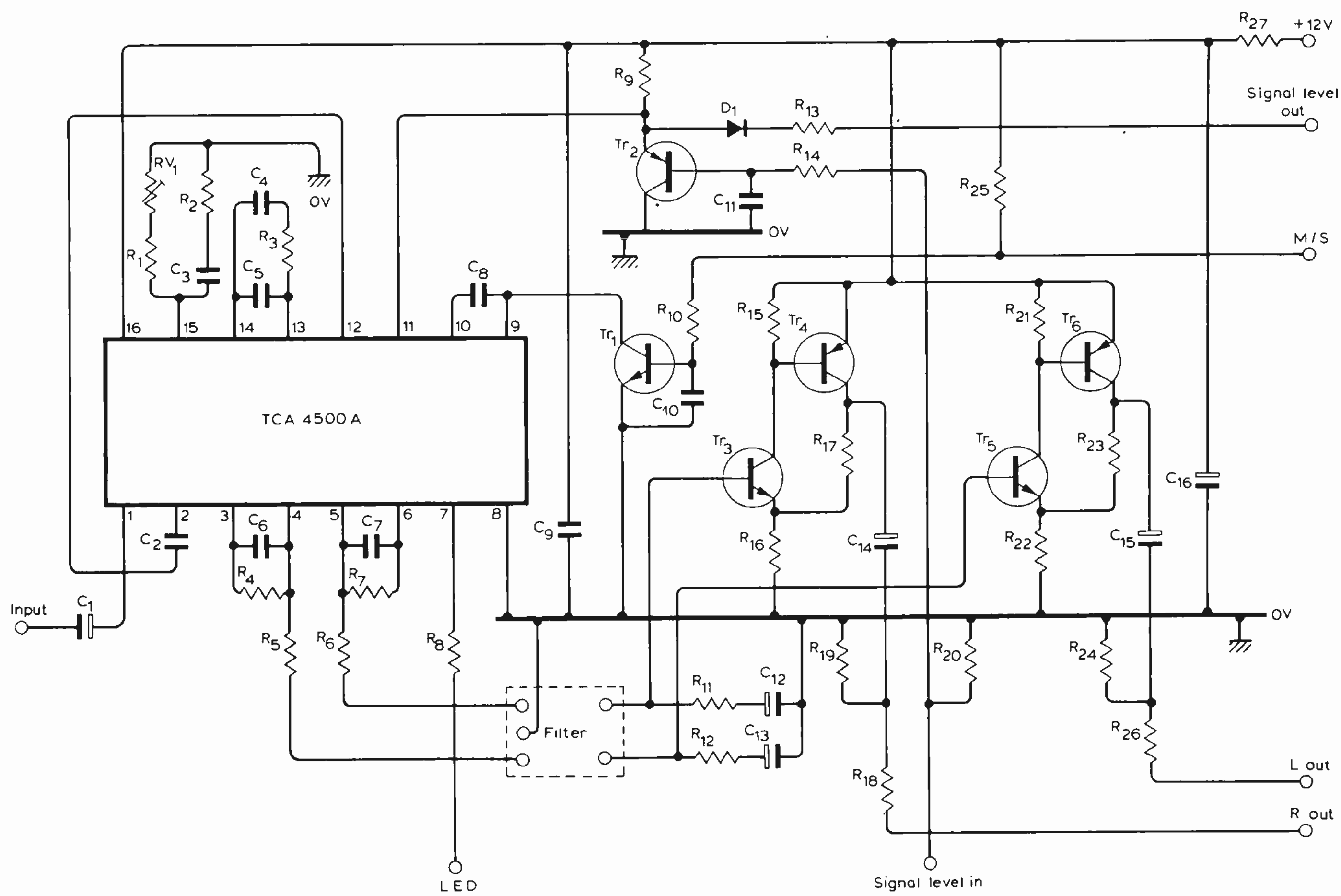


Fig.4. *Stereo decoder. Emitter follower on pin 11 of the i.c. improves the signal-to-noise ratio at low signal levels by reducing the separation.*

of IC_1. It should be noted that the tuning range of the new front-end is 1.5 to 11.5V for 87.5 to 108MHz. The a.f.c. reference of the CA3089E and CA3189E is a 5.6V zener-stabilized supply which can be used for the reference of a conventional stabilized supply. If a suitable amount of a.f.c. voltage from pin 7 of IC_1 is added to the reference supply, then the tuning voltage will change in a way that will correct the error which caused the a.f.c. output to differ from the a.f.c. reference voltage level.

The a.f.c. reference is permanently connected to the non-inverting input and the op-amp IC_2 via an f.e.t. so that it can be switched in and out. When the f.e.t. is switched on, R_{22} and R_{23} control the amount of a.f.c. voltage that is added to the reference level. The tuning voltage output is controlled by the feedback chain R_{26}, R_{27}, RV_3. The a.f.c. switch operates with the source and drain of the f.e.t. at the a.f.c. reference level. If the gate is connected to 0V the f.e.t. is biased off; if the gate is left free, R_{25} turns the f.e.t. on; an f.e.t. with a cut-off bias of less than −4V has been chosen to ensure clean switching. Values chosen for R_{24} and R_{25} allow the a.f.c. switch to be formed by a pair of touch-pad contacts between 0V and the a.f.c. on/off input. Capacitor C_{16} ensures that this input is not excessively sensitive to interference. If touch-pad operation is used it is essential that the chassis is correctly earthed and connected to the 0V line.

With this system an almost constant a.f.c. performance is achieved across the whole f.m. band because, as the tuning voltage is reduced, the amount of change due to any a.f.c. control is also reduced. The tuning characteristic of the front-end is almost perfectly logarithmic with tuning voltage. The tuning-voltage supply must be free of noise and hum to prevent spurious modulation of the oscillator frequency. This is achieved by the high common-mode supply rejection of IC_2, and by the filter R_{28}, C_{17} in the supply to IC_2.

Stereo decoder

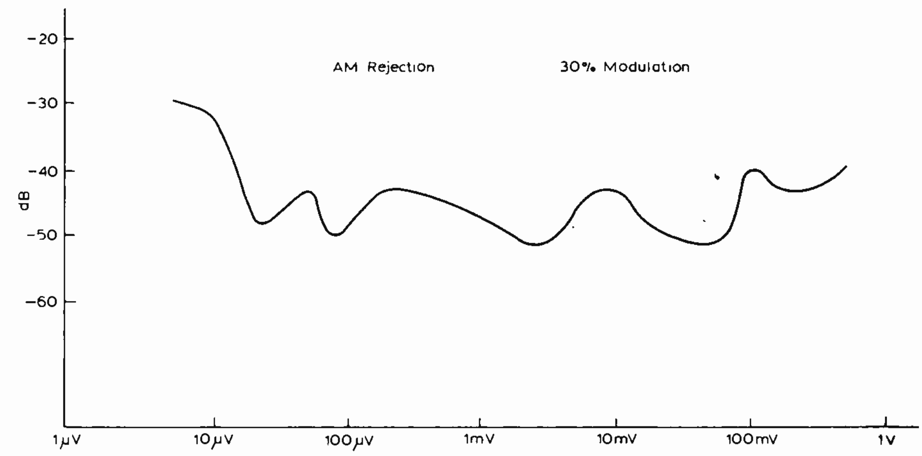
The decoder circuit in Fig. 4 is essentially the same as that published in the April 1978 edition by M. J. Gay. The capacitor between pins 2 and 12 has been made 10nF rather than 6.2nF quoted, and the input capacitor has been raised from 2µF to 4.7µF. These changes were made because my stock did not contain the original values, so they need not be implemented.

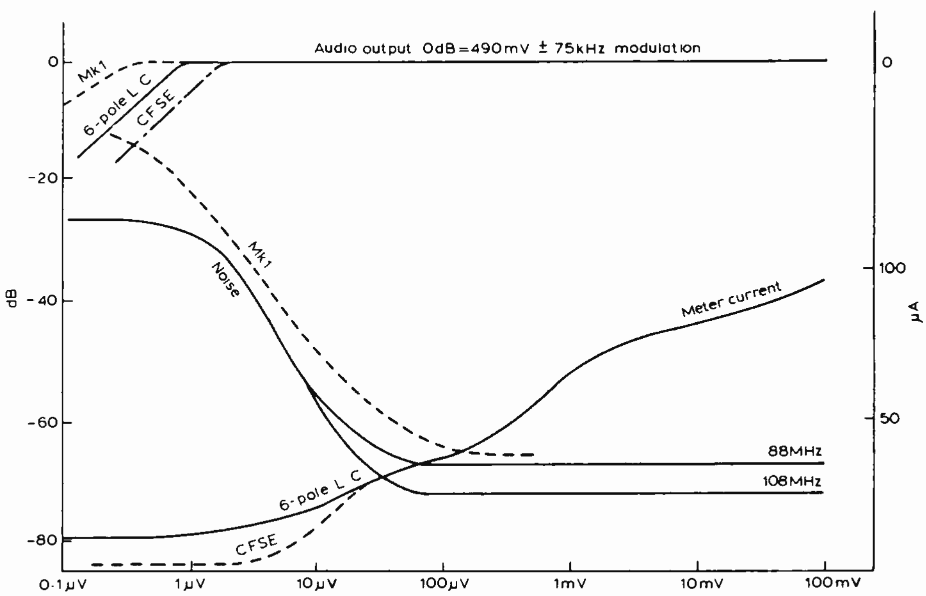
The TCA4500A has a low impedance output due to the feedback networks R_4, C_6 and R_7, C_7. It is therefore necessary to feed the multiplex filter through resistors which have a value equal to the design source impedance of 4.7kΩ for the filter. Because the design load impedance of this filter is also 4.7kΩ, there will be at least a 6dB loss. To restore the audio output level, and to isolate the filter from the load, an amplifier with a gain of two is connected to each of the stereo outputs. High negative feedback in each of these amplifiers makes the input impedance very high, so the matching network R_{11}, C_{12} and R_{12}, C_{13} is connected to ensure that the filter sees a resistive termination of 4.7kΩ. The bias for these two stages is derived from the d.c. output level of the i.c. at pins 4 and 5. The filter has a low d.c. resistance from input to output and the values of R_5 and R_6 are insufficient to cause any appreciable loss of voltage to the bases of Tr_3 and Tr_5.

Gain of the stages is defined by the equal values of load resistors R_{16}, R_{17} and R_{22}, R_{23} so only half of the output is

Receiver performance

Frequency range	87.5 to 108MHz (tuning voltage +1.5 to +11.5V)
I.f.	10.7MHz
I.f. bandwidth (−3dB)	220kHz (CFSE-10.7 filters-FM4)
	250kHz (6-pole LC filter Toko 135BBR3132A)
Input impedance	nominally 75 ohms unbalanced
Limiting input signal threshold	1µV typical
−30dB quieting level (mono)	1.5µV typical
Capture ratio	1dB
Image response	−48dB
I.f. response at input	about −100dB
Oscillator voltage at aerial input	less than 1mV
Oscillator output to counter	about 50mV into 50Ω
Muting threshold range	adjustable from 0 to about 8µV
Audio output level	490mV for ± 75kHz peak deviation
Spurious decoder outputs	better than −60dB at 19kHz and all harmonics
Audio frequency response	10Hz to 15kHz ± 1dB
De-emphasis time constant	50µs (75µs with capacitors raised by 50%)
A.f.c. pull-in range	± 500kHz (1mV input level)





Mark II tuner is better than the Mk I design on noise performance, especially at low signal levels, and this is very noticeable in listening tests. A.m. rejection of the new tuner is again better especially in listening tests.

fed back to the emitter of the input transistor. The output d.c. level is blocked by C_{14} and C_{15}, while R_{19} and R_{24} prevent clicks if the output is connected to an amplifier or switched after the receiver has been turned on. Resistors R_{18} and R_{26} in the output leads prevent oscillation in these two amplifier stages if very long and capacitive leads are used.

Stereo/mono switching is achieved by transistor Tr_1. This is normally biased on, and the decoder is in the mono state. If the m/s input is grounded, the biasing is removed and Tr_1 is turned off, which restores the decoder to stereo operation.

Capacitor C_{10}, together with the biasing resistor R_{10}, form a h.f. filter to prevent this input from causing interference. A switching transistor was used because the manufacturers' data specifies a maximum capacitance, from pin 9 to ground, of 100pF and I felt that this was too easily exceeded. Also, a long lead into the 228kHz oscillator circuit is undesirable.

The signal-level voltage from the CA3189 can be used, as detailed in the TCA4500A article, to reduce the separation at low signal levels and provide a better signal-to-noise ratio. This has been added to the decoder circuit by placing an emitter follower between the signal level input from the CA3189, and pin 11 of the TCA4500A. Use of a p-n-p emitter follower ensures that the current can be drawn out of pin 11, and also provides a low impedance drive for the signal strength meter. The recommended resistor value for R_{13} is 39kΩ, which gives close to 100μA for full signal strength. This resistor may be reduced in value for movements up to 1mA. Diode D_1 is included to remove the V_{be} of Tr_2 from the feed to the meter. Resistor R_{14} and capacitor C_{11} are included to prevent interference from passing through Tr_2. The supply to the decoder is filtered to prevent switching surges from reaching the rest of the tuner.

A stereo indication l.e.d. is driven from pin 7 through R_8 and a further 270Ω on the tuning indicator board. If this board is not used, and only the external l.e.d. to the +12V supply is required, then R_8 should be raised to 680Ω.

Tuning indicator

The circuit in Fig. 5 is exactly as used with the Mk I toner. It consists of a long-tailed pair feeding two l.e.d.s, whose brilliance will be equal for equal input voltage levels to the bases of the two transistors. A degree of degeneration is applied to lower the gain from the unbypassed resistors in the emitters. The output terminal is connected to the a.f.c. pin of the i.f. board. The stereo indicator l.e.d. in the original circuit had to be compatible with a filament lamp to match the Portus and Haywood decoder, but this requirement is not now

Parts List

Front end and i.f.

Resistors — 5% ¼E carbon film unless otherwise stated

R 1	100kΩ
6	1kΩ (3089) 39kΩ (3189)
7	omit (3089) 39kΩ (3189)
8	560Ω (6-pole) 330Ω (CFSE/FM4)
10	47Ω
12	2.7kΩ (double-tuned) omit (single-tuned)
13	18kΩ (double-tuned) 3.9kΩ (single-tuned)
18	4.7kΩ (3089) 8.2kΩ (3189)
19	omit (3089) 4.7kΩ (3189 double-tuned) 6.8kΩ (3189 single-tuned)
20	link (stereo) 4.7kΩ (mono)
21	100kΩ
22	5.6kΩ
23	33kΩ
24	2.2MΩ 10%
25	10MΩ 10%
26	10kΩ 2%
27	6.2kΩ 2%
28	680Ω
29	47Ω
30	1kΩ (stereo, or to suit meter on mono)

Capacitors — 20% tolerance unless otherwise stated

C 1	0.1μF	250V	polyester
3	10nF	100V	min. ceramic
4	10nF link	100V (6-pole) (CSFE or FM4)	min. ceramic
5,6	10nF	100V	min. ceramic
8	47nF	250V	polyester
9	10nF	100V	min. ceramic
12	10μF	25V	tantalum bead
13	33pF 4.7n	100V (stereo) 100V (mono)	min. ceramic 10% ceramic
14,15	10μF	25V	tantalum bead
16	10nF	100V	min. ceramic
17	100μF	16V	min. vertical electrolytic

Other components

Tr_1	Siliconix 2N4339 metal can n-channel f.e.t. or E113 plastic n-channel f.e.t.
RV_1	47kΩ min. horizontal skeleton potentionmeter (3189 only)
RV_3	4.7kΩ min. cermet horizontal potentiometer
L_1	22μH min. choke Sigma Products type SC10-22μH
L_2	TKACS 34342BM } (double tuned for 3089 or 3189) Toko UK Ltd
L_3	TKACS 34343AUO }
L_2	KACSK586HM (single tuned for 3089 or 3189) — Toko UK Ltd

Front-end module Key Electronics FMT2-0 — Integrex Ltd

I.f. filters

Fig.3(a)

R_2	680Ω
C_2	10pF 100V min. ceramic
Filter	Toko 135BBR3132A

Fig. 3(b)

R_2	Link
C_2	omit
R_3	220Ω
R_4	150Ω
R_5	220Ω
Filters	Toko CFSE or Vernitron FM4 (identical colour coding)

Muting circuits

3089 Fig. 3(c)

R_{14}	470Ω
R_{15}	120kΩ
R_{16}	link
RV_2	470kΩ min. horizontal skeleton
C_{10}	0.47μF 35V tantalum bead
C_{11}	omit

3189 Fig 3 (d)

R_{14}	470Ω
R_{15}	link
R_{16}	47kΩ
RV_2	10k min. horizontal skeleton
C_{10}	47μF 6.3V tantalum bead
C_{11}	2.2μF 35V tantalum bead

Stereo decoder

Resistors — 5% ¼W carbon film unless otherwise stated.

R 1	10kΩ	2%	½W metal oxide
2	100Ω		
3	1kΩ		
4,7	5.1kΩ	2%	½W metal oxide
5,6	4.7kΩ	2%	½W metal oxide
8	270Ω		
9	4.7kΩ		
10	33kΩ		
11,12	4.7kΩ	2%	½W metal oxide
13	39kΩ		(for 100μA meter)
14	4.7kΩ		
15	6.8kΩ		
16,17	2.2kΩ	2%	½W metal oxide
18	220Ω		
19	100kΩ		
20	4.7kΩ (3089) omit (3189)		
21	6.8kΩ		
22,23	2.2kΩ	2%	½W metal oxide
24	100kΩ		
25	33kΩ		
26	220Ω		
27	22Ω		
RV_1	4.7kΩ		min. horizontal cermet skeleton potentiometer

Capacitors — 20% tolerance unless otherwise stated

C 1	4.7μF 35V		tantalum bead
2	10nF 250V		polyester
3	220pF 160V	5%	polystyrene
4	0.47μF 250V	10%	polyester
5	0.22μF 250V		polyester
6,7	10nF 250V	5%	Siemens polyester or polycarbonate
8	0.22μF 250V		polyester
9	10nF 250V		polyester
10,11	10nF 100V		min. ceramic
12-15	22μF 16V		tantalum bead
16	220μF 16V		min. vertical electrolytic

Other components

IC	TCA4500A, Motorola
$Tr_{1,3,5}$	BC109, BC149, ZTX109, BC184, etc.
$Tr_{2,4,6}$	BC179, BC159, BC214 etc.
D_1	1N4148
Filter	Toko BLR3107N

Tuning indicator

R_1	4.7kΩ
2	100Ω
3	330Ω
4	100Ω
5	1kΩ
6	omit
7	270Ω
$Tr_{1,2}$	BC109, BC149, ZTX109, BC184 etc.
$D_{1,2}$	0.2in red l.e.d.
D_3	0.2in green l.e.d.

Power supply

Transformer	RS Components 6VA type 196-296 secondaries in series, or type 196-303 secondaries in parallel
Rectifiers	1N4003 (four)
Capacitors	0.1μF 250V polyester (three) 470μF and 1000μF 25V min. vertical electrolytic
Resistor	22 ohm
Regulator	type 7812 plastic i.c.
Fuse	20mm 250 or 300mA anti-surge

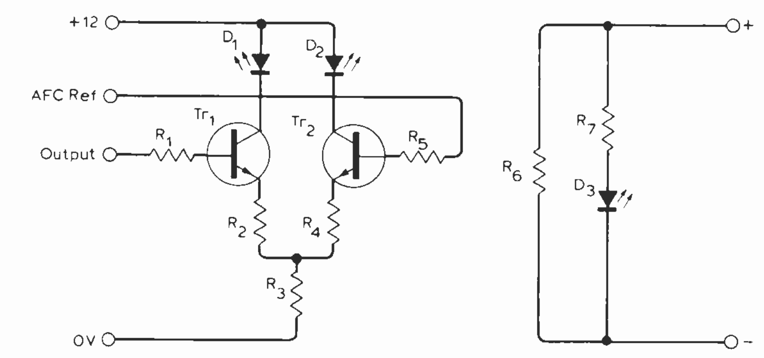
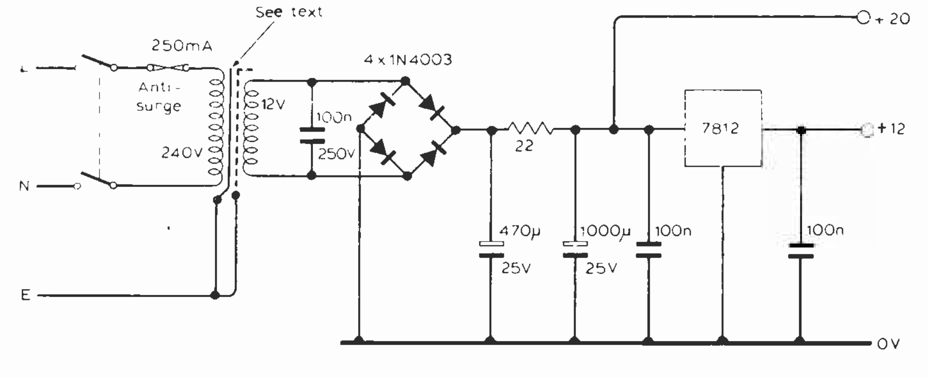


Fig.5. *L.e.d. tuning indicator and stereo indicator.*

Fig.6. *Power supply.*



needed, therefore R_6 is omitted and R_7 is 270Ω.

Power supply

The power supply shown in Fig. 6 uses a full-wave rectifier which feeds two smoothing capacitors. This arrangement produces very little ripple on the +20V supply to the a.f.c./tuning voltage circuit. The +12V supply to the tuner and decoder is stabilized by a 7812 i.c. which has two 0.1μF capacitors across its terminals for h.f. stability.

The capacitor wired across the bridge rectifier input prevents hole-storage noise in the diodes and forms a useful h.f. filter in conjunction with the leakage reactance of the mains transformer.

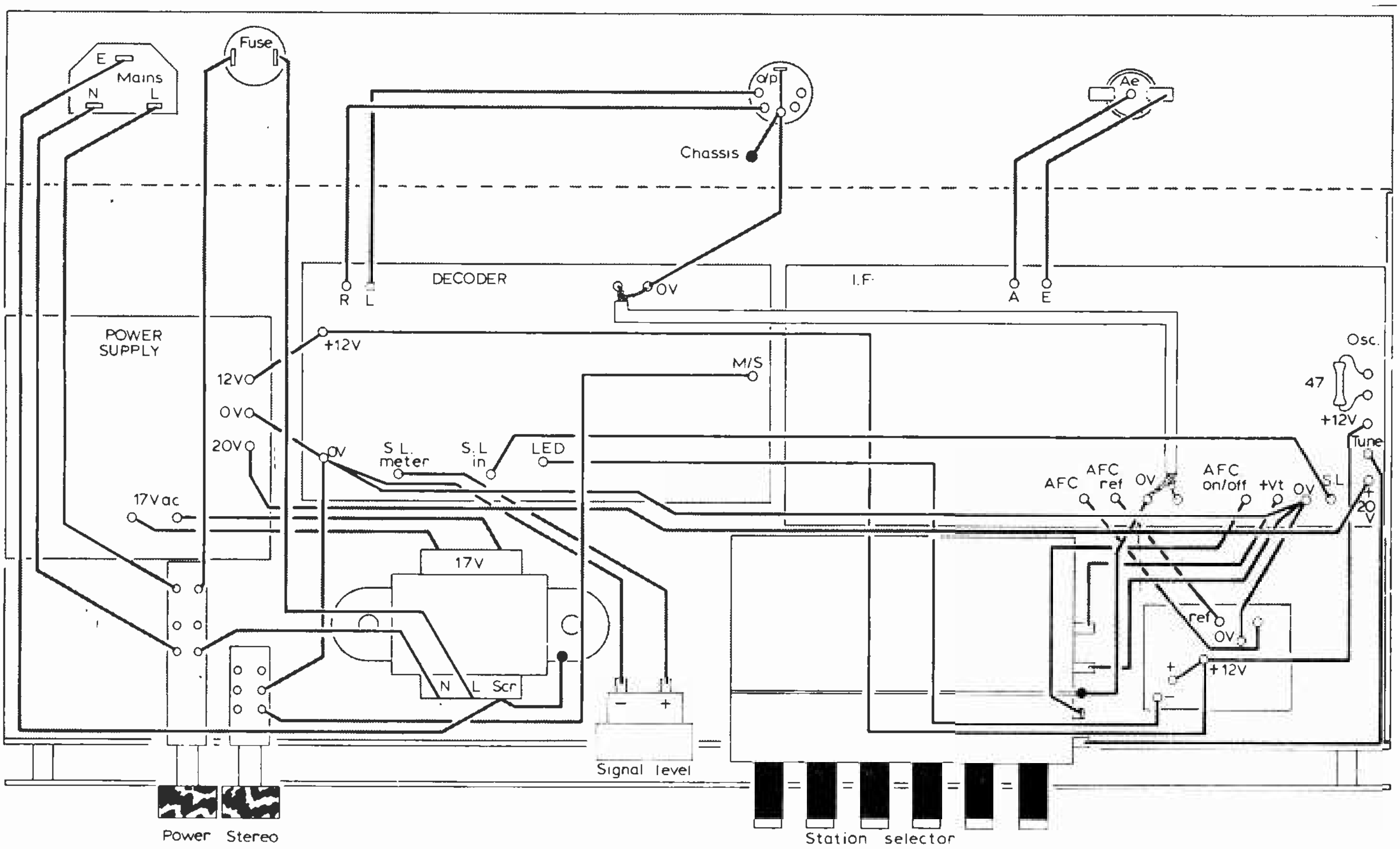
Interconnection of the tuner

The method of interconnection is shown in Fig. 7. It is important to ground the aerial input socket to the chassis only through its connection to the i.f. board. The 0V terminal and wiring must be grounded to chassis at only one point near to the output. The mains earth must be connected only to the mains transformer frame and the interwinding screen. The transformer frame is insulated from the chassis because the tuner will normally be part of an audio system, and it is usual to connect only the pre-amplifier to the mains earth.

To make such an earthing system safe it is essential to use a transformer of good construction which has a copper-foil interwinding screen, and a good earth bond to the frame. □

To be continued. The concluding article describes the alignment procedure and shows the printed circuit board layouts.

Fig.7. *Interconnection diagram.*



Instant tuning

By Cathode Ray

SEVERAL TIMES LATELY I have overheard on the radio hints of a great new idea: instead of changing from one radio* channel to another by turning a knob, meanwhile scrutinizing the movement of a pointer along a scale crowded with figures and names of places (quite likely obsolete) to find the position that will give the wanted programme, and then when at last it has been found, via a cacophony of intervening hisses and shrieks, finding it is too late to hear the start; instead, as I say, of this gruelling process several times every day, some inspired scientist (never any mention of an engineer, of course) is on the verge of making possible an instant switchover from one programme to another!

Well, of course, I thought this was just another example of how ill-informed so many people are, so that it can be commonly supposed that television was invented about 1950 and that Lindbergh was the first person to fly across the Atlantic (instead of, wasn't he, about the 55th?). But a few days ago I was pulled up short by reading in the IEE's journal *Electronics & Power*, July 1977 issue, p.547, an article by Mr James Redmond, Director of Engineering of the BBC (and therefore presumably knowing something about these matters) in which he said as follows:

'At one time there was a large audience of television viewers who remained tuned to one programme because they dared not retune the set in the hope of finding something more to their taste. Pushbutton television receivers quickly freed them from this tyranny, and now we impatiently await the pushbutton portable v.h.f. radio.'

'Impatiently await!'

I fully appreciate the point about being afraid to depart from a channel, once it has been tuned in, because of the difficulty experienced by the lay public in retuning any radio (in its correct inclusive sense) receiver. My sympathies are entirely with them. What sort of a radio engineer is he/she who designs a set that obliges them to do anything so crude?

In the 9th February 1939 issue of *W.W.* (i.e., getting on for 40 years ago) I am on record as stating 'A certain trade list of receivers now on the British market describes 665 models. Of these, 231 are to be found with pushbutton tuning.' I went on to say 'As regards the date of invention, leaving out the inevitable Chinese and Egyptian claims to priority . . . it can definitely be said that it [pushbutton tuning] was on the market at least as early as 1928' (*fifty* years ago now) and went on to describe an American Zenith model so fitted, which enjoyed a ready sale, including one to me.

By 1940 (December issue of *W.W.*, p.499) I made fun of the 'ever-patient British public grinding away at their tuning controls' to change from one programme to another. Evidently the 231 pushbutton models less than two years earlier had not prevailed against the 434 others.

But Mr Redmond was writing about *v.h.f.* radios, which these early p-b models were not. So v.h.f. p-b models may still be in the future?

My wife being one of the lay public and therefore, I consider, fully justified in demanding instant programme changing, I provided her with it almost from the start; i.e., when I married her, which was not yesterday, since our grandchildren are by now doing a bit of demanding of their own in the electronic field. When the three BBC channels became available on v.h.f. (I exclude Radio 1 from consideration, while realizing that for many members of the population this is the preferred channel, but would I be hopelessly wrong in supposing that even they *sometimes* want a change?) I fully accepted the justice of the BBC claim that from then on all right-thinking citizens should turn exclusively to v.h.f. So, nearly 20 years ago, I scrapped all else and provided my wife with an all-v.h.f. set having a three-position switch covering her 'radio' needs.

All went happily until the BBC (obliged, I am sure, by hidden political forces) began introducing intensely unwanted Open University lessons into v.h.f. channels. In distress at this unpredicted and frustrating development, my ever-loving wife turned to me; and with unfailing resourcefulness I devised a m.w. unit for Radio 4 making use of the existing switchgear.

This worked reasonably well until the next crisis, when for a time *all* Radio 4 channels, v.h.f. *and* m.w., were belting out studies on the life-style of the arachnidae or some such esoteric matter about which my wife did not at that time wish to know. Eventually it transpired that this was not more than a technical hitch lasting for a mere couple of hours, but it undermined my reputation for foreseeing and providing against every eventuality.

For the last year and more, the BBC, no doubt at the receiving end of bitter complaints from those listeners who had done as they had been bid and had changed over to v.h.f., has used every available gap between programmes to plug the necessity for a *three-waveband* receiver, long-wave, medium-wave and v.h.f., in order to be able to hear everything they provided. (I hope no unprincipled radio dealers take advantage of customers who remember only the 'three-waveband' bit, by unloading stock that technically conforms to this description but lacks v.h.f. and includes instead the not widely demanded short waves.) Among the ordinary undiscriminating British public these exhortations are unlikely to have been heeded, because the OUB public are able to get everything from the BBC on their cheap imported 'transistors,' many of which are *one*-waveband sets. Any whose interest may have been kindled to the extent of inquiring would quickly be deterred by the price of the a.m. plus f.m. models.

Some of the OUBP—housewives chiefly — got their first jolt when they suddenly found that their Tuesday and Thursday afternoon plays had turned into Questions in Parliament (cleverly disguised as live broadcasts from the Zoo) and 'Disgusted, Tunbridge Wells' became thick with complaints. The BBC could always say, in polite euphemistic terms, of course, 'We told you so.' The same thing will happen again in November, only much more so, among the one-waveband brigade when, not having taken in the oft-repeated warnings, they find themselves unable to get *any* Radio 4 programmes at all, unless they acquire new sets at least with long waves. Moreover, those of

continued on page 57

*About 25 years ago I poured scorn on the illogicality and sheer ignorance of persons on the entertainment side of broadcasting who started a custom of distinguishing between programmes and receivers confined to sound and those that provided both sound and sight by calling the former *radio* and the latter *television* (or more usually TV). How did the poor mutts imagine that TV programmes were broadcast if not by radio? Were it not that they, and the non-technical British public who swiftly copied them, would have been unaware that this absurd nomenclature needed any excusing, they might have excused themselves by the plea that there was no word ready for use for referring to sound broadcasting. All except purists might have accepted 'telesound' had not 'tele' (pronounced 'telly') come to convey to the said public the idea, not, as it should, of distance, but of 'the box' and especially its pictures. Anyway, at last I have given up the unequal struggle, and can only gaze in awe at the respect for principle exhibited by the BBC in retaining the name *Radio Times* for their weekly list of all radio programmes, with or without pictures. Come to think of it, the same inflexible devotion to a cause is displayed by *Wireless World*. And by the author of *Foundations of Wireless and Electronics*. Or could it be just resistance to change? Let's give them the benefit of the doubt!

Logic design — 15

Action / status interface design

by B. Holdsworth* and D. Zissos† *Chelsea College, University of London

†Dept of Computing Science, University of Calgary, Canada

The operation of action / status interfaces, which was the subject of part 14, continues, and design of interfaces is discussed, both in general and in two specific examples. This is the final article in the series on logic design.

With the exception of the go/no-go interface shown in Fig. 6, handshake system configurations which use two states to define the read/write cycle are easier to design and implement. Unless otherwise specified, the 'go' mode will start with a write operation. The diagram shown in Fig. 12(a) is used to define the read and write operations. For ease of reference the flip-flop used to generate the go/no-go signal G is shown in Fig. 12(b). The starting point in the design process is the basic system developed next.

Basic system

Read/write cycle. The implementation of a read/write cycle is straightforward. A block diagram of the two-device system is shown in Fig. 13(a), and its step-by-step operation is flow charted in Fig. 13(b). The state diagram of the interface logic is shown in Fig. 13(c).

By direct reference to the state diagram the following equations are obtained:

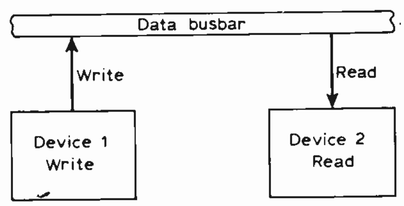
Turn-on set of $A=\bar{r}_2$,
turn-off set of $A=\bar{r}_1+R$.

$$A=\bar{r}_2=Ar_1\bar{R}$$
$$a_1=S_1r_2=Ar_2$$
$$a_2=S_0Gr_1=\bar{A}Gr_1$$

The NAND implementation of these questions is shown in Fig. 13(d).

The timing diagram for the read/write cycle is shown in Fig. 13(e). Initially, it is assumed that $r_1=0$ and that the system is in state S_0, which implies that the system is writing and that device 1 is active. When device 1 has fully responded, r_1 goes from 0 to 1, $a_2=Gr_1$ and device 2 is activated. On activation its status signal r_2 goes from 1 to 0 and thus initiates the transition from S_0 to S_1 and also turns off the action signal a_2.

In state S_1 the system is reading and it continues to do so until device 2 has completed its response, when r_2 changes from 0 to 1 and device 1 is activated. The cycle is completed when



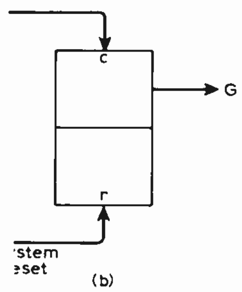
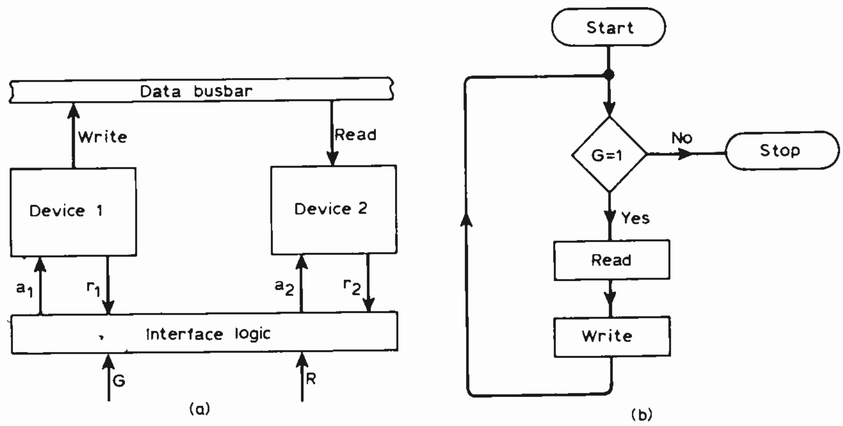
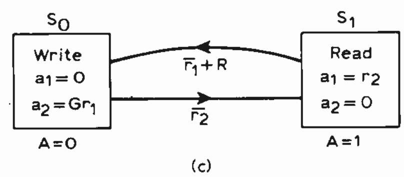


Fig. 12. Read/write cycle.





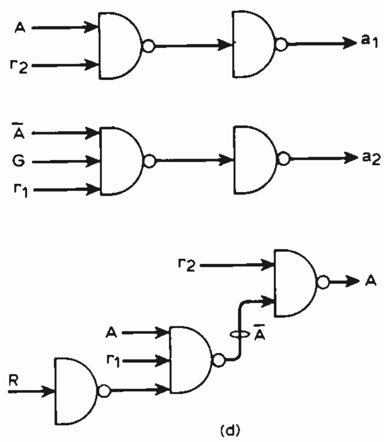
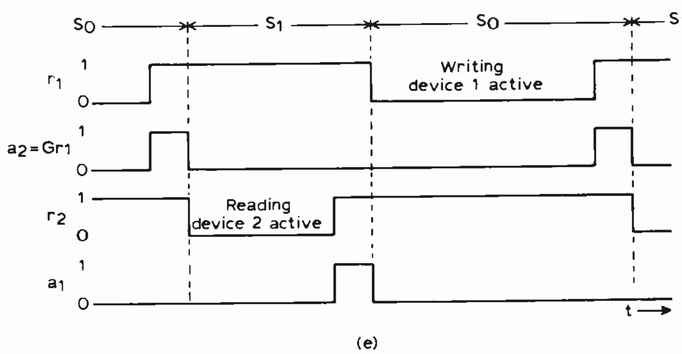


Fig. 13. Read/write cycle schematic (a) and flow diagram (b). State diagram is at (c) and NAND implementation and its timing are at (d) and (e).



the status signal of device 1, r_1 goes from 1 to 0, thus initiating a transition back from S_1 to S_0 and simultaneously turning off the action signal a_1.

Write-inhibit cycle ($i_1 = 1$). To inhibit the write operation in the basic read/write cycle, the write operation is replaced by a read operation as shown in the flow chart of Fig. 14(a). The modification to the state diagram in Fig. 13(c) as a consequence of introducing the write-inhibit process is implemented by interchanging the values of a_1 and a_2 in state S_1, when $i_1 = 1$. Expressed algebraically, the entries for write/inhibit are $a_1 = r_2 i_1$ and $a_a = Gr_2 i_1$, as shown in Fig. 14(b).

Read-inhibit ($i_2 = 1$). Similarly, to inhibit the read operation in the basic read/write cycle, a read operation is replaced by a write operation as illustrated in the flow chart of Fig. 15(a) and the corresponding modification to the state diagram is shown in Fig. 15(b).

The block diagram of the basic system with reset, go/no-go, read-inhibit and write-inhibit facilities is shown in Fig. 16(a). Its step-by-step operation is described by the flow chart of Fig. 16(b). The following equations are obtained directly from the state diagram shown in Fig. 16(c).

$$A = \bar{r}_2 + AR_1\bar{R}$$
$$a_1 = \bar{A}Gr_1\bar{i}_1 i_1 + Ar_2\bar{i}_1$$
$$a_2 = \bar{A}Gr_1\bar{i}_2 + AGr_2 i_1\bar{i}_2$$

Design steps

The design of interfaces can be accomplished in the five steps listed below, and illustrated in Fig. 17. These steps are general and can be used in all interface design problems.

Aims of the design. The system specification is first expressed in the logic interface designer's terms. This step is introduced to ensure that the system requirements are interpreted correctly by the designer.

This stage is critical and requires cooperation between the interface designer and the system designer.

Device characteristics. In this step the designer specifies the terminal characteristics of the devices to be interfaced. Consideraion of the purely internal characteristics of the devices should be avoided if possible.

System design. The interface designer specifies the system characteristics in general terms by means of a block diagram and a system flow chart and consults the designer for approval.

Hardware design. This step is provisional, and hardware design may well be modified as a consequence of the experience obtained in software design. It is accomplished conventionally using well-established methods described in this series.

Software design. On the basis of the hardware design and assuming the necessary instructions, the basic software for the operation of the device is designed. This process may well indi-

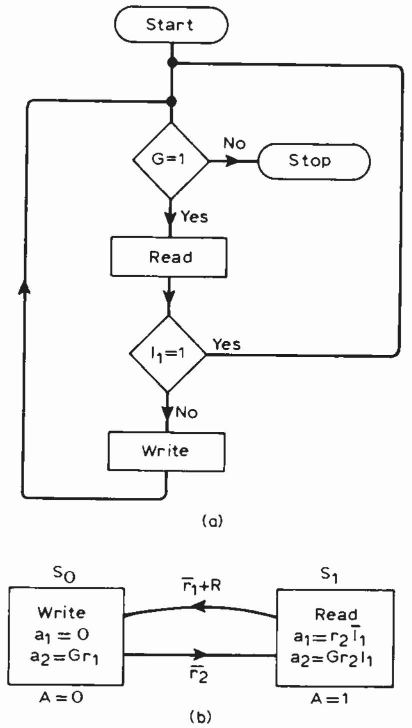


Fig. 14. Flow-chart for write-inhibit (a) and state diagram at (b).

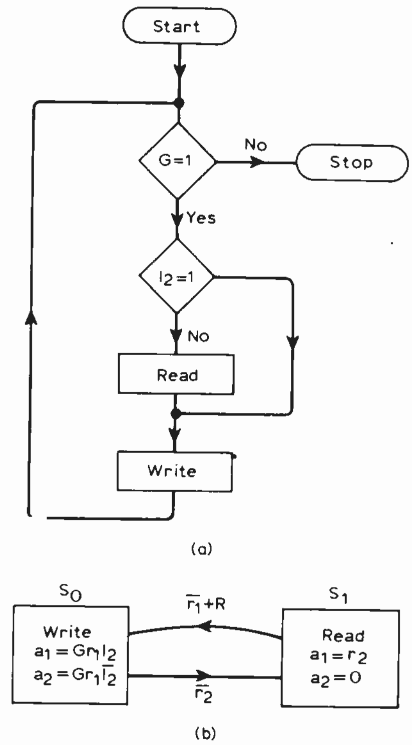
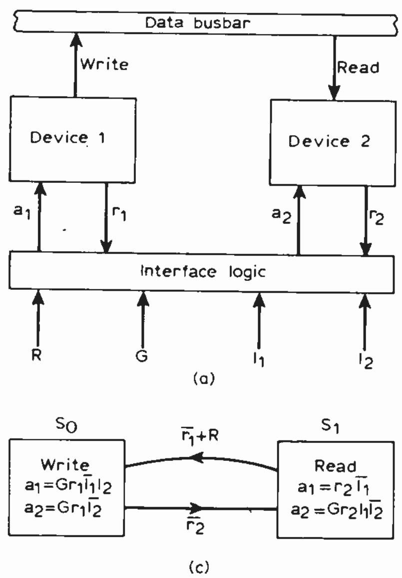


Fig. 15. Read-inhibit flow chart is at (a) and the state diagram at (b).



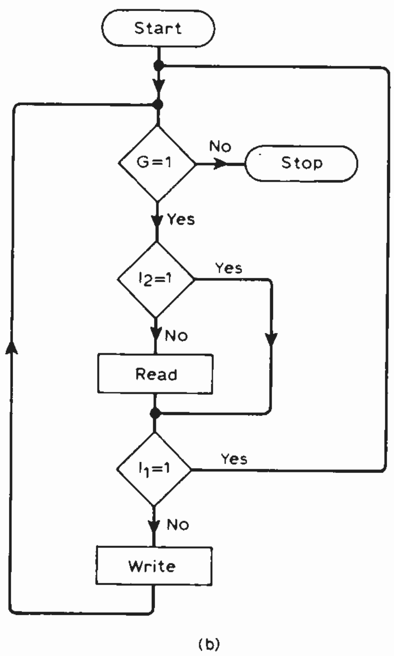


Fig. 16. (a) shows block diagram of basic system, with flow chart (b) and state diagram (c).

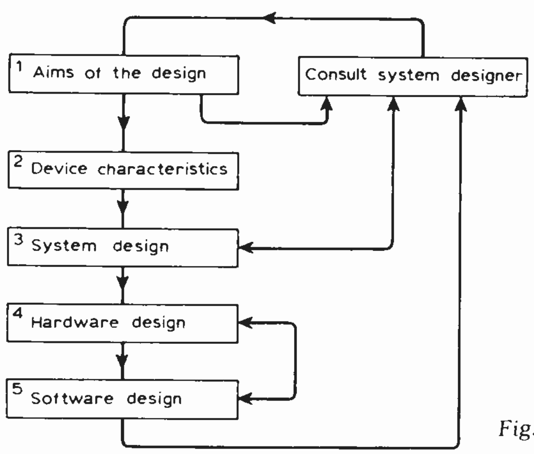
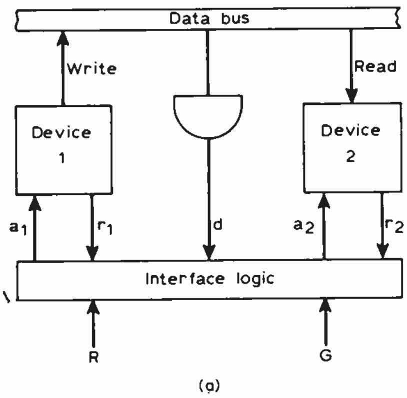


Fig. 17. Design steps for interface.



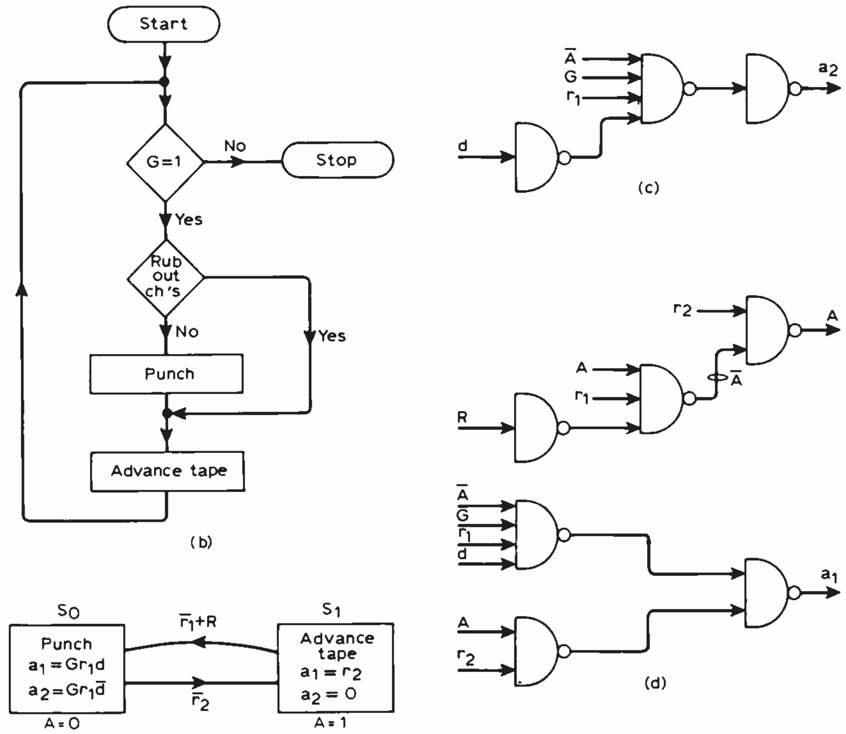
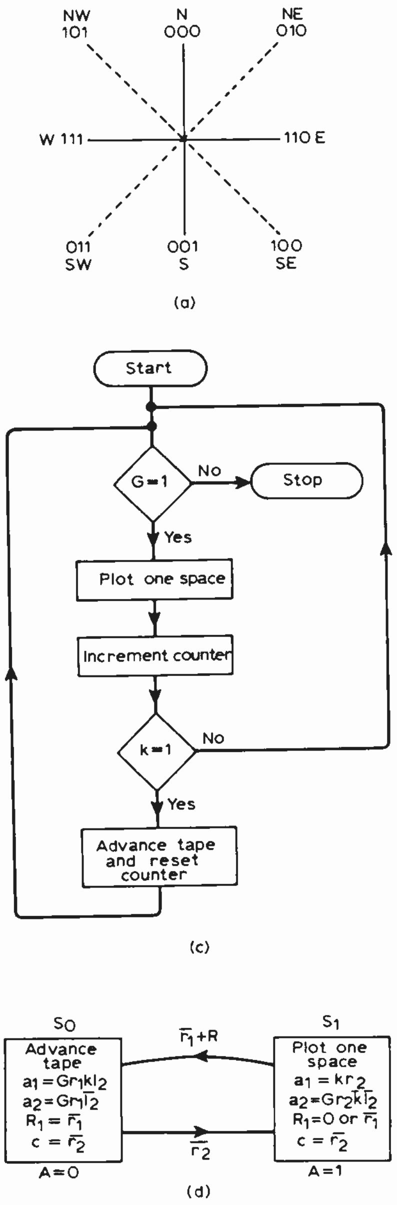
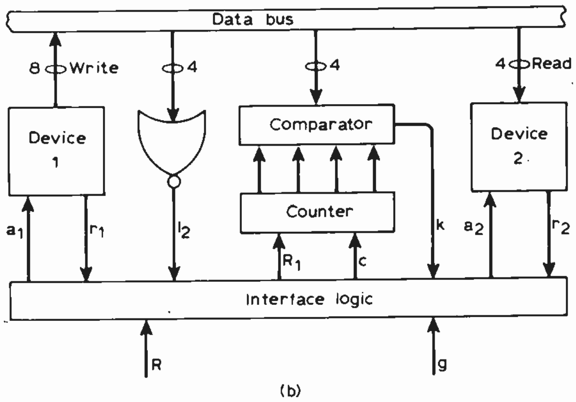


Fig. 18 (a) is block diagram for "rub-out characters" interface, with flow-chart at (b). State diagram is shown at (c) and circuit at (d).





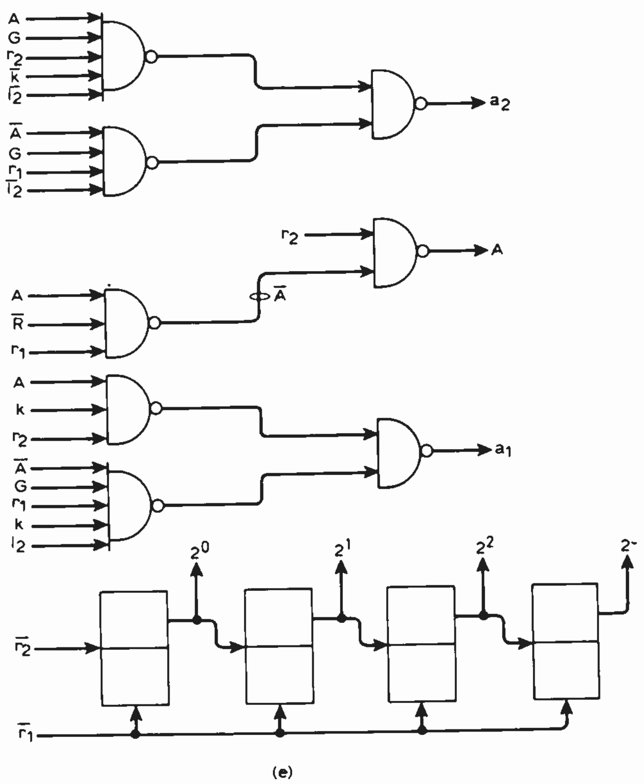


Fig. 19. (a) shows coding for eight directions of movement of digital platen, whose block diagram is at (b) and flow-chart at (c). State diagram and circuit are at (d) and (e).

cate modifications to the hardware design which may lead to improvements. In fact, software and hardware design should be regarded as complementary and should be repeated until a satisfactory design of both hardware and software has been achieved.

Problems and solutions

The design steps described are illustrated by means of two typical problems and their solution. For further design problems the interested reader is referred to the second edition of Digital Interface Design, by Zissos and Duncan, published by Oxford University Press, and to "System Design with Microprocessors," by Zissos, published by Academic Press.

Rub-out characters. Given a paper tape reader and a tape punch, design and implement a small system that allows a new tape to be produced in which the rub-out characters (all 1's) are deleted.

—The aim is to reproduce data after deleting specified characters, in this case the rub-out characters.

—Both reader and tape punch are action/status devices.

—The block diagram of the solution is shown in Fig. 18(a). The AND gate detects the rub-out characters on the data-bus. Its output d is logical '1' when all the digits on the data-bus are 1's. When $d=1$ the data is inhibited from being punched and the input tape is advanced. This is equivalent to $i_1=0$, and $i_2=d$ in the basic read/write cycle notation.

The flow chart describing the step-by-step operation of the system is shown in Fig. 18(b).

The state diagram of the interface can be derived either directly from the system flow chart in Fig. 18(b) or by substituting $i_1=0$ and $i_2=d$ in Fig. 16(c).

From the state diagram, which is shown in Fig. 18(c), the following equations are obtained:

$$A = \bar{r}_2 + Ar_1\bar{R}$$
$$a_1 = \bar{A}Gr_1d + Ar_2$$
$$a_2 = \bar{A}Gr_1d$$

The implementation of these equations is shown in Fig. 18(d).

Reader-to-plotter interface. The first four tracks of an eight-track tape specify eight actions a digital plotter can take, namely move 0.1cm N, NE, E, SE, S, SW, W and NW with the stylus up or down. The other four tracks indicate the number of times each command is to be executed. For example 10010110 is interpreted as: "Draw a line 0.6cm long from NW to SE." Design a suitable interface between the reader and the plotter. The coding of the various directions specified in the problem is shown.

—The aim is as specified above.

—Both the reader and the plotter are action/status devices.

—The block diagram of the solution is shown in Fig. 19(b). In addition to the two action signals a_1 and a_2, the interface must reset the counter with signal R_1 and increment it with signal c at the appropriate times.

Initially the counter is cleared with the system reset signal R prior to the interface being activated by the signal G.

Activating the interface causes the pen to move one space (in this case 0.1cm.) in the direction specified, with the stylus up or down, as specified by the first four tracks of the tape. When the pen begins to move, r_2 becomes 0, and the counter is incremented. When the pen stops, indicated by r_2 becoming 1, the output of the comparator circuit shown in Fig. 19(b) is tested. If the output $k=0$, the pen is moved again and the counter is incremented. This continues until $k=1$, indicating that the stylus has moved through the number of distance units specified by the second set of four tracks on the tape. At this point the input tape is advanced and the counter is cleared. The process continues until the system is turned off, that is until $G=0$.

—As in the previous problem the state diagram can be derived directly from the flowchart of Fig. 19(c) and

$$l_2 = \sum_{b_4}^{b_7} \bar{b}$$

in the state diagram of the basic system. Note $l_2=1$ when the last four digits on the tape are zeros.

The modified state diagram is shown in Fig. 19(d) and by direct reference to this figure the following equations are obtained:

$$A = \bar{r}_2 + A\bar{R}r_1$$
$$a_1 = \bar{A}Gr_1kL_2 + Akr_2$$
$$a_2 = \bar{A}Gr_1\bar{L}_2 + AGr_2\bar{k}\bar{i}_2$$
$$R_1 = \bar{r}_1$$
$$c = \bar{r}_2$$

The implementations of these equations is shown in Fig. 19(e).

Acknowledgements

The authors are grateful to Mr J. Bothoroy, a research assistant at the University of Calgary, for his contribution towards the development of action/status interfaces.

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5. "Digital Interface Design," D. Zissos and F. G. Duncan, Oxford University Press 1974.
6. Microprocessor System Design," D. Zissos, Academic Press 1978.

□

SIXTY YEARS AGO

In late 1918, the triode (a name not yet used) was beginning to gain ground, and several valve receivers were in use. But its acceptance was not as rapid as it might have been, particularly under the stimulus of war-time development. A note appeared in this issue on the Marconi Double Note Magnifier which evidently exhibited a gain of three times per stage.

"Briefly, the instruments consist of two three-electrode valves connected in series with one another in such a way that the telephone currents from the magnetic detector or crystal receiver are magnified in two successive stages before being led to the telephones themselves. The valves thus act not as detectors but as amplifiers. All circuits have been simplified to the highest degree so as to remove the need for adjustments. Electrically there is no difference between the model for the magnetic and that for the crystal except in the design of the first transformer, the primary for which has, of course, to be of lower resistance for the magnetic detector than for the crystal. In one model a switch takes the place of three sets of terminals, and is connected in such a way that, when working direct without magnification, the valve filament circuits are broken. When using first magnification, one valve only is in circuit, whilst for second magnification both valves are in circuit. Otherwise the arrangements are the same.

The total magnification obtained with this new instrument is such that signals from the magnetic detector are at least three times as strong as those obtainable with a crystal receiver. It will be noticed that a 200-volt battery is used for the plate circuit.

By the addition of the note-magnifier to the magnetic, we have available a receiver which possesses the notable reliability of the magnetic, and far greater sensitiveness than the crystal, which — with the exception of the more complicated forms of valve receivers — has hitherto formed the most sensitive commercial type."

The f.e.t. as detector

Improvements in performance over the diode detector

by Roger S. Amos, B.Sc.

The author sets out his views on the advantages of field-effect transistors over semiconductor diodes as demodulators for a.m. receivers. Reduced distortion and improved signal-to-noise ratio are claimed and a design for a receiver using the technique is presented.

MOST MODERN radio and television receivers use silicon or germanium diodes to demodulate the output of the i.f. amplifier. Such detectors are purely passive, giving no power gain, but in superhet receivers this is generally of no account, since the r.f. and i.f. stages provide all the sensitivity that is needed and deliver the power to drive the detector. Before the advent of the superhet, however, the detector in a t.r.f. receiver was often a triode valve which gave a.f. amplification besides detection, contributing to the sensitivity of the receiver.

Today, with the ready availability of f.e.ts, which in many respects behave like triode valves, it is possible to apply the advantages of semiconductor technology to the triode detector circuits of yesteryear. And this is no purely academic matter, for some popular a.m. superhet i.cs, such as the NE546A, LM1820N, µA720 and CA3123E (which are all pin-for-pin equivalents) and the rather different TBA651, have an uncommitted i.f. output, leaving the manufacturer or constructor to add the detector of his choice.

The application of f.e.ts as a.m. detectors, however, demands an understanding of both f.e.t. parameters and triode detector operation. The latter may not be familiar to those who have learned radio theory in the age of the superhet and especially the semiconductor superhet. The three most popular triode detectors were the leaky-grid detector, the infinite-impedance detector and anode-bend detector. But when these are simulated using f.e.ts, unexpected results are often obtained. This article seeks to explain those results and to show how the f.e.t. may provide an attractive alternative to the diode as an a.m. detector.

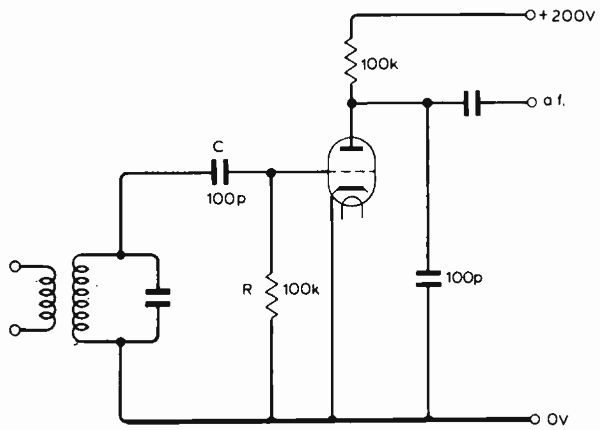


Fig. 1 *A basic leaky-grid detector. The component values shown are typical.*

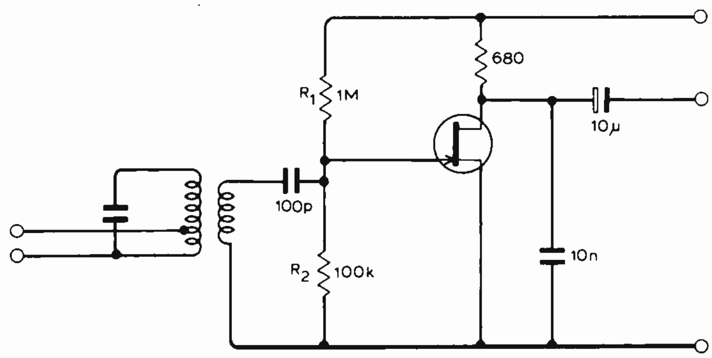


Fig. 2 *Practical circuit for the f.e.t. equivalent of the leaky-grid detector shown in Fig. 1. Component values are typical.*

Leaky-grid (or-gate) detector

The leaky-grid detector, a typical circuit of which is shown in Fig. 1, is essentially an extension of one form of thermionic diode detector, the grid of the triode acting as the anode of a diode. Hence the RC network betweeen tuned circuit and valve are similar to those used in diode circuits, and for high-quality a.m. detection would be chosen to give a time-constant of say 50µs. Positive half cycles of input cause grid current to flow (hence the circuit's name) rapidly charging the reservoir capacitor C. This charge leaks away slowly through resistor R, because this is high compared with the forward resistance of the "diode" when charging. Thus, before the charge has leaked away it is restored by the next positivie half cycle. The voltage across the capacitor therefore follows the modulation of the incoming carrier and because this voltage is applied to the valve between grid and (through the tuning inductor) cathode, the circuit gives both detection and audio amplification.

An f.e.t. equivalent of this circuit would probably employ a junction-gate f.e.t. since, in these, sufficient positive bias on the gate (an n-channel device is assumed) drives current across the gate-channel junction. Insulated-gate f.e.ts in normal use would be unsuitable since gate current is precluded, but a device having a separate substrate or base terminal could possibly be used with that terminal as the "grid"; if the

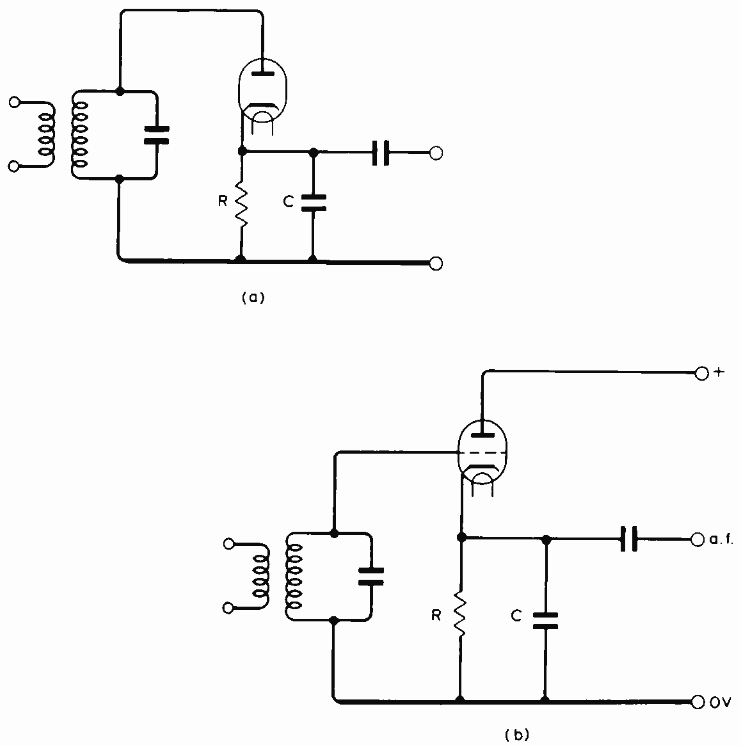


Fig. 3 *Theoretical circuits of (a) one form of thermionic diode detector and (b) an infinite-impedance detector, drawn to show the similarities.*

device is an enchancement-type, the gate would need to be biased forward to establish drain current.

Direct substitution of the valve in Fig. 1 by a suitable j.u.g.f.e.t. with appropriate amendment of component and supply values generally yields disappointing results, the output being feeble and distorted. The principal reason for this is that the gate-channel junction, like a silicon diode, does not conduct appreciably if the forward voltage is below about 0.6V. When silicon diodes are used as a.m. detectors, it is regular practice to apply forward bias to them to bring them into conduction, while maintaining the working point on a sufficiently non-linear part of the characteristic to achieve the required detection; often this bias is provided through the a.g.c. loop in the receiver. The addition of positive bias to the gate of the f.e.t., as shown in Fig. 2, greatly improves the audio quality and efficiency of detection. In the valve circuit of Fig. 1 no positive grid bias was needed because some electrons are emitted from the cathode with sufficient energy to land on the grid even when it is slightly negative relative to the cathode.

There are two main advantages in this form of detector. Firstly, like the diode detector on which it is based, it imposes a load on the tuned circuit through which power is delivered to drive the grid-cathode or gate-channel "diode". This loading can cause distortion since the "diode" resistance is non-linear, falling with increasing positive half-cycle amplitude. In addition there is some steady damping of the tuned circuit through R in Fig. 1 and the effectively parallel R_1 and R_2 in Fig. 2. These reduce the Q of the tuned circuit, limiting the gain available from the previous stage. In superhet receivers, of course, the slight power loss is no great problem since sensitivity and power are available from the preceding i.f. amplifier; in early t.r.f. receivers the loss of power, sensitivity and also selectivity was less tolerable. In high-quality applications, however, the distortion may be less acceptable. Damping of the tuned circuit can be counteracted in some measure by driving the detector from a tapping or a secondary winding, although this further reduces the power available.

Secondly, because the "diode" must be capable of giving appreciable conduction on positive half cycles of input, no reverse bias may be applied to it, hence the absence of cathode and source resistors in the circuits of Figs. 1 and 2. Consequently current consumption is heavy, the f.e.t. giving best results as its saturation drain current is approached; this can be as high as 20mA for a 2N3819, 15mA for a BF244B and 13mA for a BF256LB. While this is of little consequence in mains-driven equipment, it is clearly wasteful in battery equipment. The detector circuits to be described avoid both these disadvantages.

Infinite-impedance detector

As Fig. 3 shows, the infinite-impedance detector closely resembles one form of thermionic diode dectector. The difference is that in the former the power to drive the detector comes from the supply rather than the input tuned circuit. This gives it two advantages over the leaky-grid detector. Firstly, anode current in the cathode load resistor provides grid bias, ensuring that an effectively infinite impedance is presented to the input tuned circuit. This minimizes damping and enables the detector to make full use of the available input voltage. Consequently, distortion is low and at one time this detector was favoured in high-quality applications. Secondly, the cathode resistor limits anode current, which may be very low. Indeed, if the valve is near cut-off the non-linearity of its grid bias/anode current characteristic enhances the efficiency of detection; this non-linearity is not, however, essential to the operation of the infinite-impedance detector.

Positive half cycles of input voltage cause peaks of anode current which rapidly charge the reservoir capacitor. Since the only discharge path presents a comparatively high resistance, the charge leaks away slowly. Consequently, negative half cycles of input voltage oppose the charge on the reservoir capacitor, causing the valve to be biased back. Providing the cathode resistor and capacitor are chosen to give a suitable time constant, the cathode voltage will accurately track the peaks of the positive exclursions of input voltage. Since the detector is a cathode follower, it resembles a diode circuit in that it gives no voltage gain; it does, however, give appreciable power gain in that it transfers voltage from its practically infinite input impedance to the comparatively low output impedance at the cathode.

The valve in Fig. 3(b) may be directly substituted by an f.e.t. Since the gate will not be required to conduct, insulated-gate and junction-gate types are equally suitable, but enhancement-mode devices would require more complex biasing arrangements. Since junction-gate types are inexpensive and easier to handle, they will probably be preferred.

Figure 4 shows an infinite-impedance detector using an n-channel j.u.g.f.e.t. The circuit generally gives an excellent signal-to-noise ratio, low distortion and a higher level of audio output than might be expected; the reason for this will be discussed below. Mean drain current rises as signals are received and if amplified can be used to derive a.g.c. or "S" meter drive. In many respects this is the most promising f.e.t. detector.

The circuit, has, however, a disadvantage. In an f.e.t. there is some capacitance between gate and source; this is given as typically 8pF for the 2N3819 and 4pF for the BF244 and

BF256. Fig. 5 shows the circuit of Fig. 4 including this capacitance and a decoupling capacitor redrawn to show its similarity to a shunt-fed Colpitts oscillator. If the f.e.t. is a high-gain type or if it has a high gate-source capacitance, instability may occur. This can generally be eliminated by making the source resistor large (and the reservoir capacitor correspondingly small to maintain the required time constant) thereby reducing the gain of the f.e.t. In practice it is often helpful to make the source resistor a pre-set pot. (50kΩ is a useful value) which can be adjusted for stability and the reservoir capacitor (470pF is a typical value) can be replaced by a more suitable value if necessary. If the detector is fed from a damped tuned circuit or from a voltage step-down transformer (as in Fig. 8) instability is unlikely to cause any problems.

There are circumstances in which the potential instability of this detector can be an advantage. In receiving c.w. and s.s.b. transmissions it is often helpful if the detector can be made regenerative, and this can often be achieved very simply by the addition of a suitable external capacitor between gate and source. A variable source resistor will usually give smooth control of regeneration. If the f.e.t. is a low-noise type such as the BF256, the detector alone at the threshold of regeneration exhibits remarkable sensitivity; one constructed by the author having only a ferrite aerial and followed by a low-noise audio stage feeding a power amplifier equalled several domestic superhet receivers in sensitivity, but gave better signal-to-noise ratio and less distortion. Almost certainly the inherent positive feedback through the f.e.t.'s internal gate-source capacitance and associated external circuitry accounts for the unexpectedly high level of audio output.

Anode- (or drain-) bend detector

Like the infinite-impedance detector, the anode-bend detector, of which a typical circuit is shown in Fig. 6, presents an infinite impedance to the input tuned circuit. Detection is, however, by virtue of the non-linear characteristics of the valve near cut off. Thus, this detector shares with that previously described the advantages of minimal damping and low current consumption; furthermore, it offers the extra advantage of useful audio amplification.

The operation and design of this detector are most easily understood if it is regarded as a stage of audio amplification in which the input is at r.f. If the valve were perfectly linear and if the input signal were too small to cause overloading there would, of course, be no audio output. But because the valve is biased nearly to cut-off and is non-linear the increase in anode current on each positive half cycle of r.f. input is greater than the diminution caused by an equal negative half cycle and the mean anode current follows the modulation of the incoming carrier. This is converted to a voltage output by the insertion of an RC combination with a suitable time constant in the anode circuit of the valve. The author's experiments (with f.e.t. circuits) have shown that the cathode (or source) resistor needs to be decoupled at audio frequencies, because it is common to input circuits and, without decoupling, introduces negative feedback, reducing the audio gain. With a source resistor of 47kΩ the optimum bypass capacitor is about 10μF; higher values cause distortion and lower ones upset the audio frequency response.

The transfer characteristics of f.e.ts

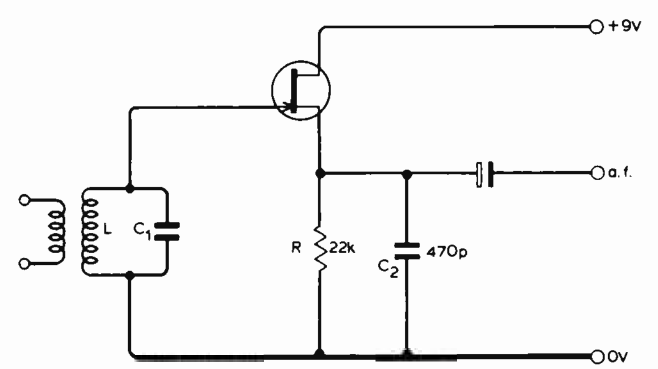


Fig. 4 *An infinite-impedance detector using an n-channel j.u.g.f.e.t. The component values are typical, but there are complications – see Fig. 5 and text.*

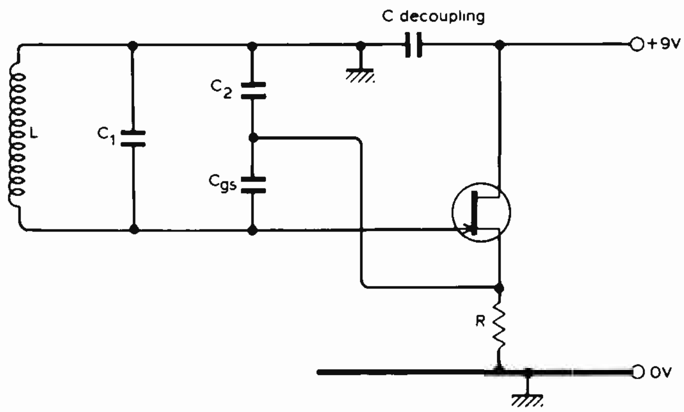


Fig. 5 *Part of the circuit of Fig. 4 including the internal gate-source capacitance of the f.e.t. (C_{gs}) and a decoupling capacitor across the supply ($C_{decoupling}$) redrawn to show the similarity of the infinite-impedance detector to a shunt-fed Colpitts oscillator. This explains the instability sometimes encountered in this form of detector.*

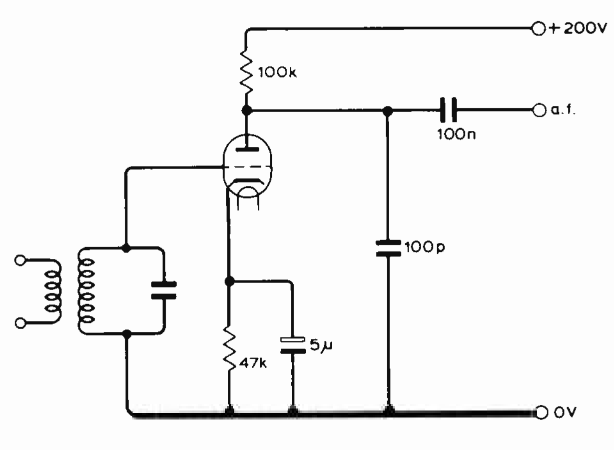


Fig. 6 *Theoretical circuit of an anode-bend detector. The component values are typical.*

resemble the grid voltage/anode current characteristics of triode valves, their non-linearity near cut-off suiting them theoretically for use in "drain-bend" detectors. As in the infinite-impedance detector, the gate will not be required to conduct, so that junction-gate and insulated-gate types are equally suitable. If an enhancement-mode device were used, it would be necessary to hold the gate bias just above the threshold voltage, which could cause complications.

If an f.e.t. were substituted for the valve in Fig. 6 and the component and supply values amended accordingly, the performance of the resulting drain-bend detector would probably be disappointing compared with that of the simpler infinite-impedance detector shown in Fig. 4. In fact the drain-bend detector poses a number of problems.

Firstly, there is a loss in sensitivity caused by the Miller effect, which consists of negative feedback at radio frequencies through both internal and stray drain-gate capacitance. Although great losses might be expected because of the high value of drain load resistance and small drain bypass capacitor, this is largely counteracted by the low g_m (or y_{fs}) of the f.e.t. near cut-off. Miller effect can be overcome by the use of neutralization or a cascode circuit; a dual-gate i.g.f.e.t. can be employed since it behaves like a cascode. Although the helpful regenerative tendency seen in the infinite-impedance detector is destroyed by the high drain load resistance and extensive source decoupling, it can be re-introduced by partial decoupling at the source, as shown in Fig. 7. At the sacrifice of some audio voltage gain this permits the introduction of an external capacitor between source and gate to neutralise Miller effect, improving the sensitivity. It also facilitates regeneration if required. The resulting detector, however, is no longer a pure drain-bend detector — it is a hybrid between drain-bend and infinite-impedance types.

Secondly, the output impedance at the drain may be as high as 50kΩ. If this is coupled to a common-emitter audio stage having a low input impedance (2kΩ is typical), the detector output voltage will collapse, leading to apparently poor results. For this reason it is advisable to follow a drain-bend detector with either an emitter-follower, as in Fig. 7, or an f.e.t. audio stage.

Thirdly, a high supply voltage may be needed. With the f.e.t. operating near cut-off, the voltage across the source resistor approaches the pinch-off voltage. If the f.e.t. were a 2N3819 this may be as high as 5V, and if the drain load resistor were, say, four times the source resistor, clearly 20V would be needed to drive the drain current through it. Ideally, at least 3V should be maintained between drain and source so that the minimum supply voltage under these conditions is 28V. This can be overcome by deliberately selecting an f.e.t. with a low V_p; some BF244s have V_p less than 1V and, using these, drain-bend detectors can be constructed which will operate satisfactorily from 9V and even 6V supplies. The BF256 can also be used with a 9V supply if component values are chosen carefully.

Fig. 7 shows a practical circuit for a hybrid drain-bend/infinite-impedance detector with emitter follower output stage in which all the performance-saving steps outlined above have been

Fig. 7 *Practical circuit diagram for a hybrid drain-bend/infinite-impedance detector with buffer emitter-follower audio stage; the latter is necessary to match the high output impedance of the detector. Neutralization is applied via the 25pF trimmer to counteract Miller effect. But the performance may in some respects be inferior to that of the simpler infinite-impedance detector in Fig. 4.*

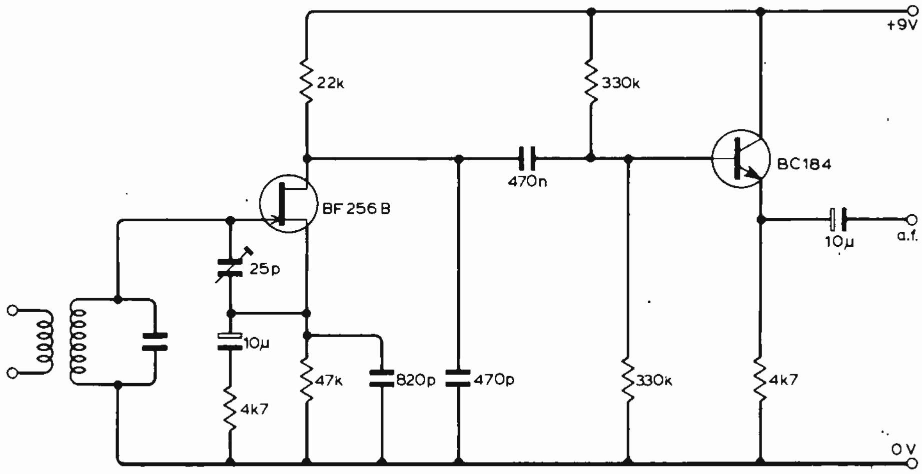
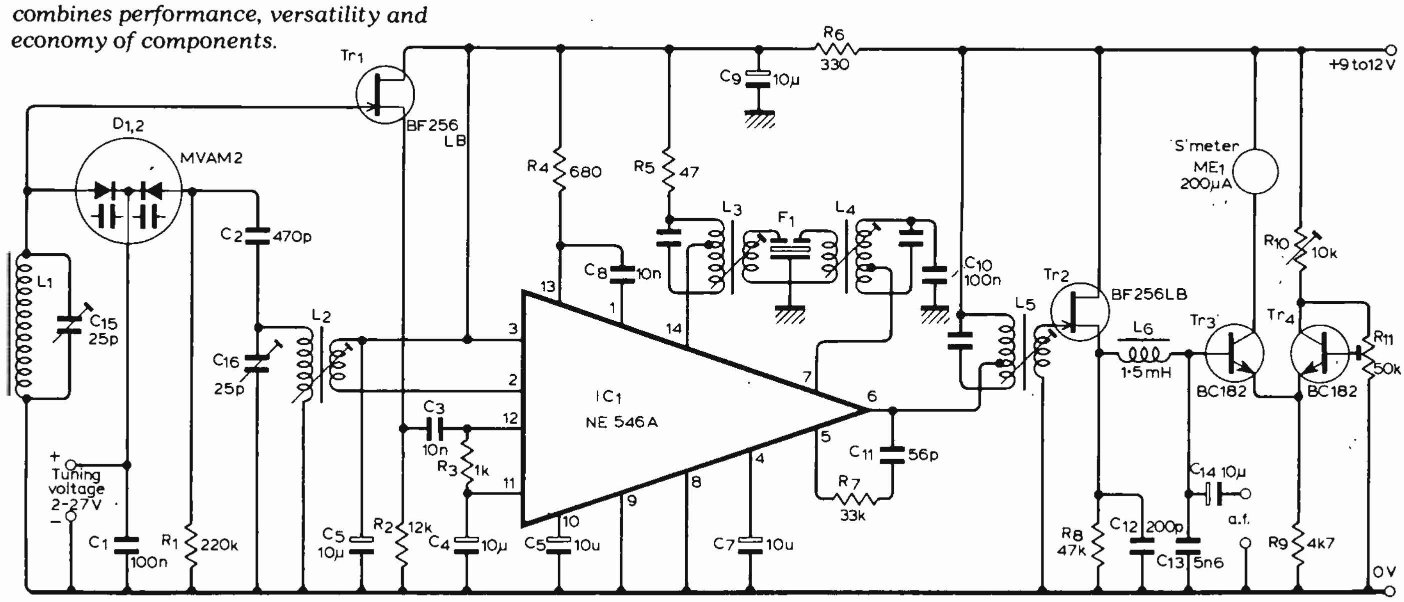


Fig. 8 *Circuit of an a.m. superhet using an i.c. for main functions and an f.e.t. infinite-impedance detector. The circuit combines performance, versatility and economy of components.*



The author
Roger Amos is Senior Publications Officer with the Institution of Chemical Engineers. Son of S. W. Amos, who has been a regular contributor to *Wireless World* for over 30 years, he has been active in radio and electronics as a hobby for as long as he can remember. Since graduating in botany from Chelsea College, London, in 1967, he has held a variety of positions in scientific and industrial publishing besides spending a number of years in the Baptist ministry. Current interests include electronic control systems for model railways.

taken. While it will generally give a greater audio output than its counterpart in Fig. 4 from the same input signal, the signal-to-noise ratio may well be inferior, and the circuit may suffer from treble-cut caused by the extra positive feedback introduced to neutralize the depredations of Miller effect. The infinite-impedance detector shown in Fig. 4 followed by a stage of low-noise a.f. amplification would give results superior in most respects using almost the same components. For this reason the latter circuit will probably be preferred.

Complete receiver

Figure 8 shows the circuit of a superhet receiver in which a readily available integrated circuit provides the functions of r.f. amplifier, local oscillator, mixer, i.f. amplifier and a.g.c. detector, an infinite-impedance detector like that in Fig. 4 providing a.f. output and a d.c. feed for an "S" meter circuit. Although a two-gang mechanical tuning capacitor could be used, the author's prototype employed a Motorola MVAM2 dual varicap diode, the tuning voltage being selected from an array of seven pre-set and one variable 100kΩ pots by an eight-way push-button switch; the 27V bias was provided by three 9V dry batteries in series, which proved remarkably stable, the pre-set stations remaining in tune over many weeks.

Source-follower Tr_1 matches the aerial tuned circuit to the r.f. stage and, helped by inherent regeneration as in an infinite-impedance detector, contributes to the sensitivity and signal-to-noise ratio of the receiver. The combination R_4/C_8 provides broadband coupling between r.f. stage and mixer. Coupling from mixer to i.f. amplifier is via the selectivity block $L_3/F_1/L_4$ which may consist either of two discrete i.f. transformers and a ceramic filter or, as in the author's prototype, an integrated block containing these elements; these are available commercially with a choice of bandwidths. The i.f. output appears at pin 6, a portion being fed through C_{11}/R_7 to a voltage doubling diode pair in the i.c. which provides a.g.c. for the r.f. stage. Signal is transferred from i.f. amplifier to detector through a discrete i.f. transformer, which in the author's prototype gave a voltage step-down, being intended for coupling to a diode detector. Although this transformer was far from ideal for its present detector, the detector nevertheless gave more than adequate output to feed a domestic high-quality amplifier. The step-down transformer also improved the stability of the detector. The combination L_6/C_{13} removes any stray i.f. which might cause distortion in the amplifier or "S" meter circuit.

The optional "S" meter drive consists of the long-tailed pair $Tr_{3/4}$ and associated circuitry. Mean drain current in the infinite-impedance detector rises when a signal is received; this appears as an increased voltage across the source resistor R_8, which biases Tr_3 forward; in the absence of a signal Tr_3 is biased off by Tr_4. For meters up to 500μA f.s.d. R_{10} and R_{11} can be adjusted for meter sensitivity and zero respectively; meters over 500μA f.s.d. may be satisfactory if R_9 is reduced. Additional a.g.c. could be derived from Tr_3 collector by the inclusion of a suitable resistor in series with the meter; this could be fed to the gate of Tr_1, the signal being fed in through a suitable capacitor.

Sensitivity of the receiver compares favourably with that of domestic superhet receivers; signal-to-noise ratio is superior and distortion very low. The latter two features are due in some measure to the nature of the detector. With junction-gate f.e.ts costing little more than silicon diodes, the infinite-impedance detector surely offers scope for an improvement in a.m. receiver design. □

LITERATURE RECEIVED

"Glossary of Microelectronic Terms, Definitions and Symbols" — JEDEC publication No. 99 costs $7.50 and is obtainable from Standards Sales Office, Electronic Industries Association, 2001 Eye Street, N.W., Washington, D.C. 20006, U.S.A.

Publications of the International Telecommunications Union are listed in a catalogue available from General Secretariat, I.T.U., Sales Service, Place des Nations, CH-1211 Geneva 20, Switzerland WW401

Electrostatic printer/plotter S1004, in both alphanumeric and graphic forms, described in a brochure from EMI Technology (SE Labs), Data Products Division, Spur Road, Feltham, Middlesex TW14 0TD ... WW402

Personal computer for small business use described by ITT in a leaflet from ITT Consumer Products (UK) Ltd, Chester Hall Lane, Basildon, Essex WW403

Transducer energising and conditioning is the function of Industrial Unit IG2104, described in a leaflet obtainable from Carl Schenck (UK) Ltd, Stonefield Way, Ruislip, Middlesex HA4 0JT WW404

Transient suppressor diodes, from 6.8 to 200V, are the subject of a data sheet from Semtech, which can be obtained from Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middlesex WW405

Miniature motors for 1978 from Portescap, using ironless motors for low inertia, described in a leaflet from Portescap (UK) Ltd, 204 Elgar Road, Reading RG2 0DD WW406

Antennas and masts are fully detailed in a large catalogue from American Electronic Laboratories, Inc., Dept. 1122, P.O. Box 552, Lonsdale, Pennsylvania 19446, U.S.A. WW407

Timers working in the 'delay on de-energize' mode, are made by Tempatron and are covered by leaflet TDD9/77 from Tempatron Ltd. 6 Portman Road, Reading WW408

Microphones, headphones, communications and test instruments are listed and fully detailed in the Sennheiser 'Revue 9' catalogue. Contains much useful information — in English. Hayden Laboratories Ltd, Hayden House, Churchfield Road, Chalfont St. Peter, Bucks SL9 9EW WW409

Screwdriving equipment, including power bits, screwdriver kits and adaptors are illustrated in Catalogue 3a from Harmsworth Townley & Co. Ltd, Todmorden, Lancs OL14 5JY WW410

Audio accessories catalogue, which also presents information on multimeters and digital timepieces, obtainable from Ross Electronics, 32 Rathbone Place, London W1P 1AD WW411

Company analysis, considering the performance of 50 largest firms in European electronics over the last few years, is obtainable at £18 from Mackintosh Publications Ltd, Mackintosh House, Napier Road, Luton LU1 1RG.

Frequency synthesizers — 1

The generation of wanted frequencies from other frequencies

by R. Thompson, M.I.E.E.

The term "frequency synthesis" is applied to processes involving the generation of some wanted frequency from one or more other frequencies. The most common forms of frequency synthesizer use high-grade fixed frequency references to generate fixed- or variable-output frequencies with stabilities similar to those of the references. Like many definitions, this one cannot be considered to be precise and we shall see that frequency synthesis represents a particular grouping of techniques, most of which are widely used in other applications of electronics.

THE NEED to generate variable frequencies with the stability of a fixed reference has led to a concentration of effort on frequency synthesis over the past 15 years. A major application of this type of synthesizer is in radio communication equipment where narrow-band modulation methods with precise carriers are required. Another major application has been in modestly priced instruments capable of very accurate measurement of time, frequency and phase.

A feature of great importance with many modern synthesizers is the ease with which the required frequency can be selected. Communication equipment design has had increasing emphasis on ease of operation, aiming in many cases to eliminate the need for specialist operators. Nowhere has this pressure been greater than with military applications. Here, the trend has been from equipment requiring tediously repetitive adjustment to switch selectable operation, and now to radio equipment having entirely automatic frequency control.

The basic requirement for generating one frequency from another can be stated as: $f_2/f_1 = X/Y$, where X and Y are rational numbers. In principle, therefore, synthesis only requires multiplication (X) and division (Y). However, as we shall see, practical considerations limit the attainable values of X and Y. where such practical limitations occur X/Y can be factored as: $X/Y = (x/y)(X_1 \pm X_2/Y_2)$. The introduction of the $\pm$ allows the multiplication/division factors to be reduced. We shall be coming back to this in more detail later; the important point here is to see that we are interested in the four basic arithmetic functions.

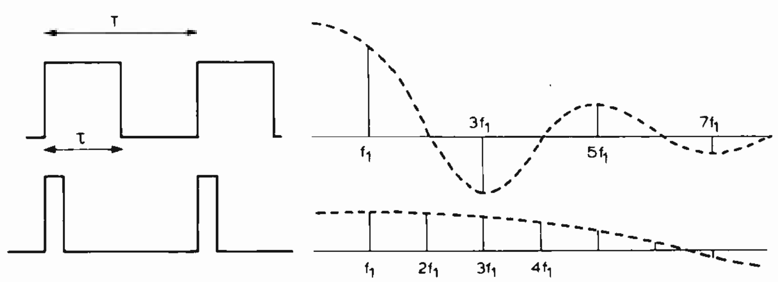


Fig. 1. *Simple rectangular waveforms and graphical representations of their associated frequency spectrums.*

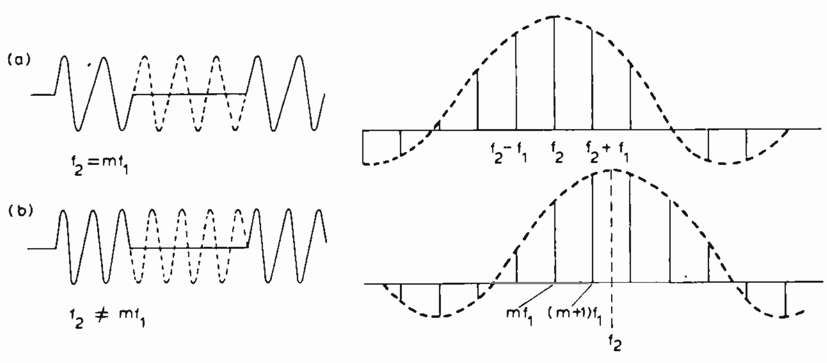


Fig. 2. *A squarewave f_1 being used to switch a sinusoidal signal f_2 to produce frequency spectrums. In (a) each burst of f_2 starts in the same phase. In (b) the squarewave forces each burst of f_2 to start in the same phase.*

Addition and multiplication

If we start with some very simple waveforms and their spectra we can get an appreciation of the possibilities and difficulties of adding and multiplying frequencies.

Figure 1 shows simple rectangular waveforms and their associated frequency spectrums. Frequencies are only present at integral multiples of the fundamental frequency f_1 and, from the general expression for the Fourier series shown below, it can be shown that their amplitudes follow a $\sin x/x$ law.

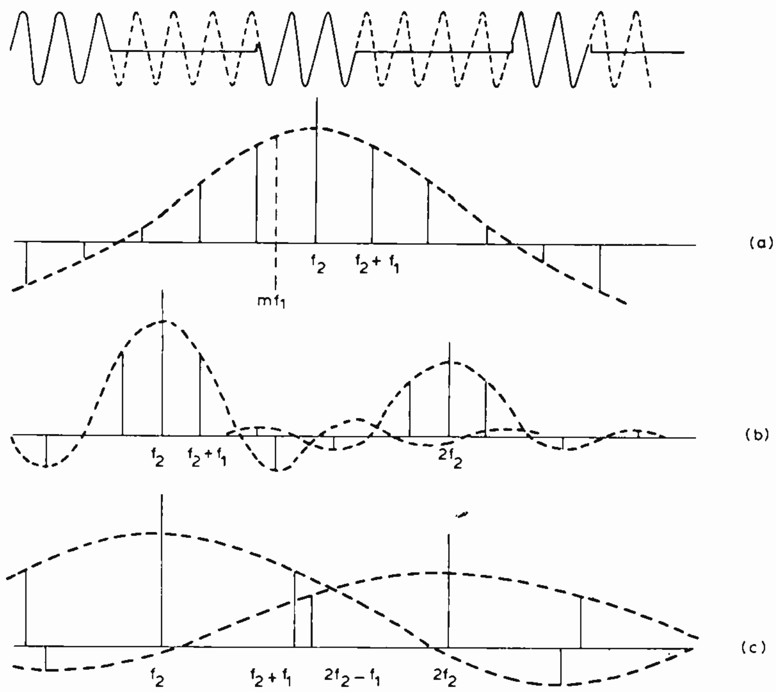
$$a(t) = \frac{A\tau}{T}\left[\tfrac{1}{2} + \sum_{m=1} \frac{T}{\tau m\pi} \sin\left(\frac{\tau m\pi}{T}\right).\cos\left(\frac{2\pi m t}{T}\right)\right]$$

Obviously a wide range of frequencies can be generated, but if a reasonably flat spectrum is required up to high order harmonics, very narrow pulses will be required. This will, however, result in very little energy being available at any selected frequency.

If we are interested only in a particular range of harmonics, one method is simply to filter the output of the square wave, even though the level quickly reduces as we increase the harmonic number. An alternative method is to use the squarewave to switch a sinusoidal signal frequency f_2, as shown in Fig. 2.

In Fig. 2(a) there is an integral relationship between f_1 and f_2, and each burst of f_2 starts in the same phase. The resultant spectrum is a double-sided version of that in Fig. 1 centred on f_2.

In Fig. 2(b), where $f_2 \neq mf_1$, the squarewave not only switches f_2 on and off but forces it to start each burst in the same phase. This gives a spectrum similar to that in Fig. 2(a) but now, although the spectral envelope is centred on f_2, there is no component there. Since the waveform is periodic at f_1 the components will be at harmonics of f_1. The forced synchronisation of an oscillator, producing an output as in Fig. 2, gives high level outputs with a frequency stability dependant only on f_1 and it can be seen that by controlling



◄ **Fig. 3.** *Diagram showing three frequency spectrums resulting from a mixing process which enables frequencies to be added or subtracted. (a) is probably a simplification because it would normally also contain harmonics of f_2. In (b) the ratio of f_2/f_1 is high and $f_2 + f_1$, f_2 and $f_2 + 2f_1$ are difficult to separate. In (c) the problem is that of removing $2f_2 - f_1$.*

Fig. 4. *The use of equal on and off periods in Fig. 3 enables the $f_2 + 2f_1$ frequency component to be suppressed. This diagram shows how, by also replacing the off period with a phase-reversed f_2, f_2 may be suppressed too. In (a), where the periods are equal, the nearest components are $2f_1$ away. (b) shows what can happen when the periods are not equal.*

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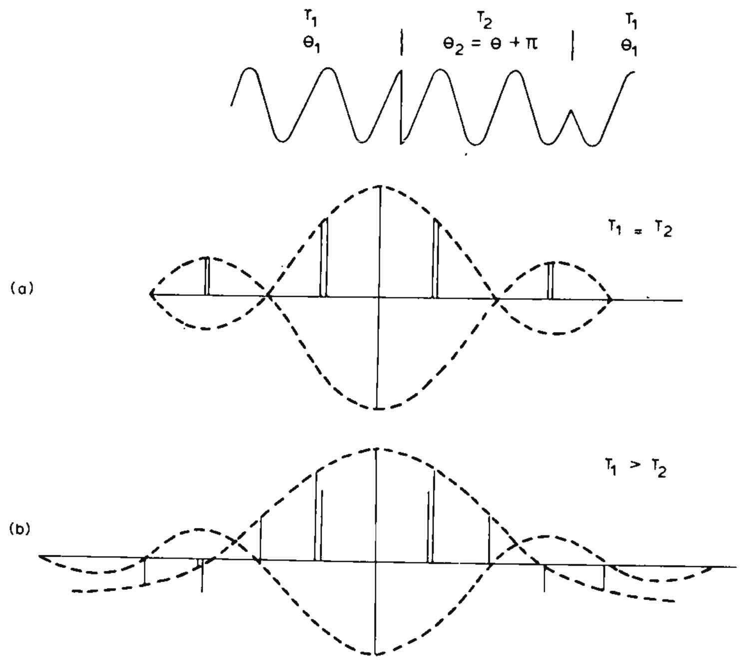


the switching pulse width a form of filtering is provided.

One of the recurrent problems in frequency synthesis is the selection of the wanted signal from a host of unwanted signals and any method capable of providing this selection is of interest. The most obvious methods are L,C,R and crystal filtering. However, these are often bulky, expensive and difficult to tune. Their selectivity is governed by the percentage frequency separation of the wanted and unwanted signals, selection becoming more difficult as percentage separation decreases. Because of these difficulties, any techniques providing selectivity, such as those illustrated in Figs. 1 and 2, are of potential interest in frequency synthesis.

Figure 3 shows a situation similar to that of Fig. 2(a) but with $f_2 \neq mf_1$, and no forced phase synchronism. The spectral envelope in Fig. 3(a) is again the sin x/x shape centred on f_2. However, in this case, components do not in general occur at harmonics of f_1, but at $f_2 \pm mf_1$. This follows from the fact that the waveform is no longer periodic at f_1 but at some rational fraction of this and the periodicity is no longer controlled only by f_1 but by the combination of f_1 and f_2.

The process shown in Fig. 3(a) is of course normally referred to simply as "mixing" and it provides a means of adding or subtracting frequencies. As with multiplication, a major problem is the rejection of unwanted frequencies. The situation is normally worse than that shown in Fig. 3(a) because harmonics of f_2 are present at the input or generated in the switching process. Figure 3(b) and (c) illustrate the problem created. In (b) the ratio f_2/f_1 is high, making it difficult to separate $f_2 + f_1$ from f_2 and $f_2 + 2f_1$. Components from the spectrum centred about the second harmonic of f_2 will also come close to $f_2 + f_1$. However, in this case, they will only be small amplitude signals.

In Fig. 3(c), the ratio f_2/f_1 is low, easing the separation of $f_2 + f_1$ from f_2. The problem is now that of separating out $2f_2 - f_1$. Filtering problems therefore set upper and lower boundaries on mixing ratios.

The problem in the case shown in Fig. 3(b) can be eased by using the selective characteristics of the spectral envelope. To start with, the use of equal on and off periods will suppress the $f_2 + 2f_1$ component. If, in addition, the off period is replaced by a phase reversed f_2, we can achieve cancellation of f_2 as well. This is illustrated in Fig. 4(a), the nearest components are now $2f_1$ away. In practice this cancellation will not be complete; for instance, if the periods are not equal, the result will be as shown in Fig. 4(b). However, very useful attenuations of 20 to 40dB, can be obtained.

These simple considerations of multiplication and addition lead us to some of the practical circuits used for these operations.

Harmonic generation can be achieved by a variety of standard pulse circuits, and modern integrated circuits can generate pulses with harmonics up to about 1GHz. Traditionally, of course, class C amplifiers have been used in transmitters as frequency multipliers and are normally a harmonic generator with some frequency selectivity incorporated.

Multiplication to very high frequencies, tens of GHz, is possible with step recovery diodes (s.r.ds). The s.r.d. functions as a switch with switching times in the region of 50×10^{-12} seconds. Figure 5 shows a particular arrangement using a s.r.d. with a resonant transmission line. The diode acts as a short circuit while passing forward current, and continues to maintain this condition after the current reverses. When all the current carriers have been swept out of the diode it rapidly switches to an open circuit, shunted by the reverse capacitance of the diode. With a suitable drive level and bias voltage V_b it can be arranged that there is a maximum current in the inductor L at the instant of switching due to L resonating with the diode capacity and the line impedance R_o, through the harmonic by-pass capacity C. The pulse generated across the diode travels down the line, is reflected at the open circuit, and returns to the diode. At this time the diode switches to forward conduction again. The energy therefore continues to be reflected up and down the line. It can be seen that the output is characterised by a forced phase synchronism of the waveform on the line. The frequency is therefore a harmonic of f_1 and independent of the line tuning. The line tuning of course, provides the selection of the required harmonic.

The quenched oscillator shown in Fig. 6 gives a similar spectrum to that of the step-recovery-diode multiplier, though this is normally used at lower frequencies. Transistor Tr_1 operates as a grounded-collector Hartley oscillator tuned by L and C to approximately the required harmonic frequency. Transistor Tr_2 is switched by f_1 causing the LC circuit to be heavily damped, thus stopping oscillation. The damping period must be sufficient to dissipate the stored energy in L and C. When Tr_2 switches off the circuit transient causes oscillation to restart, in the same phase every cycle of f_1.

In our initial consideration of mixing, Fig. 3, it was seen that simple switching of one frequency by another produces the $f_2 \pm f_1$ frequencies wanted for addition or subtraction. Mixer circuits normally apply such a switching action, though f_1 and f_2 are usually in sinusoidal form.

Figure 7(a) shows a transistor mixer in simplified form. Source f_2 switches the transistor into conduction on positive half cycles and the lower amplitude source f_1 modulates the amplitude of the pulses producing the output shown. This has components at $f_2 \pm f_1$, but simple inspection shows that there are also components at f_1 and f_2.

The possibility of cancelling components has already been mentioned and Fig. 7(b) is a reasonably obvious modification of Fig. 7(a) to provide cancellation. In (b) the two transistors

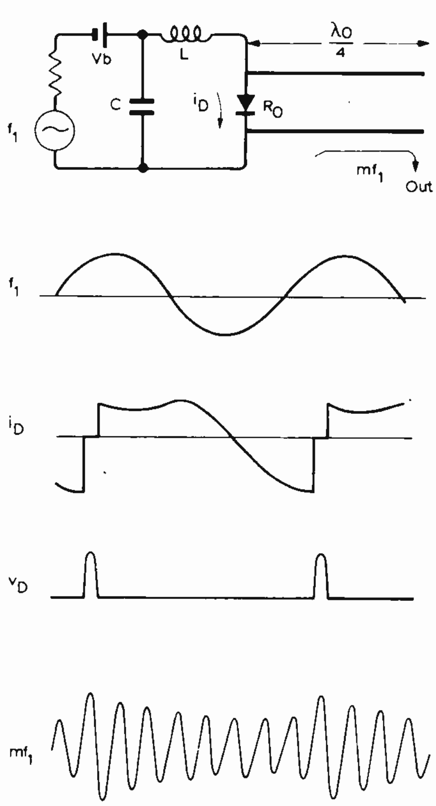


Fig. 5. *Circuit diagram and waveforms for a step-recovery-diode multiplier on a resonant transmission line. When conditions are right, the diode switches to open circuit and the pulse generated across it travels down the line, is reflected, and returns to the diode. At this time the diode switches to forward conduction again and the process is repeated – the pulse being reflected up and down the line at a frequency equal to a harmonic of f_1, depending upon the line tuning. See text.*

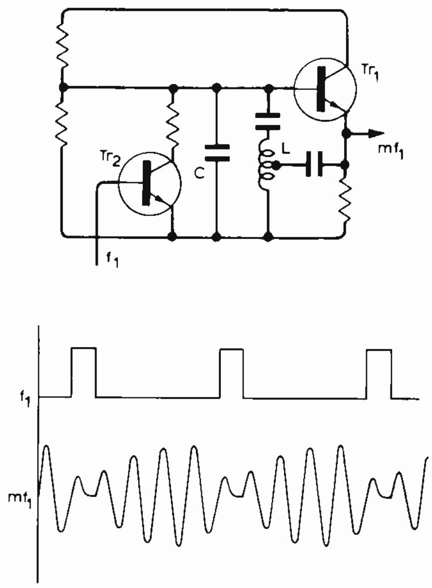
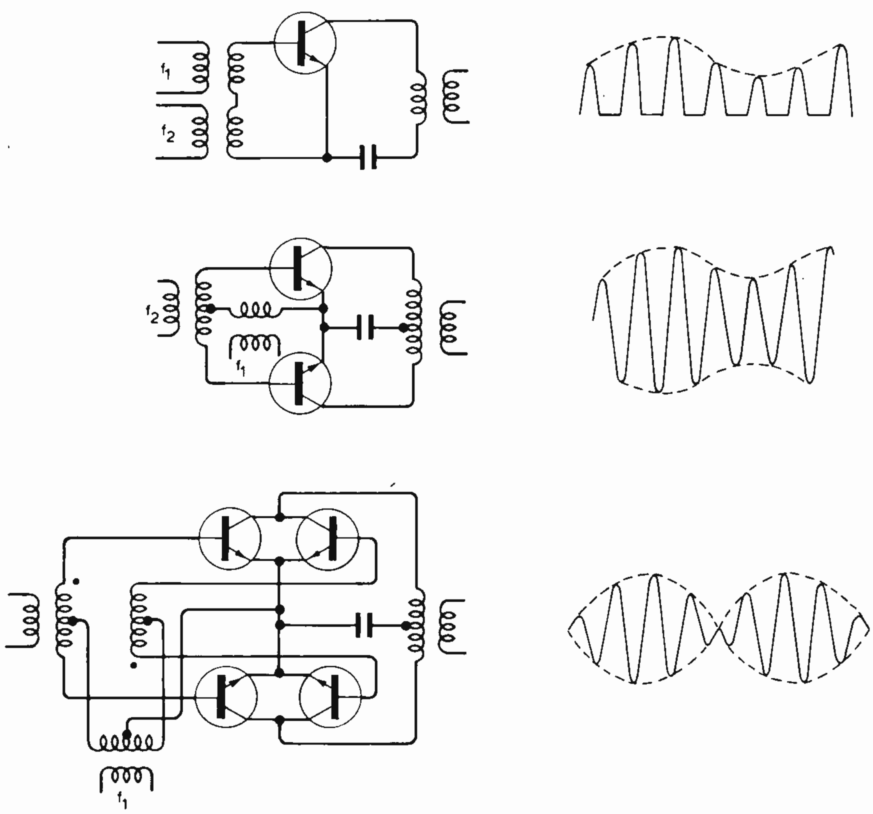
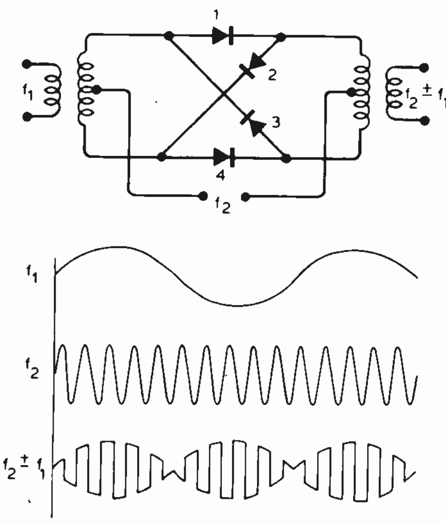


Fig. 6. *Quenched oscillator circuit which provides a similar spectrum to the multiplier in Fig. 5. See text.*

Fig. 7. *Circuit (a) is a simple transistor mixer which produces frequency components at $f_2 \pm f_1$, f_1 and f_2. In circuit (b) the f_2 components in the two transistors are in antiphase, resulting in a waveform having no f_1 component. Circuit (c) consists of two type (b) circuits and produces a resultant waveform having neither f_2 or f_1 components.*





◀ **Fig. 8.** *Circuit and waveforms for a diode ring modulator. This circuit produces a waveform having only $nf_2 \pm f_1$ components.*

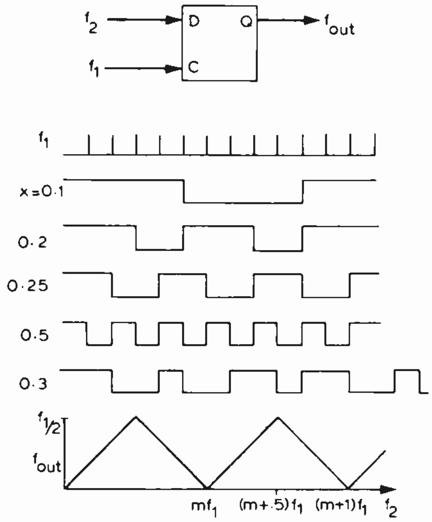


Fig. 9. *Logic bistable used as a mixer.* ▶ *Waveforms shown are outputs resulting from (m + x) cycles on D, where m is an integer. Transfer characteristic, also shown, has both a positive slope and a negative slope indicating that increasing f_2 may increase or decrease f_{out}, depending upon the frequency ratio of f_1 and f_2.*

operate similarly to that in (a) but the f_2 components are in opposite phases in the two transistors. The resulting output waveform has no f_1 component and is in fact the waveform of a conventional amplitude modulated carrier.

The logical step from the method used in Fig. 7(b) is to arrange the cancellation of f_2 as well, as shown in Fig. 7(c). This consists of two circuits of the type shown in (b) with antiphase f_2 signals. The phase of the zero crossings, at the frequency f_2, reverse every cycle of f_1, and there is in fact no frequency component at f_2. The waveform shown is that of a suppressed carrier, double sideband signal.

Mixers that suppress only one of the input frequencies are called balanced and those that suppress both of the input frequencies are called double balanced.

While the transistors in the mixers of Fig. 7 are conducting, they can introduce spurious mixing products due to the nonlinearities of the transistor characteristics. Many mixers use diodes or transistors as near ideal switches and the most common circuit is the diode ring modulator shown in Fig. 8. In this modulator the amplitude of f_2 is much larger than f_1 and switches on diodes 1 and 4, or 2 and 3. This chops the f_1 signal as shown, producing an output having suppressed f_1 and f_2 components. High drive levels and fast-switching Schottkey diodes are used to make the circuit operate as an ideal switching mixer. The only terms in the output are $nf_2 \pm f_1$, giving good separation of higher order products; that is, no $nf_2 \pm mf_1$ terms.

Another type of mixer uses a logic bistable. This 'D' flip flop, which is readily available in integrated circuit form, when clocked, simply transfers the logic state on its D terminal to its output. If two separate frequencies are applied to the D and clock inputs, the output waveform will contain a beat frequency pattern varying as the two waveforms move with respect to each other. Figure 9 shows the types of output waveform obtained with such a mixer and the mixer transfer characteristic.

Any number of cycles may occur on the D terminal between clocking pulses. If there are an exact integral number of cycles, the logic level on D at the clocking instants will always be the same. The output will be d.c. If there are $m + x$ cycles, where x is a fraction of a cycle, the level at D will vary between some successive clocking instants. Where $1/x$ is an integer, the output will be a simple waveform with a fundamental frequency equal to xf_1 or $(1 - x) f_1$, see Fig. 9.

When $1/x$ is not an integer, the fundamental frequency will be a subharmonic of xf_1, with xf_1 being present as a harmonic of that.

An important point to note is that there is a positive slope and a negative slope on the mixer transfer characteristic. This means that increasing f_2 may increase or decrease f_{out}, depending on the frequency ratio of f_1 and f_2.

Part 2 of this article will discuss frequency division circuits which use digital binary counters. It will also explain how prescalers can be used to extend the frequency range of such circuits.

The author

Raymond Thompson was born in Belfast but has spent most of his life in England. He was educated at Cheltenham and Birmingham Technical Colleges, and in 1960 joined the Plessey Company at West Leigh. In 1966 he went to Westinghouse Research in the USA where he worked on the design of high power convertors and inverters, including special inverters for h.f. fluorescent lighting and lightweight power supplies for X-ray units. In 1969 he rejoined Plessey and he is currently at their Roke Manor Establishment designing v.h.f. and u.h.f. digital radio systems for military applications. Raymond Thompson has had several papers published, including two articles in *Wireless World*.

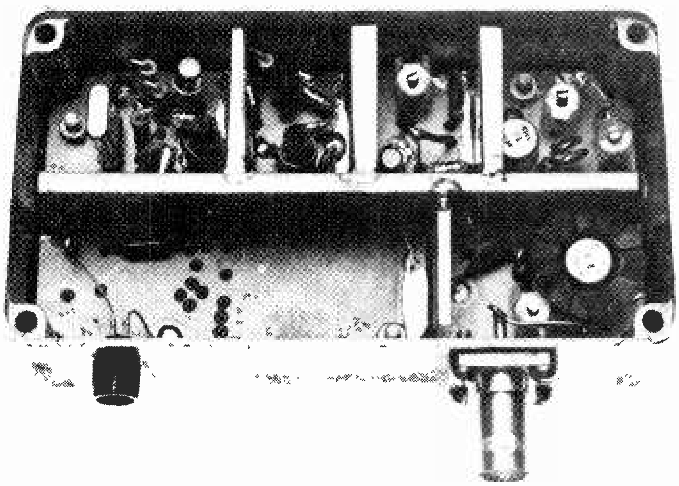
Versatile microwave source

Multiband unit comprises u.h.f. source and step recovery multiplier

by **G. D. Lean,** B.Sc., A.R.C.S., M.I.E.E.

Designed for simple communication links using Gunn diodes in either professional or amateur equipment, this unit improves frequency stability and reduces bandwidth. It can also be used as a replacement for klystrons in radar assemblies and communication systems. Comparing favourably in noise output to many earlier designs of solid-state sources it offers simplicity and improved reliability.

THIS SIMPLE MULTIPURPOSE microwave source is capable of providing milliwatts of r.f. power at frequencies between 4.5 and 8GHz. It can be used as a local oscillator or as a lower power transmitter or driver with frequency modulation of up to 80kHz peak-to-peak deviation. By using scaled versions of the final



Modulation amplifier Tr_6 of Fig. 1 can be situated in bottom left-hand compartment of this u.h.f. driver.

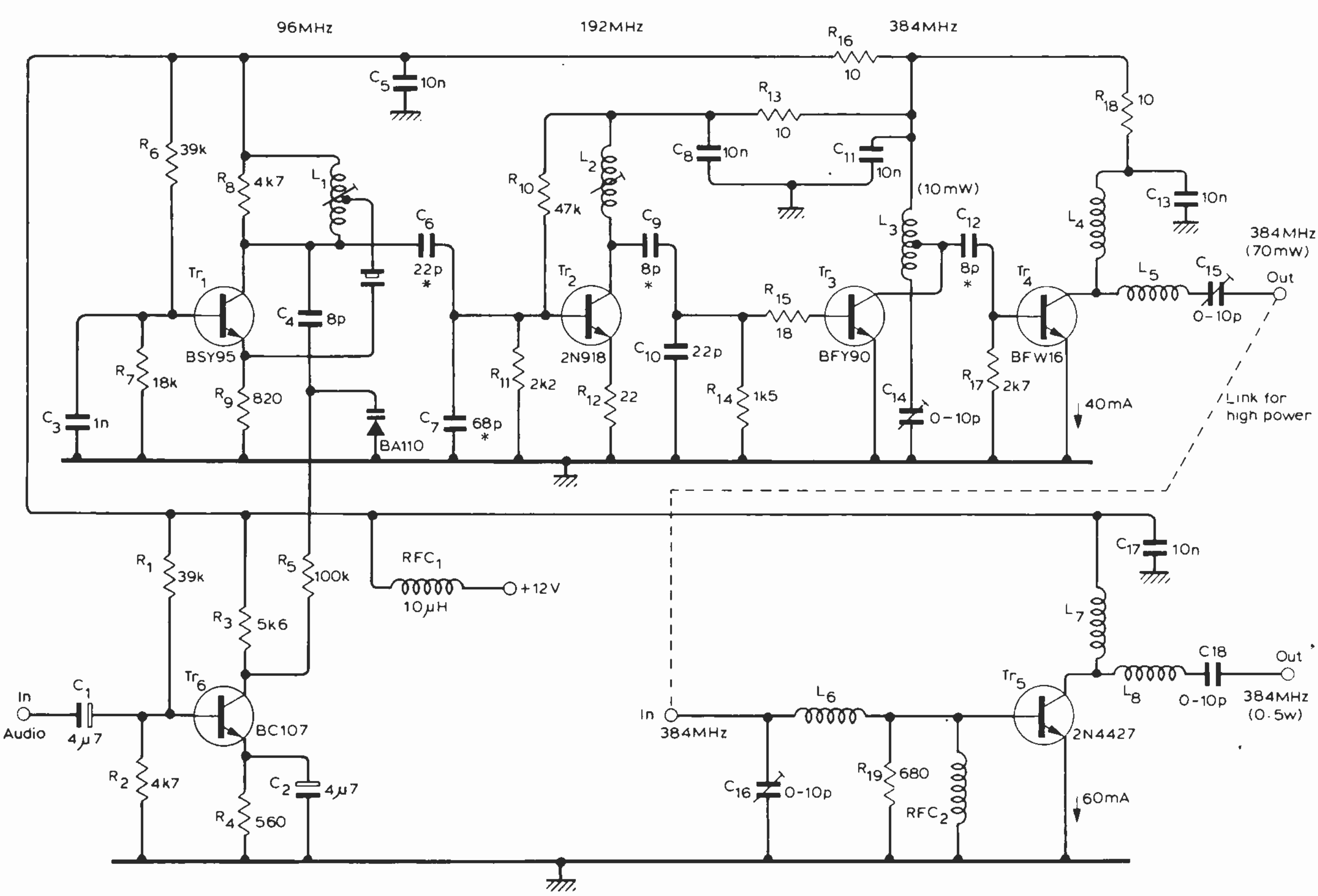


Fig. 1. *Capacitor valves marked thus * in this driver circuit should be adjusted on test for best results. Variable types are Mullard C80905/02. Decoupling capacitors are ceramic discs and others have a polystyrene dielectric.* *See p. 56 for inductor details.*

multiplier, frequencies in the range 2.5, 4.5GHz and 8.0 to 12GHz can also be obtained. Output powers in the range 1 to 10mW can be achieved depending on the output frequency and the varactor in use. The source comprises three separate units which can be built and tested separately: a u.h.f. driver, step-recovery multiplier, and harmonic selection filter.

Driver circuit

The driver circuit develops about 500mW of power at around 384MHz, with an optional output of 50mW so that Mullard modules BGY22 can be driven to operate high power multipliers for transmitter or up-convertor applications. The circuit shown in Fig. 1 is an adaptation of earlier designs[1] originally based on a compact transmitter design by G3TDZ. It uses readily available cheap transistors and the complete unit can be built for less than £10 including the crystal.

The crystal oscillator stage uses a fifth overtone crystal to give positive feedback from collector to emitter with L_1 tuned to the overtone frequency of 96MHz. Slight pulling of the oscillator can be achieved by adjusting L_1 so that the exact crystal frequency is obtained. The variable-capacitance diode and capacitor C_4 form part of the tuned circuit together with L_1, C_6 and C_7, and changes in varicap bias cause slight frequency shifts in the oscillator. The resultant narrow band f.m., with a peak deviation of about 1kHz at the crystal frequency, produces adequate deviation for telephony communication when multiplied up to the microwave bands. Transistor Tr_6 gives some gain for the modulation voltage and provides d.c. bias for the varicap diode via R_5. Resistor R_8 damps coil L_1 and prevents any tendency for self-oscillation of Tr_1 due to its internal collector-emitter capacitance. Oscillation should cease if the crystal is removed and should not vary by more than 10kHz as L_1 is tuned. Capacitors C_6 and C_7 form a capacitive tap to match into the base of the first doubler stage. Components L_2, C_9 and C_{10} form a tuned circuit at 192MHz and provide matching into the second doubler Tr_3. About 10mW can be measured at L_3 and C_4 (384MHz) by using a one-turn coupling loop feeding a power meter. Resistor R_{15} is a base "stopper" to prevent parasitic oscillations which are common in BFY90 amplifiers.

Matching into the first amplifier is achieved by tapping the coil L_3 and selecting C_{12}. About 70mW can be measured at the output of Tr_4, which is driven into conduction by the self bias created across R_{17}. Components L_5, C_{15}, L_6, C_{16} form a two-stage matching network going through 50 ohms at the link point. For low power requirements the final output can be connected to C_{15} instead of the wire link. For higher power Tr_5 gives the extra gain to provide 0.5-watt output at C_{18}. This final stage draws 60mA and is self-biased through RFC_2 and R_{19}.

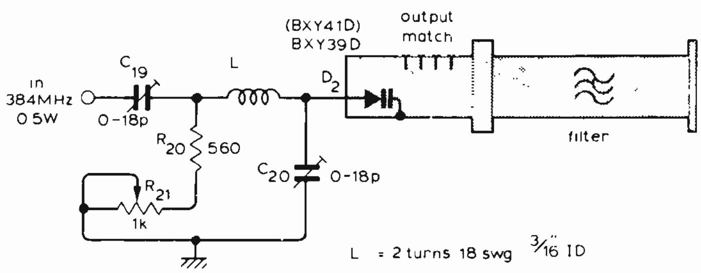


Fig. 2. *Step recovery multiplier gives a comb of frequencies spaced at 384MHz, one of which is filtered out, to give a few milliwatts at 5.76GHz. (Use BXY41D for X-band). Variable types are Mullard C80905/03.*

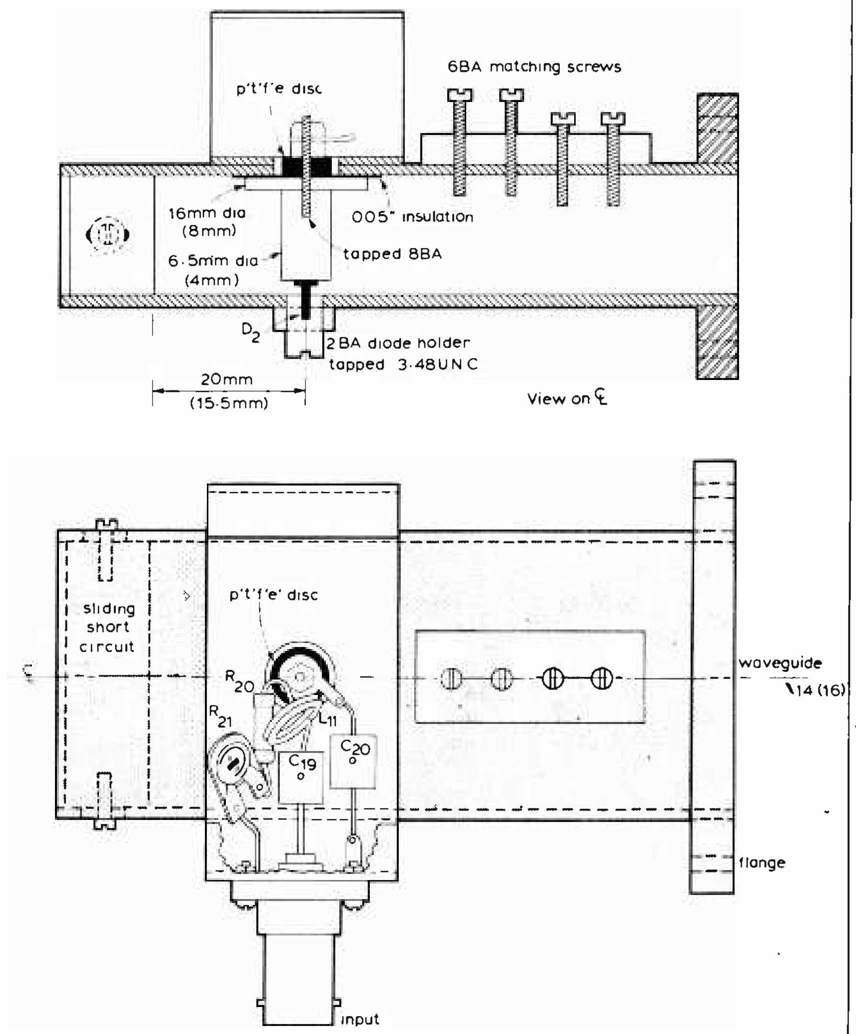
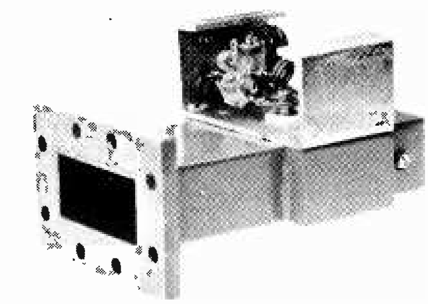


Fig. 3. *Step recovery multiplier unit and matching for 5.6 to 6GHz. Dimensions in brackets apply for 10.4GHz in waveguide 16.*

Driver construction

The unit is constructed on double-sided glass-fibre board, etched on one side as shown in the diagram. For "one-off" production the easiest way is to photocopy the pattern and stick the copy onto a suitably-sized piece of board. Then drill through the paper into the board and clean up the holes carefully. Mark out the circuit using an etch-resist pen or resistant transfers and completely paint over the earth plane side.



This view of the step-recovery multiplying circuit omits screening cover and matching screws.

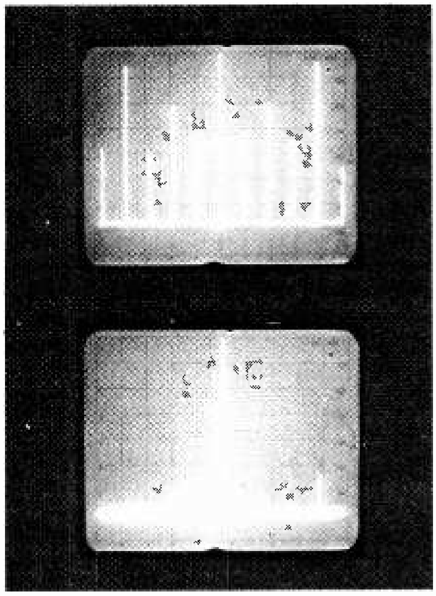


Fig. 4. *Multiplier output at 5.76GHz has 300 kHz bandwidth (top), improved to 30kHz by Fig. 5 filter (bottom). Horizontal scale 100MHz/div.*

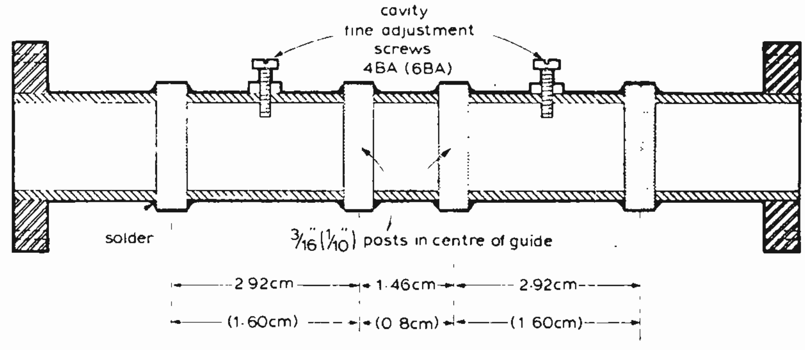


Fig. 5. *Two-section filter has 25MHz bandwidth at 5.76GHz. Dimensions in brackets refer to 10.4GHz in waveguide 16.*

Then etch the board and remove the resist. Countersink the holes on the earth plane side and fit pins to provide the external connectors. Copper or tinplate screens can then be soldered to the top side and coils L_1 and L_2 fitted. Fit the components, starting with the oscillator stage and test each stage before starting the next. Finally when the board is finished and tested mount it in a small die-cast box on 6BA nut spacers beneath the underside of the board. Modulation input, power supply and r.f. output connections can then be taken through convenient sockets in the box sides.

Multiplier design and construction

The multiplier shown in Figs. 2 & 3 is a C-band version of an X-band design[2] by P. Tunbridge (G8DEK) which uses a Mullard varactor diode to generate a comb of frequencies, one of which is selected by the output filter. The input matching components are L_9 and C_{19} while C_{20} provides some capacitance trimming to the input capacitor formed inside the waveguide by the shaped diode-support pillar. Resistors R_{21} and R_{20} provide a d.c. bias return for the varactor; these are low impedance to give improved high-order multiplication. Matching into the waveguide is provided by four tuning screws in the broad face of the waveguide together with a sliding short circuit which provides a resonant cavity at the output frequency.

First fabricate two cover mounting blocks, a diode holder nut and a matching screw block from brass, and solder these to the waveguide, together with a suitable flange. The matching screw holes can be drilled and tapped into the block and guide and only three holes spaced at λ/8 are all that are strictly necessary. However, if four or five holes are drilled at about 7mm spacing, a wider range of output frequencies can be accommodated. Two slots for the short circuit can be cut in the narrow face of the waveguide and a 3/16-in hole in the broad face for the connection to the diode support pillar. Underneath the guide the diode-holder nut should be cleared with a 2BA tap which should also continue the thread through the waveguide wall. Screwing a pointed tap right the way through until it touches the top wall will mark the position for the connection hole which can then be pilot drilled through the nut. A diode support pillar can either be turned down from a brass bar or made up of a disc of 16 s.w.g. brass or copper soldered to some ¼-in brass rod. The broad end is tapped 8BA for the connection screw. A disc of insulation material such as Micalex or just Sellotape is placed on the top of the pillar which can then be slid into the waveguide under the 3/16in connection hole. A thin 3/16-in dia insulating washer is then dropped in the hole to centralize the pillar. A further ¼-in insulating washer is used with an 8BA bolt and tag to clamp the pillar and provide electrical connection to the diode.

The diode holder is made of 2BA copper studding with a tapped hole in one and for the diode. Some diodes have untapped ends and a 1/16-in hole is all that is required to mount them in the holder. Two side cheeks of 16 s.w.g. aluminium are bolted to the cover-mounting blocks with one supporting the BNC input socker. The rest of the input components can then be soldered into circuit.

Testing

Select a Mullard BXY39D for 5.7GHz (a BXY40D may give more output around 6GHz). This should be screwed into the diode holder using a dab of thermal grease on the threads. The holder is then screwed into the multiplier unit so that the diode flat contacts the bottom of the support pillar firmly, but not too tightly. A lock-nut should then be tightened on the diode holder.

Inductor details for Fig. 1

L_1	five turns 22 s.w.g. wire tapped one turn from "cold" on 3/16-in dia former and slug.
L_2	three turns 22 s.w.g. wire on 3/16-in dia former and slug.
L_3	half turn 18 s.w.g. wire loop tapped halfway.
L_4, L_5	one turn 18 s.w.g. wire.
L_6	½-in of track.
L_7, L_8	one turn 18 s.w.g. wire.
RFC_1	10μ H.
RFC_2	two turns 26 s.w.g. on ferrite bead.

With the diode in place the v.h.f. source can be connected and powered. A 96MHz crystal will result in an output of the driver source at 384MHz, which when fed into the multiplier produces a comb of frequencies from about 4 to 10GHs with a spacing of 384MHz. Some products of 96MHz and 188MHz are also present, depending on the purity of the driver output.

Alignment of the multiplier is best carried out with a spectrum analyser, but if the filter described below is made it is possible to align the multiplier with only a diode detector or power meter. Using the analyser the required final frequency is displayed together with the two adjacent 384MHz spaced frequencies. Frequencies every 96MHz will also be present about 30dB below the 384MHz harmonics. First slide the short circuit in or out until maximum power is obtained at the output frequency. Then adjust C_{19}, C_{20} and R_{21} again for maximum power of the output. There is some interaction between R_{21} and the capacitors; R_{21} should be set in several positions whilst C_{19} and C_{20} are adjusted for optimum each time. When no more improvement in output can be obtained from the input tuning, a 6BA tuning screw can be tried in each hole in turn until the best output is obtained. It is then left in the hole. More screws should be tried in the holes until the required output frequency is peaked about 6dB more than other harmonics with the ±96MHz products well down, as shown in Fig. 4 (top). Output purity can be much improved with the filter, see Fig. 4 (bottom).

Filter

The filter is a two cavity design, adjustable from about 6.1 to 5.2GHz with the dimensions given. The design was achieved by accident as a gross mathematical error resulted in incorrect theoretical dimensions which work well in practice. Basically if a post is put in the centre of waveguide it creates a large susceptance which reflects the incident wave. If another post is a quarter wavelength away from the first it will create an equal and opposite susceptance which will cancel the effect of the first at one frequency. Two such pairs of posts spaced at a quarter wavelength will cancel any residual susceptance giving unhindered matched transmission to the design frequency. This simple theory doesn't work exactly in practice and the modified dimensions should be adhered to. The dimensions can be scaled for other frequencies, remembering to scale waveguide dimensions to λ_g rather than the free-space wavelengths. Scaled versions have been made up to 11GHz and perform just as the 5.7GHz version shown in Fig. 5.

Construction is fairly obvious and for quick prototypes the posts need not be soldered into the guide but just pushed into tight fitting holes drilled through the guide. As the 4BA tuning screws are screwed in, the pass-band frequency is reduced and the response at mid-adjustment is shown in Fig. 6. Without a spectrum analyser the filter can be adjusted first on a fundamental signal source such as a Gunn diode[3] or klystron whose frequency has been adjusted using a wavemeter. Once the filter is aligned on the correct frequency the multiplier can be adjusted for maximum output through the filter. The filter can the be slightly readjusted for maximum

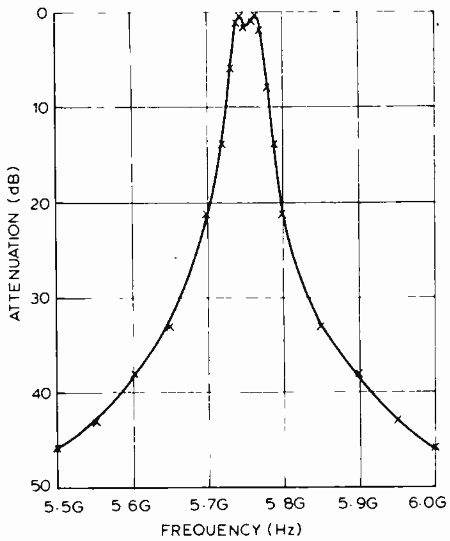


Fig. 6. *Response of two-cavity filter as measured at mid-adjustment of the tuning screws*

output on the exact frequency multiple; it is unlikely that the wrong harmonic has been chosen unless the original frequency measurement using the wavemeter was more than 188MHz out of true. Provided an output of 3 to 5mW is obtained through the filter it is unlikely that any spurious products are present.

A single cavity version of the filter can be made for simple equipment when total suppression of other products is unnecessary. The suppression of out of band products is about half that of the larger two-cavity design.

The multiplier input will accept frequencies in the range 350 to 450MHz and so 432 MHz low-power f.m. transmitters can feed into the multiplier via an attenuator, although for amateur band use not all the bands can be covered as would be possible with a single 384MHz generator. It is also possible to change crystals in the generator to produce local oscillator frequencies suitable for use with low intermediate frequencies. But to obtain the best results high intermediate frequencies (140MHz) should be used to reduce local oscillator noise getting into the receiver. This does mean that a separate local oscillator is required for each band, but for a low-power transmitter a single modulated u.h.f. source can be used with several multipliers for all the bands.

A printed board pattern and component layout appear on page 63.

References

1. Lean, G.D. Simple solid-state converter & tripler, *Radio Communication* 1976, page 506.
2. Tonbridge, P. M. Multiplier 10GHz varactor, *Radio Communication* 1976, page 202.
3. Hosking, M. W. Microwave voice link, *Wireless World*, vol. 83, October 1977, pages 49-52, and November 1977, pages 69-71 & 92.

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continued from page 40

them situated peripherally and at present served with Radio 4 by local m.w. booster stations will get a much weaker signal and one more vulnerable to electrical machine noises.

But what about the discriminating public; i.e., the people who appreciate the merits of the f.m. service and are prepared to pay for it? They have already found that many BBC programmes are *not* available on v.h.f. It is all very well to be repeatedly reminded that with three-waveband receivers they can get all that the BBC offers, but these reminders studiously refrain from mentioning that owing to the increasing practice of subdivision many of the programmes are, and will continue to be, available only on a second-class service, i.e.,

(1) No stereo
(2) Lo-fi (restricted audio frequencies)
(3) Greater liability to noise

As regards those programmes that *are* on v.h.f., in fairness to Mr Redmond again I must recall that his impatient awaiting was for *portable* v.h.f. radios. Ever since v.h.f. receivers became available in quantity, some of the better-class non-portable models have included instant tuning. The wonder to me is that anyone has the nerve to market any such model without this facility. And I cannot see any major problem in extending it to portables. In fact, being no longer in touch with the trade I was really astonished by the authoritative statement that such sets were still being awaited — hence my present eruption into these now usually erudite and well-behaved pages.

Having, as I said, every sympathy with the general public in rejecting as totally outmoded and unacceptable a technology that requires from them a skilled and time-wasting procedure every time they want to change programmes, I suspect that there are many households that have several sets, each permanently tuned to one of the limited number of channels they use. Perhaps this wasteful solution is so good for the radio trade as to account for the tardiness of that trade in fulfilling Mr Redmond's earnest hopes.

Finally I will seize this opportunity to protest about what I regard as that design monstrosity advocated — I am sure very reluctantly and unwillingly — by the BBC; the combined f.m. and a.m. receiver. The design requirements are so different that a receiver which works on both is almost two different sets in one. A few years ago an even worse monstrosity was put before the British public: the combined 405 and 625 line TV set, which consisted virtually of two quite different — opposite, really — receivers with a very complicated multi-contact (and therefore doubtfully reliable) hard-to-turn switch. I refused utterly to admit such a thing to my home, and did without colour until all-625-line sets were available. The solution to that problem was to provide all the programmes on one system.

The same solution is the only right one for radio. So *my* impatient waiting is for a broadcasting system in which *all* the programmes are obtainable on v.h.f. If they, or some of them, are also available on a.m., so much the better. But we ought to be able to go back, if we wish, to the v.h.f.-only receiver. It can be done by making available here more of the 88 to 108 MHz v.h.f. broadcasting band for the purpose of broadcasting, thus allowing the industrious student, the hard-working housewife, the parliamentary enthusiasts (if any), the pop addict and the music lover each to enjoy the benefits of f.m. stereo undisturbed.

Tunable audio equalizer

Flexible parametric equalizer with variable Q

by Martin Thomas

MOST AUDIO EQUALIZER circuits represent a compromise between cost, facilities and ease of use, and the Baxandall tone control has been by far the most successful design. For domestic audio equipment its simplicity and ease of use outweigh its disadvantage of providing only a limited degree of equalization, although the circuit can be modified to increase its flexibility[1]. Clearly, however, the "bass" and "treble" subdivision of the audio band is insufficient for many purposes, and the graphic equalizer approach of having a larger number of frequency bands becomes necessary. The only problem with this approach is that a large number of controls must be used to cover the audio band if the individual frequency bands are narrow, so even with this circuit the number of controls is a compromise.

Unquestionably the most versatile equalizer is the parametric, or tunable, type. In its simplest form it can consist of only a single boost/cut element, but its centre frequency can be varied continuously over a wide range (possibly over the whole audio band), and the Q can also be varied so that either a broad or a narrow frequency band can be equalized. This approach allows almost any equalization requirement to be met with only a small number of such elements, and since the elements are identical, no more than are actually needed can be connected together for any particular application. A parametric equalizer may not be so straightforward to use as a graphic equalizer, but once you become accustomed to the rather different controls it's much easier than you might expect.

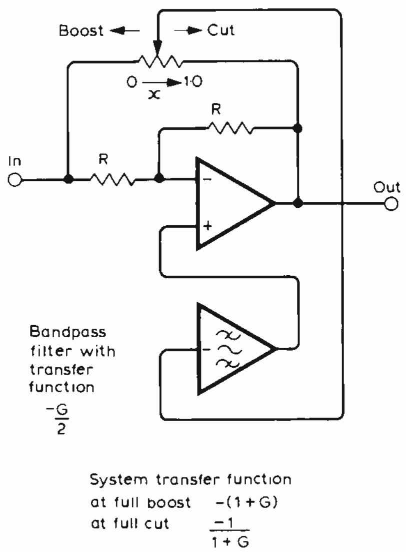

Fig. 1. *Basic equalizer design shows how to achieve either boost or cut with a single active element.*

Circuits of this type have been around for a number of years, but relatively little has been published about them. In this article I shall take the opportunity to discuss some aspects of the design theory, in addition to describing my own design. The circuit has continuously and independently variable centre frequency, boost/cut amplitude and Q, and also allows a choice of two different sets of boost/cut amplitude-frequency response curves as the control setting is varied; more about that later.

The circuit for a tunable equalizer can be broken into two sections, by which point the basic design is almost complete! The first problem is how to use a single active element either to boost or to cut a given frequency range, and this can be achieved by the circuit shown in Fig. 1. The filter used in the present design is phase-inverting, so its output is connected to the non-inverting input of the amplifier to give overall negative feedback. With this connection there is a gain of two from the filter output to the amplifier output, so the filter transfer function is specified as $-G/2$ to express the system transfer function in its simplest form. When the boost/cut potentiometer is at either end of its travel, the filter is entirely in either the forward or feedback signal path, giving transfer functions of $-(1 + G)$ and $-1/(1+G)$ respectively. An exact expression for the transfer function at other control settings will be developed later, but for now notice that when the control is at its midpoint, the forward and feedback contributions will be equal, giving a transfer function of -1 ("flat"). An extension of this circuit to include several filters and potentiometers yields the basic design for a graphic equalizer, of course, and a typical circuit is described in ref. 2.

The second problem is the design of the tunable filter. In theory this is very simple, but there are several practical difficulties. Although capacitors can be switched to change the frequency range, the variable control clearly has to be resistive, which rules out some otherwise very promising circuits such as the multi-feedback filter[3], since the Q will then also vary. The Wien-bridge configuration does meet this requirement if the resistors in the forward and feedback arms of the bridge are varied together[3], but the Q is sensitive to mismatch between these resistors. As the

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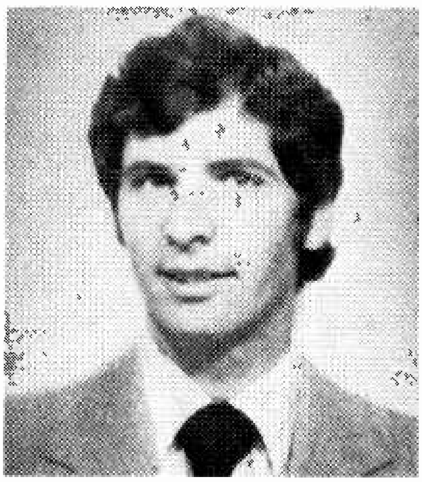
His audio interests developed while he was at Cambridge, and he designed the prototype for the equalizer there. He says his research activities aren't directly related to his audio and electronics interests, although in practice there's a lot of overlap between them. Using ion-specific dyes to follow changes in ion concentrations inside nerve and muscle cells during excitation is basically a technical problem. "I had to build a sensitive microspectrophotometer to be able to resolve the very small changes in dye absorbance, and it involved a fair amount of electronics."

Would he ever consider moving out of research and into industry? "That depends. Most companies really aren't very interested in my type of background, and I'd probably have to set up a business of my own. But I certainly wouldn't rule out doing that at some time in the future."



sensitivity increases with Q, the circuit is suitable for use only at low Q, and the long-term reliability is questionable, once the resistor tracks start getting dirty!

The state-variable filter, which is synthesized from integrators, meets the requirements very well, and has the additional advantage that it is inherently stable even at high Q. Its only drawback is that it uses three operational amplifiers rather than one, but the number of passive components is almost the same as for other circuits, and it has been chosen for the present design. Fig. 2 shows the circuit diagram. Further information on state-variable filters is given in the appendix and in ref. 4, but the basic equations are reproduced below. Referring to the component values in Fig. 2, the transfer function is

$$\frac{V_o(s)}{V_i(s)} = -\frac{R_2(R_3+R_4)}{(R_1+R_2)R_4} \times \frac{R_6C_2s}{R_5C_1R_6C_2s^2+[R_1(R_3+R_4)/(R_1+R_2)R_4]R_6C_2s+R_3/R_4}$$

and the bandpass centre frequency is

$$\omega_o = \frac{R_3}{R_5C_1R_6C_2R_4}$$

For $R_3=R_4$, and $\omega_o = 1/R_5C_1 = 1/R_6C_2$, the transfer function becomes

$$\frac{V_o(s)}{V_i(s)} = -\frac{2R_2}{R_1+R_2} \times \frac{s/\omega_o}{s^2w_0{}^2 + [_2R_1/(R_1/(R_1+R_2)]\, s/\omega_o+1}$$

$$= -\frac{2R_2}{R_1+R_2} \times \frac{\omega_o s}{s^2+[2R_1/(R_1+R_2)]\omega_o s+\omega_o{}^2}$$

Comparison of this last equation with the generalized second-order bandpass transfer function

$$\frac{V_o(s)}{V_i(s)} = \frac{\omega_o A_o s/Q}{s^2+\omega_o s/Q+\omega_o{}^2}$$

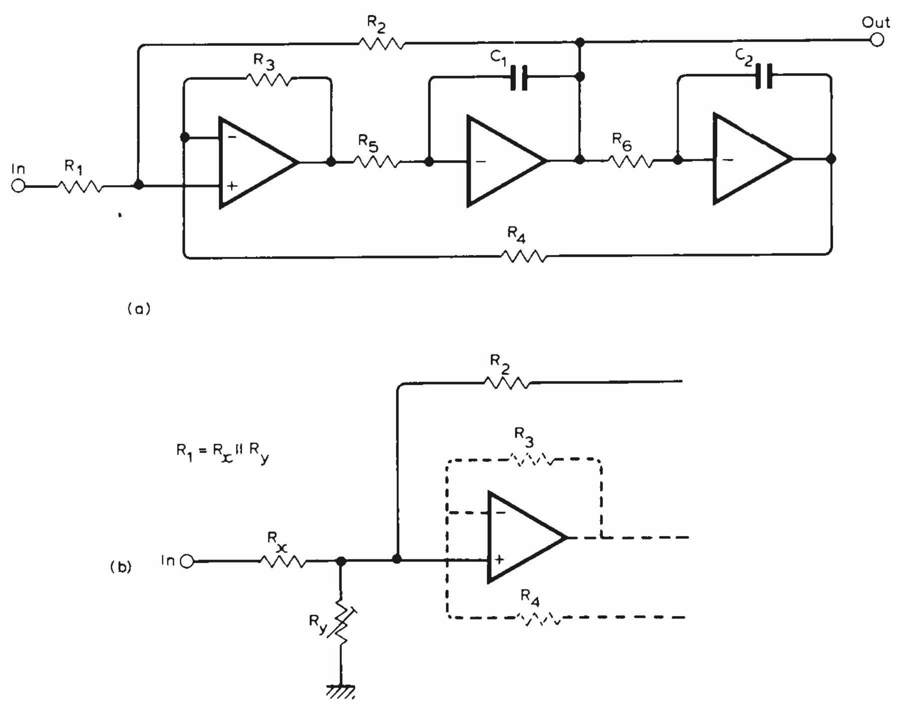
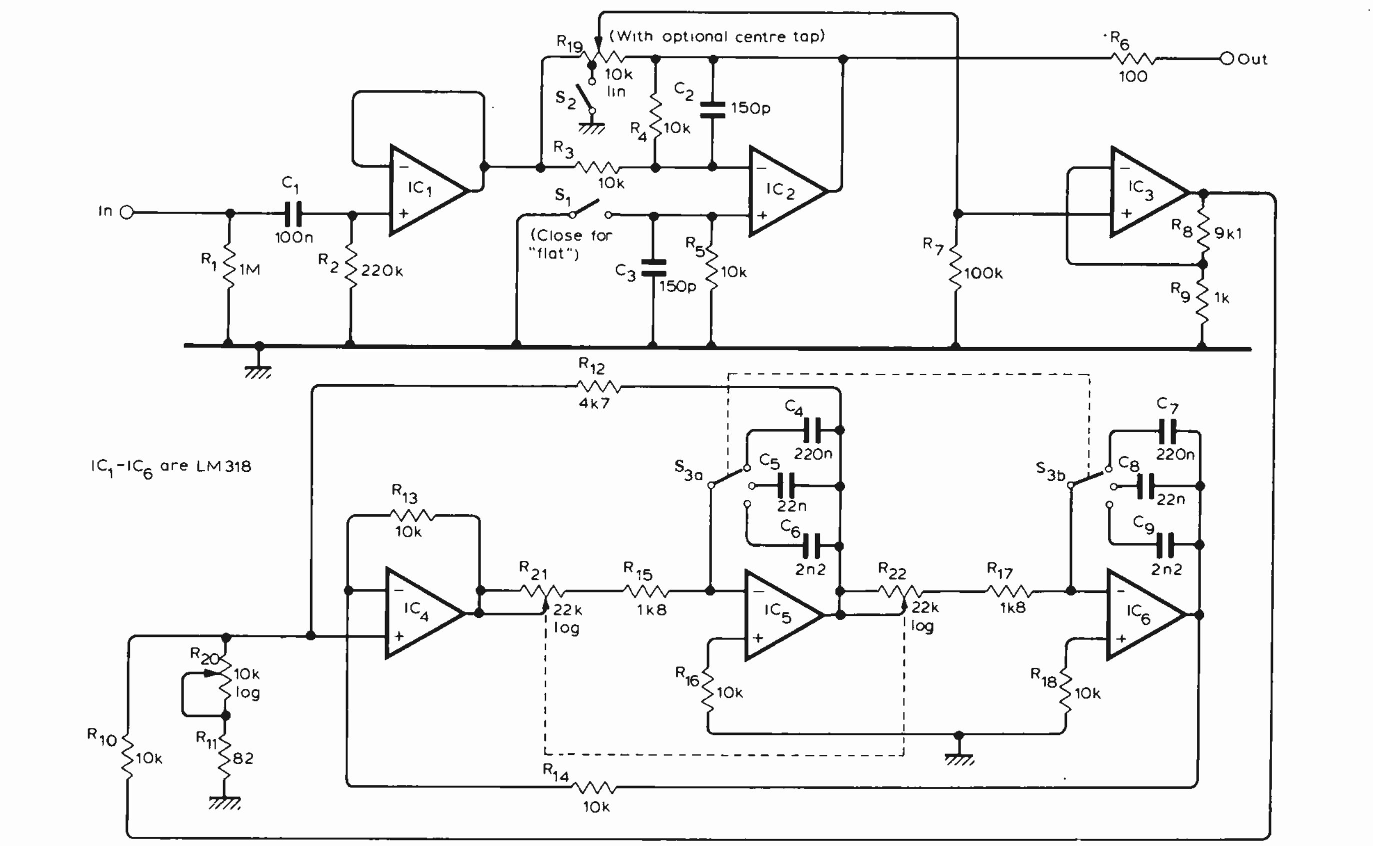


Fig. 2. *"State-variable" bandpass filter is inherently stable even at high Q, (a). Modification for constant centre-frequency amplitude, (b). Varying Ry gives independent control of Q.*

Fig. 3. *Circuit diagram for a single-section tunable equalizer. Ganged resistors $R_{21, 22}$ determine centre frequency, together with range switch S_3. Boost/cut control is R_{19} while Q is varied with R_{20}. Fig. 5 illustrates function of S_2.*



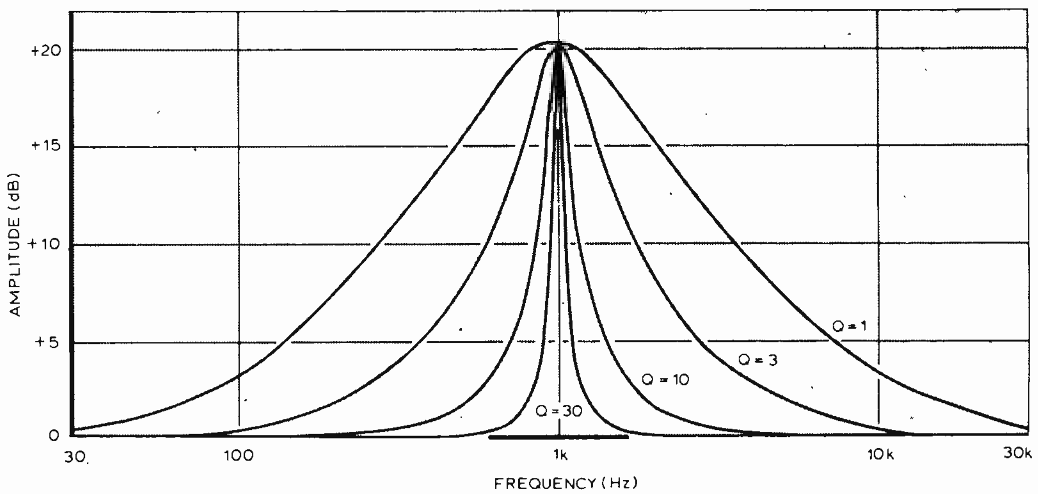


Fig. 4. *Effect of varying Q with boost/cut control at maximum boost.*

shows that Q is $(R_1+R_2)/2R_1$, and the centre-frequency gain A_o is $-R_2/R_1$. By varying R_5C_1 and R_6C_2 together, it is thus possible to vary w_o independently of Q and A_o. The Q will change if there is any mismatch between these two time constants (although A_o will remain constant), but you can see from the transfer function that the sensitivity does *not* increase with Q, and hence accurate component matching is *not* necessary.

The Q can be varied independently of ω_0 by varying R_1 or R_2, but this will also alter A_o, and the relation between A_o and Q is non-linear. Fortunately, a simple modification to the basic circuit, as shown in Fig. 2(b), overcomes these problems. Resistance R_1 is replaced by two resistors, R_x and R_y, so A_o is now — $R_2(R_x+R_y)/R_xR_y$. Resistors R_x and R_y also form an attenuator for the input signal, the gain being $R_y/(R_x+R_y)$. The overall filter gain is the product of these two terms, i.e. $-R_2/R_x$, hence by varying R_y the Q can be varied independently of the centre-frequency gain. The only disadvantage of this modification is that the overall centre-frequency gain of the filter with the component values used in the final design is only 0.5, so additional amplification in the filter path is necessary. The extra amplifier is placed before the filter, where it also provides the necessary low-impedance source.

The complete circuit is shown in Fig. 3. A low-impedance source is provided by IC_1 for the boost/cut control and its associated amplifier IC_2. The input amplifier for the filter is IC_3, and IC_4-IC_6 comprise the filter itself. Although the circuit may appear elaborate, the number of passive components is relatively small, and the size and component count can be reduced further if dual or quad ICs are used. It should be borne in mind, however, that the circuit was designed around the LM318, which is a high bandwidth device. Use of other ICs will result in inferior performance at high frequencies, although it may still be satisfactory for many applications, and possible substitutions will be discussed later on.

The present design is a general-purpose one, but the range of centre frequencies, boost/cut and Q can easily be modified if required. The centre frequency is determined by the ganged variable resistors R_{21}, R_{22} and by capacitors C_4 to C_9 (see Fig. 3). The variable frequency range is just over tenfold, and capacitor switching gives a total range of three decades, the nominal frequency ranges being 30 to 300, 300 to 3,000 and 3,000 to 30,000Hz. The range switch S_3 should be a make-before-break (shorting) type, so that the capacitative feedback paths around IC_5 and IC_6 are not interrupted during the instant of switching, otherwise the circuit could oscillate. The sliders of R_{21} & R_{22} should be connected to the clockwise end of their track, so that there is a d.c. path through the control even if the slider loses contact with the track, as the control has to provide a path for the input bias currents of IC_5 and IC_6. A logarithmic control has been specified, although it will have to be turned anticlockwise to increase the frequency, whereas a clockwise law would be preferable. A clockwise law can be obtained by using a dual antilog control (in which case the sliders should be connected to the anticlockwise ends of the tracks), but this component may not be readily available from most suppliers.

The boost/cut range is determined by the gain of IC_3 and the attenuator at the input of IC_4. There is a gain of two from the output of the filter network (at IC_5) to the output of the circuit (at IC_2), and a two-fold attenuation at the centre frequency through the filter itself, so the overall gain through the filter path at the centre frequency is given by the gain of IC_3, which is 10 with the component values shown in Fig. 3. Reference to Fig. 1 shows that the maximum boost and cut are $-(1+10)$ and $-1/(1+10)$, i.e. ± just over 20dB, but these values could easily be modified by changing the gain of IC_3, which is of course $(R_8+R_9)/R_9$. Input bias current for IC_3 is provided by the boost/cut control R_{19} and by R_7, which provides an independent path in case of poor slider contact in R_{19}.

The method of Q variation is as already described with reference to Fig. 2(b), and R_y is represented by R_{20} and its series resistor R_{11} in Fig. 3. The Q range of the circuit is 1 to 30 with the component values shown, and although the upper limit is unnecessarily high for many applications, the value of 30 was chosen simply because it can be achieved over the entire audio range when LM318s are used. It can be reduced by increasing R_{11}. Once again we have a law problem with the control; if R_{20} is a logarithmic control, the Q will increase as the control is turned anticlockwise. An antilog control can again be used to obtain a clockwise law (slider now connected to the anticlockwise end of the track), or a range of fixed, switch-selected Q values can be obtained by replacing R_{20} and R_{11} by a series of fixed resistors, Q being

$$\frac{R_{12}}{R_{10}//(R_{20}+R_{11})}$$

Obviously it is useful to be able to switch out the filtering, and this is achieved by S_1, which simply shorts the non-inverting input of IC_2. If the d.c. output of the IC_5 is not exactly zero, the d.c. output of IC_2 will shift when S_1 is closed, but the shift on the prototypes was only a few millivolts and did not cause any audible effects. In fact, the circuit is d.c. coupled throughout (apart from the input to IC_1), and it may be advisable to add a coupling capacitor at the output of IC_2 if the possibility of output offset cannot be tolerated.

The output resistor R_6 is not for protection, but rather to isolate any capacitative load from IC_2 to ensure stability. Capacitors C_2 and C_3 also help to ensure stability by rolling off the amplitude response above 100 kHz. The only other stability precaution — but which is perhaps the most important — is to decouple the ±15V supplies with

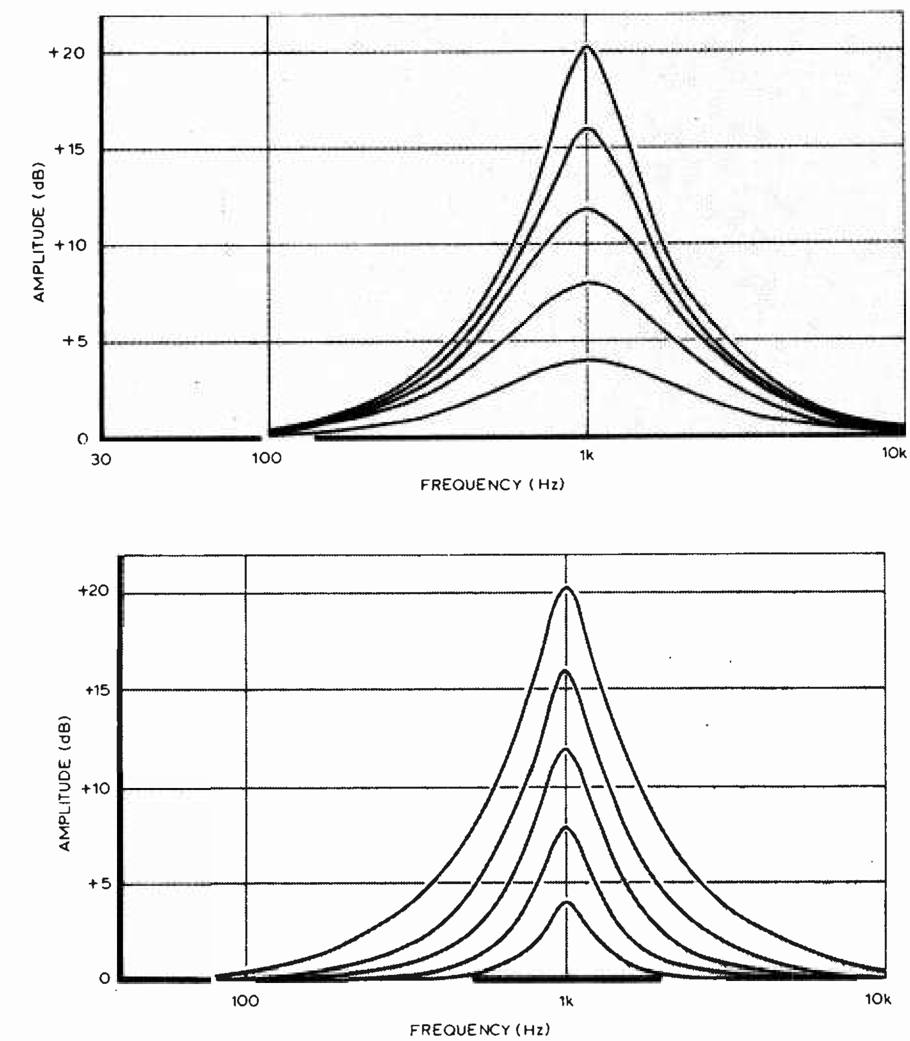


Fig. 5. *Two sets of amplitude-frequency response curves can be generated by the circuit with S_2 open circuit (a) and with S_2 closed (b). Corresponding cut curves are symmetrical about log. frequency axis.*

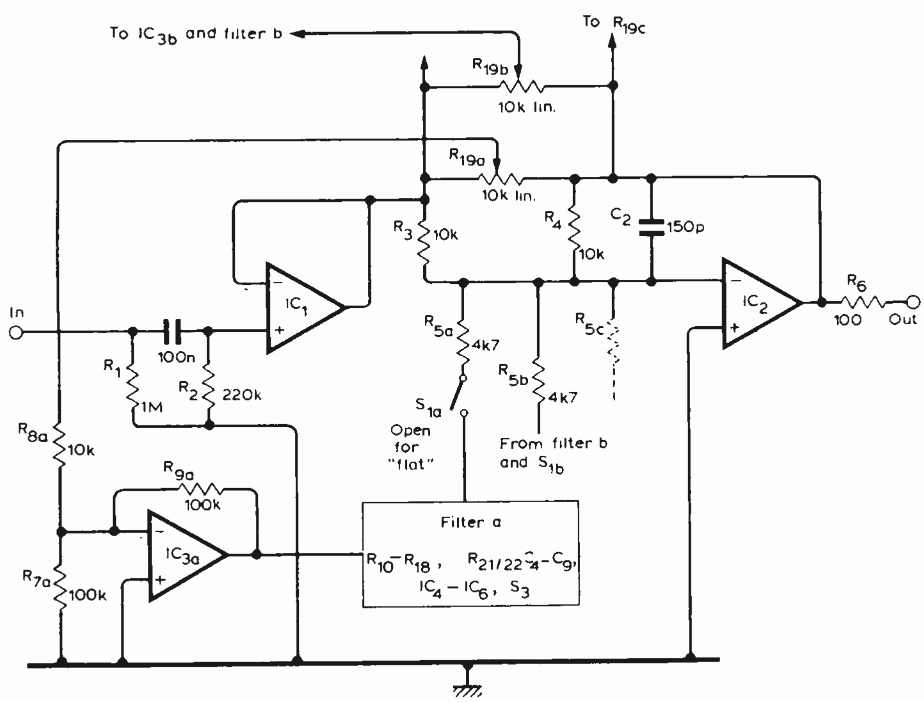


Fig. 6. *Modified circuit suitable for use with any number of filter sections.*

0.1μF capacitors. Such decoupling is very important with high bandwidth devices like the LM318, and if any instability problems are experienced, they can almost certainly be traced to this cause. On the prototypes it was found helpful to connect a capacitor directly between the supply lines in addition to the normal practice of decoupling between each supply line and ground, and the capacitors should of course be sited as close as possible to the ICs. In spite of the impression which may have been gained from these remarks, I was pleasantly surprised by the high stability of the prototypes, and there is no reason to suppose that such results cannot be obtained consistently if standard layout practices are followed.

Performance details of the circuit are given in Figs 4 and 5. These graphs have all been obtained for a centre frequency $\Omega/2\pi$ of 1kHz, but the performance for any other frequency in the audio band can be obtained by appropriately shifting the log. frequency axis. Only the boost curves are shown; the corresponding cut curves are symmetrical about the log. frequency axis. Fig. 4 shows the effect of varying the Q control when the boost/cut control is at maximum boost, and gives an idea of the very wide range of equalization curves which can be generated by the circuit. The centre-frequency gain remains independent of the Q control setting as the boost/cut control is varied, but the effect of the boost/cut control on the frequency response is not as straightforward as might be imagined. Fig. 5(a) shows the effect of the boost/cut control when R_{20} is set for a Q of 3, from which it can be seen that the Q is reduced as the control is rotated toward its centre ("flat") position. By a simple modification to the circuit, however, it is possible to generate the curves shown in Fig. 5(b), where the shape of the response remains relatively constant as the boost/cut control is varied. The reason why these two families of curves can be obtained may not be intuitively obvious, but it can be explained by the following analysis.

It has already been shown that the system transfer functions at full boost and full cut are given by $-(1+G)$ and $-1/(1+G)$. At intermediate positions of the boost/cut control R_{19}, both forward (boost) and feedback (cut) signals will pass through the filter. Let the fractional rotation of R_{19} be represented by x, such that at full boost $x=0$ and at full cut $x=1$ (see Fig. 1). Resistor R_{19} will act as a potential divider for the two signals, so the forward signal contribution to the transfer function will be $-(1+(1-x)G)$, and the feedback contribution will be $-1/(1+xG)$, which yields the system transfer function $-(1+(1-x)G)/(1+xG)$. This reduces to the forms previously given for $x=0$ and $x=1$, and to -1 (flat) when $x=0.5$. Gain G can be written as AN/D, where N and D are the numerator and denominator terms of G, and A is the centre-frequency gain through the entire filter pathway (including the A_0 term, defined previously), which is equal to 10 in the present circuit. The system transfer function now becomes

$$-(D+(1-x)AN)/(D+xAN).$$

Setting ω to 1 for convenience, we have $N = s/Q$ and $D = s^2 + s/Q + 1$.

We are now in a position to explain the curves in Fig. 5(a). When R_{19} is close to the full boost setting, x is close to 0. As x increases (R_{19} rotated away from full boost), the numerator of the transfer function is reduced, but since A is large this reduction will be small compared to the increase in the denominator. Thus when x is close to 0 the transfer function can be approximated by $-AN/(D+xAN)$, which is to say that as R_{19} is rotated away from the full boost position, the change in frequency response can be accounted for primarily by a change in the pole positions. The denominator of the transfer function is $s^2 + (1+xA)s/Q + 1$, so the effect of increasing x is to reduce the Q to a new value Q', equal to $Q/(1+xA)$, which explains the curves in Fig. 5(a). An analogous argument can of course be developed to explain the symmetrical form of the corresponding cut curves when x is close to 1.

Whether or not the behaviour in Fig. 5(a) is desirable is a debatable point, but fortunately one can have it both ways! Suppose the feedback end of R_{19} is grounded instead of being connected to the output of IC_2. The circuit will now only boost, and the transfer function will be $-(D+(1-x)AN)/D$. Since A is large, the transfer function can be approximated by $-(1-x)AN/D$ except when x is close to 1, so the major effect of changing x is now to change the centre-frequency gain without affecting the Q. The response curves obtained under these conditions are shown in Fig. 5(b).

There are several ways of modifying the circuit to obtain these curves, and the method used is to some extent a matter of personal choice, but here are three! First, changeover switches could be used to ground one or other end of R_{19} to obtain either the boost or cut curves. Second, the gain of IC_3 could be made variable, when the curves in Fig. 5(b) would be obtained with R_{19} at maximum boost. The third possibility is my personal favourite, and I have indicated it on the circuit diagram (Fig. 3). This is to use a centre-tapped control for R_{19} (I really must apologise for continually recommending obscure potentiometers!) and to ground the tap via S_2 to obtain the Fig. 1(b) curves. The advantage of this method is that the boost/cut setting is determined only by the control setting, just as before, although the control law will be changed. As will be appreciated from the change in the form of the transfer function, the centre-frequency gain will approach 0dB less rapidly as the control is rotated towards its midpoint when the centre tap is grounded. Well, you can't have everything!

This effect can be reduced, however, by connecting a 1kΩ resistor between the slider of R_{19} and ground when the centre tap is grounded, which will mean using a double-pole switch for S_2. The compensation is not exact, but it reduces the worst-case centre-frequency mismatch to below 3dB. The ultimate solution would be to replace R_{19} by two parallel chains of resistors, one of which is grounded at the centre, and to select a point along one or other chain by a multiway switch. The resistor values would be chosen to obtain equal dB steps between the switch points, and it would probably be much quicker to determine the correct values

State-variable filters

Although the present circuit uses the state-variable approach to provide only a bandpass filter, highpass (HP) bandpass (BP) and lowpass (LP) outputs are available simultaneously, as indicated in the accompanying derivation. Note that the basic form of the transfer function is quite simple, and the final expression is relatively cumbersome only because of the form of the a_1 and a_2 coefficients. The derivation also shows more clearly how it is possible to change the Q independently of the centre-frequency gain. Since $a_2 = 1/Q$, we merely have to vary a_1 and a_2 together, which is achieved in the present circuit by a variable resistor (R_{20}) to ground from the a_1 and a_2 summing point. This obviously requires that the two signals go to the same amplifier input, and since the a_2 coefficient must be positive, a_1 has to be as well. If this facility is not required, a_1 could of course be either positive or negative.

A further advantage of the state-variable approach is that it can provide *any* second-order function, although this has not been exploited in the present circuit. The HP, LP and BP outputs are summed by a further amplifier (see ref. 4 for the system transfer function), which allows the corresponding reject functions to be synthesised. By making the appropriate coefficients variable, it would be possible to generate a continuous range of bandpass and band reject functions within the filter itself, rather than by changing the position of the filter within an amplifier feedback loop as in the present circuit. There may not be much to choose between the two methods, but I preferred the feedback loop method because it can be used with any kind of filter, and any number of filters can be placed within a single feedback loop as shown in Fig. 6. It also allows the choice of two sets of frequency response curves (see Fig. 5), which may not be so easy to arrange by the other method.

$BP = HP \times -1/R_5C_1S$, where $S = j\omega$

$LP = BP \times -1/R_6C_2S = HP \times 1/R_5C_1R_6C_2S^2$

$HP = a_1 \times input + a_2 \times BP - a_3 \times LP$

$$a_1 \times input = HP - a_2 \times BP + a_3 \times LP = HP\left(1 + \frac{a_2}{R_5C_1S} + \frac{a_3}{R_5C_1R_6C_2S^2}\right)$$

$$\frac{HP}{input} = \frac{a_1}{1 + \frac{a_2}{R_5C_1S} + \frac{a_3}{R_5C_1R_6C_2S^2}}$$

$$= \frac{a_1R_5C_1R_6C_2S^2}{R_5C_1R_6C_2S^2 + a_2R_6C_2S + a_3}$$

Referring to Fig. 2, the a coefficients are

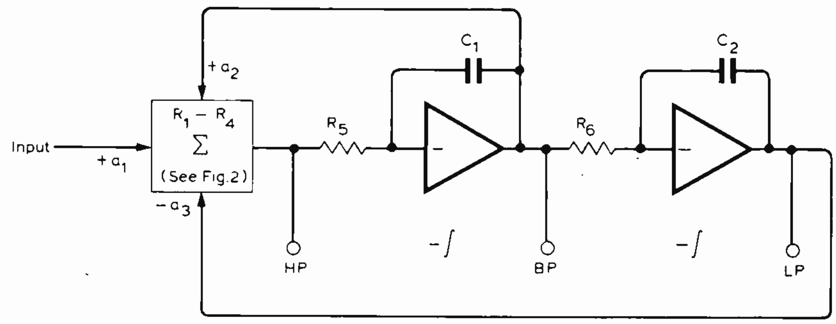
$$a_1 = \frac{R_2(R_3+R_4)}{(R_1+R_2)R_4};\quad a_2 = \frac{R_1(R_3+R_4)}{(R_1+R_2)R_4};\quad a_3 = \frac{R_3}{R_4}.$$

Thus the complete highpass transfer function is

$$\frac{HP}{input} = \frac{R_2(R_3+R_4)}{(R_1+R_2)R_4} \times \frac{R_5C_1R_6C_2S^2}{R_5C_1R_6C_2S^2 + \frac{R_1(R_3+R_4)}{(R_1+R_2)R_4}R_6C_2S + \frac{R_3}{R_4}}$$

The bandpass and lowpass transfer functions are obtained by multiplying the high-pass transfer function by $-1/R_5C_1S$ and $1/R_5C_1R_6C_2S^2$.

When $R_5C_1 = R_6C_2$, $a_2 = 1/Q$.



by measurement than by calculation!

We can now consider the remaining aspects of circuit performance. When LM318 devices are used, the distortion is extremely low, and it was difficult to make any reliable measurement at midfrequencies. For a +20dBm (22V peak-to-peak) output signal at 20kHz, however, I managed to obtain a value of 0.015%, but this fell rapidly as the signal level was reduced. In general, the control settings affected the distortion only insofar as they changed the output signal level. This excellent performance is a result of the very high bandwidth (15MHz) and slew rate (70V/μs) of the LM318, but there is sufficient latitude to allow the use of other devices for many applications.

The best alternative devices are the various families of f.e.t. input high bandwidth operational amplifiers, and the circuit performance was also evaluated with one of these, namely the Fairchild μAF356, which has a 5MHz bandwidth and 15V/μs slew rate. Using this device throughout, the distortion for a +20dBm output at 20kHz rose to 0.05%, and when the Q was increased at high centre frequencies, the centre-frequency gain also increased slightly – an effect not observed with the LM318. Device substitution showed that the effect, which occurred only at high Q, originated at IC_4, and most of the extra distortion was generated by IC_3. Both the LM318 and the μAF356 have an input voltage noise of around 15nV $\sqrt{Hz}$ at midfrequencies, but the μAF356 may be slightly quieter since its input current noise is lower. I have not given any noise specification for the circuit, since the amplitude and frequency content of the noise will be greatly affected by the control settings, and to quote one or two blanket values could be misleading. However, I have tried to keep circuit impedances below 10kΩ wherever possible in order to keep the noise down to a level where it should be dominated by that of the ICs.

As mentioned previously, the circuit could be made more compact by the use of dual or quad i.cs. A possible i.c. is the Texas TL074 series, but the bandwidth is only 3MHz, which will limit the performance at high frequencies. By the time this article appears, however, a wider range of quad devices may have become available.

Many applications will call for the use of more than one equaliser section, and the sections can be combined in two ways. The easier method is to connect them in series, and if the connection is permanent the buffer stage IC_1 can be omitted from the subsequent sections. This approach is best suited for a modular design, as it allows each section to be used independently. The other method is for the filter sections to be connected in parallel (as for a graphic equalizer), where IC_3-IC_6 and all the controls are duplicated, but share the same IC_1 and IC_2. The circuit configuration must be changed, however, to allow the filter outputs to be combined, and the modified circuit is shown in Fig. 6. Circuit IC_2 is now a virtual-earth mixer, which can sum any number of filter outputs without interaction, but to achieve this the outputs have to be sent to the inverting instead of the noninverting input of IC_2, so we need to make a compensating phase reversal in the filter path. In theory, this could be done by moving the filter input connection from the noninverting to the inverting input of IC_4, but we would then lose the interaction which allows the Q to be varied independently of the centre-frequency gain (see appendix). The solution adopted is to rewire IC_3 as an inverting amplifier, which has the minor disadvantage that the gain of this stage will interact slightly with the setting of R_{19}, but the effect will make no difference in practice. Each filter section can be switched out independently as shown in Fig. 6, or they can be switched out together by a single switch between the common ends of the R_5 resistors and the inverting input of IC_2.

How does the circuit sound? My advice is to build it and find out! At low Q, the response can be corrected over a large frequency range by as few as two stagger-tuned sections, and in this mode the circuit is a very useful "shelf" filter. As the Q is increased, the circuit becomes more like a graphic equalizer, and ultimately resembles a musical instrument! A wide variety of special effects can be created by tuning one or two high-Q sections up and down the audio band, and at high Q the circuit also becomes a useful notch filter. Obviously this design is too complex for it to pose a significant threat to the popularity of the Baxandall tone control, even though it is a lot more versatile. But if you really *prefer* the mode of action of the Baxandall circuit, don't worry – this design will give quite a reasonable approximation to it if you tune one section to each end of the audio band and set them both to minimum Q. Now all you have to do is to label one control bass and the other one treble. Well, I told you it was versatile!

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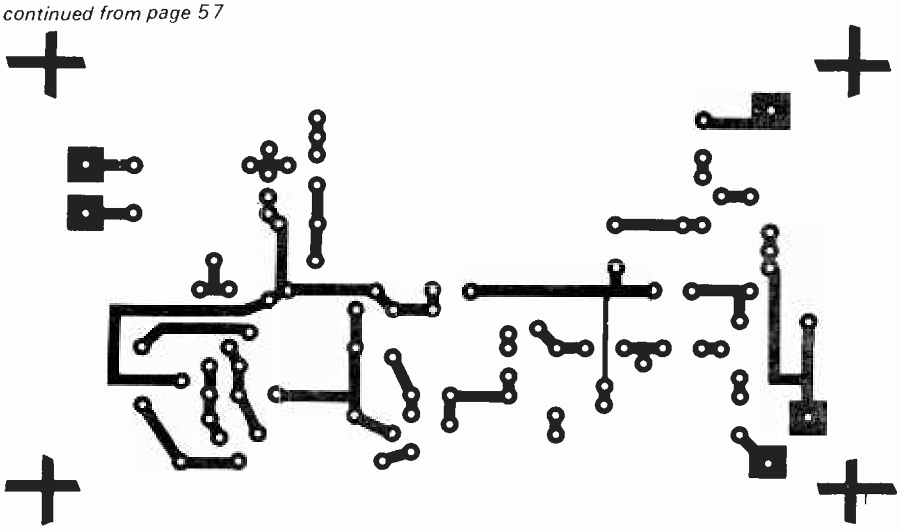
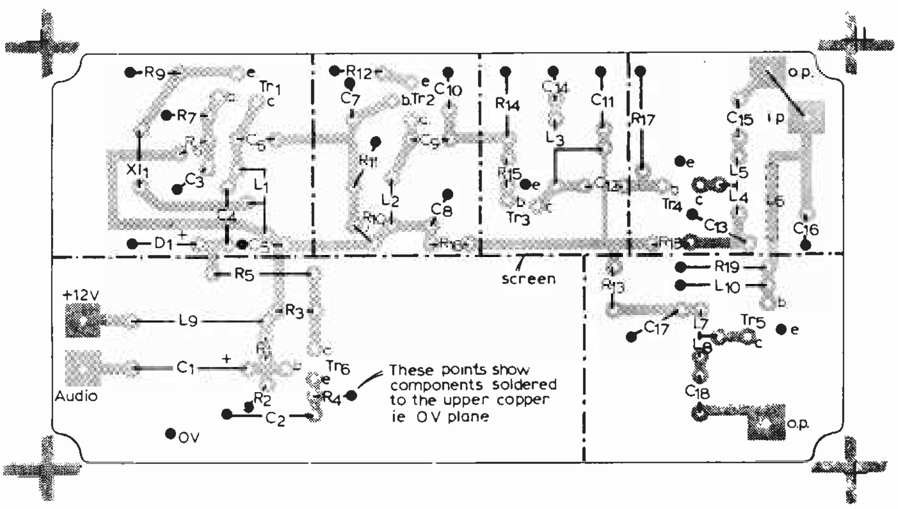




WORLD OF AMATEUR RADIO

50 years of "Empire" broadcasting

Each year the callsign of the late Gerald Marcuse, G2NM, is re-activated by the Chichester club to commemorate the many facets of his remarkable pioneering activities that extended over the period from about 1912 until his death in 1961. This year the event emphasised that it was Marcuse who during the period 1927 to 1929 provided the first series of broadcasts from the UK aimed at listeners in many parts of the "British Empire." These began in September 1927 some months before the first experimental BBC service from G5SW at Chelmsford and several years before the official start of the old BBC "Empire Service" in December 1932. *Wireless World* played a prominent part in campaigning for the broadcasts, against BBC opposition.

With Post Office permission, Marcuse broadcast daily from his home in Caterham, Surrey, including concerts and song recitals from a "studio" set up in the home of Percy Valentine and also unofficial relays of BBC medium-wave programmes. Even full-sized orchestras were fitted into the studio and many well-known musicians and singers took part. "Outside broadcasts" included bird songs from his garden and it was the G2NM broadcasts that first enabled listeners in many parts of the world to hear Big Ben. With a 100ft mast and Zepp aerial he ran about 1.5kW on 32.5m and the station was well received in many parts of the world until Post Office permission was withdrawn in 1929 and the role of Empire broadcasting was left to G5SW.

A British Oscar?

Almost a decade ago an attempt was made by a number of British amateurs to plan the construction of an amateur satellite for inclusion in the Oscar series ("Project Trident"). Although little came of these proposals, the idea has been revived, this time with the emphasis on providing the more technical amateurs with an experimental facility rather than a purely communications aid. The project is being formulated jointly by the University of Surrey UOS-AMSAT group and AMSAT-UK and will be run by the university's Space Studies Research Group, relying on support from industrial and research organisations and with the aim of establishing AMSAT-UK as a flight hardware group in its own right.

A number of suggestions on useful experimental facilities that could be included in such a satellite have been formulated, including the provision of real-time information for h.f operators on the state of the ionosphere by using h.f beacons as "topside sounders." It is also hoped that WARC 1979 will make provision for amateur satellites to carry beacons on microwave bands including 10 GHz. Martin Sweeting, G3YJ0 of the University group emphasises however that as a first venture the spacecraft would have to be kept simple and power consumption of all experiments might need to be restricted to an average of 5 or 10 watts.

WARC 1979

Although for most countries official proposals for frequency allocations to be formulated at the World Administrative Radio Conference next year still seem to be in a state of flux, radio amateurs have welcomed the news that the latest US proposals (although not necessarily representing final American policy) include three new amateur bands at 10, 18 and 25 MHz — 10.1 to 10.2 MHz, 18.068 to 18.162 MHz and 25.11 to 25.21 MHz — and in general represent an attitude favourable to the hobby. However, it is recognized that since the creation of the three separate ITU "regions" in 1947, amateurs in Region 2 (the Americas) have enjoyed significantly more favourable allocations than those in Region 1 (Europe and Africa) where European delegations have often proved among the most hostile to amateur allocations. The Home Office report "Preparation for the WARC 1979" (see July issue, News) notes that the decreased reliance on h.f for international fixed service communications makes it possible to consider additional frequencies for various categories of users, including radio amateurs.

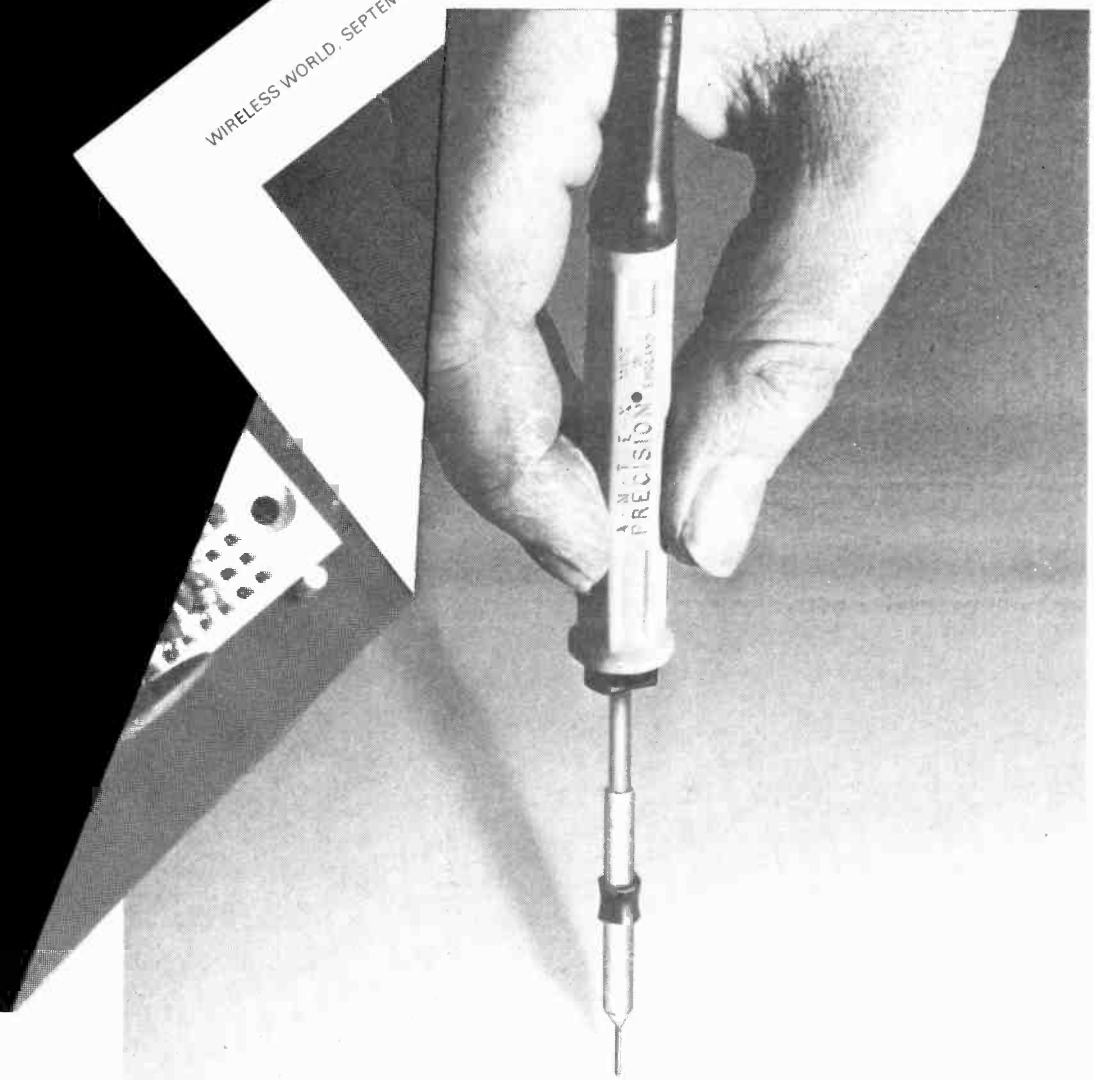
Spotty sun

Solar activity — and consequently maximum usable frequencies — continue to run ahead of predictions. This points either to an extremely high peak of activity during 1980, possibly even exceeding the remarkable Solar Cycle 19 peak of 1958 or to the peak being reached earlier than 1980. With several h.f daylight radio blackouts this year, with transequatorial paths extending up to u.h.f. and the many auroral events (averaging almost one day in three), it may well appear that we are already approaching peak conditions. Chris Bartram, G4DGU, however believes that the considerable number of 144MHz TE-mode contacts reflects the greater number of well-equipped 144/432MHz amateur stations resulting from Oscar satellite operations.

In brief

In an article in the UK FM Group (London) newsletter, Kris Partridge G8AUU proposed the introduction of 12.5kHz channel spacing in place of the current 25kHz in the f.m simplex and f.m. repeater sections of the 144MHz band (145.0 to 145.837 MHz). This year's RSGB National Mobile Rally is at Woburn Abbey on August 6 . . . Arthur Milne, G2MI, read his 1000th GB2RS news bulletin on May 7 . . . The Home Office has resumed licensing of the "Phase 3" u.h.f. repeaters and will also consider applications for experimental repeaters on microwave bands although additional v.h.f. repeaters are still excluded . . . Special event "v.h.f./u.h.f." stations, with the prefix GB8, are being licensed by the Home Office through the RSGB . . . British amateur (maritime) licences for stations on board ship are no longer restricted to crystal control on h.f. bands . . . A beacon station, W6IRT, at Hollywood, California on 28.888MHz has been licensed for 6 months by the FCC . . . The International Amateur Radio Union is sponsoring a special amateur radio training course in Colombo, Sri Lanka with instructors from West Germany . . . Over 70 West German amateurs are operating on 10GHz. Activity is also reported from East Germany, Switzerland and Luxembourg . . . *REF* reports that 7 repeater stations (144 MHz) are in operation in France, 5 are undergoing tests; 5 are in construction; and 4 in the planning stage. Output ranges up to 100-watts and heights above sea level to 1,200 metres . . . According to Pierce Healy, VK2APQ in "Electronics Australia," an experimental amateur moonbounce installation of the University of Woolongong was wantonly damaged by vandals early this year. The station ("Project Dapto") has been built up over the past 8 years and may now have to be moved elsewhere . . . Evening classes for those taking the Radio Amateur's Examination in December or (with the new syllabus and with multi-choice questions) in May 1979 are being run in many parts of the country with enrolment during early September. Enquiries should be made at local adult education centres . . . Yukon, Canada is to use the prefix VY1 . . . The Yeovil Mobile Rally is to be held at the STC/ITT Social Centre, Brixham Road, Paignton, Devon, on August 27.

PAT HAWKER G3VA



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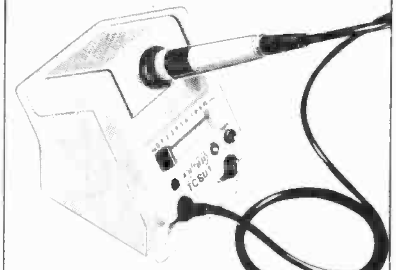

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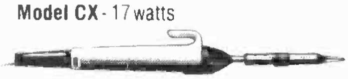

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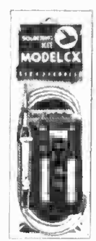

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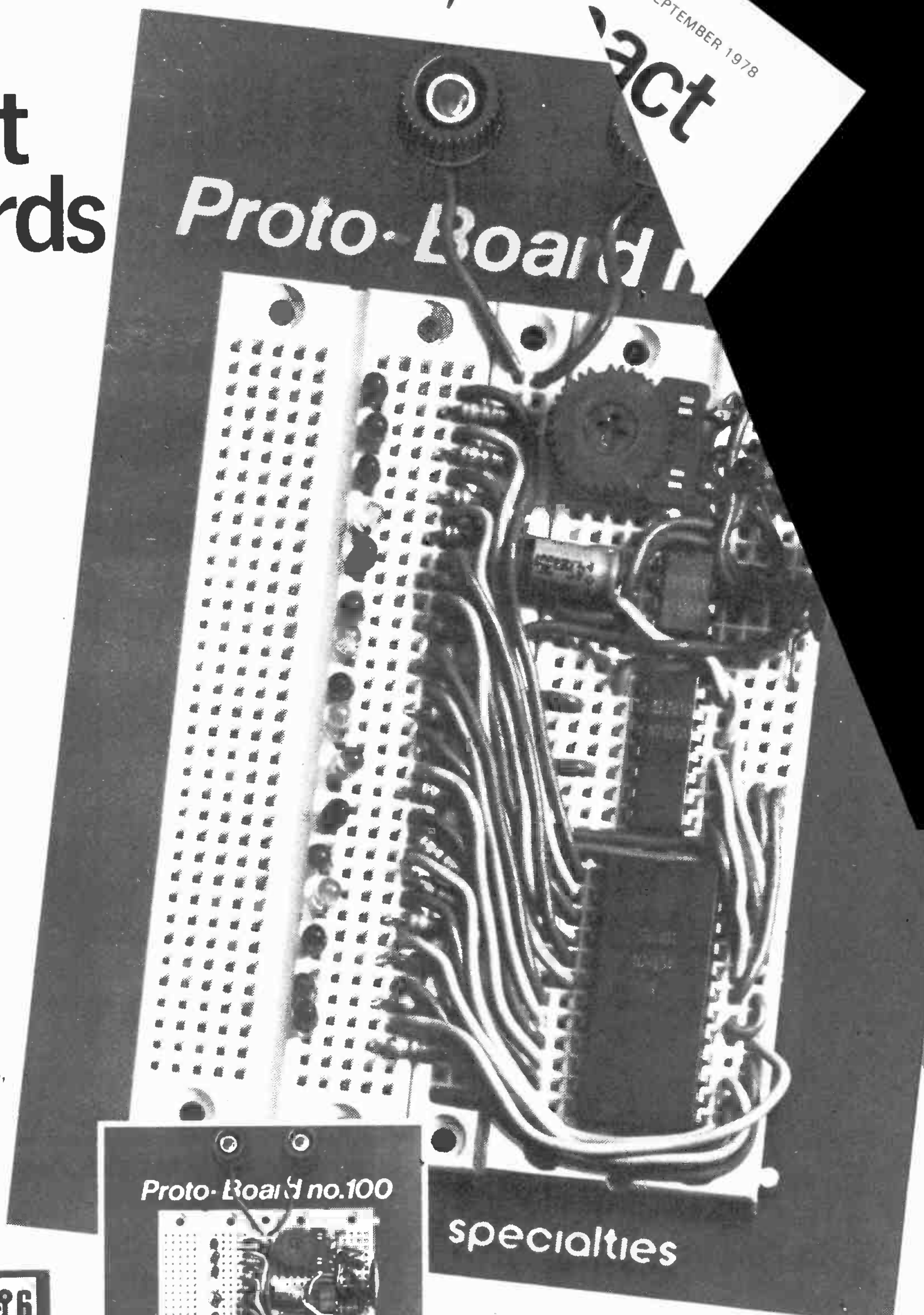

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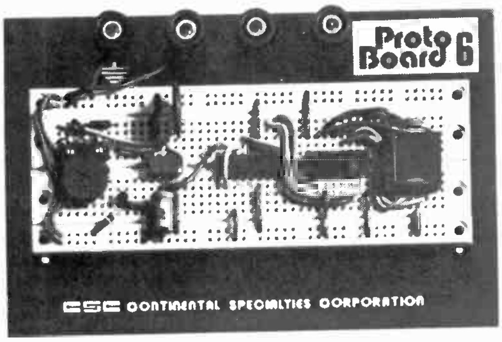

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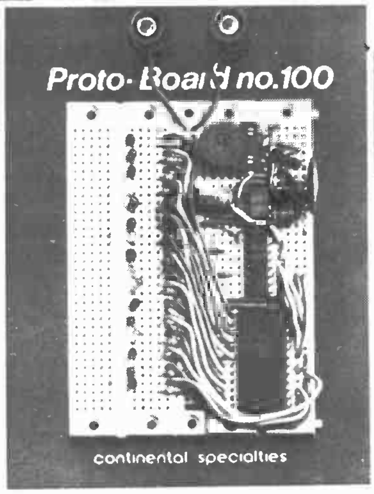

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Trends in microprocessors

An analysis of types now available on the market

by David A. Russell, B.Sc. Computer Technology Ltd

Since the last survey of microprocessors in *Wireless World* (December 1975 issue) a great many new devices with a wide range of capabilities have been introduced. This article provides a background to the current situation and discusses in general terms the directions that developments seem to be taking.

THERE are a number of starting points that could be considered when attempting to categorise the available devices, such as word width or technology. My own preference is to start from the product/market situation and determine where in the cost, performance and volume spectra the product will be. High volume, cost-sensitive applications will generally use a completely different type of microprocessor system from that used in a high performance, low volume application, even if both systems use 8-bit words. See Fig. 1, an adaptation of some information produced by Intel. Also, the memory and i/o requirements vary considerably, and this affects, for example, the type of memory used and the design of the i/o.

Before considering the details of the various configurations, it is worth looking at the costs of minimum sets of basic l.s.i. parts typically used in various microprocessor systems (see Fig. 2). The wide range of performances is reflected in a similarly wide spread in costs; it will be appreciated that, in practice, there are overlaps between the various categories shown. These costs do not include any allowance for overheads such as translators or buffers and drivers, printed circuit boards, power supplies and so on. Also, the quantities are assumed to relate to the application; for example, the minimum order quantity for single chip microprocessors is typically 1000-5000 pieces because they use mask-programmed r.o.ms., whereas 100+ volumes are shown for the high performance bit slice systems.

At the design stage, the integrated

	Chips	Quantity per annum
4-, 8- and 16-bit single chip microcomputers	1	5k – 1M
8-bit chip sets	2+	1 – 100k*
8-, 12- and 16-bit general-purpose systems	3	1 – 10k
16-bit high-performance systems	10	1 – 1k
2- and 4-bit slices	30	1 – 100

*Except automotive market

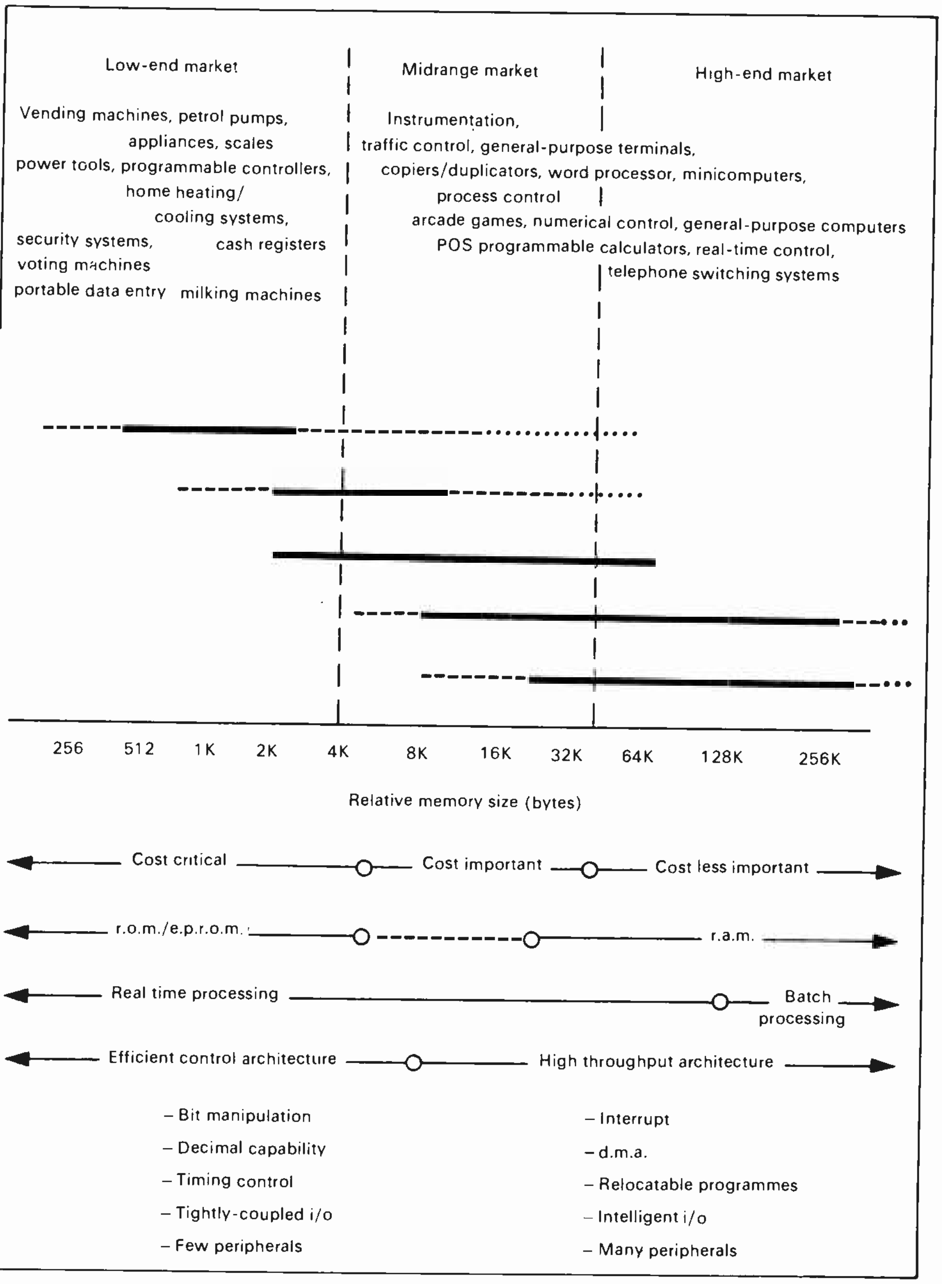


Fig. 1. *Application markets related to types of microprocessors and relative memory capacity.*

Explaining diagrams Fig. 4 onwards
In the diagrams, the rectangles drawn in thin lines are functional blocks, while the areas enclosed by thick lines represent actual chips. Where a functional block protrudes outside of a thick line, this means that extra logic, external to the chip, is required to take full advantage of the facilities available. Shaded areas imply that the part uses an interface specific to the microprocessor.

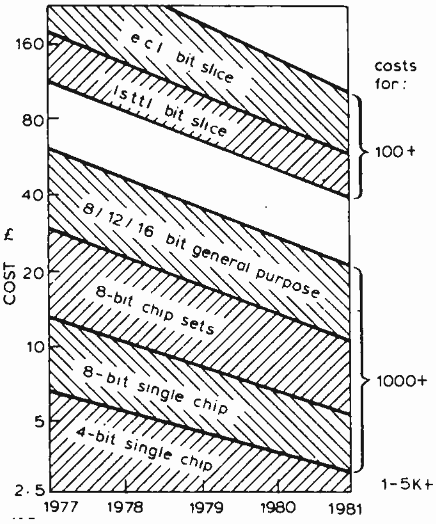


Fig. 2. *Costs of l.s.i. parts used in microprocessor systems showing the falling trend over a number of years.*

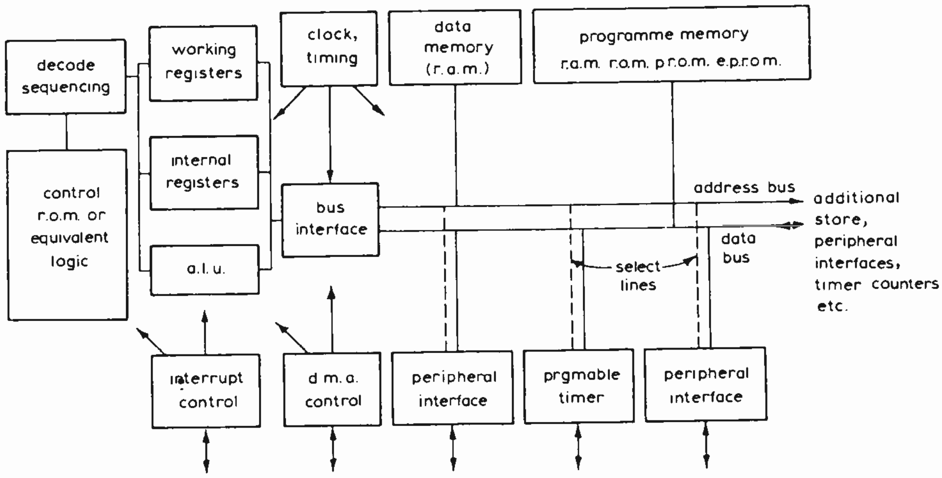


Fig. 3. *Typical arrangement of functional blocks in a microprocessor unit.*

circuit manufacturers face specific trade-offs between costs and chip size, gate packing density, gate delays, power dissipation and package pin counts. To meet the requirements of the wide spectrum of applications the manufacturers are obliged to produce a range of products having differing implementations of the hardware functional blocks in a microprocessor system, depending on cost, performance, instruction set and flexibility (expandability) objectives. I shall illustrate this in the diagrams by using a standard format for the functional blocks (thin lines) and "overlaying" the actual chip functions (thick lines).

The blocks generally include programme memory (r.o.m., e.p.r.o.m., or r.a.m.); data memory (r.a.m.); peripheral interface logic (general purpose or specific to a particular peripheral); timers (hardware timers are tending to replace software loops) and interrupt or test inputs. For high speed peripherals, a direct memory access facility is often included. These functions usually connect to the microprocessor unit (m.p.u.) via a common bus, and a clock generator and timing circuitry will control transfers across the bus.

Within the m.p.u. there will be an arithmetic logic unit (a.l.u.); the working registers (available to the programmer); internal registers (e.g. temporarily storing the current instruction or the next address); a control r.o.m. or equivalent logic, and instruction decode and sequencing logic (see Fig. 3). The established 6800 family is an example of a system in which the m.p.u. and the other functional blocks are provided by individual packages and the system is expanded by connecting more memory or i/o chips onto the bus.

Single chip microprocessors

The i.c. manufacturers seem to be agreed that a single chip microprocessor is a device that contains all the essential functional blocks (r.o.m., r.a.m., m.p.u., i/o, timer) to allow it to be

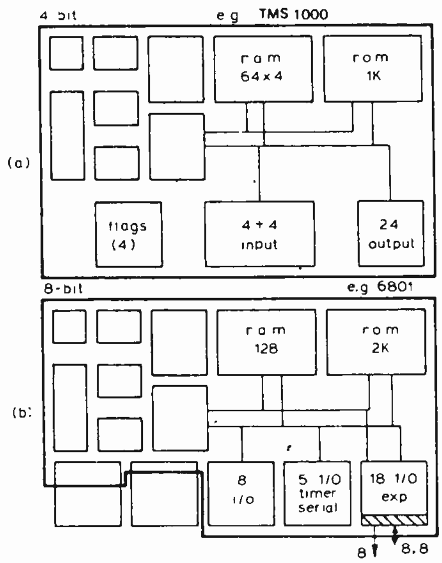


Fig. 4. *Examples of single-chip microprocessors: (a) the 4-bit TMS1000, and (b) the expandable 8-bit 6801.*

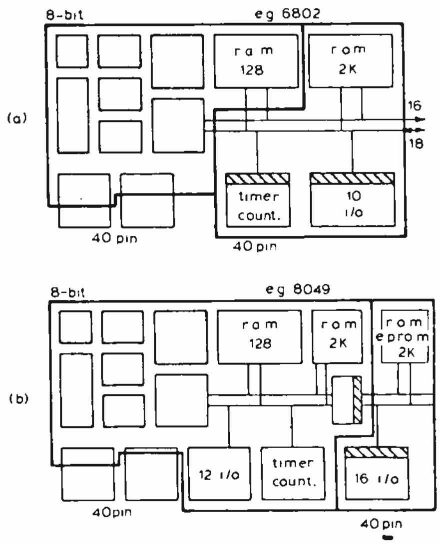


Fig. 5. *Examples of two-chip set microprocessors: (a) the 8-bit 6802 and (b) the expandable 8-bit 8049.*

used in low cost, high volume applications such as microwave ovens, washing machines and electronic games. One can identify two basic types available: first, very low cost, non-expandable microprocessor chips, with fixed capacity of memory and i/o. These are devices like the 4-bit TMS1000 (Texas), the 8-bit 3870 (Fairchild, Mostek) and the more recent 8-bit 8021 (Intel), see Fig. 4(a). Because the applications are very cost-sensitive, the manufacturers are producing variations on the theme to meet particular requirements, with extra r.o.m. or i/o on larger chips, and, in the case of Intel's 8022[1], they have integrated much of the external logic normally required in microwave oven applications by including a two-channel analogue multiplexer and an analogue to digital converter on the chip. Intel say that this is the first of a number of 802X parts that will be designed for specific high volume applications.

The second type of single chip microprocessor is expandable, allowing the use of more memory and/or i/o than is included on the basic chip. This would also be useful where the design requires both r.o.m. and e.p.r.o.m.; the e.p.r.o.m. would allow specific customer variants to be produced, while the main programme would be in r.o.m. to reduce cost. Examples are the 8048 and 8049 families (Intel), 6801 (Motorola)[2], Z8 (Zilog) and 9940 (Texas). See Fig. 4(b) and 5(b). Some of these types are available with serial i/o for distributed processing, and in due course versions with e.p.r.o.m. rather than r.o.m. should be increasingly available, allowing low quantity applications to use single chip microprocessors. Minor variants of these microcomputers can be used as peripheral controllers on microprocessor systems such as the 8080, 6800 and Z80. Examples are the 8041 universal interface (u.p.i., Intel) and the 6801E (Motorola).

It is interesting to consider that the performance of the faster types of microprocessors exceeds that of the early 8-bit microprocessors, such as the 8080 and 6800, even though the faster devices contain so much extra logic!

Two-chip expandable systems

Another approach for obtaining flexibility is to base the system design on chips that split the minimum system into two packages and can be expanded by the addition of bus-compatible devices. The longest established example is probably the F8 (Fairchild). Others to consider are the 6802 (m.p.u. and r.a.m.) used with the 6846 (r.o.m., i/o and timer) from Motorola, the 6500 series m.p.us used with r.o.m., r.a.m., i/o and timer chips from M.O.S. Technology, and similar systems for the National Semiconductor SC/MP and Signetics 2650 (see Fig. 5(a)). More recently "cut-down" versions of single-chip microprocessors have been made available, such as the 8035, which can then be used with r.o.m., i/o combination chips or e.p.r.o.m., i/o chips from Intel.

As can be seen, with the introduction of the combination memory-and-peripheral chips, the various single chip microprocessors and the m.p.u., i/o and memory combinations, the designer has plenty of scope if r.o.m. based systems are required. The choice is more limited if e.p.r.o.m. is needed, but this situation should improve during early 1979.

8, 12 and 16 bit general purpose microprocessor systems

There are various situations where the previously mentioned systems would not be appropriate. For example, if greater performance is required or if large amounts of r.a.m. are to be used, such as in intelligent terminals or development systems, the familiar microprocessors such as the 8085, 6800, Z80 or 9980 would probably be the next types to consider (see Fig. 6). The families generally included selected high speed versions, with the manufacturers leapfrogging each other as new devices are introduced. The 8085A-2 and Z80A seem to be the fastest available at the moment (it depends on who is running the benchmarks as to which wins!). They will shortly be challenged by the 6809[2] (Motorola) which, like the Z80, has a large instruction set and extended register set, some features of which are described below (see Fig. 7).

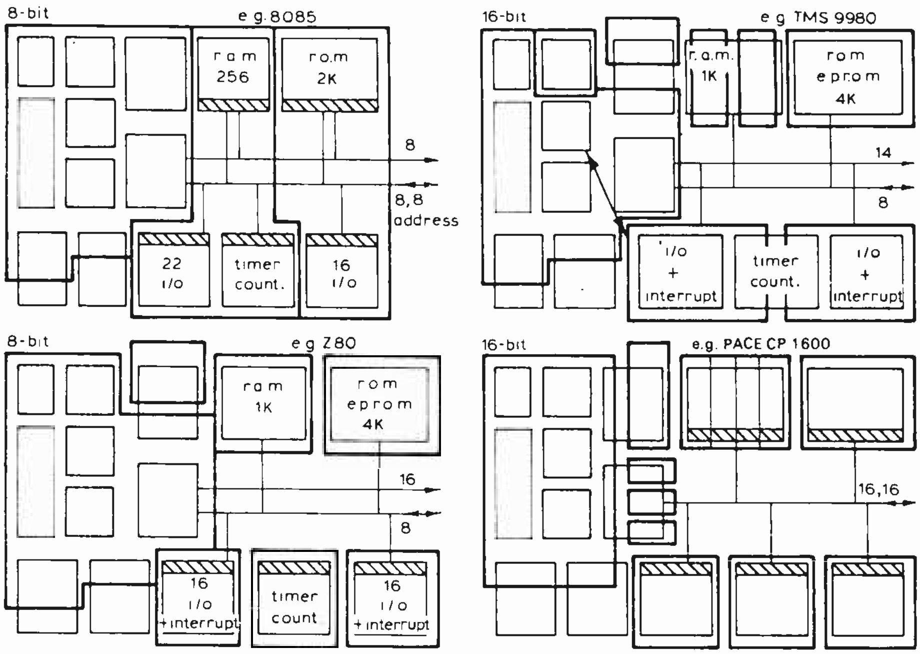
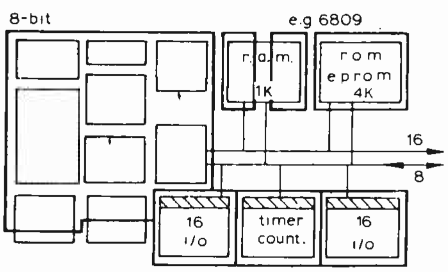


Fig. 6. *Examples of general-purpose microprocessors: (a) the 8-bit 8085, (b) the 8-bit Z80, (c) the 16-bit TMS9980 and (d) the 16-bit PACE or CP1600.*



The applications where these more powerful devices are used will often involve interfacing to a variety of peripherals, and the recent and continuing developments in peripheral controller chips are significantly reducing the design complexity, costs and chip counts incurred. Devices like s.d.l.c./h.d.l.c.* chips, floppy disc controllers, and c.r.t. controllers can replace a whole board of t.t.l. m.s.i. logic. Some of the more recent peripheral controller chips are actually based on universal peripheral interfaces (u.p.i.), so that the specific requirements of a high volume user can be taken into account by modifying the programme in the u.p.i. (e.g. the Intel 8278 matrix printer controller).

Another point to consider is that in some cases it is possible to use one manufacturer's peripheral chips with another's microprocessor, which may be useful where your own manufacturer's device doesn't have the facilities required, or is not available.

*Synchronous data link control/high level data link control.

The new 16-bit microprocessors

There is a lot of activity in the 16-bit microprocessors, with the 8086[3] (Intel) and Z8000 (Zilog) coming onto the scene and the MACS (Motorola Advanced Computing System) in the design phase, to join the existing devices such as the 9900 (Texas), F100C (Ferranti) and more recent 9440 (Fairchild). The 9440, 8086 and Z8000 are all claimed to have performances comparable with powerful minicomputers (i.e. Nova range, PDP 11/45 and PDP 11/70 without cache memory), and have very much larger instruction sets than most 8-bit microprocessors. In common with the 6809, the software features being emphasized by some manufacturers include the ability to use position independent code (which facilitates the use of r.o.m. libraries such as maths packages, interpreters and so on), the availability of a large number of registers, and instruction sets designed for array and repetitive operations, such as are required in compilers, editors and executives.

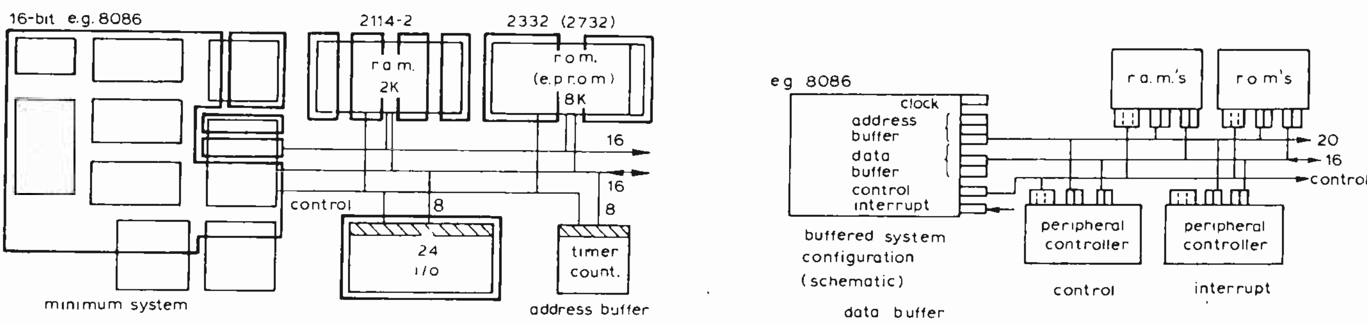


Fig. 7. *High performance microprocessor systems: top, the 8-bit 6809; below, the 16-bit 8086 in the "minimum mode" and the "buffered mode".*

Another feature of some units is the inclusion of hardware and software controls for use in multi-microprocessor systems.

The 8086 and Z8000 are both able to address more than 64K bytes of memory, and to achieve the large address ranges both manufacturers use different configurations for small and large systems. The 8086 (1Mbyte addressing) has a pin that is strapped to V_{CC} or ground to determine whether the "minimum mode" or "buffered mode" is selected, while the 5Mbyte version of the Z8000 will use a 48-pin package instead of the 40-pin package used on the standard version (see Figs, 7b, 7c). Whilst such large address ranges may seem out of place in microprocessor applications, with the rapidly increasing capacity of memory chips and the advent of the r.o.m. libraries, addressing beyond 64Kbytes seems likely to become a useful feature in many applications.

Bit slice systems

The bit slice families have been developed as an extension to the existing Schottky t.t.l., e.c.l. and c.m.o.s. logic families, to combine the desirable performance characteristics and design flexibility of the logic families with the reduced costs and reduced package counts of l.s.i. Various chips are available that allow the designer to implement the functional blocks within a processor, such as a.l.u. and registers, control p.r.o.m., microinstructions sequencer (which determines the next address of the p.r.o.m.) instruction decode, and memory interface[4].

In the schematic examples shown in Fig. 8 using the 2901 family (Advanced Micro Devices) the a.l.u., registers and some control is implemented in 4-bit slices, known as slice microprocessors. These can be cascaded to make a system of the desired word width; four of them are used to make a 16-bit system. The microinstruction sequencing is controlled by a set of chips that are also cascadable 4 bits at a time, although recently a single-chip sequencer has been introduced (2912).

The author
David Russell graduated from Southampton University in 1969 and completed a sandwich course at A.E.R.E. Harwell the following year. In 1970, he joined CTL, starting in the Circuits and Memories group. After working with semiconductor memories and high speed logic families he moved into the Systems group and was involved in the design of a number of products including power supplies, peripheral controllers and switching units for ultra-reliable systems. More recently in the Product Group, in which he is now the company authority on microprocessors, he has been working in applications using microprocessors in peripheral controllers, and has presented papers reviewing the microprocessor scene at several symposia in the last two years.

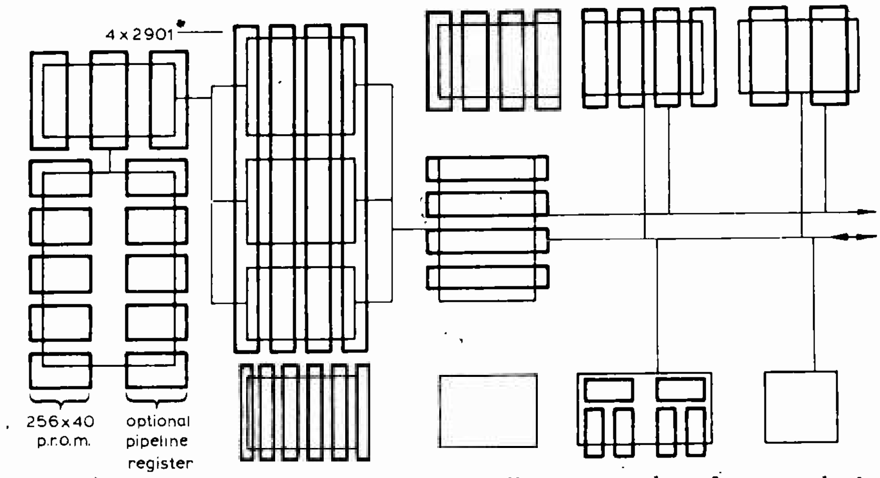


Fig. 8. *Schematic showing the principle of bit-slice systems, here for example, 1 × 29811, 2 × 2911, etc.*

These systems can, for example, be used for emulating existing minicomputers, or in the design of controllers for high speed peripherals such as rigid disc drivers[5]. The instruction set to be obeyed by the system is determined by the contents of the control p.r.o.m. The width of this is also in the hands of the designer, and may be in the region of 28-36 bits for small processors or peripheral controllers and 48-60 bits for emulation of powerful minicomputers.

The available families include the 9400 (Fairchild); 745481 (Texas) 6701 (Monolithic Memories) and the 10800 (an e.c.l. system from Motorola), but the market leader is the 2901 family, which has been very widely second sourced. A recent addition is the 2903, a 4-bit slice much like the 2901, except that more registers can be added onto the basic set via expansion ports and multiply and divide instructions are included.

To improve the performance of bit slice systems, more powerful memory control chips are being introduced that include an a.l.u. and registers, dedicated to calculation of the next address, while the main 4-bit slice microprocessor system continues with the current instruction. (This arrangement is also used in the 8086 16-bit microprocessor.)

As for future improvements in performance, the basic (internal) cycle times of Schottky t.t.l. systems probably cannot be reduced much below 150ns, so some of the i.c. designers are turning towards the use of e.c.l. circuitry inside the slice family chips, while retaining s.t.t.l. or l.s.t.t.l.-compatibility by putting buffers on the chips[6].

An alternative that may become attractive to the minicomputer designer is to switch to using an e.c.l. bit-slice family to overcome the speed limitations of the other technologies, such as the 10800 (Motorola), especially as translators to s.t.t.l. bus systems are available, as are development systems.

Conclusion

When microprocessors were originally introduced they were cheap, but slow and very basic, requiring a considerable amount of support logic around them. We are on the verge of a new phase, where the microprocessor manufacturers can provide practically tailor-made l.s.i. systems, for example at the high volume, low cost end, using the application oriented single-chip microprocessors, and, for larger systems, using peripheral controller chips and standard r.o.m. packages with high performance microprocessors. With the steadily falling cost and increasing performance trends, the point will soon be reached where conventional uses of microprocessors will leave a lot of power to spare, and new and novel uses for them will be devised.

A major problem the manufacturers now face is ensuring that designers are able to use the increasingly more powerful microprocessor in sufficient volume to justify the enormous cost of development.

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NEWS OF THE MONTH

Government conclusion —

The advantages of citizens-band radio are more than outweighed by the disadvantages

THE SUBJECT of citizen's-band radio was again raised in the House of Lords, on July 11, and again Lord Wells-Pestell made it clear that the Government had no intention of providing it in the UK. This time, however, his answers were far more relevant to the subject than they were last time (see News, July issue, p47).

Prior to the debate, Lord Torphichen told *Wireless World* that Lord Tanlaw would be posing a question in the House, and would be avoiding the use of the words "citizen's-band radio" – in the hope that it would be better received. Lord Tanlaw's question was as follows: "To ask Her Majesty's Government whether they will accept a recommendation of the National Electronics Council to improve public communications by allowing individuals access to the radio spectrum for A to B communication." Lord W-P, saying "No" and introducing the description "citizen's-band radio," replied that the Government remained of the view that the advantages of introducing such a service would be outweighed by the disadvantages.

To this Lord Tanlaw asked whether the Minister had conveniently overlooked that the radio spectrum ignored all national boundaries and was governed only by the law of nature, and if so could he justify his reply when there was no legal or constitutional basis for any nation State to claim a part or the whole of the magnetosphere, or to prevent an individual from having access to it. Would he then say why the UK was one of the few democracies outside the Communist bloc that had not allocated a frequency over which members of the public could communicate freely with one another.

In reply, Lord W-P said that it was the view of the Government not to provide citizen's band radio for a whole variety of reasons – too many to go into at question time. The Government had taken advice and had looked at what had happened in other countries. "There are many competing demands by the necessary users of radio, by mobile radio and by commercial industrial firms."

Reminding the House that there was evidence of abuse and misuse in countries that have c.b. radio, he then made reference to part of an *Electronics Australia* editorial, printed in the RSGB's journal *Radio Communication*, which told of things that could be heard over the air, such as school kids swopping dirty yarns and prostitutes touting for business. The noble Lord did not think that this was funny and quoted another piece from the editorial: "It seems possible that citizen's band may even have played a key role in a recent murder." The final part of his quote said that c.b. radio was becoming notorious, and many people were suggesting that the authorities should reverse last year's decision and try to suppress it altogether.

Lord Wells-Pestell concluded his answer by saying, "We see no reason to introduce the possibility of that kind of thing here."

When asked by Lord Tanlaw whether he was prepared to say that the examples which he had given did not take place over the telephone system, Lord W-P said that he did not think that the two were to be compared and pointed out that conversations on the telephone took place between two people and were not necessarily heard by a large number of people.

Lord Torphichen then wished to know whether the noble Lord, representing the Government, thought it wise that casual would-be users of radio communication should be forced to use either the already overloaded Post Office radio telephone network or, worse, to misuse the amateur frequencies. Seemingly becoming impatient, Lord W-P repeated that the Government had studied c.b. radio in other countries and had come to the conclusion that the advantages were more than outweighed by the disadvantages.

After the debate Lord Tanlaw told *Wireless World* that he will still continue to press for c.b. to be heard in the House of Commons. □

Mini-Nyquist speech prototypes in 18 months

CONTRACTS ARE already being negotiated for the commercial exploitation of a speech processing technique which can transmit at one-seventh of the Nyquist sampling rate. The technique, developed by Brigadier Reginald King with the collaboration of the School of Electronic Engineering under Professor William Gosling at Bath University, reduces speech to an "alphabet" of 27 "letters" which are then transmitted at about 1000 five-bit words per second. One of the problems yet to be overcome is that the samples appear at non-regular intervals and present transmission techniques allow only for regular transmission rates, but Brigadier King told *Wireless World* that a prototype device, using microcprocessors, would be ready in about 18 months, and that commercial devices would appear in about four to five years if all went well. He emphasised that the technique did not make current techniques obsolete overnight.

Brigadier King, who completed his work during a sabbatical year at Bath University, said his work had been based on a well-known paper published many years ago in the United States in which the authors described the effects of severely limiting the amplitude of human speech. They discovered that with 100% limiting, when all that was left of the speech waveform was a series of events corresponding to the zero-crossing-points in the speech, the intelligibility was still 97%. This meant that although the odd word was lost the sentences could still be understood. Brigadier King first worked on this and other speech processing techniques at the Royal Military College of Science at Shrivenham eight years ago.

The sound of such "infinitely-clipped" speech was, as Brigadier King says, "pretty awful to listen to," but it aroused a great deal of interest. King and others were sure that the time intervals between zero-crossing-points in human speech conveyed the bulk of the information, "but there was something missing; some mislaid clue that we had yet to discover."

Then in May last year Bell Laboratories published a paper explaining why researchers into zero-crossing frequency were barking up the wrong tree. The paper "proved" that the reduction of data rates by using zero-crossing was theoretically impossible. A lot of the other researchers turned to other things. King stuck with it. It was after this that he began a year's sabbatical at Bath. He stresses the value of Bath's co-operation. He was given the use of staff and a PDP8 computer. Just as valuable, though, was that he and Professor Gosling were agreed on their approach, and that Bath, too, had done some work on zero crossing.

"We were looking for a way of sampling without involving the Nyquist rate. We had got to dispense with amplitude descriptors and linear processing." The mathematical model was shortly provided in a book by two Russians: "Distribution of Zeros of Entire Functions." Speech, said King, was an entire function, having real and complex components. "The thing that was missing was the locations of the complex zeros."

The task was to identify one sub-set of complex zeros which would identify speech. The technique was not entirely accurate, said Brigadier King, "but all modulation systems are approximations."

The work so far, using computer simulations, has only confirmed that the technique works. "We've only cracked open the oyster, as it were." Bath is now refining the method, identifying, perhaps, other sub-sets of complex zeros which might improve it. A key to the technique is that, effectively, the packets of five-bit words occur in regular clusters, and this makes further condensation possible. Although there are 27 letters in the current alphabet, alphabets with as few as seven or eight letters have proved intelligible, though unpleasant to listen to.

Brigadier King says the technique is much simpler than current vocoder techniques. According to an Army statement, the equipment could be sold "at less than a tenth of the cost of any other existing system and will be housed in a terminal smaller than a shoebox."

The Army statement went on to say that the details of the technique were classified, but it appears that this is as much for commercial as for military reasons. □

Custom i.cs produced by computer aided design

EQUIPMENT MANUFACTURERS can now get integrated circuits custom designed and produced for them by a British computer aided design service and chip manufacturing plant which offers speed and convenience as its main features. Conventional draughtsmen's work in the layout of masks is eliminated and layout design time is reduced from weeks to minutes. Customers, it is claimed, can get a price quotation for a given number of completed devices on the same day that they bring in a diagram of a prototype system that is to be integrated. Finished samples of the manufactured devices are available in ten weeks. The convenience comes from the fact that a computer system can provide a quick feedback of information that enables the customer to check the design process as it is taking place. For example, the computer will run a simulation of a customer's logic system to make sure that what is specified on the system diagram will actually do what the customer requires of it when it appears as a manufactured device.

Design it yourself

The new service has just been started by GEC Semiconductors Ltd, who specialize in custom designed i.cs, and is called 'Cellmos". This name derives from the principle that the customer designs his own integrated circuit using standard "cells" or circuits from a library of circuits taken from standard 4000 series c.m.o.s. logic parts. At present the GECS Ltd library at their Wembley plant runs to about 500 items. Of course, this restriction of the customer's design options to a given library of elements is what "pays for" the gain in speed and convenience.

After a customer's engineer has designed his required system in these standard parts, and perhaps built a prototype in breadboard form, he supplies a logic diagram to GECS. At Wembley an accurate copy of this diagram is made and on it all the cells, or discrete logic circuits, and their connections are given code numbers and letters. From these code symbols a list is compiled which defines the logic completely in known terms and is a full description of the customer's requirements. In addition, the customer can supplement the circuit information with a set of test waveform definitions.

The list, either handwritten, typewritten or in computer readable form, is fed into a GEC 4070 computer to carry out compatibility checks (such as that an x-input gate is in fact receiving x-inputs). This may take anything from 15 to 30 seconds. If waveforms are supplied the service will run a logic simulation of the circuit on the same computer and return the results of this to the customer for him to verify that the circuit works as he intended and that the data have been transferred accurately. This takes from 1 to 13 minutes according to the complexity of the integrated circuit, and a similar time is needed to print out the results.

Once all this data has been verified by the customer's engineer and approved, it is released to the part of the service which lays out the integrated circuit. The layout process, claimed to be unique, optimises the placing of the cells and interconnections on the chip and then generates two plots on paper. One plot shows the proposed physical layout of the i.c. with pad positions and so on. The second plot is a diagram of the chip in logic diagram form, and allows the customer to check this version against his original circuit.

Checking the layouts

At this stage changes can still be made in the initial list to correct errors or modify the circuit. If this is done, the procedure is repeated until the customer's requirement is met. Once the two layout plots are certified correct by the customer's engineer, the layout is translated into magnetic tape format for the preparation of masks on computer-based equipment. If waveforms were supplied, these can be used to produce a test programme for an automatic test equipment used by the service.'

The final cost of such a custom-made integrated circuit is determined by the chip area and size of package. The greater the number of cells, the greater will be the chip area, the larger the package and the higher the cost. But GECS claim that, because of the reduction in the time required for design and the convenience of the whole design approach, "the overall cost of developing custom l.s.i. circuits can be significantly reduced for the smaller quantity user."

NEB details confirmed

THE NATIONAL Enterprise Board has published further details of the newly-formed microelectronics company into which £50 million of public money is to be invested. A statement was issued on July 22 saying that, initially, £25 million was to be invested in a new company called Inmos, and an agreement to that effect had been signed by the NEB, Inmos, and the three founders: Dr Richard Petritz, Dr Paul Schroeder and Mr Iann Barron, of whom more later.

The NEB say that provision of the second £25 million will depend on the achievements of the company. The funding will be in the form of ordinary and convertible preference shares. "Key employees will have the opportunity to purchase ordinary shares in the company. When investment in the company reaches the level currently envisaged, the founders and the future employees could hold up to 27.5% of the voting shares in the company." The NEB's investment will have a preferred position because of the differentiation of rights attaching to the ordinary and preference shares.

Inmos will concentrate on the next generation of m.o.s. technology, according to the NEB. Their products will include very large scale integration (v.l.s.i.) memory and microcomputer devices. This means the production of 64K r.a.ms, compared with the current maximum of 16K. Inmos will also, it is hoped, produce microcomputers — central processing units (c.p.us) on a single chip.

The company's headquarters and production will be based in the UK but technological and product development will be split between here and the United States, where the biggest market is. Operations will start simultaneously here and in the USA. A prototype production line will be based in the USA but by 1981 Inmos plan to establish volume production in the UK. The first task will be to establish design teams and plan production facilities. An NEB spokesman said that, as yet, no other appointments had been made than the three founders, but that the company was having "discussions with people about recruitment." By the middle of the 1980s, 4,000 people would be employed in the UK and 1,000 in the US. The NEB said they were looking at sites though no definite decisions had been made. The statement said that areas of high unemployment would be given special consideration, and the spokesman said this meant careful study of the North and North-West.

Dr Richard L. Petritz, 55, received a Ph.D. in Physics from North Western University. After lecturing and Navy work he was director of Texas Instruments' semiconductor r&d laboratory for ten years from 1958. He established TI's UK lab at Bedford. In 1968 he founded New Business Resources to launch new electronics companies and, in 1969, Mostek. As a consultant he advised the World Bank and the Korean Government in setting up electronic business in the Korean Republic.

Mr Iann Barron, 42, did Army and Air Force research after receiving a Cambridge MA. He was head of systems research in the computer research laboratory of Elliott Automation. In 1965 he founded Computer Technology Ltd, the first UK minicomputer company, and was managing director until 1971. Since then, as a consultant, he has advised the Department of Industry on future developments in computers and information technology.

Dr Paul Schroeder, 38, won a Ph.D. in Physics from Massachusetts Institute of Technology in 1967 and worked for Bell on memory design until 1974. He moved to Mostek becoming, in 1967, director of memory design engineering. He is thought of as a leading expert in m.o.s. dynamic storage devices design.

One of the most interesting aspects of these appointments is that the head of the trio, Petritz, has based his business in Dallas on the finding of funds for new ventures. It is a comment on the willingness of the holders of risk capital to take risks that he has now thrown in his lot with the NEB, though he is said to find the new venture attractive because it will eventually allow the company to regain its independence from the NEB. Another attraction is that labour costs in the UK are lower than in the US, a fact which has also encouraged Japanese investment here of late. The memory products, first off the production line, will be made in the US to build up the company, and the microprocessors will be made in the UK.

Post Office approve phone-line tv system — a new aid to the British police

THE POST OFFICE have accepted for evaluation an application by Aero & General Supplies, of Nottingham, for a slow-scan television (s.s.tv) system to be used as a private attachment to their public switched telephone network and private circuits. In addition, the British police, who were earlier given technical approval by the Post Office for a similar system for use on private circuits have now put s.s.tv into their research and development programme.

The heart of the system which has been proposed for the public switched telephone network is a slow-scan transceiver called the Robot Model 530. This unit is already in use in a number of phone-line tv systems in America and Canada, and has recently been technically-approved in Spain and the Netherlands. According to Aero & General Supplies, the Post Office had four months previously similarly approved the system for use on private telephone networks in the UK, but policy issues delayed approval for the public network. One may be forgiven for speculating that these policy issues could have had something to do with the fact that a s.s.tv system of this kind could in many cases compete with the Post Office's proposed Viewphone.

The Model 530 s.s.tv system, however, must run the Post Office gauntlet—the usual process of assessments and trials — because the approvals are subject to it meeting their technical requirements, which are to ensure the system's compatibility with the PO's networks and systems. Robot are confident that these requirements, which should involve only minor modifications to the equipment, can be met. These modifications will be discussed later.

Both the police system and the proposed switched-telephone network system, which are manufactured by Robot Research Incorporated of California, can be used with telephones, or any other "speech-communication" medium because they only require audio bandwidths to convey all of their picture information. The picture obtained is stationary and updated about every eight seconds (almost like a slide show)

Fig. 1

or can be held as long as required. The frame, in each case, is composed of a 256-line display having 128 × 128 discrete picture elements retained in a memory, and each coded into one of 16 grey shades. Although the picture definition does not compare with that of 625-line fast-scan tv, it is nevertheless surprisingly good, as shown in Fig. 1. A normal 625-line fast-scan tv camera is used to obtain the picture and this is sampled at a slow-scan rate and then transmitted immediately or recorded for later transmission if required. The display may be shown on a normal 625-line monitor, or even on a domestic tv receiver (slightly modified).

S.s.tv systems have created enormous interest throughout the world and are already being used by security firms, banks, police and meteorologists. They are, for example, ideal for the quick transmission of "mug shots," fingerprints, cheque signatures and for security surveillance. When connected to a telephone answering machine they enable one remote operator to contact any chosen premises, a bank for example, and see a picture of the strongroom within seconds. When a system is connected to a burglar alarm, the police can not only receive an alarm call, but can see a picture of what is happening. The eight-second interval between samples is sufficiently short for monitoring high security areas, and future developments are likely to include a system which compares one frame with the next to trigger an alarm after any picture-content change, caused by an intruder for example.

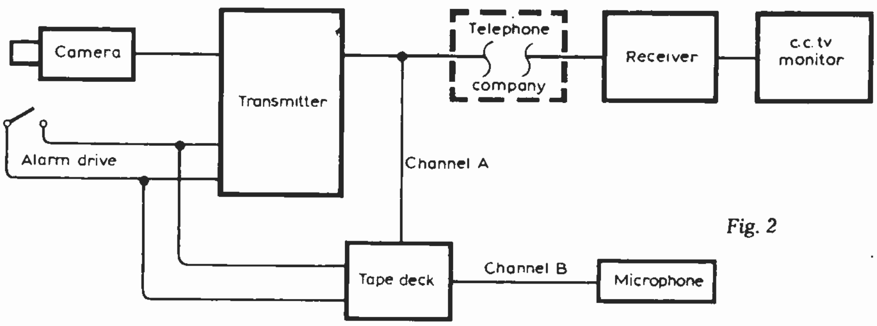


Fig. 2

A typical s.s.tv system is shown in Fig. 2. This is a one-way system using transmitter and receiver separates. Transceivers can be used for two-way communications.

In the last few months, at least one British police force has carried out experiments with one of Robot's s.s.tv systems to determine its usefulness. They are using Robot's Model 400 which, being the amateur version of the Model 530, has more controls. As one might expect, they will be exploiting the system to the full and many modes and methods of transmission have been investigated — including telephone lines, and v.h.f., and h.f. radio — over both long and short distances.

For the system to be most beneficial to the police, they will be doubling the memory capability of the system and increasing the grey scale from 16 to 64 levels. Certainly, an s.s.tv system having 64 levels would be very useful for the transmission of both pictures and fingerprints. Robot also intend to make this modification some time in the future.

Continued on page 74

More about s.s.tv

In s.s.tv a television picture is slowed down so that it may be contained within audio bandwidths. This slowing down results in a picture having about 120 lines (128 lines in the case of the Model 530) with a scan time of 7.2 (for a 120-line, 50Hz system).

Because the total bandwidth of s.s.tv lies well within the audio spectrum, it is possible to convey pictures using normal radio transmitters, telephones or other audio systems. In addition, the signals may be recorded on ordinary domestic tape recorders for later playback or for programme construction.

A slow-scan signal usually consists of a 1200Hz audio subcarrier which is frequency modulated by the composite video signal. The resultant f.m. signal is normally used by radio amateurs to modulate a s.s.b. transmitter. Figure 3 shows the frequency composition of part of the f.m. signal — a single slow-scan line — in which an audio frequency of 1500Hz represents a black level, and an audio frequency of 2300Hz represents a white level. Intermediate shades of grey are represented by the frequencies between 1500Hz and 2300Hz. In the case of the Model 530, each picture element is represented by one of 16 grey shades in a digital memory. The memory being a 65,536-bit store, made up of sixteen 4,096-bit r.a.ms.

The aspect ratio of a s.s.tv picture is usually 1:1, mainly because the surplus cathode-ray tubes, generally used by radio amateurs for s.s.tv, are round, and the square format used the maximum available screen area.

All synchronisation pulses are transmitted at the 'ultra-black' subcarrier frequency of 1200Hz and consequently they do not appear on the screen. As shown in Fig. 3, the line scan consists of a 5ms sync pulse at 1200Hz followed by the frequency variations representing the light intensities of the visual image which has been scanned. The spot on the monitor screen flies back during the sync pulse period. At the beginning of each complete frame the 5ms sync pulse is replaced by a 30ms frame sync pulse during which the spot resets from the bottom right to the top left of the picture.

Although s.s.tv is almost entirely an amateur development pioneered by an American team headed by Copthorne Macdonald, W4 ZII, in 1958, it was only fairly recently (1968 in the USA and 1976 in the UK) that the controlling bodies (the FCC and the Home Office, Directorate of Radio Technology) put it into the standard radio amateur licence. Before about 1975, UK responsibility was with the Ministry of Posts and Telecommunications, who set fairly rigid standards for s.s.tv. These standards are no longer applicable, and providing s.s.tv is confined to the allocated frequency bands 3.5 to 3.8, 7 to 7.1, 14 to 14.35, 21 to 21.45, 28 to 29.7 and 144 to 146MHz, and the normal limitations of power and bandwidth are complied with, amateur s.s.tv transmissions may use any standards the operator wishes. This will not, however, be true of any unit proposed for private or public use with Post Office networks.

Because the Post Office insist on good mains isolation, one modification to the Model 530 will probably be to fit special transformers having screens between primary and secondary windings. The alternative is to add a mains isolation unit to each piece of equipment: this is how the police have solved the problem.

Problems are bound to arise because there is a Post Office line-signalling tone within the 1200 to 2300Hz bandwidth required for the s.s.tv transceiver. This tone, at 2280Hz, is used in the most common private (ac13 or ac15) and public (ac9 or ac11) networks to seize and release the line during phone calls. A 2280 ± 15Hz receiver is used to sense this tone and it responds, only when the tone is pure and of sufficient duration, by cutting off the call. Since the s.s.tv system is f.m. it may be possible for it to produce a pure tone, which for one reason or another occurs within the bandwidth of the receiver and is, because of the picture content, of sufficient duration. This would also cut out the call.

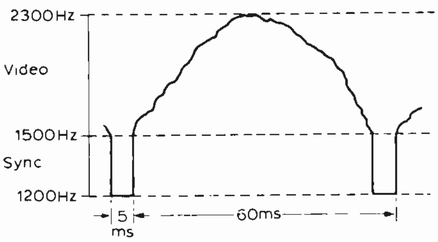


Fig. 3

Other tones on 2280Hz are for address signalling (dialling) and will therefore not affect the s.s.tv transmission.

One way in which this problem could be overcome is for the s.s.tv unit to produce a second tone (at 1000Hz say) so that even if a tone of 2280Hz was produced, it would not be pure because of the presence of the second tone — this would be interpreted as speech. Alternatively, the whole s.s.tv frequency band may be shifted down a few hertz to avoid 2280Hz. Robot considered the use of a second tone but the idea was dropped when it was discovered that, whatever second frequency was chosen, the beat frequencies created either interfered with the picture or fell outside the frequency bands permitted by the Post Office. Eventually Robot chose a bandwidth from 800 to 1900Hz and are now trying to make this a standard acceptable to the whole of Europe and America. The police are also going to comply with this.

At the moment the model 530 is being retailed by Aero & General Supplies, but their intention is to distribute it through a franchised network consisting mainly of established closed circuit video dealers.

According to the company, a price cannot, at this stage, be fixed for the equipment if it is used on P.O. lines, but it is anticipated that a phone-line television transceiver, as it will be called, will be offered for less than £1,500. The equipment is available now for uses which do not require P.O. approval, for less than this, and transmitters and receivers for one way transmission are available for even less. □

Large-size l.c.ds to have longer lives

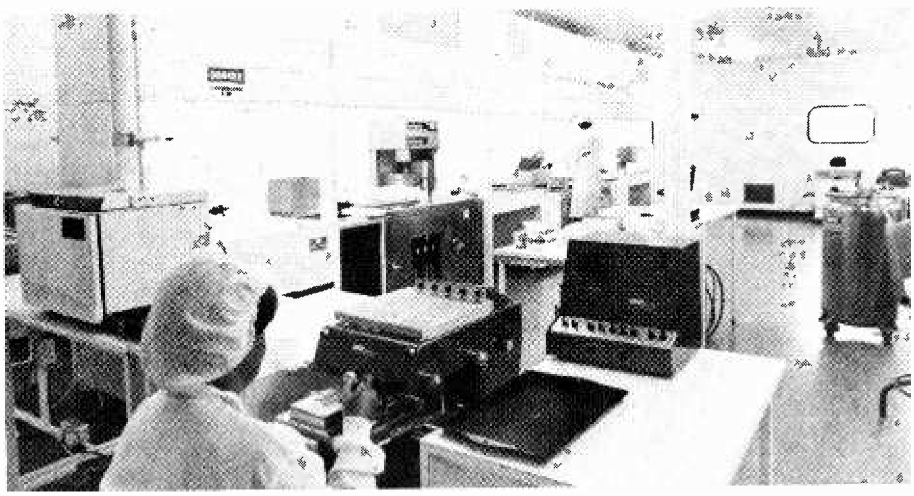
GLASS FRIT SEALING, currently recognised as the best method of sealing liquid crystal between glass plates for the production of long-life l.c.ds, has been so well mastered by ITT Components Group Europe that they are now successfully mass producing displays having character heights as large as 13mm. Few l.c.ds are given a life expectancy of greater than two years, but this UK company feels confident that their products will last for at least five years.

If a l.c.d. is to have a long life it is essential that the seal between the glass plates is impervious to all materials which could contaminate the liquid crystal. There are two types of seal in common use; glass frit and plastic. Since glass is more inert, physically and chemically, than plastic, it can withstand much worse environments, and is consequently expected to exhibit higher reliability. Unfortunately, the glass frit technique, which involves depositing low-softening point glass (frit), in paste form, on to the edges of the glass plates, and firing at about 500°C, is extremely difficult to master. Difficulties arise because the glass plates must be separated by only about ½ thousandth of an inch (12 microns), over the whole display surface and, of course, as the display gets larger these become even harder to overcome. Although a number of manufacturers are using the glass frit technique on small-size displays, Siemens in Germany, Brown Boveri in Switzerland, Electrovac in Austria and Motorola in the USA, ITT claim to be the first company in Europe and probably in the world to produce large-size displays in quantity.

ITT, although late entering the l.c.d. market, recognised the long-term potential of glass-frit seals and decided, at an early stage, to concentrate on this technique. The real importance of the technique is expected to be seen in the future when the ambient temperature range of l.c.ds is extended. With the current, restricted, operating temperature range (typically 0 to 60°C) the difference in reliability between glass-frit seals and plastic seals is not market.

ITT intends to achieve, within the next five years, a 25% share of the European market and a 10% share of the World market for displays having a minimum 12mm character height. The actual display that they are investing in is a field effective (twisted nematic) l.c.d. measuring 82 x 34mm overall. (For a description of the constructions and types of l.c.d. available see p230, May 1975 issue of *Wireless World*.)

General production area for ITT's liquid crystal displays. To achieve high yields it was accepted that airborne particles had to be virtually eliminated, and this purpose-built clean room area was constructed to create ultra-clean conditions for all critical operations.



The company is currently supplying l.c.ds at a rate of about 1,000 pieces per week, and they forecast that this figure will be up to 3,500 by the end of 1978 and 10,000 by the end of 1979. At the moment, however, ITT admit that yields are unrealistic and a figure of 60% is the most any manufacturer could expect to obtain. They are working to improve the performance of twisted nematic l.c.ds, in particular to extend their operating temperature range. In the future we can expect to see larger displays with drive circuits mounted directly on them.

At ITT's Central Research Laboratory at Harlow, completely new types of l.c.d. are being developed. These include a display based on cholesteric l.c. which contains a dye enabling it to have its own intrinsic colour and avoid the need for polarizers. Research is also progressing into the use of smectic l.c. materials in displays. These l.c.ds would have memory and continue to display a message after removal of the drive signal. □

News in Brief

The Radio Industries Club of Great Britain announce that Howard Thomas, Chairman of Thames TV, is to take over from Douglas Muggeridge, Deptuy Managing Director of BBC Radio, as the Club's President. John Record, Thorn Industries' National Sales Manager, will take over from Alan Pederson, of Antiference, as the Club Chairman.

Admiral of the Fleet Sir Edward Ashmore, G.C.B., D.S.C., Chief of the Defence Staff until his retirement last year, has accepted an invitation to join the Board of **Racal Electronics Ltd.**

Robert Telford, Managing Director of GEC-Marconi Electronics Ltd, has been knighted for his services to export. Under Sir Robert's guidance the GEC-Marconi Electronics Group's overseas sales have risen from about £18 million in 1968 to over £230 million, and since 1966, the Group has been awarded 19 Queen's Awards, of which 11 were for export.

A **Marshall (London) Ltd** have moved their offices, sales and stores departments to new premises at Kingsgate House, Kingsgate Place, London NW6.

Mains interference and filtering

Protecting logic systems from mains borne noise

by **I. Catt and M. F. Davidson** (CAM Consultants), and **D. S. Walton** (Icthus Instruments Limited)

Although great trouble is taken when designing d.c. power supplies for large digital systems, interference on the mains power lines is often overlooked or underestimated. This article outlines the types of noise that occur, and describes a suitable filter for overcoming the problem.

INTERFERENCE from the mains can be classified into three types. Balanced, where the noise signal travels equally down the live and neutral lines, and the earth line acts as a return path. This is often called common mode noise, and it causes earth currents which can upset high gain linear circuits. Unbalanced, where the noise signal travels down the live line and back on the neutral line, leaving the earth line unaffected. This is often called differential mode noise and may be lost or suppressed in the d.c. power supplies of a circuit. It can be shown that any complex signal travelling down the three lines can be resolved into a common mode component and a differential mode component. Mains borne radiated noise, which can be both balanced and unbalanced, enters the equipment via the three power lines, and then radiates directly into the logic.

Susceptibility of a digital system to mains noise

Differential mode noise on the live and neutral lines tends to be smoothed out at the unregulated and regulated d.c. points. However, because large value capacitors have a significant series inductance, some of the noise, if not suppressed before the transformer primary, will pass through the power supply and cause transient variations which can disrupt the logic operation. Screening the transformer will not help significantly because differential noise is fed through the transformer from primary to secondary and not via interwinding capacitance.

Common mode noise, however, does pass through the transformer via interwinding capacitance, so a screened transformer will help to suppress the interference. The typical inter-winding capacitance for an unscreened transformer is 100pF. With screening, this falls to around 1pF. Any common mode noise that does pass through the transformer tends to raise the positive voltage relative to 0V, and tends to lift the level of 0V at some points but not others. The use of a choke rather than a link between 0V and earth will help to render the logic immune to this noise because all of the logic supply lines will tend to move together. Therefore, any common mode noise which does pass through the regulated d.c. supply will see three loads in series. The link between the earth line and frame, the link between frame and 0V, and the line carrying 0V across the logic to the link. If the 0V to frame to earth link has a high impedance, such as a choke, most of the noise will appear harmlessly across it. The d.c. resistance of the choke should be below 0.1Ω to conform to BS3861. If, however, the 0V to earth link is a low impedance, the noise will lift the potential at one point on the 0V grid. This will degrade the logic signals and tend to cause a malfunction.

Mains borne radiated noise, which is emitted from the mains wiring, can be greatly reduced by screening the live and neutral lines, and earthing the screens to the frame. Another method of reducing the radiated noise is to include a mains filter at the point where the power lines enter the circuit module. A third approach is to have mains lines in the module separated from the vulnerable logic by correctly earthed bulkheads. Once past the mains filter, the mains cables do not normally need to be screened. If power is switched on and off to loads within the module these power lines should also be screened.

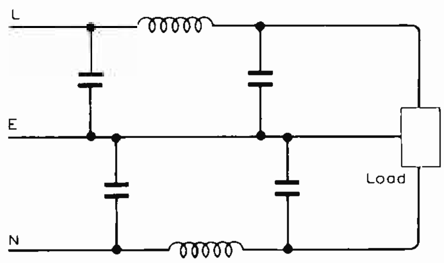


Fig. 1

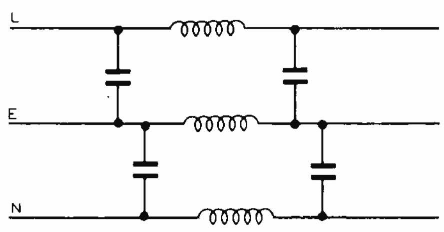


Fig. 2

Magnitude of mains borne interference

A reasonable noise amplitude to design against in a 240V single phase supply is 2kV over the range 100kHz to 10MHz. The noise may be common mode or differential mode and can be caused by, for example, switching off an electric motor which is on the same supply. It is wise to assume large amplitude noise above the nominal 240V of the line, and also that it is both common and differential mode.

The source impedance of the noise is difficult to determine, but it is safest to assume a very low source impedance of, say, two ohms. Both of these assumptions might surprise the reader, but they have been chosen to give a reasonable safety margin.

Mains filtering

Mains filters are constructed from capacitors and inductors. The capacitors require an adequate voltage rating and also have to be able to dissipate the heat generated from the maximum current. By Ohm's law, $V = I Z$ so $I = V/1/6 fC$ which is 240 . 300 . C. Therefore, for a 1fiF capacitor the current is around 100mA. It is worth noting that the mains filter can significantly alter the power factor of a load. The series inductance of such a capacitor can be as low as 10nH, which is very satisfactory in this application.

With inductors, it is important to make sure that they do not saturate at the peak current. If the power taken by a circuit is around 1kW, the r.m.s. current is around 4A and the peak current may be as high as 10A. A choke which saturates at 20A and has an inductance of 200μH can have a parallel capacitance as low as 10pF which again is satisfactory for this application. The d.c. resistance of such a choke is around 0.1 ohms, so it is possible to meet the safety requirements even if the choke is placed in the earth line.

A mains filter is a low pass device and the usual circuit is a double π as shown in Fig. 1. High frequency signals entering either the live or neutral lines see a high impedance inductor ahead and are shunted to earth through a low impedance capacitor. Typically, at

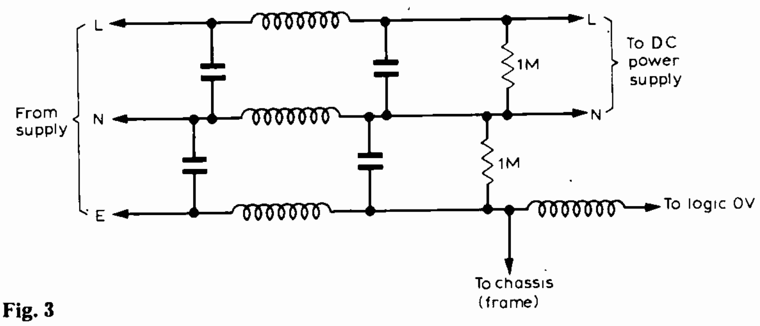


Fig. 3

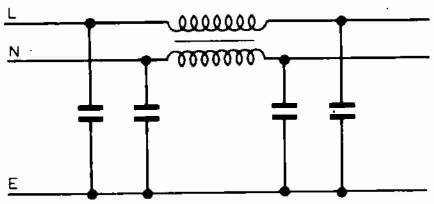


Fig. 4

1MHz, with 1μF capacitors and 200μH inductors, Z_c is around 0.2Ω and Z_L is around 1kΩ. If the source impedance of the noise is 1kΩ or higher, the noise is attenuated by a factor of 1kΩ/0.2Ω = 5,000 or about 70dB. If the source impedance of the noise is low, the first capacitor is ineffective, but the potential divider formed by the inductor and the second capacitor still gives around 70dB attenuation at 1MHz.

Any high frequency signals approaching from either direction see a short to earth, and a high impedance series inductor blocking the path ahead. This arrangement works well if noise is the only problem. But, because the input and output of both lines are connected together at high frequency, an "earth loop" pickup of externally radiated noise can occur. Also, the possibility of electrostatic discharge into the circuit is much more likely. From the point of view of radiated noise the circuit in Fig. 2, which blocks the passage of high frequency signals down all of the lines, is preferable. It makes the path down the lines an open circuit to high frequencies, and tends to isolate the system. This filter does however cause a disquieting amount of earth current. If the capacitors are 1μF, the total earth current is about 150mA. With the circuit rearranged as in Fig. 3, the noise suppression is virtually unaltered and the earth current is reduced to around 2mA. This circuit is also safer because there are no components linking live directly to earth, and a single shorted capacitor does not present a safety hazard. The two resistors discharge the capacitors if the filter is disconnected from the mains.

Commercial mains filters

Medium performance commercial filters have a specification of around 60dB insertion loss in the region of 1MHz. A filter of this type would cause 2kV of noise to be reduced to a mere 2V, which would easily be suppressed on its way through the power supply. Higher performance filters, specified at 100dB insertion loss, reduce noise of 2kV down to an unnecessarily low 20mV. The most serious shortcoming in commercial units is when the windings of both chokes are on the same core as shown in Fig. 4. The theory is that the currents in the live and neutral lines, being equal and opposite, create zero total magnetic flux in the choke. This means that for a heavy live and neutral current the core will not saturate, and a single toroid can be used in place of two separate and more expensive chokes. However, instead of two chokes there is a transformer which will not stop any differential mode noise. The author has not seen a manufacturer's specification where insertion losses for both differential and common mode noise have been unambiguously defined. The insertion loss is the ratio of the output amplitude from the filter into a load divided by the input from a source with the same impedance. Sometimes the specification does not state this impedance so it is virtually impossible to determine the filter performance. The correct specification is the minimum insertion loss when the source impedance and load impedance are independently varied from zero ohms to open circuit. □

This article is based on material from a book "Digital Electronic Design", by the above authors, published by C.A.M. Publishing, 17 King Harry Lane, St Albans, Herts, price £8.00 including postage. For information on the availability of the mains filters described write to Icthus Instruments Ltd, Princesway, Team Valley Estate, Gateshead. C.A.M. Consultants will be giving their next seminar on digital electronics design in St Albans, October 9 and 10. Information from 17 King Harry Lane, St Albans, Herts.

New 3-D military radar

MODERN RADAR DEFENCE SYSTEMS require faster reaction capabilities in order to combat the dramatic increase in aircraft speeds and manoeuvrability of targets. To achieve this, automatic data processing facilities, capable of carrying out high speed tracking and prediction from radar returns, have become essential. To operate with maximum effectiveness these automatic systems require continuous height information on all targets as well as their plan positions. Marconi Radar Systems Ltd have introduced a 3-D radar, called Martello, which does just this.

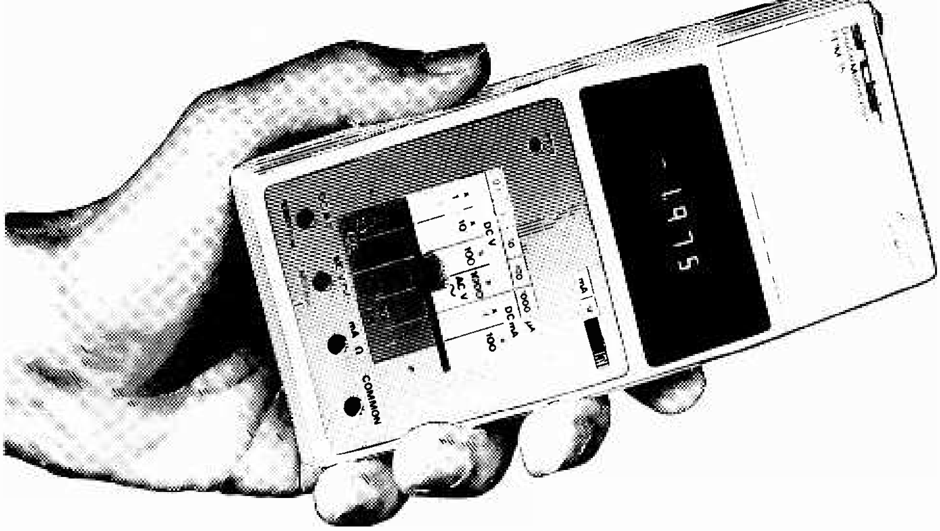
Martello has been designed for long range cover, transportability and to provide frequent height measurement to ensure that tactical height changes can be detected in good time. It is also equipped with full electronic counter-countermeasures (e.c.c.m.). The radar, which operates in L band and provides automatic detection and plotting of targets, even in hostile environments, detects intruders at ranges in excess of 300 nautical miles and altitudes in excess of 100,000 feet. Elevation cover extends from zero to 30 degrees.

Range, azimuth and height is recorded for every target detected, on every revolution, with accuracies of 0.05nm, 0.5nm (at (100nm) and 1,000 feet (at 100nm) respectively. For height finding Martello uses what is claimed to be a unique parallel receiving system. This has a vertical stack planar array antenna comprising sixty identical horizontal linear array elements, each with its own receiver. Each array has the same-shaped amplitude distribution, giving a narrow azimuth beam width. By precisely controlling the amplitude and phase feeds to each array, the side lobes are kept to a minimum. In elevation, the transmitted r.f. power is distributed between the arrays to give cosec² target illumination, and every target within the elevation coverage is illuminated on every transmission.

Returns from a target are received by all of the arrays and the individual receiver outputs are then combined in a simple passive beam-forming network. This synthesizes the cosec² surveillance pattern and eight elevation patterns matched to the required elevation coverage. The surveillance pattern and the lowest elevation pattern are pulse-compressed and processed either automatically or manually. Target range and azimuth are extracted from series of individual returns by a plot-forming unit and the height data is obtained by measuring the returns in adjacent elevation patterns.

The system is designed to self-adapt to the radar environment and it has comprehensive facilities for monitoring system performance necessary for complete control of the system parameters.

The Sinclair PDM35.
A personal digital multimeter for only £29.95 (+8% VAT)



Now everyone can afford to own a digital multimeter

A digital multimeter used to mean an expensive, bulky piece of equipment.

The Sinclair PDM35 changes that. It's got all the functions and features you want in a digital multimeter, yet they're neatly packaged in a rugged but light pocket-size case, ready to go anywhere.

The Sinclair PDM35 gives you all the benefits of an ordinary digital multimeter – quick clear readings, high accuracy and resolution, high input impedence. Yet at £29.95 (+8% VAT), it costs less than you'd expect to pay for an analogue meter!

The Sinclair PDM35 is tailor-made for anyone who needs to make rapid measurements. Development engineers, field service engineers, lab technicians, computer specialists, radio and electronic hobbyists will find it ideal.

With its rugged construction and battery operation, the PDM35 is perfectly suited for hand work in the field, while its angled display and optional AC power facility make it just as useful on the bench.

What you get with a PDM35

3½ digit resolution.
Sharp, bright, easily read LED display, reading to ± 1.999.
Automatic polarity selection.
Resolution of 1 mV and 0.1 nA (0.0001 μA).
Direct reading of semiconductor forward voltages at 5 different currents.
Resistance measured up to 20 MΩ.
1% of reading accuracy.
Operation from replaceable battery or AC adaptor.
Industry standard 10 MΩ input impedance.

Compare it with an analogue meter!

The PDM 35's 1% of reading compares with 3% of full scale for a comparable analogue meter. That makes it around 5 times more accurate on average.

The PDM35 will resolve 1 mV against around 10 mV for a comparable analogue meter – and resolution on current is over 1000 times greater.

The PDM35's DC input impedance of 10 MΩ is 50 times higher than a 20 kΩ/volt analogue meter on the 10 V range.

The PDM35 gives precise digital readings. So there's no need to interpret ambiguous scales, no parallax errors. There's no need to reverse leads for negative readings. There's no delicate meter movement to damage. And you can resolve current as low as 0.1 nA and measure transistor and diode junctions over 5 decades of current.

Technical specification

DC Volts (4 ranges)
Range: 1 mV to 1000 V.
Accuracy of reading 1.0% ± 1 count.
Note: 10 MΩ input impedance.

AC Volts (40 Hz-5 kHz)
Range: 1 V to 500 V.
Accuracy of reading: 1.0% ± 2 counts.

DC Current (6 ranges)
Range: 1 nA to 200 mA.
Accuracy of reading: 1.0% ± 1 count.
Note: Max. resolution 0.1 nA.

Resistance (5 ranges)
Range: 1Ω to 20 MΩ.
Accuracy of reading: 1.5% ± 1 count.
Also provides 5 junction-test ranges.

Dimensions: 6 in x 3 in x 1½ in.
Weight: 6½ oz.
Power supply: 9 V battery or Sinclair AC adaptor.
Sockets: Standard 4 mm for resilient plugs.
Options: AC adaptor for 240 V 50 Hz power. De-luxe padded carrying wallet. 30 kV probe.

The Sinclair credentials

Sinclair have pioneered a whole range of electronic world-firsts – from programmable pocket calculators to miniature TVs. The PDM35 embodies six years' experience in digital multimeter design, in which time Sinclair have become one of the world's largest producers.

Tried, tested, ready to go!

When you buy your PDM35 it comes complete with leads and test prods, carrying wallet and comprehensive operating instructions.

The PDM35 is a new concept in multimeters – but over 20,000 have already been sold! If you'd like to know more about the PDM35, and how to get one, complete the coupon and post it to us. We'll send you detailed information by return. Send the coupon today!

Sinclair Radionics Ltd, London Road, St Ives, Huntingdon, Cambs., PE17 4HJ, England.

To Sinclair Radionics Ltd, London Road, St Ives, Huntingdon, Cambs., PE17 4HJ.
Please send me more information on the Sinclair PDM35 personal digital multimeter.

Name ....

Occupation ....

Address ....

....

....

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WW/9

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World leaders in fingertip electronics

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LETTERS TO THE EDITOR

MOBILE RADIO BANDWIDTHS

It is with great interest that I read Mr W. M. Pannell's article on mobile radio bandwidths in the June issue. Some of the proof of the pudding has been tasted by us, a public utility, some five years or more. In the face of great scepticism we obtained permission to operate some standard USA made 30kHz fm fixed and mobile equipment at 15kHz spacing using a little more than 2kHz deviation. The equipment is used in hilly and mountainous country.

The practical result of our experiment, using single frequency simplex in the two-metre band, can be summarized quite simply:

1. Utilisation of speech under difficult conditions with no perceptible degradation of intelligibility.

2. If base stations (100 watt) are placed at least some 25km apart, possible use of the next channel at a 15kHz spacing.

Please note all this with standard 30kHz equipment. It is also necessary to state that propagation conditions in this area are such that they may almost be defined as anti-fading conditions, such that good results are a little surprising even to us. However, the peripheral mobiles suffer less noise (see par. 1) as a result and so operator acceptance was maintained.

Mr Pannell is to be congratulated on the redefinition of a technical problem which has very many economic and investment aspects. However, I hope that good sense will win out and that 12½kHz or 15kHz channels will become a standard. The latter seems the more likely to me, due to existing channel allocation in the USA and also its greater suitability for future 2.5kHz narrow band allocations (see June issue, p. 48; "FCC produces ideas for better spectrum use"), which may yet be interleaved with the existing allocation scheme.

P. Hirschmann
The Israel Electric Corporation Ltd
Haifa
Israel

AUDIO EQUIPMENT REVIEWS

In a report in your July issue (p.49) you asked the question: "How accurate are audio reviews?" Instead of attempting to give the answer your reporter used his available space to explore the inner details of particular events. From this the reader could come to some extremely unpleasant conclusions. May I, therefore, through the courtesy of your pages and as a reviewer of long standing, attempt to supply the answer that you failed to give?

The accuracy of a review will depend upon a number of factors. Among these some of the most important are:

1. The personal experience of the reviewer himself which will obviously be variable from individual to individual.

2. The adequacy of his measurement facility to cope with the fine limits of distinction that must be observed in a scientific appraisal.

3. The ability of the reviewer to interpret correctly the integration of his measurements and subjective impressions, taking into account the further variations induced by programme source material, listening room acoustics and the fallibility of his own ears.

It follows that just as there is no "perfect" piece of equipment neither is there a "perfect" review. The eventual arbiter is in every case the customer, upon whom there devolves the final decision which is expressed through his cheque book.

As a matter of interest I have been using Bowers & Wilkins DM7 loudspeakers in my listening room for several weeks. My subjective impressions are slightly different to the opinions quoted from the *Gramophone* review by Mr John Gilbert, but more closely accord with his feelings than with the comments of Mr Attewell as expressed in your extracts from his *Hi-Fi News* review. This fundamental difference does not in any way invalidate either of the two published reviews but serves only to underline the dangers of confusing "accuracy" with "conformity".

It seems to me that your reporter was preoccupied with considerations of *integrity* rather than *accuracy*. Let me therefore add that I have in the past been pleased to accept hospitality from Bowers & Wilkins and in my capacity as publisher of *Hi-Fi Trade Journal* have indirectly accepted money from that company as payment for advertising space. The nub of the question is surely this: Have the "wicked men" of Worthing "got at me" to express the opinion quoted above? I find it very hard to believe that any serious minded person could entertain such a preposterous proposition for a single moment. The truth of the reviewing business is very, very different indeed.

In some twenty years I have frequently written critical reviews, some of which have been so condemning that the product has been withdrawn from the market. In all that time I can recall only one instance where any unpleasantness arose between the manufacturer/distributor and myself. To the contrary, an accurate but "bad" review is regarded as helpful by any sensible manufacturer since it points to the direction of essential improvement if he is to be successful in the market-place. This success is, after all, his final objective.

I have never at any time been put under any pressure to alter or suppress measurements; such a thing has never even been suggested to me and if it were the proposal would be most forcefully rejected.

In order to consolidate my own position as an "accurate" reviewer I have made a personal investment in test equipment and facilities amounting to a five-figure sum. My laboratory is used for consultancy work on behalf of clients, some of whose products I have reviewed or will be reviewing. The object of this exercise is to advise on performance characteristics so that improvement can be effected where necessary. Is this not in the true interests of both the consumer and the distributor? To suggest any kind of malfeasance is to imply a contrary endeavour; i.e. a deliberate attempt to market a poor quality product to a gullible and unsuspecting public. Any firm which attempts to embark on such a course within this highly competitive industry would be taking the shortest possible road to disaster.

Perhaps my point of view might be regarded as naive, originating from a simple mind. If so, such a judgement will be accepted as a compliment.

Denys G. Killick
Pontypridd
Mid Glam.

WANTED: EARLY WW VOLUMES

The Radio Society of Great Britain is anxious to obtain copies of the early volumes of *Wireless World* for the period when it was the official organ of the Wireless Society of London and later the RSGB.

The volumes required are: volume 8, 3 April, 1920-19 March, 1921; volume 9, 2 April, 1921-10 March, 1922; volume 10, 1 April, 1922-30 September, 1922; volume 11, 7 October, 1922-31 March, 1923; volume 12, 7 April, 1923-26 September, 1923; volume 14, 2 April, 1924-24 September, 1924; and volume 15, 1 October, 1924-4 February, 1925.

The Society is also anxious to obtain volume 2 of *Experimental Wireless*, October, 1924-December, 1925.

If any of your readers could help the Society by supplying any of these volumes I would be glad to hear from them.

G. R. Jessop, G6JP
Consultant
Radio Society of Great Britain
35 Doughty Street
London WC1N 2AE

POOR PROSPECTS IN ELECTRONIC ENGINEERING

How wholeheartedly I concur with the perceptive exposition of your contributor in "Open letter to Finniston" (Letters, July). I, too, am saddened by our industry's attitude to young graduates. It is in the nature of the "small-minded people" who manage our industry that jealousy ranks high in their emotions, and leads to the notion that these arrogant young persons need to be kept in their place. If they are engineers that place will be fairly lowly. No lunches with customers or company cars for them!

The next hurdle for the unwary graduate I would describe as the Barnes Wallace syndrome, experienced as total opposition to the novel concept. The grinding down begins! This, surely more than any biological phenomena, leads to the misconception that a person's inventiveness declines asymptotically to zero at the age of 30. I satisfy myself that this is a myth by observing that my own "rate of acquisition of patents" index is no less now that I have passed 40. Not being afraid of the unconventional I have obstinately gone on designing things and being an engineer. But at what cost?

Taking the price of a house as reference level, my salary in a senior engineering post is less now in real terms than it was over 20 years ago when I took my first job as a technical assistant.

To my mind, a crucial factor in this continuing decline in living standards is that engineers are not generally militant by nature. Even if they were, what hold have engineers got compared with, say, train drivers? If we all stopped designing and developing things tomorrow, who would notice? Who, anymore than would have "noticed" if radar, television or the digital computer had never been invented?

If it is accepted that the electronics industry has some merit in society, then for its survival very positive steps must be taken to provide a sufficiently attractive working climate for the young to develop their engineering skills, and without the necessity to go abroad, move into "sales" or "management" or even the drawing office, to feed their children.

D. B. Brown
Charlwood
Surrey

Several points raised in the "Open Letter to Finniston" by "Chartered Engineer" (Letters, July) have a depressingly familiar ring to them. Phrases such as "short-term industrial fodder" – "managed by narrow and small-minded people" – "irrespective of experience" – are amply justified in the light of my own, albeit short, experience.

To a young electronics engineer working at least, until recently – in a large company, part of an even larger privately owned group, the management philosophy (or is it a lack of one?) has been made abundantly clear. Staff who have gained experience on a particular system – and who are consequently much better at their job than those who have never seen that system before in their life, regardless of qualifications – are treated no better in any respect than new recruits. For instance, graduate entrants with no previous training are paid the same, in some cases greater, salary as some of my contemporaries who have not only had a year's system experience but also undergone "sandwich" course training with the company. And though they may start out as "bright eyed and bushy tailed", by the time they have grown wise to the way they themselves are being treated (even with the least perceptive engineer this process takes only a few months – in some cases less than a week), disillusionment and cynicism have set in for good – as witness the present writer. In such a climate, even if the job itself and its environment are pleasant and enjoyable – not always the case – dissatisfaction is inevitable.

If this malaise were confined to one large company, or even to one group, there would be little point in publishing this letter. But, from conversations with friends who have joined other organisations, this seems not to be the case. How many engineers in large companies do *you* know who are quite satisfied with their employers? The solution is therefore not to be found simply by moving among different leviathans (the grass is always greener ...). A general rule would appear to be that the smaller a firm is, the better it treats its employees; but, of course, small firms do not employ the bulk of the country's electronic engineers, and also they prefer those who have already gained some practical experience. Hence the reluctance of graduates to enter the industry, an instance of which is provided by the letter cited above.

In these circumstances, the most sensible course for a young engineer is initially to take a job with a large company solely in order to gain enough experience that he can leave after a year or two, to join or form a small firm where he will have a much greater chance of finding job satisfaction. If this were to happen on a large scale, the effect would be to leave the large groups with inexperienced youngsters and experienced no-hopers (some would have it that this is already so); in which case, if their senior management were unaware or, through inertia, unable to rectify the situation, they would simply collapse, due to inability to compete — in the absence of other market factors. It may be that this process is already in motion, and that the elephants have had their day. While to many this would be a cause for rejoicing, it would be a shame if the vast resources inherent in them were to go to waste, and it is to be hoped that some at least of their creative potential could be salvaged in such event.

Young engineers should therefore be encouraged to be more aware of the state of the industry they are entering, and reassured that there is a future for them, albeit perhaps along slightly different lines to what is obvious at the present. It is, after all, far better to give birth to something new and vital than to despair of the dying.

Tim Williams
Ely
Cambs.

The "name and address supplied" open letter to Finniston in your July issue makes chilling reading. There, but for the grace of God, go I. The poor man is fifty-one, trapped in the horror of an electronic engineering career.

I graduated in Engineering in Cambridge in 1959 and went into electronics R&D. I finally read the writing on the wall late – very late – and gave up the idea of a professional career in Engineering in 1971. I began teaching Remedial English in a secondary school, for which I received the same pay, although unqualified and inexperienced, as I had been receiving as a design engineer with a State Scholarship in Mathematics, a Cambridge degree, many publications in the top journals, some impressive research and development achievements behind me, and twelve years of experience.

Recently, when I was asked to give Science and Technology career advice to the pupils at my son's school, Haberdashers', I told them that if they took up such a career they would look forward to being on half pay, and that Britain was getting out of high technology. I told them that if they were really keen they should make certain to study foreign languages and think in terms of a career abroad.

Contrary to some reports, I have never attacked Finniston or his Committee of Inquiry into the Engineering Profession. However, I would now like to say that in my opinion there is no chance that their final report will be helpful to those who work in electronics and computer design. This is because none of the seventeen members of his committee is drawn from electronics, although electronics is a very large part of the engineering profession. (Computers alone are the third biggest industry in the USA.) The Committee will repeat the lie that our best engineers must be coaxed into rolling up their sleeves (like the good plumbers they really are) and getting into production. Because of their limited background, their lack of experience in high technology industry, the committee members will not know that Production is a facet which tends to disappear as the sophistication of the technology increases. It is difficult even to find the production department in a high technology company, for instance one involved in advanced radar. If you think that Production is the essence of advanced engineering, you ignore the kind of message that Marshall McLuhan was trying to put across thirteen years ago. Notice that all examples on tv lauding the supposedly noble, against-the-tide first class engineer working in production are taken from old, declining industries. Such stories are merely another attack on high technology and its massive potential.

I am pretty certain that I can guess, from the tone of his letter, which company the fifty-one year old is working for. I would advise him that although the harassment of professional engineers is severe throughout British industry, in the case of his company it is a little worse than usual. The managing director of his company is systematically rooting out the engineering competence in his company, and by now has to a large extent completed the task. In five years' time, this managing director will be pilloried for destroying his company. But that is all in the future, and cold comfort for the fifty one year old.

Ivor Catt
St. Albans
Herts.

TALKING TO COMPUTERS

I was amused to read Mixer's remarks on computer programming (p.92, June).

The real reason we don't programme computers in the Queen's English is the same reason we don't write algebra textbooks in English prose – a formalized language is far clearer than a human language. There are things I can tell a computer succinctly in PL/1 which I couldn't tell it (unless very awkwardly) in English.

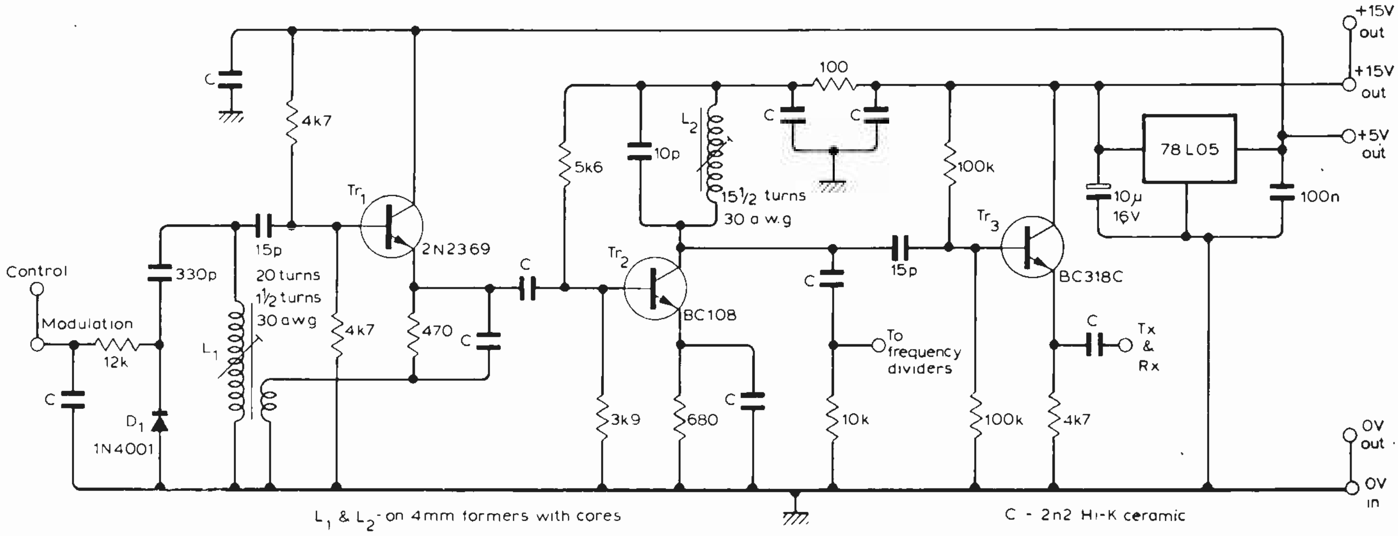
Human languages are context-dependent; to understand a human language the hearer needs much more background knowledge and must make many more assumptions than are necessary in understanding a formal language. Though computer handling of natural language is not far away and will be quite useful, formal programming languages will hardly be superseded.

Michael A. Covington
Athens
Georgia, USA

F.M. TRANSCEIVER SYNTHESISER

Like Mr Hankins (Letters, June) I have constructed the synthesiser part of T. D. Forrester's two-metre f.m. transceiver (November and December, 1977). I have also found modifications essential to make it work. These are as follows:

1. L_1 was increased to 20 turns, with a separate 1-turn coupling coil. The varicap diode D_{17} was replaced by a device of greater capacitance – in my case a 1N4001 rectifier diode worked well – and C_7 was increased to 330 pF.



The modified v.c.o.

2. I added a level shifter between the t.t.l. and c.m.o.s. to provide a proper voltage swing – this was similar in design to Mr Hankins' circuit.

3. I found that the sensitivity of the 74LS74 was improved by increasing rather than decreasing R_{39}: I used a value of 10kΩ. The reason for this is that this allows the t.t.l. output to bias itself up to the logic "1" level; the input resistor forward biases the input diode of the gate to a point where its noise margin is effectively nil; and the full "gain" of the circuit is used to amplify the input signal.

As the input impedance of the low-power Schottky device is quite high – about 18kΩ – I found it made no difference to dispense with the buffer stage, Tr_4, altogether and to connect the t.t.l. input straight through a 2n2 capacitor to the collector of Tr_2. This saves 12mA or so of current.

4. In a further attempt to reduce the power consumption of the v.c.o. I removed the zener dioide, D_{18}, and ran the oscillator stage (with changed resistor values) from the 5-volt t.t.l. power supply (obtained from a 78LO5).

Replacing the 4049 hex c.m.o.s. buffer with a 4069 hex inverter might reduce the consumption of this chip, but unfortunately these devices are not pin-compatible.

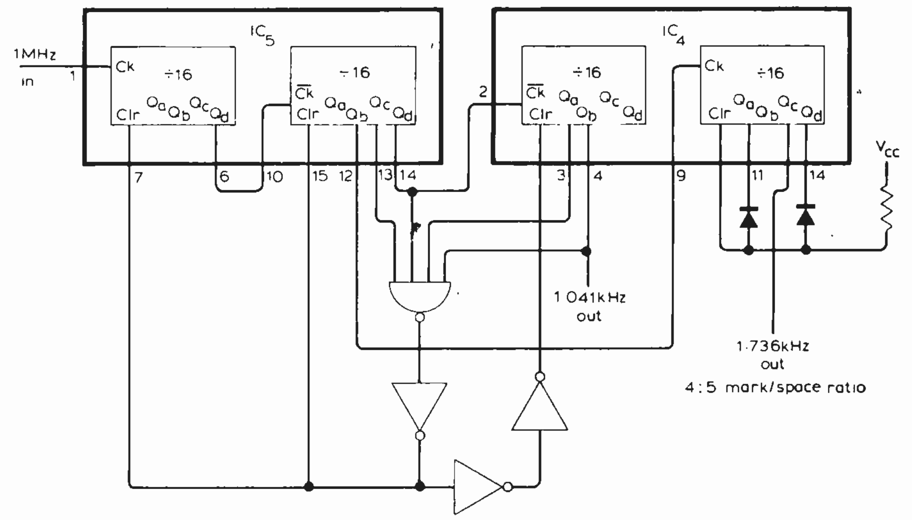
5. Apart from using a different arrangement of switches and gates to obtain the Tx, Rx, Tx(Rpt) and Rx(Rev. rpt) lines in the synthesiser logic, I also dispensed with many of the diodes and resistors: I used five diodes, and it can be done with four.

7. I used the spare divider section in IC_4 to obtain a frequency close to 1750Hz, for use as a toneburst generator.

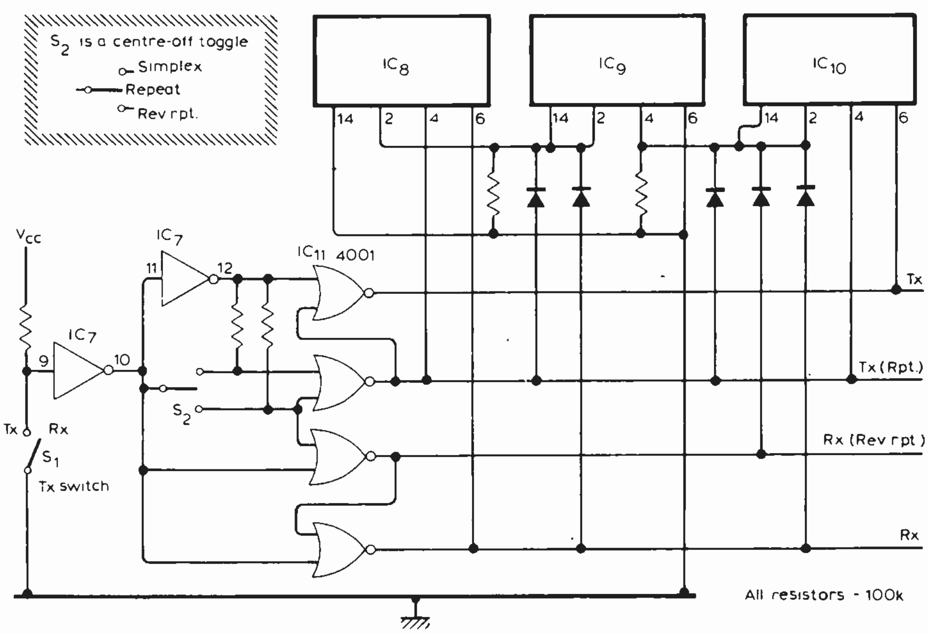
The accompanying circuits illustrate these points.

As a further suggestion the whole v.c.o. could possibly be replaced with a single t.t.l. v.c.o. chip, such as the 74LS324, which has a typical operating limit of 30MHz, a consumption of 30mA maximum, and, of course, a t.t.l. output. The output would be rich in odd order harmonics, so could be followed by a frequency tripler, with a doubler up to 144MHz: this is better practice as it avoids the generation of 48MHz.

A friend has observed that on his synthesiser (and on mine) the frequency overshoots its target value. This could indicate that the filter components after the phase detector have not been chosen for critical damping of the control loop. Another problem that has been suggested is in the quadrature detector



Repeater access tone generator. By applying a suitable positive-going pulse to pin 10 of IC_4, the tone generator could be gated to provide a tone-burst.



The new Rx/Tx line generation and arrangement of diodes and resistors at inputs to b.c.d. adders.

of the i.f.: the use of a crystal here is really only suitable for ultra-narrow bandwidths, and a friend who has tried this circuit reports that it doesn't work.

I would appreciate advice and suggestions concerning this design from other constructors; for example, the use of alternative microphone pre-amp/compressor circuits instead of the rather expensive Plessey chip specified.

I would like to conclude by congratulating Mr Forrester on producing an alternative to the Japanese "black boxes", although I daresay some constructors will be less enthusiastic about the D.I.Y. (Design-it-Yourself) aspects than those of us with access to 'scopes, frequency meters, etc.

J. D. Stumbles
Imperial College Computer Centre
Exhibition Road
London, SW7

AUDIO OSCILLATOR PRODUCTION DESIGNS

I have designed, and brought to a fully developed engineering state, two sine-wave audio oscillators having unusual and attractive performance characteristics.

The more complex design, which is neither a function generator nor a b.f.o., covers the complete audio spectrum in a single sweep, either by rotation of a dial having an accurately logarithmic scale shape, or by means of an internally or externally generated ramp voltage. Frequency-marker pulses are generated as the frequency sweeps through 0.1, 1 and 10kHz. A warble-tone facility is also incorporated, the oscillator being intended for acoustic measurement work.

The total harmonic distortion of the above instrument is less than 0.05% from 40Hz to 10kHz and less than 0.1% from 20Hz to 40kHz. The distortion is mainly second and third harmonic. The variation in output amplitude with frequency does not exceed ±0.1dB from 20Hz to 40kHz and there is no significant bounce.

The basic circuit is an R-C oscillator in which the R's have been replaced by transistor junctions whose d.c. bias voltage is varied to control the frequency in an inherently logarithmic manner. Two outputs in phase quadrature are available and could be used in association with a simple type of tracking filter. Very great care indeed has been taken to achieve accurate temperature compensation of frequency under production conditions.

In addition to the complete battery-operated instrument with the above facilities, ten of the main 11cm × 12cm printed-circuit boards have by now been made, of which eight are in use by a large and well-known loudspeaker firm who have standardised on the design for their production test purposes. Experience with these eleven basic oscillators has shown that the design can readily be set up on a production basis to meet the performance specification. A complete test schedule has been written and special production-test items have been made.

The second design is a simple two-op-amp thermistor-controlled R-C oscillator giving less than 0.001% total harmonic distortion from 100Hz to 10kHz — about 0.0003% at 1kHz — and less than 0.002% at 30Hz and 20kHz. The oscillator operates from a couple of PP9 batteries and takes about 14mA. In its present form the instrument is switch-tuned to give a number of spot frequencies throughout the audio band, but has a fine-tuning adjustment. A simple potentiometer output control is provided, this being adequate for most distortion-measuring applications.

The good performance of this latter oscillator results from (a) adopting an unconventional basic oscillator circuit giving far greater attenuation of thermistor distortion than does the usual Wien-bridge circuit, (b) giving careful thought to the theory of thermistor control-loop behaviour in order to obtain an optimum compromise between distortion and amplitude bounce, and (c) using good wide-band i.c. op amps. The total component cost, at Radiospares prices, including the instrument case, is about £14.

I would be glad to hear from any firm interested in the possibility of commercial exploitation of these designs.

Peter J. Baxandall
Malvern
Worcs.

PROGRAMMING MICROPROCESSORS

Alas, K. G. Parr (August Letters) and I (June Letters) seem to be addressing different audiences, and so our viewpoints are difficult to reconcile. His admirable letter aligns with the opinions of at least one of my colleagues who is professionally engaged in systems development, both hardware and software, and who has both the opportunity (and perhaps the personality) to make effective use of microprocessors. I would be the first to concede that if one is committed to design these chips into, say, gambling machines (August issue, p.57) commercially, then one must try to be as impeccably disciplined as K. G. Parr suggests. Even so, as he tells us, "bugs still remain." And not only can they reveal themselves years later when an established programme faults, but so also one may discover errors in flow diagrams. This is not to disparage the flow diagram as a sometimes useful tool; but for a definitive final document I have usually found it more useful to edit a listing of the programme with some relevant textual comments, including reference to sources of algorithms, and with labelled arrows to indicate the purpose of loops, switches, jumps etc.

I hope that the readership of *Wireless World* includes already many "hobby programmers"; though surely *all* its readers are hobbyists at heart? I see that there will soon be a new generation of microprocessors designed to that they can be *completely* tested before use. So, hobbyists take heart if you are struggling with octal and hexadecimal. It can only be matter of time before decimalisation catches on.

Desmond Thackeray
Department of Chemical Physics
University of Surrey

DISCRIMINATIVE METAL DETECTOR

I read the article "Discriminative metal detector" by R. C. V. Macario (July issue) with interest. Although the author states that eddy currents mask diamagnetic effects in non-ferromagnetic samples it is worth noting that these eddy currents do cause an increase in oscillator frequency. This is, of course, in the opposite direction to that caused by ferromagnetic samples, where the ferromagnetic effect usually masks the eddy currents.

The effect of eddy currents can easily be demonstrated by comparing the influence of a closed loop of thin wire with that of the same loop opened. [*Surely a coupled shorted-turn. – Ed.*]

The directional information could be restored with headphones by using the Q outputs of IC_2 to drive a simple resistor ladder and voltage controlled oscillator (eliminating IC_3, etc.).

M. Walne
Halifax

More letters on the metal detector will be published next month.–Ed.

PICKUP-ARM PROBLEMS

I would like to point out that adoption of the technique proposed by F. Holloway (Letters, July) of producing discs by means of a cutting head on a radius-arm does not overcome the other serious shortcomings of the radius-arm reproducer so well highlighted in Mr Randhawa's article, i.e. side-thrust compensation and lateral balance.

There is *no* case for "concentrating the difficulty and cost of mechanical design once and for all in the recording equipment" as your editorial note suggests when parallel-tracking arm designs with electronic controls are now coming to the fore and which solve all three problems at a stroke.

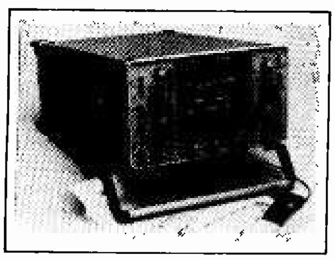
Is it not about time that electronic engineers turned their attention from designing amplifiers with specifications of unnecessary excellence and concentrated their talents on programme sources such as tape and disc, which are still producing distortions that are audible?

R. Cooper
Sutton Coldfield

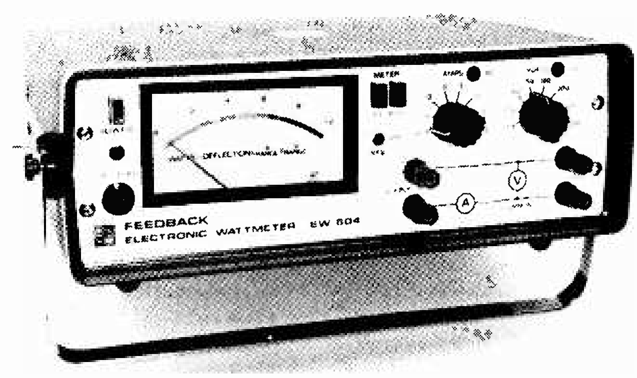
NEW PRODUCTS

Filter
A bucket-brigade filter, said to be the first charge transfer device filter i.c., is introduced by the American Reticon Corporation. The circuits consist of a 64-stage, split-electrode brigade, the capacitors being the basic metal-oxide semiconductors. Low-pass and band-pass filters are available, each being tuned by varying the clock frequency, and possess a linear phase characteristic. Extremely steep rolloffs of over 200dB/ octave are exhibited. An example quoted is that of a band-pass filter, in which the centre frequency is at 0.25 the clock frequency (250Hz-1MHz), the bandwidth 0.055 the clock frequency and the ratio between stop band and pass band attenuation is 52dB. The rate of change is 270dB/octave. Herbert Sigma Ltd, Spring Road, Letchworth, Herts.
WW301

Storage oscilloscope
Signal storage is performed digitally in the Advance OS4100 oscilloscope. It is a two-channel instrument using a digitizer and 1kbit r.a.m. to provide a bandwidth of 600kHz. An X-Y display

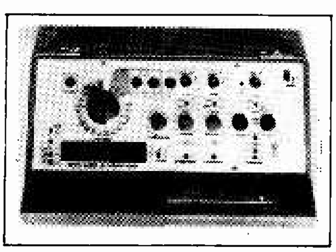


is also provided; the sum or difference of the two inputs can be displayed and an unusual feature is a triggering window, in which triggering takes place outside two threshholds. Triggering can be obtained from 2mm of trace deflection and a delay can be used to display events occurring up to a quarter of the time-base period before the trigger. The trace consists of a number of dots, which can be 'smoothed' if required, and a split-trace mode can be selected where alternate samples can be sorted and viewed against a new trace for comparison. Gould Instruments Division, Roebuck Road, Hainault, Essex IG6 3UE.
WW302



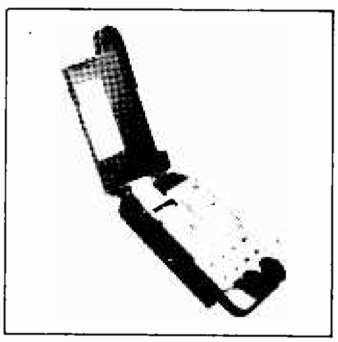
Electronic wattmeter
An electronic multiplying technique used in Feedback Instruments EW604 power meter allows wide frequency and power ranges to be handled by the one instrument. It also means that waveforms other than sinusoids can be measured. The range of the instrument is 0.25W to 10kW f.s.d., 5V to 1kV r.m.s., 80mA to 10A r.m.s., all in the frequency band from zero to 20kHz. To reduce effects on the circuit under test, the input resistance is 5kΩ per volt, drawing 200μA full scale, and the resistance offered to a current input is 60mΩ. Feedback Instruments Ltd, Park Road, Crowborough, Sussex TN6 2QR.
WW303

Digital tester
Comprehensive facilities for measurement in the time and frequency domain, voltage, resistance and temperature are contained in one new Tektronix instrument, the 851 Digital Tester. A 5-digit display is fed by a 35MHz counter, which performs all the usual frequency,



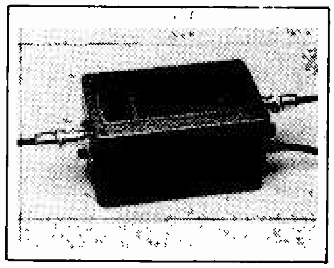
time, ratio and event counting from three input channels; a digital multimeter of 4½-digit resolution measuring voltage, resistance, temperature and the thresholds of the input channels, together with polarity. The inputs can be set to t.t.l. as a calibrated knob setting or to any thresholds compatible with other logic families within ±30V. All necessary probes are housed within the case of the instrument. Tektronix UK Ltd, Beaverton House, P.O. Box 69, Harpenden, Herts.
WW304

Audio system measurement
ATR-1 Audiotracer consists of a voltage-controlled oscillator, logarithmic in frequency from 20Hz-20kHz or 200Hz-200kHz, an



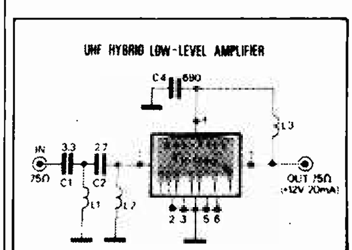
output amplifier, a log. or linear input amplifier, a true r.m.s. rectifier and a pen recorder. The whole thing is contained in a 11 × 5½ × 3in case and is intended to measure and record the frequency/amplitude performance of electronic or electro-acoustic systems. A measuring microphone and an artificial ear coupler are available for acoustic measurements. The unit is mains-powered. ATR-1 is made by Neutrik A.G. of Switzerland and distributed here by Eardley Electronics Ltd, Eardley House, 182/4 Campden Hill Road, Kensington, London W8 7AS.
WW305

Frequency scalers
Frequency scalers are dividers, used to reduce high frequencies to within the capability of low-frequency counter-type frequency meters. There is no display, and the division factor must be re-applied to the counter display. Two units produced by MTG fulfil this function, the PS1200 enabling a 10MHz counter to measure a frequency of 1GHZ (PS520 up to 500MHz). Both units will accept 10mV minimum input and are well protected against overload and out-



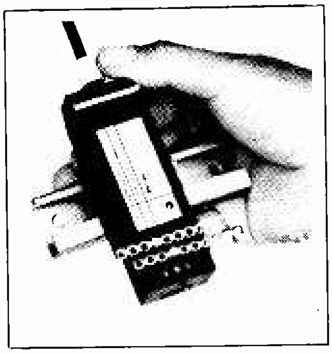
put short circuits. Versions offering division ratios of 10 or 100:1 are available. MTG (Instruments) Ltd, Beacon House, Christchurch Road, Lansdowne, Bournemouth, Dorset BH1 3LB.
WW306

U.h.f. amplifier
A two-stage hybrid amplifer, the SH120A offers 16dB of gain, which is said to be constant from 40-900MHz, and a noise figure of 5dB. It is a low-level aerial amplifier, being terminated in 75 ohms in and out and its maximum output is 100mV. Voltage supply needed is 12V. SGS-Ates (UK) Ltd, Planar House, Walton Street, Aylesbury, Bucks HP21 7QN.
WW307



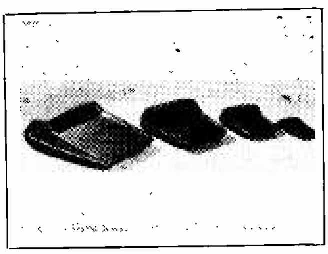
Pressure transducer

Two transducers from Philips convert pneumatic pressure to standard 4-20mA signals for transmission or processing. A metric type (PR9363/20) covers the range 0.2-1 Bar, while an Imperial version (PR9363/30) works from 3-15 p.s.i., both units conforming to DIN 19231 and IEC 381. Unstabilized power can be used. The principle of the devices is the deflection of a strain-sensitive diaphragm by the pressure, unbalance in the strain elements giving rise to an output voltage. Pye Ether Ltd, Caxton Way, Stevenage, Herts.
WW308



Instrument cases

The new 'Princess' range of cabinets from West Hyde is intended to house the various kinds of equipment to do with computers, e.d.p. and calculators. The cases are made from ABS, in two horizontal parts, and have two frontal surfaces, at differing slopes, for mounting controls and displays. The plastic can be drilled and cut and is finished in an imitation leather texture, in black



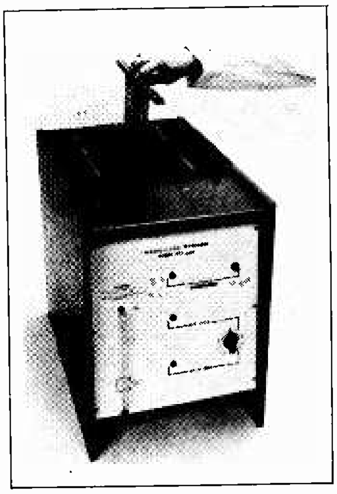
or black and tan. The internal dimensions are keyed to the Eurocard shape, the largest case taking double Eurocards. West Hyde Developments Ltd, Unit 9, Park Street Industrial Estate, Aylesbury, Bucks HP20 1ET.
WW309

Frequency meter

A u.h.f. counter, of the non-displaying scaler type, of high stability and accuracy offered by the American firm of Davis is the 7208 Frequency Counter. The instrument will measure frequency up to 600MHz at 10mV up to 60MHz and 100mV at 600MHz—less with an optional preamplifier. Crystal frequency error is 1 part per million or 0.5 p.p.m. with the optional oven, while the drift is 1 p.p.m. per hour or 0.5 p.p.m. per month, again with the oven. An l.e.d. display of eight digits is used, with decimal point being adjusted by the switching. Davis Electronics, 636 Sheridan Drive, Tonawanda, New York.
WW310

Spray etcher

This unit, from P.B. Electronics, is a double-sided etcher, which is small enough to stand on a bench and fast enough to etch a 12in square board in less than three minutes. It uses four gallons of etchant, which is kept at 120°F, and a timer stops the pump after a given time. A lid interlock reduces the chances of etching the ceiling. P.B. say that the etcher will be followed by other units for sensitizing, exposing and developing. P.B. Electronics (Scotland) Ltd, 9 Radwinter Road, Saffron Walden, Essex CB11 3HU.
WW311

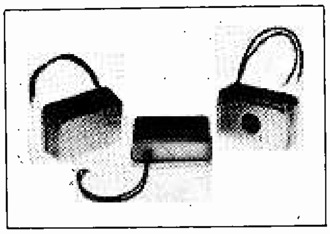


Voltage-to-frequency converter

The option of linear or logarithmic conversion and a dynamic range of more than seven decades are the features of the Aragorn VFD1 module. The output is a 10V square wave, which responds to a 0-90% step within 1 cycle, the maximum output frequency being 2MHz or 20kHz to order. Accuracy of conversion is 0.1% and frequency stability is 200 parts per million at 1kHz. Voltage supply needed is 15-0-15V and the module measures 45 × 30 × 16mm, with pins on a 0.1in grid. Aragorn Dynamics Ltd, 8 South Side, Clapham Common, London SW4 7AA.
WW312

Buzzers

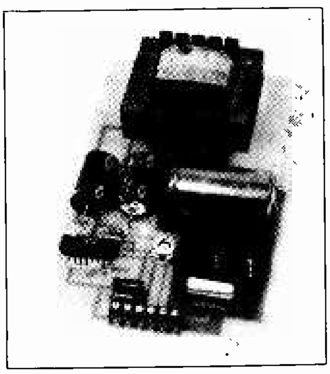
These are miniature, electronic units for use in clocks, timers, telephones, etc. They are for use where 2.5V, 6V or 12V supplies, of low stability, are present. At least



70dB relative to 0.0002 dynes/sq.cm. is produced 22cm away from the unit, while taking around 20mA from the supply. Type number is GA100. Highland Electronics Ltd, Highland House, 8 Old Steine, Brighton, East Sussex BN1 1EJ.
WW313

V.m.o.s. memory

Two static 4K memories from AMI use the v.m.o.s. technique to provide high-speed access and high density. The S2114 is organized as a 1024 × 4 bit r.a.m. and is intended as a high-speed Intel 2114 replacement, for which it is claimed to be pin-compatible. Maximum response time can be down to 150ns. The S4017 is a 4096 × 1 bit r.a.m. with a response time down to 55ns. Both types are usable with t.t.l., operating from 5V, and are contained in 18-pin plastic or ceramic packages. AMI Microsystems Ltd, 108A Commercial Road, Swindon, Wiltshire.
WW314



P.s.u. for logic and linear

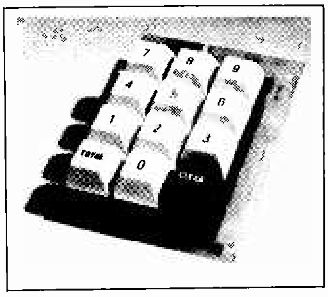
Where 5V digital circuitry and linear i.cs are to be used together the power needed can conveniently be provided by the Lascar 3-rail power supply. Outputs are 5V at 1A and tracking rails of 5 to 15V, positive and negative, at 100mA. The single and dual supplies are isolated from each other and both are well protected. A 160 × 100mm board carries the whole unit. Lascar Electronics Ltd, P.O. Box 12, Module House, Billericay, Essex CM12 9QA.
WW315

Signal conditioner

Platinum resistance elements are widely used in temperature measurement bridges, but their non-linearity restricts them to laboratory use, in the main. Ancom have now produced a signal conditioner, 15RP-3, to allow the use of a platinum sensor with a linear measuring system – a digital panel meter, for example. The 51 × 29 × 16mm, encapsulated, p.c.-mounted module provides 10mV per degree Centigrade output, within the −110°C to 100°C working range, with errors of better than ±0.1°C and ±0.1% of reading. Power needed is 15-0-15V at 10mA (each rail). Ancom Ltd, Devonshire Street, Cheltenham, Glos. GL50 3TL.
WW316

Keypad

This 12-key pad from FR Electronics is of low height (less than 25mm when the buttons are down – unspecified when they are not) and is said to offer a high degree of reliability as a consequence of its use of reed switches. The keys are mounted on a printed board, with



an edge connexion, from which the outputs are in binary form, compatible with t.t.l. levels. Voltage supply needed is 5V and two-key rollover is a standard provision. F.R. Electronics Ltd, Wimborne, Dorset BH21 2BJ.
WW317

Microwave f.e.t.

A noise figure of 1.7dB or better at 4GHz and a useful range of application from 1-12GHz is claimed for the HFET-1102 GaAs f.e.t. from Hewlett-Packard. Minimum associated small-signal gain is quoted as 11dB at 4GHz. The encapsulation is HPAC-100A. Hewlett-Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.
WW318

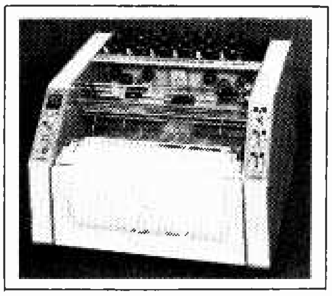
Coaxial relays

Between 2 and 30 coaxial inputs, switching to a single coax. output, all of either 50 or 75-ohms, form a single-pole, multi-way, coaxial r.f. switch, with isolation of around 100dB. Unselected inputs may be earthed, open-circuited or terminated in the relay block; contacts of the reed

relay can be expected to endure up to 20 million operations and will handle 250mA at 100V or less, depending on the switching mode. The switching signal can be anything from 5 to 50V d.c. or a.c. Hercoax Ltd, Plumpton House, Plumpton Road, Hoddesdon, Herts.
WW319

Chart recorder

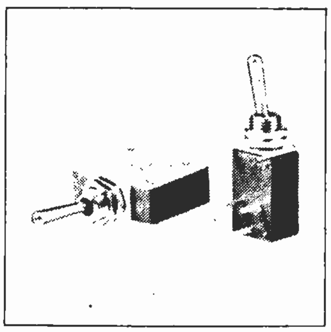
Unicorders are desk-top, potentiometric chart recorders with three to six steel pens, which may overlap. A complete traverse of



the 250mm chart takes 0.3s, and the pens can be lifted individually, by solenoid as an option. The 20m chart is stepper-motor driven at a speed selected from 199 dial-selected or remotely-controlled possibilities. Plug-in amplifiers accommodate the voltage range 1mV to 200V, currents from 1μA to 500mA and thermocouples at 0°C–1600°C. Common-mode rejection ratio is 170dB at zero frequency and 160dB with alternating signals. Rostol Ltd, 33 Byron Road, Earley, Reading, Berks IG6 1EP.
WW320

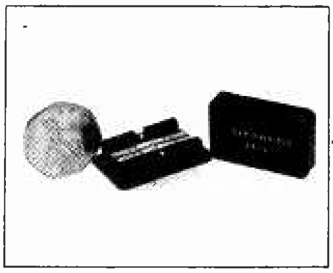
P.c. switches

APEM 21000N toggle switches are designed to be mounted on printed boards, projecting only 9mm above the surface. Single-pole switches are 11 × 7 × 7.8mm; double-pole 21 × 17 × 7.8mm, excluding pins. They possess either two or three positions, latched or momentary and have silver or gold-plated contacts. Voltage and current capability for the silver contacts are 250V a.c. and 2A a.c. and the gold contacts will control 10mA at 50mV. Iskra Ltd, Redlands, Coulsdon, Surrey CR3 2HT.
WW321



Mechanical filters

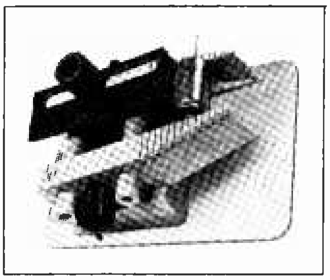
Low-frequency filters using flexure-mode mechanical resonators are announced by Rockwell-Collins. Nickel-iron bars and piezoelectric ceramics are the active elements, pro-



ducing a response of 0.2 to 1.5% bandwidth/centre frequency which is equivalent to a Q of 500 to 70. The filters work in the range 3.5-70kHz, with an insertion loss of 2.5dB, and terminating resistance of 33kΩ. Centre frequency varies less than 4Hz over a 0°C to 60°C range of temperature. G. A. Stanley Palmer Ltd, Elmbridge Works, Island Farm Avenue, West Molesey Trading Estate, Surrey KT8 OUR.
WW322

Lead forming tool

Consistency and accuracy in the bending of component leads for printed-board mounting is the aim of the Litesold Opsec tool.



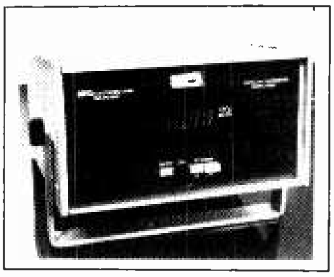
Components are dropped against a graduated step into the slots on the jaws, which are also graduated to take components of varying lengths. The tool is made of high-impact plastic and has non-slip feet, which can be screwed to a bench. Light Soldering Developments Ltd, 97/99 Gloucester Road, Croydon, Surrey CRO 2DN.
WW323

Low-resistance meter

A main-frame and plug-in adaptors, the 1700 series, from Electro Scientific Industries are capable of measurement and numerical display of resistance values in the range 1 micro-ohm to 200 milliohms, in which lie the resistances of contacts, inductor windings and printed-board tracks. One of the plug-in units offers the option of d.c. measurement for reactive components or a pulsed test for those components whose characteristic would change if current were to be passed continuously. Tranchant Electronics Ltd, Tranchant House, 100A High Street, Hampton, Middlesex TW12 2ST.
WW324

R.f calorimeter

A numerical reading in kW, allied to the calorimetric determination of radio-frequency power, enables convenient power measurements to be made by the Bird 6080 up to 80kW with a maxi-



mum error of ±3%. Temperature sensors and water flow monitors are remote, being connected via an 8ft cable to the power meter. Aspen Electronics Ltd, 2 Kildare Close, Eastcote, Middlesex HA4 9UR.
WW325

Dual-lamp switch

A dual-lamp switch, available from Pye Electro-Devices Ltd, has a ¾in-square cap incorporating two T13/4 lamps with a midget flange base and a matching indicator. The cap has horizontal or vertical split screens, with five choices of filter and eight lens colours for each of the two zones of the screen. Silver or gold contacts, with momentary or alternative actions, are available in s.p.d.t. and d.p.d.t. configurations. Pye Electro-Devices Limited, Controls Division, Exning Road, Newmarket, Suffolk CB8 0AX.
WW326

Darlingtons for tv deflectors

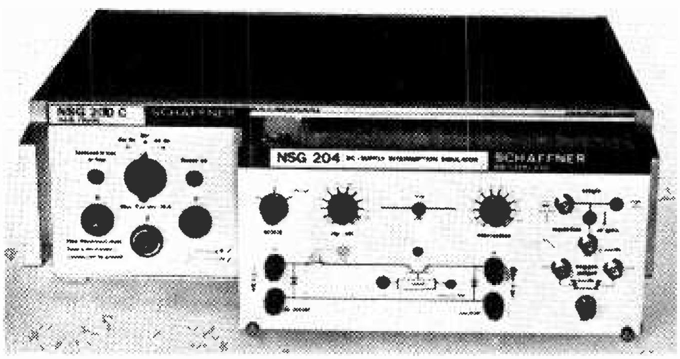
Two high power transistors, the BU806 and the BU807, are particularly suitable for use as horizontal deflectors in black and white televisions. The low driving power typical of the Darlington configuration allows elimination of the driving transformer and consequently reduces the cost of the stage. The high switching speed required is guaranteed by the presence of an integrated diode which extracts the charges accumulated during conduction. A clamper diode is also integrated in the devices. These devices, when used with the integrated horizontal deflection circuit, the TDA1180, no longer require a driving transistor and consequently the cost of the system is further reduced. SGS-Ates (United Kingdom) Limited, Planar House, Walton Street, Aylesbury, Bucks, HP21 7QN.
WW327

Fibre light guides

General purpose fibre-optic light guides in a p.v.c. sheath and terminated in stainless steel end fittings are produced by Valtec. Fibres of 0.002 in diameter are used in single, bifurcated and trifurcated branch types in lengths up to 30 ft attenuation is 600-700dB/km, numerical aperture is 0.56 with a 68 degree acceptance angle. Fiberoptics Division, Valtec Corporation, West Boylston, MA, USA 01583.
WW328

Supply failure simulator

Interference simulation by the Schaffner NSG200 series is extended to allow the simulation of d.c. power failure and interruptions. A new plug-in unit, the NSG204, is for use with the 200C mainframe, and permits d.c. supplies between 5V and 220V at up to 10A to be interrupted for adjustable duration between 1ms and 2s. The interruptions may be generated by an external trigger, a push-button or an internal timing generator, working between 5Hz and 0-1Hz. Switching time is around 2μs off and 1μs on. Lyons Instrument Ltd, Hoddesdon, Herts.
WW329



SIDEBANDS by Mixer

π-test

Embarrassing moments experienced by television and film "personalities" can't be the same kind as those I have – they always seem so delighted to tell anyone who asks them all about the grisly faux pas and face-burning ineptitudes they've committed. I can't bring myself to tell anyone about mine, but I'm always happy to hear of other people's. The only time I've ever been able to see one of my own episodes as even remotely funny was when I sidled up to my wife, who was trying on a hat in a shop and said "You can always use it as a flower-pot when you're tired of it" and yes, you've guessed it, it wasn't my wife. The woman wasn't trying on hats, either; it was her own.

"What's all this to do with electronics?" I hear all my readers ask, both at once. Well, it's just that we were talking, this morning, about Chairman's Visit time, from which many of us have suffered. You know what I mean; the one day a year that makes it all worthwhile. White lines are painted on the factory floor, guards are put on machines and all design engineers are told to wear their clean shirt and tie and have a shave if they can possibly manage it.

Our chairman used to come round the labs. and demonstrate that democracy was still a force to be reckoned with by speaking to us. Actually, he usually directed his questions to us by way of the chief engineer, and didn't bother listening to the answers, but the intention was there. We always had to show him the newest bits of gear we had prised out the buying officer during the year so that the management could show him how forward-looking they were and, this year, we had bought an oven for environmental testing of components. It was a big metal box, with lots of terminals and leads sprouting from them and any amount of meters and generators clustered round it. The chap who was using it explained what it was for but seemed a bit reluctant to open the door. It would upset the test run and probably spoil a lot of hard work and other protestations, but the Man wanted a look inside, so with a dramatic flourish, the door was opened. There were three shelves inside and nothing else at all, except that right in the middle of the centre shelf was a very small pork pie, gently steaming.

Not a word was spoken. The group moved on and the only sign of anything amiss was that our chief engineer was abstractedly chewing his tie. I don't remember what happened to the chap with the pie – he's probably a permanent lab. assistant now.

Timeo Danaos

It seems we're about to be saved. You can all come back in off the window ledge, because Whitehall has decided that the electronics industry could do with a hand and is intent on injecting £50m or so to revitalize, rejuvenate and rekindle the sparkle in our eyes.

Well, that's great, but you will, I hope, forgive me if I don't instantly leap to my feet and turn cartwheels all the way along Stamford Street. I'm too old and frail, for one thing, and the other is that I have this sudden presentiment of doom. I put it down to the SADIM syndrome, so named because of a Greek character — a king, as it happens — who had a regrettable tendency to turn everything he touched into clay; he could have made a fortune in the china industry but he had no marketing sense. There he sat all day, strumming on his bouzouki and surrounded by little piles of pure gold; every now and then he would snatch a pile of gold and, calling on his training as an alchemist, transmogrify it into base clay. (His old prof. used to say that the lad had never seemed to get the point of the subject).

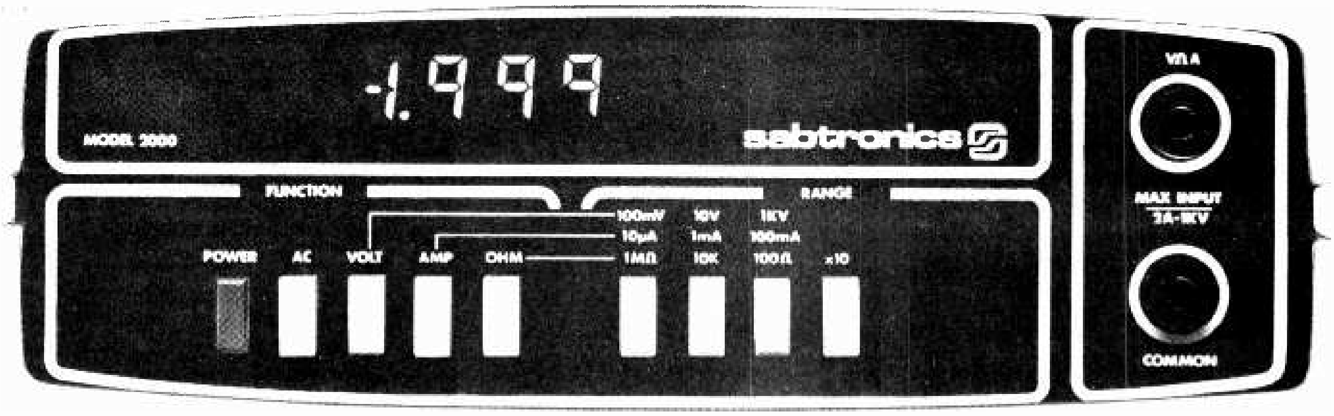
The striking thing about all this is, though, that not only did we learn our democracy from chaps like that, but some of his financial expertise seems to have rubbed off too. The cream of our society at Westminster have, it seems, only to take a passing interest in an industry for it to become a disaster area. There is no need to plod wearily through the list of victims, but if you kick off with the Brabazon and doff a mental hat at the TSR2 and the Hovertrain, finishing up with British Leyland (or whatever they call it these days) and Strathearn you'll see what I mean. It isn't a view of life to make one happy at the sight of Ministers bearing gifts.

Still, the china industry could have a rosy future.

Byter bit

Among the faults of David Bligh,
excessive faith in l.s.i.
was very probably the worst,
though in this field he was the first.
He gathered chips from every source,
attended every single course
and ultimately he was known
as Dai the Sums, and stood alone.
As hardware goes, it came and went
(around a thousand pounds he spent)
but gradually, he amassed
sufficient gear, and stopped his fast.
Computers large, computers small,
Dai knew the workings of them all.
His own could indicate, at speed
with all the confidence you need
the contents of its ROM, in clear
on a v.d.u., and bend your ear
with cacaphonic sounds of bytes
in battle for their storage rights.
When Dai was asked if this was what
his monster did, he waxed quite hot
and instantly applied his mind
to write a programme of a kind
to show quite positively that
computing's really where it's at.
His friends all gathered round to stare
being sure he'd finished with hot air.
He ran the tape – the display flashed,
the printer rattled – keys were bashed.
Then, on the screen in letters twee
was printed "Pawn to King's Knight
Three".
The move was made, but all in vain,
because a rook in wait had lain;
it sidled gently up and said
"Checkmate, old son, afraid you're
dead!"

Uncompromising performance. Incredible price. A professional $3\frac{1}{2}$ digit DMM Kit for less than £ 50.00



Incredible? True! Professionals and hobbyists alike are believers in this Sabtronics 2000, the only portable/bench DMM which offers such uncompromising performance at the astonishingly low price of £ 49.95.

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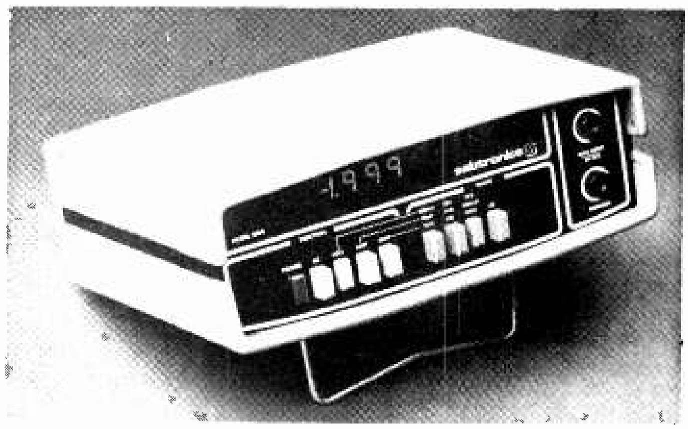
Now you too can have it! A professional-quality $3\frac{1}{2}$ digit Sabtronics Model 2000 DMM kit for only £ 49.95. If you don't have one in your lab, use the coupon below to order NOW.



sabtronics USA

Brief Specifications:

DC volts in 5 ranges: 100 µV to 1 kV – AC volts in 5 ranges: 100 µV to 1 kV – DC current in 6 ranges: 100 nA to 2 A – AC current in 6 ranges: 100 nA to 2 A – Resistance: 0.1 Ω to 20 M Ω in 6 ranges – AC frequency response: 40 Hz to 50 kHz – Display: 0.36" (9,1 mm) 7-segment LED – Input impedance: 10 MΩ – Size: 8" W × 6.5" D × 3" H (203 × 165 × 76 mm) – Power requirement: 4 "C" cells (not included).

Ordering information for overseas readers:

The price listed is for readers in U.K. only. Since export orders are exempt from VAT you may send your orders directly to

Sabtronics International
Winkelriedstrasse 35
CH-6003 Luzern/Switzerland

Price: £ 49.95 plus £ 6.50 for shipping and handling.

TIMWOOD LTD, Prospect Road, Cowes, Isle of Wight. England. Telex: 86892

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Total enclosed herewith: £ ____________

Name: ______________________________

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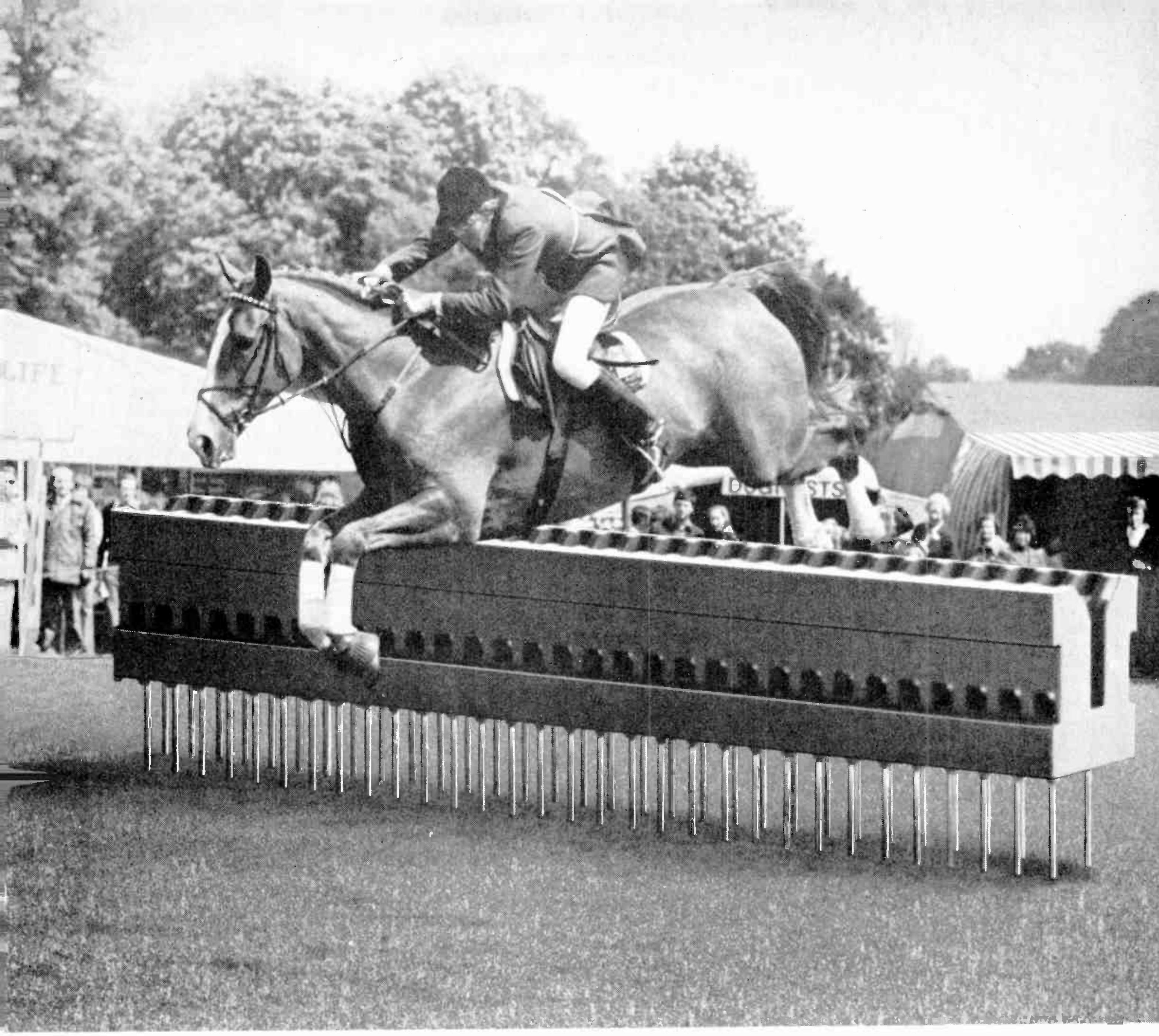
City ____________________ Postal Code __________

*Overseas Readers please see ordering information on this page.

WW—097 FOR FURTHER DETAILS



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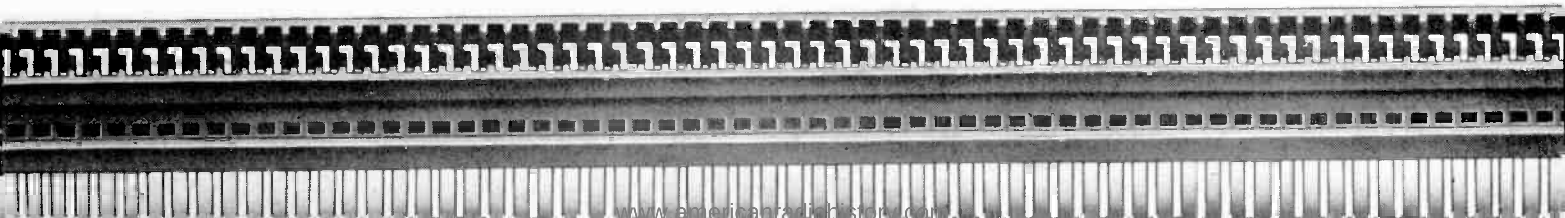
Contact: Connector Sales, Ferranti Limited,
Professional Components Department Dunsinane Avenue,
Dundee DD2 3PN, Scotland.
Telephone: 0382 89321 Telex: 76166
Distributors: Giltech Components Ltd., 22 Portman Road,
Battle Farm Industrial Estate, Reading, Berks. RG3 1ES.
Telephone: 0734 582131.

FERRANTI
Connector Capability

DS/T325

WW—115 FOR FURTHER DETAILS



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4012	17p	4072	20p	4538	150p
4013	55p	4073	20p	4539	110p
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4019	60p	4078	20p	4553	440p
4020	93p	4081	20p	4554	153p
4021	82p	4082	20p	4556	77p
4022	90p	4085	82p	4557	386p
4023	17p	4086	82p	4558	117p
4024	76p	4089	150p	4559	388p
4025	17p	4093	50p	4560	218p
4026	180p	4094	190p	4561	65p
4027	55p	4096	105p	4562	530p
4028	72p	4097	372p	4566	159p
4029	100p	4098	110p	4568	281p
4030	58p	4099	122p	4569	303p
4031	250p	4160	90p	4572	25p
4032	100p	4161	90p	4580	600p
4033	145p	4162	90p	4581	319p
4034	200p	4163	90p	4582	164p
4035	120p	4174	104p	4583	84p
4036	250p	4175	95p	4584	63p
4037	100p	4194	95p	4585	100p
4038	105p	4501	23p		
4039	250p	4502	91p		
4040	83p	4503	69p		
4041	90p	4506	51p		
4042	85p	4507	55p		
4043	85p	4508	248p		
4044	80p	4510	99p		
4045	150p	4511	149p		
4046	130p	4512	98p		
4047	99p	4513	206p		
4048	60p	4514	260p		
4049	55p	4515	300p		
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7401	13	20	7460	17		74128	74		74188	275		74365	49
7402	14	20	7463		110	74132	73	78	74190	115	92	74366	49
7403	14	20	7470	28		74133		29	74191			74367	43
7404	14	24	7472	28		74136		40	74192	105	180	74368	49
7405	18	26	7473	32	38	74138		60	74193	105	180	74373	70
7406	38		7474	27	38	74139		60	74194	105	187	74374	70
7407	38		7475	38	40	74141	56		74195	95	137	74375	60
7408	17	24	7476	37	38	74142	265		74196	99	110	74377	100
7409	17	24	7478		38	74143	312		74197	85	110	74378	90
7410	15	24	7480	48		74144	312		74198	150		74379	130
7411	20	24	7481	86		74145	65	95	74199	160		74386	55
7412	17	24	7482	69		74147	175		74200		374	74390	140
7413	30	52	7483A		110	74148	109	105	74202		374	74393	140
7414	51	130	7484	97		74150	99		74221			74395	110
7415		24	7485	104	99	74151	64	84	74240		100	74396	133
7416	30		7486	31	40	74153	64	54	74247		75	74398	200
7417	30		7489	205		74154	96		74248		90	74399	150
7420	16	24	7490	33	90	74155	54	110	74249		90	74445	92
7421	29	24	7491	76	110	74156	80	110	74251		90	74447	90
7422	24	24	7492	38	78	74157	67	55	74253		105	74490	140
7423	27		7493	32	99	74158		60	74257		108	74668	110
7425	27		7494	78		74159	210		74261		295	74670	220
7426	36	27	7495A	65	99	74160	82	130	74266		40		
7427	27	29	7496	58	120	74161	92	78	74273		90		
7428	35	32	7497	185		74162	92	130	74278		175		
7430	17	24	74100	119		74163	92	78	74279		52		
7432	25	24	74104	63		74164	104	130	74283		120		
7433	40	32	74105	62		74165	105	110	74289	340			
7437	40	24	74107	32	38	74166		110	74290		90		
7438	33	24	74109	63	38	74167	20		74293		95		
7440	17	24	74110	54		74168		200	74295		120		
7441	74		74111	68		74169		200	74298		100		
7442	70	99	74112	88	38	74170	230	200	74299		300		
7443	115		74113		38	74172	625		74300		350		
7444	112		74114		38	74173	170		74302		350		
7445	94		74116	198		74174	87	120	74324		115		
7446	94		74118	83		74175	87	110	74325		140		
7447	82	99	74119	119		74176	75		74326		140		
7448	56	99	74120	115		74177	78		74327		145		
7449		99	74121	25		74180	85		74352		95		
7450	17		74122	46	50	74181	165	350	74353		100		
7451	17	24	74123	48	55	74182	160		74258		110		
7453	17		74124		88	74183		210	74260		26		
7454	17	24	74125	38	44	74184	135						

MISC

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Due to rapid price changes in ICs, please check for current and quantity prices

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930	36x63mm	internal 12v	375p
940 twin	35x45mm	from behind	350p
950	55x45mm	from behind	300p

Stock movement 200uA/750Ω. The 930 series is 5% linear, others are 77uA at 50% FSD. These and many others available in quantity for OEMs *SAE for full scale details please. (Not in cat.)*

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TDA1062	DC to VHF front end system	1.95
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TDA1090/ULN2242	am/fm hifi tuner system	3.35
HA1197	LF/30MHz am receiver system	1.40
CA3123E/uA720	LF/30MHz linear system	1.40
TBA651	LF/30MHz linear system	1.81
SD6000	DMOS RF/Mixer pair	3.75
IF amplifiers		
CA3089E/KB4402	famous FM IF system	1.94
HA1137W/KB4420	as 3089 + deviation mute	2.20
CA3189E	update with deviation mute	2.75
TBA120a/SN76660N	FM if and detector	0.75
TBA120S	hi gain version TBA120	1.00
MC1350P	agc IF amp	1.20
MC1330P	synch AM demodulator	1.35
MC1495L	precision 4 quad multiplier	6.86*
MC1496P	popular double balanced mixer	1.25
Communications circuits		
KB4406	differential amplifier	0.50
KB4412	2 bal.mixers/agc/gain/doub. conv	2.55
KB4413	am/fm/ssb det. AGC, ANL, mute	2.75
KB4417	3mV mic processor preamp	2.55
KB4423	FM noise blanker system	2.55
Audio preamps		
LM381	stereo high gain/low THD	1.81
LM1303	stereo audio optimized OA	0.99
TDA1054	high quality with alc option	1.95
KB4417	see above	
Audio Power amps		
TBA810AS	7W RMS overload protected	1.09
TDA2002	8W/2Ω in pentawatt package	1.95
TDA2020	15W RMS hifi power dc coupled	2.99
TCA940	10W higher voltage 810	1.80
ULN2283	1W 2.5 to 12 v supply capability	1.00
LM380N8	1W power	1.00
LM380N14	2.5W power	1.00
HA1370	HiFi 15w in easy heatsink pack	2.99
Stereo Decoder Devices		
MC1310/KB4400	original pll decoder	2.20
CA3090AQ	RCA's pll decoder	3.25
uA758	Buffered version of 1310	2.20
LM1307/uA707	non pll type	1.55
HA1196	advanced adj.sep pll low thd	3.95
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BBR3132A	6pole linear phase 10.7MHz	250p

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BLR2007	Stereo 3k3 impedance	220p
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BLR3157	Mono 4k7/3k0 imp	100p

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MFL series 2.4kHz ssb /455kHz carrier	995p
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MFK series 7/9kHz BW on 455kHz	165p
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CFM2455 6kHz micro mechanical	65p
SFD455/470kHz murata IF filter	85p
CFT455B/C 6/8kHz min + 2IFTs	60p
CFU470C 6kHz on 470kHz	65p

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KAN1508/9	10.7MHz ratio detector	66p
94ACS15106/7	10.7MHz ratio detector	66p

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WW—085 FOR FURTHER DETAILS

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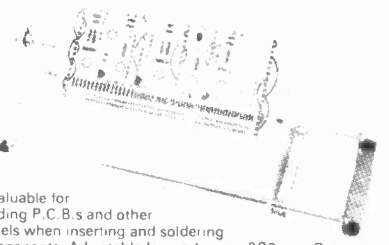

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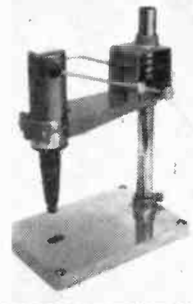

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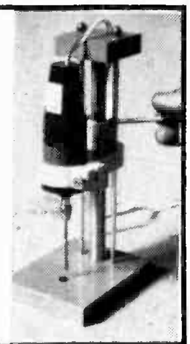

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4021	.97★	7401	.16★	74107	.27★
4022	.88★	7402	.16★	74121	.27★
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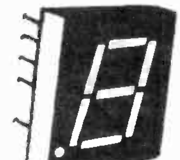

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WW—043 FOR FURTHER DETAILS

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WW—118 FOR FURTHER DETAILS

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CP-DR1 — £41.40 incl. (U.K.). £43.40 incl. (Export).

Also available: Pre-Amplifiers, Power Amplifiers, Filters, Peak Programme Monitors, Active Crossovers, Stereo Function Modules, Power Supplies, plus all pots, switches, etc.

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WW—052 FOR FURTHER DETAILS

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WW—045 FOR FURTHER DETAILS

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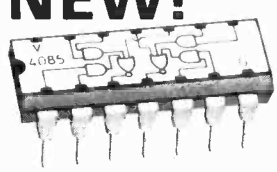

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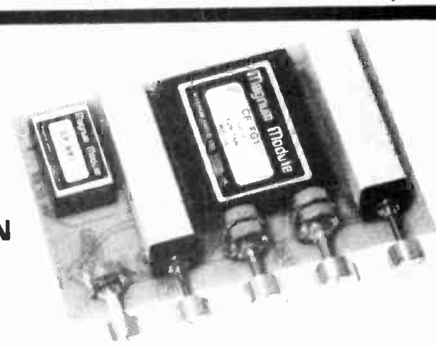
WW—017 FOR FURTHER DETAILS

STEREO FUNCTION MODULE CP-FG1



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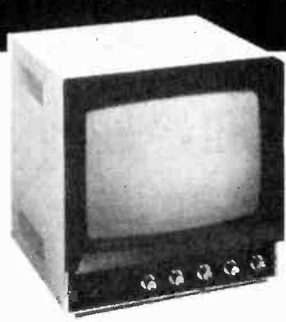

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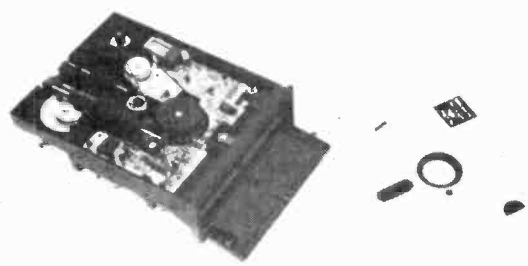

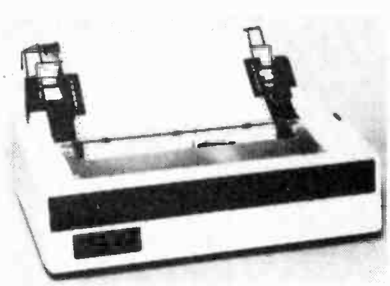

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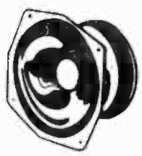

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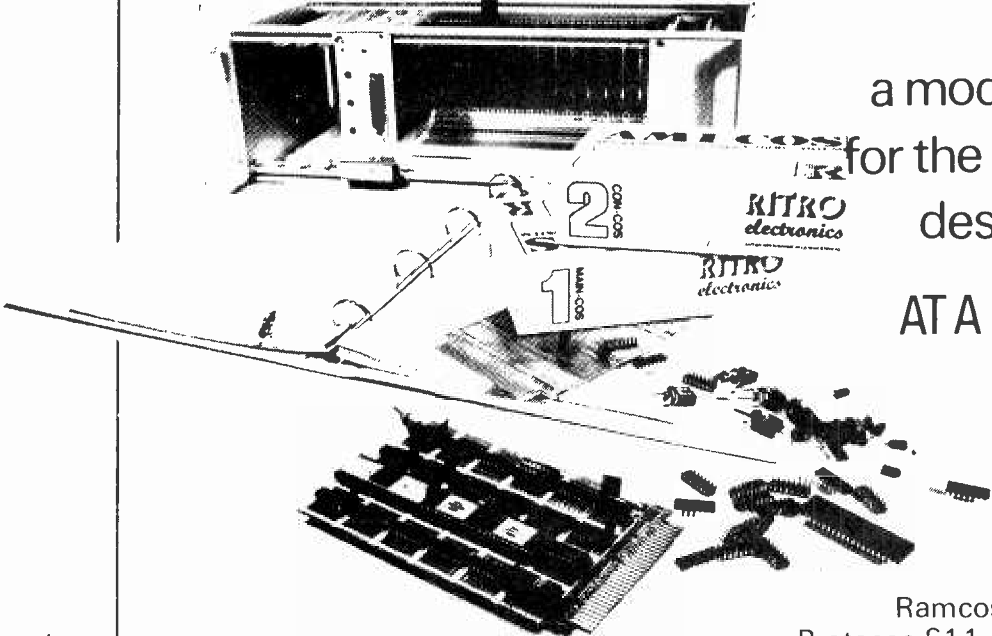
AMI-COS microprocessor system



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WW — 121 FOR FURTHER DETAILS

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CA3052	150p	NE562B	350p
CA3054	115p	NE565A	120p
CA3075	180p	NE566V	150p
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CA3081	125p	SN76003N	200p
CA3089	180p	SN76013N	140p
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4012	15p	4066	40p
4013	35p	4068	20p
4015	60p	4069	16p
4016	35p	4070	16p
4017	55p	4071	16p
4018	65p	4072	16p
4020	80p	4073	16p
4022	55p	4075	16p
4023	15p	4078	16p
4024	45p	4081	16p
4025	15p	4510	70p
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7407	24p	74110	35p
7408	14p	74111	45p
7409	14p	74116	95p
7410	12p	74118	82p
7411	19p	74119	140p
7412	17p	74121	28p
7413	25p	74123	40p
7414	48p	74125	35p
7416	24p	74126	35p
7417	24p	74132	50p
7420	12p	74141	56p
7421	22p	74142	200p
7422	18p	74145	58p
7423	22p	74147	110p
7425	22p	74148	90p
7426	24p	74150	70p
7427	24p	74151	50p
7428	28p	74153	50p
7430	12p	74154	85p
7432	23p	74155	52p
7433	32p	74156	52p
7437	22p	74157	53p
7438	22p	74160	60p
7440	13p	74161	65p
7441	52p	74162	65p
7442	43p	74163	65p
7443	75p	74164	70p
7444	75p	74165	70p
7445	70p	74166	80p
7446	55p	74167	180p
7447	55p	74170	125p
7448	58p	74172	400p
7450	14p	74173	95p
7451	14p	74174	68p
7452	13p	74175	85p
7454	14p	74176	58p
7460	14p	74177	58p
7470	28p	74178	80p
7472	24p	74181	145p
7473	25p	74182	60p
7474	25p	74185	110p
7475	32p	74190	72p
7476	28p	74191	72p
7483	60p	74192	64p
7485	70p	74193	64p
7486	24p	74194	60p
7489	145p	74195	55p
7490	32p	74196	55p
7491	45p	74197	55p
7492	35p	74198	110p
7493	34p	74199	110p
7494	80p		
7495	52p		

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AC126	18p	BC559	13p	ZTX310	13p	2N3705	9p
AC127	17p	BCY70	14p	ZTX311	14p	2N3706	9p
AC128	16p	BCY71	14p	ZTX314	22p	2N3707	9p
AC176	18p	BCY72	14p	ZTX341	21p	2N3708	8p
AC186	24p	BD115	52p	ZTX500	16p	2N3709	8p
AD161	38p	BD131	35p	ZTX501	16p	2N3710	8p
AD162	38p	BD132	35p	ZTX502	20p	2N3711	8p
AF124	27p	BD133	44p	ZTX503	20p	2N3715	10p
AF125	27p	BD135	38p	ZTX504	25p	2N3819	22p
AF126	27p	BD136	38p	ZTX530	30p	2N3823	65p
AF127	27p	BD137	38p	ZTX550	24p	2N3824	75p
AF139	36p	BD138	38p	2N696	32p	2N3866	55p
AF239	40p	BD139	35p	2N697	12p	2N3903	8p
BC107	8p	BD140	35p	2N698	28p	2N3904	8p
BC107B	10p	BF244B	36p	2N699	50p	2N3905	8p
BC108	8p	BFX29	25p	2N706	13p	2N3906	8p
BC108B	8p	BFX84	23p	2N706A	13p	2N4037	30p
BC108C	10p	BFX87	20p	2N708	20p	2N4058	12p
BC109	8p	BFX88	20p	2N914	22p	2N4059	10p
BC109C	10p	BFY50	15p	2N918	30p	2N4060	12p
BC147	7p	BFY51	15p	2N919	50p	2N4061	12p
BC148	7p	BFY52	15p	2N920	54p	2N5179	50p
BC149	8p	BU105	170p	2N929	25p	2N5457	32p
BC157	9p	BU205	140p	2N930	20p	2N5458	30p
BC158	9p	BU208	160p	2N1131	23p	2N5459	32p
BC159	9p	MJ2955	98p	2N1132	23p	2N5777	50p
BC167	8p	MPF102	36p	2N1302	38p		
BC168	8p	MPSA06	30p	2N1303	54p	**Diodes**	
BC169	8p	MPSA56	30p	2N1304	54p	0A47	10p
BC169C	9p	TIP29	40p	2N1613	22p	0A91	5p
BC170	9p	TIP29A	44p	2N1671	130p	0A200	6p
BC171	9p	TIP29B	40p	2N2160	100p	1N914	4p
BC172	7p	TIP29C	80p	2N2243	28p	1N916	5p
BC173	9p	TIP3D	40p	2N2297	45p	1N4001	4p
BC177	14p	TIP30A	48p	2N2368	15p	1N4002	4p
BC178	14p	TIP30B	55p	2N2369	16p	1N4006	6p
BC179	14p	TIP30C	70p	2N2484	22p	1N4148	3p
BC182	10p	TIP31	50p	2N2846	70p		
BC182L	10p	TIP31A	50p	2N2904	22p	**Regulators**	
BC183	10p	TIP31B	60p	2N2094A	23p	7805	60p
BC183L	10p	TIP31C	65p	2N2905	22p	7812	60p
BC184	10p	TIP32	55p	2N2905A	22p	7815	60p
BC184L	10p	TIP32A	60p	2N2906	22p	7818	60p
BC207	10p	TIP32B	75p	N2906A	22p	7824	60p
BC208	8p	TIP32C	80p	2N2907	22p	78L05	30p
BC209C	10p	TIP33	75p	2N2907A	25p	78L12	30p
BC212	10p	TIP33A	80p	2N2926G	10p	78L15	30p
BC212L	10p	TIP33B	103p	2N2926R	8p	7905	80p
BC213	10p	TIP33C	116p	2N3011	22p	7912	80p
BC213L	10p	TIP34	98p	2N3053	18p	7915	80p
BC214	10p	TIP34A	95p	2N3054	50p	7918	80p
BC214L	10p	TIP34B	128p	2N3055	50p	7924	80p
BC477	19p	ZTX107	14p	2N3121	25p	79L05	70p
BC478	18p	ZTX108	14p	2N3133	25p	79L12	70p
BC479	18p	ZTX109	14p	2N3440	80p	79L15	70p
BC547	11p	ZTX300	16p	2N3441	120p	LM309K	110p
BC548	10p	ZTX301	16p	2N3442	135p	LM317K	300p
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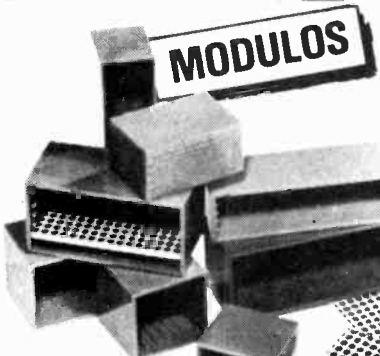

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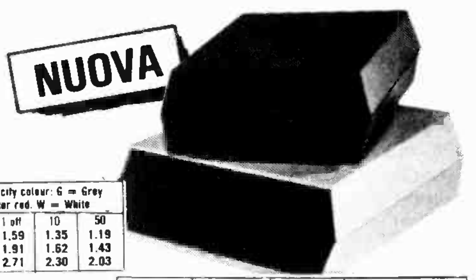

NUOVA Specify colour: G = Grey L = Lobster red, W = White	1 off	10	50
TEK D12X	1.59	1.35	1.19
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	W	H	D	W	H	D	Horizontal		Vertical	
TEK D12X	120	50	90	116	41	70	65	110	61	40
TEK D13X	135	55	150	120	46	130	120	130	120	46
TEK D14X	180	58	155	163	53	135	135	163	163	53

TEKO MODULOS

Lgth mm	Wth mm	Hgt mm	Specify colour G = Grey, R = Red, V = Sea Green		1 off	10	50
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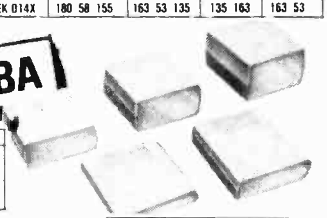
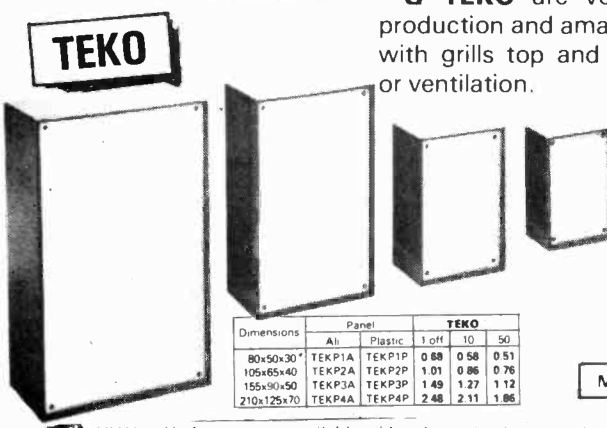
30	20	20	TEK L30 X	Pk 4	0.93	0 79	0 70
40	20	20	TEK L40 X	Pk 4	1.06	0.89	0.79
50	20	20	TEK L50 X	Pk 4	1.06	0 89	0 79
19	12 5	17 5	TEK S19 X	Pk 4	0.93	0 79	0 70
27	12 5	17 5	TEK S27 X	Pk 4	0.93	0.79	0.70
38	12 5	17 5	TEK S38 X	Pk 4	1.06	0.89	0 79
51	12 5	17 5	TEK S51 X	Pk 4	1.06	0.89	0.79
Asst of 8 pieces			TEK SL8 X	Pk 8	1 87	1 59	1 40



	Lgth	Wth	Hgt
TEK A11	198	180	40
TEK A12	198	180	55
TEK A22	198	180	70
TEK A23	198	180	90
TEK A33	198	180	110

TEKO ALBA Specify colour G = Grey, L = Lobster Red	1 off	10	50
TEK A11 X	3.15	2.68	2.36
TEK A12 X	3.40	2.89	2.56
TEK A22 X	3.60	3.06	2.70
TEK A23 X	3.85	3.27	2.89
TEK A33 X	4.10	3.48	3.07



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210x125x70	TEKP4A	TEKP4P	2 48	2.11	1.86

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L	W	D	E	DESKO	1 off	10	50
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74LS10	.21	74LS48	.96	74LS138	.65
74LS11	.26	74LS51	.21	74LS139	.65
74LS12	.21	74LS54	.21	74LS151	.96
74LS13	.55	74LS55	.21	74LS153	.58
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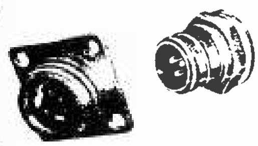

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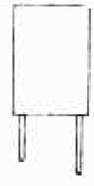

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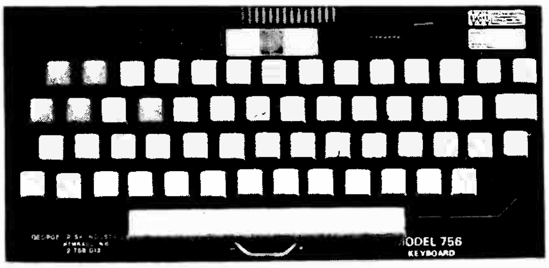

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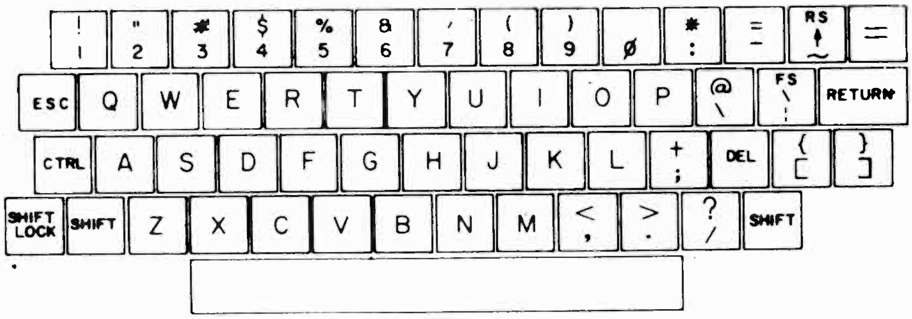

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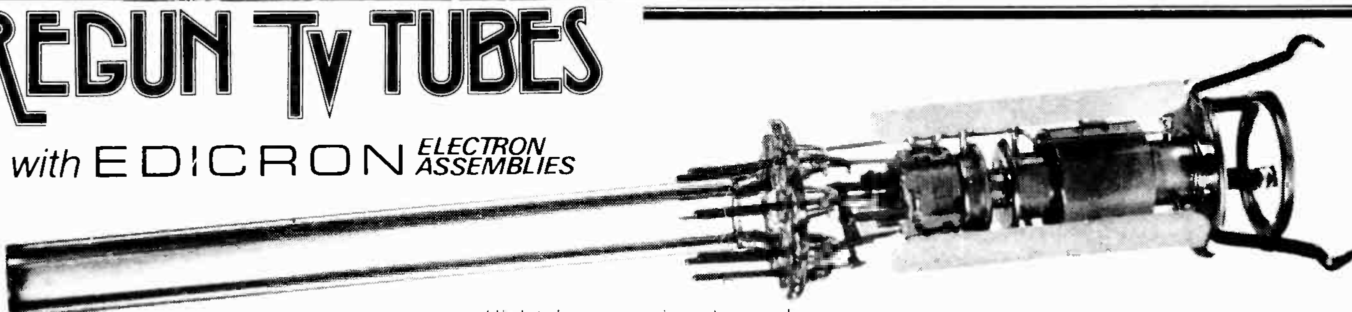
with EDICRON ELECTRON ASSEMBLIES



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AC127	16p	BC179	12p	BF196	12p	TIP41B	35p	2N2218	15p
AC128	16p	BC182	9p	BF197	12p	TIP41C	36p	2N2218A	18p
AC128K	24p	BC182L	9p	BF200	25p	TIP42A	36p	2N2219	15p
AC176	16p	BC183	9p	BFX29	22p	TIP42B	37p	2N2219A	18p
AC176K	24p	BC183L	9p	BFX84	18p	TIP42C	38p	2N2221	15p
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AC187K	26p	BC184L	9p	BFY51	12p	TIP3055	42p	2N2222	15p
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AC188K	26p	BC212L	10p	MPSA05	22p	ZTX108	6p	2N2369	10p
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BC107	6p	BC251	10p	OC45	12p	ZTX500	8p	2N2906	12p
BC108	6p	BCY70	12p	OC71	9p	ZTX501	10p	2N2906A	14p
BC109	6p	BCY71	12p	OC72	12p	ZTX502	12p	2N2907	12p
BC118	10p	BCY72	12p	OC75	10p	2N696	10p	2N2907A	13p
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BC149	8p	BD132	37p	TIP29B	36p	2N706A	8p	2N3053	12p
BC154	16p	BF115	17p	TIP29C	38p	2N708	8p	2N3055	35p
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BC159	9p	BF180	15p	TIP30C	38p	2N1304	15p	2N3704	6p
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BC170	6p	BF182	25p	TIP31B	33p	2N1308	22p	2N3904	11p
BC171	6p	BF183	25p	TIP31C	34p	2N1309	22p	2N3905	11p
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CD4012	£0.17	CD4031	£1.80	CD4071	£0.20
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S7	6 x Phono Plugs Plastic	50p*
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S9	5 x 2 5mm Chassis Sockets (switched)	25p*
S10	4 x Metal Std Chassis Switched Jack Sockets	50p*
S11	2 x Stereo Jack Sockets with instruction leaflet for H/phone connection	50p*
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P & P Please add 35p towards postage & packing unless otherwise stated

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BI-PAK

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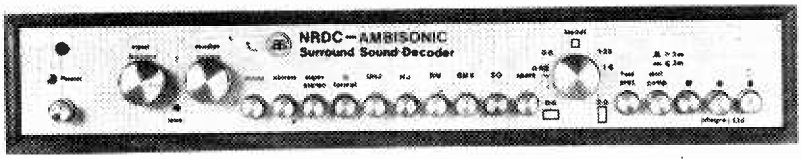
NEW STYLING

NRDC-AMBISONIC UHJ



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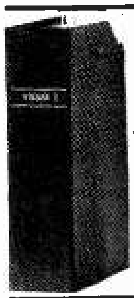
The **first ever** kit specialy produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug., '77.
The unit is designed to decode not only UHJ but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC HJ 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit. Complete with mains power supply, wooden cabinet, panel, knobs, etc.

Complete kit, including licence fee **£45.00** + VAT
or ready built and tested **£61.50** + VAT



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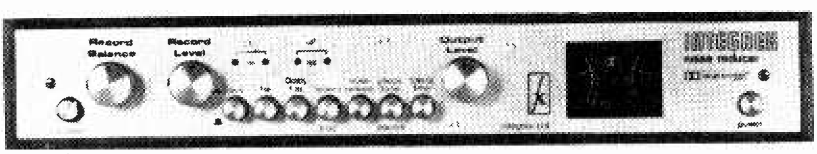
With Home Office Type approval
As in "Wireless World", designed by Mike Hosking, 240V ac mains operated and disguised as a hardbacked book. Detection range up to 30 feet.

Complete exclusive designer approved kit **£46.00** + VAT
or ready built and tested, **£54.00** + VAT

Wireless World Dolby(TM) noise reducer

Trademark of Dolby Laboratories Inc.



Featuring:
- switching for both encoding (low-level h.f. compression) and decoding
- a switchable f.m. stereo multiplex and bias filter.
- provision for decoding Dolby f.m. radio transmissions (as in USA).
- no equipment needed for alignment.
- suitability for both open-reel and cassette tape machines.
- check tape switch for encoded monitoring in three-head machines.

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: £39.90**+VAT

Also available ready built and tested . . . . **Price £54.00**+VAT

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Single channel plug-in Dolby(TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components . . . . **Price £8.20**+VAT

Single channel board with selected fet . . . . **Price £2.50**+VAT

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Selected FETs **60p** each+VAT, **100p**+VAT for two, **£1.90**+VAT for four
Please add VAT @ 12½% unless marked thus*, when 8% applies (or current rates)

We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?

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INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET

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

Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88–104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter. **PRICE: £58.95**+VAT

NELSON-JONES MK. I STEREO FM TUNER KIT

A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

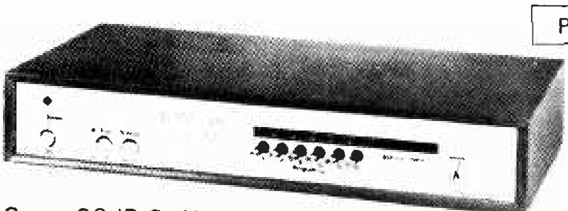
Brief Spec. Tuning range 88–104MHz. 20dB mono quieting @ 0.75μV. Image rejection – 70dB. IF rejection – 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price.

Mono £32.40+VAT
With ICPL Decoder £36.67+VAT
With Portus-Haywood Decoder £39.20+VAT

Please send for details of the Nelson-Jones Mk. II Kit as in this month's W.W.

STEREO MODULE TUNER KIT



A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter Push-button tuning

Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88–104MHz
LED sig. strength and stereo indicator

PRICE: Stereo £31.95+VAT

S-2020A AMPLIFIER KIT

Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring Power 'on/off' FET transient protection.

Typ Spec. 24+24W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £33.95+VAT

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS

BASIC NELSON-JONES TUNER KIT £14.28+VAT
BASIC MODULE TUNER KIT (stereo) £16.75+VAT
PHASE-LOCKED IC DECODER KIT ... £4.47+VAT
PUSH-BUTTON UNIT .... £5.00+VAT
PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT .... £8.00+VAT

TTLs by TEXAS

7400	13p
7401	14p
7402	14p
7403	14p
7404	17p
74S04	90p
7405	18p
7406	32p
7407	32p
7408	19p
7409	19p
7410	15p
7411	24p
7412	20p
7413	30p
7414	60p
7416	27p
7417	27p
7420	17p
7421	40p
7422	22p
7423	34p
7425	30p
7426	40p
7427	34p
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	60p
7448	80p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	34p
7474	30p
7475	36p
7476	35p
7480	50p
7481	100p
7482	84p
7483A	90p
7484	100p
7485	110p
7486	34p
7489	210p
7490A	33p
7491	80p
7492A	46p
7493A	33p
7494	84p
7495A	70p
7496	65p
7497	180p
74100	130p
74104	65p
74105	65p
74107	34p
74109	55p
74110	55p
74111	70p
74116	200p
74118	130p
74119	210p
74120	110p
74121	28p
74122	48p
74123	55p
74125	55p
74126	60p
74128	75p
74132	75p
74136	75p
74141	70p
74142	200p
74145	90p
74147	190p
74148	150p
74150	100p
74151A	70p
74153	70p
74154	100p
74155	90p
74156	90p
74157	70p
74159	190p
74160	100p
74161	100p
74162	100p
74163	100p
74164	120p
74165	130p
74166	140p
74167	200p
74170	240p
74172	720p
74173	120p
74174	93p
74175	85p
74176	90p
74177	90p
74178	160p
74180	93p
74181	200p
74182	90p
74184A	150p
74185	150p
74186	700p
74190	100p
74191	100p
74192	100p
74193	100p
74194	100p
74195	95p
74196	95p
74197	80p
74198	150p
74199	150p
74200	£10
74221	160p
74251	140p
74259	250p
74265	90p
74278	290p
74279	140p
74283	190p
74284	400p
74285	400p
74290	150p
74293	150p
74294	200p
74298	200p
74365	150p
74366	150p
74367	120p
74368	150p
74390	200p
74393	200p
74490	225p

74LS SERIES

74LS00	22p
74LS02	22p
74LS04	25p
74LS08	25p
74LS10	24p
74LS11	40p
74LS13	45p
74LS14	100p
74LS20	22p
74LS22	28p
74LS27	38p
74LS30	22p
74LS32	40p
74LS47	90p
74LS55	30p
74LS73	50p
74LS74	40p
74LS75	50p
74LS83	110p
74LS85	100p
74LS86	40p
74LS90	90p
74LS93	90p
74LS107	45p
74LS112	100p
74LS123	75p
74LS124	180p
74LS132	120p
74LS133	60p
74LS138	60p
74LS139	60p
74LS151	100p
74LS153	60p
74LS157	60p
74LS158	120p
74LS160	130p
74LS161	100p
74LS162	140p
74LS163	140p
74LS164	120p
74LS165	180p
74LS166	180p
74LS173	110p
74LS174	110p
74LS175	110p
74LS181	320p
74LS190	100p
74LS191	100p
74LS192	140p
74LS193	140p
74LS195	140p
74LS196	120p
74LS221	140p
74LS240	245p
74LS241	245p
74LS242	245p
74LS243	245p
74LS245	300p
74LS251	200p
74LS257	120p
74LS259	175p
74LS273	130p
74LS298	249p
74LS373	200p
74LS374	195p

4000 SERIES

4000	15p
4001	17p
4002	17p
4006	95p
4007	18p
4008	80p
4009	40p
4010	50p
4011	17p
4012	18p
4013	50p
4014	84p
4015	84p
4016	45p
4017	80p
4018	89p
4019	45p
4020	100p
4021	110p
4022	100p
4023	22p
4024	65p
4025	20p
4026	130p
4027	50p
4028	84p
4029	100p
4030	55p
4031	200p
4033	180p
4034	200p
4035	110p
4040	100p
4041	80p
4042	80p
4043	90p
4044	90p
4046	130p
4047	100p
4048	55p
4049	40p
4050	49p
4051	80p
4052	80p
4053	80p
4055	125p
4056	135p
4059	600p
4060	115p
4063	120p
4066	55p
4067	475p
4068	22p
4069	20p
4070	30p
4071	22p
4072	22p
4073	22p
4075	22p
4076	107p
4081	22p
4082	22p
4093	80p
4098	107p
4411	£11
4502	120p
4503	70p
4507	55p
4510	99p
4511	150p
4514	250p
4516	110p
4518	100p
4520	100p
4528	100p
4543	180p
4553	450p
4560	250p
4583	90p
4584	90p
40014	90p
40085	200p
40097	90p
14433	£11

INTERFACE ICs

MC1488	100p
MC1489	100p
75107	160p
75182	230p
75324	375p
75451	72p
75491/2	96p
8T28	300p
81LS95	140p
81LS96	140p
81LS97	140p
81LS98	140p
9601	100p
9602	220p
9603	60p

93 SERIES

9301	160p
9302	175p
9308	316p
9310	275p
9311	275p
9312	160p
9314	165p
9316	225p
9322	150p
9334	225p
9368	200p
9370	200p
9374	200p

NEW IC-SFF 96364 TV-CRT CONTROLLER

Used with a few other ICs allows to change any TV set into a VDU for computing systems

28 pin DIL **£14.50**

Data 50p+S.a.e.

LINEAR I.C.s

*AY1-0212	600p
*AY1-1313	668p
*AY1-5050	211p
*AY5-1315	600p
*AY5-1317	636p
*AY5-1320	320p
*CA3019	80p
*CA3046	70p
*CA3048	225p
CA3080E	72p
*CA3089E	225p
*CA3090AQ	375p
CA3130S	100p
CA3140E	70p
CA3160E	100p
FX209	750p
ICL7106	925p
ICL8038	340p
LM301An	36p
LM311	120p
LM318	200p
LM324	70p
LM339	75p
LM348	95p
*LM377	175p
*LM380	99p
*LM381AN	160p
*LM389N	140p
LM709	38p
LM710	50p
LM733	100p
LM741	22p
LM747	70p
LM748	35p
LM3900	70p
LM3911	130p
LM4136	120p
*MC1310P	150p
MC1458	55p
MC1495L	400p
*MC1496	100p
*MC3340P	160p
*MC3360P	120p
*MFC4000B	120p
MK50398	750p
NE531	130p
*NE540L	200p
*NE543K	225p
NE555	30p
NE556	70p
NE561B	425p
NE562B	425p
NE565	130p
NE566	155p
NE567	175p
RC4151	400p
*SN76003N	175p
*SN76013N	140p
*SN76013ND	120p
*SN76023N	140p
*SN76023ND	120p
*SN76033N	175p
*SP8515	750p
*TBA641B11	225p
*TBA800	90p
*TBA810	100p
*TBA820	90p
*TCA940	175p
*TDA1004	300p
*TDA1022	600p
XR2206	400p
XR2207	400p
*XR2216	675p
XR2240	400p
*ZN414	90p
ZN424E	135p
ZN425E	400p
ZN1034E	200p
95H90	800p

VOLTAGE REGULATORS

Fixed Plastic TO-220

1A	+ve		–ve	
5V	7805	90p	7905	120p
12V	7812	90p	7912	120p
15V	7815	90p	7915	120p
18V	7818	90p	7918	120p
24V	7824	90p	7924	120p

100mA	TO-92			
5V	78L05	35p	79L05	80p
12V	78L12	35p	79L12	80p
15V	78L15	35p	79L15	80p

OTHER REGULATORS

LM309K	135p	TBA625B	120p
LM317T	200p	TL430	65p
LM323K	625p	78HO5KC	675p
LM723	37p	78MGT2C	135p

OPTO-ELECTRONICS

2N5777	45p	OCP71	130p
ORP12	90p	ORP60	90p
ORP61	90p	TIL78	70p

LEDS

0.125		0.2	
TIL321R	75p	TIL220 Red	16p
TIL209 Red	13p	TIL222 Gr	18p
TIL211 Gr	20p	TIL228 Red	22p
TIL212 Ye	25p	MV5491 TS	120p
TIL216 Red	18p	Clips	3p

DISPLAYS

3015F	200p	FND500	120p
DL704	140p	FND507	120p
DL707 Red	140p	TIL311	600p
707 Gr	140p	TIL312/3	110p
DL747 Red	225p	TIL321/2	130p
747 Gr	225p	TIL330	140p
FND357	120p		

TRANSISTORS

AC126	25p
AC127/8	25p
AC176	25p
AC187/8	25p
AF116/7	30p
AD149	70p
AD161/2	45p
*BC107/8	11p
BC109	11p
*BC147/8	9p
*BC149	10p
*BC157/8	10p
*BC159	11p
*BC169C	12p
*BC172	12p
BC177/8	17p
BC179	18p
*BC182/3	10p
*BC184	11p
*BC187	30p
*BC212/3	11p
*BC214	12p
BC461	36p
BC477/8	30p
*BC516/7	50p
*BC5478	16p
*BC549C	18p
*BC557B	16p
*BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BDY56	200p
BF200	32p
*BF244B	35p
*BF256B	70p
BF257/8	32p
BF259	36p
*BFR39	30p
*BFR40	30p
*BFR41	30p
*BFR79	30p
*BFR80	30p
*BFR81	30p
BFX29	30p
BFX30	34p
BFX84/5	30p
BFX86/7	30p
BFX88	30p
BFW10	90p
BFY50	22p
BFY51/2	22p
BFY56	33p
BFY90	90p
BLY83	700p
BRY39	45p
BSX19/20	20p
BU104	225p
*BU105	190p
*BU108	250p
BU109	225p
*BU205	220p
*BU208	200p
*BU406	145p
MJ481	175p
MJ491	200p
MJ2501	225p
MJ2955	100p
MJ3001	225p
*MJE340	65p
MJE2955	100p
MJE3055	70p
*MPF102	45p
*MPF103/4	40p
*MPF105/6	40p
MPSA06	30p
*MPSA12	50p
*MPSA56	32p
*MPSU06	63p
*MPSU56	78p
OC28	130p
OC35	130p
*R2008B	200p
*R2010B	200p
*TIP29A	40p
*TIP29C	55p
*TIP30A	48p
*TIP30C	60p
*TIP31A	58p
TIP31C	62p
TIP32A	68p
TIP32C	82p
TIP33A	90p
TIP33C	114p
TIP34A	115p
TIP34C	160p
TIP35A	225p
TIP35C	290p
TIP36A	270p
TIP36C	340p
TIP41A	65p
TIP41C	78p
TIP42A	70p
TIP42C	82p
TIP2955	78p
TIP3055	70p
*TIS43	34p
*TIS93	30p
*ZTX108	12p
*ZTX300	13p
*ZTX500	15p
*ZTX502	18p
*ZTX504	30p
2N457A	250p
2N696	35p
2N697	25p
2N697	45p
2N706A	20p
2N708A	20p
2N918	45p
2N930	18p
2N1131/2	20p
2N1613	25p
2N1711	25p
2N2102	60p
2N2160	120p
2N2219A	20p
2N2222A	20p
2N2369A	16p
2N2484	30p
2N2646	50p
2N2904/5	25p
2N2906A	24p
2N2907A	30p
*2N2926	9p
2N3053	20p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
*2N3565	30p
*2N3643/4	48p
*2N3702/3	12p
*2N3704/5	12p
*2N3706/7	14p
*2N3708/9	12p
*2N3773	300p
*2N3819	25p
*2N3820	50p
2N3823	70p
2N3866	90p
*2N3903/4	18p
*2N3905/6	20p
*2N4036	65p
*2N4058/9	12p
*2N4060	12p
*2N4061/2	18p
*2N4123/4	22p
*2N4125/6	22p
*2N4289	20p
*2N4401/3	27p
2N4427	90p
*2N4871	60p
*2N5087	27p
*2N5089	27p
*2N5172	27p
2N5179	27p
2N5191	83p
2N5194	90p
*2N5245	40p
*2N5296	55p
*2N5401	50p
*2N5457/8	40p
*2N5459	40p
*2N5460	40p
*2N5485	44p
*2N6027	48p
2N6247	190p
2N6254	130p
*2N6290	65p
2N6292	65p
3N128	120p
3N140	100p
3N141	110p
3N201	110p
3N204	100p
40290	250p
40360	40p
40361/2	45p
40364	120p
40408	70p
40409	65p
40410	65p
40411	300p
40594	97p
40595	105p
40603	58p
40673	75p
40841	90p
40871/2	90p

DIODES

*BY127	12p
*OA47	9p
*OA81	15p
*OA85	15p
*OA90	9p
*OA91	9p
*OA95	9p
*OA200	9p
*OA202	10p
*1N914	4p
*1N916	7p
*1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
10A 400V	200p
25A 400V	400p

TRIACS PLASTIC

3A 400V	60p
3A 500V	65p
6A 400V	70p
6A 500V	88p
8A 400V	75p
8A 500V	95p
12A 400V	85p
12A 500V	105p
16A 400V	110p
16A 500V	130p

***ZENERS**

2.7V-33V

400mW	9p
1W	15p

THYRISTORS

1A 50V	40p
1A 400V	65p
1A 600V	70p
3A 400V	90p
8A 600V	140p
12A 400V	160p
16A 100V	160p
16A 400V	180p
16A 600V	220p
BT106	110p
C106D	45p
*MCR101	36p
2N3525	120p
*2N5060	34p
*2N5064	40p

HEAT SINKS

For TO220 Voltage Regs and Transistors	22p
For TO5	12p

BRIDGE RECTIFIERS

*1A 50V	21p
*1A 100V	22p
*1A 400V	30p
*2A 50V	30p
*2A 100V	35p
*2A 400V	45p
*3A 200V	60p
*3A 600V	72p
*4A 100V	95p
*4A 400V	100p
6A 50V	90p
6A 100V	100p
6A 400V	120p

PLEASE SEND SAE FOR FULL LIST

VAT RATES. All items at 8% except marked * which are at 12½%

MEMORIES

2102	100p
2102 2	120p
2102L 4	140p
2107B	600p
2111-1	325p
2112-2	300p
2114	1500p
5101	510p
6810	400p

ROM/PROMs

74S188	225p
74S287	400p
74S387	400p
93436	650p
93446	650p

CPUs

4040A	670p
6502	1200p
6800	1020p
8080A	650p

EPROMS

1702A	600p
2708	900p
2716	3000p
4702	900p

UART

AY-3-1015P	550p
AY-5-1013P	450p
TMS6011NC	450p

CHARACTER GENERATOR

MCM6576	750p
RO-3-2513 U C	800p
RO-3 2513 L C	550p
SN74S262AN	1360p

OTHER

3205	320p
3245	400p
4201	390p
4289	970p
4801	500p
6820	600p
6850	700p
8205	320p
8212	225p
8216	225p
8224	400p
8228	525p
8251	700p
8255	550p
9905	200p
9906	275p

SPECIAL OFFERS

100-741	£16
100-555	£20
100-RCA 2N3055	£36

CRYSTALS

100KHz	300p
1MHz	370p
3.2768MHz	350p
10.7MHz	350p
27.135MHz	300p

EDGEBOARD CONNECTORS

0.156" Solder Tail

2 x 10 way	85p
2 x 15 way	100p
2 x 18 way	120p
2 x 22 way	135p
2 x 25 way	160p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin	11p	18 pin	25p	24 pin	33p
14 pin	13p	20 pin	28p	28 pin	42p
16 pin	14p	22 pin	30p	40 pin	51p

WIRE WRAP SOCKETS

8 pin	30p	24 pin	80p
14 pin	40p	28 pin	100p
16 pin	55p	40 pin	120p

NEW IC SN76477 COMPLEX SOUND GENERATOR

The device provides Noise, Tone, or Low Frequency (or a combination thereof) based complex sounds. Programming is via external components, that are user-defined, which allows a wide variety of sounds to be created. It is designed for ultimate flexibility in user-defined sounds, and may be applied in any application requiring audio feedback to the operator (i.e. arcade/home video games, pinball games, toys, etc). consumer oriented equipment such as timers, alarms, controls, etc, industrial equipment for indicators, alarms, feedback controls, etc.

28 pin DIL **£5.50** Data 0 30p+S.a.e

Please add 25p p&p & VAT at appropriate rates.

Government, Colleges, etc. Orders accepted.

CALLERS WELCOME Mon-Fri 9 30-5 30 Saturday 10 30-4 30

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Semiconductor Supplies (CROYDON) LIMITED

SUMMER **1978** CATALOGUE

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Telephone: 01-647 1006 (5 LINES) TELEX 946650

CIRCLE WW—034 TO OBTAIN YOUR OWN CATALOGUE

LATEST BARGAINS IN TEST EQUIPMENT

MANUFACTURER	TYPE NO	DESCRIPTION	PRICE £
Acoustic			
CEL	112	LEQ meter. Digital readout 80dB. Dynamic range (147dB max.)	625.00
Logic Analysers			
HP	1601L	Logic state analyser. Clock to 10MHz. 12 channel display (This item to be sold with HP 184 series mainframe included).	1450.00
Oscilloscopes			
Hewlett Packard	184A	DC-100MHz. Mainframe. Storage facility.	850.00
	1801A	DC-50MHz. Dual channel. 5mV-20V/Div.	350.00
	1822A	Time Base. 50ns-1s/Div. Dual & delayed sweep.	300.00
Tektronix	7704	DC-105MHz. CRT readout. Mainframe for 4 Plug-ins.	450.00
	7A11	DC-150MHz. Built-in FET Probe DC offset. 5mV-20V/Div.	425.00
	7A13	DC-100MHz. Differential comparator 1mV-5V/Div.	350.00
	7B70 7B71	Dual Time Base. 2ns-5s/Div. Dual and delayed sweep. Triggering to 200MHz	275.00
Recorders & Signal Conditioning Equipment			
SE Labs	3006DLT	12 channels U.V. Recorder. 1250 mm/sec–25 mm/min. 6" chart.	450.00
	A100	Galvo 60Hz. 3.7µA/cm.	30.00
	A2500	Galvo 1600Hz. 2.5mA/cm	30.00
	B450	Galvo 300Hz. 50µA/cm.	30.00
Smiths	RE551.20	X-Y Plotter A3 50µV–500mV/cm sens on both axis Timebase fitted.	575.00
Voltmeters – Digital			
Solartron	A200	19999 FSD. DC only. 1µV–1000V 0.01% Autorange.	200.00
	A205	19999 FSD. AC/DC/OHMS. 1µV–1000V DC 0.01% 10µV–1000V AC (true RMS). 100mΩ–10MΩ	300.00
Wave Analysers			
Rohde & Schwarz	FAT3	5Hz-20kHz. Input 0.1mV–30V. Dynamic range 100dB Mixer unit for sideband analysis to 500MHz. Sweep unit.	3850.00

These are just a few of some 150 different types of Test Instruments and accessories from the world's leading manufacturers now available for sale from our own stocks.

Full details in the new Carston list obtainable FREE from any of our companies – just 'phone 01-267 4257 or circle WW129 on postcard

CARSTON ELECTRONICS LIMITED
Shirley House 27 Camden Road London NW1 9NR Telephone No. 01-267 4257

WW — 129 FOR FURTHER DETAILS

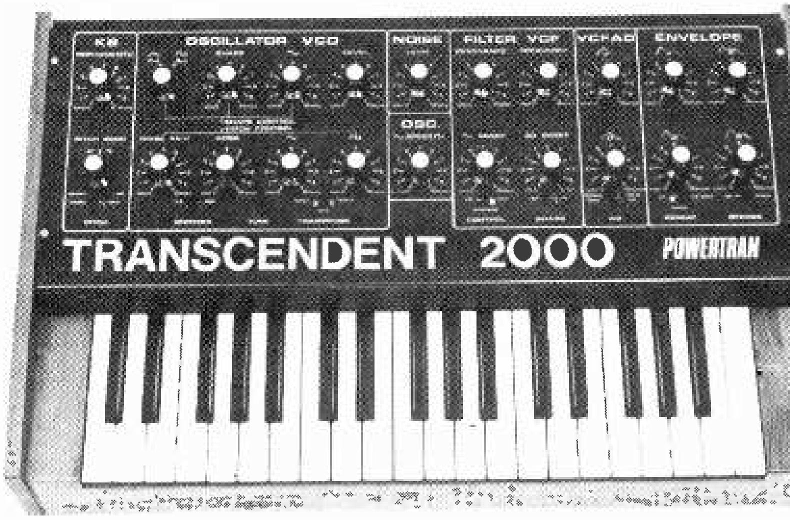
KENYA HOLLAND JAMAICA UNITED ARAB EMIRATES FALKLAND ISLANDS PORTUGAL GUYANA INDIA GREECE JORDAN UNITED STATES OF AMERICA YUGOSLAVIA ASCENSION ISLAND

EIRE GRENADA SAUDI ARABIA NEW ZEALAND NORWAY SINGAPORE ICELAND SWEDEN MALAYA INDONESIA BRAZIL SWITZERLAND ZAMBIA GIBRALTAR CHILE SPAIN

AUDIO KITS OF DISTINCTION FROM POWERTRAN

NEW!

TRANSCENDENT 2000
SINGLE BOARD SYNTHESIZER
As featured in Electronics Today International (July, August 1978)



Live performance synthesizer designed by consultant Tim Orr (formerly synthesizer designer for EMS Ltd) and featured as a constructional article in Electronics Today International, the TRANSCENDENT 2000 is a 3 octave instrument transposable 2 octaves up or down with portamento, pitch bending, a VCO with shape modulation, a versatile VCF with both low and high pass outputs and a separate dynamic sweep control a noise generator and an ADSR envelope shaper There is also a slow oscillator and a new pitch detector amongst its many features

Kit includes fully finished metalwork, solid teak cabinet, filter sweep pedal and really is complete — right down to the last nut and bolt Virtually everything is on one circuit board 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!

INTRODUCTORY OFFER
£172!

Due to the fantastic success of the launching of this superb new kit we are able to continue the Special Introductory Offer of £172 for complete kit

INTERNATIONAL POWERSLAVE 200 + 200 watt AMPLIFIER

As featured in Electronics Today International

400W rms continuous — 800W peak!
0.03% THD at FULL power!
PLUS all the following features too!

- ★ Each channel totally independent with its own stabilised power supply driven by custom designed TOROIDAL transformers!
- ★ Inherent reliability — monster heat sinks for cool running at the hottest venues — electronic open and short circuit protection!
- ★ Ultra low feedback (an incredible low 14dB overall!) super high slewing rate (20V/μs) 200W rms continuous to 4 ohm from EACH channel, input sensitivity 0 775V (0dB)
- ★ Professional quality components, sturdy 19 rack mounting chassis complete with sleeve and feet for free standing work too.
- ★ Easy to build — plenty of working space with ready access to all components minimal wiring, extensive instruction suitable for both experienced constructors and newcomers to electronics
- ★ Value for money — quality and performance comparable with ready-built amplifiers costing over £600!

Pack		Price
1.	Fibre glass printed circuit board for power amp	£4.20
2.	Set of capacitors, metal oxide resistors, thermistor, cormet pre-sets for power amp	£6.40
3.	Set of semiconductors for power and with mounting hardware, cooling tabs	£27.60
4.	Pair of monster black drilled heat sinks, transistor mounting bracket	£6.90
5.	Toroidal transformer, Primary 0-117V-234V, Secondaries 42-0-42V, 0-15V, 0-15V, Electrostatic screen	£17.50
6.	Set of all parts for stabilized power supply including fibre glass printed circuit board, mounting bracket, semiconductors, resistors, capacitors, etc	£18.90
7A.	Set of all parts for buffer/overdrive unit including fibre glass printed circuit board, semiconductors, resistors, capacitors, controls — required for PSI 4001 only	£3.80
7B.	Set of parts for peak power meter including professional quality meter, fibre glass printed circuit board, components, controls — required for PSI 4002 only	£8.50
8.	Set of all miscellaneous parts including sockets, illum. mains switches, fuse holders, fuses, cut-outs, cable, etc	£12.10
9.	Cabinet, including chassis, anodised silver on black panels, fixing parts, etc. Please state whether Slave or Studio model required	£25.50
10.	Handbook £0.50 or free on request when ordering any of above packs.	

2 each of packs 1-7 (A or B), 1 each 8, 9 and 10 are required for complete 200 + 200W professional amplifier.

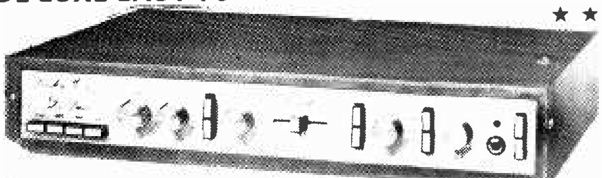
Total cost of individually purchased packs PS1 4001 £208.20; PS1 4002 £217.60

PSI 4001 SLAVE MODEL ★ ★

SPECIAL PRICES FOR COMPLETE KITS!
PS1 4001 — £187.50
PS1 4002 — £196.90

PSI 4002 STUDIO MODEL ★ ★

DE LUXE EASY TO BUILD LINSLEY-HOOD 75W AMPLIFIER ★ ★



Pack		Price
1.	Fibreglass printed circuit board for power amp	£1.15
2.	Set of resistors, capacitors, pre-sets for power amp	£2.50
3.	Set of semiconductors for power amp	£6.50
4.	Pair of 2 drilled, tinned heat sinks	£1.10
5.	Fibreglass printed-circuit board for pre-amp	£1.90
6.	Set of low noise resistors, capacitors, pre-sets for pre-amp	£4.10
7.	Set of low noise, high gain semiconductors for pre-amp	£2.40
8.	Set of potentiometers (including mains switch)	£3.50
9.	Set of 4 push-button switches, rotary mode switch	£5.40
10.	Toroidal transformer complete with magnetic screen/ housing primary: 0 117-234 V; secondaries: 33-0-33 V, 25-0-25 V	£12.95
11.	Fibreglass printed-circuit board for power supply	£0.85
12.	Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£5.40
13.	Set of miscellaneous parts including DIN skts., mains input skt., fuse holder, interconnecting cable, control knobs	£6.20
14	Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£8.20
15.	Handbook	£0.30
16.	High Quality Teak Veneer cabinet 18.3" x 12.7" x 3.1"	£10.70

2 each of packs 1-7, 1 each of packs 8-16 inclusive are required for complete stereo amplifier. Total cost of individually purchased packs £92.80

PACK PRICES FOR STANDARD KIT

AVAILABLE AS SEPARATE PACKS
PRICES IN OUR FREE CATALOGUE

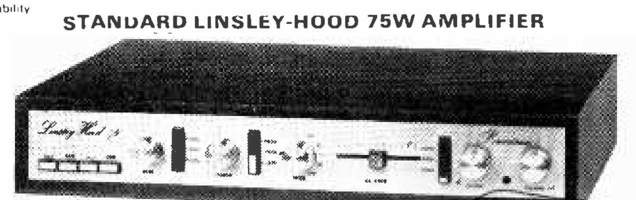
SPECIAL PRICE FOR COMPLETE KIT £99.30

The standard model of our kit for Mr Linsley Hood's 75 watt design has for a long time offered exceptional performance at a very modest cost with high quality high power ready-built units of comparable quality generally being over three times the price

Features of the amplifier include very low distortion (less than 0.01%) 75W rms per channel power output rumble filter variable slope scratch filter variable transition frequency tone controls tape monitoring facilities and individually adjustable inputs This model is based on 5 circuit boards which not having the controls mounted on them can if desired be effectively used separately in high performance audio systems not based on our metalwork

Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and are designed to have the potentiometers and switches mounted upon them This system almost eliminates internal wiring making installation after their assembly delightfully straightforward and as each board can be easily removed in seconds from the chassis checking and maintenance is so simple that even newcomers to electronics will be able to cope competently with the kit Additional features of our new model are inclusion of the latest circuit improvements generously sized heat sinks for heavy duty use even in tropical climates and metal oxide resistors throughout for long-term stability and reliability

STANDARD LINSLEY-HOOD 75W AMPLIFIER



SPECIAL PRICE FOR COMPLETE KIT £79.80

ADVANCE BOARD No. 70065. A modern fibre glass circuit board made for computer but never issued, all components can be assumed perfect.

Major items — 8 transistors type BC 107, 8 transistors type BC 212, 9 miniature diodes, 4 preset variable pots. A 200 UF 63v capacitor, 2 47UF 40 volt capacitors, 2 220UF 10 volt capacitors, 1 1UF 63 volt capacitor, 50 assorted resistors ⅛, ¼ watt. Board size approx. 5 x 4½". Most components can be removed with working length leads **£1.00.**

Telephone Answering Machine. Used, but we understand are in good working order, however, we can supply only for breaking up — they are not be used for telephone answering. They contain

4 pole tape motor, twin capstans with heavy flywheels, 4 record-playback heads, erase head, tape spools to take standard reels, tape guides and solenoid operated brake, 8 piano key type switching and control mechanism, tape used counter, elliptical speaker, 2 solenoids, 9 pin plug and socket, 36 pin plug and socket 5 Circuit boards containing varied assortment of transistors in small parts. All the above mentioned components are mounted in the main chassis and there is a sub chassis with 5 miniature 4 pole relays, ferrite transformer, 4 iron cored transformers, 5 variable pots, 35 transistors, over 300 various resistors, capacitors, diodes, etc., full wave rectifier panel, 4 way push down wire connection block, two-way ditto, stereo input socket, 3 push-in neon bulbs, lid switch, 4 electrolytic capacitors, 2 power output transistors. The unit is nicely cased size about 27" x 10" 6" and should be suitable for conversion to open reel tape recorder, background music machine, echo chamber etc. etc. Price **£12.25.**

High Voltage Mains Transformer. Normal mains primary-secondary by our measuring equipment is 8KV approx at 5 ma. We are offering these at a bargain price of **£4.75.** Our ref. no. TM45.

Sorry, sold out of transformer ref. No. TM 37 but we have just received another transformer which may fill your need. This is a 100w transformer 80 volt secondary, tapped at 20, 40 and 60 volts. So this could be used as a 80v. 1 5 amp. 60v at 2 amp, 40 volt 3 amp, a 20-0-20 volt 3 amp or a 40-0-40v 1 5 amp, price **£5.55.**

Smith's Blower. Snail shape with exterior motor, oblong outlet size 4½ x 1¾ approx., paddle type air rotor coupled to mains induction motor, with anti vibration mountings overall size of fan approx 4½" high x 6½" wide x 4½" diameter. **£5.80.**

Torrin Blower. Snail type similar but smaller to above, aperture size 2½" x 1¾" approx. Normal mains induction motor overall size 5¼" high x 5¼" wide x 5½" diameter Price **£5.86.**

High Voltage Capacitors. 80 nf 5 KV working ex equipment but with useable length leads. Normally a very expensive capacitor, our price **25p + 2p each**

Flex Bargain. 3 Core (standard colour coding), black outer pvc cover, all made from heat resistant plastic. Suitable for connecting direct to heating appliances but being tougher than usual it is ideal also for extension leads especially outdoor ones. 5mm conductors so suitable for up to 7 5 amp 100 met coil, price **£10.95.**

⅓ rev per minute mains driven motor, 2 watts also suitable only for timers or other lightweight operations, price **£2.70.**

Moving Coil Panel Meter. 75 mA fsd 2½" diameter this is an ex government item and the scale is headed Radiation, limited quantity available **£1.89.**

A Clock Switch, 12 hour type as fitted to cookers. This comprises a normal 12 hour continuously running clock coupled to 25 amp switches with levers for setting time plus a further minute winder bell switchable up to 60 minutes. Less knobs which can be quite easily made from plastic rod. Size approx. 7¼" wide, 3¼" high, 3" deep, limited quantity **£2.12.**

Mains Relay single screw fixing open type with single 10 amp changeover contact ex equipment with our usual guarantee price **60p + 4p,** 10 for **£5 + 40p.**

Adjustable Air Thermostat with 15 amp contacts, spindle protrudes enough for normal type knob, can be easily assessable, screw enables these to be set for normal air temperatures 30-80 f or lower or higher **50p + 4p** each, 10 for **£4.50 + 36p.**

Car Speakers. Two bargains this month both elliptical, both 4 ohm size. Price **£1.50 + 19p,** post 60p

Immersion Heater Thermostats, made by Satchwell 7", 11" and 17" lengths, standard fit in most immersion heaters, **£2.10.**

Thermostat Pocket, to fit the above thermostat into a tank without heater then you need a pocket to hold the thermostat, 18" long threaded complete with nut and washer, price **£1.62.** Also available 8" long for 7" thermostat, same price.

Hot Wire Vacuum Relay Switch. 4 pin plug-in type. This has a heater coil wound around a bi-metallic strip causes switch on after a time which is adjustable. The energising voltage varies between 4v & 7v time delay time — from a few seconds upwards Price **£1.08.**

Boiler Stat, 60-90 C remote phial type capillary length approx. with control knob marked 20 to 80 C, price **£2.16.**

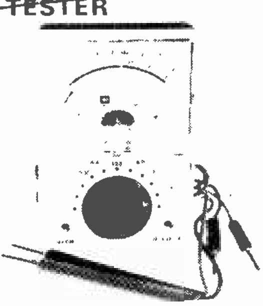
Transistor holder for TO5 (OC 26, etc.) allows transistor to be replaced quickly, also threaded for holding screws AC capacitor 1.25µF for 40 volts rms. Aluminium can with tag connections ex new equipment covered by normal guarantee, **30p + 2p.**

MINI-MULTI-TESTER

Mazing deluxe pocket size precision moving coil instrument — jewelled bearings — 1000 opv — mirrored scale

11 instant ranges measures

DC volts 10 50 250 1000
AC volts 10 50 150 1000
DC amps 0-1 mA and 0-100 mA
Continuity and resistance 0-150K ohms
Complete with insulated probes, leads, battery, circuit diagrams and instructions
Unbelievable value only **£6.50.**



MULLARD UNILEX

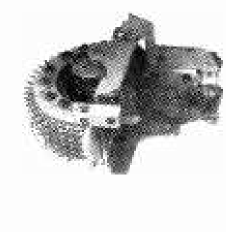
A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone in easy-to-assemble modular form and complete with a pair of Plessey speakers this should sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£15** including VAT and postage

10 watt amps to upgrade unilex **£3.50** each

UNISELECTORS

These are pulse operated switches as used in automatic telephone switchboards etc. The pulse moves the switch arm through one position. Except where indicated the selectors are 25 position types and 50v Coil is standard 24v or 12v operation extra at **£2** per switch

3 pole	**£5.90**
4 pole	**£6.98**
5 pole	**£8.20**
6 pole	**£9.25**
8 pole	**£11.40**
10 pole	**£13.60**
12 pole	**£15.88**
2 pole 50 way	**£8.60**
3 pole 50 way	**£11.40**



24 HOUR TIMERS

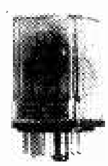
The one illustrated is the E control this uses the Smiths mechanism as in their autoset 2 on off s per 24 hours 13 amp contacts override switch **£6.50.**

Smiths 100 amp model one on off per 24 hours **£10.50,** extra contacts **£1.00** per set

AEG 60 amp model with clockwork standby one on off per 24 hours **£9.50,** extra contacts **£1.00** per set

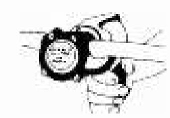
RELAYS

12 volt two 10 amp changeover plug in **95p.** 12v three 10 amp changeover plug in **£1.28.** 12v two changeover miniature wire ended **95p.** 12 volt open single screw fixing two 10 amp changeovers **85p.** 12 volt open three 10 amp changeovers **£1.25.** Latching relay mains operated 2 c o contacts **£2.11.** Mains operated three 10 amp changeovers open type one screw fixing **£1.25.** Many other types with different coil voltages and contact arrangements are in stock enquiries invited



ROTARY PUMP

Self priming portable fits drill or electric motor pumps up to 200 gallons per hour depending upon revs. Virtually uncorrodable use to suck water, oil, petrol, fertiliser, chemicals, anything liquid. Hose connector each end **£2** post paid



DELAY SWITCH

Mains operated — delay can be accurately set with pointers knob for periods of up to 2½ hrs 2 contacts suitable to switch 10 amps — second contact opens few minutes after 1st contact **95p.**

HUMIDITY SWITCH

American made by Ranco their type No. J11. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch adjustable by a screw. Quite sensitive — breathing on it for instance will switch it on. Micro 3 amp at 250V a.c. Overall size of the device approx 3⅛in long 1in wide and 1 in deep **75p.**

INDUCTION MOTORS

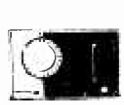
One illustrated is our reference MM11 made for ITT ¼ stack 1½ spindle **£2.25,** ½ stack model **£1.75.** 1 stack **£2.75.** 1½ stack **£3.25.**

EXTRACTOR FAN

Ex-computers made by Woods of Colchester ideal for fixing through panel — reasonably quiet running — very powerful 2500 rpm Choice of two sizes 5 or 6½ dia **£5** and **£6.**

SMITHS CENTRAL HEATING CONTROLLER

push button gives 10 variations as follows (1) continuous hot water and continuous central heating (2) continuous hot water but central heating off at night (3) continuous hot water but central heating on only for 2 periods during the day (4) hot water and central heating both on but day time only (5) hot water all day but central heating only for 2 periods during the day (6) hot water and central heating on for 2 periods during the day time only — then for summer time use with central heating off (7) hot water continuous (8) hot water day time only (9) hot water twice daily (10) everything off. A handsome looking unit with 24 hour movement and the switches and other parts necessary to select the desired programme of heating. Supplied complete with wiring diagram. Originally sold we believe at over **£15** — we offer these while stocks last at **£7.50** each including VAT & Postage



TERMS:
Prices include Post & VAT but orders under £6 00 please add 50p to offset packing etc. Bulk enquiries please phone for generous discount 01-688 1833

J. BULL (ELECTRICAL) LTD
(Dept. WW)
103 TAMWORTH ROAD
CROYDON CR9 1SG

IT'S FREE!

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived — often bargains which sell out before our advertisement can appear. — It's an interesting list and it's free — just send S.A.E. Below are a few of the Bargains still available from previous lists.

Mains operated Siren. Don't let intruders get away with your possessions — they will never stay in a house when one of these sirens is going. Quite small but very alarming **£13.50.**

Lever Switch as fitted to modern telephone switchboards 8 pole changeover contacts made by Pye/TMC biassed to return when pushed up, stays down when pushed down, price **£1.08.**

Pulsing Switch. Motorized unit which gives pulses every 30 seconds, length of pulse can be adjusted up to 30 seconds and the pulse can be up to 20 amps at normal mains voltage. Made up by famous Cramer Company of America, the drive motor of this device is 115v 50hz but we supply complete with series voltage dropping device to make it suitable for our mains. This is in a cylindrical plastic case overall size, with a knob on the front for adjusting the pulse length. 20 amp switch "inside" is a changeover switch so this device could also be used as a time sharing switch, when one circuit is on the other circuit would be off for a length of time determined by switch control setting, price **£4.82.**

16 Line Connecting Box. This is 16 way twin grub screw type connecting strip, mounted in a standard 2 gang MK white surface box with cover made for Satchwell so obviously a good product. The cables are brought in through breakaways in the plastic box. 16 connection points are all numbered for easy identification, price **£1.92.**

Air Thermostat with remote setting dial. This is a Satchwell thermostat using a sensor connected to the switch by a 26" length of capillary. The control setting adjustable from 30 to 140 F complete with control knob showing temperature setting **£2.46.**

Twin 13 amp Rocker Switches (DOT), price **49p** the pair

Pressure Gauge, standard airline thread. Reads 0-30 lbs per sq inch Price **81p.**

Bargain for callers only. VDU with 18" CR Tube rather large, **£14.50.**

4 Way Terminal Blocks, twin grub screw type PVC covered 10 for **65p.**

Spares for Dimplex Heaters. We have just taken delivery of a large quantity of various spare parts for Dimplex heaters including storage heaters, if you need any of these then please let us have your enquiries

Heavy Duty Casters. Four of these would carry a ton, set of 4 **£2.65.**

Super Power 2N3055. RCA 52360, in our trials this does all that the 2N3055 will do but very much better — truly a remarkable transistor **85p.**

200 watt Transformer, 40v-0-40v, normal type construction and primary wound for 230 50hz, **£6.65.**

High Voltage Rectifier. 5kv working at 5mA these are ex unused equipment but have good length leads, ideal for use with the EHT transformer if joined in series, price **33p.**

Speaker Cabinets. Simulated teak finish, nice handy size, modern black sponge type front **£3.75.**

In Car Speaker Cabinet. White with black edge very modern looking plastic with threaded studs for mounting speaker with back, price **£2.25.**

AC Capacitors for use on fluorescent lighting for power factor correction or as a voltage dropping device, these are very rugged and will stand DC voltages up to 3 times their RMS voltage. A big purchase enables us to offer these at about one-third of the current manufacturers price, all are 300v RMS working or higher and are in aluminium cans with tags or wire ends, following values 1 25µF **38p,** 5µF **49p,** 3µF **59p,** 4µF **70p,** 7µF **92p,** 8µF **£1.07,** 15µF **£1.35.**

Numerical Display Tubes (Nixie tubes). Mullard ref ZM 1175, this is a sideways viewing device which displays all figures from 0-9, has wire leadouts, now in box **92p** each

Waterproof Diecast Box, very suitable for protecting a switch or a thermostat or a similar device where this is mounted outside or in a greenhouse, price **£1.62.**

Multiway Switches, GEC silver finished metal box with cable knockouts each complete with switch mounting grid and matching recessed cover, suitable for conduit or TRS. Single switch **50p,** twin switch **60p,** 4 switch **75p,** 6 switch **£1,** 12 switch **£1.50.**

Modern toggle type miniature switches by GEC to fit above boxes, mains rating 5 amp on/off **35p,** 15 amp on/off **45p,** 5 amp 2 way **30p,** 2 way and off **50p,** intermediate (polarity changeover **50p**), bell push **35p** (available in several colours. Please add 8% VAT to total cost of boxes and switches

Most of the above switches can be supplied without toggles but operated by a special key, add **10p** per switch and **25p** per key

Can Any Reader help! We have recently acquired some very nice American made motors 50 cycle for 50hz 220v working obviously made for the British Market but they have 5 lead out wires and we have not been able to find out the correct method of working. It is possible that they need a capacitor. The colours of the leadout wire are red, white, yellow and blue. The maker's name is Robbins and Myers and the model number of the motor is KS-PP30-601 rated at 1/12 hp single phase 1425 rpm. Price of the motor **£5.50 + 44p.** Post and packing £2.

Boiler Stat. Satchwell remote dial type with knob calibrated 20-90 C Price **£2.42.**

MINIATURE RELAY

12v dc operated with two sets of changeover contacts. The unique feature of this relay is its heavy lead out wires. These provide adequate support and therefore the relay needs no fixing. On the other hand there is a fixing bolt through one side so if you wish you can fix the relay and use its very strong lead outs to secure circuit components—an expensive relay. We are offering them at only 87p each

Don't miss this exceptional bargain.

T.T.L. 74 I.C.s By TEXAS, NATIONAL, I.T.T., FAIRCHILD ETC.

7400	14p	7426	25p	7473	30p	74121	30p	74151	65p	74179	140p
7401	14p	7427	25p	7474	30p	74122	40p	74153	65p	74180	100p
7402	14p	7428	40p	7475	30p	74123	60p	74154	120p	74181	200p
7403	14p	7430	15p	7476	40p	74125	50p	74155	70p	74182	75p
7404	14p	7432	25p	7480	15p	74126	50p	74156	70p	74184	150p
7405	14p	7437	25p	7485	100p	74130	130p	74157	70p	74185	150p
7406	40p	7438	25p	7486	30p	74131	100p	74160	90p	74188	350p
7407	40p	7440	15p	7489	250p	74132	65p	74161	90p	74189	350p
7408	20p	7441	[illegible]	7490	35p	74135	100p	74162	90p	74190	140p
7409	20p	7442	65p	7491	75p	74136	80p	74163	90p	74191	140p
7410	15p	7445	80p	7492	45p	74137	100p	74164	125p	74192	120p
7400	20p	7446	80p	7493	40p	74138	125p	74165	125p	74193	120p
7412	20p	7447	75p	7495	60p	74139	100p	74166	125p	74194	100p
7413	30p	7448	70p	7496	70p	74141	60p	74167	325p	74195	100p
7414	60p	7450	15p	74100	95p	74142	270p	74170	200p	74196	100p
7416	30p	7451	15p	74104	90p	74143	270p	74173	150p	74197	100p
7417	30p	7453	15p	74105	40p	74144	270p	74174	100p	74198	185p
7420	15p	7454	15p	74107	30p	74145	75p	74175	75p	74199	185p
7422	20p	7460	15p	74109	50p	74147	230p	74176	100p		
7423	25p	7470	30p	74118	90p	74148	160p	74177	100p		
7425	25p	7472	25p	74120	90p	74150	120p	74178	140p		

C.MOS

4000	14p	4030	55p
4001	14p	4032	95p
4002	14p	4033	120p
4006	90p	4047	100p
4007	16p	4048	55p
4009	55p	4049	40p
4011	14p	4040	40p
4012	14p	4054	120p
4013	50p	4055	140p
4015	90p	4056	135p
4016	40p	4060	120p
4017	90p	4066	55p
4018	90p	4069	20p
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4022	90p	4072	16p
4023	16p	4081	16p
4024	65p	4082	16p
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150	100	**7.13**	1.14
151	200	**11.16**	1.14
152	250	**12.79**	1.50
153	350	**16.28**	1.84
154	500	**19.15**	2.15
155	750	**29.06**	OA
156	1000	**37.20**	OA
157	1500	**45.60**	OA
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Ref	Amps 12v	Amps 24v	£	P&P
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213	1.0	0.5	**2.64**	.78
71	2	1	**3.51**	.78
18	4	2	**4.03**	.96
70	6	3	**5.35**	.96
108	8	4	**6.98**	1.14
72	10	5	**7.67**	1.14
116	12	6	**8.99**	1.32
17	16	8	**10.39**	1.32
115	20	10	**13.18**	2.08
187	30	15	**17.05**	2.08
226	60	30	**26.82**	OA

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

Ref.	Amps	£	P&P
102	0.5	**3.41**	.78
103	1.0	**4.57**	.96
104	2.0	**6.98**	1.14
105	3.0	**8.45**	1.32
106	4.0	**10.70**	1.50
107	6.0	**14.62**	1.64
118	8.0	**17.05**	2.08
119	10.0	**21.70**	OA

30 VOLT RANGE

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

Ref.	Amps	£	P&P
112	0.5	**2.64**	.78
79	1.0	**3.57**	.96
3	2.0	**5.27**	.96
20	3.0	**6.20**	1.14
21	4.0	**7.44**	1.14
51	5.0	**8.37**	1.32
117	6.0	**9.92**	1.45
88	8.0	**11.73**	1.64
89	10.0	**13.33**	1.84

60 VOLT RANGE

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

Ref.	Amps	£	P&P
124	0.5	**3.88**	.96
126	1.0	**5.58**	.96
127	2.0	**7.60**	1.14
125	3.0	**10.54**	1.32
123	4.0	**12.23**	1.84
40	5.0	**13.95**	1.64
120	6.0	**15.66**	1.84
121	8.0	**20.15**	OA
122	10.0	**24.03**	OA
189	12.0	**27.13**	OA

AUTO TRANSFORMERS

Ref.	4VA (Watts)	TAPS	£	P&P
113	15	0-115-210-240V	**2.48**	.71
64	75	0-115-210-240V	**3.95**	.96
4	150	0-115-200-220-240V	**5.35**	.96
66	300	" "	**7.75**	1.14
67	500	" "	**10.99**	1.64
84	1000	" "	**18.76**	2.08
93	1500	" "	**23.28**	OA
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350	247	**14.11**	1.84
1000	250	**41.76**	OA
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Ref.	mA	Volts	£	P&P
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212	1A, 1A	0-6, 0-6	**2.85**	.78
13	100	9-0-9	**2.14**	.38
235	330, 330	0-9, 0-9	**1.99**	.38
207	500, 500	0-8-9, 0-8-9	**2.59**	.71
208	1A, 1A	0-8-9, 0-8-9	**3.53**	.78
236	200, 200	0-15, 0-15	**1.99**	.38
239	50MA	12-0-12	**1.99**	.38
214	300, 300	0-20, 2-20	**2.56**	.78
221	700 (DC)	20-12-0-12-20	**3.41**	.78
206	1A, 1A	0-15-20, 0-15-20	**4.63**	.96
203	500, 500	0-15-27, 0-15-27	**3.99**	.96
204	1A, 1A	0-15-27, 0-15-27	**5.39**	.96
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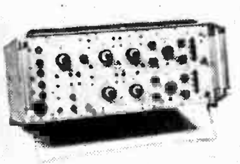

Pulse Generator PG59 (Type CT600). Produces a pulse controllable in frequency, width, amplitude, delay and rise and fall times. Also produces prepulse and gate outputs. Repetition frequency 1Hz to 10MHz. Pulse width 25nsec to 1sec. Rise and fall times 12nsec to 1 sec. Delay 25usec to 1sec. Trigger: Internal, external and single shot £595.00

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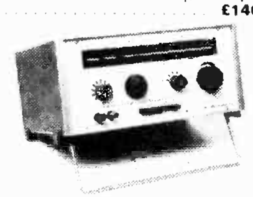

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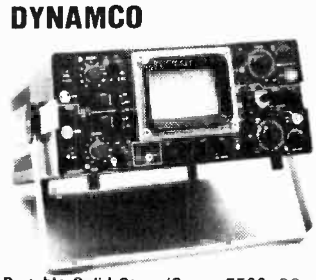

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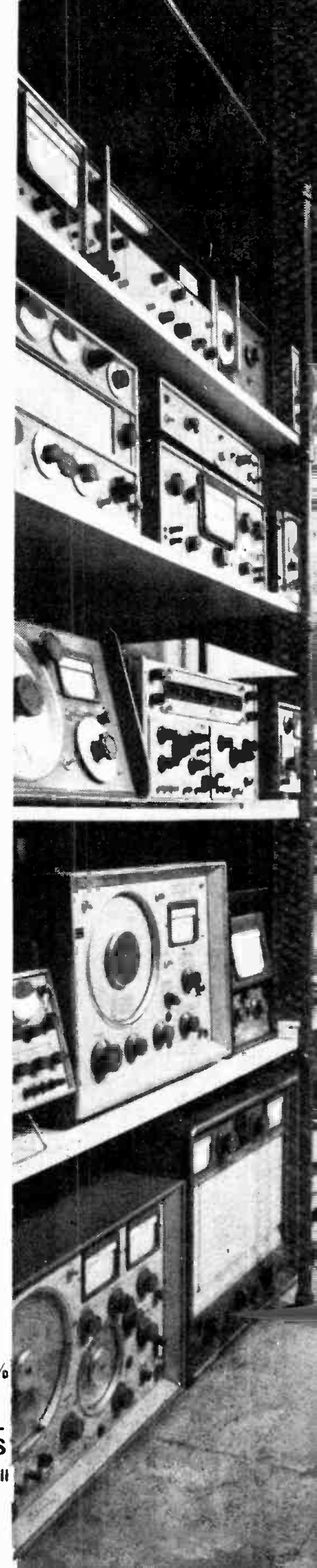

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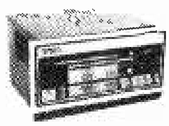

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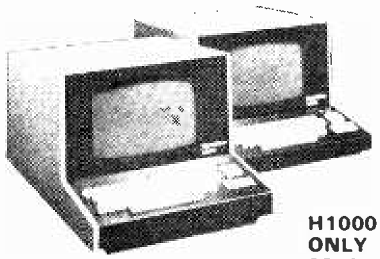


H1000 ONLY £350

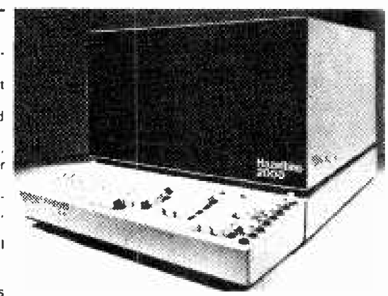
H1200 ONLY £425

HAZELTINE H1000 and H1200 SPECIFICATION

SCREEN SIZE — 12 diagonal
SCREEN CAPACITY —
H1000 — 960 characters 80 per line x 12 lines
H1200 — 1920 characters 80 per line x 24 lines
CHARACTER GENERATION — 5 x 7 dot matrix 625 line raster
CHARACTER SET — 64 ASCII alphanumerics and symbols
CHARACTER SIZE —
H1000-1/8 inch (32cm) nominal height 3/32 inch (24cm) nominal width
H1200 — 1/10 inch (25cm) nominal height 3/32 inch (24cm) nominal width
CURSOR —
H1000 underline **H1200** reverse image block
TUBE PHOSPHOR — P4 (white on black)
REFRESH RATE — 50 fields per second
KEYBOARDS — TTY format attached
INDICATORS — Power On Parity Error Dataset ready
PARITY — Parity error indicated by Parity light and question mark (?) displayed in character position
TRANSMISSION — Asynchronous Switch-selectable for any two standard rates up to 9600 baud
OPERATING MODES — Full/half Duplex
MEMORY — High speed MOS refresh
STANDARD INTERFACE — CC ITT V-24 (EIA RS-232 B/C), 202C Optional

HAZELTINE H2000 SPECIFICATION

SCREEN SIZE — 12 diagonal 1998 characters, 74 per line x 27 lines
CHARACTER GENERATION — 5 x 7 dot matrix 625 line raster
CHARACTER SET — 64 alphanumerics and symbols 32 ASCII control codes
KEYBOARD — Detachable, solid state, teletypewriter design' 10-key numeric cluster plus editing and cursor control keys
TRANSMISSION — Asynchronous. Switch-selectable for combinations of 5 standard rates, 75 to 9600 baud
OPERATING MODES — Switch-selectable, full duplex, half duplex or batch (buffered)
MEMORY TYPE — 2048 x 8 RAM
EDITING FEATURES — Full Cursor controls plus Insert/Delete Character, Insert/Delete Line, Clear Screen, Clear Foreground Data Only, Tab
STANDARD INTERFACE — CC ITT V-24 (EIA RS-232 B/C) or 202C Compatible
REMOTE COMMANDS — Insert/Delete Line Clear Screen, Clear Foreground Data Only, Home Cursor, Address Cursor Set Background Intensity Set Foreground Intensity, Carriage Return, Backspace, Ring Bell, Transmit, Print



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TUBE PHOSPHOR — P39 (green on black)

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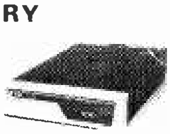

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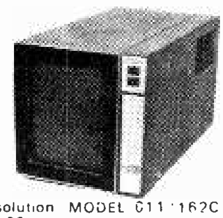

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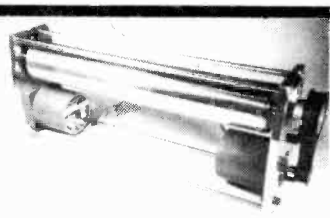
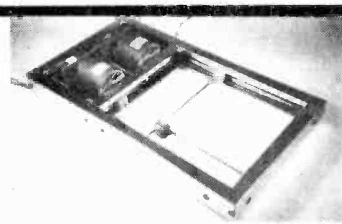
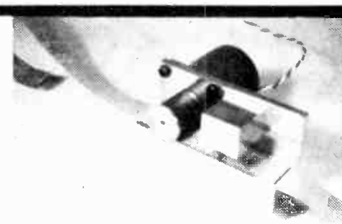


BARREL TYPE X-Y PLOTTER ASSEMBLY



X-Y PLOTTER ASSEMBLY



PAPER TAPE READER ASSEMBLY

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Device	10	100
AA 119	60	4 00
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Device	1	10
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Device	1	10
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Device	10	100
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100 250 Axial	3 20	24 00
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Texas

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74L00	2 40
74L04	2 70
74L73	4 90
74L74	4 30
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Fairchild

9000	5 90
9002	3 00
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9304	12 00
9308	25 00
9309	10 00
9311	21 00
9316	18 00
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9324	16 00
9601	8 50
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Horiz. Preset

Device	10
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Device	10	100
2 5W Axial	90	6 50
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All items new and marked

***Pak 1**
100 Gen purpose transistors including BC 149, 2N3703, etc £5

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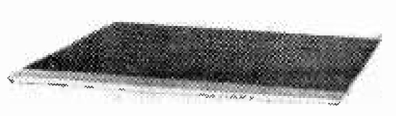

New Style Elegant Instrument Cases
In anodised aluminium with black vinyl top and bottom. Gives a professional finish to your assemblies.

Height	Width		
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All depth 9"

Add 80p for p&p; do not add VAT

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WW—123 FOR FURTHER INFORMATION

PORTABLE TEST EQUIPMENT BY

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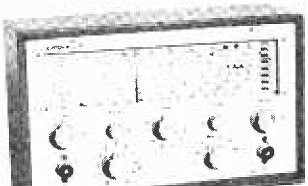

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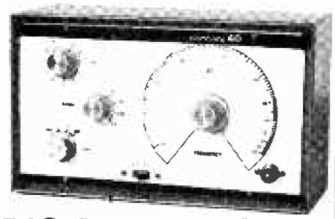

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- ★ 4 ranges 10Hz-100 KHz
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- ★ Dual calibrated attenuator
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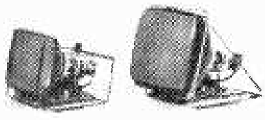
WW — 127 FOR FURTHER DETAILS

TV MONITOR KITS

VISIONKITS

gives you professional TV equipment in kit form for all data display and picture applications, providing far superior results to converted TV receivers.



Top quality monitors exactly as produced by one of today s leading manufacturers All parts plus comprehensive assembly instructions supplied along with full application notes 9" or 12" tube plus chassis kits are available with a separate printed circuit module kit to fit either size of tube

SPECIFICATION
Video – Composite 1V ± 6dB Input impedance 10K ohms
Power — + 12 volts stabilised Current 1 amp
System – 625 lines 50 fields and 525 lines 60 fields
Video response to 10MHz
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PRICE LIST: (Including VAT and inland postage and packing)

9" tube and chassis kit	£45.00
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Mains power supply for 12" monitor (built)	£40.00

Please allow 21 days for delivery
Send s a e for copy of application notes only
Mail order only

VISIONKITS

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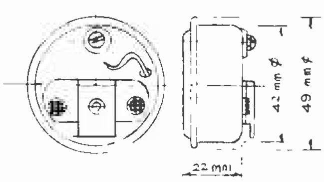
HIGH OUTPUT ELECTRO-MECHANICAL BUZZERS

Operating Voltages 3-9 volts D C
Prices (ex VAT)
Typical Output 110 db (A) at 1 ft
I = 60 — 100 ma

1 off	10 off	100 off
90p each	**80p each**	**65p each**

Supplied less bracket unless ordered



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ELECTRONIC DEVELOPMENT ENGINEERS

61 KIDMORE ROAD CAVERSHAM READING RG4 7LZ

PRECISION POLYCARBONATE CAPACITORS

All high stability-extremely low leakage

440V ac range (+—10%)

µF	L (mm)	D	£1each
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0 22	33	16	1 66
0.25	33	16	1 78
0.47	33	19	2 08
0 5	33	19	2 24
0 68	50 8	19	2 48
1 0	50 8	19	2 64
2 0	50 8	25 4	3 74

63V DC RANGE

µF	(Tol +—1%	+—2%	+—5%
0 01-0 2	1 80	1 22	0 88
0 22-0 47	1 82	1 24	0 90
1 0	2 26	1 52	1 08
2 2	2 80	1 94	1 42
4 7	4 00	2 72	2 24
6 8	4 88	3 36	2 66
10 0	6 94	4 68	3 56
22 0	13 32	9 98	6 80

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RESISTORS: High stability low noise, carbon film + –5% tol ½W @40 C ⅓@70 C E12 series only — from 2 2 ohm to 4 7M All 2p each 15p/10 of any one value 95p/100 of any one value £4 35/500 (may be mixed in 100's) £8/1000 (may be mixed in 100 s)
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Appointments

Advertisements accepted up to 12 moon Monday, September 4 for the October issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £7.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1.10 per line, minimum three lines.
BOX NUMBERS: 50p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Barry Leary on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

ELECTRICAL & ELECTRONICS STAFF

The Test House of the British Standards Institution at Hemel Hempstead have several vacancies within these Sections.

Senior Electrical Engineer

Responsible for the management of the Electrical Machines Laboratory which is engaged in the testing of Electro-Mechanical and Electronic equipment to recognised safety and performance standards. The products include office machines, portable tools and domestic appliances.
Candidates should be Chartered Engineers, preferably with experience in a relevant industry.
Salary Scale £5,260 - £6,874 inclusive of salary supplements.
Ref. HHC/E/36/676.

Senior Electronics Engineer

Responsible for the management of the Electronics Laboratory engaged in the testing of Radio and TV Products to recognised safety standards. The applicants should be familiar with the requirements of BS 415 and IEC 65. The Senior Engineer is expected to attend the relevant technical committees and to liaise with clients.
Candidates should be Chartered Engineers, preferably with experience in the radio and TV industry.
Salary Scale £5,260-£6,874 inclusive of salary supplements.
Ref. HHC/E/36/645.

Electro-Medical Technicians/Engineers

Several vacancies have arisen in this new laboratory for the testing and assessment of electrically operated medical equipment to British and IET specifications. The work is interesting and varied and offers opportunities to work in an expanding National Test House associated with advanced technology.
Applicants should hold a Degree/HND/HNC in Physics or Electronic/Electrical Engineering and preferably have some experience of electro-medical equipment.
Salary Scale Negotiable and dependant on relevant experience.
Ref. HHC/E/36/675.

The above posts are permanent and pensionable with five weeks' holiday for Engineer grades and four weeks for Technician grades.

Please apply, quoting the appropriate reference number, to

Personnel Department
British Standards Institution
Maylands Avenue
Hemel Hempstead, Herts.
Tel. (0442) 3111

BRITISH STANDARDS INSTITUTION
BSI

(8473)

ELECTRONICS TECHNICIANS

When you see a good job advertised what do you look for next?

Obviously, before you contemplate a change of job and possibly area you must weigh-up your present job prospects, pay and surroundings and measure them against those that have attracted you.
Really that's all we want you to do NOW—we are confident that the combination of Marconi Instruments and its locations in St. Albans and Luton will persuade you to give very serious consideration to the appointments we have vacant.

Job Satisfaction
If you would like working for a successful Company you'll like us – 66% of our products ranging from microwave test equipment to automated test systems are exported. Unlike any other in the business we achieved the 'double' in 1977 with the Queen's Award for both Exports and Technological Achievement – just two reasons why our people have every reason to be proud of their Company and its expertise.

Housing
The Hertfordshire/Bedfordshire area is probably one of the most picturesque of the counties surrounding London and contains some very reasonably priced housing both of the modern and rural varieties. The average family house is priced in the region of £16,000 to £22,000.

Schooling
The family man will be particularly impressed with the local schools both Junior and Senior – modern, spacious buildings are the order of the day and individual successes are very encouraging.

Sports and Social Activities
For the energetic our own sports and social club is very active, particularly with the recent addition of a squash court. Golf courses, cricket and football clubs abound and for the less energetic many social activities are available.

Local Amenities
If you still have time on your hands you will enjoy a visit to the theatre in either St. Albans, Luton or Watford. The local Rep. is very well supported.

All in all we can offer you a really worthwhile job, attractive pay, relocation and equally important, excellent local surroundings. Why not ring John Prodger, Personnel Officer, he lives locally and can give you first hand information about the jobs and surrounding districts.

MARCONI INSTRUMENTS LIMITED
Longacres, Hatfield Road, St. Albans, Herts.
Tel: St. Albans 59292 or after 6pm and weekends St. Albans 30602

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A GEC MARCONI ELECTRONICS COMPANY

...to the future.

Post – Design Services International

To £5,600 Herts

An unusual and exciting appointment for either a Digital Designer seeking customer contact and overseas travel, or for a Mini-computer Service Engineer who wishes to retain mobility but is interested in problem-solving and design.

The job entails updating and modifying minicomputer-based systems to suit customer requirements and investigating and over-coming operating problems in close liaison with the user. This could involve, on average, perhaps one trip per month overseas – within Europe or further afield.

Our client is a progressive, medium-sized company whose products have earned an international reputation. As a member of a small friendly team in which hard work is rewarded, you may confidently expect an excellent salary/benefits package.

For further information, please contact Mike Gernat, ref: MC8

Digital Projects

To £5,300 North-West London

An excellent opportunity to join a multi-disciplinary team and use your creative skills to design and commission sophisticated pro-cessor based Production Control and Information Systems. In addition you will be encouraged to master new skills and evaluate possible applications using the latest tech-nology.

This small but essential department serves a large company with several UK sites giving you project variety and a chance for occasional travel.

With one year's design experience, coupled with an HNC or Degree in an Electronic or related discipline, there are exciting prospects for career advancement.

The remuneration package is excellent, with regular salary reviews and attractive fringe benefits including removal expenses.

For further information, please contact Geoff Aldridge, ref: GC8

Probe Advanced Engineering

Rewarding opportunities at the forefront of technology for Test Technicians at all levels.

TEST SUPERVISOR c. £5,500

If you have 4 years' Analogue and Digital test experience, and proven supervisory ability, this post offers you the opportunity to develop a useful new expertise while equip-ping yourself for future advancement – promotion, on merit, is a *real* possibility.

You will be responsible for the smooth running of a team of 40 Technicians, their training and work scheduling.

TEST TECHNICIANS To £5,000

With a minimum of 4 years' Analogue and Digital test experience, you could be working on varied and advanced systems gaining the right experience to improve your future prospects.

These appointments are largely new ones due to the success and expansion of the company. It is based in North-West London, and offers an attractive benefits package, including housing assistance.

For further information, please contact Geoff Aldridge, ref: GD8

An Open Invitation

Technomark invites you to discuss your career with our qualified consultants who understand your needs and ambitions. We offer you FREE and constructive advice on advancement opportunities and can bring a new dimension to your career.

This advertising feature outlines only a few of the many and varied opportunities available to our candidates: many more are never advertised.

If you have any questions regarding your future – or the services offered by Technomark – please phone us or complete this coupon, sending it to our FREEPOST address.

My experience is in

Management Sales
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Name

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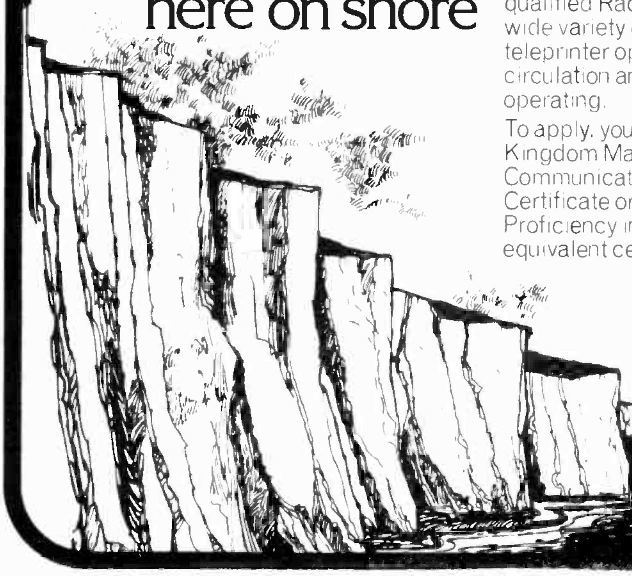
Land a good job

Your Radio Officer's qualifications can mean a lot here on shore



If you're thinking of a shore-based job, here's where you'll find interesting work, job security, good money, and the opportunity to enjoy all the comforts of home where you appreciate them most – at home!

The Post Office Maritime Service has vacancies at Portishead Radio and some of its other coast stations for qualified Radio Officers to undertake a wide variety of duties, from Morse and teleprinter operating to traffic circulation and radio telephone operating.

To apply, you must have a United Kingdom Maritime Radio Communication Operator's General Certificate or First Class Certificate of Proficiency in Radio-telegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic. And, ideally, you should have some sea-going experience.

The starting pay at 25 or over works out at around £4093; after three years' service this figure rises to around £5093. (If you are between 19 and 24 your pay on entry will vary between approximately £3222 and £3732). Overtime is additional, and there is a good pension scheme, sick-pay benefits, at least 4 weeks' holiday a year, and excellent prospects of promotion to senior management.

For further information, please telephone Andree Trionfi on 01-432 4869 or write to her at the following address: ETE Maritime Radio Services Division (L690), ET17.1.2, Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

7141

ELECTRONICS ENGINEER

THE COMPANY
We are a young company experiencing vigorous growth, full of good ideas and successful in putting these ideas into practical uses.

We are now the dominant force in our original market area and have expanded into others.

THE PRODUCTS:
Our products are state of the art, well conceived and built with care. To back this up we pride ourselves on the service our customers receive. Our products include Traffic Monitoring Equipment, Data Loggers, through to OEM Single Board Microcomputers.

THE JOB:
This involves the design, development and debugging of microprocessor based products. The ability to work in an inventive and practical manner is essential. Knowledge of programming would also be an advantage.

THE APPLICANT:
This person will be qualified and hold a relevant degree, H.N.C. or H.N.D., although the emphasis is on ability rather than qualifications. A good salary is offered and the chance to grow with the company.

IT'S YOU? Then for an interview write or phone Roy Tuthill (Technical Director) —

Golden River Company Limited
Telford Road
Bicester (086-92) 44551
Oxfordshire

(8454)

R & D Engineers at senior and intermediate levels

required to work on digital and cable television systems for the domestic and surveillance market.

Engineers should hold a degree, HNC or equivalent qualification and have some knowledge of either HF video or digital circuit design.

Salaries will be commensurate with qualifications, age and experience.

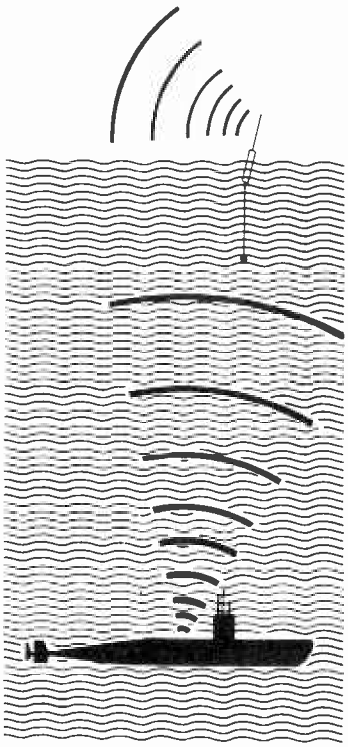
Fringe benefits include a contributory pension, life assurance scheme, subsidised canteen, etc.

If you are seeking an enjoyable position in R & D, write, giving full details of your career to date, or telephone Dr. G. O. Towler, B.Sc., Ph.D. (Manager), Research and Development Establishment, British Relay Ltd., Cleeve Road, Leatherhead, Surrey. Tel. 76056

8469

british relay

Listening-in at 75 fathoms needs your kind of engineering experience



Modern anti-submarine warfare relies heavily on detection devices such as the sono-buoys manufactured by UEL Electronic Communications Ltd that, after drop from an aircraft flying at up to 10,000 ft, deploy themselves automatically, lowering hydrophones to a pre-selected depth and raising a radio aerial so as to listen for tell-tale engine noises, amplify them and transmit the information back to submarine hunting aircraft.

The company part of the international Dowty Group, also manufactures and develops communication control systems and intercom units for civil and military aircraft, airborne emergency radios, and beacons for homing and rescue applications. Our latest project is in the area of VHF radio where we are providing British Rail with a communication system between signal boxes and trains. Many of these systems need a high degree of ingenuity and the kind of engineering experience that maybe you can offer. In particular we are looking for the following men or women:

Electronic Development Engineers

We are looking for men or women to join a small team of Engineers and Technicians working on the design of analogue systems and circuits. Visits to trials may be necessary and opportunities might arise for visits to clients and suppliers.

Applicants should be qualified to HND or preferably degree level with several years design experience

Senior Development Technicians

We require men or women to join project teams working on the design and development of analogue systems and circuits for prototype equipment. Will be responsible for building, testing and evaluating experimental equipment and for assisting with the development of analogue circuitry.

Applicants, aged between 25 and 45, should hold City & Guilds Electronics, Radio & TV, or Telecommunications Certificates up to Part 1 or Intermediate level and have at least 5 years' development experience, preferably involving government contracts.

Test Technicians

Our production department require additional male or female Testers with experience of radio or analogue circuits and test equipment. Candidates should have several years practical experience in this area with or without qualifications.

We are offering attractive salaries, negotiable according to qualifications and experience plus a wide range of attractive large company benefits. There are good promotion prospects and generous relocation package is available where necessary covering all legal and estate agency fees, Building Society survey fees, viewing expenses, and a disturbance allowance

For further information and an application form phone or write to –
Mr Gavin Rendall, Personnel Manager, Ultra Electronic Communications Limited, 419 Bridport Road, Greenford, Middlesex UB6 8AU. Tel: 01-578 0081.

UEL
Electronic Communications Limited

Listening-in at 75 fathoms needs your kind of engineering experience

8441

Electronics Technician

required to work with small team of Engineers on custom built equipment

Duties include assembly, wiring and test of complete equipment as well as testing small batches of PCB's

Previous experience of wiring essential, preferably to military standards, previous production testing experience would be an advantage

Suitable candidate must be able to work unsupervised

Telemotive looks only for above average personnel, and this is reflected in conditions of employment offered

Please apply in writing, giving details of previous experience, to —

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BYFLEET 47117**

(8453)

Ministry of Defence
Radio Technicians

The Ministry of Defence has vacancies at RAF Henlow for Radio Technicians to work on the maintenance, fault diagnosis, repair, recalibration and modification of radio communication, radar, and electrical and electronic test equipment. Applicants must be experienced technicians in the radio/electronics field.

Starting pay according to age, up to £3,700 a year (at age 25) rising to £4,252 a year.

5 day week — 4 weeks paid holiday in addition to Public Holidays — prospects of promotion — pension scheme.

Applicants must be United Kingdom residents.

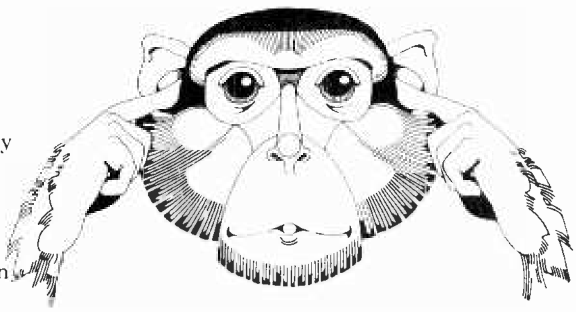
Write for further details to:

**Officer Commanding
Radio Engineering Unit
Royal Air Force
Henlow
Bedfordshire SG16 6DW**

(8424)

A word to the wise

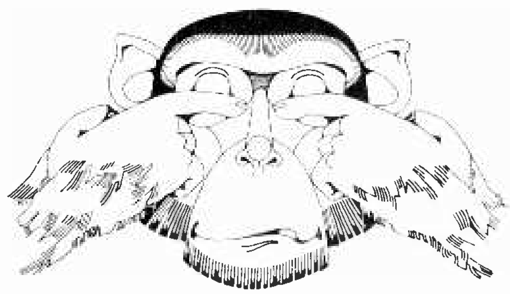
About our advanced support engineering at Basildon



In the field of electro-optics, we're leading lights in more ways than one. Our work covers the development and manufacture of a wide range of advanced equipment for ground based, airborne, shipborne and underwater surveillance, guidance and tracking systems. We're working on acoustics and optical projects and the technology employs sensors in the visual to IR band and data transmission links together with all the associated signal processing.

It's a see all, hear all, and tell all environment and in our Electro-Optical Systems Group here in Basildon we can provide engineers with exceptional scope for creative involvement in all manner of high interest projects.

The continuing growth of our work has created unusually attractive career development opportunities for both men and women and at the moment we have a particular requirement for:–



Field Trials Engineers

To provide support to the development programmes during engineering and customer evaluation trials; commissioning, calibration and maintenance of prototype systems; acquisition of trials data and assisting with post trials analysis.

Trials Planning and Analysis Engineers

For detailed planning of proving trials including definition of trials requirement; co-ordinating trials and analysing results, utilising such data acquisition techniques as audio and video recording and data analysis using computing facilities.

Component Engineers

To liaise closely with project development teams to ensure correct choice of components; prepare purchasing documents to ensure quality and reliability requirements and liaise with suppliers to secure acceptance of specification.

Product Support Engineers

Entails close liaison with company engineering production and test departments and with customers' technical staff in support of established equipments during manufacture and customer evaluation.

Technical Writers

To prepare documentation in support of commercial and military projects including design and test specifications, handbooks and the preparation and editing of proposals and technical reports.

These appointments call for at least ONC and preferably an HNC or equivalent qualification with relevant experience in servicing or design of major electronic systems.

If you have the sort of qualifications and experience we're looking for you'd be wise to get in touch with us without delay. Write with details of your career to date to J. S. Nealon at Marconi Avionics Limited, Christopher Martin Road, Basildon, Essex. Telephone: Basildon (0268) 22822 ext. 86. Where necessary we can assist you with relocation to this attractive part of the country.

MARCONI AVIONICS

A GEC-Marconi Electronics Company

(8444)

TECHNICAL INSTRUCTOR

c.£5,500

The Company wishes to appoint a Technical Instructor with HNC or equivalent experience in electronics. Preference will be given to candidates with proven lecturing experience covering analogue and digital techniques, including microprocessors.

Successful applicants, either male or female, will be responsible for the preparation and evaluation of course material using modern training aids which include OHP, slides, CCTV and video tape. This job involves training in-house staff, including sales and service engineers, customers' engineers and operators, and assisting where necessary in the preparation of technical and operators manuals. Occasional overseas travel may be necessary for 'on-site' training.

Based in London, this position offers the challenge, interest, satisfaction and rewards to attract the best of today's technical instructors.

Please telephone or write, quoting reference G/2002, to:—
Mrs L Geers, Personnel Officer, Crosfield Electronics Limited, 766 Holloway Road, London N19 3JG. Telephone 01-272 7766.

Crosfield Electronics — A De La Rue Company — 1973 1976

BRENT AND HARROW AREA HEALTH AUTHORITY
(Harrow District)
NORTHWICK PARK HOSPITAL AND CLINICAL RESEARCH CENTRE
Watford Road, Harrow
Middlesex HA1 3UJ
Tel: 01-864 5311

ELECTRONICS TECHNICIAN
(MPT GRADE III)

A technician is required to service and calibrate a wide range of equipment used for medical, surgical and engineering purpose. The successful applicant will work closely with medical and other professional staff. ONC, HNC, HND or Science Degree (or three years' previous experience as a Technician Grade IV) is a necessity. Salary £3744-£4788 plus £354 London Weighting Allowance.

For further details and application form please contact Personnel Department, Ext. 2001.

(8429)

TELECINE/VTR ENGINEERS

If you have VTR and Telecine experience and want to move into Broadcasting in the West Country then Westward Television would like to hear from you.

Vacancies exist within two teams of six engineers to undertake operational and maintenance duties.

Salary according to age and experience up to a maximum of £5,000 basic.

Apply, in writing, giving full details to the Personnel Manager, Westward TV Ltd., Derry's Cross, Plymouth PL1 2SP, or telephone 0752 69311 ext. 215 for further details and application form.

WESTWARD TV

(8415)

RADIO INSTALLERS

London **up to £3946**

North Thames Gas in Fulham would like to hear from experienced Radio Installers. Your duties will include the installation of mobile radio telephone in the Region's vehicles, the elementary servicing of V.H.F. mobiles as well as the servicing of some radio base-station equipment (under guidance).

You should be experienced in the installation of mobiles, and have some knowledge of servicing V.H.F. mobile radio-telephone equipment.

Qualifications to City & Guilds standard in Electronics, Radio or T.V. servicing are preferred, and a current driving licence is essential.

Starting salary for both men and women will be £3285 pa on a scale rising to £3946 pa including supplements.

Write or telephone for an application form, quoting reference E4131 to: Recruitment and Selection Officer, North Thames Gas, North Thames House, 17-51 London Road, Staines, Middx. Tel: Staines 61666 ext 3282.

NORTH THAMES GAS

(8491)

Radio and Radar Engineer

BRITISH AEROSPACE
Dunsfold Aerodrome

This is a worthwhile position for a man or a woman wishing to strengthen a small team responsible for servicing and maintaining air traffic radio/radar installations.

Applicants should have a minimum of 5 years' current air traffic radio/radar equipment maintenance experience.

We will pay you an attractive salary and facilities include a subsidised Canteen and an active Sports and Social Club.

Please write or telephone quoting WW/92 to

The Personnel Officer
BRITISH AEROSPACE
Aircraft Group
Kingston-Brough Division
Dunsfold Aerodrome
Nr. Godalming
Surrey
Telephone: Cranleigh 2121

(8411)

BRITISH AEROSPACE AIRCRAFT GROUP

H.M.G.C.C.

ELECTRONIC ENGINEERS

Designers and Development Engineers are required for work in the HF and UHF fields and in general analogue and digital circuitry.

The Establishment is sited in rural surroundings in North Bucks. within easy reach of Northampton, Bedford and Milton Keynes. A frequent rail service and the M1 motorway provide easy access to London. House prices in the area are still at provincial levels.

Minimum academic qualification is HNC and, for Higher Scientific Officer, five years' post-qualification experience (for graduates with First or Second Class Honours this is reduced to two years' post-graduate experience).

Salaries are:

Scientific Officer £2839-£4415
Higher Scientific Officer £4101-£5448

DRAWING OFFICE STAFF

Drawing Office Staff are required in a supporting role to the above engineers.

Salaries are in the ranges: £3148-£4326
£4326-£4869

Salaries for Drawing Office Assistants are £2119-£3189, depending upon age, qualifications and experience.

For application form please apply to:

The Administrative Officer (Dept. WW)
HM Government Communications Centre
Hanslope Park
Hanslope
Milton Keynes
Bucks.
MK19 7BH

(8376)

TYNE TEES TELEVISION LIMITED

A Member of the Trident Television Group

HAVE A VACANCY FOR AN

ENGINEER

In the Central Technical Facilities Department for operational duties in video tape recording, film transmission and network circuit tests. H.N.C./H.N.D. in an appropriate subject is a desirable qualification together with an interest in current television broadcasting techniques.

Starting salary for an experienced applicant, in accordance with A.C.T.T. scale, will not be less than £3580 per annum. Shift working required. Company benefits include pension scheme, 4 weeks' holiday and staff restaurant.

Please write, in confidence, to:

Mrs. J. M. Jacobson, Personnel Manager
TYNE TEES TELEVISION LIMITED
The Television Centre, City Road
Newcastle-upon-Tyne NE1 2AL

(8440)

Service Engineer

Dixons Technical forms part of the Dixons group of Companies. We wholesale export and provide sophisticated close circuit and video equipment to major T.V. companies, commerce and industry.

We are currently looking for a Service Engineer with a minimum of two years' experience in the video field to work in our new headquarters in Croydon. Service experience on VTR is essential and training will be given in servicing cameras and monitors.

We can offer you a competitive salary, excellent fringe benefits which include 4 weeks' holiday and massive discounts on the very best photographic and audio equipment.

Contact:

Ron Irving, Personnel Manager
Dixons Photographic UK Ltd., Prinz House
54-58 High Street, Edgware, Middx.
Tel. 01-952 2345, ext. 341

(8452)

Dixons

AUDIO + VIDEO LTD.

SENIOR VIDEO ENGINEERS AND HIGH GRADE TELEVISION ENGINEERS

Because Audio + Video are the largest video duplicators in Europe, we naturally have a lot of high-class equipment tp produce our top quality video tapes. We have in house, the Marconi D.I.C.E., the Rank Cintel Flying Spot Telecine, the RCA TK28 Telecine, TR60, TR70c and Ampex 2000 2" Quad machines, Sony D100 duplicator, 2850, 2600, 2030, 2630, Betamax, Philips VCR 1500 and 1700, VHS, Keyline editor, etc.

We now require Senior Video Engineers with experience of maintaining and servicing any or all of the above equipment and high grade Television Engineers who can be trained to help maintain most of it. We will pay salaries in excess of £5,500 for the right people who enjoy working in television.

Please contact Cliff Carroll on 01-580 7161.

(8446)

Home Office

telecommunications

We require staff, male or female, to prepare and maintain the latest in communications equipment used by the Police and Fire Brigades in England and Wales.

You will need to be qualified at least to City and Guilds Intermediate Telecommunications standard and be able to demonstrate practical skills in locating and diagnosing faults in a wide range of equipment from computer based data transmission to FM and AM radio systems. You would live near to and work from our service centres located throughout England and Wales or our Headquarters in the London area. Specialised courses of training are run to assist staff to keep up to date with developments and new equipment, and there are opportunities for day release to gain higher qualifications. Applications from registered disabled persons will be considered.

Promotion prospects are good and the work represents a secure future with generous leave allowances and a non-contributory pension scheme.

Possession of a driving licence is essential since some travelling will normally be involved.

The salary is £2627 (at 17), £3176 (at 21) and £3700 (at 25), rising to £4252.

If you are interested in working with us, then write for further details and an application form to:—

Mr C B Constable
Directorate of Telecommunications
Horseferry House
Dean Ryle Street
LONDON SW1P 2AW
Telephone: 01-211 6420

(8428)

The City University

Studio Technician

required to work in a team developing new facilities in the University. There will be two main areas of responsibility

In the Electronic Music Studio: with responsibility for developing and maintaining equipment for students work as well as planning a computer link and a digital research programme.

In the Language Laboratory: carrying out regular servicing and immediate fault correction on language equipment and participating in forward planning.

Applicants should have experience of both design and practical work; some knowledge and interest in electronic music is useful.

Salary will be on the scale £3441-£3890 or £3674-£4209 per annum inclusive. Application forms are obtainable from: Mrs K. Fowler, Personnel Office, The City University, St. John Street, London EC1V 4PB (01-253 4399, ext. 334).

(8400)

How to find a better job without leaving your armchair.

Don't for a single moment question your motives. Striving for a higher income is a philosophy practised by people in all walks of life.

Perhaps though, you cannot get a fair picture of the opportunities available from the standard, limited sources of job information.

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We match your ambitions and skills with our clients' needs. When the two are compatible, the clients hear about you right away and you should get an invitation to talk.

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Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 2282 (24 hour answering service).

Our clients are keen to meet men and women, aged 20 to 40 years, with potential earnings of between £4000 and £7000 p.a.

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Address: ______________

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Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 2282 (24 hour answering service) 8485

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For those too busy doing a good job to find a better one.

FOREIGN AND COMMONWEALTH OFFICE
COMMUNICATIONS DIVISION

has vacancies for

RADIO TECHNICIANS

to carry out shift duties concerned with MW and HF broadcasting systems involving frequency changing, fault finding and routine maintenance, keeping logs, and recordings.

Applicants should have minimum qualifications of City and Guilds Intermediate Certificate in Telecommunications or its equivalent.

The successful candidates will serve initially at Crowborough, but may be required to serve elsewhere in the UK or overseas should the necessity arise.

Salary is according to age, e.g. £3,176 per annum at age 21, £3,435 at age 23, £3,700 at age 25 or over on entry rising by annual increments to a maximum of £4,252 per annum.

The appointments attracts 4 weeks ' paid holiday and prospects of pensionable employment.

Recruitment Section
Foreign and Commonwealth Office
Hanslope Park, Hanslope, Milton Keynes MK19 7BH

(8320)

Sound out your new career in Hi-Fi

Hardman's are now the No. 1 name in hi-fi retailing in Birmingham, Chester, Liverpool, Manchester and Preston with superb spacious showrooms offering the best hi-fi selection in town. But we're not just a single fast expanding company with five stores and more to follow; we're part of a large and successful Group with interests throughout the leisure industry. To you that means the big benefits that only a large Group can offer you: security plus the almost unlimited scope that an enthusiast like you will relish.

Expansion has created these vacancies in all five stores:

Senior Audio and Hi-Fi Sales Staff

You must have a proven sales ability and/or sound audio or hi-fi experience. We'll give you specific sales training and keep you up to date with regular seminars. Good salary plus commission. PLUS excellent opportunities for promotion to management within the group.

Hi-Fi Engineers

You're a qualified hi-fi/audio/video engineer, or you're mid way through an apprenticeship scheme with no immediate opportunities. You'd like to service, test and repair hi-fi equipment in our well-equipped premises. We'll tell you all about the equipment and keep you updated on new developments. Excellent salary.

Please write for an application form to:

The Managing Director, Hardman Radio Limited, 26 Exchange Street East, Liverpool, L2 3PH.

(8401)

Talk to the helpful Hi-Fi people

HARDMANS

Development Engineers

for Pye TVT,
the Broadcast Company of Philips.

We are fast expanding into the areas of digital signal processing, microprocessors and computer based systems in studio engineering.

We are therefore looking for Development Engineers with at least 4 years experience in the design of high-speed digital signal and/or data processing equipment.

They will be involved in and carry responsibility for all aspects of the design of digital equipment for broadcast TV applications.

Applicants should possess a degree or equivalent. Software experience is an advantage, together with a background in broadcast TV equipment.

The positions offer competitive salaries, plus relocation expenses and the normal benefits offered by a progressive company at the forefront of broadcast technology.

For further details, contact
Alison Millar, Personnel Department,
Pye TVT Limited. Coldhams Lane,
Cambridge CB1 3JU.
Telephone Cambridge (0223) 45115

(8484)

Pye TVT Limited
The Broadcast Company of Philips
A member of the Pye of Cambridge Group

Senior Design — Development Engineer

Circa £9,000 p.a. + car + benefits

HIGH FREQUENCY — HIGH POWER GENERATION FOR INDUSTRIAL PROCESSING

A unique opportunity exists for a first-class engineer to contribute originality and professionalism to a number of development projects newly created within a vigorous, progressive company situated in the South of England.

The position calls for proven ability in innovative development and experience in R.F. Generation, High Voltage techniques and a working knowledge of light current electronics including digital and analogue circuitry. Emphasis is placed upon the candidates willingness to adopt more than one engineering discipline.

This attractive post carries benefits consistent with the responsibility and status of the position. Advancement within the company will relate to the contribution of the candidate — progress to a Board position is expected. Additional benefits include BUPA, first-class superannuation and, where necessary, relocation expenses.

In the first instance telephone your nearest branch or write, enclosing c.v. to:

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Manchester 061-832 5856
Edinburgh 031-226 5381

(8443)

ata

BRENTFORD ELECTRIC LIMITED

A thriving Company of over 400 people with a number of "firsts" to its credit in the field of Industrial Power Converters seeks:

ELECTRONICS DESIGN ENGINEER

for General Circuit Design

Qualifications A First Degree or equivalent and 2-3 years' experience in the production design of analogue circuits for servo controls. Some experience with digital hardware would be an advantage.

This post is a responsible one carrying a corresponding salary and four weeks' holiday Housing available.

Assistance with removal expenditure.

Please write with details of your career or for further information to

Michael Fry, Technical Director.

(8478)

BRENTFORD ELECTRIC LIMITED
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VIDEO ENGINEER

TECHNICOLOR VIDTRONICS LTD. have a vacancy for a Broadcast video engineer. Cinema film technology experience an advantage. Salary in a range of £3,900 to £5,300 commensurate with experience plus pending increase.

Telephone 01-759 5432 and ask for Mr. Edgerton or Mr. Blight.

Technicolor Vidtronics Ltd. Bath Road, Harmondsworth, Middx.

(8474)

ASSISTANT MANAGER

Lynx offers an opportunity for an ambitious, enthusiastic young hobbyist to help build Lynx into a major mail order retail organisation. This will involve expanding the range of products such as IC's, discreet semiconductors and passives. Knowledge of radio, T.V. and other electronic projects would be most useful.

Applications in writing to W. J. Bulman, Lynx Electronics Ltd., 92 Broad Street, Chesham, Bucks.

(8421)

Broadcast and Audio Visual Engineer/ Operators . . .

The equipment to please

If you come and join the team at Rank Video Centre, you'll find an impressive array of equipment. We have the most sophisticated 2" VTR's available, the best-respected telecines on the market, 'state-of-the-art' tape-to-film transfer machines exploiting laser technology and the most impressive capability for videotape editing and cassette copying in Europe.

The variety to please

Our range of equipment and services, unique outside the States, has attracted 500 international clients to RVC. The result is that our Engineer/Operators can expect variety. Today, TV transmission work; tomorrow, editing a TV drama; the day after, making cassette copies of the latest feature film.

The pay to please

Interesting starting salaries of between £5,018 and £6,603 p.a. benefit further from an annual increment scheme which, within 4 years, adds 30% to the prevailing ITCA basic rates.

So, for experienced Engineers or Operators, male or female, RVC has . . . The Jobs to Please.

Telephone or write to Gary McJannett, Operations Manager, Rank Video Centre, Film House, 142 Wardour Street, London W.1. Tel: 01-734 2235.

. . . what's behind

RANK VIDEO CENTRE

(8422)

NEWCASTLE AREA HEALTH AUTHORITY (TEACHING)
ELECTRONICS & MEDICAL ENGINEERING SECTION
NEWCASTLE GENERAL HOSPITAL

CHIEF ELECTRONICS TECHNICIAN (GRADE 2)

Applications are invited for the above position. The Chief Electronics Technician will assist the Senior Area Electronics Engineer in the maintenance of electronic and medical engineering equipment.

The position offers a unique opportunity to lead a specialist team of Technicians covering all applications of electronics in medicine, including brain scanning equipment and communications.

Salary Scale £4,470 rising to £5,610 by 8 annual increments.

Candidates must have a broad experience of electronics, experience of medical electronics an advantage. Minimum academic qualifications — H.N.C. Electronic Engineering or equivalent.

Job description and application forms available from Area Engineer's Office, Newcastle Area Health Authority (T), Area Headquarters, Scottish Life House, 2-10 Archbold Terrace, Newcastle upon Tyne NE2 1EF. Closing date for completed application forms, Friday, 25th August, 1978.

(8431)

ELECTRONICS ENGINEERS

ITA's expansion programme has created more engineering vacancies. Secure future for Engineers with proven electronic ability. Varied and interesting work providing an attractive salary.

Contact the Chief Engineer.

INDUSTRIAL TAPE APPLICATIONS
1-7 HAREWOOD AVENUE, MARYLEBONE,
LONDON, NW1
TELEPHONE: 01-724 2497/8

(8470)

Electronic Design Engineer

This new appointment is to join a small but growing engineering team involved in the design and development of electronic wheel balancers and electronic wheel alignment equipment. It involves completing product design from an initial outline specification, prototype production, and assistance to manufacturing during the initial production stages.

The Electronic Design Engineer will be responsible to the Engineering Manager for electronic aspects of the company's designs, and will work with development engineers, design draughtsmen and technicians. Some travel within the United Kingdom and occasionally abroad is required.

The successful candidate, male or female, will be educated to degree or HNC level in Electronic or Electrical Engineering, and have at least three years' experience with analogue and digital circuit techniques utilising transistors and integrated circuits.

We offer an attractive starting salary, together with the employment benefits one would expect from a major industrial group.

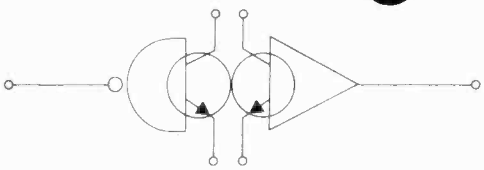
Please write for an application form, or telephone, Mrs. S. R. Ballantyne, V. L. Churchill Limited, PO Box 3, London Road, Daventry, Northants, NN11 4NF. Telephone Daventry (032-72) 4461.

TI CHURCHILL

(8463)

TOPS Course

Train as an Electronic Technician Engineer



The **Chelmer Institute of Higher Education (Chelmsford)** and **Reading College of Technology,** in conjunction with the Manpower Services Commission, Training Opportunities Scheme (TOPS), are running a twelve month full-time course starting in January 1979, leading to the Higher National Certificate in Electrical and Electronic Engineering.

WHAT DO YOU LEARN?

The course is based on an electronic systems approach with particular emphasis on electronic duties and signal generation, transmission, processing and display. It is intended to cover the knowledge and practical abilities for employment as an electronic technician engineer in a wide variety of functions such as development, diagnostic testing, commissioning or installation of electronic equipment and systems.

WOULD IT SUIT YOU?

The course is open to men and women aged 25 or over, who have been away from full-time education for a total of three years, have not taken a TOPS Course in the last five years and are between jobs or willing to leave their present job. Applicants should have had experience in electrical or electronic engineering in industry or the Services, and have at least an appropriate ONC, OND, or City & Guilds technician certificate.

EARN AS YOU LEARN.

Tuition is free. TOPS tax-free weekly allowances are payable during training. Travelling and /or lodging allowances may also be payable in approved circumstances.

FURTHER INFORMATION

If you are interested write to or telephone the appropriate office:

CHELMSFORD

Mr. John Powell, Manpower Services Commission,
Training Services Division, District Office,
93 Southchurch Road, Southend-on-Sea, Essex SS1 2NX.
Tel: Southend (0702) 613134.

READING

Mrs. P. Evans, Manpower Services Commission,
Training Services Division, District Office,
Friars Walk, Friar Street, Reading, Berks RG1 1BT.
Tel: Reading (0734) 56633.

06/C/70

MSC Training Services Division
Manpower Services Commission

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ARE YOU IN TEST SERVICE OR MAINTENANCE ENGINEERING?

WOULD YOU LIKE TO:

- live out in the North Bucks countryside where housing is available?
- enjoy good working conditions including generous holidays?
- service a wide variety of electronic-based scientific equipment?

If so, and you would like to know more, ring Dave Jones on Milton Keynes (0908) 63356. (Ref. MH/3061/1)

(8399)

COVENTRY AREA HEALTH AUTHORITY

WALSGRAVE HOSPITAL
Department of Clinical Physics and Bio-Engineering

MEDICAL PHYSICS TECHNICIAN/ELECTRONICS ENGINEER

Applications are invited from persons experienced in electronic engineering to join a team in the electronic section of the above department. There is a wide range of physiological measurement equipment, nucleonic equipment and laboratory equipment. A knowledge of diagnostic maintenance of instrumentation and/or mini computers would be desirable. Candidates for the post should hold an O.N.C., H.N.C., or equivalent qualification. Salary scale — Medical Physics Technician, Grade III within the range £3405 to £4353 inclusive of Stages I and II pay supplements. Further details can be obtained from Chief Physicist, Walsgrave Hospital, Extension 482. Application forms (quoting ref: WW) obtained from the Sector Administrator, Walsgrave Hospital, Clifford Bridge Road, Walsgrave, Coventry CV2 2DX. Closing date: 31st August, 1978.

UNIVERSITY OF WARWICK

ELECTRONICS TECHNICIAN

A vacancy has arisen in the Department of Chemistry and Molecular Sciences for an experienced Electronics Technician, Grade 6, to take charge of a well-equipped electronics workshop. The duties include responsibility for maintenance of both electrical and electronic equipment in the Department, design and construction of one-off instruments and modifications to existing equipment, and the supervision of a Grade 4 technician employed primarily on repair and maintenance work. The University is situated in pleasant rural surroundings and is within easy commuting distance of Coventry and Kenilworth. The successful candidate will probably hold an HNC or equivalent in the field of electronics and have a wide experience in the maintenance of intricate equipment and the design of circuits. Salary is on an incremental scale: £3.654-£4.365 p.a., starting point depending on experience and qualifications.

Apply by letter giving full details and quoting Ref. No. 50/T/78 to the Academic Registrar, University of Warwick, Coventry CV4 7AL, as soon as possible.

(8435)

RADIO ENGINEER HAITI

required to work as technical adviser to the Haitian Radio School team working on a new adult literacy scheme. Responsibility for the maintenance and repair of the radio station equipment and the training of Haitian counterparts.

A British Volunteer Programme Post, language training provided.

For further information write with details of curriculum vitae to CIIR Overseas Volunteers, 1 Cambridge Terrace, London NW1 4JL.

(8449)

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To £6,000

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REQUIRED IN IRAN, Electronic Engineer with at least ten years experience, to work in C.N.C. Department for maintaining Batchmatics, Devielegs, Cim-X. Hardware. Will also be expected to help train our engineers in this field. Please apply to Mr Eshragi, Personnel Officer Machine Sazi Tabriz, P.O. Box 183, Tabriz, Iran. (8420

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GEC Gas Turbines Limited are one of the world's leaders in gas turbine manufacture. Our latest innovations include a new generation of large gas turbines, our unique mobile power stations, plus a full range of heavy duty and jet powered units.

To continue our development programme we are seeking an

Electronic Controls Engineer

The successful applicant will be responsible for the design and development of electronic control units and complete systems. He/she must be conversant with the latest codes and practices of engineering drawing, and experience in electrical/electronic engineering would be desirable, particularly with light current semi conductors. A relevant HNC is essential.

An attractive salary is offered and working conditions are good. Relocation expenses will be paid where appropriate.

Write with brief details of age, experience and qualifications to
H P Cross
GEC GAS TURBINES LTD
Cambridge Road, Whetstone, Leicester LE8 3LH
Tel: Leicester 863434.

GEC GAS TURBINES LIMITED

(8455)

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High quality DC-AC. Also "no break" (2ms) static switch. 19" rack. Auto Charger.

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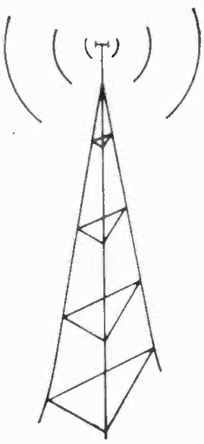
Offers are invited for a 6-element Duddell Oscillograph. Made in 1957 and very little used. Offers should be made in writing addressed to

Head of Department of Electrical and Electronic Engineering, The Polytechnic, Wolverhampton WV1 1LY. Telephone 0902/27371.

(8488)

Are You Interested In

Radio Communications



and do you have practical experience in this field

if you have City and Guilds Intermediate Certificate in Electronics or Telecommunications; ONC; or an equivalent qualification

then the Metropolitan Police Office has a job for you as a Radio Technician.

vacancies are at our depots in Central and South London

we offer
Good pay, Excellent prospects
Secure employment
4 weeks holiday, Day release

For further information and an application form please apply to: The Secretary, Room 213/WW/RT, 105 Regency Street, London, SW1P 4AN or telephone 01-230 3122 (24 hour answering service).

(8402)

Radio Communications Electronics Engineers and Software Designers

Mid-Sussex - S.W. London

Salaries up to £7,000

To join our expanding R & D Laboratories covering a wide range of the R. F. spectrum, from L.F. to V.H.F. Equipments include transmitters and receivers for marine and land based use, radio navaids and radio monitoring remote computer controlled systems.

Electronics Engineers should have experience in transmitter or receiver design, analogue or digital circuit design, micro processor applications.

Software Designers should be experienced Programmers with an interest in control, signal processing or navigational software.

Attractive salaries are complemented by excellent prospects and generous benefits.

Contact: The Personnel Manager, Redifon Telecommunications Limited, Broomhill Road, Wandsworth, London, S.W.18. Phone: 01-874 7281 (Reverse charge).

(8315)

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WITH 37 YEARS' EXPERIENCE we have the expertise to design and manufacture ANY TYPE OF AUDIO TRANSFORMER AT THE RIGHT PRICE

Whilst we specialise in every kind of transformer for audio control decks and mixers, demands are increasing for **LOUDSPEAKER TRANSFORMERS** and **100 VOLT LINE AUDIO OUTPUT TRANSFORMERS** for most kind of amplifier from 30 watts to 500 watts output. We have standard designs for AMCRON and BOSE amplifiers and can also supply **Multi-output transformers for COLUMN LOUDSPEAKERS** in a wide variety of powers. A recent tendency is the demand for **OUTPUT TRANSFORMERS FOR ULTRA LINEAR VALVE AMPLIFIERS** using KT88 and KT66 BEAM TETRODES and for these we have standard designs with exceptional performance. Many of our output transformers for loudspeakers have been installed in Theatres, Television Studios, Lecture and Concert Halls, Churches and Outdoor Arenas whilst others are in constant use for high quality portable Public Address Systems. We will supply single transformers, or any quantity, with short delivery times and, without obligation on your part, will quote price and exact dispatch on receipt of your requirements.

KINDLY NOTE OUR NEW ADDRESS AND TELEPHONE NUMBER: E. A. SOWTER LTD., Transformer manufacturers and designers, P.O. BOX No. 36, IPSWICH IP1 2EL, ENGLAND. Tel: Ipswich (0473) 52794-219390.

(8289)

VHF MONITOR RECEIVERS, air, marine or business bands (low, mid, high or AM or FM). All crystal controlled high performance models. Send 15p P.O., not stamps, Radio Communications Ltd, St Sampsons, Guernsey, Channel Isles.

ELECTRONIC KITS — SAE for new catalogue, and clearance list of obsolete kits. AMTRON, 7 Hughenden Road, Hastings, Sx. (8226

REWINDING TRANFORMERS, a new manual covering 1VA to 5KVA single phase, from Magnum Power Tools, Brinksway, Trading Estate, Stockport, Cheshire, SK3 0BZ. £4.30 post paid by return. (8230

60KHz MSF Rugby Receiver. BCD TIME OF DAY OUTPUT. High performance, phase locked loop radio receiver, 5V operation with 1 second LED indication. Kit complete with tuned ferrite rod aerial £14.08 (including postage and VAT). Assembled circuit and cased-up version also available. Send for details, Toolex, Sherborne (4359), Dorset. (8252

SEEN MY CAT? 5000 odds and ends. Mechanical, Electrical. Cat free. Whiston Dept. WW, New Mills, Stockport. (7983

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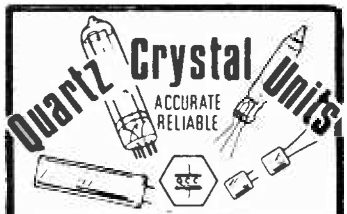

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Printed in Great Britain by QB Ltd. Sheepen Place, Colchester and Published by the Proprietors IPC ELECTRICAL-ELECTRONIC PRESS LTD., Dorset House, Stamford St., London, SE1 9LU, telephone 01-261 8000. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service Ltd, Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd: William Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Distributors Inc., 14th Floor, 111 Eighth Avenue, New York, N.Y. 10011.