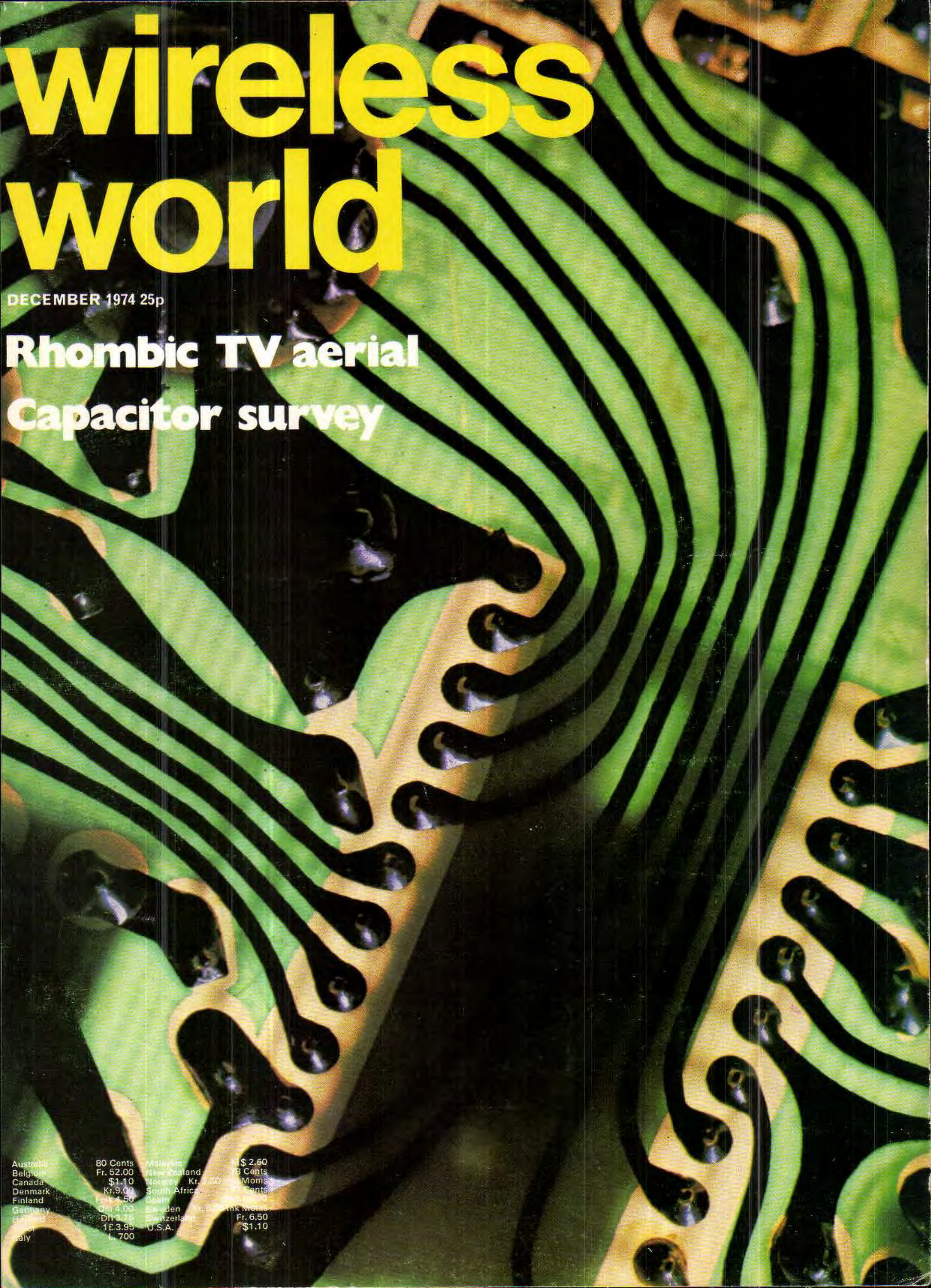


wireless world

DECEMBER 1974 25p

Rhombic TV aerial

Capacitor survey

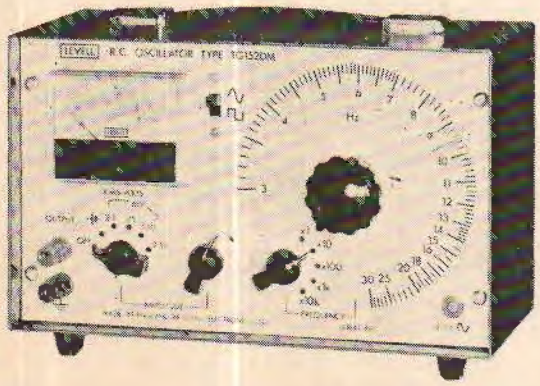
Australia	80 Cents	Malaysia	M$ 2.60
Belgium	Fr. 52.00	New Zealand	[illegible] Cents
Canada	$1.10	Norway	Kr. [illegible] Moms
Denmark	Kr.9.00	South Africa	[illegible] Cents
Finland	[illegible] 4.50	Spain	[illegible]
Germany	[illegible] 4.00	Sweden	[illegible] Moms
[illegible]	Dfl 3.[illegible]	Switzerland	Fr. 6.50
[illegible]	I£3.95	U.S.A.	$1.10
Italy	L. 700		

LOW COST RC OSCILLATORS

LEVELL

PORTABLE INSTRUMENTS

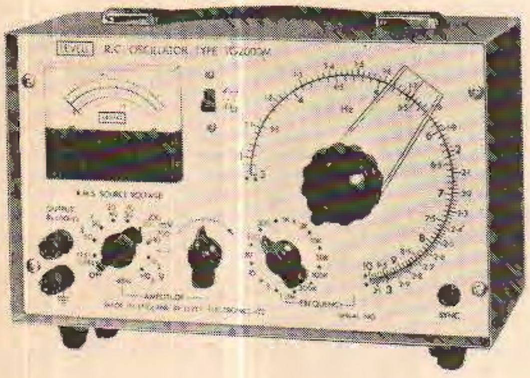
ANALOGUE



FREQUENCY	3Hz to 300kHz in 5 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 50Hz 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.
SIZE & WEIGHT	7″ high x 10¼″ wide x 5½″ deep. 8 lbs.

TG152D Without meter. **£46**

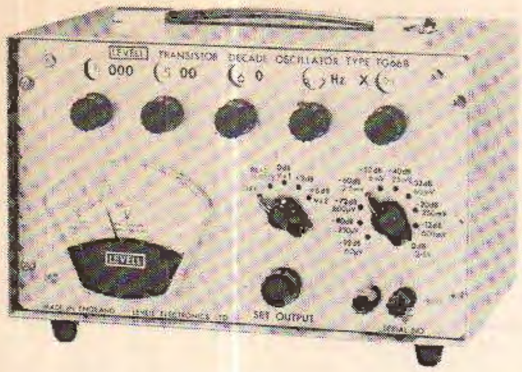
TG152DM With meter. **£56**



FREQUENCY	1 Hz to 1 MHz in 12 ranges. Acc. ± 2% ±0.03Hz.
SINE OUTPUT	7V r.m.s. down to <200µV with Rs = 600 Ω
DISTORTION	<0.1% to 5V, <0.2% at 7V from 10Hz to 100kHz.
SQUARE OUTPUT	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	0/2V, 0/7V & −14/+6dBm. on TG200M & DM only.
SIZE & WEIGHT	7″ high x 10¼″ x 5½″ deep. 10 lbs.

TG200	TG200D	TG200M	TG200DM
Sine O/P	Sine & Sq. O/P.	Sine O/P + meter.	Sine & Sq. O/P + meter.
£55	**£58**	**£65**	**£68**

DIGITAL



FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	±0.02Hz below 6Hz ±0.3% from 6Hz to 100kHz ±1% from 100 kHz to 300 kHz ±3% above 300 kHz.
SINE OUTPUT	5V r.m.s. down to 30µV with Rs=600 Ω
DISTORTION	<0.15% from 15Hz to 15 kHz. <0.5% at 1.5Hz and 150kHz.
METER SCALES	2 Expanded voltage & −2/+4dBm.
SIZE & WEIGHT	7″ high x 10¼″ wide x 7″ deep. 12 lbs.

TG66B Battery model. **£150**

TG66A Mains & battery model. **£170**

LEVELL ELECTRONICS LTD.
Moxon Street, High Barnet, Herts. EN5 5SD
Tel: 01-449 5028/440 8686

Prices include batteries and U.K. delivery. VAT extra. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.

WW—008 FOR FURTHER DETAILS

After we've introduced our new models, we'll let them speak for themselves.

On the left, our new portable dual-trace oscilloscope, the SO-4510. On the right, our new function generator, the SG-1271.

Both are in our assembled instrument catalogue, although soon they'll also be available in kit form.

And, coming from Heathkit, the world's largest makers of electronic kits, they have a lot of advantages.

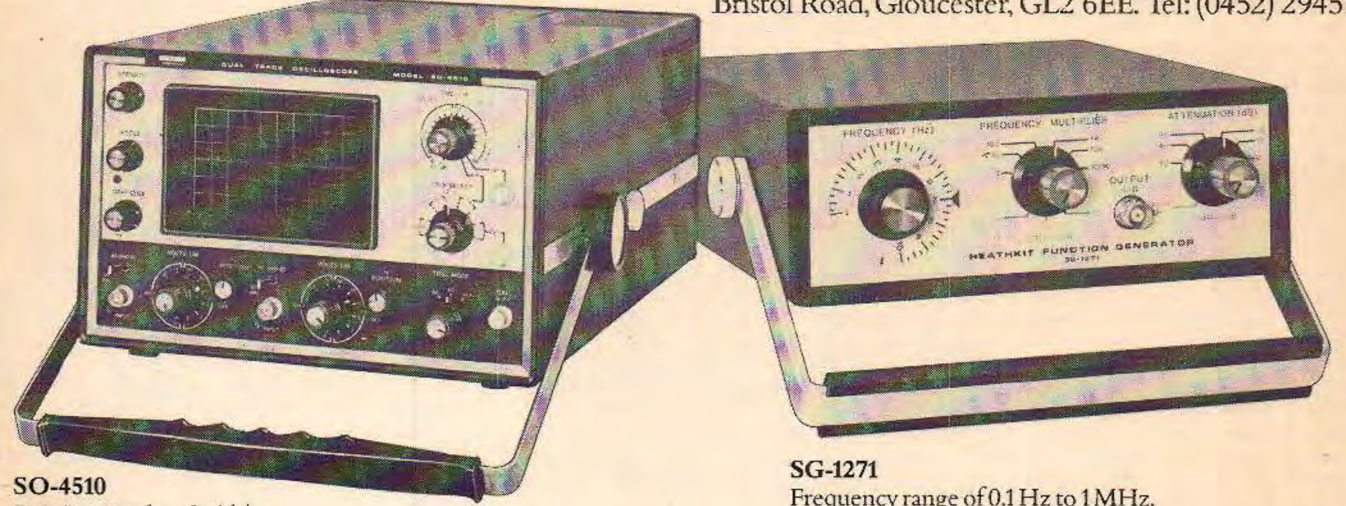
Every component, for instance, has to be a lot more rugged and reliable than the components in run of the mill equipment.

With the result that Heathkit equipment is of very high quality. And being specifically designed to permit easy servicing, makes a very good investment.

For full details just post the coupon and we'll send you your free Heathkit catalogues. Or call in at the London Heathkit Centre, 233 Tottenham Court Road, or at our showroom in Bristol Road, Gloucester.

Meanwhile we'll just let the facts speak for themselves.

Heath (Gloucester) Limited, Dept WW124, Bristol Road, Gloucester, GL2 6EE. Tel: (0452) 29451.



SO-4510
DC-15 MHz bandwidth.
Dual trace
1 mV/cm input sensitivity.
All major circuitry on five removable circuit boards for easy servicing.
Time base sweep to 100 ns/cm.
Vertical delay lines provide at least 20 ns of pretriggered waveform for complete signal display.

SG-1271
Frequency range of 0.1 Hz to 1 MHz.
Sine, square or triangle waveforms.
Calibrated attenuation from 0 to 50 dB in 10 dB steps.
Output 10 volts peak to peak.
Frequency accuracy of ± 3% of full scale on dial.

To: Heath (Gloucester) Limited, Dept WW124, Gloucester, GL2 6EE.
Please send me my free Heathkit catalogues of assembled instruments ☐ kits ☐

Name ________ Address ________

____

________ Postcode ________

HEATH
Schlumberger

ANDERS MEANS METERS...

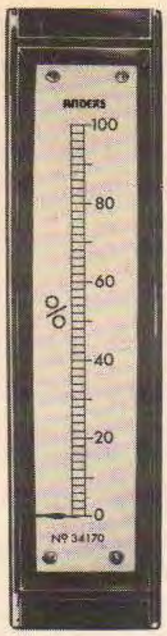
PRESTIGE RANGE

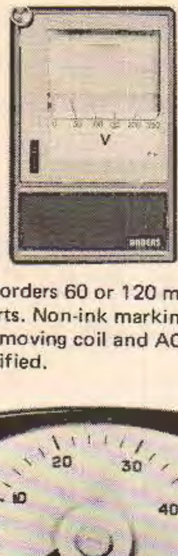
- High accuracy and stability
- Clear Sperry Display
- Automatic zero-ing
- High noise rejection (78 db CMR)
- Extremely versatile
- Competitive prices.

Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

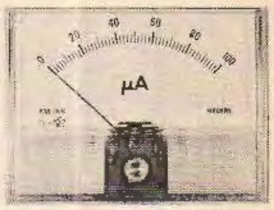
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.

Vulcan Moving Iron. 4 models, 1·5", 1·8", 2·7", 3·7" scales. Voltmeters, ammeters and motor starting meters.





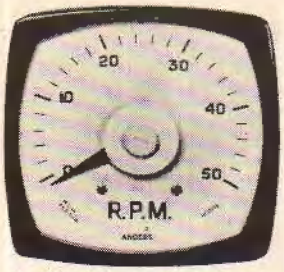
Recorders 60 or 120 mm. charts. Non-ink marking. DC moving coil and AC rectified.



Kestrel Clear Front. 7 models, 1·3" – 5·25" scales. DC moving coil, AC moving coil rectified, AC moving iron.

Regal Range 100° flattened arc. 2 models 2.5" and 3.2" scales. Taut band. DC moving coil and AC moving coil rectified.

Profile 350 edgewise 4·3" scale. DC moving coil and AC moving coil rectified. Horizontal or vertical mounting.



Stafford Long Scale 240°. 6 models, 3·5"–11·5" scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.

Lancaster Long Scale 240°. 2 models, 4", 5·5" scales. DC moving coil and AC moving coil rectified.

Send for fully illustrated catalogue

ANDERS ELECTRONICS LIMITED 48/56 Bayham Place, Bayham Street, London, N.W.1. Telephone 01-387 9092.

Manufacturers and distributors of Electrical Measuring Instruments. Sole U.K. distributors of FRAHM Resonant Reed Frequency Meters and Tachometers. Manufacturers of purpose built electrical and electronic equipment to customers' requirements.

standards go on getting higher. helps keep up the good work...

million component hours.

Unreliable products mean more servicing, more replacements, more guarantee claims . . . dissatisfied customers . . . so you won't save any money by leaving component quality to chance. Unknown components mean that your goods inward testing has to be much more stringent too.

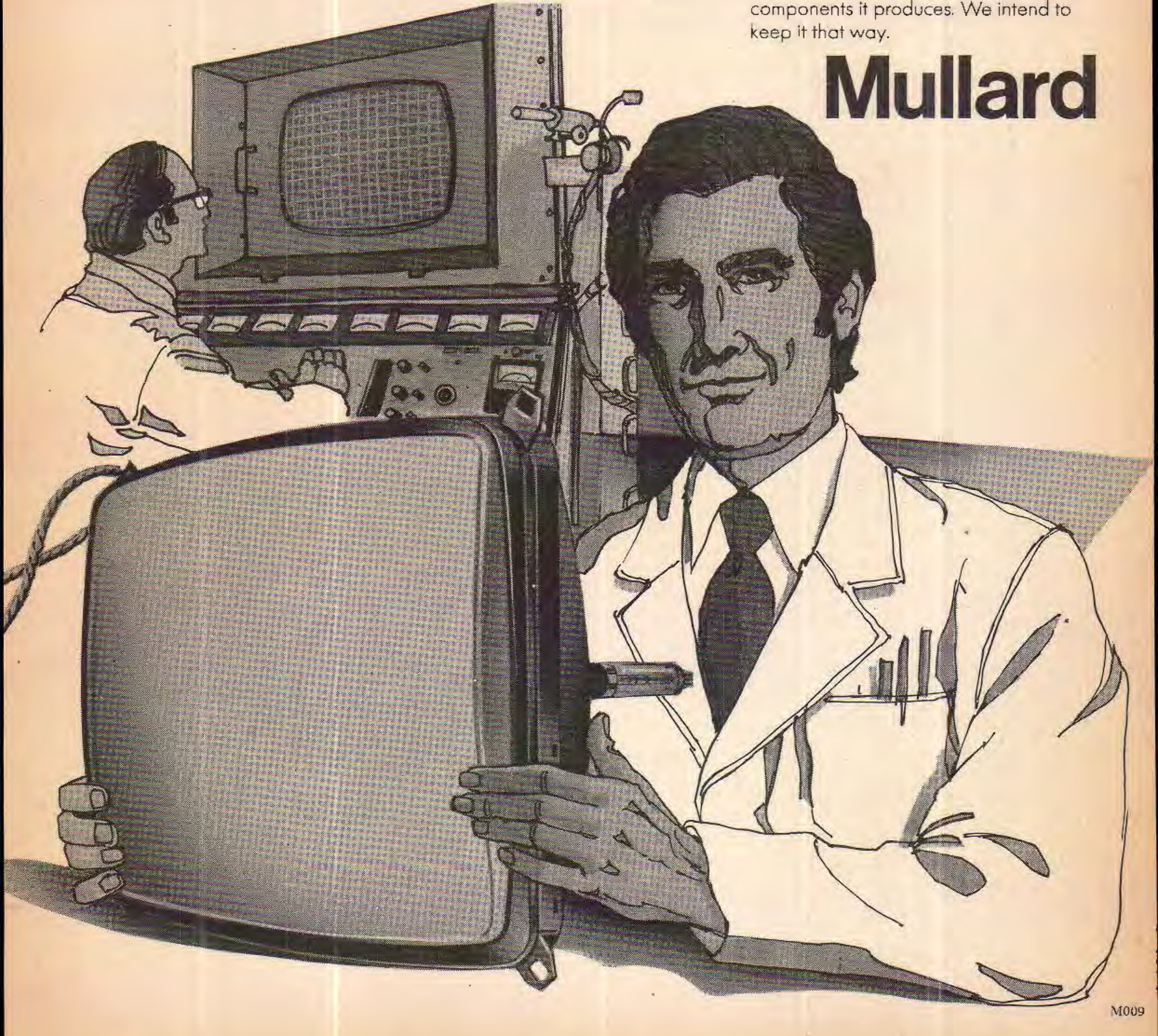
Remember that quality can't be 'tested into' a component after it's been made. It's a function of every step from initial design and raw material specification right through each production process to the finished product.

We have developed a series of quality assurance criteria which are applied throughout the Mullard organisation wherever actions or decisions can affect quality, however indirectly.

- Quality targets are clearly defined for all components.
- Test specifications cover all approved applications.
- Procurement specifications define essential quality requirements for outside suppliers.
- Manufacturing specifications are precise on all factors affecting quality.
- Accelerated test procedures are continually re-evaluated and stringent control is exercised on early life failures.
- Regular quality cost analysis is used to show whether costs incurred are to the best advantage of the user.

Mullard has an unrivalled name for the quality and reliability of the components it produces. We intend to keep it that way.

Mullard



M009

New

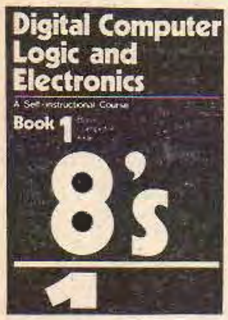
New Course in Digital Design

Understand the latest developments in calculators, computers, watches, telephones,

television, automotive instrumentation....

Each of the 6 volumes of this self-instruction course measures 11¾" x 8¼" and contains 60 pages packed with information, diagrams and questions designed to lead you step-by-step through number systems and Boolean algebra, to memories, counters and simple arithmetic circuits, and on to a complete understanding of the design and operation of calculators and computers.

After completing this course you will have broadened your career prospects and considerably increased your fundamental understanding of the changing technological world around you.



Also available – a more elementary course assuming no prior knowledge except simple arithmetic.

In 4 volumes:

1. Basic Computer Logic
2. Logical Circuit Elements
3. Designing Circuits to Carry Out Logical Functions
4. Flip flops and Registers

£3.95 inc p&p

Offer Order this together with Design of Digital Systems for the bargain price of £9.25.

Design of Digital Systems contains over twice as much information in each volume as the simpler course, Digital Computer Logic and Electronics. All the information in the simpler course is covered as part of the first volumes of Design of Digital Systems which, as you can see from its contents, also covers many more advanced topics.

Designer
Manager
Enthusiast
Scientist
Engineer
Student

These courses were written so that you could teach yourself the theory and application of digital logic. Learning by self-instruction has the advantages of being quicker and more thorough than classroom learning. You work at your own speed and must respond by answering questions on each new piece of information before proceeding to the next.

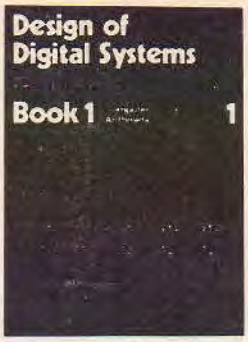
Guarantee–no risk to you

If you are not entirely satisfied with Design of Digital Systems or Digital Computer Logic and Electronics, you may return them to us and your money will be refunded in full, no questions asked.

Design of Digital Systems

A Self-Instruction Course in 6 Volumes

1. Computer Arithmetic
2. Boolean Logic
3. Arithmetic Circuits
4. Memories & Counters
5. Calculator Design
6. Computer Architecture



£5.95

including packing and surface post anywhere in the world (VAT zero rated). Payments may be made in foreign currencies. Quantity discounts are available on request. Total packaged weight does not exceed 4lb —please allow enough extra for air mail.

To: Cambridge Learning Enterprises,
FREEPOST, St. Ives, Huntingdon, Cambs PE17 4BR.

*Please send me.....set(s) of Design of Digital Systems at £5.95 each,

*or.....set(s) of Digital Computer Logic and Electronics at £3.95 each,

*or.....combined set(s) at £9.25 each.

Name..

Address...

....

....

*delete as applicable.

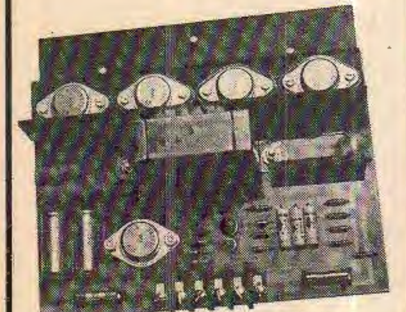
No need to use a stamp—just print FREEPOST on the envelope.

TUAC

TRANSISTOR UNIVERSAL AMPLIFICATION CO.LTD.
163 MITCHAM RD·LONDON SW17 9PG 01-672 3137/9080

MANUFACTURERS OF ELECTRONIC & AMPLIFICATION EQUIPMENT, ALSO QUALITY TRANSISTOR EQUIPMENT.
OPEN MON–SAT 9.30am–6.00pm.

NEW TUAC POWER MODULES offering more power and quality than ever before



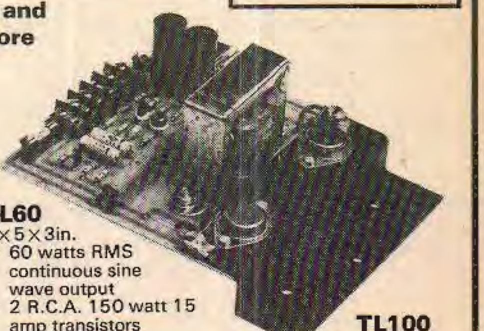
TP125 7×6½×3in.

★ 4 R.C.A. 150 watt 15 amp output transistors
★ 125 watts RMS continuous sine wave output

£17·00

TL30 4×5¼×2½in. **£9·30**

★ 30 watts RMS continuous sine wave output
★ 2 R.C.A. 40 watt output transistors



TL60 5×5×3in.
★ 60 watts RMS continuous sine wave output
★ 2 R.C.A. 150 watt 15 amp transistors

£11·50

TL100 5×5×3in.
★ 100 watts R.M.S. continuous sine wave output
★ 2 R.C.A. 150 watt 15 amp transistors

£13·20

★ Rugged layer wound driver transformer
★ Short—Open—and Thermal overload protection
★ Only 6 connections

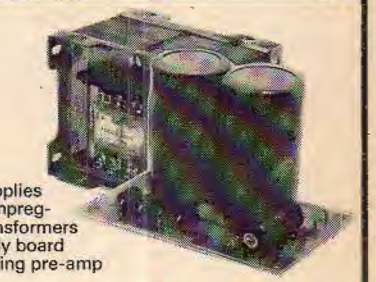
Specification on all power modules: All output power ratings ±1dB: Output impedance 8–15 ohms: THD at full power 2% typically 1%: Input sensitivity 60mV into 10kΩ; Frequency response 20Hz–20kHz ±2dB: Hum and noise better than −70dB.

TUAC DISCOTHEQUE MIXER WITH AUTO FADE £26·50

PANEL SIZE 18 × 4½ in. DEPTH 3 in.

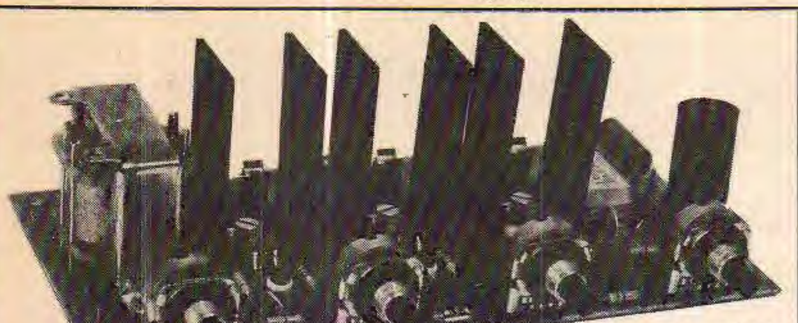
Designed for the discerning D.J. of professional standard. Offering a vast variety of functions. Controls: Mic Vol; Tone, over-ride depth; auto/Manual Sw; Tape Vol; L & R Deck Faders; Deck Volume; Treble and Bass; H. Phon Vol Selector; Master Vol On/Off Sw. Max output IV RMS.

Specification: Deck Inputs—50mV into 1mΩ; Deck Tone Controls *Treble +20 −10dB at 12kHz. Bass +22 −15dB at 40Hz; Mic input—200 ohms upwards. 2mV into 10kΩ; Mic Tone Control—Total Variation Treble 15dB. Total Variation Bass 10dB; Tape input—30mV into 47kΩ; Power Requirements—30–45 volts at 100mA.



Power supplies vacuum impregnated Transformers with supply board incorporating pre-amp supply:

PS 125	±50 volts for one TP125	£11·50
PS 100	±45 volts for one TL100	£10·50
PS 60	±40 volts for one TL60	£9·30
PS 30	±50 volts for one TL30	£6·85
PSU 2	for supplying disco mixer	£4·65



NEW!

3 CHANNEL LIGHT MODULATOR

- R.C.A. 8 Amp Triacs
- 1000W per channel
- Each channel fully suppressed and fused
- Master control to operate from 1W to 100W
- Full wave control—12 easy connections

£14·90 Single Channel Version **£6·60**

PREAMPLIFIERS

All TUAC audio modules are constructed on glass fibre P.C. board, are ready assembled and fully tested. Low noise silicon and FET transistors together with H.S. carbon film resistors are used throughout. Extensive research has gone into various wide range tone control circuits producing superb sound quality from any signal.

VAO8 Vol. Treble, Mid and Bass controls. Hi. IMP. FET. I/P. suitable Mid. Guitar, Radio, Crystal/Ceramic P.U. Sensitivity 4mV. Treble +35dB at 16kHz. Mid +20 −15dB at 1Hz. Bass +20 −10dB at 40Hz. **£4·90**

VAO6 Vol. Treble and Bass controls. Sensitivity 8mV. Treble +28 −15dB at 12kHz. Bass +18dB at 40Hz. **£4·15**

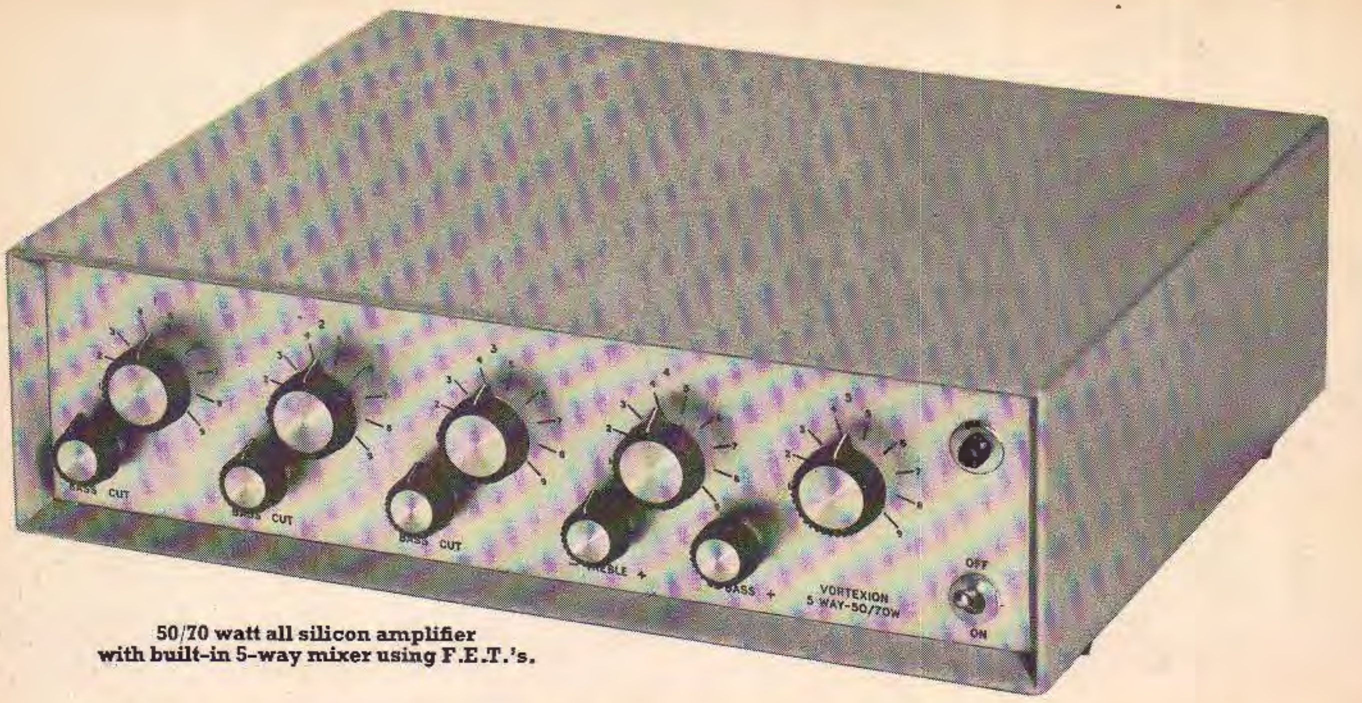
HOW TO ORDER BY POST

Make cheques/P.O's payable to TUAC (WW). OR QUOTE ACCESS/BARCLAY CARD NO. and post to TUAC LTD (WW) 163 MITCHAM ROAD, LONDON SW17 9PG. We accept phone orders against ACCESS/Barclay Card Holders. Phone 672-3137.

ALL PRICES INCLUDE V.A.T. POST & PACKING FREE

Stockists—Callers only.

A1. MUSIC CENTRE, 88 Oxford St, Manchester 1. Tel. 061-236-0340.
BRISTOL DISCO CENTRE, 86 Stoke Croft, Bristol 1. Tel. Bristol 41666.
CALBARRIE AUDIO, 88 Wellington St, Luton, Beds. Tel. Luton 411733.
SOCODI, 9 The Friars, Canterbury, Kent. Tel. Canterbury 60948.
WEC LIGHTING, 35 Northam Road, Southampton. Tel. Southampton 28102.



50/70 watt all silicon amplifier with built-in 5-way mixer using F.E.T.'s.

SOUND SENSE = VORTEXION

VORTEXION Design and manufacture public address equipment to meet a range of specific requirements for AIRPORTS, HOTELS, THEATRES, GOVERNMENT AUTHORITIES, LOCAL AUTHORITIES, SUPERMARKETS, SCHOOLS, SPORTING COMPLEXES, POP GROUPS AND THE LOCAL VILLAGE HALL.

The high fidelity amplifier illustrated has bass cut controls on each of the three low impedance balanced line microphone stages and a high impedance gram stage with bass and treble controls, plus the usual line or tape input. All the input stages are protected against overload by back to back low self capacity diodes and all use F.E.T.'s for low noise, low intermodulation distortion and freedom from radio breakthrough.

A voltage stabilised supply is used for the pre-amplifiers making it independent of mains supply fluctuations and another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75 % efficient and 100 V balanced line or 8-16 ohms output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected.

The mixer section has an additional emitter follower output for driving a slave amplifier, phones or tape recorder, output 0.3 V out on 600 ohms upwards.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER using the circuit of our reliable 100 Watt Amplifier with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer Amplifier, again fully protected against overload and radio breakthrough. The mixer is arranged for 2-30/60 Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output OR 5-15 Ω and 100 volt line.

100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms-15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100 K ohms.

THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4-channel F.E.T. mixer. 2-30/60 Ω balanced microphone inputs, 1-HiZ gram input and 1-auxiliary input with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25 % and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

20/30 WATT MIXER AMPLIFIER. High fidelity all silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. Standard model 1-low mic. balanced input and HiZ gram. Outputs available 8/15 ohms OR 100 volt line.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms-15 ohms and 100 volt line. Bass and treble controls fitted.

Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s-20 Kc/s. Can be used to drive mechanical devices for which power is 120 watts on continuous sine wave. Input 1 mW 600 ohms. Output 100-120 V or 200-240 V. Additional matching transformers for other impedances are available.

F.E.T. MIXERS and PPM's. Various types of mixers available. 3, 4, 6 and 8 channel with Peak Programme Meter. 4, 6, 8 and 10 Way Mixers. Twin 3, 4 and 5 channel Stereo, also twin 4 and 5 channel Stereo with 2 PPM's.

VORTEXION

Vortexion Ltd., 257-263 The Broadway, Wimbledon, SW19 1SF. Telephone: 01-542 2814 and 01-542 6242/3/4. Telegrams: "Vortexion London SW19"

For further information and technical leaflets write to Vortexion

Name

Address

WW—011 FOR FURTHER DETAILS

The first of a new range of high quality loudspeakers
This model employs three active drive units, the total range of which extends beyond the nine audible octaves.

By giving attention to all components and design detail the colouration and distortion is negligible and the energy distribution is as constant as possible.

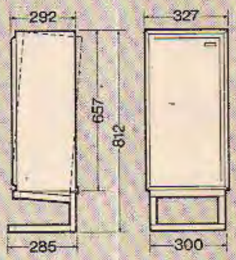
Five year warranty
Because of the precision required in manufacturing loudspeakers to a consistent specified performance, we can confidently predict that the Achromat 400 will have a long and trouble-free life when correctly operated.

We can therefore offer a five-year warranty on this loudspeaker system.

Stand
The Achromat 400 will give its most accurate reproduction in normal conditions when spaced at a distance of 10–20 cms above the floor.

The Goodmans Loudspeaker Stand CS3 is recommended and gives the option of vertical or 5° tilt positioning.

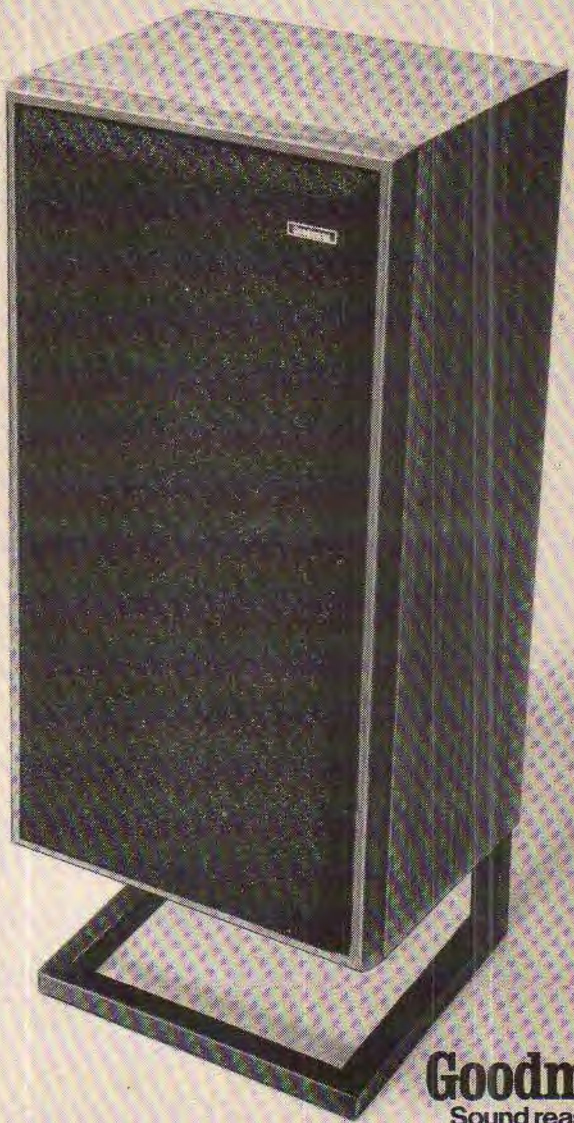
Specification
Drive units
Bass unit 26cm dia long-throw
Mid-range unit 44mm dia viscous damped dome radiator. Flush mounted
HF unit 25mm dia viscous damped dome radiator. Flush mounted



Frequency range 40–22,000 Hz ± 5dB
Nominal impedance 8 ohms.
The loudspeaker is suitable for use with amplifiers rated at 4 or 8 ohms.
Recommended amplifier music power rating 25 to 75 Watts
Sensitivity 12 Watts for 96dB at 1 metre
Effective enclosure volume 39.5 litres
Dividing frequencies 900 and 3,500Hz
Weight 16.5 kg (36 lbs) net
Recommended Retail Price £79.47+VAT
Stand £ 6.64+VAT

For illustrated details please write to
Goodmans Loudspeakers Limited
Downley Road, Havant, Hants PO9 2NL

A member of The Thorn Group



Goodmans Achromat*400

*from *Shorter Oxford Dictionary*
Achromatic 1. Optics – free from colour, not showing colour
2. Biol. – of tissue, uncoloured (1882) ie after staining
Achromatization – the action or process of removing colour

Goodmans
Sound reasoning.

If you're looking for trouble you needn't look any further.

It's not only technicians who can see the finer points of Eagle multi-meters.

Every handyman notices them too.

They're easy to read.

They're tough.

Their construction comes up to laboratory standards.

Even our inexpensive pocket sized models have features you'd usually only find on professional equipment.

Take a look through our catalogue.

You'll see over twenty models.

Specifications that would impress the most experienced technician.

And a price range that takes in amateurs as well as professionals.

We guarantee every one for two years.

With parts to service them in no time.

So you can confidently find fault in anything.

Eagle®

The name on Britain's widest range of electronic equipment.

Please send me the Eagle electronics catalogue containing the complete range of test equipment.

Name________________________

Address________________________

____

WW4

Eagle International Precision Centre Heather Park Drive Wembley HA0 1SU Telephone 01-903 0144

New automatic digital bridge from Wayne Kerr

Wayne Kerr's new B900 is one of the best value-for-money bridges in the world.

It is universal, has a wide range, and gives immediate digital readout of resistive and reactive terms–simultaneously.

On all ten ranges, for every type of measurement available, the displays provide a complete indication of the numerical value (up to 19999), polarity, decimal points and units–automatically and in half a second.

Direct measurements of Q, dissipation and dc volts.
2, 3, & 4–terminal. Automatic lead compensation.
4–Quadrant: +ve or –ve C, L, 1/C, G and R.
Overall coverage:

$10\mu\Omega$	– $200M\Omega$	1nH	– 20kH
0.001pF	– $20{,}000\mu F$	10p℧	– 200℧

Accuracy: 0.1% (10Ω–$200M\Omega$), 0.3% ($10m\Omega$–10Ω) in all quadrants. Frequency: 1kHz Outputs: Analog and TTL.

For more information phone Bognor (02433) 25811, or fill in the coupon.

Please send me details of the B900.

For the attention of Mr ____________________

Company name and address ____________________

____

____

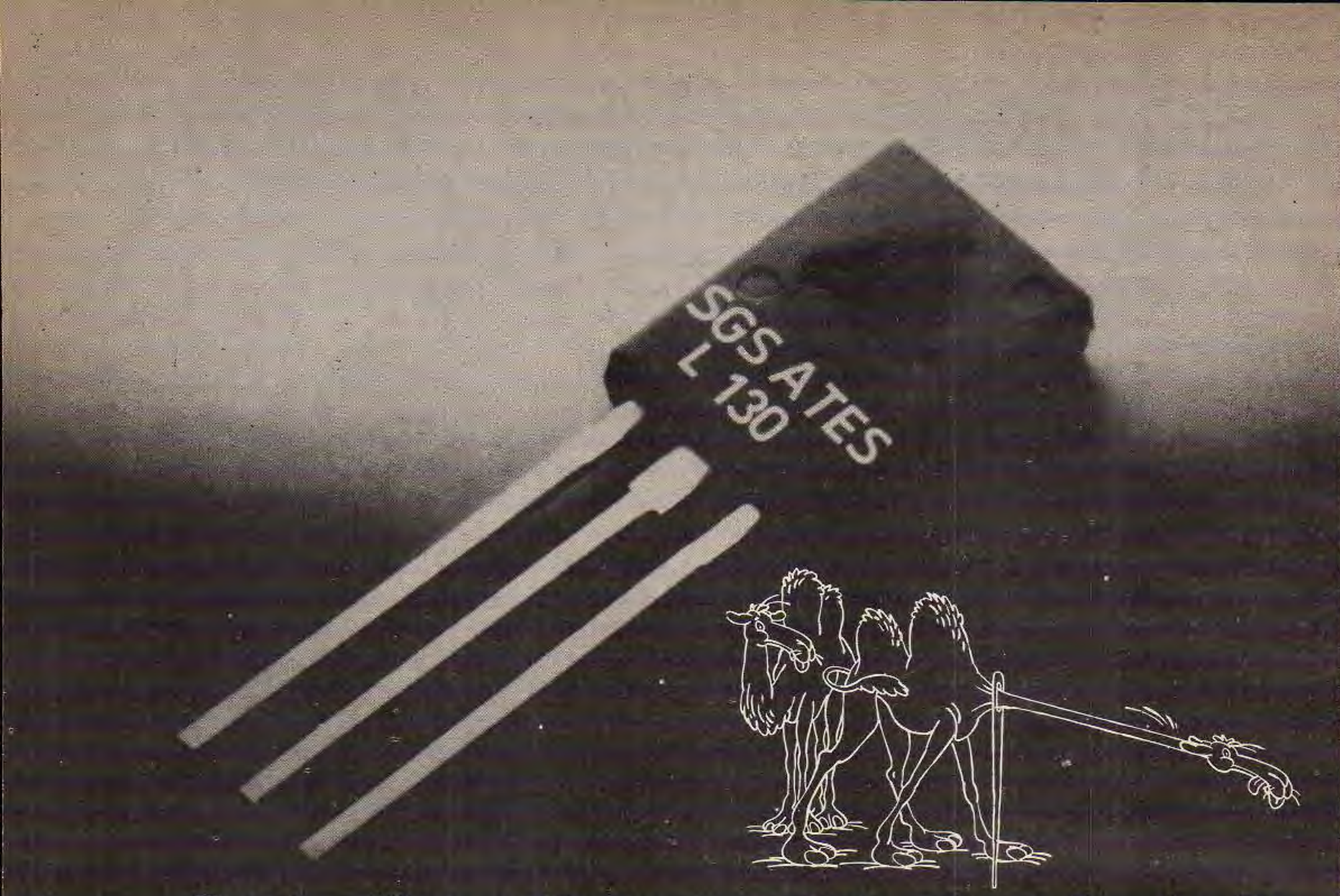
____

WW—Dec.

Post to Wayne Kerr, Durban Road, Bognor Regis, Sussex PO22 9RL

WAYNE KERR

A member of the Wilmot Breeden group.



Bestselling voltage regulators now in plastic

Following the sweeping success of SGS-ATES' integrated fixed voltage regulators in TO-3 metal can, these circuits are now also available, ex stock, in SOT 32 plastic package.
Designated L129, L130 and L131, they are suitable for low cost applications in professional, industrial and consumer equipment requiring compact components with low/medium output current, such as

- desk calculators
- video displays
- computer peripherals
- touch tuning and remote control for TV sets
- TV subsystems, such as video IF, sound IF, sync and chroma stages

A particularly interesting area of application is in local regulation systems. The main advantages of this circuit technique over traditional single point regulation are the reduction in common ground and inter-circuit coupling, high noise immunity and the elimination of problems due to line voltage drops.

Special features of the circuits include

- tight tolerance on the output voltage
- load regulation less than 1%
- ripple rejection 60 dB typical
- internal overload protection
- short circuit protection

The L129, L130 and L131 are designed to operate in the -20 °C to + 85 °C temperature range. For the standard operating temperature range, 0 °C to +70 °C, these plastic voltage regulators are available with type numbers TDA1405, 1412 and 1415.

-20° to +85 °C	V_o	I_o reg. typical	0° to +70 °C
L 129	**5V**	**850 mA**	**TDA 1405**
L 130	**12V**	**720 mA**	**TDA 1412**
L 131	**15V**	**600 mA**	**TDA 1415**

SGS ATES
(United Kingdom) Ltd.

Distributors in the UK: Distronic Ltd., Harlow, 02796-32947 - Electronic Component Supplies Ltd., Windsor, 07535-68101 - Hawnt Electronics Ltd., Birmingham, 021-3594301 - ITT Electronic Services, Harlow, 02796-26777 - REL Equipment & Components Ltd., Hitchen, 0462-50551 - Quarndon Electronics Ltd., Derby, 32651.

COMMUNICATIONS CONTACT!

4 PAGES of news from Mullard

Wide range of TTL to Post Office Spec

The Mullard range of TTL integrated circuits approved and provisionally approved to the stringent Post Office Specification D3000 now comprises 22 types. They are being supplied to Post Office contractors and are to be offered to other equipment manufacturers who are concerned with very high standards of reliability.

All types in the D3000 range are functionally equivalent to types in the well-known GFB7400D series. Encapsulation is ceramic 14- and 16-lead dual-in-line.

The specification includes important overstress and endurance tests with exacting internal inspection requirements. It assures an extremely high standard of reliability and long life performance, and users can expect a component life of forty years with cumulative failures not greater than 2 per cent. For a leaflet summarising the range use reader enquiry service no. WW069.

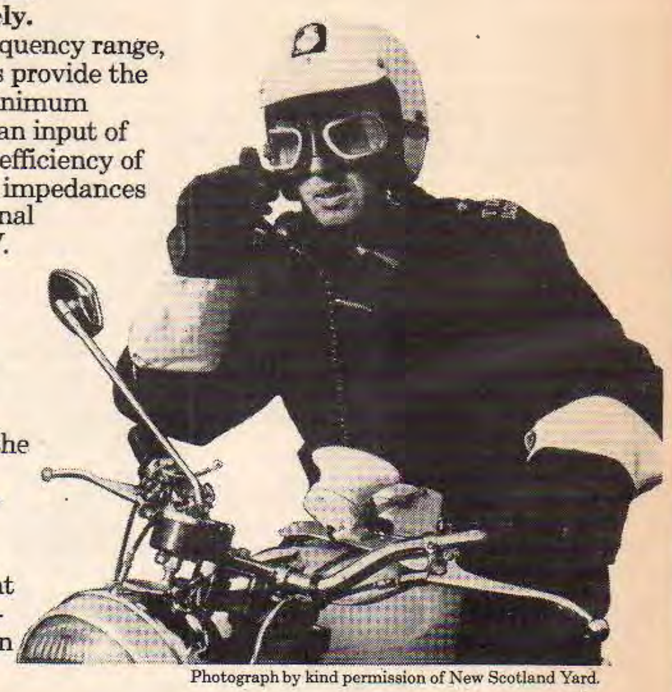
NEW MODULES FOR MOBILES

The highly successful u.h.f. amplifier modules manufactured by Mullard are to be followed up by two v.h.f. types. These are type numbers 437BGY and 438BGY covering the frequency ranges 148–174MHz and 68–88MHz respectively.

Apart from their frequency range, both the v.h.f. modules provide the same performance: minimum output power 18W for an input of 150mW with a typical efficiency of 45%. Input and output impedances are 50Ω, and the nominal supply voltage is 12·5V.

Among the operational features are the ability to withstand severe load mismatch and the provision for control of the output power by variation of the supply voltage. The operating temperature range is from −40° to +90°C.

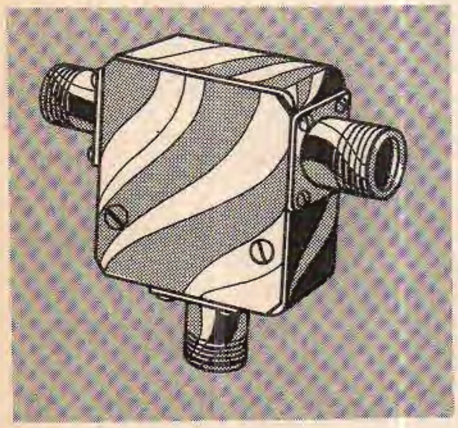
By basing equipment on the modules, manufacturers can cut design time and also reduce the number of assembly operations. Furthermore, as the modules are untuned, no adjustment is needed in the test room. For provisional data please use reader enquiry service no. WW070.



Photograph by kind permission of New Scotland Yard.

Space-saving circulators

Significant savings in space and weight can be made in communications and radar equipment by using Mullard miniature circulators. Despite their small size, they feature the same low-loss characteristics and wide bandwiths as their full-size counterparts.



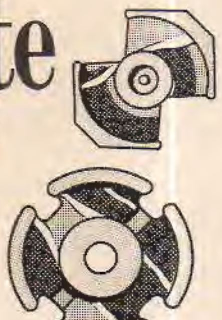
There are eight ferrite 3-port types capable of handling up to 300W in the u.h.f. region, and four microwave types rated at 50W.

The u.h.f. types are divided into 100W and 300W families. Bandwidths fall within the spectrum 470 to 1000MHz, and isolation is typically 25dB. Connectors are N-type with the option of HF 7/16 DIN 47223 connectors for the high power circulators.

The four microwave circulators are broadband types providing coverage through the S, C and X bands, and isolator versions are available of each type. Isolation depends on the band and is typically between 23 and 27dB. Connectors are SMA coaxial.

For further information please use reader enquiry service no. WW072.

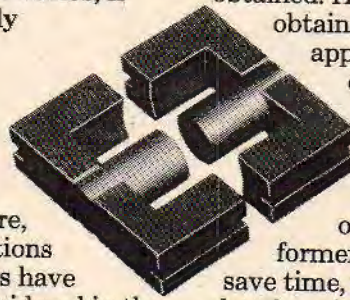
Which Ferrite Core?



A useful aid to finding the right type of ferrite inductor or transformer core for any particular application is provided by a new wallchart from Mullard. All preferred design types in their various shapes, sizes and materials are clearly summarised. For a copy please use reader enquiry service no. WW071.

NEW CORES SPECIFICALLY FOR SWITCHED MODE POWER

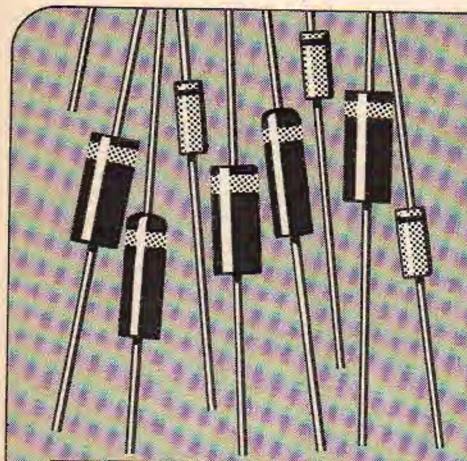
Designers of switched mode power supplies no longer have to use transformer cores of a material and shape which are meant for quite different applications. A new range of ferrite cores being introduced by Mullard, the FX3700 series, is intended specifically for the job.



Insulation and safety, the special stresses of switched mode operation, winding economics, modes of circuit failure, mechanical specifications and BSI requirements have all been carefully considered in the design.

The cores may be used in units where the input is derived from rectified mains or from batteries, and are suitable for designs covering a wide range of outputs. When used in 25kHz push-pull circuits at the unfavourable end of the application spectrum (supplying low voltage, 5V, output) d.c. output powers from 50W to 500W can be obtained. Higher outputs can be obtained in more favourable applications, and the cores can, of course, also be used in single-ended circuits.

An application note is available which not only simplifies transformer design but helps to save time, money and trouble elsewhere in the circuit. For a free copy and data on the cores please write to Dept. C.I.H., Ref: CPS/C23, Mullard Ltd., New Road, Mitcham, Surrey CR4 4XY.



ZENERS
JUST THE WAY YOU WANT THEM

You can get Mullard 400mW and 1W Zeners selected for voltage and other parameters to meet your own exact specifications. Voltages can be within 1% if you want them that way.

Quantities of up to 2,000 can be supplied with fast delivery through the Mullard SOSWIFT Service. Bulk selections of over 2,000 pieces can be made to negotiated delivery times through the SELECT 61, 79 and 88 Services.

400-MILLIWATT TYPES

BZY88: DO-7 glass encapsulation 2·7 to 36V SOSWIFT Service and SELECT 88 Bulk Selection Service.

BZX79: DO-35 miniature glass encapsulation 4·7 to 75V SELECT 79 Bulk Selection Service

1-WATT TYPES

BZX61: DO-15 plastic encapsulation 7·5 to 75V SOSWIFT Service and SELECT 61 Bulk Selection Service

Mullard

Please use reader enquiry service no. WW073 for data on all of the above types.

Linear power for S.S.B.

Three highly linear r.f. power transistors for single-sideband applications from manpacks to ship-to-shore transmitters are available from Mullard.

In all three the intermodulation products are typically more than 30dB down on full rated output. Under some conditions this figure is even better than 40dB. Furthermore, all three are electrically rugged and can withstand severe load mismatch.

The most powerful member of the family is the BLX15. Operating from supplies of up to 50V in the range 1·6 to 28MHz, it can supply 150W p.e.p. singly or 300W p.e.p. in push-pull. Also, the full power rating is maintained up to 108MHz in the c.w. mode.

The two companion types, the BLX13 and BLX14, operating from 24/28V supplies over the range 1·6 to 28MHz can supply p.e.p. outputs of 25W and 50W respectively.

All three transistors are in plastic 'capstan' packages. For full data please use reader enquiry service no. WW074.

Key to colour camera tv reliability

Millions of burning hours are being registered by Plumbicon* colour camera tubes in television broadcasting in the U.K. Some programme companies are reporting lives of over 7,000 hours. In telecine equipment, lives of over 10,000 hours are not uncommon.

If you are 'tubing up for colour', Plumbicon tubes from Mullard are a wise choice. There are 36 types to choose from. Use reader enquiry service no. WW075 for a wallchart.

**Registered trademark for television camera tubes.*

Mullard Communications Contact

SINGLE-CHIP ERROR DETECTOR

What is virtually a complete sophisticated error detection system is contained in one 18-lead DIL integrated circuit recently announced by Mullard. Designated type GZF1202, it is a LOCMOS (local oxidised silicon complementary MOS) device, and consequently has a low power consumption and can be used with TTL components.

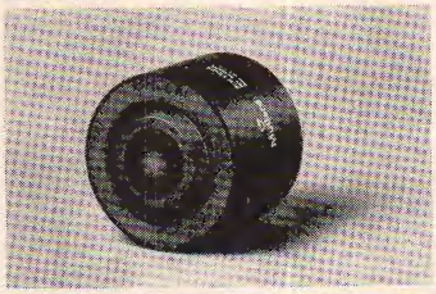
In operation, a GZF1202 at the transmitter and another at the receiver divide the message by a polynomial expression and the remainders are compared. If they are different, an error has occurred. The message is transmitted in its original form with the remainder added to the end.

The GZF1202 provides for the use of six standard polynomials, and is thus suited for use in a variety of applications from modem interfaces to peripheral equipment such as disc stores. Samples of the IC are available for evaluation and data can be obtained by using reader enquiry service no. WW076.

A HUNDRED-THOUSAND TIMES BRIGHTER

Image intensifiers which enable you to see on an overcast moonless night, by amplifying light by as much as 100,000 times, are fully-engineered items in regular production at Mullard.

The intensifiers manufactured include single- and multi-stage electrostatically focused types and electrostatically focused microchannel inverter types. For information on the range and its special features use reader enquiry service no. WW077.



Contact Column

SECOND GENERATION BROADBAND TRANSISTORS

The Mullard company is no newcomer to the supply of components for TV distribution systems and similar applications. For nearly a decade it has made available broadband transistors, and types such as the BFY90, BFW30 and BFW16A are now well established.

With demands for lower and lower cross-modulation distortion and more and more channel capacity, a second generation of Mullard broadband transistors has appeared. Prominent among them is the BFR94. This has an f_T of 3GHz which is maintained at currents up to the unusually high region of 125mA. In this transistor, low cross-modulation, intermodulation and second-order distortion are combined with excellent broadband and low-noise performance.

Moreover, the low cross-modulation behaviour is straightforward and does not depend on operation at critically favourable collector currents and output voltages. A shift–due to a change in temperature, say–does not therefore result in a rapid rise in cross-modulation distortion.

Another second-generation broadband device, the BFR96, can be used to drive the BFR94. It covers the range 40 to 860MHz, power gain is typically 8dB and typical output voltage is 600mV. Other types of transistor of similar interest are the BFR90 to BFR93. Data on all types mentioned can be obtained through the reader enquiry service no. WW078. ***by 'Electron'***

Mullard

Components for communications — broadcasting, telecommunications, radar, navaids, military

Mullard Limited Mullard House Torrington Place London WC1E 7HD Telephone: 01-580 6633 M.010

British...

Wherever there is appreciation of fine sound reproduction, insistence is upon British loudspeaker systems. Renowned among the discerning for their outstanding quality, the products of Mordaunt·Short Ltd. are specified by professionals and by enthusiasts the world over. Choose them for your home - where the finest most concerns you.

...at its best.

Mordaunt-Short Ltd

Designers and Manufacturers of Quality Loudspeaker Systems

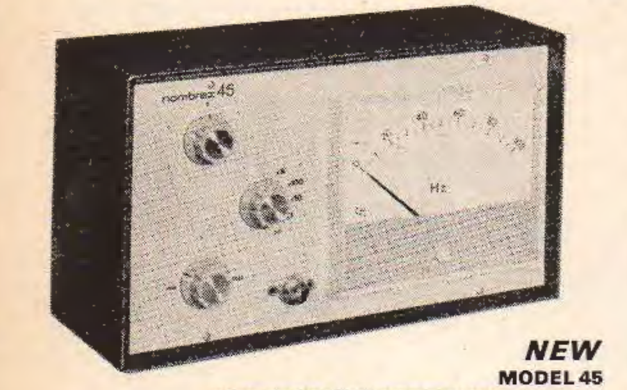
To receive immediately full information and the name and address of the Stockists nearest to you, please complete this coupon and return it to us direct.

Name **Address**

Mordaunt-Short Ltd. The Causeway, Petersfield, Hampshire, GU31 4JT. Tel: Petersfield (STD 0730) 4631-5 W10

WW—062 FOR FURTHER DETAILS

nombrex



NEW

MODEL 45

DIRECT READING FREQUENCY METER

PRICE £42.50 + VAT

- **MEASURES FREQUENCY FROM 10 Hz TO 100 kHz.**
- **MEASUREMENT INDEPENDENT OF SIGNAL WAVE FORM.**
- **ACCEPTS INPUT LEVELS FROM 10mV TO 5V.**
- **FOUR DECADE SWITCH RANGES.**
- **SENSITIVITY CONTROL.**
- **CALIBRATION CONTROL.**
- **POWERED BY 9 VOLT BATTERY.**

Trade and Export enquiries welcome.
Send for full technical leaflets.
Post and Packing 50p extra.

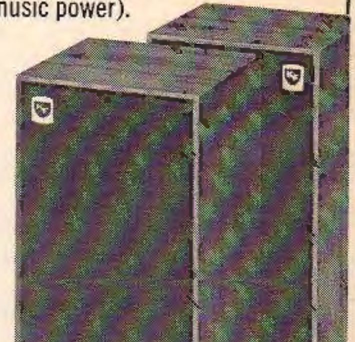
NOMBREX (1969) LTD., EXMOUTH, DEVON
Tel: 03-952 3515

WW—065 FOR FURTHER DETAILS

The symbol of sound quality.

Hi-Fi Speakers

The KR range consists of five outstanding speaker designs with power ratings from 18 watts (music power) to 90 watts (music power).



Made from selected high-density Swedish chipboard, the cabinets are hand-made, hand-finished and matched in identically grained pairs.

To ensure consistent sound quality, all speakers are individually tested before leaving our factory.

Ask for a K.F. demonstration and hear for yourself.

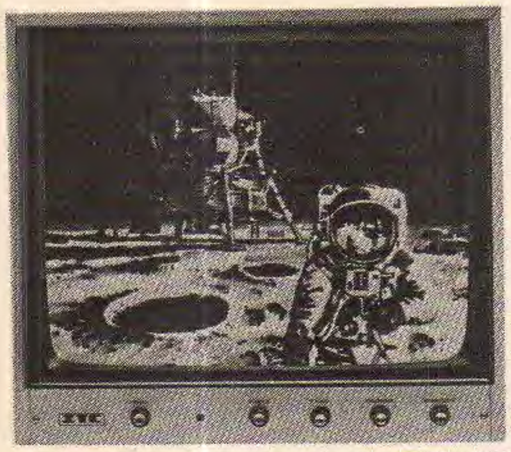
KR10. A two way, two unit system, typical of K.F. quality and design.

For further information and address of your local stockist write to:
K.F. Products Ltd., Ashton Road, Bredbury, Stockport, Cheshire.

WW—031 FOR FURTHER DETAILS

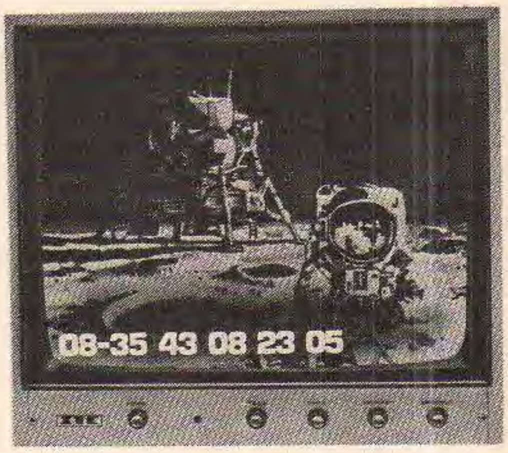
Four easy steps to improve your instructional video system.

1



First purchase a good monitor. The ITC PM 171T for example, is perfect. It guarantees clarity, brilliance and definition; even if the picture comes straight from the moon. And our price is strictly earthbound, just £140. With the special video effects we have in mind, you'll need the ITC PM 171T monitor.

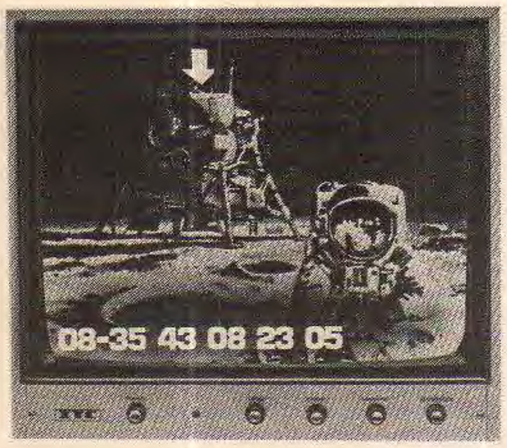
2



Next purchase the VTG-33F time and date generator. It gives legible reading from 100th of a second, through seconds, minutes, hour, day, month.* Perfect for any countdown. The precise timing is provided by the electronic crystal controlled IC circuitry. This generator is compatible with any new or existing television system, colour or black and white. And costs just £280.

(Prices subject to VAT)

3



Now add the VP 315 video pointer. This advanced unit superimposes an arrow indication on your video system picture. The joy-stick control panel makes arrow positioning simple. And the arrow can be shown in black or white in a steady or flashing model either horizontal or vertical, in any size you want. We bring it to you at only £285.

4

Lastly, step into Dixons Technical. That's where you can buy all the above hardware. While you're in, look over all the other space-age equipment we have for improving your video system. We'll give you a personal demonstration, help you choose the equipment you need, then install it.

Please send full details for the

ITC PM 171T Monitor ☐
The VTG-33F Video Display Generator ☐
The VP 315 Video Pointer ☐

Name ____________________

Address ____________________

____

To: Dixons Technical,
3 Soho Square,
London W1.
Tel: 01-437 8811

Dixons Technical Ltd
OF SOHO SQUARE

WW/35/12

*Also available showing seconds, minutes, hour, day, month, year. This model is very suitable for time lapse video recording.

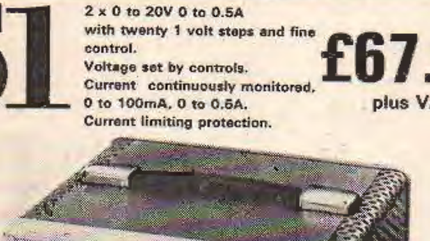
Linstead Twin Stabilised Power Supplies

Each comprising:
Two powerful bench supplies.
Continuously variable.
Independently operable, or in series, or parallel.
Fully protected against overload and short circuit.
In one compact robust case.

S1

2 x 0 to 20V 0 to 0.5A
with twenty 1 volt steps and fine control.
Voltage set by controls.
Current continuously monitored, 0 to 100mA, 0 to 0.5A.
Current limiting protection.

£67.90 plus VAT



S7

2 x 0 to 30V 0 to 1A.
Set by switches and fine control.
Meters switchable for volts, 0 to 100mA and 0 to 1A.
Re-entrant protection. Pilot indication of overload.

£79.90 plus VAT

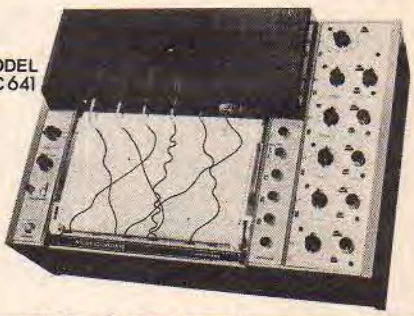
Linstead
the best for less
BRITISH MADE BY LINSTEAD
Linstead Electronics, Roslyn Works, Roslyn Road London N15 5JB. Telephone 01-802 5144

Ireland, Lennox Laboratory Supplies Ltd., 3-4 South Leinster Street P.O. Box 212A, Dublin 2
Denmark, Scanfysik, 13-15 Hjorringgade, DK 2100, Copenhagen
Sweden, EMI Svenska A/B, Tritonvagen 17, Fack, 171 19 Solna I
Norway, EMI Norsk A/S, Postboks 42 Korsvoll, Oslo 8
Malaysia, Laboratory Equipment Sdn. Bhd., P.O. Box 60, Batu Pahat
Benelux, A.S.E. Ltd., Nationalestreet 38, B-2000 Antwerp

WW—057 FOR FURTHER DETAILS

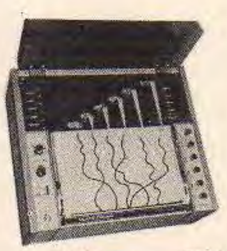
New MULTI-PEN RECORDERS

MODEL MC641



with even greater performance.
100 µV f.s.
0.3 sec. f.s.

MULTICORDER



* Multi-channel, 2 – 6 with full range zero set.
* Multi-pen – felt tipped. 6 colours.
* 16 switched chart speeds, 2.5 mm/hr. to 1200 mm/min.
* Choice of Z fold or roll chart.
* Five plug-in preamplifiers switched ranges 100 uv – 500 V f.s. sensitivity. Also 100 mV for OEM.

OEM version

ENVIRONMENTAL EQUIPMENTS LTD.
Eastheath Avenue, Wokingham, Berkshire RG11 2PP. Tel: Wokingham 784922.

WW—009 FOR FURTHER DETAILS

Make light work of wiring with the NEW SELF ADHESIVE WIRE STAPLES

Countless uses in industry and offices

* QUICK AND EASY TO APPLY – EVEN IN AWKWARD PLACES
* SAVES DAMAGE TO WOOD AND PAINTWORK
* STICKS ON INSTANTLY : HOLDS WIRE FIRMLY

You'll save enormous time and trouble with the new Brandauer adhesive staple. Just peel off the backing strip and press staple into place. Then bend clips over to hold wire firmly in position. No messing with pins, tacks, soldering or drilling. No damage to woodwork, e.g. skirting boards. Use the Brandauer Staple for any wall, frame or cabinet wiring jobs — it's wonderfully easy for fitting in those awkward corners.

Send now for details to:

SPECIAL PRODUCTS DISTRIBUTORS LTD.
81 Piccadilly, London W1V OHL. Tel: 01-629 9556.

WW—046 FOR FURTHER DETAILS

BIG NEWS FROM BARR & STROUD
MODULAR FILTERING
ONE MAIN FRAME – MANY OPTIONS

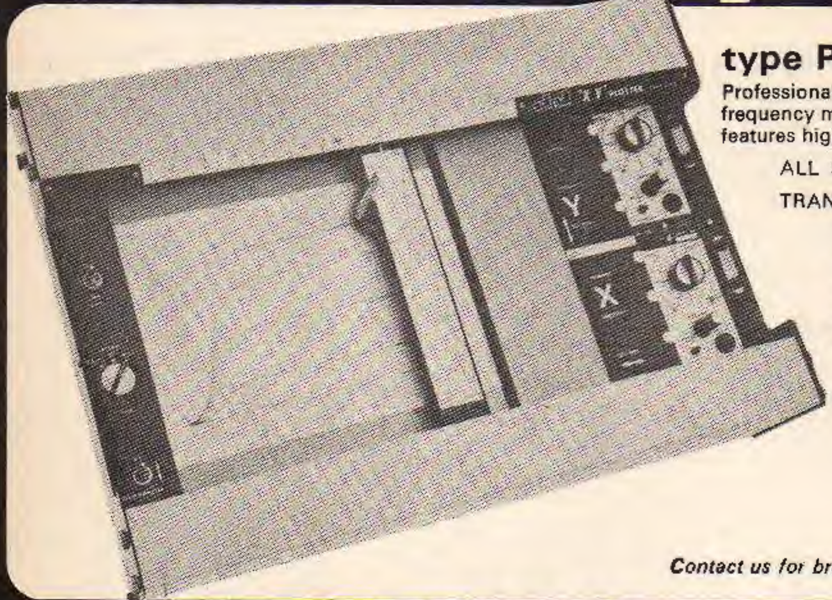
Barr & Stroud's new EF3 Electronic Filter System means no more compromises when you buy variable filters. Now you can get the filter you need today, and additional plug-in units tomorrow. Today — the basic main frame and your choice of two modules to operate in low-pass, high-pass, band-pass, band-stop, band-separate, band-combine or cascade modes. Tomorrow — other interchangeable modules to meet your newest requirements. The first two modules, already available, provide filtering with variable cut-offs between 0.01 Hz and 10.0kHz, stop-band attenuation of 48dB/oct. (96dB/oct. in cascade), and pass-band response from dc to 500kHz. Get full details of EF3, the big breakthrough in electronic filtering from

BARR & STROUD LIMITED
1 Pall Mall East, London SW1Y 5AU
Tel: 01-930 1541
Telex: 261877

BARR AND STROUD
Glasgow and London

WW—015 FOR FURTHER DETAILS

XY/t plotter



type PL100

Professionally designed to cater for a wide spectrum of low-frequency measurement and display needs, this British plotter features high-grade, versatile performance at a realistic price.

ALL SOLID STATE ELECTRONICS
TRANSDUCER POWER AND INPUT FACILITIES
PLUG-IN FRONT END FLEXIBILITY

High gain — 1 mV and 1 μA/cm
Differential — 50 μV/cm
Linear Level — 500 μV/cm
Logarithmic — 2 and 5 voltage decades
Time Base — 11 sweep speeds–5 sec 500 mins

Linearity — 0.1%
Repeatability — ±0.1%
Writing Speed — 200 mm/sec

BASIC PLOTTER
£253

Contact us for brochure and demonstration. Prices subject to VAT.

JJ INSTRUMENTS

J.J. Lloyd Instruments Limited
Brook Avenue, Warsash, Southampton SO3 6HP. Tel: Locks Heath 4221
Telex No: 477042 – JAY JAY – SOTON

WW—014 FOR FURTHER DETAILS

Now suitable for U.K., European and American voltages...

Minimod, the versatile British made range of encapsulated power supplies first introduced in 1973, has now been extended to cover European and North American mains voltages (and is interchangeable with most American types). Normally available ex-stock, all units are fully stabilised with fold back current limiting – the 5V models have over voltage crowbar too!

STANDARD MODELS

Type Number	Output Voltage	Output Current Amps	Short Circuit Current mA (Typical)	% Regulation Line and Load (Typical)
PU01	5 ± 0.1	0.5	370	0.3
PU02	5 ± 0.1	1.0	770	0.5
PU03	15–0–15 ± 0.2	0.10	37	0.1
PU04	15–0–15 ± 0.2	0.20	84	0.1
PU05	12–0–12 ± 0.2	0.12	45	0.1
PU06	12–0–12 ± 0.2	0.24	120	0.2

Input voltage ranges 103 - 126V, 200 - 240V. 210 - 250V. Frequency 50 - 400 Hz all types.

Comprehensive specification given in brochure GT 29b which is available on request.

★SPECIAL DESIGN SERVICE

Custom built units for applications requiring different specifications are produced as part of our standard service. Try us first.

Gardners

Specialists in Electronic Transformers & Power Supplies.

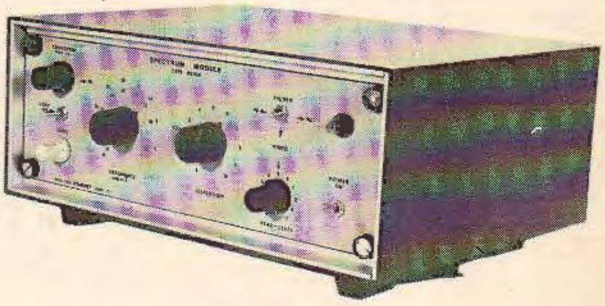
GARDNERS
TRANSFORMERS LIMITED

Gardners Transformers Limited, Christchurch, Dorset, BH23 3PN
Tel. Christchurch 2284 (STD 0201 5 2284) Telex. 41276 GARDNERS XCH

WW—056 FOR FURTHER DETAILS

STARWET

Spectrum Analyser Module ST858



SPECIFICATION: Frequency range 10 MHz to 850 MHz in two calibrated ranges **Sensitivity** Better than 50 mv for 0.5V per cm **Resolution** Better than 25 KHz. **Dispersion** From less than 1 MHz to 400 MHz variable **Input** Via 50 ohm BNC connector on front panel **Output 1** Coax cable for connection to Y input on scope **Output 2** Coax cable for connection to sync. input on scope **Power requirements** 240 volts AC 50 Hz 10 watts. (Other voltages and frequencies available as required) **Size** Width 11in (28cm.) Height 4.375in. (11.2cm.) Depth 8.5in. (21.6cm.) **Nett weight** 7.5lbs (3.4 Kg) **Gross weight** 10lbs (4.5 Kg.)

For further details contact the sole distributors of STARWET equipment:

CHILTMEAD LTD
7–9 ARTHUR ROAD, READING, BERKS
(rear Tech College) Tel. Reading 582605

WW—084 FOR FURTHER DETAILS

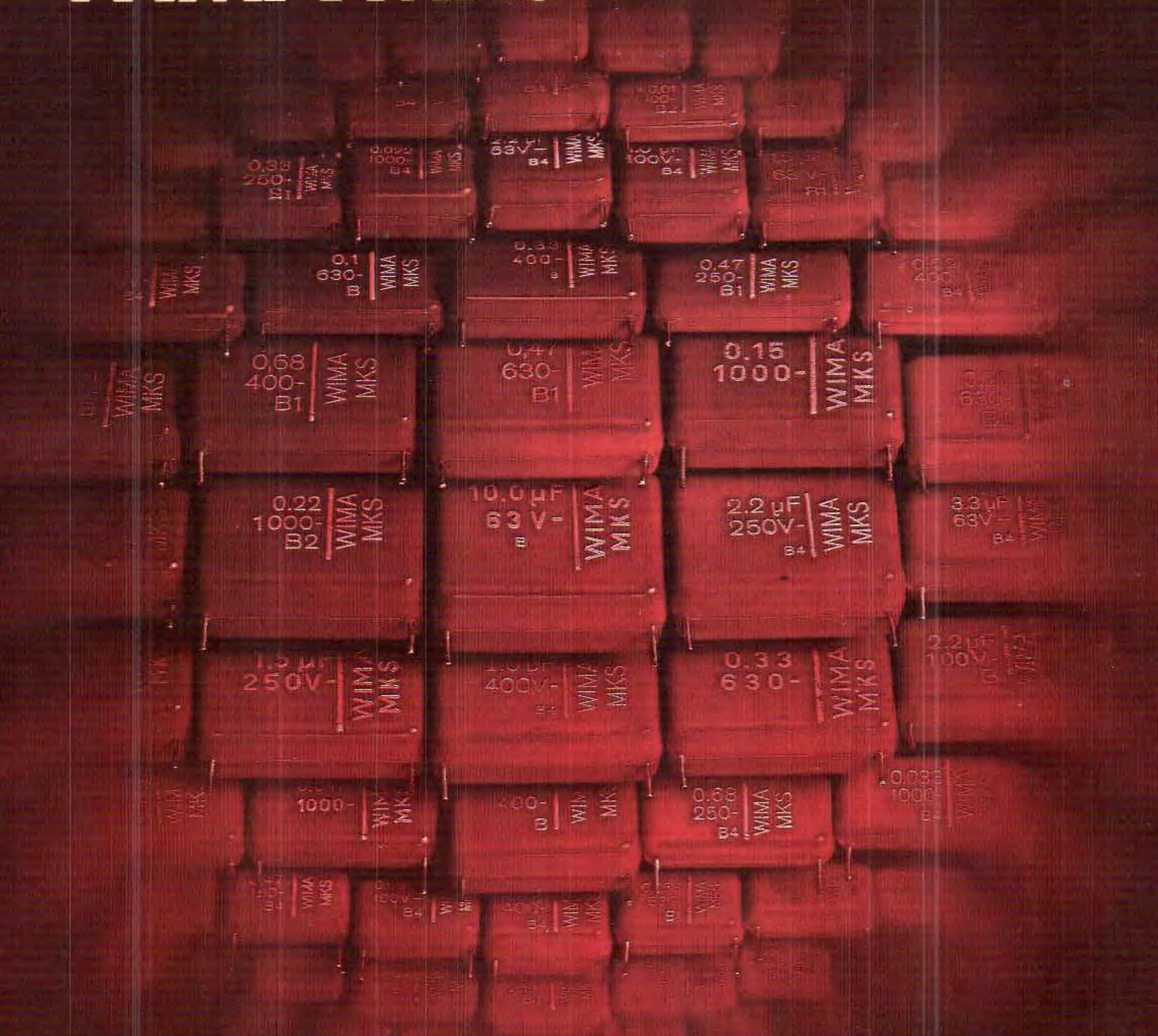
INSIST ON VERSATOWER

Acclaimed as the World's leading telescopic tiltover tower in the field of radio communication
Models from 25' to 120'

Look for the name
STRUMECH
Strumech Engineering Co Ltd
Coppice Side, Brownhills, Walsall, Staffs.

WW—027 FOR FURTHER DETAILS

WIMA® MKS



the complete capacitor range

The electronics industry's standard radial lead metallised polyester capacitor. Designed for all general purpose applications.
63 V.d.c. 0.22 to 10 mfd.
100 V.d.c. 0.01 to 6.8 mfd.
250 V.d.c. 0.01 to 2.2 mfd.
400 V.d.c. 0.01 to 1 mfd.
630 V.d.c. 0.01 to 0.47 mfd.
1000 V.d.c. 0.01 to 0.22 mfd.
Very good delivery.

Wima Capacitors are manufactured by Wilhelm Westermann, West Germany.

WAYCOM LIMITED

Wokingham Road,
Bracknell, Berks RG12 1ND
Tel: Bracknell 22751 Telex: 848402

Hi-fi starts here

The quality of the sound you hear from your hi-fi depends on the quality of transcription from the record–so you won't want to skimp on quality. When you choose your turntable deck, you'll probably choose Garrard.

Fifty-five years of Garrard experience and know-how in producing top-quality record playing equipment is concentrated in the range of record playing units now available. There are three modules complete with attractive bases and lift-off covers, ready-wired for instant installation.

The SP25 Mk IV is the most popular budget unit on the market. It features the famous Garrard four-pole synchronous motor to ensure smooth, constant speeds, the finely engineered pickup arm with resiliently mounted counterbalance weight, calibrated bias compensation and damped cueing.

The 86SB represents just about the best buy in hi-fi today. It incorporates belt drive, the famous Garrard four-pole synchronous motor, high inertia turntable, contoured mat, precision pickup arm with fine stylus force adjustment and bias compensation calibrated for elliptical and conical styli.

The Zero 100SB has every quality feature you could expect to find on a record deck. What makes it truly unique is the tangential tracking pickup arm virtually eliminating tracking error and consequent harmonic distortion. Other features include adjustable, resiliently-mounted, counterbalance weight, fine stylus force adjustment, magnetic bias compensation calibrated for elliptical and conical styli, high inertia turntable with contoured mat, a record counter and the famous Garrard four-pole synchronous motor.

Use the coupon to obtain your free copy of the full-colour brochure on the complete range of Garrard record playing units.

Garrard
A PLESSEY QUALITY PRODUCT

Garrard, Newcastle Street, Swindon, Wiltshire.

Please send me your full-colour brochure describing the famous Garrard range of top-quality hi-fi equipment.

Name

Address

623 P036

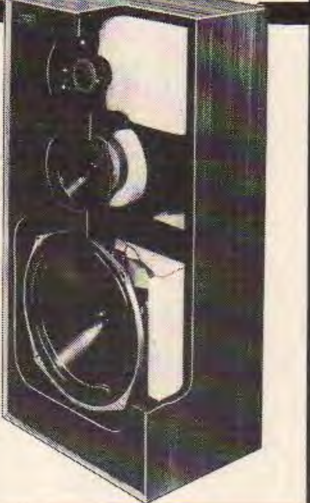
Eliminate TV receiver distortion with Celestion *TELEFI*

TELEFI

At last you can enjoy TV entertainment with the added pleasure of true Hi-Fi sound. Telefi is a unique electronic invention which picks up VHF from the TV and relays this through your own Hi-Fi equipment. Telefi ensures crisp, full-range, distortion-free reproduction of music and speech providing an improvement over ordinary TV sound which will amaze you. Tele-fi is safe and requires no permanent connection to the TV set. Telefi is indispensable to the TV viewer who requires Hi-Fi TV sound.

"As selected for The Design Centre, London".

LOUDSPEAKERS



Celestion Loudspeakers are engineered to the highest standard and provide superlative sound reproduction. The cut-away illustration shows the high, mid and bass speakers used in the Ditton 44 Monitor, one of the most popular loudspeakers available to the discerning listener.

A range of models is available to suit your personal requirements, Celestion Hi-Fi Loudspeakers carry a five-year guarantee.

The Hadleigh loudspeaker, was specially created to meet a public demand for a high quality speaker of compact proportions. Not a difficult task for Celestion who produce the most popular bookshelf speaker ever (Ditton 15) – but we set out not only to produce an immaculate loudspeaker with a sparkling performance, but to do so at a budget price. For the enthusiast seeking a really excellent Hi-Fi system at reasonable outlay we recommend without hesitation the Hadleigh.

Celestion

Loudspeakers for the Perfectionist

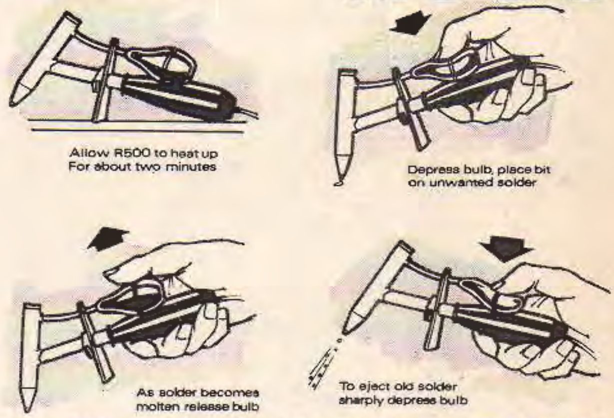
DITTON WORKS, FOXHALL ROAD, IPSWICH, SUFFOLK IP3 8JP.

WW—059 FOR FURTHER DETAILS

From ADCOLA The Highly Successful Electric De-soldering Instrument

R500

SIMPLE TO USE



TEN GOOD REASONS FOR ITS SUCCESS

1. The efficient way of removing unwanted solder
2. Purpose designed not an adaption to a soldering iron
3. No air or vacuum lines
4. One hand operation
5. Robust construction
6. Easy to use
7. Overall design gives clear vision of work
8. Well balanced
9. Trouble free
10. All voltages available

Can you afford NOT to have an **R500?**

ADCOLA PRODUCTS LTD. ADCOLA HOUSE, DEP WW. GAUDEN RD. CLAPHAM SW4 6LH.
REG. No. 442762 VAT. No. 235-6153-72

Please send immediately an R500 De-soldering instrument cheque enclosed for £8·09 plus 10% V.A.T. (postage paid U.K. only) ☐

Please send further details (tick appropriate box) ☐

NAME ____________________

ADDRESS ____________________

To obtain further details of any of the coded items mentioned in the Editorial or Advertisement pages of this issue, please complete one or more of the attached cards entering the reference number(s). Your enquiries will be passed on to the manufacturers concerned and you can expect to hear from them direct in due course. Cards posted from abroad require a stamp. These Service Cards are valid for six months from the date of publication.

Please Use Capital Letters

If you are way down on the circulation list, you may not be getting the information you require from the journal as soon as you should. Why not have your own copy?

To start a one year's subscription, place a tick in the box on one of the postage-free cards opposite and fill in your name and address.

CUT HERE

Postage will be paid by Licensee

Do not affix Postage Stamps if posted in Gt. Britain, Channel Islands or N. Ireland

BUSINESS REPLY SERVICE
Licence No. 12045

2

WIRELESS WORLD,
READER ENQUIRY SERVICE,
429 BRIGHTON ROAD,
SOUTH CROYDON,
SURREY
CR2 9PS

CUT HERE

Enquiry Service for Professional Readers

WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....
WW....	WW....	WW....

WIRELESS WORLD

Wireless World, December 1974

Please arrange for me to receive further details of the products listed, the appropriate reference numbers of which have been entered in the space provided.

Name ....

Name of Company ....

Address ....

....

Telephone Number ....

PUBLISHERS USE ONLY			A/E			

Position in Company ....

Nature of Company/Business ....

No. of employees at this establishment ....

I wish to subscribe to Wireless World ☐

VALID FOR SIX MONTHS ONLY

CUT HERE

Postage will be paid by Licensee

Do not affix Postage Stamps if posted in Gt. Britain, Channel Islands or N. Ireland

BUSINESS REPLY SERVICE
Licence No. 12045

2

WIRELESS WORLD,
READER ENQUIRY SERVICE,
429 BRIGHTON ROAD,
SOUTH CROYDON,
SURREY
CR2 9PS

Enquiry Service for Professional Readers

Wireless World, December 1974

WIRELESS WORLD

WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .

Please arrange for me to receive further details of the products listed, the appropriate reference numbers of which have been entered in the space provided.

Name . . . .

Name of Company . . . .

Address . . . .

. . . .

Telephone Number . . . .

PUBLISHERS USE ONLY			A/E			

Position in Company . . . .

Nature of Company/Business . . . .

No. of employees at this establishment . . . .

I wish to subscribe to Wireless World ☐

VALID FOR SIX MONTHS ONLY

CUT HERE

Do not affix Postage Stamps if posted in Gt. Britain, Channel Islands or N. Ireland

Postage will be paid by Licensee

BUSINESS REPLY SERVICE
Licence No. 12045

2

WIRELESS WORLD,
READER ENQUIRY SERVICE,
429 BRIGHTON ROAD,
SOUTH CROYDON,
SURREY
CR2 9PS

CUT HERE

Enquiry Service for Professional Readers

Wireless World, December 1974

WIRELESS WORLD

WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .
WW	WW	WW . . . .

Please arrange for me to receive further details of the products listed, the appropriate reference numbers of which have been entered in the space provided.

Name . . . .

Name of Company . . . .

Address . . . .

. . . .

Telephone Number . . . .

PUBLISHERS USE ONLY			A/E			

Position in Company . . . .

Nature of Company/Business . . . .

No. of employees at this establishment . . . .

I wish to subscribe to Wireless World ☐

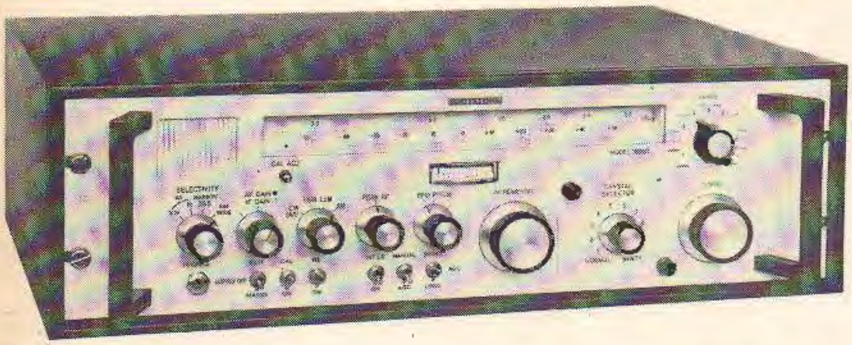
VALID FOR SIX MONTHS ONLY

CUT HERE

Eddystone Radio

Economy! Simplicity! Reliability!

1830 Series C.W, M.C.W, A.M, S.S.B



- Crystal controlled
- Transistorized HF/MF general purpose receiver
- 120 kHz – 30 MHz in 9 ranges
- Rack mounting as standard
- Cabinet optional extra
- AC or battery operation
- British MPT approved as ships reserve receiver

Illustrated brochure from:

Eddystone Radio Limited

Alvechurch Road, Birmingham B31 3PP. Tel: 021-475 2231. Telex 337081.

A member of Marconi Communication Systems Ltd

LTD/ED105

WW—017 FOR FURTHER DETAILS

CONVERTERS

VOLTAGE TO FREQUENCY
FREQUENCY TO VOLTAGE

* All ANCOM converters have built-in reference sources
* Linearity and stability, factory specified
* Negative or Positive input types
* Floating output
* Applications, A-D conversion
  Precision Integrators
  Telemetry of analogue signals
  Shaft rotation etc.
* Auxiliary modules
  Telemetry amplifiers
  Clock modules

BRITISH MADE
QUICK DELIVERY

ancom

DEVONSHIRE STREET
CHELTENHAM, ENGLAND
☎ 0242 53861 or 24690

WW—091 FOR FURTHER DETAILS

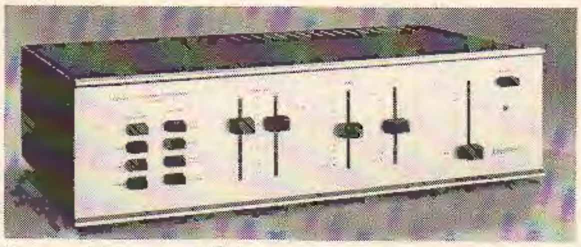
WW—053 FOR FURTHER DETAILS

WW—092 FOR FURTHER DETAILS

WW—067 FOR FURTHER DETAILS

A NEW STANDARD FOR SOUND REPRODUCTION

HD250 High Definition Stereo Control Amplifier



Designed for disc and tuner input and two tape machines, with complete recording and reproducing facilities.

The HD250 amplifier establishes a new standard in amplifiers for sound reproduction in the home. Improvements have been made in respect of performance, engineering design and quality of construction. We believe that no other amplifier in the world can match the overall specification of the HD250. Look at extracts from the specification below.

Power output.

Rated:	50 watts average continuous power per channel, into any impedance from 4 to 8 ohms, both channels driven.
Maximum:	90 watts average power per channel into 5 ohms load.

Distortion.

Pre-amplifier:	Virtually zero. (Typically below noise of measuring instrument.)
Power amplifier. at rated output:	Less than 0.02% (typically 0.01% at 1kHz).
at 25w output:	Typically 0.006%.

Overload margin.

Disc input	40 dB min.

Hum and noise output.

Disc:	—83dBV Measured flat with noise bandwidth of 23kHz.
	—88dBV Measured with 'A' weighted characteristic.
Line:	—85dBV Measured flat.
	—88dBV 'A' weighted.
Size:	17 inches × $4\frac{3}{4}$ inches × 11 inches deep overall.
Weight:	21 lb.

Write or phone for leaflet which describes the design philosophy and conception of the HD250 together with a complete specification.

RADFORD AUDIO LIMITED, BRISTOL, BS3 2HZ Telephone: 0272 662301

WW—060 FOR FURTHER DETAILS

ARISTON ~ Olympic performance

'ARISTON' was a word used sparingly by the ancient Greeks, in their eternal search for the best in all things. Following classic example, the name Ariston Audio is associated exclusively with the finest in sound reproduction. We take pride in presenting the latest results of our own search.

CLASSIC PERFORMANCE —The Ariston RD11 Transcription Deck

PERFECT PARTNER— (shown here) The Ariston AT1007 Tone Arm

ARISTOCRATIC COMPANY— The Ariston HS100 Headset

Please send me your FREE illustrated brochure, including specifications and prices for the outstanding Ariston Audio range

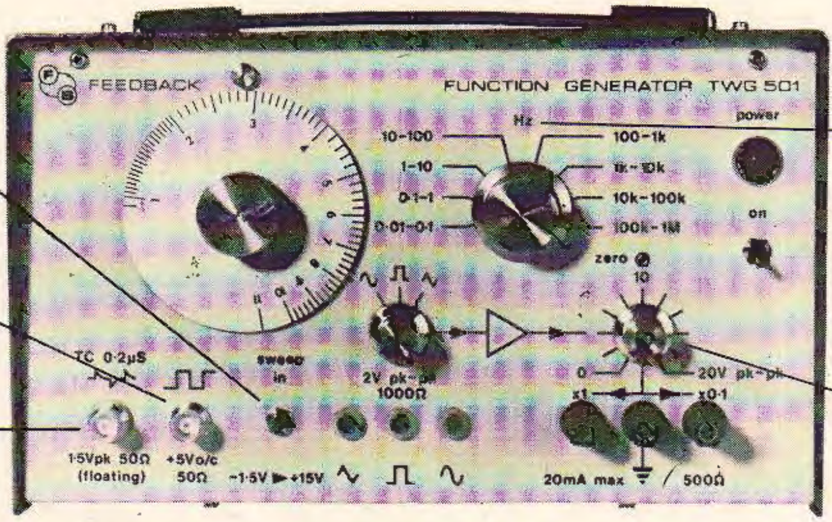
To: **ARISTON AUDIO Ltd.**
(Dept. WW)
P.O. BOX 13,
IRVINE KA12 8JL
SCOTLAND
Tel: 0294 75211 Telex: 779103

This is why the TWG 501 performs the function of a good generator

Voltage control sweep 1 decade linear 4 decades exponential

Fast rise time square < 15ns with current sinking capacity for 5 TTL loads.

Trigger pulse



Frequency range 0.009Hz to 1.1MHZ

DC offset ±2V on X1 output

All seven outputs are simultaneously available with amplitudes constant over frequency range

Size: 254 x 121 x 157mm
Wt: 2.2kg

FEEDBACK INSTRUMENTS LTD Crowborough, Sussex. Tel: Crowborough (089-26) 3322

Icon Design

Electronic Design Specialists

NOW you can build our LUXURY F.M. STEREO TUNER Complete

(see W.W. APRIL/MAY 1974)

As announced in advance last month, we can now offer a complete kit to build this superb design. The cabinet and chassis kit now available are up to the same high original design standards as the circuit design, and the same high quality of materials has been used. The metal work is in rustproof cadnium plated steel sheet, fully drilled and prepared. The front panel is in two tone gold and brown brushed anodised finish, while the drop over cabinet is made from high grade solid wood, finished in a light satin gloss varnish. The net result is a tuner of the very highest standards of performance and appearance.

Kits now available		Price	Postage
K1-4	All parts to build the main receiver board	£24·95	30p
K5-7	Complete stereo decoder with anti-birdy filters	£9·95	30p
K8	A 4 way push button assembly for the function switching	£3·45	10p
K9	A 6 way pre-select push button unit, gold plated contacts, cermet trim-pots, P.C. Board with meter drive circuitry	£14·14	10p
K10	A regulated power supply including mains transformer (210-250v)	£5·82	30p
K11	Complete cabinet/metalwork set as described, including all plugs and sockets, mains lead, nuts and bolts, wire, etc.	£25·00	50p
Meter	An edgwise meter with frequency calibration to suit K9	£6·50	20p
K1-11	All above parts, package price	£85·00	50p

PLEASE ADD V.A.T. TO TOTAL

Other individual parts available include the SL301B, SL3045, SBA750, MC1310P, Filter SFG10.7MA, etc. Also individual K1-7 prices available, other parts may be quoted on request. All parts and performance are guaranteed. Send a S.A.E. (9 × 4 preferred) for further details to :—

Icon Design 33, Restrop View, Purton, WILTS SN5 9DG

COUTANT 'L' SERIES

. . . more variable power than ever before with 16 types available from stock

With the addition of the new LQT Twin Unit power supply, offering double the voltage range, the Coutant 'L' Series is ideally suited for the wide range of laboratory and general applications where continuously variable high performance power is essential.

LB SERIES
LB 200: 0 to 50V @ 0 to 2A
LB 500: 0 to 30V @ 0 to 5A
LB 1,000: 0 to 15V @ 0 to 10A
PRICE £109.00

LA SERIES
LA 100 : 0 to 50V @ 0 to 1A
LA 200 : 0 to 30V @ 0 to 2A
LA 400 : 0 to 15V @ 0 to 4A
PRICE £74.00

LAB SERIES
LAB 100 : 0 to 50V @ 0 to 1A
LAB 200 : 0 to 30V @ 0 to 2A
LAB 400 : 0 to 15V @ 0 to 4A
PRICE £48.00

LQT SERIES
LQT 100 : 0 to ± 30V @ 0 to 1A x 2
or 0 to ± 30V @ 0 to 1A with slave O/P tracking master
or 0 to 30V @ 0 to 2A
or 0 to 60V @ 0 to 1A
LQT 200 : 0 to ± 15V @ 0 to 2A x 2
or 0 to ± 15V @ 0 to 2A with slave O/P tracking Master
or 0 to 15V @ 0 to 4A
or 0 to 30V @ 2A
PRICE £92.00

LQ SERIES
LQ 50: 0 to 50V @ 0 to 0·5A
LQ 100: 0 to 30V @ 0 to 1A
LQ 200: 0 to 15V @ 0 to 2A
PRICE £42.00

LM SERIES
LM 50: 0 to 30V @ 0 to 0·5A
LM 100: 0 to 15V @ 0 to 1A
PRICE £34.00

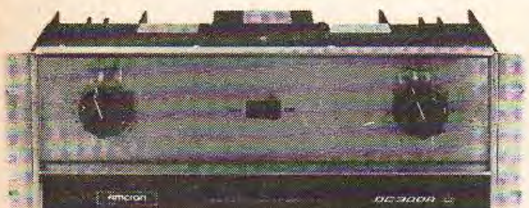
Ask today for further details

Coutant Electronics Limited
Trafford Road, Reading RG1 8JR
Tel: 0734 55391 Telex 847519

Coutant take the initiative in new technology

WW—102 FOR FURTHER DETAILS

HIGH POWER DC-COUPLED AMPLIFIER



- ★ **UP TO 500 WATTS RMS FROM ONE CHANNEL**
- ★ **DC-COUPLED THROUGHOUT**
- ★ **OPERATES INTO LOADS AS LOW AS 1 OHM**
- ★ **FULLY PROTECTED AGAINST SHORT CCT, MISMATCH, ETC.**
- ★ **3 YEAR WARRANTY ON PARTS AND LABOUR**

The DC300A Power Amplifier is the successor to the world famous DC300 which is so widely used in Industrial, and Research applications in this country. It is DC-coupled throughout so providing a power bandwidth from DC to over 20,000Hz. The ability of the DC300A to operate without fuss into totally reactive loads while delivering its full power, and maintaining its faithful reproduction of Pulse or complex waveforms has established the DC300A as the world's leading power amplifier. Each of the two channels will operate into loads as low as 1 ohm, and the amplifier can be rapidly connected as a single ended amplifier providing over 650 watts RMS into a 4 ohms load, and still providing a bandwidth down to DC. Below is a brief specification of the DC300A, but if you require a data sheet, or a demonstration of this fine equipment please let us know.

Power Bandwidth	DC-20kHz @ 150 watts + 1db, − 0db.
Power at clip point (1 chan)	500 watts rms into 2.5 ohms
Phase Response	+0, −15' DC to 20kHz, 1 watt 8Ω
Harmonic Distortion	Below 0.05% DC to 20kHz
Intermod. Distortion	Below 0.05% 0.01 watt to 150 watts
Damping Factor	Greater than 200 DC to 1kHz at 8Ω
Hum & Noise (20-20kHz)	At least 110db below 150 watts
Slewing Rate	8 volts per microsecond
Load impedance	1 ohm to infinity
Input sensitivity	1.75 V for 150 watts into 8Ω
Input Impedance	10K ohms to 100K ohms
Protection	Short, mismatch & open cct. protection
Power supply	120-256V, 50-400Hz
Dimensions	19" Rackmount, 7" High, 9½" Deep

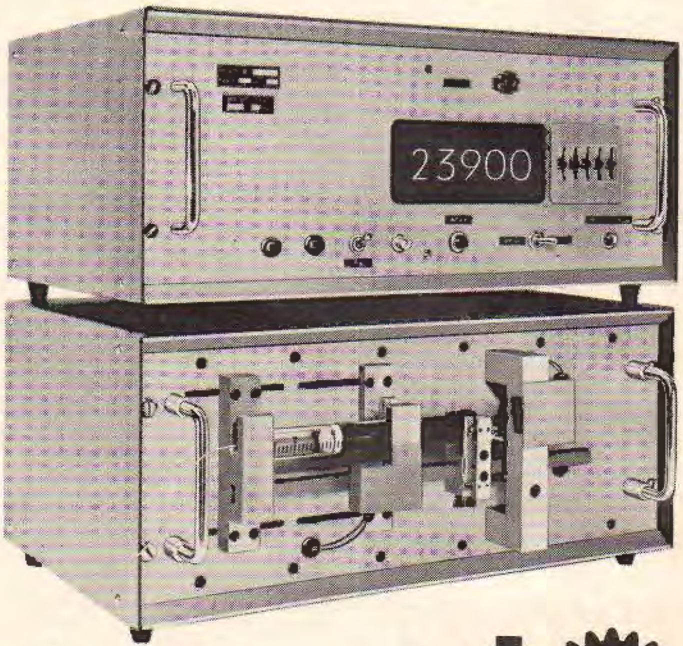
Other models in the range: D60 — 60 watts per channel D150 — 150 watts per channel

MACINNES LABORATORIES LTD
MACINNES HOUSE, CARLTON PARK INDUSTRIAL ESTATE, SAXMUNDHAM, SUFFOLK IP17 2NL
TEL: (0728) 2262 2615

WW—098 FOR FURTHER DETAILS

Digitize that Fluid Input

McLennan Engineering are pioneering in the field of digitized liquid delivery. The equipment illustrated is suitable for medical, veterinary, chemical and general laboratory applications.



DIGITAL SYRINGE TYPE DS110
Fluid pulse 1·0 or 10 micro litres
Number of pulses presettable from 1–50,000
Pulse rate 400Hz–1 Hz or ·01 Hz in the case of frequency divider model
Digital 'fluid delivered' display monitors output at all times
External B.C.D. signals can programme the number of pulses
Remote multiple syringe facility
High reliability. Drive designed around Impex stepper motor system.

OTHER ITEMS MANUFACTURED BY McLENNAN ENGINEERING INCLUDE:
Digital and analogue servo systems
Peristatic pumps
Process and machine tool control equipment
Custom-built gearheads and actuator mechanisms
Precision potentiometer drives.

If you have a problem in any of the above fields we shall be pleased to discuss your special requirements. Please get in touch – it costs nothing to talk.

McLennan Engineering Ltd.
CONTROL SYSTEMS AND COMPONENTS
Kings Road Crowthorne Berkshire
Telephone: Crowthorne 5757/8.

WW—101 FOR FURTHER DETAILS

ERA

when reliability and quality count

Suppliers of Television Valves, Picture Tubes, Industrial and Transmitting Tubes to the Electronic Industry.
Available Ex Stock at advantageous prices.
Enquiries from
Agents and Importers welcome.

EDICRON LIMITED

Redan House, 1 Redan Place, London W2 4SA
Telephone: 01-727 0091/2 Telex: 265531
Cables: Edicron London W2

WW—081 FOR FURTHER DETAILS

COLOUR TELEVISION SERVICING

GORDON J. KING,

RTechEng, MIPRE, FSRE, MRTS, FISTC

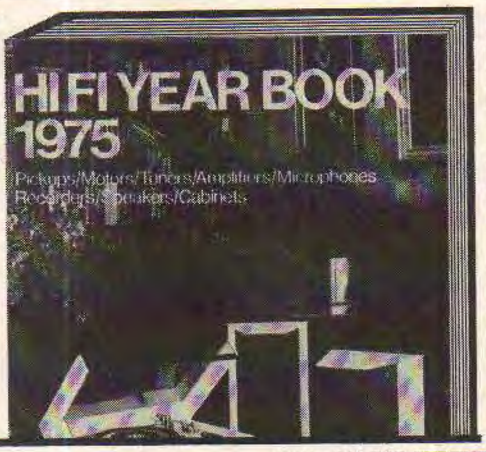
This comprehensive book deals straightforwardly with the servicing of PAL receivers, using a minimum of mathematics.

It is divided into three sections: the first surveys the colour TV system as a whole, the second studies the elements involved (e.g. picture tubes, conveyance systems, chroma channels) and the third is devoted exclusively to servicing.

0 408 00044 9 328 pages illustrated 1971
£4.40

NEWNES-BUTTERWORTH
Borough Green, Sevenoaks, Kent TN15 8PH

THE WHO, WHAT AND WHERE OF HI-FI



In the search for quality it helps to know where to look. Hi-Fi Year Book tells you everything you need to know, with separate illustrated sections for every major category, giving you prices and specifications of over 2,000 products. And it's got directories of dealers and manufacturers – plus a host of articles on the latest hi-fi developments and their application. So if you want information like you want hi-fi, order your copy today because it sells out pretty quickly! £2.00 inclusive from the publishers.

HI-FI YEAR BOOK 1975

ORDER FORM:

To: Room 11, IPC Electrical-Electronic Press Ltd., Dorset House, Stamford Street, London SE1 9LU.

Please send me .... copy/copies of Hi-Fi Year Book 1975 at £2.00 per copy inclusive.

I enclose remittance of £..

(cheque/P.O. payable to IPC Business Press Ltd).

NAME..
(please print)
ADDRESS..

....

....

Registered in England No. 677128
Regd. Office Dorset House, Stamford Street, London SE1 9LU

WW—044 FOR FURTHER DETAILS

Principles and Calculations for Radio Mechanics Part 1

R. A. Bravery and A. P. Gilbert

Part of the Radio, Television and Electronics Servicing Series, this volume deals with the subject matter for Part 1 of the City and Guilds Radio Mechanics Course 222.

1974 152 pp., illustrated 0 408 00119 4 £1.50

Rapid Servicing of Transistor Equipment 2nd Edition

Gordon J. King

This completely revised second edition takes account of recent developments such as capacitor-diodes, f.e.t.s and integrated circuits.

1973 180pp., illustrated 0 408 00116 X £1.90

Robotics

John F. Young

The object of this book is to present a comprehensive and orderly account of the principles and practice of robotics. It will provide a valuable sonrce of reference for research workers and those in related fields.

1973 304 pp., illustrated 0 408 70522 2 £6.00

Obtainable through any bookseller or from

NEWNES-BUTTERWORTH

Borough Green, Sevenoaks, Kent TN15 8PH. Tel. Borough Green 2247.

MORE AND BETTER PROGRAMMES FROM YOUR TV/HI-FI by Turning Your Aerial TO THE DISTANT STATIONS OR FOR LESS BACKGROUND

By simply dialling the direction, new programmes may be yours or in some areas you may get the choice of two or more different commercial TV stations.

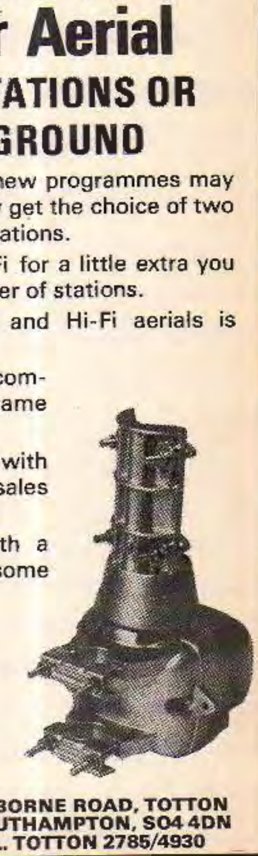
If you spend £100s on your Hi-Fi for a little extra you may improve the quality and number of stations.

The **AR30** for normal-sized TV and Hi-Fi aerials is **£27.65.**

For large or stacked aerials, we recommend the **AR40**, using the same control unit, **£32.95.**

Buy direct from us, the importer with the experience and the after-sales service.

Despatched by SECURICOR with a 24-hour delivery (48 hours some parts of Scotland).



S.M.C. LTD OSBORNE ROAD, TOTTON SOUTHAMPTON, SO4 4DN TEL. TOTTON 2785/4930

WW—097 FOR FURTHER DETAILS

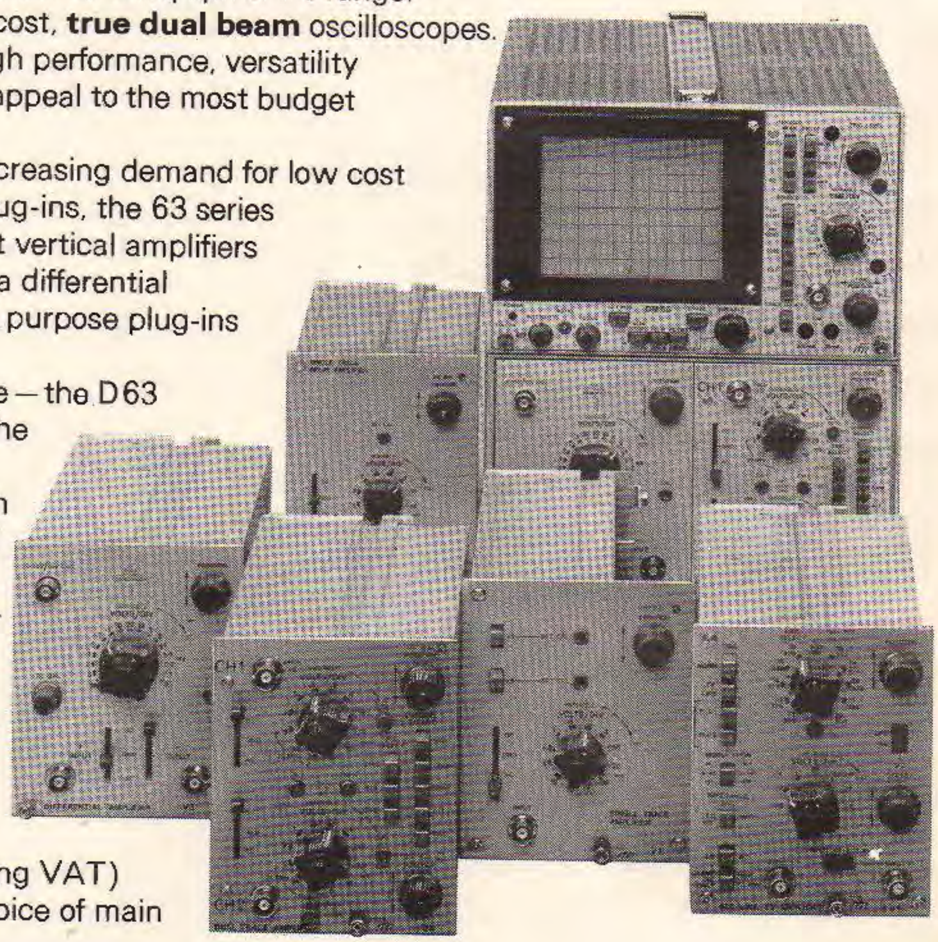
WW—099 FOR FURTHER DETAILS

It's New
It's Versatile
It's from Telequipment

Yes indeed !, yet another addition to Telequipment's range. This time it's a series of low cost, **true dual beam** oscilloscopes. Setting new standards for high performance, versatility and value, the 63 series will appeal to the most budget conscious of organisations.

Designed to meet the ever increasing demand for low cost 15 MHz oscilloscopes with plug-ins, the 63 series offers the choice of 5 different vertical amplifiers which include a TV monitor, a differential amplifier and 15 MHz general purpose plug-ins with or without signal delay.

Two main frames are available – the D63 with a conventional c.r.t., or the DM 63 fitted with a variable persistence storage tube, both accepting any combination of two from the five vertical plug-ins available. These plug-ins cover a wide range of requirements in single, dual and four channel operation, in addition to X-Y applications requiring low phase-shift characteristics.



UK provisional prices (excluding VAT) £310–£665 depending on choice of main frame and plug-ins.

Write now for details and find out the full scope of Telequipment's 63 series. You won't be disappointed.

Telequipment gives you more scope for your budget

TELEQUIPMENT

Tektronix U.K. Ltd.,
Beaverton House, P.O. Box 69,
Harpenden, Herts.
Telephone: Harpenden 63141
Telex: 25559

Sales and Service throughout the world

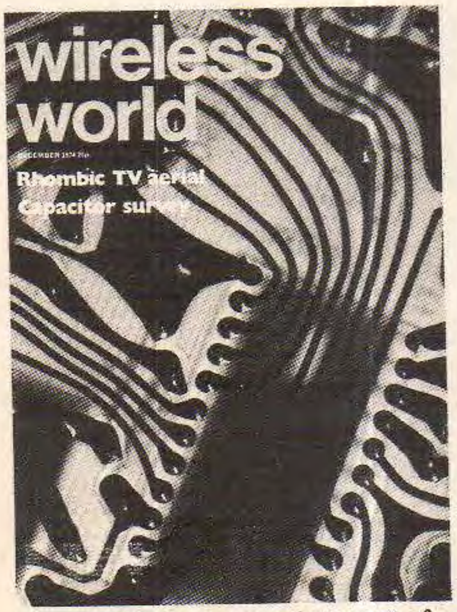
TQ15 10/74

wireless world

Electronics, Television, Radio, Audio

DECEMBER 1974 Vol 80 No 1468

SIXTY-FOURTH YEAR OF PUBLICATION



This month's front cover shows part of a printed circuit of Sphericall, a Pye TMC l.s.i. device for push-button telephone dialling.
(Photographer Paul Brierley)

Contents

IN OUR NEXT ISSUE
(published December 18)

Electronics and oil. An inside view of the communications, telemetry and navigational aids used in drilling for North Sea oil

Silent switch for stereo-pair comparisons. Construction of an f.e.t. electronic switch that meets stringent requirements

ibpa
International Business Press Associates

I.P.C. Electrical-Electronic Press Ltd
Managing Director: George Fowkes
Administration Director: George H. Mansell
Publisher: Gordon Henderson

Price 25p (Back numbers 50p)
Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.
Telephones: Editorial 01-261 8620; Advertising 01-261 8339.
Telegrams/Telex, Wiworld Bisnespres 25137 London. Cables, "Ethaworld, London S.E.1."
Subscription rates: 1 year, £5 UK and overseas ($13 USA and Canada), 3 years, £14 UK and overseas ($36 USA and Canada). Student rates: 1 year, £2.50 UK and overseas ($6.50 USA and Canada), 3 years, £7 UK and overseas ($18.20 USA and Canada).
Distribution: 40 Bowling Green Lane, London EC1R 0NE. Telephone 01-837 3636.
Subscriptions: Oakfield House, Perrymount Rd, Haywards Heath, Sussex RH16 3DH. Telephone 0444 53281
Subscribers are requested to notify a change of address four weeks in advance and to return envelope bearing previous address.

When flashover is the danger. Use EEV spark gaps.

Photograph courtesy of C.E.G.B.

You name it. EEV spark gaps can stop it from happening.

Our range covers any voltage from 400-40,000V and handles powers up to 15 kilo joules. Types are available in glass or ceramic envelopes.

EEV spark gaps are very rugged and will work in any environment, unaffected by dust, damp or atmospheric changes. They are also compact, consistently dependable and long-lasting.

We make 2-electrode and 3-electrode types, and the whole range covers many applications including:

Flash-over protection. Crowbar protection circuits. Protection from transient phenomena. Protection circuitry for s/c drives for thermionic tubes.

Capacitor discharge circuits. Firing circuits. Relaxation oscillator circuits for gas ignition equipment. Quench circuits. TIG welding equipment.

For data and any help you need, write or 'phone EEV at the address below.

Right, GXQ400, a crowbar protection device and GXU40, for protection circuits in ground/air communications equipment.

LAP 93

EEV and M-OV know how.

THE M-O VALVE CO LTD, Hammersmith, London, England W6 7PE. Tel: 01-603 3431. Telex: 234356. Grams: Thermionic London.
ENGLISH ELECTRIC VALVE CO LTD, Chelmsford, Essex, England CM1 2QU. Tel: 0245 61777. Telex: 99103. Grams: Enelectico Chelmsford.

GEC

WW—007 FOR FURTHER DETAILS

wireless world

New directions in sound

In the April 1958 issue we commented that the results of demonstrations of the new stereo discs were "practically indistinguishable from the master . . .". Such a test has been applied on numerous occasions when demonstrating two-channel quadraphonic (which we take to mean surround sound using four loudspeakers) systems. Inventors of these systems deserve credit for their technical achievement in being able to mount A-B comparisons between four-track master tapes and their two-channel-processed versions; some of them are very effective. But is comparison with the master tape the best test of a system's capabilities?

Two things suggest it isn't. One is the relative inability of the master to do a good job in the first place. Acute sensitivity to listener position and—as Michael Gerzon points out in this issue—the instability of phantom images make one query the use of pan-potted masters as the starting point.

Possibly more important is compatibility. Whatever the quality of quadraphonic performance, records must have stereo and mono compatibility. Differences between two-channel systems, for instance, really amount to differing priorities as to the relative quality of mono, stereo and quadraphonic reproduction. And much of the current debate on the relative merits of systems could be settled once it has been agreed whose interests to give what weight to. No one body in the record industry appears to have accepted responsibility for doing this.

This issue may well be settled by the broadcasters. Weighing the interests of a minority against those of a majority is something broadcast authorities ought to be used to. Given that a two-channel quadraphonic system must be perfectly mono compatible (not only because the majority of receivers in use are mono, but imperfect mono compatibility is a much more serious thing than stereo compatibility), one problem that poses itself is: how much degradation of the stereo image is going to be acceptable, in the interests of a limited quadraphonic audience?

This question is implicit in the detailed NQRC study*, now in progress. Another question being studied, fundamental to choosing a surround-sound system, is the effect of the number of transmission channels on quadraphonic performance—"directional fidelity" in particular. This is clearly of utmost importance in broadcasting, if only because it affects the magnitude of quality loss that must occur in delivering a compatible service.

What engineers should concern themselves with, it seems to us, is providing the best possible method of conveying sound direction, within the constraint of a limited number of channels, commensurate with agreed priorities in compatibility. (Given such a means, decisions about whether to use the medium for drama, ambience portrayal, pan-potted material or special effects such as "overhead" sound, then become the province of others.)

This is basically what Nippon Columbia Co have been doing in developing their new UD-4 system, with Peter Fellgett's NRDC-backed UK group thinking along the same lines but emphasizing a microphone technique that collects ambience in a uniform way.

It will be interesting to see how the NQRC weigh the various priorities and how relevant their priority mix, and hence their conclusion, is to other countries.

---

*See page 458, November issue.

Charge-coupled devices

1—Introduction, early device structure and operation

by Ted Williams

Royal Radar Establishment

Charge-coupled devices, which consist of chains of charge-storage elements along which charge packets are transferred, are already turning out to be the most significant advance in electronics since development of m.o.s. circuits. Usually associated with imaging in solid-state cameras, their unique performance characteristics, small size and high yield will produce far-reaching effects on signal processing techniques and in digital memories. After the four or five years since inception, advanced signal processors and memories are about to leave the drawing board. What gives the c.c.d. this position is discussed in a series of articles written by two leading authorities in the UK. This article describes operation of simple devices; a second article will outline fabrication processes and modifications to improve performance. Later articles will discuss applications.

The charge-coupled device has aroused considerable interest ever since it was first conceived and tested in 1970.[1] Since then the interest has never slackened. This is borne out by the rapid commercial development of the c.c.d.

1973—first device offered for sale by Fairchild

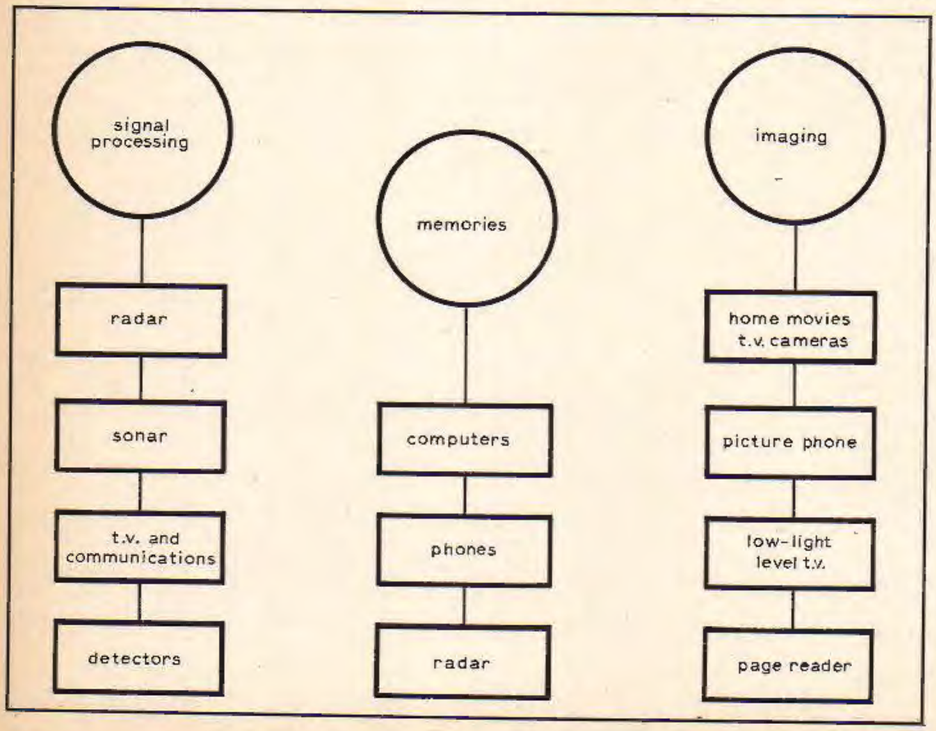
1973—successfully built into simulated radar systems

1974—c.c.d. TV camera became available; and

1974—first complete signal processing system expected on the market.

Complete systems rather than individual devices will be offered for sale because of their much higher profit potential. Nowadays, many products, of which the pocket calculator is one example, are being built as complete systems by one manufacturer. Selling devices no longer makes big profits unless you have cheap labour; and in Europe and America labour is not cheap. The profit expected from the c.c.d. systems business is enormous. One American estimate[2] predicts that the annual systems business will be worth over £100 million.

This optimism explains why the Americans have put so much effort into c.c.ds. In 1973, for example, the manpower effort at companies like Texas Instruments and Fairchild was built up to an extremely large team of scientists and engineers. With so many people working on c.c.ds the chances of success are very high. There is little doubt that in the seventies the way to succeed with a promising new device is to put big teams to work on it.



There are three reasons why there has been so much interest in c.c.ds:

- Cheap technology makes them very competitive.
- Flexibility: analogue, digital, and optical signals can be handled.
- Applications are extensive (see chart).

Fig. 1 compares the c.c.d. shift register element to the previous generations of m.o.s. and bipolar devices. From this it is clear that the c.c.d. *element* is much simpler and consequently much cheaper because no diffusions are required. This absence of diffusions also makes integrated circuit design much easier and, in particular, very cheap high area density arrays can be produced.

A second article will show how this basic technology does have some disadvantages, and how some process innovations have been adopted which overcome these problems. But to understand the basic operation this article is restricted to the first technology that was developed for the c.c.d. In spite of its limitations, this is still used for some of the simpler applications.

These basic applications, together with some of the more sophisticated systems applications, especially imaging, signal processing and memories, will form the subject of further articles.

Device structure

Anyone who is familiar with the metal-oxide-silicon transistor will have no difficulty in understanding the device structure and operation of a c.c.d., because

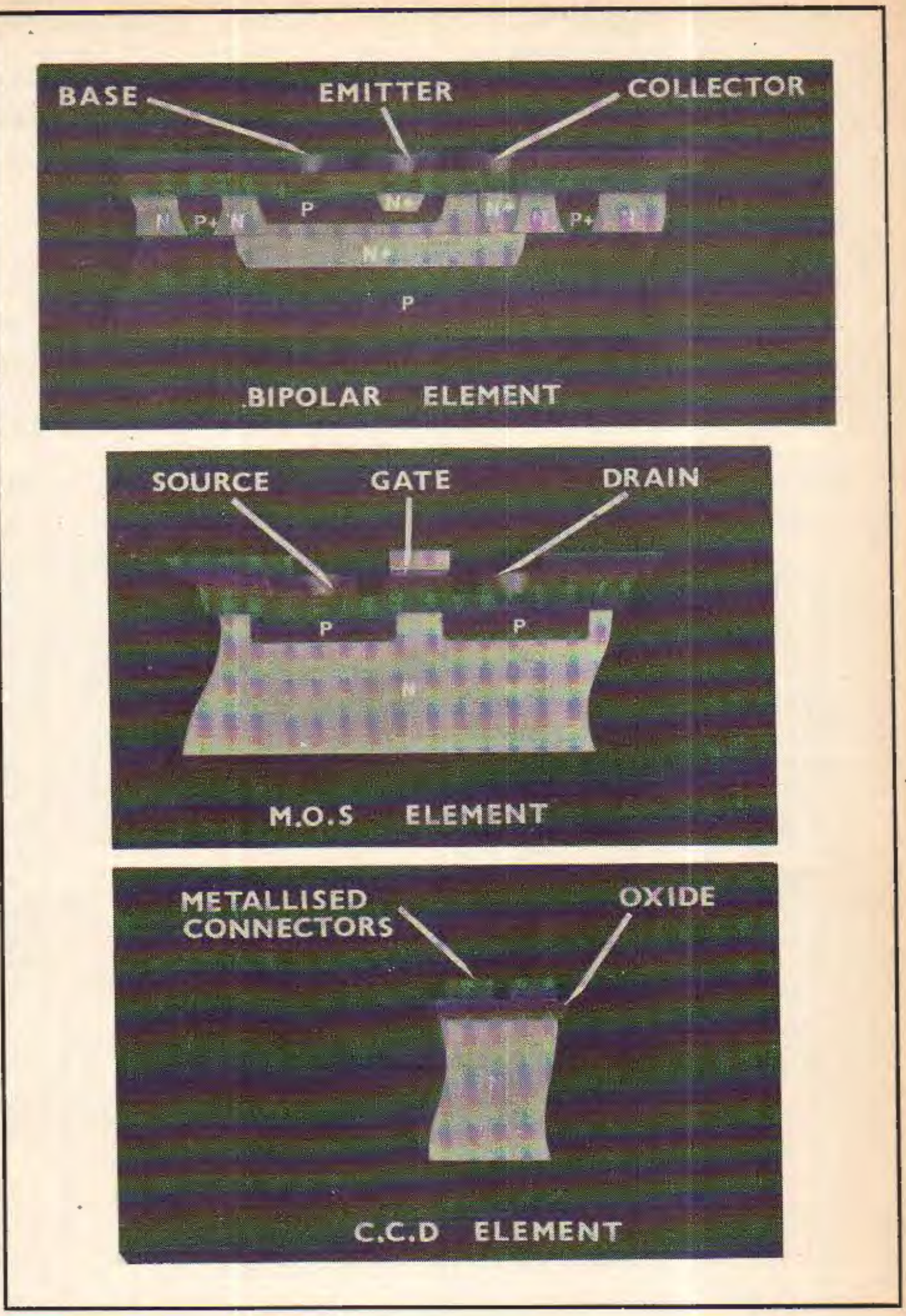


Fig. 1. Comparison of the c.c.d. shift register element with m.o.s. and bipolar elements.

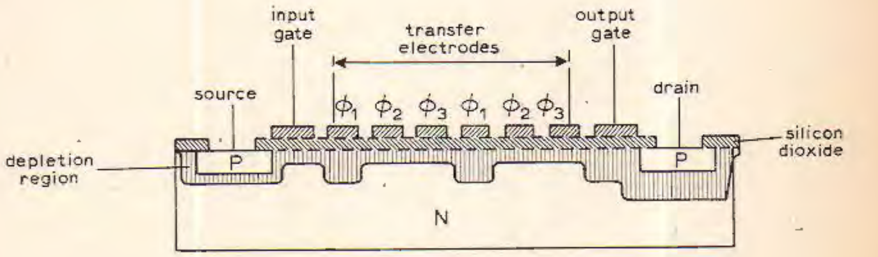


Fig. 2. Cross-section of a complete two-bit p-channel c.c.d.

it can be thought of as a multi-gate m.o.s. transistor.

Fig. 2 shows the structure of a basic two-bit, p-channel, c.c.d. shift register. The silicon semiconductor substrate is doped n-type (with electrons as the majority carriers and holes as the minority carriers), whereas the source and drain diffusions are p-type (with holes as the majority carriers and electrons as the minority carriers). The oxide, or more correctly the silicon dioxide, which is grown on top of the silicon substrate is about 150nm thick; and the aluminium, which makes up the contacts to the source, drain, the input gate, output gate, and the transfer electrodes, is 200nm thick.

A negative-voltage reverse bias is applied via a load resistor to the drain diffusion. This bias makes the drain a sink for holes and a barrier to electrons. Holes are injected from the earthed source diffusion to the surface under the first transfer electrode ϕ_1 by switching on the negative input gate voltage at the same time as the first clock transfer electrode negative voltage pulse. The time sequence of the input gate pulse and the clock pulses is shown in Fig. 3. This shows that as soon as the second phase voltage is switched on, ϕ_1 is reduced to zero in a time defined as the overlap time t.

During t, the charge under ϕ_1 will be transferred to the surface under ϕ_2. Similarly when ϕ_2 begins to turn off, ϕ_3 is turned on and the charge is transferred under ϕ_3. Then ϕ_1 is switched on again and the charge moves under ϕ_1 for the second time. At this point in time the charge has now shifted through one bit or three phases of the device. Referring back to Fig. 2, at the end of the second complete shift, or bit, the charge is transferred into the drain—the output of the device. The final charge transfer is accomplished either by switching on the output gate in phase with ϕ_3 or by leaving a permanent negative d.c. bias on the output gate.

Fig. 4 shows a top-view photograph of a complete eight-bit p-channel c.c.d. made at the Royal Radar Establishment. Comparing this with Fig. 2 makes it easy to identify the source and drain diffusions, the input and output gate, and the transfer gates. The three-phase clock lines are linked together to minimize the number of contact pads and to facilitate the production of a complete depletion region right across the device as shown in Fig. 2. (Production of a depletion region is discussed later.) The oblong-shaped, heavily doped n-type channel stop diffusion prevents holes diffusing out from the transfer electrodes to the contact pads. Total device area or chip size was 1mm^2, and the transfer electrode size was 12μm long (in the transfer directions) by 300μm wide with a gap between the electrodes of 2.5μm.

Digital operation

Digital operation of a p-channel device is illustrated in Fig. 5. This shows the input signal applied as a square pulse to the input gate with the source earthed. The pulse generator which provides the input pulse is triggered by the clock generator through a divider board to give a "one" pulse in phase with ϕ_1 followed by a series of n zeros. The output is studied by connecting an oscilloscope to the drain. The accompanying table shows typical operating voltages for a p-channel device.

Fig. 6(a) shows the digital output from a 64-bit device. The value of n used for

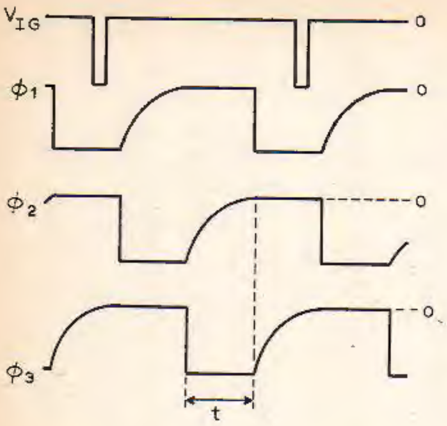
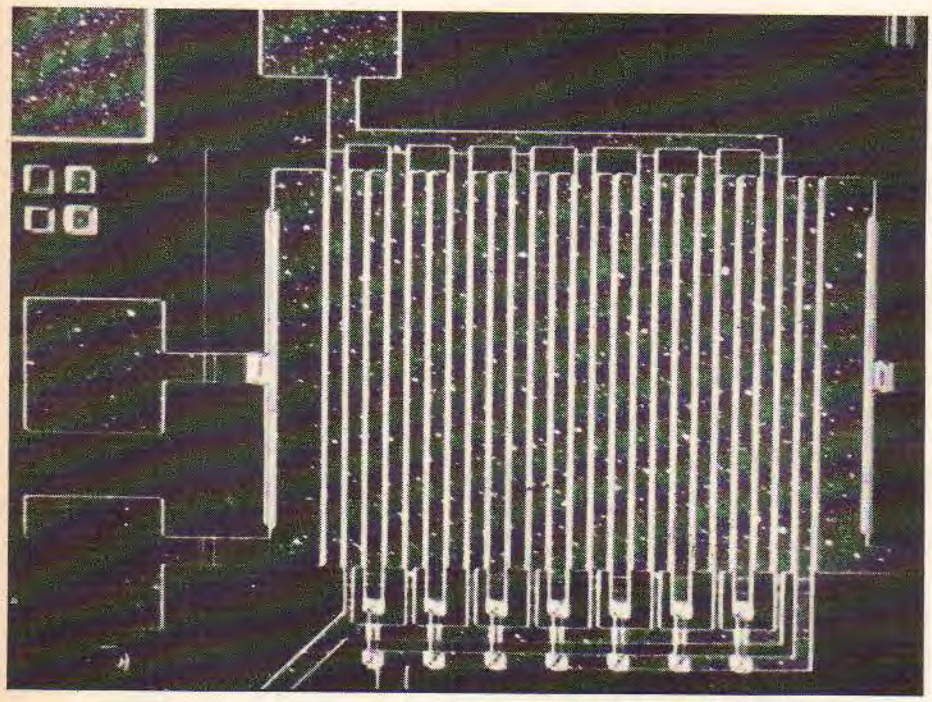
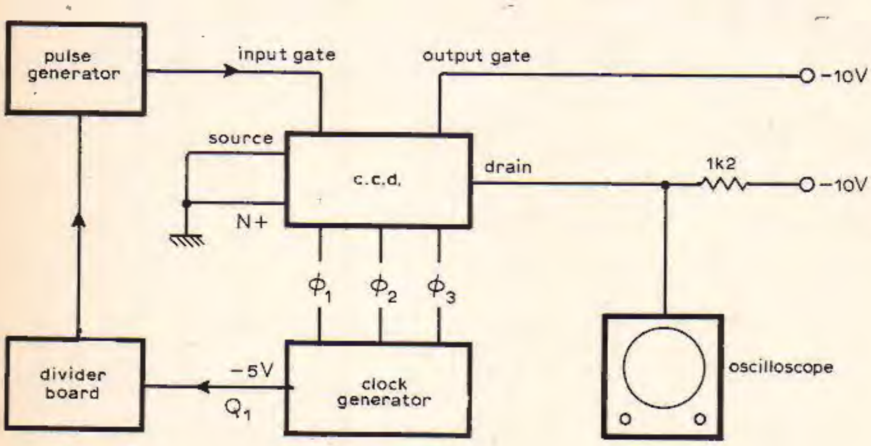


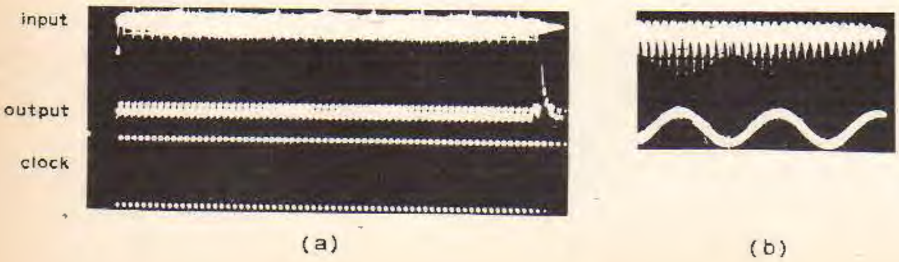
TABLE Digital operating conditions for an eight-bit p-channel c.c.d*

Clock frequency	20kHz to 5MHz
Source	earthed
Input gate, V_{IG}	−4.4V
Output gate, V_{OG}	−6V
Clock voltages ϕ_1, ϕ_2, ϕ_3	−30V
Drain bias	−10V
Drain load	1.2kΩ

*Silicon substrate, *n*-type, 50 ohm cm, and <100> orientation







the input gate pulse was 128 and equal to twice the number of bits in the device. The clock phase voltage pulse is also shown. The output pulse is shown delayed by 64 time intervals—bits ("range bins" in radar terminology)—from the input gate, square wave digital pulse.

Analogue operation

Fig. 6(b) top shows a sinusoidal analogue signal input that was applied to the same 64-bit p-channel device whose digital operation was shown in Fig. 6(a). In this case the analogue signal is applied via a capacitor to a negatively biased source diffusion as illustrated in Fig. 7. As with digital operation shown in Fig. 5, the channel stop diffnsion is earthed. But in the analogue case the input gate has a d.c. bias of about −5V. The outpnt is observed on an oscilloscope connected via a capacitor to the drain. The bottom part of Fig. 6(b) shows the delayed time quantized output of the analogue signal.

More details will be given abont the operation and the nse of the c.c.d. as an analogue delay line in a later article when radar applications are discussed.

Digital testing

Testing new devices for c.c.d. action is normally carried out digitally. The same circuit that was used in Fig. 5 to show digital operation can also be used for digital testing. Using this test set-up the digital characteristic of the device can be rapidly obtained by plotting the output from the drain, V_{OUT}, as a function of the input gate voltage, V_{IG}, for a series of constant values of the d.c. voltage applied to the output gate, V_{OG}. Fig 8 shows the transfer characteristic for the eight-bit device pictured in Fig. 3. As the inpnt gate voltage is gradually increased a critical voltage is reached at which the devices switch on and this critical voltage is called V_T, the threshold voltage of the device. For the device shown in Fig. 8 V_T was −3.8V; V_{OG} must also be set above this voltage, V_T, or the device will not operate. As V_{IG} is increased above V_T the output increases until V_S, the saturation voltage, is reached. Above V_S no further increase in output occurs; V_S does not vary for output gate voltages above V_T. The output from the drain does vary with the output gate voltage and for

Fig. 3. Input gate and the clock pulse time sequence; t is the overlap between clock phases.

Fig. 4. Eight-bit p-channel c.c.d. made at RRE.

Fig. 5. Digital test set-up for a p-channel c.c.d.

Fig. 6. Digital input and delayed output from a 64-bit c.c.d. compared to clock waveform, (a). Analogue input and output for the same device, (b). Note that analogue output is quantized in time.

the device shown it reaches a maximum for output gate voltages in the range −6 to −8V.

Understanding the threshold voltage

To understand the threshold voltage consider what happens when a voltage is applied to the metal gate electrode of an m.o.s. structure, Fig. 9(a) shows a plot of the charge density $\rho(x)$ against distance x through a cross-section of an m.o.s. structure without any voltage applied to the gate, that is $V_G = 0$. The semiconductor is n-type and the interface between the semiconductor and the oxide occurs at $x = 0$ on the diagram. The charge trapped at the surface states, Q_{SS}, is shown schematically as a block of positive charge of density, $\rho(x)$, lying on the oxide side of the semiconductor-oxide interface. This is because the majority of these surface states come from positive ions in the oxide and the maximum number of these ions are found just inside the oxide. Just as in a capacitor, when you apply a positive voltage or charge to one plate of the capacitor, an equal and opposite charge is induced on the other plate, so when a positive charge is present on one side of the semiconductor–oxide interface an equal and opposite negative charge must balance it on the other side of the interface. In the last case, as shown in Fig. 7(a), Q_{SS} is balanced by Q_A, a contribution of negative charge (electrons) from the n-type semiconductor in which the electrons are the majority carrier. The Q_A charge is referred to as the accumulation layer because it builds up or accumulates as the surface state charge increases in the oxide during and just after the growth of the oxide on the semiconductor. Under accumulation conditions:

$$Q_{SS} + Q_A = 0, (\text{for } V_G = 0).$$

Now, to move on to what happens when a negative voltage is applied to the gate. As this negative voltage increases, the electrons in the accumulation layer are repelled and gradually the accumulation layer is lost. Further increase in negative gate voltage after the disappearance of the accumulation layer results in further negative charge being repelled from the semiconductor-oxide interface. This produces a depletion region, as shown in Fig. 9(b). Charge Q_D due to the depletion region is shown as positive because it has resulted from the removal of electron majority carriers. The depletion region is depleted of all charge —both electrons and holes. (The depletion region in an operating c.c.d. normally extends all the way from the source to the drain, see Fig. 2.)

Further increase in the negative gate voltage results in attraction of positive holes to the interface. The surface of the silicon has now changed from being dominated by electrons as in Fig. 9(a) to one dominated by holes and is therefore said to have inverted from an n-type surface to a p-type one. Holes can now pass along this p surface channel. Hence an m.o.s. device, or in particular a c.c.d., that is produced on an n-type semiconductor is called a p-channel device. The size of the

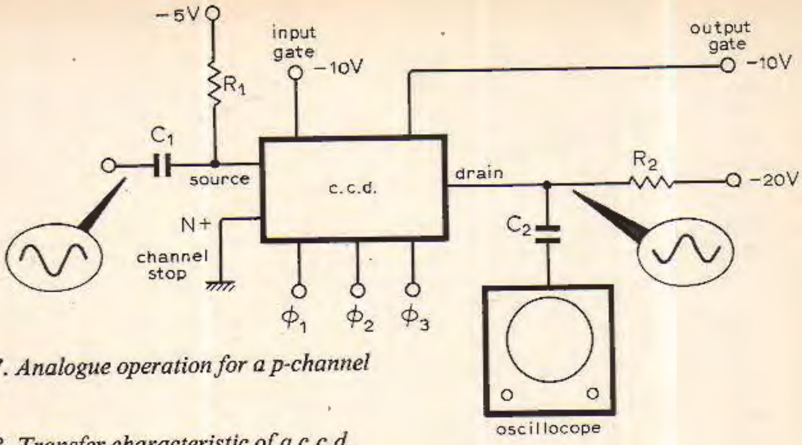
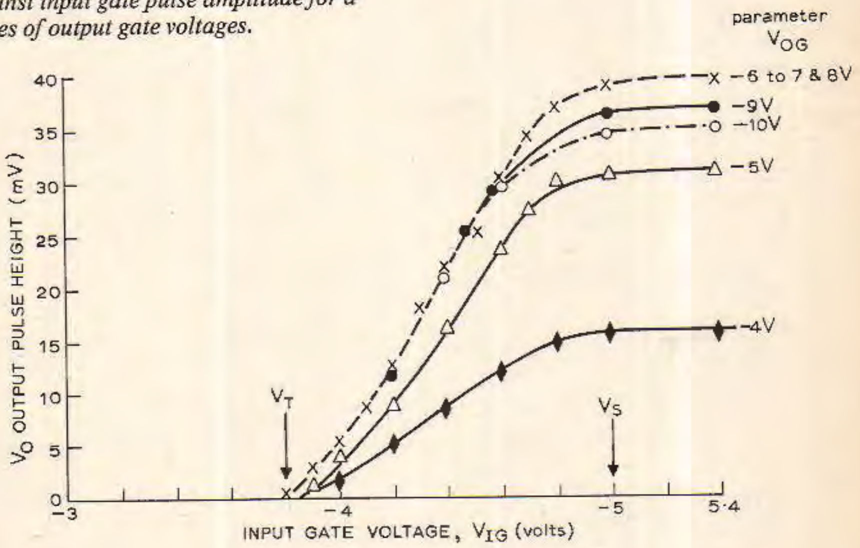


Fig. 7. Analogue operation for a p-channel c.c.d.

Fig. 8. Transfer characteristic of a c.c.d. Output voltage from drain is plotted against input gate pulse amplitude for a series of output gate voltages.



gate voltage determines the hole density in the channel region and so this means that the gate voltage controls or gates the channel current.

The threshold voltage, V_T, is the voltage required to produce inversion or current flow in the channel. It is usually defined as the voltage required to produce a current flow of 1µA, because it is well above the leakage current (or noise) levels which are usually of the order of nanoamperes. V_T for a p-channel c.c.d. normally lies in the region of 1.8 to 4.0V. For n-channel devices, however, the threshold is usually below a volt and a second article will show how the properties of n- and p-channel c.c.ds compare.

Surface states

Surface states act as traps for electrous and holes travelling along the surface of the semiconductor and they have a large effect on the operation of a surface channel c.c.d., such as the one described previously.

Surface states arise in many different ways. Some of the major causes of surface states are:

- —impurity ions in the oxide
- —defects at the semiconductor surface due to impurities, or defects in the crystal structure of the semiconductor, or a combination of both
- —absorbed impurities on the surface of the semiconductor.

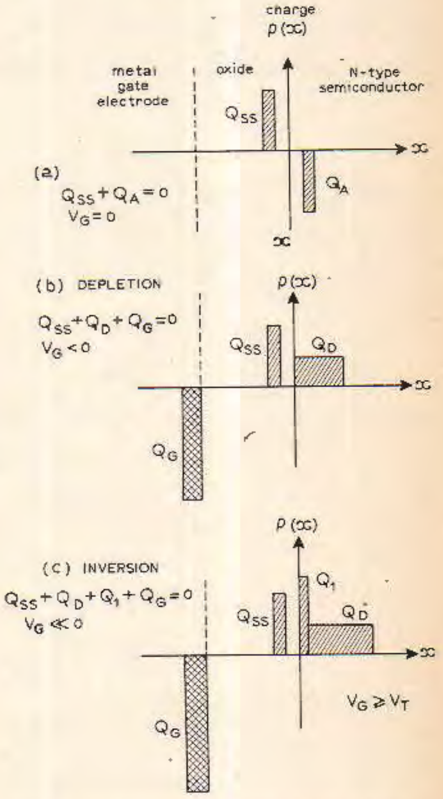


Fig. 9. Schematic diagram of the charge distribution in an m.o.s. structure for three cases: (a) zero volts on the gate, (b) depletion, and (c) inversion.

The surface states which arise from positively charged impurity ions such as sodium in the oxide are known to be the major cause of surface states in the case of c.c.d. Some of these ions are trapped at the surface when the oxide is grown on the semiconductor during c.c.d. manufacture. Others remain in the oxide very close to the interface, and then the charges trapped on these states drift to the surface when the device is switched on. The negative voltage that is applied to the gate drives the positive charge to the interface, and the time taken by the charge to move to the interface is usually seconds or minutes so these surface states are referred to as slow states. Slow surface states can often be observed in poor-quality devices. A certain warm-up time of a few minutes is required before the device reaches a maximum due to the electron trapping of these slow states. Once the trapping slows down to its equilibrium level the device reaches a maximum.

Fast surface states are those which can trap charge in a few milliseconds or less. These fast states arise from all the three sources discussed above and they control to a large extent the high frequency limit of operation of the device.

Charge transfer efficiency

The transfer efficiency gives a measure of the efficiency of charge transfer in c.c.d. It is the most critical parameter and much more important than the threshold voltage.

The charge transfer efficiency is defined as the fraction of the charge transferred when a charge packet moves from under one clock transfer gate electrode to the next. Charge loss can be considered as having two contributions:

—the fractional charge lost during the transfer across the gap between the electrodes, q_T (or α)

the fractional charge left behind under the electrode, the so-called residual charge, q_R (or ϵ).

The charge transfer efficiency, η_T, can therefore be written as

$\eta_T = (q_n/q_{n-1})100 = (1 - q_T - q_R)$, 100%, where q_n is the charge under the nth electrode and q_{n-1} is the charge under the $n-1$ electrode. The fractional charge lost during transfer, q_T, depends on

—surface state density

—width of the gap between the transfer electrodes

—strength of the input signal; that is, the amount of charge injected into the device from the source

—speed of transfer or the frequency of operation of the device.

The residual charge, q_R, is a function of the above and also on the length of the transfer electrode.

For optimum transfer efficiency q_R and q_T must be minimized. Only when the transfer efficiency is high enough will the c.c.d. meet the stringent requirements of most of the systems applications for imaging and radar.

To minimize both q_R and q_T the surface state density must be kept as small as possible by using careful selection of the silicon material that is used for the devices and the silicon processing that is carried out. A second article will outline some of these processing techniques and also discuss the buried-channel c.c.d. in which the charge transfer is carried out under the surface of the silicon so that surface states are avoided altogether.

For the surface-channel device, the gap width must be kept to 3μm or below to give a reasonable transfer efficiency and must be maintained across the device. In addition, if the gap can be made less than 1μm and the electrode size can be kept to 10μm or below, operation in the frequency range 1 to 10MHz becomes very efficient. New surface-channel technologies have been developed to produce very-small-gap and gapless devices and will be discussed in a later article.

The input signal strength is very important when considering operating efficiencies. If it is too small, the transfer efficiency is very low because surface state trapping dominates. For this reason most c.c.ds are operated in the fat zero mode.

In this mode a constant trickle of charge or level of channel current is maintained either by not allowing the input gate voltage to go below V_T, or by exposure of the whole of the device to a constant light level so that a small number of carriers are optically generated in the channel. Of these two, the first is most commonly used where the signal is superposed on the small channel current provided by the offset d.c. bias on the input gate.

Signal strength must also not be too large and should be kept well away from output level saturation. This is because near saturation, thermally generated carriers and any fluctuations in device geometry, can result in the overflow of carriers from a potential well under one transfer electrode to an adjoining well. As a result the signal is smeared out and, in the case of analogue operation in particular, vital information can be lost.

Dependence of transfer efficiency on signal strength is clearly illustrated in Fig. 10 where the full line shows the transfer efficiency plotted against the voltage on the input gate. (The dashed line shows the output voltage seen on the oscilloscope using the circuit shown in Fig. 5, also plotted against the input gate voltage.) The centre of the flat plateau of constant transfer efficiency coincides with half the maximum output signal and this represents the optimum working condition.

Transfer efficiency values shown in Fig. 10 were measured with a scanning light-spot technique[3]. This method is only one of several different measurement techniques[3,4] that have been used for measuring transfer efficiency. The trailing pulse technique is the simplest of these. In this case the ratio of output pulse to the next ϕ_1 trailing pulse is used to calculate the transfer efficiency. This technique has the advantage that it needs no extra equipment and can be easily calculated at the same time as a new device is being tested.

In the same way, none of the sophisticated technologies that have been developed for the c.c.d. is perfect for a wide range of conditions. But the currently available technologies to be described in another article do improve the potential of the c.c.d. and make it look a very attractive proposition for many applications.

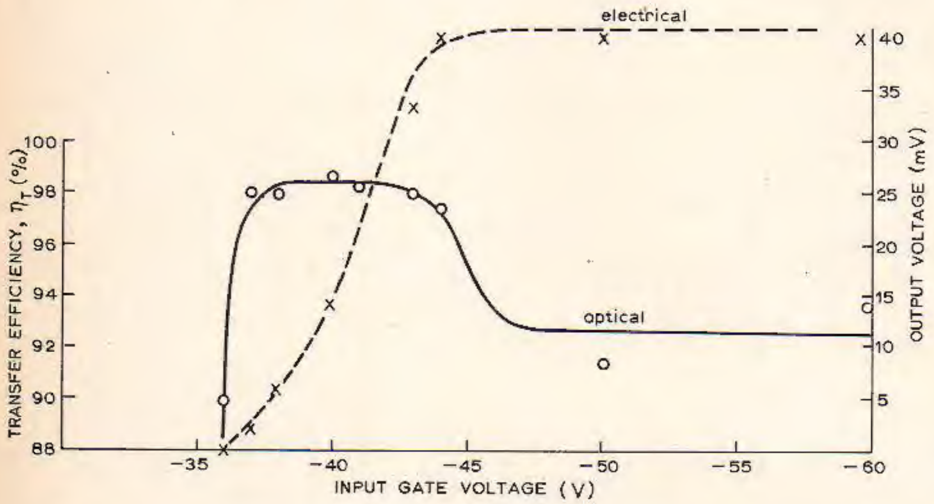


Fig. 10. Variation of optical transfer efficiency with voltage on input gate for an eight-bit p-channel device. Dashed line shows electrical transfer characteristic for the same device.

Acknowledgement This article is published with the permission of the director of RRE. Figs. 2, 3, 4 and 8 appeared in an article published by the Institute of Physics in *J Phy D*, August 1974.

References

1. Boyle, W. S. and Smith, G. E., *Bell Systems Tech J*, vol. 49, 1970, p. 587. Amelio, G. F., Tompsett, M. F. and Smith, G. E., *Bell Systems Tech J*, vol. 49, 1970, p. 593.
2. Gilder, J. H., *Electronic Design*, vol 25, December 6, 1973, p. 32.
3. Williams, E. W., *et al. J Phys D: Appl Phys*, vol. 7, 1974, L4.
4. Brodersen, R. W., *et al. CCD Applications Conference*, San Diego, 1973, p. 169. Vanstone, *et al. Solid-State Electronics*, to be published.

Rhombic u.h.f. TV aerial

Design for loft installation uses coaxial-to-wire impedance conversion device

by A. B. Starks-Field, B.Sc., M.I.E.E.

The account which follows was triggered by a chain of circumstances that originated in the motor industry. Because of the increasing level of ignition interference from many of the modern cars (manufacturers, please note!) the time came when I had to do something about the picture on my 17-year-old home-constructed 45MHz television receiver.

A preliminary examination showed that the flywheel synchronizer locking was no longer able to cope. Because of the set's age I decided to pension it off in favour of a 600MHz receiver, and this in turn raised the question of whether to build or to buy. Being preoccupied with other matters, I decided to buy and put up with the inferior sound reproduction.

The choice of aerial was the next query to raise its ugly head, and I say "ugly" advisedly, becanse a roof-top Yagi is not a thiug of beauty; neither is it cheap, particularly if one has to pay someone to erect it. The alternative was a loft antenna of some kind; this was attractive, for although I have reached the years of discretion when roof-clambering has lost its savour, I am still agile enough to reach the loft where I have a power point and can work in comparative comfort. The indoor aerial has the further advantages of being protected from wind and weather and there are no swaying feeders ultimately to break.

The next question was, which type to use? My local (booster) BBC station radiates a horizontally polarized signal and (according to a field-strength contour map) provides better than 10mV per metre in my area. There are, however, notorious "holes" in the district and, taking this and the opacity of the roof into consideration, I judged that I should need an aerial of some significant gain and directivity; but what?

In my amateur days (G6YG) in the late 1930s my particular pipedream was to have a shack at the hub of a set of rhombics all pointing in the most useful directions. This remained only a dream because of the relatively small garden space available, but the desire to use a rhombic has always remained. Well, why not do so? The loft is large enough to accommodate one about 11 wavelengths long and pointing towards the local BBC and IBA stations.

According to Terman[1], if a rhombic has legs of six wavelengths each it has a gain of 65 times (approximately 18dB) and a horizontal beamwidth null-to-null of about 22°, and about twice this in the vertical direction. Yes, this should be satisfactory for my requirement and because of its lack of resonant components it performs reasonably well to less than half its optimum frequency, so there is no bandwidth limitation.

However, we are not there yet. We always thought of rhombics as terminated with a 600Ω resistor and using a parallel wire feeder of 600Ω characteristic impedance (c.i.). The television receiver would be required to work with a 70Ω c.i. cable and in any case a 600Ω c.i. feeder would be a difficult one to accommodate up the walls and into the loft. A further point is that at this impedance, using 18swg wire, the required spacing is of the order of four inches which is a significant part of a wavelength and so the feeder is likely to receive or radiate. No, some form of coaxial-to-wire impedance conversion was required.

The first thing which came to mind, rather reluctantly because of its resonant quality, was a quarter-wave matching section. Calculation indicates that if one wishes to match 70Ω to 600Ω the c.i. of the matching section has to be about 200Ω. Looking up the spacing indicated in the *W.W.* Radio Charts for this impedance one finds that it is very small, as shown roughly to scale in Fig. 1.

Now at 600Ω c.i. the spacing of 18swg wires (as has already been said) is of the order of four inches and the quarter-wave matching section requires to be about $6\frac{3}{4}$in long, with the result shown in Fig. 2. The wires connecting the matching section to the 600Ω line—which may, in fact, be the start of the rhombic aerial—are a significant length in terms of a wavelength, so that this scheme clearly will not work. Are there then any other ways of achieving this transition?

Going back to amateur days again, Fig. 3 shows a very popular aerial which we used to call a Y-matched dipole. The significant feature about this one is that the 600Ω feeder was brought to a point below the aerial where it then spread out to two points A and B, where connection was made to a half-wave radiator.

The selection of points A and B are such that the aerial presents an impedance which corresponds to the c.i. of the feeder wires at the spacing of AB, probably something of the order of 1000Ω. The Y section is thus a flared transition between the 600Ω line and 1000Ω and because of the continuous gradation of c.i. does not produce a mismatch and therefore no standing waves. As this form of matching works from 600Ω to 1000Ω, then it seemed to me that in principle it should also be effective from 70Ω to 600Ω.

I have no doubt that some of my mathematically minded colleagues could produce a rigorous proof, but for the moment let me suggest a mechanism whereby a true impedance transformation is effected and at least gives an approach for the mathematician. Fig. 4 shows a series of lumped elements of part of the transition where C_1 represents the capacitance per unit length and L_1 the inductance per unit length before the flare. C_2, L_2, C_3, L_3, etc., are all parts of the flare where C_n progressively becomes less as the flare progresses while L_n pro-

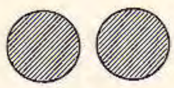


Fig. 1. Wire spacing for 200Ω characteristic impedance.

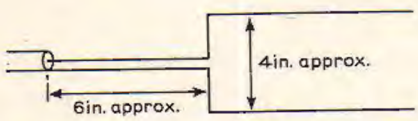


Fig. 2. Matching a 70Ω coaxial cable to a 600Ω wire feeder; the spread is significant compared with the wavelength.

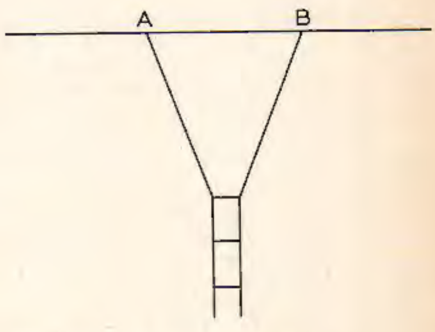


Fig. 3. The Y-matched dipole.

gressively increases. One can imagine an established current in L_1 charging C_1 at the expense of the magnetic energy in L_1. As the voltage builds up in C_1 current starts to flow in L_2 which in turn starts to fill C_2. This is the basic process of the running wave. Now since C_2 is less than C_1 and L_2 is greater than L_1 they will pass the same amount of power at higher voltage and less current. Likewise with C_3 and L_3, so that as the wave progresses it will acquire more voltage and less current. By the time it reaches the 600Ω spacing of the flare the impedance transformation will be complete and the wave may be launched in a 600Ω line. This, of course, is not the whole story because if the flare is short compared with a wavelength it does not work. Mathematicians, please note that I think the transition must at least be $\frac{1}{4}\lambda$ and preferably longer but I have made no attempt to prove it. Of course, this sort of transition must take place on the rhombic aerial itself as the wires spread out, but more of this later. The above is, of course, argued in terms of transmission but the reverse is true in reception.

Thinking in practical terms, then, what sort of flare is needed from the 70Ω coaxial cable? Without fussing about minimum size it appeared to me that the desirable arrangement would be first to arrange a transition from the semi-solid dielectric coaxial cable to a convenient diameter of airspaced coaxial, followed by some sort of graded transition to an open-wire line. This is because nature has decreed that enormous spacings are required to produce a coaxial of c.i. higher than 150Ω and negligible spacings are required for an open-wire line of the same impedance. The simplest way to do this was to taper the polythene inner insulation down to zero thickness and at the same time to flare the outer in some way to the diameter corresponding to about 150Ω c.i. From this point onwards the flare would be cut away to a tapered point where it would be joined to one wire of the rhombic. The inner would, of course, be extended to join the other wire.

I discussed this with a colleague and, jointly, we arrived at the design shown in Fig. 5. We then each built a rhombic and its transition into our respective lofts. I should add that my collaborator is in a locally notorious signal-strength "hole", where even diffracted signals are loth to reach.

The flare of the transition is made of pieces of copper foil cut to form a cone which has a diameter of 0.6in at about 4in from the start. Beyond this the copper cone is cut away in a gentle curve to a point about 10in from the start. (Provided that sharp discontinuities are avoided, the dimensions are not critical.) The polythene inner insulation of the coaxial cable is tapered down to zero thickness at about 2in from the start of the cone; thereafter, the bare wire emerges to a suitable anchoring point (see later). The wire should run through the middle of the cone, but it was found that this requirement is not ultra-critical (a 10% deviation either way made no significant difference) and the wire is sufficiently self-supporting to remain *in situ* without spacers. The complete device is mounted on a Perspex cradle which keeps the structure rigid and provides means of anchorage for the connections. As already stated, one end of the rhombic is connected to the end of the tapered copper cone, while the other end connects to the central bare wire. My colleague, being more finished-product-conscious than I am, decided to fit a connector at the coaxial end, whereas mine is simply joined directly to the down-lead to the receiver. Fig. 6 is a photograph of his version.

The next problem was how to check it and see if it would work. We had available to us a Rohde and Schwarz Polyskop which covered the frequency range up to 1000MHz and is a combined frequency sweep generator and cathode-ray display. Basically this instrument feeds the output terminal from a high impedance source, measures the voltage amplitude of the signal at this point and displays the result against a timebase synchronized with the frequency sweep. Thus it can measure the effective impedance of any device connected to its output.

We therefore decided to connect a short length of coaxial cable to our flare, terminating it with a 560Ω resistor, and in effect measure the input impedance of the coaxial cable. Over the range of freqnencies where the termination is correct, the Polyskop trace shonld be level, and if not, the trace should show a series of undulations where the frequencies corresponded to those at which the cable is a multiple of quarter-wavelengths long. As would be expected at low frequencies the standing

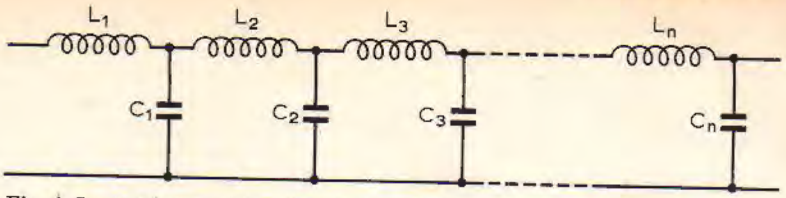


Fig. 4. Lumped constant representation of a transmission line.

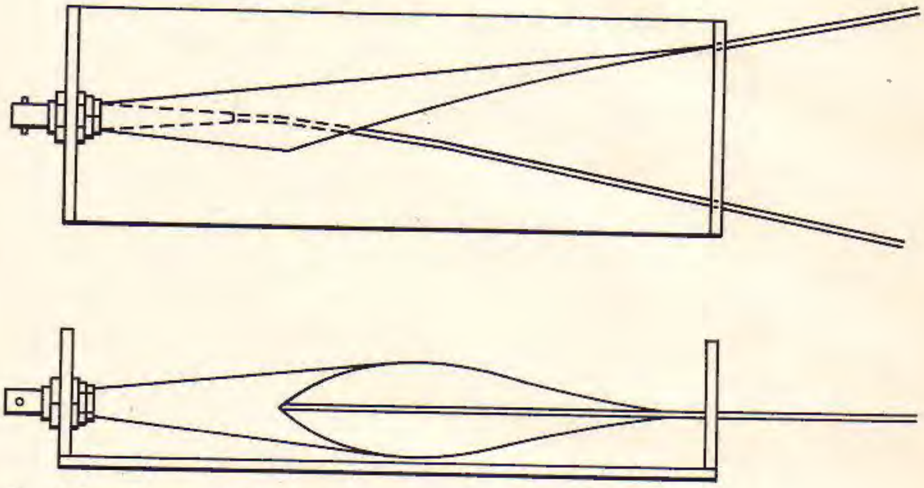


Fig. 5. Coaxial to open-wire flare.

Fig. 6. Construction of the coaxial to open-wire flare shown in Fig. 5.

wave ratio, which is in effect what the test is showing, was bad, but over the range of about 550 to 680MHz it was only 3:2 which is quite satisfactory. We found this was little different from the cable terminated with a standard 70Ω load. However, the surprising thing was that it started to increase again above this frequency.

It then dawned on us that the fault lay not in the flare but in the terminating resistor which, together with its end wires, was too long. Standing waves were being built up on it, resulting in various values of effective terminating impedance.

On the entry to the rhombic aerial this, of course, is of no consequence as it is simply a continuation of the flare, but it suggests that the spacing at the far end should be reduced to about ½in which is the length of a resistor and is sufficiently small compared with a wavelength. The termination would then be about 400Ω, the nearest preferred value being 390.

However, by the time these conclusions were reached my own aerial was installed and it is unfortunate that I have left the end spacing at about 4in and terminated with 560Ω but this is clearly not critical.

Let me say at this juncture that so far I have made no attempt to explore the transition v.s.w.r. situation in greater depth, as the construction of the arrangement described was essentially a practical exercise and an unavoidable interruption to my other electronic interests! One day I hope to experiment, but in the meantime some interested reader might care to take the matter further.

One possible approach is shown in Fig. 7. This consists of a flare from 70Ω to 600Ω spacing, followed by a length of 600Ω line and then a reverse flare to the terminating resistance. I suggest that the terminating flare should be brought down to about 300Ω spacing and terminated with two 150Ω resistors as shown.

The whole could then be tried on a Polyskop or some other device which permits the checking of the v.s.w.rs. If any reader happens to live in an area where there are two transmitters on reciprocal bearings, a flare could be fitted to both ends of the rhombic and a coaxial lead brought down from each. In theory the lead which is out of use should be terminated in 50Ω or 70Ω

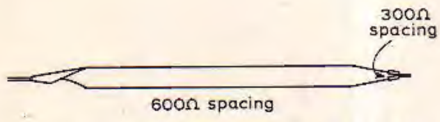


Fig. 7. Improved arrangement for checking flare matching.

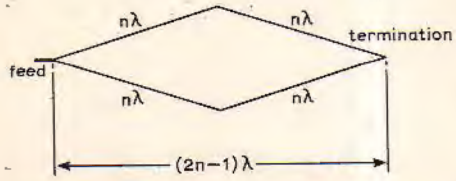


Fig. 8. Rhombic aerial dimensions. Note that n does not have to be an integer.

as the case may be; however, the loss on an open-circuited coaxial may be enough to terminate the aerial adequately.

One further point that may occur to readers contemplating building this device is that here we have the classic situation of a balanced aerial being fed with an unbalanced feeder and is therefore one in which squint might be introduced.

The only contribution I can make at the moment is a practical comment. After installation I discovered that the local 600MHz transmitters were farther east than I had thought and that an additional error had put them just about on the edge of the expected beam. (So much for being in a hurry!) However, subsequent correction to the geographical line-of-sight made only a slight improvement in the original received signal. My knowledge of field theory is somewhat limited, but I would have thought that, because of the large voltage transformation to the point of maximum spread (12 or 14:1), squint is unlikely to be significant. The phase considerations are unaffected and my present belief is that the capacitance between the lines and nearby objects (wiring conduit, water pipes, etc.) would mask any basic effects. However, it would be interesting to explore the field with a directional probe and examine all the perturbations in orientation.

But enough of theory. The more practical will want to know something of received picture quality. In fact this was eminently satisfactory, all three local transmissions (two BBC and one IBA) coming in clearly with no noise either on sound or on vision. Here, perhaps, I should add that my own experience does not in itself settle whether it is a good aerial or not, firstly because I am probably in a fairly strong region of field strength and secondly because I had no previous u.h.f. aerial with which to compare it. My colleague, however, is in a field strength "hole" and has hitherto used a log periodic aerial previously described in *Wireless World*[2]. This, at his location, gave a very poor signal-to-noise ratio. The rhombic on the other hand, has given a startling improvement; an estimated gain of about 10dB signal-to-noise.

I have not dealt with the construction of the rhombic itself as there is plenty of literature concerning the design of such aerials. Those unfamiliar with such a device will see from Fig. 8 that the construction is extremely simple and eminently suitable for medium-sized lofts. Larger aerials still are obviously possible where space permits and may be desirable in extreme fringe areas. In regions where the signals are vertically polarized, the aerial should, of course, be turned over on its side.

In conclusion, I should like to thank my colleague Mr R. A. Tyler for his help and also the Editor of *W.W.* for his valuable suggestions concerning the presentation of this article.

References

1. Frederick E. Terman. Electronic and Radio Engineering. McGraw Hill.
2. M. F. Radford. "Logarithmic Aerials for Bands IV and V", *Wireless World*, Sept. and Oct., 1964.

Meetings

LONDON
2nd IEE—"Early development of the television camera" by Prof. J. D. McGee at 17.30 at Savoy Pl., WC2.
4th IEE—"High power radar studies of the ionosphere" by Dr. J. V. Evans (Tenth Appleton Lecture) at 17.30 at Savoy Pl., WC2.
5th RTS—"The Canadian domestic communication satellite system" by R. F. Chinnick (Shoenberg memorial lecture) at 19.00 at the Royal Institution, Albemarle St., W1.
9th IEETE/Inst. MI—"The applications of electronics to the design and testing of automobiles" by T. R. Aston at 18.30 at the IEE, Savoy Pl., WC2.
10th IEE—"Electroluminescence" by A. Vecht at 17.30 at Savoy Pl., WC2.
10th IEE—"High power stepping devices" by Prof. P. J. Lawrenson and Prof. R. J. A. Paul at 17.30 at Savoy Pl., WC2.
11th IERE—Colloquium on "The graduate electronic engineer in Britain and Europe" at 10.00 at 9 Bedford Sq., WC1.
11th IEE—"Some applications of digital techniques to television broadcasting" by F. H. Steele at 17.30 at Savoy Pl., WC2.
12th IEE/R.Ae.S.—Symposium on "The application of digital avionic systems in aircraft" at 9.45 at the Royal Aeronautical Society, 4 Hamilton Pl., W1.
13th IEE—Colloquium on "Techniques at high voltages" at 10.30 at Savoy Pl., WC2.
16th IEE—"Exposition of quadraphony" at 14.30 at Savoy Pl., WC2.
17th AES—"Audio oscillators" by P. J. Baxandall at 19.15 at the IEE, Savoy Pl., WC2.
18th IERE—Colloquium on "Electronics and the motor vehicle" at 10.00 at 9 Bedford Sq., WC1.
18th IEE—Colloqrium on "Integrated circuits for analogue functions" at 14.30 at Savoy Pl., WC2.
18th IEE—"Transformer multiflow hottest-spot rating proposed standard specification" by E. T. Norris at 17.30 at Savoy Pl., WC2.

BRIGHTON
12th IEETE—"Simply and or not—a review of elementary logic gates" by E. Keeler at 19.30 at Royal Albion Hotel, Old Steine.

EXETER
5th IEETE—"Computers and programming" by L. M. Goddard at 19.30 at Exeter College, Hele Road.

GUILDFORD
4th IEE—"Nuclear power—its promise and problems" by H. H. Gott at 19.30 at the University of Surrey, Stag Hill.

HULL
11th SERT—"Trinitron tube" by speaker from Sony (UK) Ltd at 19.30 at Hull College of Technology.

LEEDS
12th IEETE—"New developments in integrated environmental design" by R. D. Parker at 19.00 at Kitson College, Cookridge St.

MAIDSTONE
2nd IEE—"Electronic aids to night vision" by Dr. P. Schagen at 19.00 at S.E.E.B. Maidstone Dist. Offices, Parkwood, Sutton Road.

READING
5th IERE/IEE—"The application of electronics in telephone exchange switching" by F. W. Croft at 19.30 at the J. J. Thomson Physical Laboratory, University of Reading, Whiteknights Park.

Tickets are required for some meetings: readers are advised therefore to communicate with the society concerned.

News of the Month

Low-light camera

The determined intruder is not easily defeated, but the use of invisible "light" with television cameras must pose a pretty problem to him. We were recently shown a system developed by ADT which uses radiation at a wavelength of 1.1 microns (effectively total darkness), or a slightly more visible 0.8 microns, to irradiate the scene, reflected radiation being picked up by a silicon diode array.

The use of the diode pick-up tube is claimed to offer advantages over the conventional method of a vidicon camera used with an image intensifier, the main one being that the signal-to-noise ratio is markedly improved. As the diodes have their peak sensitivity at the radiation wavelength used, a very small aperture can be used, with a consequent increase in the depth of field. Readers may remember that a similar pick-up tube used on a normal moon-shot suffered a dismal fate when it was accidentally aimed at the sun. ADT have fitted an automatic iris which varies the aperture from f1.2 to f360 sufficiently rapidly to protect the diodes against burn-out.

Apart from the obvious security value, the system is expected to find application in hospital surveillance, where the absence of visible lighting would be of great benefit to patients.

The low-light television surveillance system by Electronic Protection Services, Hillgate House, 26 Old Bailey, London EC4, a subsidiary of ADT of America (see accompanying news item).

Quis custodiet

The Design Centre in Haymarket, London will be reconsidering their security arrangements during the next few days, following the disappearance of one of their "high-technology" displays. An electronic transmitting key and control unit made by security experts Distloc, and used for remotely locking and unlocking strong doors, van doors, cash registers, petrol pumps etc, have been taken from their display case. Distloc promise enough flashing lights and clanging bells around any future exhibits to send any prospective purloiner on a hallucinatory trip.

Electric gas cookers

Electronic spark ignition units are not new, but the application of electronics to spark ignition for gas appliances is relatively recent. Ignition for fuel gases, unlike petrol vapour, demands a high degree of efficiency. This can be provided by the capacitor discharge principle. One of the major advantages of using these electronic spark ignition units is that ordinary pilot lights are rendered unnecessary. In California, legislation aimed at saving natural gas by the elimination of gas-fuelled pilot lights has recently become law. During the preparation of the bill, it was estimated that between 10 and 15% of natural gas used by domestic appliances throughout the state was consumed by pilot jets.

Plessey Windings has received a substantial order from the Caloric Corporation, Topton, Pennsylvania, USA for the supply of electronic spark ignition units. The Caloric Corporation, one of the major cooker manufacturers in the USA, is incorporating the units in its latest gas cookers.

Energy conversion alternatives

Methods of producing electrical power from coal will be assessed by a NASA industrial team in an 11-month study. Development and operating costs and the impact on the environment will be compared for a variety of systems using coal or coal-derived fuels. Conventional fossil-fuelled power plants operate at efficiencies of up to 40%, but greater efficiencies are possible. For example, a potassium Rankine system added as a "topping cycle" (additional heating stage) to a plant may increase efficiency to 50%. The study will compare a variety of energy systems. These include: advanced steam plants; open and closed cycle gas turbine systems; combined systems such as a gas turbine system used with a steam plant; supercritical carbon dioxide systems; liquid metal Rankine topping cycle magnetohydrodynamic systems and fuel cells.

Scotland goes stereo

From the start of programmes on October 14, some of Radio Scotland's music and light entertainment programmes and certain Radio 4 items are now broadcast in stereo from the Kirk o'Shotts v.h.f. transmitter. Radio 2 and Radio 3 are already in stereo. The stereo signals will be re-broadcast by the relay stations at Ashkirk (serving much of the border country), Ayr, Campbeltown, Forfar, Millburn Mair (Vale of Leven), Rosneath (Gareloch) and Toward. Some of these stations are a long way from Kirk o'Shotts so the quality and the consistency of the re-broadcast stereo signals will not be known until some time after tests have been carried out. The programme link to Scotland uses p.c.m.

Business abroad for Britain

The UK is rapidly expanding its electronics operations in North America. In response to fast-developing market opportunities, notably in the areas of advanced technology, commercial and medical electronics, the EMI Group is now progressively establishing a network of manufacturing and marketing facilities throughout the USA. Their latest move is the acquisition of Electron Technology Inc. of Kewny, New Jersey, who manufacture specialised glass components for the electron tube industry.

Back home, the tape division of EMI has recently launched a new ferric oxide cassette tape which is 30% cheaper than high quality chromium dioxide cassettes but is claimed to produce results at least as satisfactory as chrome formulations. The new Emitape X1000 is the result of two years' research and development using a new ferric oxide micro-particle. The main technical improvements claimed compared to low noise tapes are: an increase of 3-4dB output in the 8–15kHz region; improved overload characteristics; wider dynamic range; improved h.f. response and lower intermodulation distortion.

Channel link in service

Expansion of Britain's busiest single international route, the 38-mile radio "hop" across the English Channel, has taken a further step forward. Under the Post Office's plan to double the route's call-carrying capacity the first 60 telephone circuits of a new microwave link are now carrying calls to France. The new link, which will eventually be handling up to 1,800 calls simultaneously is the first of two to be provided in the Post Office's drive to expand telephone and telex services with Europe.

The route from the microwave station on Kent's Channel coast to its French counterpart can at present carry 2,160 telephone calls simultaneously. The new microwave links will boost this to 5,760. Under present plans, the Post Office expects to add 1,000 circuits of the extra capacity during the next five mouths. Further groups of circuits will be progressively introduced next year.

Broadcasting conference opened

The first session of a Regional Administrative Conference for the re-plauning of medium- and long-wave broadcasting in Regions 1 (Europe and Africa) and 3 (Asia and Australasia) opened at the beginning of October at the Geneva International Conference Centre. More than 400 delegates from 70 member countries of the International Telecommunications Union took part in the conference which lasted for three weeks (see August issue pp. 266–271, "The future of medium- and long-wave broadcasting", which described the problems facing the conference). This first sessiou concentrated on formulating the technical and operational criteria and the planning methods which will serve as a basis for the preparation by the second session of frequency assignment plans covering the l.f./m.f. broadcastiug bands in Regions 1 and 3. The second session is to be held from October 6 to November 22, 1975.

Technical and operational criteria took into account propagation data, modulation standards and channel spacings, protection ratios (including noise levels), transmitting antenna characteristics and transmitter powers and planning methods.

On the left the chassis of a 1923 medium- and long-wave receiver and on the right its present-day equivalent. These are two Philips radio receivers on show in a display covering the story of radio at the newly opened extension of the IBA's Broadcasting Gallery, Brompton Road, London.

Giro errors detected

Holland's largest commercial bank is installing a new British electronic error detector and control unit to further safeguard the accuracy of its Giro payment transfers. The units are plugged in to the bank's electric typewriters which are used to prepare the optical character reading input for the payment transfers. Each unit can be added on to a standard office typewriter without requiring any electrical interconnection and can be operated directly from the typewriter keyboard to carry out computer compatible check digit verification and a variety of totalling or other functions according to a pre-determined programme.

It is important to safeguard the accuracy of the two different bank account numbers which are being debited or credited with the money value involved in each transaction. Normally, any transposition or transcription errors are discovered as soon as the data reaches the central computer, but at that stage the problems involved in investigating and rectifying errors in account numbers are such that it becomes increasingly important for any errors to be detected at the original point of entry when the source documents are still at hand.

Not a telephonist's nightmare, but a giant mobile telephone built in the USA by General Telephone and Electronics Corporation to promote a new concept to conserve petrol, "dial before drive". Motorists are urged in a TV commercial to phone before setting out in their car to check that the trip is really necessary. The giant phone is mounted on a VW chassis and can be driven up to 35 mph

Stereo f.m. radio in Australia

The Federal Cabinet in Canberra has authorised the introduction of stereophonic frequency modulated radio in Australia and the establishment of new radio stations in both Sydney and Melbourne for the Australian Broadcasting Commission. The new f.m. stations will be operated by the musical broadcasting societies of New South Wales and Victoria and will aim to be self-supporting. A number of stations could be licensed over the next few years. The initial steps will enable the Government to assess the demand for public broadcasting.

Camera on Mars

The first tests of the camera that will photograph Mars from ground level when NASA's Viking spacecraft lands on the planet in 1976 have been successful. The camera has very small photo-diodes positioned in the focal plane where film would be in a conventional camera. An image is reflected from a mirror through lenses onto the diodes. The mirror rotation essentially scans the image and each time it moves through one cycle, a single vertical line is scanned in the field of view. The entire camera is then slightly rotated and the next vertical line is scanned. Several minutes are needed to obtain a complete photograph because the image information is sequentially acquired at about five lines per second. Colour photos are produced by combining data from three diodes (blue, green and red sensitive).

Each Viking spacecraft consists of an "orbiter" and a "lander". The lander's imaging system consists of two cameras providing colour, black-and-white, infrared and stereoscopic views of the Martian surface. The instruments are facsimile cameras designed for operation in unusual conditions. One of the most important jobs will be to characterize the area near the lander, so scientists on Earth can select spots from which samples should be obtained for chemical and biological analysis in the miniature laboratory on board each lander. The imaging system will also provide photometric information from near-by materials that will help deduce composition and particle sizes. It will monitor the Martian atmosphere opacity and record the position of the sun and brighter planets, to allow precise location of the lander on Mars.

Domestic satellite launch

The United States second commercial domestic communications satellite was launched aboard a Delta rocket during October. Final positioning of the satellite is in a synchronous orbit over the equator south of Los Angeles.

Each of the satellite's 12 independent fixed-gain amplifiers has a bandwidth of 36MHz. A duplicate receiver is on board that can be switched on if necessary—the onboard wideband receiver is common to all transponders and is necessary for proper functioning.

Ion engine survives

An electric rocket engine which short-circuited on a NASA spacecraft nearly four years ago has been restarted in space, prompting scientists at the Lewis Research Centre, Cleveland, to resume the Space Electric Rocket Test (SERT II) mission on a part-time basis. Launched in 1970, the SERT II mission was intended to demonstrate the feasibility of electric propulsion for future space missions such as planetary probes or station-keeping in Earth orbit. The aim was to operate an ion engine for six months in space.

Engineers are dwarfed by the US Air Force's newest and most sophisticated weather watcher, a 17-ft-tall giant called the Defence Meteorological Satellite. The spacecraft uses a single on-board control system which steers both the launch vehicle and the satellite.

Presumably, the sliver of molybdenum which caused the October 1970 short-out of thruster 2 is now gone. Spinning the spacecraft to obtain a better Sun angle for the solar arrays created a small amount of artificial gravity which could have dislodged the chip. Since then thruster 2 has been operated successfully several times for short periods of up to 60% of maximum thrust, proving the long term reliability of this thruster system design.

In the ion thruster, used for orbital manoeuvre secondary engines, an electrical discharge in mercury vapour provides a dense "plasma" of electrons and positive ions. The ions are accelerated out of the thruster by a strong electric field to produce the desired thrust. Such a thruster has also been under development by the Space Department of the Royal Aircraft Establishment, Farnborough. The first use of this thruster will probably be for north-south station-keeping on a communications satellite. In this role, its thrust will be used to balance the gravitational effects of the sun and moon which would otherwise cause the satellite's position to oscillate daily in a north-south direction. With no oscillation, such a satellite could broadcast directly to individual households using fixed, inexpensive aerials.

Telemetry transmission

The telemetry links that will be used in Europe in the near future for satellites, missiles and launchers, will operate from 2.2 to 2.3GHz (in S-band). So states the introduction to a description of the new S-band telemetry transmitter specially developed for ESRO (ITT *Electrical Communication*, Vol. 49, No. 3, p.251). For satellites, phase modulation is used with a peak modulation index that can reach several radians. Missiles and launchers, however, use frequency modulation. Typically, the modulating signal can be a message of the p.c.m./phase shift keying type modulating the carrier directly or alternatively, a composite signal containing subcarriers modulated by various analogue or digital signals representing telemetry and distance measurement information. The spectral bandwidth of the modulating signal may well be several megahertz for large capacity satellites and this puts severe constraints on the phase modulator.

Output power for the transmitter depends on the information rate and on the link budget and this varies from one satellite to another. A telemetry transmitter on board a satellite can work alone or as part of a coherent transponder. In the first case it is fed with a signal delivered by the oscillator of the phase lock loop of the associated receiver which is thus in phase with the signal received by the transponder. This enables Doppler effect on the carrier to be measured so that the radial velocity of the satellite can be determined.

Surround-sound psychoacoustics

Criteria for the design of matrix and discrete surround-sound systems

by Michael Gerzon

Mathematical Institute, University of Oxford

There are a number of different mechanisms by which the ears localize sounds, including several low-frequency, mid-frequency and high-frequency mechanisms, as well as information derived from the reverberation of sounds. With only a few transmission channels available, one cannot hope to satisfy them all, but most existing "discrete" and "matrix" systems do not satisfy more than one or two criteria. The approaches associated with the Nippon Columbia UMX system and the NRDC ambisonic system are the only ones so far to adequately allow for several criteria.

When stereo was introduced commercially in the 1950s, it had been subjected to experiments and theoretical studies for 25 years, by Fletcher[1] in the USA, Blumlein[2] in England, and de Boer[3] in the Netherlands. Despite a remarkable anticipation of modern "matrix" four-speaker systems by Blumlein[2] in 1931, virtually no work had been done on four-speaker surround sound before its recent commercial introduction. We are thus only beginning to understand how it works, and it is the object of this paper to describe the fruits of this new understanding. Not surprisingly, hastily introduced commercial systems have proved to be sub-optimal.

Because the mathematical description of surround-sound systems is far from elementary, this aspect is not dealt with here; references[4 to 10] contain such information. In this article the principles of surround-sound psychoacoustics are described, i.e. the relationship between the sound field presented to the listener and what he actually hears.

Lord Rayleigh discovered[11, 12] that the human hearing system appears to use different mechanisms to localize sounds at frequencies below and above 700Hz. Other evidence by Rayleigh[12, 13], Stevens & Newman[14] and Roffler & Butler[15] and others suggests that above about 5KHz, yet other localization mechanisms come into play, relying on the pinnae (the flaps on the ears) to modify sounds from different directions.

To make matters even more complicated, there is considerable disagreement both among theorists and experimenters as to the localization mechanism used within each band of freqnencies, quite contrary results being obtained in different cases[16]. It seems that the ears must nse a number of different methods of sound localization, possibly deciding on a "majority verdict" in the case when different mechanisms would, if used in isolation, give differing results.

In the presence of such contradictory information, the apparent localization of a sound also depends on the experience and expectations of the listener and on the type of attention he is paying to the sound. This can easily be demonstrated by reproducing via a stereo pair of good loudspeakers a sound positioned half-way towards the left speaker, but with the speakers connected out of phase. A suitably positioned listener can then hear the sonnd to be either between the speakers or beyond the left speaker (sometimes, both at once!).

Because most matrix four-speaker systems give highly ambiguous sound position information to the listener's ears, the results obtained will depend on the individual listener. Some listeners will learn to assign sounds to their "correct" positions with experience, and others will not. As a degree of subjectivism is a poor basis for any technology, the general principles behind various different sound localization mechanisms will be examined, with a view to extracting from these common features that can be used in designing surround-sound reproduction systems.

To design surround-sound systems we do not need to understand the full intricacies of the sound processing mechanisms in the ears and brain. As far as engineering is concerned, all we need know is what type of stimulus (i.e. sound field information) is needed to create a given subjective impression, and then we can design apparatus to produce a stimulus of the required type.

However, it is also necessary to have a description of the required stimulus that is simple enough mathematically to handle in detailed calculations. Otherwise we will only be able to design a system by guessing a circuit configuration and then "number crunching" the data in a computer to see whether it will work. As there are many millions of possible system configurations, it is extremely unlikely that such a design procedure would happen to hit upon the best possible result, or even something approximating to it. Such considerations rule out from our account such phenomena as the Haas effect, which says in essence that the earliest arrival of a sound at the ears determines its apparent direction. This is difficult to analyse mathematically, as well as being an unreliable guide to the subjective sound

Quadraphonic quandary

While this article was written before publication of B. J. Shelley's article *Quadraphonic Quandary* (*Wireless World*, July 1974 pp. 235–6), it does deal with many of the queries he raised on the aims and methods of quadraphonics. You may find it instructive to decide how far his particular criticisms are answered here. But note two points. Firstly, that two of the systems earlier proposed by the author on purely mathematical grounds (two-channel periphony and, via a tetrahedron of speakers, four-channel periphony) are here shown to be inadequate on the type of psychoacoustic grounds suggested by Shelley. And secondly that disagreements among experimenters about quadraphonic psychoacoustics are no new thing; Harwood[16] documented how little agreement there is on ordinary stereo localization. These disagreements may well be due to the conflicting directional cues at the ears inherent in all two-speaker stereo and in badly designed quadraphonic systems.

direction when sounds arrive from all round.

First, what is the aim of surround sound reproduction?

Recreating a sound field

Ideally, one would like a surround-sound system to recreate exactly over a reasonable listening area the original sound field of the concert hall, or in the case of popular or electronic music, a sound field envisaged by the record producer, with many different sounds in different directions at different distances. Unfortunately, arguments from information theory can be used to show that to recreate a sound field over a two-metre diameter listening area for frequencies up to 20KHz, one would need 400,000 channels and loudspeakers. These would occupy 8GHz of bandwidth, equivalent to the space used up by 1,000 625-line television channels!

The best that can be done with the two, three or four channels currently available is as follows. For each possible position of a sound in space, for each possible direction and for each possible distance away from the listener, assign a particular way of storing the sound on the available channels. Different sound positions correspond to the stored sound having different relative phases and amplitudes on the various channels. To reproduce the sound, first decide on a layout of loudspeakers around the listener, and then choose what combinations of the recorded information channels, with what phases and amplitudes, are to be fed to each speaker. The apparatus that converts the information channels to speaker feed signals is called a "decoder", and must be designed to ensure the best subjective approximation to the effect of the original sound field.

In commercial "discrete" practice, the process of assigning positions in the sound field to the available channels, known as "encoding", is done using four channels. Sounds not in the four corner positions are, in this procedure, assigned to just those two of the four channels representing corner directions adjacent to the desired direction. This only handles distant sounds in a horizontal direction, and it is by no means evident that this is the best way of assigning such a sound field to four channels. Similarly, it is not evident, and not in fact true, that feeding these channels directly to a square of speakers gives an optimum recreation of the original sound field.

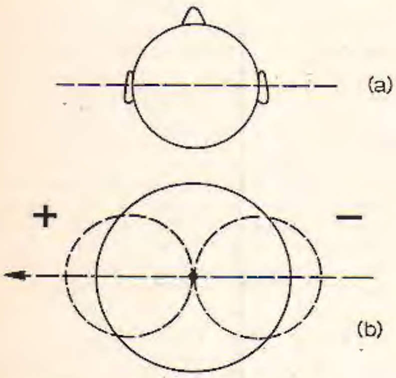


Fig. 1. Omnidirectional and velocity microphones (picture b) receiving the same low frequency information as the human hearing system (picture a).

Thus any surround-sound system gives rise to two distinct but related psycho-acoustic questions:

- Is a given method of encoding the sound field *ever* capable of good subjective re-creation of the sound field? That is, does the encoding method used permit the possibility of designing *some* decoder giving good results?
- Given a good method of encoding, what is the best design of decoder for use with a given layout of loudspeakers?

Low-frequency localization

The distance between the human ears is half a wavelength of a sound having a frequency of 700Hz. At frequencies appreciably below this, the head offers no obstacle to sound waves, and so the amplitude of sound reaching the two ears is virtually identical[11, 17–19]. The only information available at these low frequencies for sound localization is the phase difference between the two ears, and in 1907 Rayleigh[11] indeed showed that this was used to localize sounds below 700Hz.

There has, however, been disagreement as to how this low-frequency phase difference information is used to deduce sound position. One school of thought, represented by Clark, Dutton & Vanderlyn[20] and Bauer[21], derived a theory assuming that the listener does not move his head, whereas Makita[22], Leakey[23] and Tager[24] assume that the brain uses additional information from variations at the two ears caused by rotations of the head within the sound field.

It is possible to construct a "super-theory" including the above two classes of theories as special cases. Essentially, the sum of the waveforms reaching the two ears is the sound pressure that would be at the position of the centre of the listener's head were he absent. This information is the same as that picked up by an omnidirectional microphone (see Fig. 1). The remaining directional information at low frequencies reaching the listener is the difference of the waveforms at the two ears, which is the velocity of the sound field along the ear-axis (see Fig. 1). This is the information picked up by a sideways-pointing velocity or figure-of-eight microphone.

The fixed-head theories thus assume that the information picked up by an omnidirectional and by a sideways-facing velocity microphone is all that is available to the brain. The assumption that no use is made of amplitude differences at the two ears amounts to assuming that components of the velocity microphone information that are 90° out of phase with the omnidirectional information are not used in deducing the direction of sounds. The "moving head" theories assume that the velocity microphone information may point in any direction, but still assume that 90° out-of-phase velocity microphone information is not used.

It is not difficult to compute the "omnidirectional" and "velocity microphone" information produced by a quadraphonic reproduction system, and hence to calculate whether the useful information at low frequencies reaching the ears is the same as for live sounds (see Fig. 2).

Such calculations reveal that, for low frequencies, no existing two-channel matrix encode/decode system reproduces all the useful information as it occurs in live sounds, although the Cooper/Nippon Columbia BMX system[5] satisfies the hypotheses of Makita and Leakey. More remarkably, conventional discrete four-channel sound also does not satisfy low-frequency criteria other than those of Makita and Leakey. This is because phantom inter-speaker sound images with this system give too large an omnidirectional component of the sound field[25], which causes front-centre and side-centre sounds to be very poorly localized[26].

The poor positioning of phantom images suggests that discrete four-channel systems should not be used as a standard of excellence by which other systems are judged. There are better ways of representing the set of possible directions around the listener via four loudspeakers[8, 26]. The National Research and Development Corporation has recently been developing, with the author, a two-channel decoding apparatus for BMX or RM-encoded sounds, to feed four loudspeakers so as to satisfy the low frequency criteria shown in Fig. 2, and also the mid-high frequency criteria described later.

The three-channel system discovered

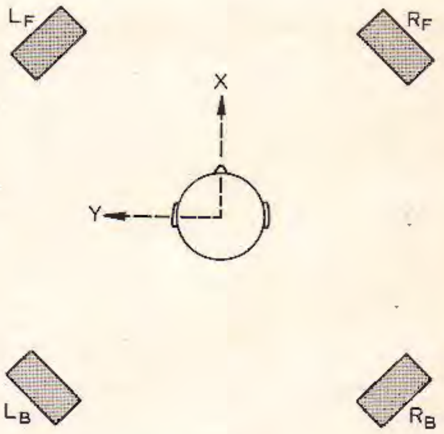


Fig. 2. Low-frequency quadraphonic localization information available to the ears.

Omnidirectional information:

$$\Omega = L_B + L_F + R_F + R_B$$

x-velocity information:

$$X = \text{Real}(-L_B + L_F + R_F - R_B)$$

y-velocity information:

$$Y = \text{Real}(L_B + L_F - R_F - R_B)$$

For "live" sounds we must have

$$\Omega^2 = \tfrac{1}{2}(X^2 + Y^2).$$

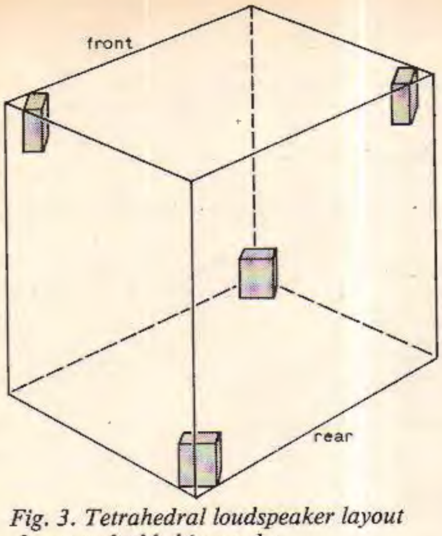


Fig. 3. Tetrahedral loudspeaker layout shown embedded in a cube.

independently by the author[10], Gibson et al[27], Eargle[28], Madsen (unpublished) and Cooper[5], is capable of correct low frequency results, as is the four-channel QMX system[5] and the tetrahedral with-height system of the author[6, 10, 29], which is reproduced via the speaker layout of Fig. 3. It is also possible to design a decoder for discrete recordings so as to satisfy all low-frequency requirements.

It is well known that velocity microphones give an exaggerated bass for very close sounds. Because the ears use velocity microphone information to localize sounds, close loudspeakers modify the directional effect at the ears. In particular, 90° out-of-phase velocity components caused by phase shifts are converted to phase differences between the ears. This causes the very low frequencies of phase-shifted sounds to be rotated around the listener. This effect has been observed by Bauer et al[30] via two speakers, but can be removed electronically. The degree of the effect is inversely proportional to loudspeaker distance.

Statistical methods may be used to apply the above theory to listeners not placed in the centre of the loudspeaker layout. The details are involved, but give results somewhat similar to the mid-high frequency theory of sound localization described next.

Mid-high frequency localization

Above 700Hz, the wavelength of sound is sufficiently small that the phase relationships between the loudspeakers are no longer of primary importance in sound localization. Under these conditions, what matters is the directional behaviour of the energy field around the listener. It is possible to show that, because of the positive nature of energy (in the mathematical sense), one can only exactly recreate the energy field of a live sound source through a small number of loudspeakers if the sound happens to be at the position of one of these. Thus at mid and high frequencies, not all of the ear's localization mechanisms can be satisfied in a practical reproduction system.

However, it is possible to analyse the directional energy field into omnidirectional and vector components analogous to those used for the sonnd amplitude field at low frequencies. If one assumes that the effect of head movement is nsed by the brain, these sound energy components can be used to estimate the probable subjective mid- and high-frequency sound direction. For a sound reproduced through several speakers, this direction may be calculated as the direction of the sum of vectors, one pointing at each speaker, each having as length the energy of the sound from that speaker. Calculations using this theory indicate that various four-speaker sound reproduction systems give the mid-high frequency sound localizations shown in Fig. 4, which agrees well with experimental data[26].

Note that if the number of channels equals the number of speakers (as for "discrete" and QMX via four speakers), then phantom inter-speaker sounds are drawn toward the nearest speaker. Cooper[31, 32] has called this the "detent" effect, but it is not significant for his BMX (two-channel) or TMX (three-channel) systems. A similar "pull" by the speakers is found for tetrahedral with-height reproduction (Fig. 3), but not when a cube of speakers is used.

The ratio of the length of the above-defined energy vector to the total reproduced energy should ideally be unity; iu practice the larger it is the better defined the sound image—it is this that makes TMX better than two-channel BMX.

This mid-high frequency theory holds only so long as the ears do not have too great a directionality in their response to sounds. The data of Sivian & White[17] and Rolls[19] on the ear's directionality show that above about 5kHz a new theory is needed.

Localization above 5KHz

In 1907, Rayleigh[11] found that when the head was stationary the ability to distinguish front from rear relied entirely on high frequencies. This has been confirmed by Stevens & Newman[14] and Roffler & Butler[15], who showed that the ears could localize sounds in the plane of symmetry of the human head quite accurately despite the two ears receiving the same sound waveform! This ability disappeared when the pinnae were masked. Conversely, many workers have found that dummy head recordings (which incorporate the effect of the pinnae's acoustic obstruction) give good spatial localization when reproduced either via headphones or via loudspeakers with the pinnae masked[33]. Perhaps using the ultimate "purist" microphone technique, Edmund Rolls of Oxford University has made similar recordings using microphones inside the ears of real heads!

The pinnae localization mechanism is not well understood, but appears to rely on the fact that sounds from each direction arrive inside the listener's ear with a distinctive colouration. Thus, if we can reproduce that colouration in a recording, we can reinforce the sense of direction created; to the author's knowledge, this has not yet been done in surround-sound recordings.

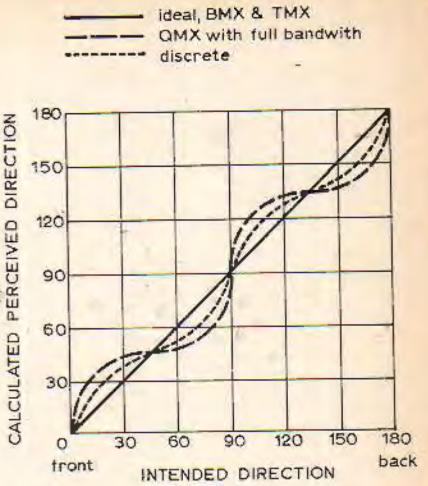


Fig. 4. Perceived localization vs intended direction of sounds in degrees, according to the mid-high frequency theory of this paper, for various systems via a square of speakers as in Fig. 2. Triangles indicate speaker positions. QMX data only applies for a full bandwidth system. Compare with Figs 19 and 20 of reference 26.

Reverberation to aid localization

It is possible to locate sounds more accurately in a moderately reverberant room than when there is no reverberation. Although the mechanism is not understood, it is found that correctly recorded reverberation also aids sound localization during reproduction[34], although poor artificial reverberation makes the sound image more indistinct. The author has computed the distribution of reverberation energy around the listener given by various recording techniques[34], and it is found that the most accurate sound localization is obtained when the energy is uniformly distributed, and not concentrated too much in any one direction.

Thus if a surround-sound system is to work optimally, it must be capable of capturing all nuances of reverberant sound and of reproducing these uniformly around the listener. Certain popular commercial matrix systems assign the original sound field to the two available channels in such a discontinuous manner[8, 9] that these criteria cannot be satisfied. "Variable matrix" or "logic" decoders, which work by pushing the whole sound field towards those directions in which the sound is momentarily strongest, clearly cannot reproduce those nuances of reverberation needed by the ears to localize sounds. The "detent" effect of discrete reproduction (Fig. 4) also prevents uniformly distributed reverberation.

Acknowledgment

This article is a revision of a paper by Michael Gerzon given at the 1974 Festival du Son, Paris. (Published in French in Conférences des Journées d'Etudes 1974 du Festival du Son—Editions Radio.)

References

Abbreviations JAES and JASA mean Journal of the Audio Engineering Society, and Journal of the Acoustical Society of America, respectively.

1. Fletcher, H. Stereophonic sound film system—general theory, *JASA*. vol. 13, 1941, pp. 88–99.
2. Blumlein, A. D. British Patent 394,325 (1931).
3. de Boer, K. Stereophonic sound production, *Philips Tech. Rev.*, vol. 5, 1940, pp. 107–44.
4. Shorter, G. Four-channel stereo, *Wireless World*, vol. 78, 1972, pp. 2–5, 54–7. See also *Wireless World Annual*, 1975, pp. 84–9.
5. Cooper, D. H. & Shiga, T. Discrete-matrix multi-channel stereo, *JAES*, vol. 20, 1972, pp. 346–60.
6. Gerzon, M. A. Periphony: with-height sound reproduction, *JAES*, vol. 21, 1973, pp. 2–10.
7. Scheiber, P. Analyzing phase-amplitude matrices, *JAES*, vol. 19, 1971, pp. 835–9.
8. Fellgett, P. B. Perspectives for surround sound, *Hi-Fi Sound Annual*, 1974.
9. Fellgett, P. B. Japanese regular matrix, *Hi-Fi News*, Dec., 1972.
10. Gerzon, M. A. Principles of quadraphonic recording (in two parts), *Studio Sound*, Aug. & Sept., 1970.
11.* Strutt, J. W. (Lord Rayleigh). On our perception of sound direction, *Phil. Mag.*, vol. 13, 1907, pp. 214–32.
12.* Strutt, J. W. Our perception of the direction of a source of sound, *Nature*, vol. 14, 1876, pp. 32, 33.
13.* Strutt, J. W. Acoustical observations—1, *Phil. Mag.*, 1877, pp. 456. 457.
14. Stevens, S. S. & Newman, E. B. Localization of actual sources of sound, *Amer. J. Psychol.*, vol. 48, 1936, pp. 297–306.
15. Roffler, S. K. & Butler, R. A. Factors that influence the localization of sound in the vertical plane, *JASA*, vol. 43, 1968, pp. 1255–9.
16. Harwood, H. D. Stereophonic image sharpness, *Wireless World*, vol. 74, 1968, pp. 207–11.
17. Sivian, L. J. & White, S. D. *JASA*, vol. 4, 1933, pp. 296–8.
18. Wiener, F. M. On the diffraction of a progressive sound wave by the human head, *JASA*, vol. 19, 1947, pp. 143–6.
19. Rolls, E. (private communication).
20. Clark, H. A. M., Dutton, G. F. & Vanderlyn, P. B. The stereosonic recording & reproducing system, *I.R.E. Trans. on Audio*, 1957, pp. 96–111.
21. Bauer, B. B. Phasor analysis of some stereophonic phenomena, *JASA*, vol. 33, 1961, pp. 1536–9.
22. Makita, Y. On the directional localization of sound in the stereophonic sound field, *EBU Review*, part A no. 73, 1962, pp. 102–8.
23. Leakey, D. M. Some measurements on the effects of interchannel intensity and time difference in two-channel sound systems, *JASA*, vol. 31, 1959, pp. 977–87.
24. Tager, P. G. Some features of physical structure of acoustic fields of stereophonic systems, *JSMPTE*, vol. 76, 1967, pp. 105–10.
25. Fellgett, P. B. Directional information in reproduced sound, *Wireless World*, vol. 78, 1972, pp. 413–7.
26. Kohsaka, O., Satoh, E. & Nakayama, T. Sound-image localization in multichannel matrix reproduction, *JAES*, vol. 20, 1972, pp. 542–8.
27. Gibson, J. J., Christensen, R. M. & Limberg, A. L. R. Compatible f.m. broadcasting of panoramic sound, *JAES*, vol. 20, 1972, pp. 816–22.
28. Eargle, J. M. Multichannel stereo matrix systems: an overview, *JAES*, vol. 19, 1971, pp. 552–9.
29. Gerzon, M. A. Experimental tetrahedral recording (in three parts), *Studio Sound*, Aug., Sept. & Oct. 1971.
30. Bauer, B. B., Gravereaux, D. W. & Gust, A. J. Compatible stereo-quadraphonic (SQ) record system, *JAES*, vol. 19, 1971, p. 641.
31. Cooper, D. H. Proposal for QMX discrete/matrix carrier-channel disc, privately circulated report, July 15, 1972.
32. Cooper, D. H., Shiga, T. & Takagi, T. QMX carrier-channel disc, *JAES*, vol. 21, 1973, pp.614–24.
33. Sennheiser Kunstkopf-Stereofonie, 45 rev./min. record, Sennheiser Electronic, 3002 Bissendorf (1973).
34. Gerzon, M. A. Recording techniques for multichannel stereo, *British Kinematography, Sound & Television*, vol. 53, 1971, pp.274–9.

*Refs 11–13 are in: Lord Rayleigh, Scientific Papers, Dover Publications, New York.

Integrated injection logic

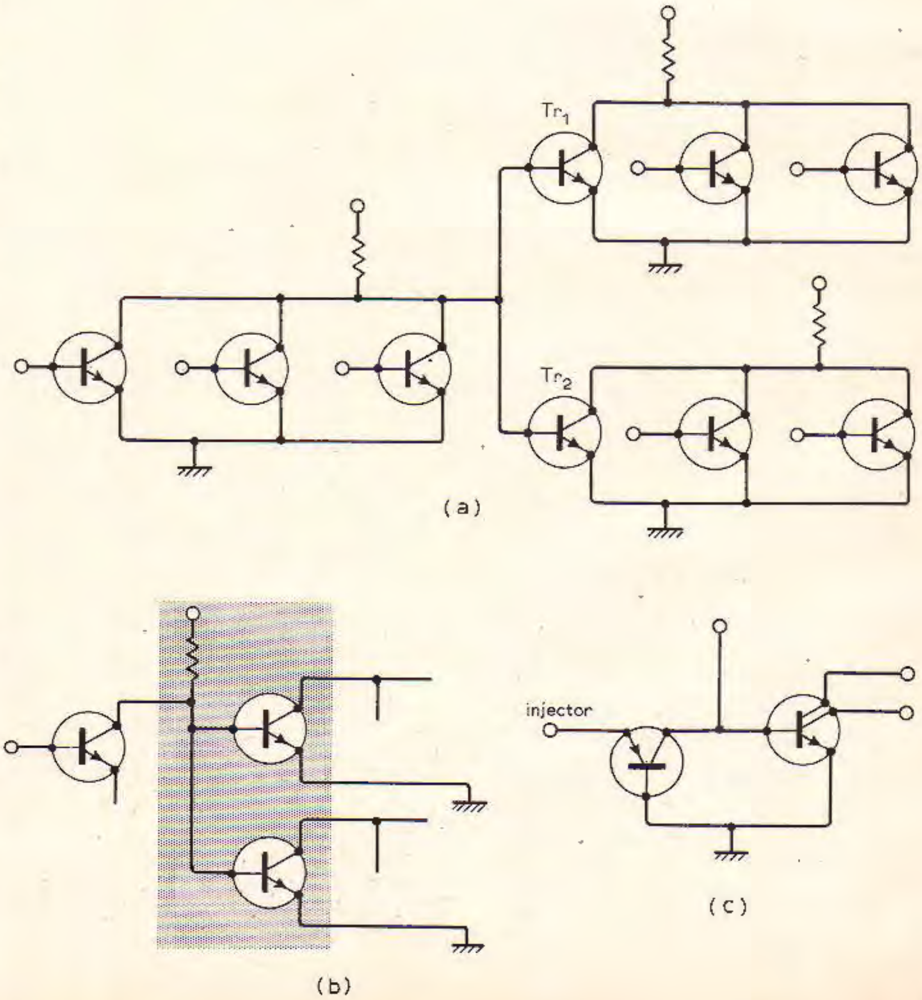
The development of new techniques in circuit integration has apparently been concentrated in the field of m.o.s. devices, and the amount of information appearing in the technical press about m.o.s. has tended to obscure the latest arrival on the bipolar logic field—integrated injection logic (i^2.l. for short). Its characteristics are impressive and it seems set to take over from conventional t.t.l. circuitry when packing density and low power dissipation are the essential requirements of a system.

As a result of the elimination of passive components in the basic gate and a reduction in the number of devices per gate, up to 3000 gates can be fabricated in one chip—an increase by a factor of ten over t.t.l. chips. The speed of i^2.l. is lower than that of t.t.l. (delay around 30ns instead of 10ns) but the speed-power product is only about 0.4pJ or less for i^2.l., compared with 100pJ. Cost is lower than in i.cs using the m.o.s. technology, particularly so as the same chip can coutain both digital and analogue circuits.

The circuit takes the form of a radically rationalized direct-coupled-transistor-logic (d.c.t.l.) element. In the diagram at (a), a typical d.c.t.l. gate (on the left) is shown driving one input of two other gates. Rearranging the interface gives (b) in the drawing, which can be further simplified by replacing the base resistor by an active current source and by substituting a multi-collector transistor for those with common bases. The result is (c), where the input emitter is termed the injector, the whole circuit being contained within the area of a t.t.l. multi-emitter input transistor. The combining of the two base emitter junctions of the interface gives protection against the effect, when junction voltages on different chips differ, of one gate monopolizing the current output from the previous gate, starving others connected in parallel.

The basic gate can operate at a current of around 1nA and a logic swing of 0.6V, which means interface circuits are needed between i^2.l. and other logic systems or linear devices. Variations of voltage and current can be obtained for different applications.

The new logic family can be used in a similar range of work as other l.s.i. systems. It was originated by Philips at Eindhoven, Netherlands, and at about the same time, but independently, by IBM at Boblingen.



Weather satellite ground station—2

Reception of cloud cover pictures; limiter and phase-locked loop system

by G. R. Kennedy

In an f.m. receiver, the signal limiter amplifies the signal so that any amplitude variations are minimized, in order that the detector may see a constant amplitude frequency modulated carrier. All f.m. detectors respond to some degree to a.m. as well as f.m. The principle of most limiters is amplification by a saturation amplifier. The process is sometimes referred to a clipping, although this implies a truncated sine output, with flat-topped sinewaves. Ideally, true f.m. receiver limiters should produce undistorted sinewaves. The amplitude variations in the i.f. signal may be due to relatively slow changes in the received carrier strength as well as due to faster impulse noise. The input signal, and i.f. signal strength may vary over a wide range, and hence the limiter must have a wide dynamic range. In order to limit amplitude changes at low signal input levels as well as at high levels, considerable gain must precede the limiter. A single-transistor limiting stage (Fig. 12) will not handle a wide range of limiting levels, and several cascaded stages must be employed.

Transistor Tr_{14} is biased so that with a small input of a few hundred millivolts the transistor saturates. The saturation knee-voltage may be varied by altering R_{48}, within the limits imposed by thermal runaway. Considerably more efficient limiting can be contrived using one of the commercially available integrated circuit limiters, made by such manufacturers as RCA and Motorola, or by employing an i.c. wide band amplifier and limiting the output above the knee voltage with diodes. Fig. 13 shows the simple connection of the RCA CA3076 limiter integrated circuit. The pin connections refer to the lead numbers of the eight-lead TO-5 package. The CA3076 will operate up to 20MHz, and at 10.7MHz provides 80dB voltage gain with a limiting knee above 50μV input. Fig. 14 shows two wide-band amplifiers connected for limiter service. The short circuits between 3 and 4, 6 and 7, and 8 and 9 of each i.c. connect diodes internally which limit the output voltage to about 25mV for any input voltage between 300μV and 3 volts r.m.s. up to 30MHz. The overall gain is about 100dB.

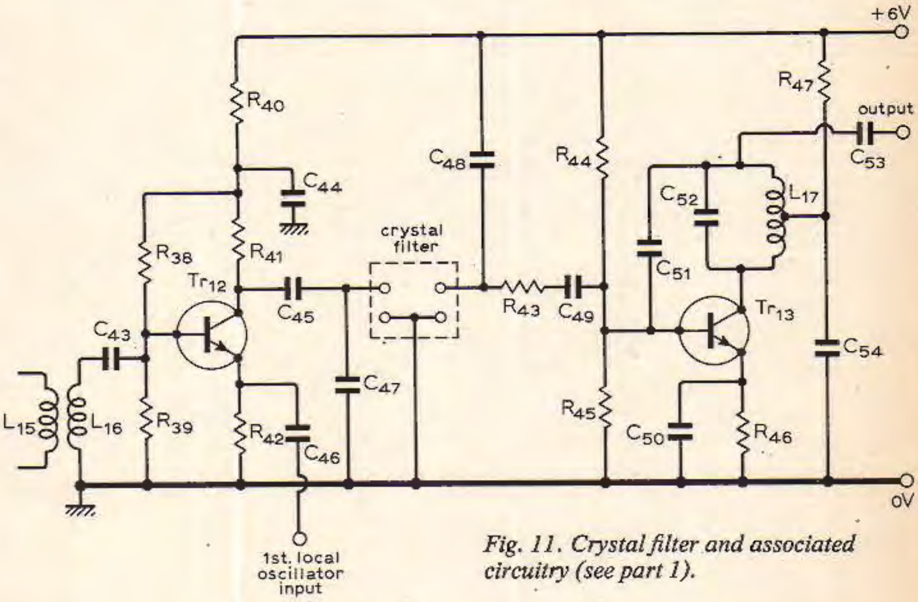


Fig. 11. Crystal filter and associated circuitry (see part 1).

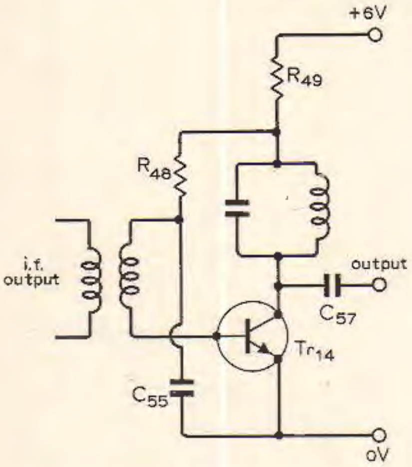
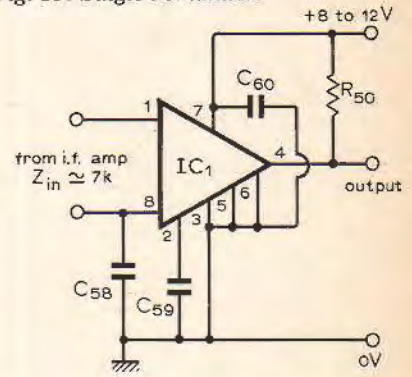


Fig. 12 (left). Single stage limiter.

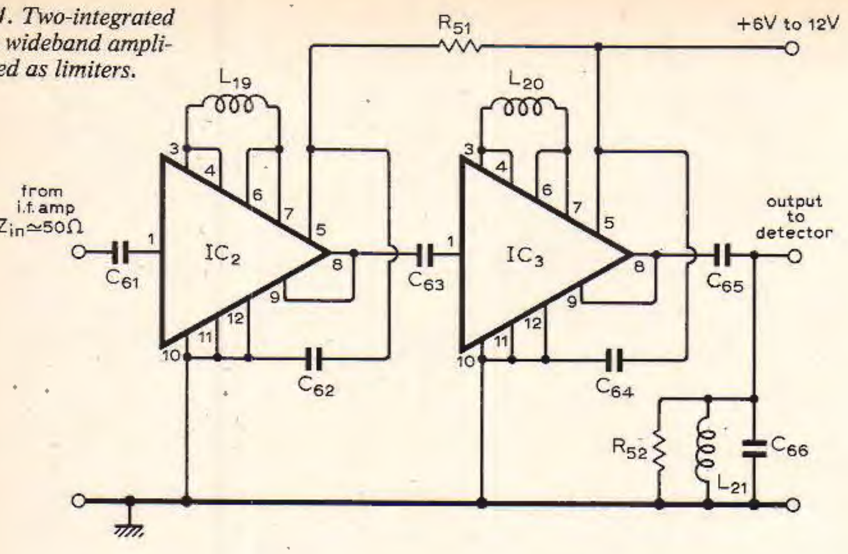
Fig. 13. Single i.c. limiter.



Phase-lock loop detector

For weather satellite applications the phase-lock loop detector is outstanding in performance[6]. The a.m. rejection and deviation linearity are far better than for conventional ratio detectors. Although limiters have been described, an integrated circuit phase-lock loop detector such as the Signetics NE565 does not need elaborate limiting preceding it[6], since the a.m. rejection is 40dB or so. However, phase-lock loops built from discrete components, such as a synchronized Wien bridge may not have such outstanding a.m. rejection. The basic block diagram of a phase-lock loop is shown in Fig. 15. The p.l.l. is a closed-loop servo where the input is a frequency signal, the error device is a phase-sensitive detector (p.s.d.), and the feedback path is a voltage-controlled oscillator (v.c.o.) fed through a low-pass filter which in turn is fed by the error output after amplification. The output is taken from the p.s.d. output either before or after filtering, depending on whether further filtering and buffering is required. The sense of the feedback path is such that a difference in phase (and hence, instantaneously, frequency) between the input or reference signal and the v.c.o. or control frequency, produces an output which alters the v.c.o. frequency to reduce the error. Since the phase detector is a sum-

Fig. 14. Two-integrated circuit wideband amplifier used as limiters.



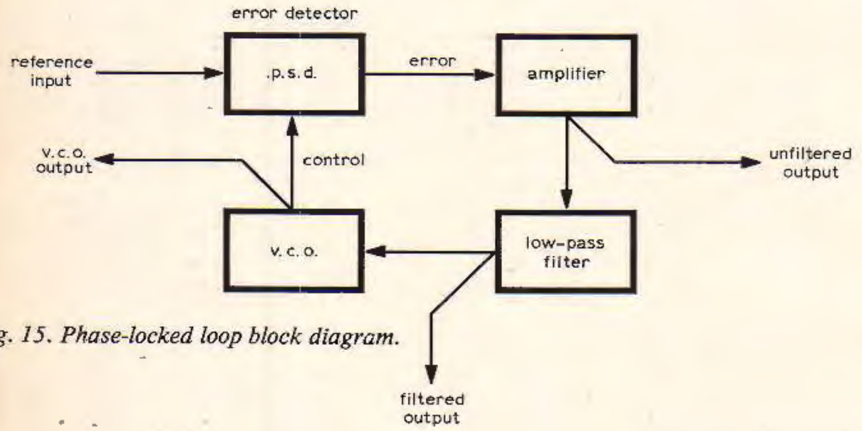


Fig. 15. Phase-locked loop block diagram.

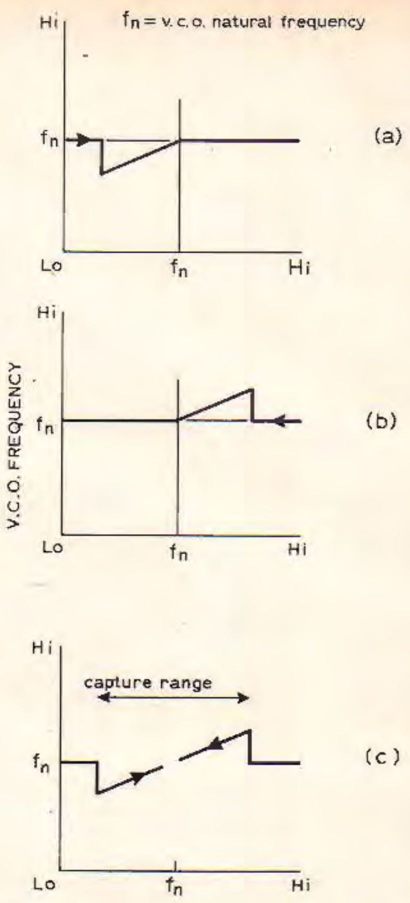


Fig. 16. Phase-locked loop capture range (a) reference frequency rising (b) reference frequency falling (c) resultant capture range. The v.c.o. natural frequency is f_n.

and-difference device much the same as the mixer in a superheterodyne receiver, there are sum-and-difference products produced at the p.s.d. output. The low-pass filter removes the higher frequency component, and allows an l.f. error voltage to drive the v.c.o. If the loop is in lock with a constant frequency reference, and the reference changes in frequency, the v.c.o. will change frequency in sympathy. If the reference input is frequency modulated, then, the p.s.d. output will vary with the reference frequency modulating frequency. The p.s.d. output can be made extremely linear with error and hence f.m. deviation, so that the p.s.d. output is an accurate f.m.-detected outpnt signal. The phase-sensitive detector cannot have an infinite bandwidth. There comes a point where the freqnency difference between the reference and v.c.o. frequencies is so large that the loop is not in lock, and the v.c.o. runs at its natural frequency f_n. As the reference frequency approaches the v.c.o. frequency at a given point the loop will lock up and the v.c.o. will run at the reference input frequency. This will happen at the same difference frequency, higher or lower, than the v.c.o. natural frequency. The difference between these frequencies is called the "capture range". This is shown diagrammatically in Fig. 16. There is frequency hysteresis in the p.l.l. operation so that if the reference frequency alters away from f_n, the loop will remain in lock beyond the capture point frequencies. The difference between the point where a locked loop will lose lock for an increasing or decreasing frequency from f_n is the "tracking" or "lock range". This is shown in Fig. 17. It then follows that as an input frequency sweeps high-to-low or low-to-high, the locking of the loop will not be symmetrical about f_n (Fig. 18). The apparent asymmetrical operation of the loop is important when the bandwidth of the receiver and the likely Doppler shift of the satellite received frequency are considered. If the receiver bandwidth is insufficient, the phase-lock loop may drop back at an extreme of carrier frequency deviation. This will cause the v.c.o to return to f_n, and lock will not be required until the deviation has returned through the appropriate capture point. There is therefore a longer period of dropped lock —and hence picture deterioration—than might be thought by simply regarding the tracking range. The capture range should be sufficient to lock on the expected satellite frequency deviation plus Doppler, but not too wide to allow transient lock on very strong out-of-channel signals which may break through even the narrow bandwidth i.f. amplifier stage. The use of the p.l.l. has an unexpected advantage when receiving grossly fading signals: if the loop does drop lock, the return of the v.c.o. to f_n causes the picture display to return to mid grey. This is the least conspicuous tone for picture interference.

A practical circuit, using a Signetics NE565 p.l.l. for an i.f. of 470kHz, is shown in Fig. 19. Here a single-rail supply is used, with appropriate biasing of the differential input, pins 2 and 3. The input is 470kHz deviated at a rate of 2.4kHz and may be to either of the input terminals for optimum a.m. rejection. The input for the NE565 should not exceed 400mV. Pins 8 and 9 set the v.c.o. frequency. Frequency f_n is given approximately by

$$f_n \sim \frac{1\cdot2}{4R_5C_7} \text{ where}$$

f is in Hz, R in ohms, C in farads. Resistor R_5 is usually set to be below 20kΩ, and ideally at 4kΩ. Capacitor C_3 decouples some of the input frequency from the output, which is taken from pin 7 and C_6 decouples the supply at the device pins, C_4 is the loop filter capacitor and sets the capture range of the loop.

Fig. 20 shows typical values of C_4 for an NE565 p.l.l. operating at 470kHz. For a 470kHz input at 300mV pk to pk deviated ± 10kHz the output at pin 7 is approximately 30mV pk to pk with a considerable amount of 470kHz output, which must be filtered out. Fig. 21 shows a two-stage 2.4kHz filter. The performance is as follows: input 30mV pk to pk; output at max. gain setting 7.5V pk to pk at 2.4kHz; overall gain 47dB; bandwidth 1.9kHz: 3dB points 1.2kHz, 3.1kHz.

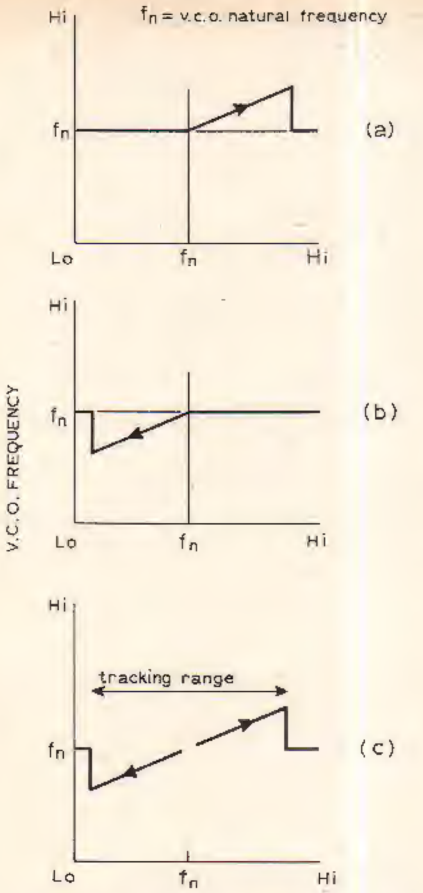


Fig. 17. Tracking range diagram for the p.l.l. (a) reference frequency rising (b) reference frequency falling (c) resultant tracking range.

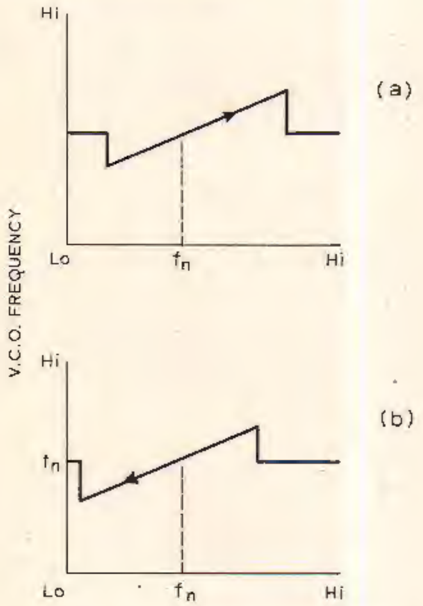
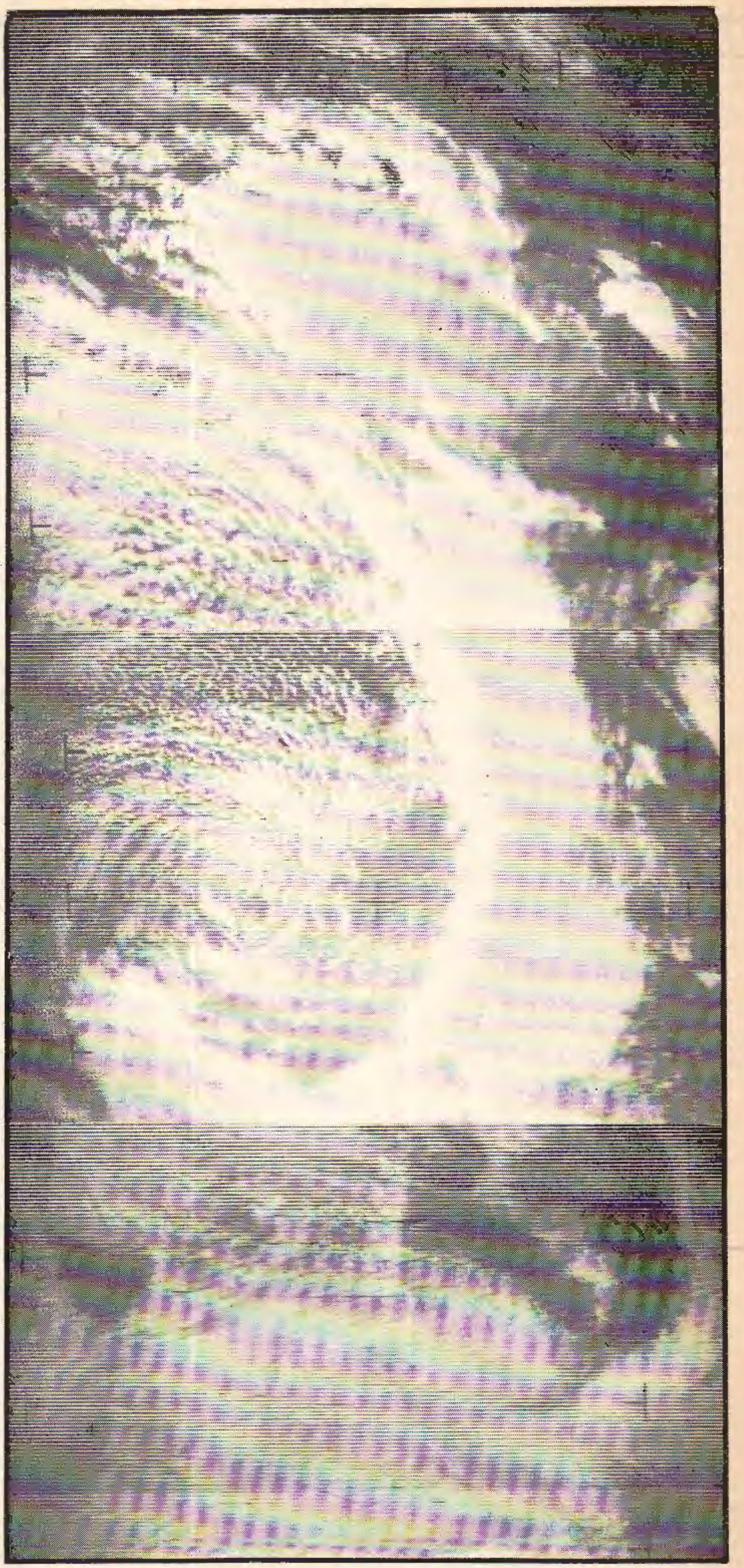


Fig. 18. Asymmetrical locking diagram of the phase-locked loop. (a) reference frequency rising (b) reference frequency falling.



Cyclonic depression in the North Atlantic between Greenland and the UK taken on Saturday, 21 Sept, 1974. The satellite was 68-114-A, ESSA-8.

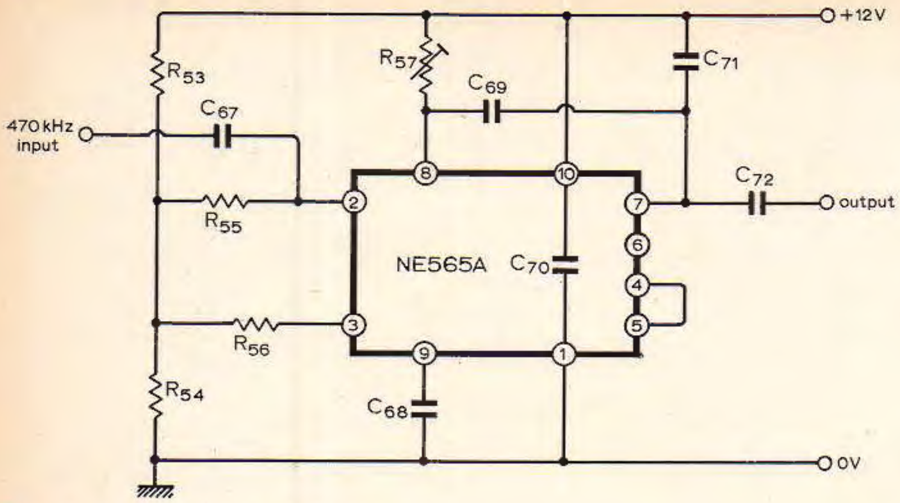


Fig. 19. Practical phase-locked loop circuitry.

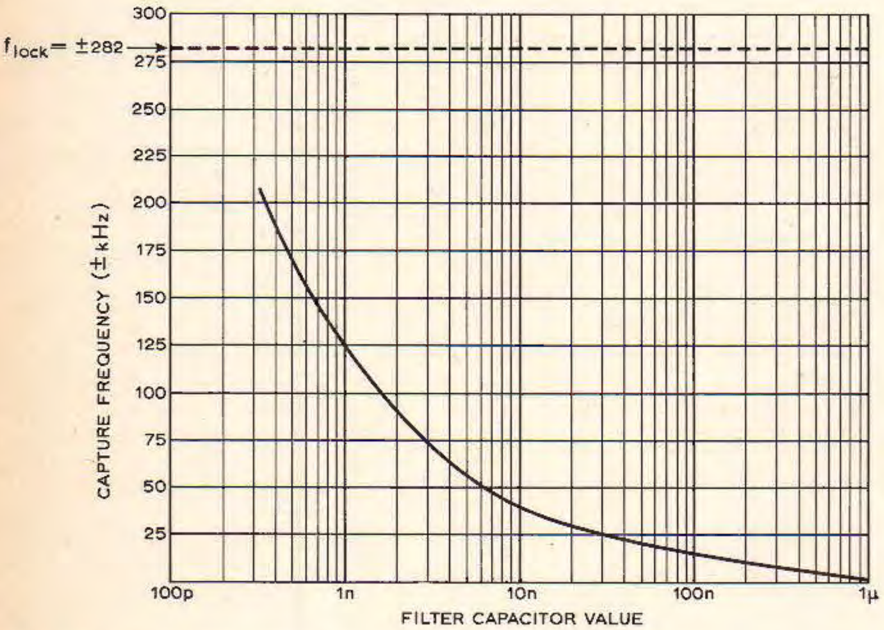


Fig. 20. Capture range versus filter capacitance for 475kHz p.l.l. circuit in Fig. 19. Discriminated output at pin 7 ≈ 100mV per 25kHz shift.

Components list

Resistors—*R*

Fig. 11. 38 18k
39 3.3k
40 330
41 820
42 2.2k
43 680
44 15k
45 10k
46 1k
47 1.8k
Fig. 12. 48 82k
49 1k
Fig. 13. 50 2.7k
Fig. 14. 51 100
52 5.6k
Fig. 19. 53 10k
54 4.7k
55 1k
56 1k
57 5k
Fig. 21. 58 680
59 10k
60 10k
61 680
62 250k
63 10k
64 10k
65 10k
66 10k
67 1k
68 10k
69 1k
70
71 10k

Capacitors—*C*

Fig. 11. 43 1n
44 1n
45 1n
46 1n
47 18p
48 18p
49 1n
50 5n
51 5.6p
52 20p*
53 10n
54 10n
Fig. 12. 55 10n
57 10n
Fig. 13. 58 10n
59 10n
60 10n
Fig. 14. 61 10n
62 10n
63 10n
64 10n
65 10n
66 20p*
Fig. 19. 67 1.5n
68 150p
69 1n
70 10n
71
72 10n
Fig. 21. 73 10n
74 150p
75 22n
76 10n
77 10n
78 100p
79 0.1μ

Inductors—*L*

Fig. 11. 15 0.05 *link coupling
16 0.5 *
17 10 total tapped one-third way up
Fig. 14. 19 Self-resonant at i.f. frequency
20 Self-resonant at i.f. frequency
21 10 *

*Value depends on circuit tuning

Transistors—*Tr*

Fig. 11. 12 BSX20
13 BSX20
Fig. 12. 14 BSX20

Crystal filter

Fig. 11. ITT 015AD or 901AM or similar for 10.7MHz

Integrated circuit

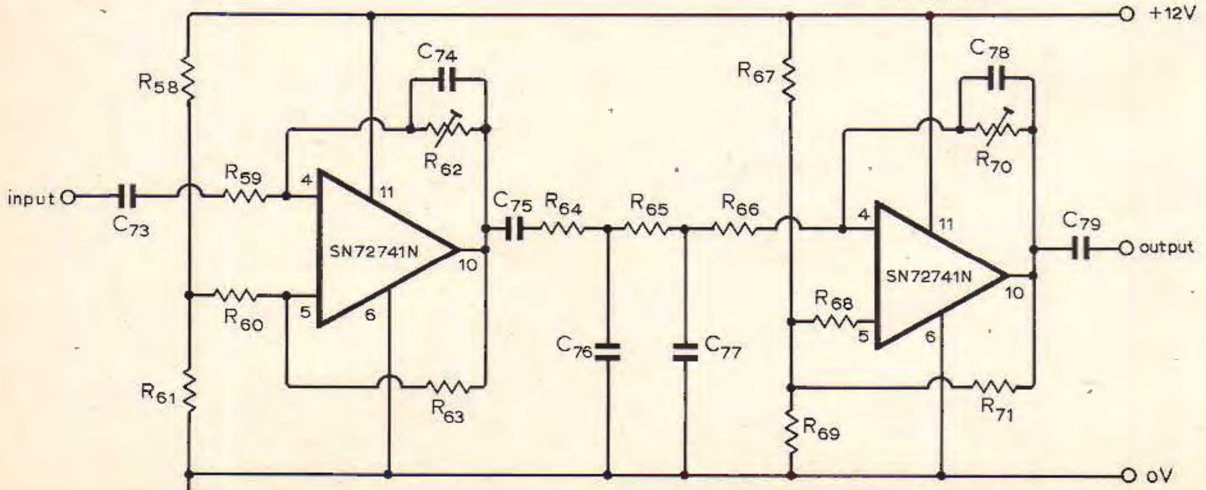
Fig. 13. 1 CA3076

(To be concluded)

Reference

6. Signetics Linear Phase Locked Loops Application Book, Signetics International Corporation, Yeoman House, 63 Croydon Road, London SE20.

Fig. 21. Two stage 2.4kHz filter.



PROJECT

A digital clock and calendar

Part 3. Concluding the clock calendar project with leap-year logic and a power supply design

by J. K. F. Nosworthy and N. J. Roffe

Fig. 10 shows the circuitry for the years counter and the associated leap-year logic. The years counter itself is straightforward, consisting of four sequential decade counters IC_{13-16}. Drive is of course derived from the output of the months section. Reset is to 0000, presenting no problems, and this is actnated conventionally from the terminal output.

Leap-year detection follows the principles already set forth. Reviewing these, it will be seen that it is necessary to examine the last two digits of the year in order to decide whether or not the year is an ordinary leap-year, and all four digits in the event that the last two are 00 (century) in order to decide a century leap-year. For the first and third digits, to cover all contingencies, all possible digits from 0–9 need to be examined; for the second and fourth digits, only even numbers (including 0) need to be examined.

Examination of the year being displayed is by the array of NAND gates IC_{20-25} so far as the last two year digits are concerned (i.e. examination for ordinary leap-years) and by a duplication of these to deal with the first two digits for century leap-years. All these gates are fed either direct from the binary-coded outputs of the years counters, or via inverters IC_{17-19}, according to their particular logic requirements. Breaking the gates down into groups, IC_{20-22} deal with the fourth digit; an output being passed by IC_{20} (a) or (b) for a 0 or a 4 respectively; IC_{21} (a) or (b) for a 8 or a 2; IC_{22} (a) for a 6. The ontput in each case, if it occurs, is a low, and this is inverted by IC_{23} to a high before being passed to an input of IC_{24} or IC_{25}. IC_{24} and IC_{25} repeat the screening process on the third digit; if this is odd, it will enable, via the A6 output from IC_{14}, both IC_{24} (d) and IC_{25} (a); so that if a fourth-digit 2 or 6 has been screened through by IC_{21} (b) or IC_{22} (a) an output will be derived from $IC_{24/25}$. Similarly, if the third digit is even, the $\overline{A6}$ output from IC_{14} via IC_{17} will enable IC_{23} (a, b, c); so that if a fourth-digit 0, 4, 8 has been screened through by IC_{20} (a) or (b) again an output will be derived from IC_{24}. In each case the output from IC_{24} or IC_{25} will be a logic 0; and since these are open-collector i.cs with a common collector load R_5, wired-OR logic applies so that the input of invertor IC_{23} will be driven to logic 0.

A final piece of detection must be applied to the last two digits of the year; that is the detection of a specific 00. This must be detected if it occurs in order that the "repeat" circuitry for scanning the first two digits may be actuated in the case of a century leap-year. This is done by IC_{26}, an 8-input NAND gate fed with the appropriate outputs of counters IC_{15} aud IC_{16}. If the output from IC_{26} is favourable, it enables (after suitable inversion) the top gate of IC_{25} to accept a signal from the first two digits screening circuitry, indicating the presence of a century leap-year. If IC_{26} output is unfavourable, it will leave the second gate of IC_{25} in operation so as to allow an output throngh from the last two

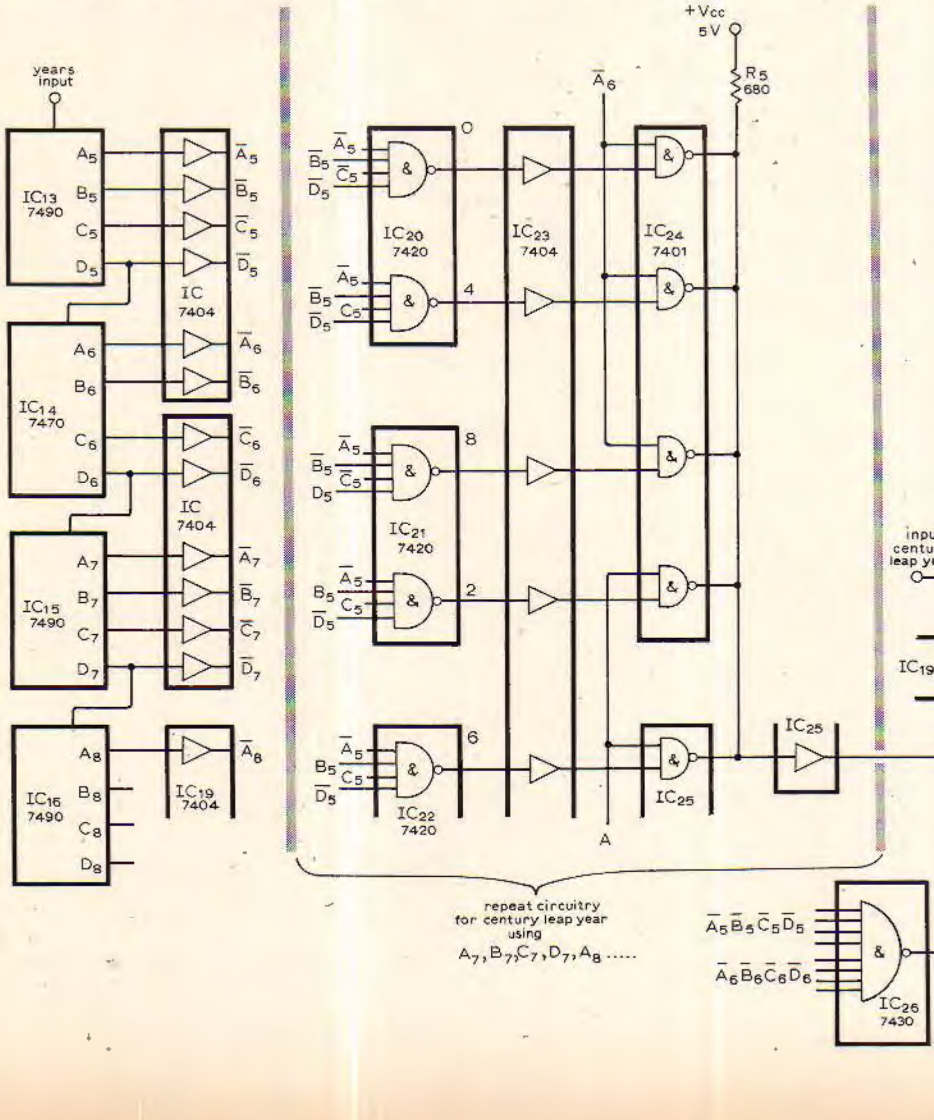
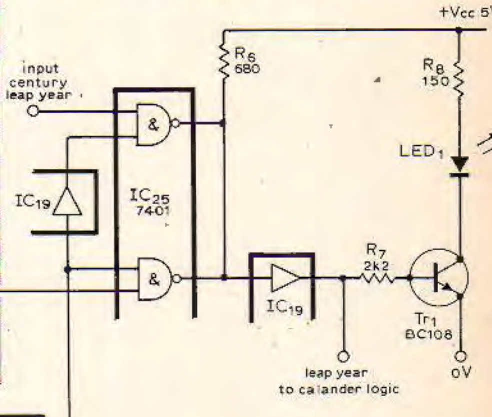



Fig. 10. "Years" counter and "leap-year" logic. Gates are identified from the top of the diagram, e.g. $IC_{20(a)}$ is associated with "0" and $IC_{21(b)}$ with "2". The input A to $IC_{24,25}$ is A6 from IC_{14}.

digits screening circuitry, for indication of ordinary leap-year. In either case, whichever gate a signal comes through, it will cause a resultant output of logic 0 since again IC_{25} is an open-collector type and the common collector resistor R_6 gives wired-OR logic.

Finally, the resultant leap-year signal is inverted by IC_{19} to give a high, and this is used both to drive the alternative February line on the ROM matrix (see Fig. 9) and to drive TR_1 for illumination of the l.e.d. which indicates a leap-year. (TR_1 is interposed between IC_{19} output and the l.e.d. because the direct output from IC_{19} would not give sufficient brightness owing to its current-sink limitations—an alternative, if any spare sections of i.cs were available, would be to parallel several of them up to increase the current availability.)

Main power supply

The circuit for this is given in Fig. 11. The principle adopted is that the function of the main power unit is to produce a minimal 24V supply, thoroughly smoothed as regards mains ripple and major supply transients but not necessarily precision-regulated. This supply is fed to the various units, and these each contain their own on-card i.c. regulators, providing for each unit a precisely regulated supply rail which is readily adjustable to individual unit requirements. This two-stage approach also ensures really efficient inter-unit decoupling which, as any user of digital i.cs has doubtless found out the hard way, is absolutely vital!

Two separate outputs are in fact provided; the reason being that, on considering the requirements for the stand-by battery facility, it is found that several portions of the clock do not have to be kept powered during a mains power cut. These are principally the nixie decoder/drivers, which consume quite a fair amount of current, also various ancillary portions such as the BBC accuracy comparator. The display itself can also be dispensed with during a power cut; and obviously these economies are desirable in order to lengthen stand-by battery life. The 24V output is therefore split into one line which must always be kept alive, i.e. backed up by the batteries, and one which is powered solely from the mains. The two outputs are respectively labelled (2) and (1).

For the stand-by battery supply, manganese dry-cells are used. Rechargeable batteries were considered, but lead-acid was thought to be too messy and labour-demanding and alkaline cells, which would have been ideal as they could have been left on permanent floating charge, were unfortunately ruled out by expense. Since, therefore, a floating-charge principle cannot be used, it was necessary to devise a change-over system which would operate in the event of main failure; and for this we have adopted the principle of steering diodes. The mains-fed supply is arranged to be of slightly higher voltage than that from the batteries, and the two are commoned via diodes (D_3, D_4). Under mains operation, therefore, the diode in the battery line will be reverse-biased, so that no current flows from the batteries, whilst the one in the mains-fed line will conduct. In the event of mains failure or serious mains under-voltage, the situation is reversed; the battery series diode supplying output current and the mains-fed diode preventing this from flowing back through the rectifier circuit. The principle is simple, foolproof and gives, of course, an instantaneous changeover. The only precaution which must be observed during design and initial set-up procedure is to ensure that the voltage limits are fairly carefully set so that, whilst the battery diode is held firmly off by the over-voltage of the mains-fed supply, this over-voltage is not so large as to give rise to an unmanageable falling transient as the batteries cut in. A point which is not perhaps immediately obvious in this connection is that the mains-fed supply must be substantially free from ripple, as otherwise its instantaneous voltage becomes a variable—hence the necessity for including a series regulator (TR_1) in the mains-fed supply line.

The standing drain from the batteries is very small, and their shelf life is long; but it was thought nevertheless desirable to provide a warning indication of when they were becoming exhausted. This is done by a 709 op-amp which continually compares the battery voltage with that set by a reference zener D_2 fed from the mains-operated supply. Preset R_4 adjusts this reference voltage to the level at which it is desired that warning shall be given (this can be decided on by reference to the battery manufacturer's data—we have actually decided on 20.5V). While the battery voltage is above this level, a positive output is derived from the op-amp which turns TR_2 on and illuminates LP_2. When, however, the battery voltage falls below that selected by R_4, the op-amp output swings to negative, TR_2 cuts off, turning on TR_3 which lights LP_3. We used the 709 op-amp in preference to the more obvious 710 voltage-comparator because we found the latter to be troublesome during the changeover period, which is of course very slow—the 710 tended to give parasitic oscillatious during this time. The 709 is used on open-loop gain and the 100µF used as output frequency compensator gives the necessary slight hysteresis. The back-to-back zeners strapped across the op-amp inputs merely limit the maximum input voltage in either direction to a safe level. The op-amp and its circuitry are fed from the 24V line by a 15V regulator, since 24V is considerably higher than its maximum V_s rating. In this application, the provision of a negative op-amp supply rail is not necessary, and the $-V_s$ connection is simply grounded.

Switch S_3 is provided so that the operation of the comparator circuit may be checked from time to time. In its normal position (up) it supplies battery voltage to the op-amp, as described above. Depressed, it supplies instead an auxiliary reference voltage derived from D_2 by R_5. This is set to be slightly lower than the voltage from R_4, so that it simulates a low battery voltage and operates the warning indicator.

To save stand-by battery current during

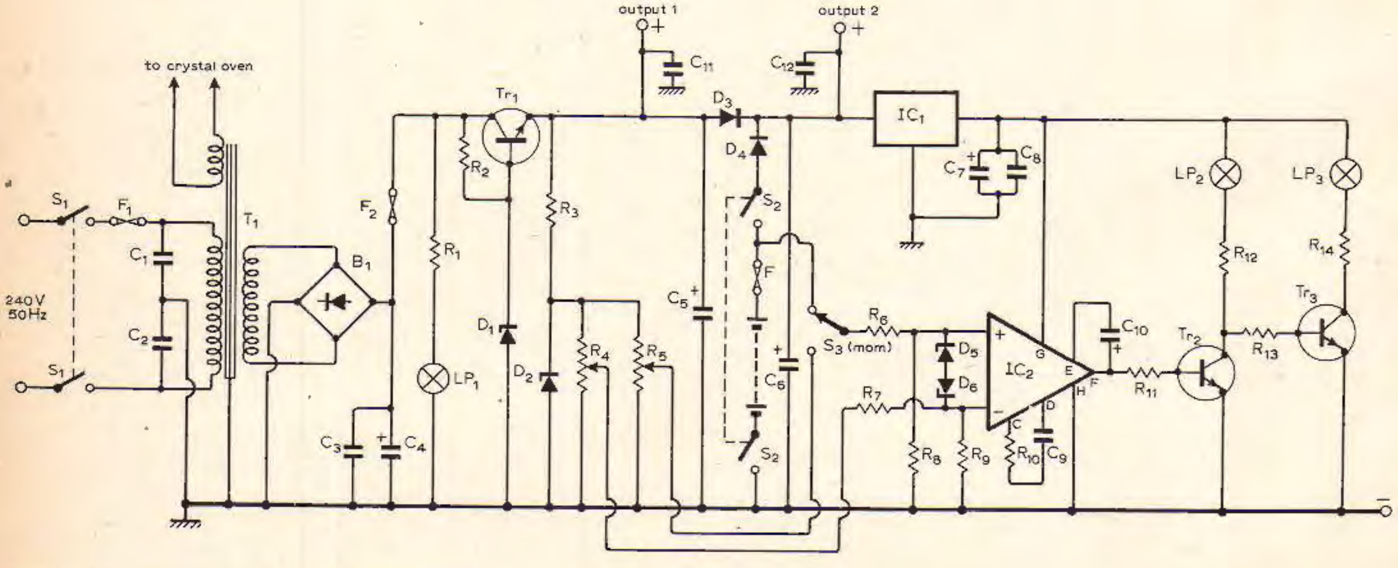


Fig. 11. Main power supply, with battery-condition indicator.

power cuts, the indicator circuitry could be fed from output (1) instead of from output (2). However, if this is done LP_2 will not be illuminated during a power cut, neither will any other indicator; and since the display will also be off, there will be no indication that the clock is functioning at all. We thought this to be undesirable.

The main power supply feeds all the units except the nixie display and the BBC accuracy monitor. For the former, the usual 180V is required, with no stand-by battery facility; we do not give the circuit here since it presents no difficulty. (It is, however, interesting to note in passing that our solution for the regulation requirement was the use of a good old-fashioned cathode follower—solid-state circuitry still has a few outposts to conquer!) For the latter, again no stand-by facility is required; and since it requires a dual-rail supply for its op-amp, we found it simplest to power it via a small separate on-card supply, using a sub-miniature mains transformer and an MC1468 dual-tracking regulator.

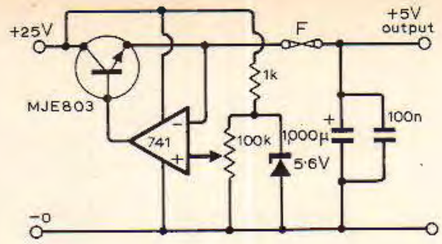
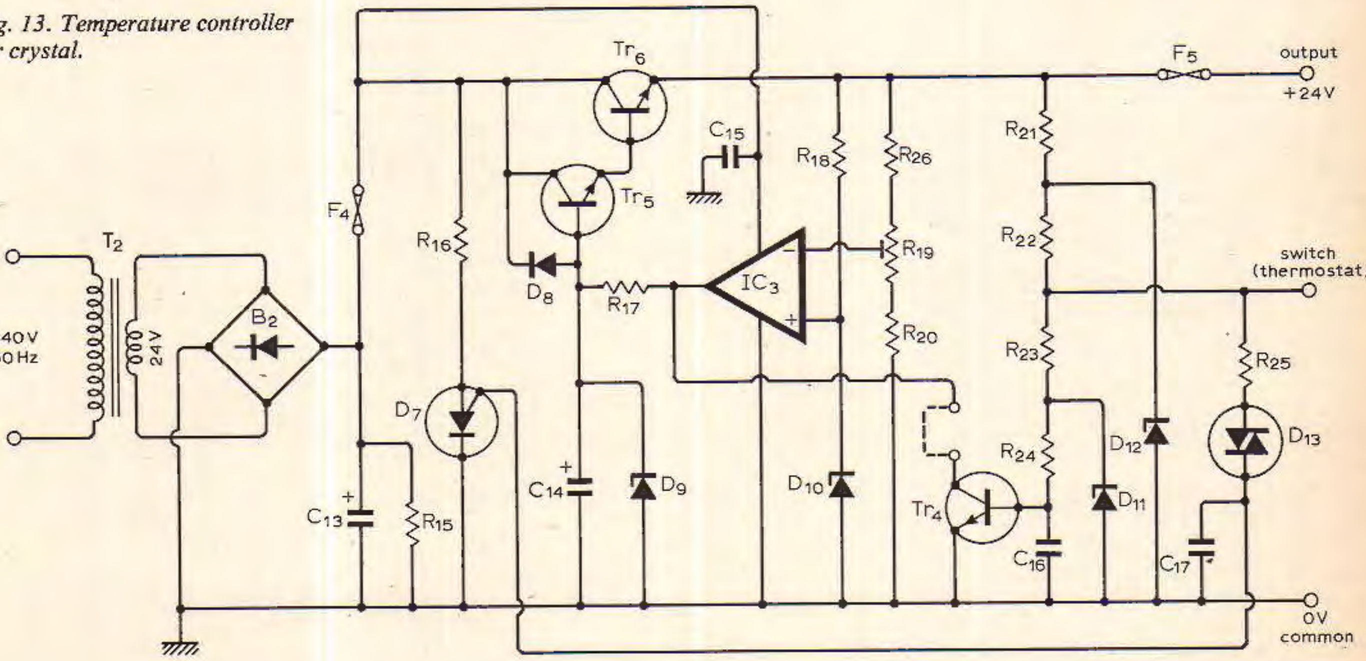


Fig. 12. Circuit of high-current 5V regulator for on-card use.

For remaining on-card regulation of the 5V logic rails, either LM309K potted regulators have been used or, where higher output current is reqnired, the circuit shown in Fig. 12. The theoretical maximum current available from this circuit is 2A, representing a dissipation in the series transistor of 40W, but practical limitations of heat-sink restrict this to about 1.5A. It should be uoted that the output voltage control R_4 is used to tap down the zener reference source instead of, as is more usual, the output voltage—this not only gives better stability, since errors in output voltage are not attenuated before being fed back, but it also allows the use of a 5.6V

Fig. 13. Temperature controller for crystal.



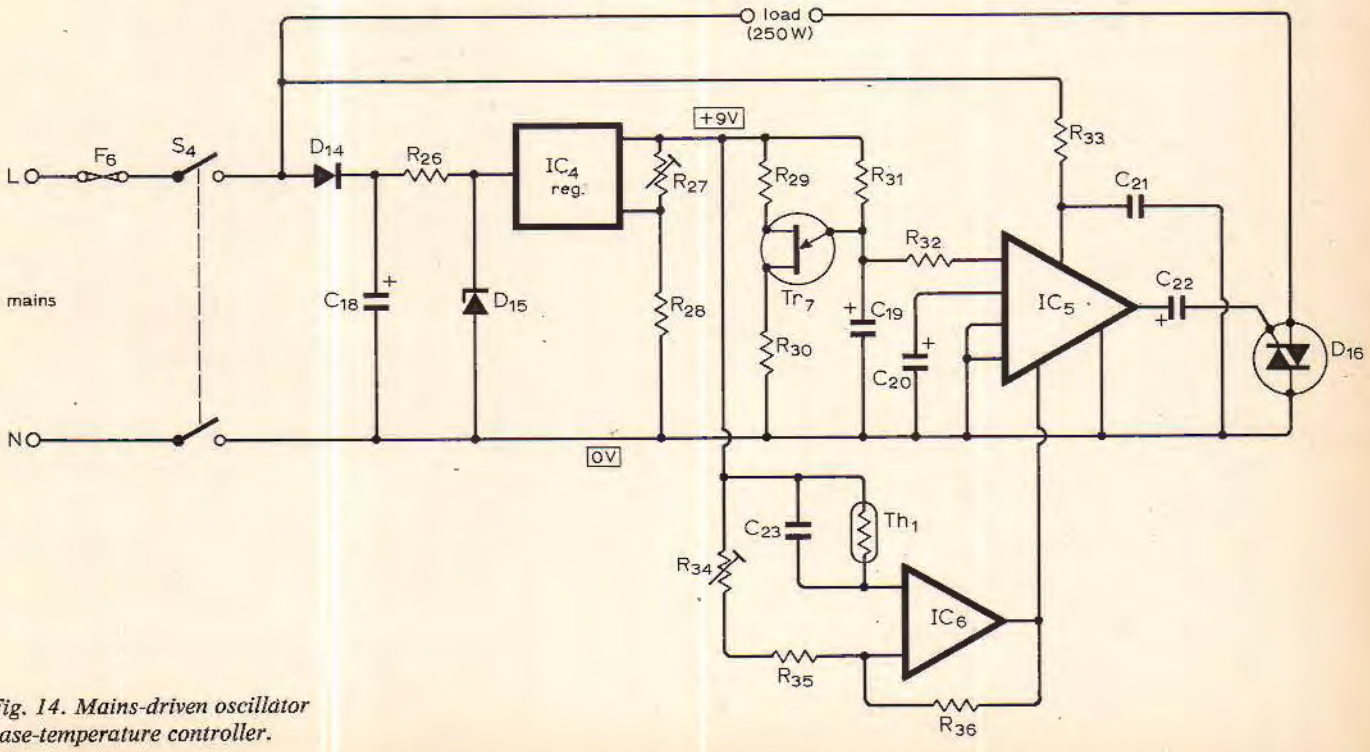


Fig. 14. Mains-driven oscillator case-temperature controller.

Parts list for oscillator chain (Fig. 2)

Resistors

R_1	1MΩ
R_2	2.2kΩ
R_3	1.5kΩ
R_4	22kΩ
R_5	47kΩ preset
R_6	22kΩ
R_7	470Ω
R_8	1kΩ (see corrections)
R_9	8.2kΩ
R_{10}	12kΩ
R_{11}	1kΩ
R_{12}	5.6kΩ
R_{13}	2.2kΩ
R_{14}	1.5kΩ
R_{15}	5.6kΩ
R_{16}	560Ω
R_{17}	470Ω
R_{18}	5kΩ multi-turn preset
R_{19}	4.7kΩ

Capacitors

C_1	0.1μF
C_2	0.1μF
C_3	39pF preset
C_4	200pF
C_5	30pF preset (see correction)
C_6	500pF preset (see correction)
C_7	300pF
C_8	0.1μF
C_9	0.01μF

Semiconductors

D_1	1N4004 (used as varicap)
D_2	6.8V zener diode
$Tr_{1,2}$	2N3819
$Tr_{3,4,5}$	BC108
Tr_6	BC477

Transformer

T_1	Denco IT

Parts list for BBC comparator (Fig. 4)

Resistors

R_{20}	10kΩ
R_{21}	47kΩ
R_{22}	10kΩ preset
R_{23}	470kΩ
R_{24}	2.2kΩ
R_{25}	39kΩ
R_{26}	1kΩ
R_{27}	220Ω
R_{28}	39kΩ
R_{29}	560Ω
R_{30}	390Ω
R_{31}	12kΩ
R_{32}	100kΩ
R_{33}	12kΩ
R_{34}	1MΩ
R_{35}	2.2kΩ
R_{36}	12kΩ
R_{37}	47kΩ
R_{38}	1.5kΩ
R_{39}	10kΩ preset
R_{40}	100kΩ preset

Semiconductors

Tr_7	2N3819
Tr_8	2N3819
Tr_9	BC109
Tr_{10}	BC479
Tr_{11}	2N3820
Tr_{12}	2N3819
IC_1	Signetics NE561B
IC_2	709 operational amplifier
D_3	1N4001
D_4	1N4001

Capacitors

C_{10}	1–6pF preset
C_{11}	33pF
C_{12}	1–6pF preset
C_{13}	2400pF
C_{14}	0.01μF
C_{15}	0.01μF
C_{16}	0.1μF
C_{17}	1000pF
C_{18}	0.1μF
C_{19}	0.1μF
C_{20}	10pF
C_{21}	0.1μF
C_{22}	0.1μF
C_{23}	5000pF
C_{24}	0.1μF
C_{25}	200pF
C_{26}	0.1μF
C_{27}	2μF

Transformer

T_2	Denco IT Blue
T_3	Denco IT Yellow

Meter

M_1	200—0—200A

Parts list for main power supply (Fig. 11)

Resistors

R_1	150Ω
R_2	150Ω
R_3	68Ω
R_4	2kΩ preset
R_5	2kΩ preset
R_6	100kΩ
R_7	100kΩ
R_8	68kΩ
R_9	68kΩ
R_{10}	1.5kΩ
R_{11}	4.7kΩ
R_{12}	33Ω
R_{13}	4.7kΩ
R_{14}	33Ω

Miscellaneous

LP_1	24V, 1W lamp
$LP_{2,3}$	12V, 0.1A lamp
F_1	2A antisurge
F_2	3A antisurge
F_3	3A antisurge

Capacitors

C_1	0.1μF
C_2	0.1μF
C_3	0.1μF
C_4	3,300μF electrolytic
C_5	10μF electrolytic
C_6	10,000μF electrolytic
C_7	5,000μF electrolytic
C_8	0.1μF
C_9	4.7nF
C_{10}	100μF electrolytic
C_{11}	0.1μF
C_{12}	0.1μF

Semiconductors

B_1	4 × Rec 31 (Radiospares)
D_1	26V zener diode
D_2	24V zener diode
$D_{3,4}$	1N5401
$D_{5,6}$	3.9V zener diodes
IC_1	Reg 15V (Radiospares)
IC_2	709
$Tr_{1,2,3}$	2N3055

Parts list for oven supply (Fig. 13)

Resistors

R_{15}	15kΩ
R_{16}	3.9Ω
R_{17}	1kΩ
R_{18}	470Ω
R_{19}	1kΩ preset
R_{20}	4.7kΩ
R_{21}	2.2kΩ
R_{22}	2.2kΩ
R_{23}	2.2kΩ
R_{24}	27kΩ
R_{25}	1MΩ

Miscellaneous

F_4	2A fuse
F_5	2A fuse

Capacitors

C_{13}	5,000μF electrolytic
C_{14}	2,200μF electrolytic
C_{15}	0.1μF
C_{16}	0.1μF
C_{17}	0.1μF

Semiconductors

B_1	4 × 1N5401
D_7	C106B1 (s.c.r.)
D_8	1N4001
D_9	27V zener diode
D_{10}	12V zener diode
D_{11}	3.3V zener diode
D_{12}	3.0V zener diode
D_{13}	ST4
Tr_4	MPS13
$Tr_{5,6}$	2N3054
IC_3	741

Transformers

T_2	240V Prim, 24V Secondary

Parts list for temperature controller (Fig. 14)

Resistors

R_{26}	1kΩ, 10W
R_{27}	4.7kΩ preset
R_{28}	2kΩ
R_{29}	2.2kΩ
R_{30}	47Ω
R_{31}	22kΩ
R_{32}	2.2kΩ
R_{33}	20kΩ, 5W
R_{34}	1MΩ preset
R_{35}	150kΩ
R_{36}	1.5MΩ

Miscellaneous

F_6	2A fuse

Capacitors

C_{18}	32µF, 450V electrolytic
C_{19}	100µF electrolytic
C_{20}	470µF electrolytic
C_{21}	0.1µF
C_{22}	47µF electrolytic
C_{23}	0.1µF

Semiconductors

D_{14}	1N4005
D_{15}	20V zener diode
D_{16}	2N6073
IC_4	MFC4060A
IC_5	JA424 (Jermyn)
IC_6	$\frac{1}{4}$ MC3301P
Tr_7	2N2646
TH_1	THB11

zener, which is the best choice from the point of view of temperature coefficient.

Temperature control

This is necessary both in the case of the crystal, which is of prime importance, and in the case of the oscillator circuit as a whole. We found, in fact, that it was necessary to maintain the crystal itself within very fine limits of temperature (of the order of 0.01°C) and the oscillator circuit as a whole within ±0.25°C in order to achieve our designed accuracy of frequency stability.

For control of the crystal temperature, we had the good fortune to be given a suitable oven by Marconi Ltd, to whom we are therefore greatly indebted. The temperature controlling element in this oven is stable within ±0.0014°C. We did, however, encounter one difficulty with it—we originally fed its heater element, which consumes 36W when active, from a.c. (50Hz), but found that this induced hum modulation into the crystal. The obvious answer was to provide a d.c. source; but this in turn gave the problem of switching transients each time the thermostat switch cut in or out. The final solution was the power supply shown in Fig. 13, giving a stable heater supply with very slow switching action (approx. 3s rise and fall times). Switch-on is accomplished by the thermostat switch grounding the base of Tr_4, which therefore ceases to conduct; the short-circuit which it represents in the conducting state is removed from the output of op-amp IC_3; IC_3 output therefore swings positive because its input potentials are unbalanced, thus charging C_{14} through R_{17} which takes about 3s. The potential on C_{14} controls the series Darlington pair $Tr_{5,6}$, giving the required output of 24V at the emitter of Tr_6, the output stabilizing, of course, when the potential at the slider of R_{19} equals that of D_{10} reference zener. It is worth noting, incidentally, that D_{10} is fed from *within* the feedback loop—a concept which has been discussed previously in this journal[3]. Turn-off of the supply is achieved by the reverse action; thermostat switch opens, Tr_4 base is switched via R_{21-24}, Tr_4 conducts and discharges C_{14} via R_{18} (and a further discharge path is provided through the output circuitry of IC_3 as the output voltage dies). Zener diode D_{11} limits the voltage handled by the thermostat switch to approximately 1.5V; D_{11} limits the maximum voltage applied to the base of Tr_4; D_8 has the not very obvious function of preventing C_{14} discharging back through the base-collector circuit of Tr_5 should the incoming mains supply be switched off—we lost a couple of transistors before we woke up to this hazard! Zener diode D_9 limits the maximum output voltage to approximately 26V in case of any other accident. Resistor R_{21}, D_{11}, R_{23} and D_7 form a final safety circuit. The thermostat switch is arranged mechanically so that gross overheating of the oven forces its live contact by thermal expansion against the live terminal of the heater winding. This passes a trigger current to D_7, which latches in across the supply and blows F_3.

For control of oscillator temperature, we decided that the most practical course was to temperature-stabilize the entire clock case using proportional temperature control. A 250W mains-fed heating pad is used and control is by the circuit of Fig. 14.

Conclusion

As we said at the beginning of this article, construction of this project has taken almost three years. Looking back, it is sobering to realize how much this branch of technology has changed during even this comparatively short period. In fact we chose a fortunate moment to commence the project, being the period when bipolar digital i.cs had dropped to an acceptable price level but before their successors in technology (c.m.o.s.) had begun to be too demanding of attention. We have already given the reasons why we as a school undertook the project, and our aims in this respect have certainly been vindicated. Perhaps one proof of this lies in the fact that, of the two co-authors of this article, one is a master at the school and the other a former pupil.

References and acknowledgement

1. Osborne, J. M., "High standard low frequency source", *Wireless World*, Jan. 1973.
2. Clayton, G. B., "Op-amp used as phase sensitive detector", *Wireless World*, July 1973.
3. Letters, "Regulated power supplies", *Wireless World*, Nov. 1972; Anon, "Thermometer", *Practical Electronics*, Nov. 1973.

We also wish to acknowledge gratefully the gift by Marconi Ltd to the school of the high-quality crystal oven used in this project.

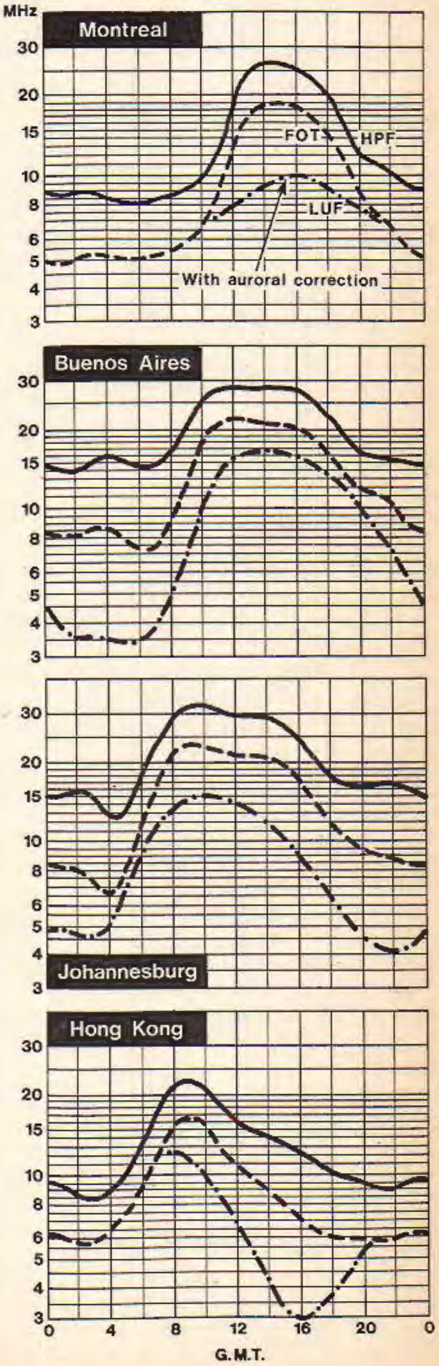
Corrections

Fig. 2. Resistor R_8 should be connected in the emitter lead of Tr_3, below the emitter connection with Tr_4. Two trimmer capacitors appear with the designation C_5. The correct C_5 is connected across L_1 and the second trimmer across the secondary of T_1 should be C_6. The control output of the varicap control unit should have a 100kΩ resistor connected in series.
Fig. 4. A connection should exist between the top end of R_{35} and the junction of R_{34} and C_{21}.
Fig. 9. Outputs to IC_3 should be labelled A_1, B_1 D_1 (not C_1) and A_2.

HF predictions

MUF (maximum usable frequency) at a given hour varies from day to day. HPF (highest probable frequency) and FOT (optimum working frequency) curves enclose the decile range of this MUF variation. The prediction is that on 24 days of a month (30 days) observed MUFs will lie between HPF and FOT, on three days MUFs will be greater than HPF and on the remaining three days MUFs will lie below FOT.

The above assumes a quiet ionosphere; on disturbed days MUFs will generally lie below predicted quiet FOT. Prediction of disturbed days in these notes, based on a 27-day recurrence pattern, has been about 70% correct over the last two years.



Letters to the Editor

THYRISTOR CONTROL OF D.C. MOTORS

We read with interest the article on thyristor control of d.c. motors by F. Butler in the September issue. The article itself was excellent but perhaps might be a little misleading, especially as on page 328 he states "Merely by up-rating the semiconductor devices the scheme appears to be applicable to large motors, certainly up to tens of horsepower". This is not strictly true for thyristor controllers using the "thyristor across the bridge technique" and unfortunately most users, power supply authorities and thyristor drive manufacturers would similarly disagree with that conclusion simply from the viewpoint of harmonic interference injected into a single phase supply.

However, the uninitiated reader might well fall into another trap as, again on the same page, Mr Butler refers to the requirement for "an overriding control which will limit the circuit current to a safe value". Alas, this could well be an understatement because many other would-be users have condemned thyristor motor speed controllers because "when they switched on the supply the fuses blew and kept on blowing". What they had forgotten of course was that the d.c. shunt wound machine, without some form of acceleration control and current limiting, presents almost a short circuit across the supply system with the inevitable result that the fuses blow.

To sum up, the article is indeed praiseworthy but should be regarded with a certain amount of caution, the maximum horsepower, from a reasonable design point of view anyway, being of the order of 2h.p.—certainly not tens as stated in the article.

P. A. Bennett,
Allen Bennett Ltd,
Sheffield,
Yorks.

Mr Butler replies:

Some of the points raised by Mr Bennett were discussed in my original article. However, they are worth stressing a little more forcibly, as he has done, and his letter gives me the opportunity of adding a few comments on matters which were omitted or glossed over in my paper.

As regards power limitations of thyristor drives, a glance through the advertisement pages of technical journals shows that systems up to 260kW (350h.p.) are readily available from companies such as Laurence, Scott and Electromotors, Maudsley and Hugh J. Scott. No doubt the larger installations operate from three-phase supplies, but in principle there is nothing against the use of single-phase sources, subject only to restrictions imposed by supply authorities.

A valid criticism of thyristor controllers is concerned with waveform distortion. To avoid this, variable phase-angle control must be abandoned and the "missing cycle" system used instead. In this system, thyristor firing either occurs at the start of a particular half-cycle or not at all. Though more acceptable to the supply authority, the scheme does not always appeal to the user because of the violent torque fluctuations at low speed and low power.

Starting problems with large d.c. motors are just as bad whether operation is from d.c. mains or from a.c. through a thyristor controller. In the first case, full field current is applied and a manual or automatic starter feeds armature current through a stepped resistor, sections of which are shorted out as the motor gathers speed. It is damaging if not dangerous to overspeed this operation.

With the thyristor controller, the motor must be started with fully retarded firing pulses; the control must then be advanced slowly or some overriding current-limit control must be fitted. The Mullard trigger modules MY 5001 and MY 5051 together give these facilities The simpler arrangement I described is perfectly satisfactory if used sensibly. Its only weakness is that the motor speed tends to drop as the load is increased. To counter this, a feedback loop, such as I mentioned in the article must be added. This, too, is available with the Mullard units.

The vital elements in my controller are the auxiliary power diodes and thyristor load resistor. These prevent the repeated fuse-blowing which is the bane of the simpler controllers. Another point, not previously mentioned, concerns the power factor of a thyristor drive. Delayed firing pulses obviously cause a lagging current to be drawn from the supply, though it is doubtful if matters are worse than when using under-loaded induction motors. Because of the distorted current waveform, precise correction by shunt capacitance across the supply line is impossible.

Since my article was written I have built a universal grinder, the wheel-head drive being from a variable-speed d.c. motor of $\frac{3}{4}$hp. Grinding wheels between 1 and 6in diameter can be run at the optimum speed, which can be measured by a non-contacting tachometer. A colleague, Mr B. Reid, developed a very useful instrument for this purpose. Unfortunately, variable speed grinders contravene the Factory Acts, so that they cannot be used industrially (overspeeding can result in burst wheels). The drive unit for this machine has given no trouble. Another colleague, Mr John Lennan, has built a 1kW controller to supply a 1h.p. motor used to drive a 6-in centre lathe. This, too, has given trouble-free service and I can see no reason why larger units cannot be built with every confidence. Fractional-h.p. motors pose no problems at all.

COMPONENT IDENTIFICATION

As an engineer, I welcome, as I am sure many of my fellows do, the now almost universal adoption of the BS 1825 resistance code. In this, and similar systems, the decimal point and multiplier are combined, so that a one-point-five ohm resistor is expressed as "1R5", and a point-one-five ohm component as "R15".

This is fine, but why, then, is a one hundred and fifty ohm device specified as "150R"? Surely, "K15" would be more logical, as it conserves the three-character format, and is no less informative. This system may of course be extended to capacitors and inductors, "n10" neatly replacing "100p".

Such a modification to accepted practice is only justifiable if widely publicised and understood. I would welcome readers' comments on my suggestion.

S. J. Pardoe,
Altrincham,
Cheshire.

HORN LOUDSPEAKER DESIGN

A number of readers have pointed out that in many cases the minimum space necessary to enclose the rear of the bass loudspeaker apparently exceeds the optimum cavity volume for giving the correct upper cut-off frequency, often by a factor of four or five times. Since the cut-off frequency is inversely proportional to the cavity volume, this will have the effect of giving a serious "trough" in the overall frequency response before the mid-frequency horn takes over. The answer is to reduce the cavity to the correct volume by means of a circular plaster or wood moulding leading from the rear of the loudspeaker diaphragm to the throat of the horn. This technique has been well described by John Crabbe (*Wireless World*, Feb. 1958, my ref. 19).

A further point raised by several readers is the lack of detailed constructional data for the practical horns described in part 3. This was a deliberate policy on my part, because earlier experience had shown that no design seemed to suit more than a very small number of constructors. Indeed, I have already received a number of letters proposing alternative designs and configurations, and asking for my advice regarding their performance—advice which in most cases is quite impossible to give.

Nevertheless, I am very sympathetic

towards those readers who require detailed constructional information, and I hope to make available early next year detailed drawings of a moderately-sized corner horn which gives a very satisfactory performance.
J. Dinsdale,
Olney,
Bucks.

As ref. 20 in the interesting series of articles on acoustic horn design by Mr Dinsdale (March, May, June issues), I would like to reinforce the warning on differential time delay given by Mr Hamill in the September issue. Experience with a 16-ft bass horn (described in "Acoustic Compensation", *Hi-Fi News*, November 1964) confirms that the reproduction of transients is most subjectively accurate when l.f. and h.f. path delays are similar, although if some differential must be endured results are less unnatural if h.f. energy is received first. Experiments suggest that, as a rough empirical guide, the time differential introduced should not exceed $1/f_c$, where f_c is the crossover frequency. Thus, for f_c at 400Hz, up to 2.5ms would be allowable, equivalent to a path difference of nearly 3ft.
R. N. Baldock,
Harrow,
Middlesex.

DIGITAL SPEEDOMETER

Having designed and partly constructed a digital speedometer before coming to Saudi Arabia this summer, I was interested to note the similarity of approach in the design offered by Messrs Bishop and Woodruff (September, October issues). Perhaps you would allow me to make the following comments.

Firstly, by expanding the display to three digits and altering the count period generator to include a switched resistor, the display could indicate either miles or kilometres per hour, together, perhaps, with a suitable indicator to show which is being displayed.

Secondly, in my design I used an optical pick-up from a modified speedometer, and by doing this was able to dispense with the frequency multiplier. This reduces the circuit complexity quite considerably, but requires knowledge of the individual speedometer gearing to calculate the correct number of slots in the rotating disc. I have also considered the use of storage and calculation logic to display acceleration. But this seems to be adding much cost and work for very little gain.

I have been thinking about the addition of variable retard or advance to a thyristor ignition circuit. Perhaps an automobile engineer could tell us whether such a control on the dashboard would be of advantage in the fields of performance or economy?

During the petrol crisis last winter I connected a reed relay and light bulb to indicate each stroke of the electric petrol pump. Although the pump frequency varies with engine speed, and thus the display cannot give a true indication of m.p.g., it is certainly a constant—and effective—reminder of the absolute rate of flow of fuel!
N. H. Jennings,
Dhahran,
Saudi Arabia.

CALCULATOR AS SIGNAL SOURCE

At the risk of appearing frivolous, may I suggest a possible secondary application for the now ubiquitous electronic pocket calculator?

Recently, while re-aligning a pre-war a.m. broadcast receiver, it became necessary to convert wavelength (in which the set's tuning scale was calibrated) into frequency and this simple calculation was carried out on a Sinclair "Cambridge", which I keep handy in the workshop. With the set switched on it was noticed that a high pitched buzzing emanated from the speaker whenever the calculator was operated and that this note could be altered in pitch as the various function keys were depressed.

Analysis of the "r.f. field" with an oscilloscope indicated a strong square wave radiation extending up to 3MHz. Subsequent experimenting suggested that the calculator acts as a very effective signal injector and my "Cambridge" has in fact been used as such (in addition to its normal intended use, of course!) in the repair of long- and medium-wave radio receivers for the past few months. It would be interesting to hear other readers' comments—other calculators currently available may yield quite different results and may possibly radiate at frequencies above 3MHz.
A. D. Thomas (GW8DXA),
Cardigan,
West Wales.

F.M. TUNING INDICATORS

I have followed with interest the correspondence on f.m. tuning indicators, and I think readers may be interested in my approach to the problem.

My circuit arrangement has the advantage of the two-lamp system, i.e. it indicates direction of mistuning and also has the additional advantages of maximum sensitivity at the tuning point and requires no judgement to be made by the operator.

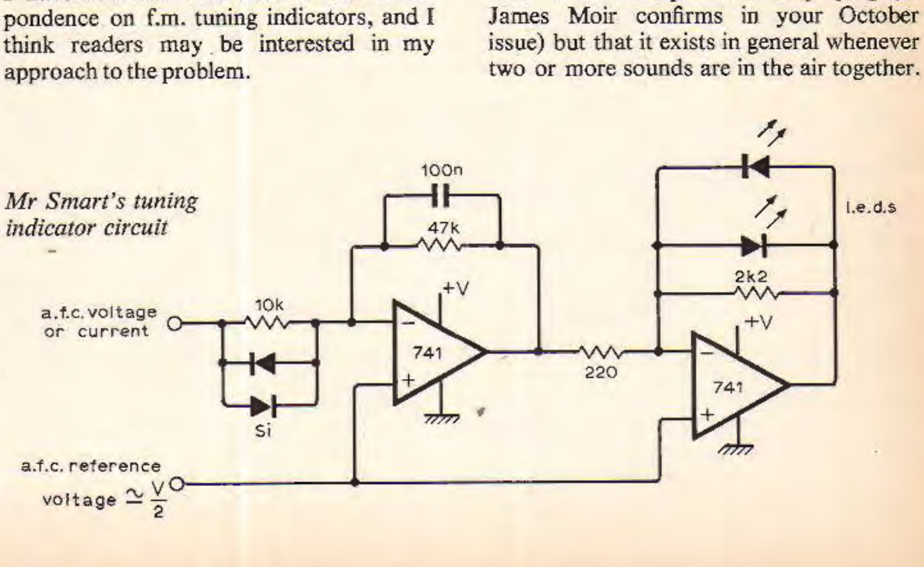
These features are obtained by putting the two lamps (l.e.ds) in the feedback loop of an op-amp (741). The high open-loop gain of the 741 and the forward voltage drops of the l.e.ds combine to prodnce a very sensitive null detector. The a.f.c. reference voltage is fed to the non-inverting input of the 741 and the a.f.c. voltage to the inverting input via a second 741 as an amplifier/buffer. When the set is on tune the output of the 741 will be at mid-rail voltage and neither l.e.d. lit, but only a small tuning error is required to swing the output to the "knee" of the l.e.d. characteristic, turning it on and so indicating mistuning in that direction. The l.e.d. current in the "off tune" state will be automatically limited by the built-in current limit of the 741. To reduce the sensitivity to usable levels a shunt resistor is connected across the l.e.ds, otherwise the output level will tend to sit so that one or other of the l.e.ds is conducting. The gain of the buffer and the value of the input resistor, which sets the l.e.d. current, are chosen to suit the a.f.c. voltage available. Typical values are given on the diagram. This circuit is used with an RCA CA3089 i.f. chip, which has the a.f.c. output in the form of a current. Silicon diodes across the a.f.c. resistor limit the range of the a.f.c. in a similar manner to the design by J. A. Skingley and N. C. Thomson (*W. W.* April, 1974).

The capacitor across the first 741 removes the modulation components from the a.f.c.
M. G. Smart,
Sunbury-on-Thames,
Middlesex.

DOPPLER IN LOUDSPEAKERS

Mr Edgar's novel approach (August Letters) made me think again about this matter, and I came to the conclusion that not only does Doppler effect physically exist when loudspeakers are playing (as James Moir confirms in your October issue) but that it exists in general whenever two or more sounds are in the air together.

Mr Smart's tuning indicator circuit



The fact that in most cases the effect is negligibly small does not affect the principle. Or can someone explain why (e.g.) a large-amplitude low-frequency waving of the air to and fro does *not* frequency-modulate a small-amplitude high-frequency wave (from another source) being carried by that sinusoidally moving air?
"Cathode Ray".

MAKING P.C. BOARDS

For some years now I have been using Letraset for making printed boards. Perhaps your readers would like to know of this method. As a start I can recommend sheets number 557, 556, 804. About three years ago I contacted Letraset in the U.K. and they showed interest. Perhaps if someone produced a greater variety of connections then the use of this method would become more popular.

I would like to put these points forward: 1, clean the copper board well, e.g. with steel wool and warm water, then dry completely and allow to reach room temperature, which should be at least 20°C. 2, use light pressure when rubbing; do not burnish, just press down with finger. 3, when making joints, "overlap". 4, to cut just use a sharp knife. 5, mistakes are easily removed by scraping with a plastic tool on tape, but beware of this as it could leave a trace of adhesive which will prevent etching.

H. Wedemeyer,
Vanse,
Norway.

LOUDSPEAKER DAMPING

Mr Marshall refers in a letter in the October issue to a contribution (Transients and Loudspeaker Damping) I made in May 1950 on the subject of the damping factor of amplifiers. Reference to the contribution indicates the degree of misunderstanding commonly involved in thinking that high damping factors are significant.

Briefly, motion of the loudspeaker voice coil is "damped" by the motionally induced current circulating in the voice coil-amplifier circuit. The amplitude of the current is controlled by the *total* impedance of the circuit, amplifier + voice coil + wiring. The amplifier output impedance obviously has no significant effect on the total current when it is only some 10% or less of the total circuit impedance. Thus extremely high damping factors, i.e. very low amplifier output impedances, are of no engineering significance in damping the oscillation of the voice coil; indeed they may impair the performance of a loudspeaker. The contribution includes some oscillograms showing the actual effect of amplifier output impedance on the transient oscillations of the voice coil of a typical loudspeaker.

It is also worth noting that while the amplifier output circuit impedance may have some effect on the transient oscillations at low frequency, the cone is so loosely coupled to the voice coil in the middle and high frequency bands that the cone or small areas of the cone can continue to oscillate although the voice coil is stationary.

As the contribution demonstrated, there appears to be no engineering advantage in achieving damping factors much greater than about ten. In many instances there are positive disadvantages in using amplifiers with high damping factors.

James Moir,
Chipperfield,
Herts.

TRIALS—AND TRIBULATIONS!

A photograph of a charming young lady holding one of the new push-button dialling telephones (STC Trimphone, I believe) appears on p. 374 of your October issue. The caption states that if the London trials "go as the Post Office expects" the new phones will be made available progressively in other parts of the country.

If one compares the telephone keyboard with that used on calculators it will be seen that only four figures—4, 5, 6 and 0—are in the same positions. (See, for example, the calculator advertised on p. a53 of the same issue.) It does not require much imagination to foresee the sort of confusion which could arise if the two instruments—calculator and push-button phone—are side by side on a desk.

The calculator keyboard has been standardized for some time. Whey then should a telephone manufacturer and/or the Post Office introduce a variant? It can, of course, be argued that the Trimphone keyboard with the zero after figure 9 is in keeping with the sequence of figures on the normal telephone dial. With the logic of this one would agree, but with the calculator becoming increasingly a tool of everyday life, would it not have been logical for the new phone keyboard to conform with what is established practice in another branch of electronics?

Harold Barnard,
Leigh-on-Sea,
Essex.

AUDIO VISUAL GROUP

May I inform you that the British Kinematograph, Sound and Television Society has, for some time past, been planning to improve services to existing members working in the audio visual field and to fill a suspected need of potential members for an organisation that will provide papers, presentations, technical articles and technical information on audio visuals.

Although the Society originated as a film orientated organisation it has widened its scope by entering the television and sound fields where appropriate to its aims and objects and now has considerable experience and some reputation in the proper integration of these three separate techniques. Where better then to find the resources and the skill in the efficient use of film, television, video, sound and vision techniques used in combination?

The very nature of the Society's undertaking requires the closest co-operation with all organisations catering to the separate needs of those techniques that go to make up audio visuals, and the BKSTS has every intention to provide its members not only with their brand of information but information on the activities of other organisations bearing on audio visuals.

In this connection I hope that we can be of mutual service to *Wireless World* and to its many readers, some of whom may be looking for an organization to serve their needs in the dissemination of technical information which, in these days, comes and goes in such prolific quantity and at such a rapid pace.

The BKSTS Audio Visual Working Party has, as its brief, the task of improving existing services and of creating a climate that will encourage an increase in our 2,000 strong membership.

Robert R. E. Pulman,
BKSTS Audio Visual Working Party,
London, WC1.

ELECTROSTATIC FORCES ON PICKUPS

Like Mr Hide I have also found when using an SME arm under a plastic cover that the arm would occasionally lift from the playing surface. I have found that a cure could be effected by damping the cover by means of a damp cloth or by using an anti-static cleaner to clean the cover (similar to the method of preventing dust accumulation on TV screens).

However, I also suffered from snap, crackle and pop, and, blaming this on central heating and a rather dry atmosphere, I now use a wet sponge in a tray on the baseboard of my plinth, inside the cover. This overcomes the spurious clicks and no longer is the pickup arm liable to lift from the record, presumably because the slight increase in humidity inside the plinth inhibits the development of electrostatic charges on record or cover.

Previously the pickup could be lifted off the record simply by rubbing on the outer surface of the cover (not to be recommended with an expensive stylus and one's favourite disc) wheu the pickup could be induced to lift and return to position to the outside of the record. With this primitive humidifier device *in situ* no amount of rubbing on the cover will induce the pickup to miss a note.

Alec West,
Milton Keynes,
Bucks.

WESCON 1974 convention

Electronics in medicine ● microprocessors ● speech recognition

by Aubrey Harris
University of California

The 1974 WESCON (Western Electronic Show and Convention), the big electronics event of the year in the Western United States, was held September 10 to 13 in Los Angeles. Many of the papers this year stressed practical applications and only a small number of new items were displayed in the show: the big semiconductor manufacturers were notably absent.

One of the areas in which electronics is becoming more and more needed, and accepted, is the field of medicine. Perhaps the earliest application of electronics was in the use of x-rays last century, but since then a whole host of uses have been developed: electro-cardiograph and electro-encephalograph apparatus, pacemakers, hearing aids, myo-electric control and many measuring and monitoring equipments. These latter are of particular importance for such uses as alerting medical personnel in the event of a change in vital body functions of critically ill patients.

A paper by J. R. Singer, T. Grover and A. Poggio, "Progress in blood flow measurements" described their work in this area using nuclear magnetic resonance (n.m.r.). This technique has advantages because blood flow can be determined without inserting probes or other devices into the subject to be tested. A large percentage of blood is water, and it is the magnetic properties of the hydrogen nuclei of the water molecules which are used in the measurements.

It is known that the hydrogen protons in the blood are magnetic and possess spin, and each proton is like a gyroscope or spinning magnetic top. When placed in an external magnetic field, the "magnetic tops" align themselves north-to-south with the external field. In fact, this alignment is not immediate but takes about three seconds in pure water and in venous blood (because of the paramagnetic nature of the haemoglobin molecules) the protons require only 0.5 sec to align (Fig. 1). When the alignment has taken place the protons as a group behave as a gyroscope and precess. That is, just as a spinning top will do, the axis tilts out of the vertical and describes a cone due to the force of gravity. In the case of a fluid in a magnetic field, the hydrogen protons precess in a similar way (Fig. 2).

The tilt may be increased to a greater extent by applying a radio frequency field in such a way that the magnetic action of the r.f. provides torque to tip the spinning protons. A coil carrying a few milliwatts of pulsed r.f. power produces a rotating magnetic field (during each pulse) and when the rotation is equivalent to the rate of the spinning protons they will tip. In these experiments the r.f. was at 10MHz.

Another coil is used to detect the tipping and is arranged to be perpendicular to the excitation coil, some 3cm away. The precessing protons, being magnetic, induce small signal voltages in the detector coil which, after amplification, can be measured. Protons tipped by the r.f. will produce a different output in the detector coil compared to untipped protons; this is because of the different angles which the axes of the tipped and untipped protons make with the axis of the detector coil.

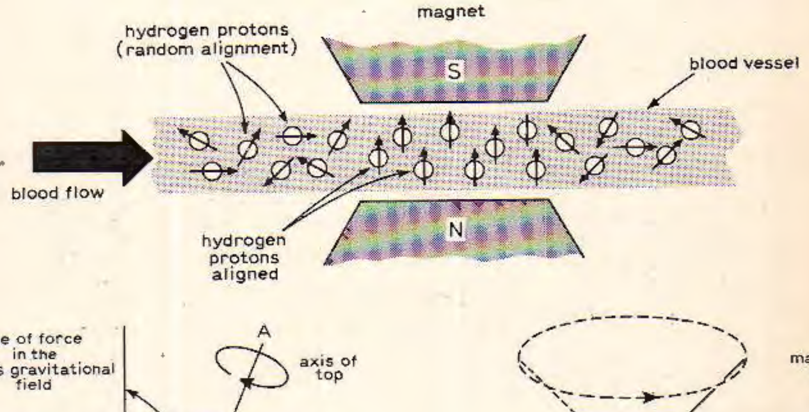


Fig. 1. Hydrogen protons in the blood being aligned during their passage through a magnetic field.

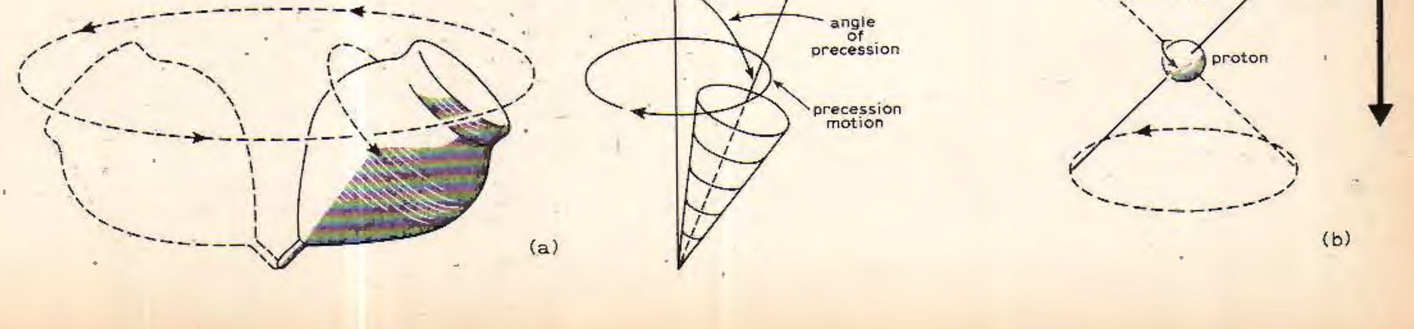
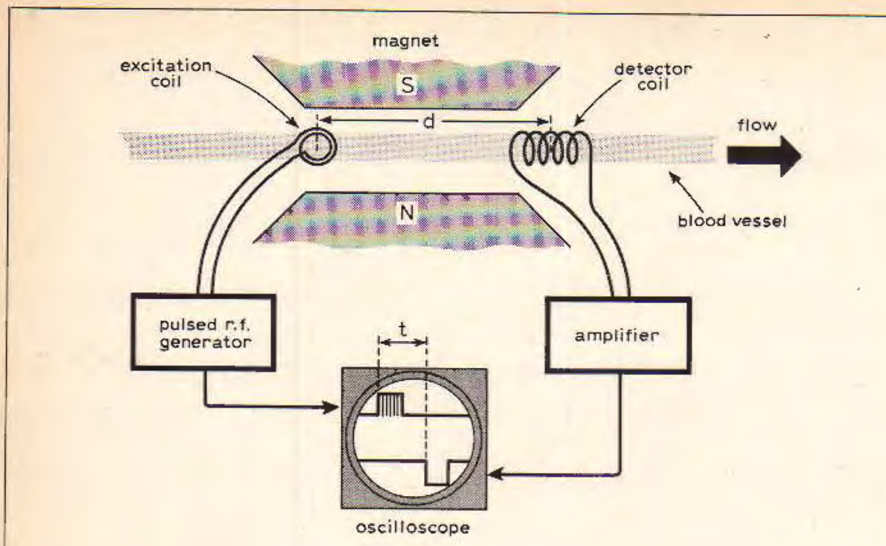
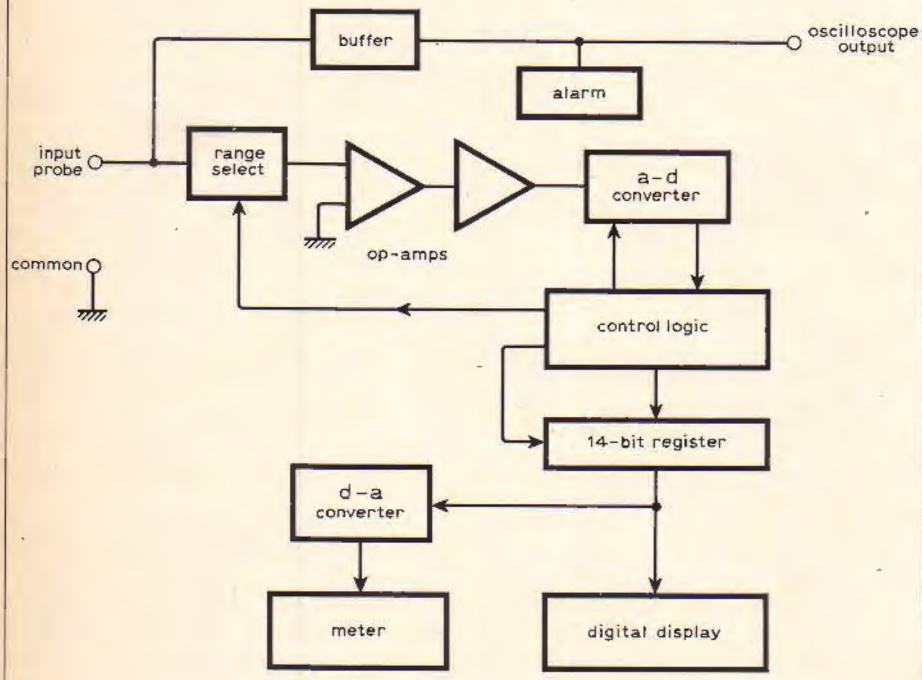


Fig. 2. Representation of the proton or group of protons as a spinning top which precesses about the direction of a magnetic pole. A top precesses about the gravitational field in a familiar way. (a) The proton has spin like a top and precesses about the magnetic field. (b) The description is very similar even though the proton motion is invisible.





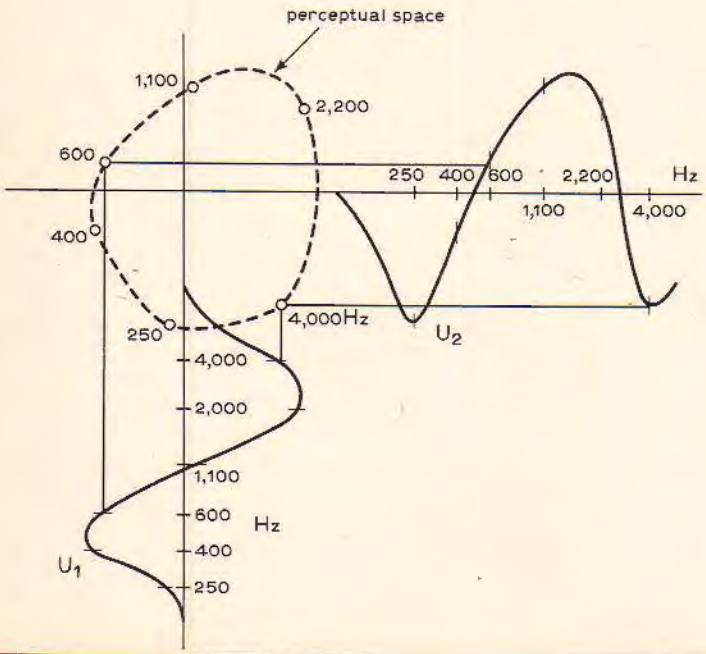


Fig. 3. Schematic arrangement for determining blood flow using nuclear magnetic resonance. The time taken (t) for protons "tipped" at the excitation point to reach the detector coil is used to calculate flow. Typical spacing (d) is 3cm.

Fig. 4. Block diagram of "acumonitor" for use in acupuncture.

Fig. 5. Voice entry encoder: the perceptual space and its relationship to the sine (U_1) and cosine (U_2) functions. Filter frequencies are also indicated.

Thus, it is possible to determine at the pick-up coil when protons in the blood which have been tipped by an r.f. pulse are passing the detector point. The flow rate may then be determined by noting the time taken for tipped protons to move between the excitation and detector coils, and, knowing the spacing between the two points, the average flow velocity may be determined (Fig. 3).

One problem in using this system under clinical conditions is the cost of the large magnet required, which has a magnetic flux density of about 2500 gauss. These may be produced in quantities economically but are expensive in small, experimental numbers. It is hoped that this restraint can be soon overcome.

A related series of papers under the collective title of "Psychotronics" was chaired by Dr Thelma Moss of the Neuropsychiatric Institute of the University of California, Los Angeles. Although not strictly directly related to electronic equipment, a tremendous interest was aroused amongst engineers at WESCON with about 1200 of them attending an evening meeting on the subject. This serves to emphasize the growing appreciation and realization by many professionals that there is a large number of events and "happenings" which cannot be explained by our present scientific knowledge.

My apologies to those of my readers who are disbelievers (or pre-believers) of such esoteric manifestations as are described hereunder; I, too, was among your erstwhile millions—now, no longer so.

The areas covered included a laboratory investigation of telepathy, some new work in Kirlian photography, a remarkable demonstration of changes in human physical states by Jack Gray using his own personal energies of an, as yet, unexplained nature, and some work on an "acumonitor" by B. E. Taff. He explained that there has been increasing interest in the past few years by the medical profession in the Western world in acupuncture, the ancient Chinese method of preventive medicine and pain reduction. Their theories state that there are 12 meridians in the body, acting as prime "energy circuits": for perfect health the energy in these circuits must be balanced properly between the meridians. Acupuncture is used as an aid in obtaining the correct balance. The meridians are thought to be a fourth (and distinct) body system in addition to our blood circulation, lymph and nerve systems. The actual nature of the "energy" in the meridians is not clear but has been shown to be real.

There are various methods of stimulation for correcting the energy imbalance in the circuits: (a) by chemical means, (b) by massage or pressure (acupressure), (c) by needles (acupuncture), (d) by electrical energy injection, and (e) by laser beams.

These latter two require a good deal of understanding and sophisticated equipment; however, it was demonstrated in the USSR that a mild intensity laser beam directed at the meridian above the lip caused immediate cessation of an epileptic seizure. Work has been directed at devices capable of determining the location of the meridians. The Russian scientist V. G. Adamenko wrote in 1972 about a device called the "tobiscope" enabling measurements of resistance points on the body to be made, which show a one-to-one correspondence with the known oriental acupuncture meridians. The device appears as a metal cylinder with a probe at the top, insulated from the metal body. In use, an operator holds the cylindrical part and applies the probe to the skin of the subject. The operator completes the electrical circuit by maintaining contact to the subject's body with his free hand.

Networks of low resistance can be traced which correspond within a millimetre or so to the acupuncture meridians. These networks are differentiated from skin probing of other areas of the body by a ten-to-one resistance ratio. Approximate measurements recorded are 0.5 to 1.5×10^5 ohms at the meridians and about 10^6 ohms on other areas. Due regard is taken of shunt low resistance paths due to moist skin. For this work low values of direct current were used (a few microamps at four volts) but some experiments have also been successfully made with a.c. at 1000Hz.

A more sophisticated device designed and developed by Taff is the "acumonitor" mentioned above, basically a single channel d.c. analogue/digital metering device. It has stainless steel electrodes, one a 2mm probe and the other a hand-held circuit return. A block diagram is shown in Fig. 4: the actual circuit is still proprietary. The probe signal is fed through several stages of i.c. f.e.t. operational amplification providing an input impedance of about 2×10^8 ohms. In searching for the acupuncture meridians an alarm is set to trigger whenever potential is indicated at over 37 millivolts and resistance under 2.5×10^5 ohms. However, parameters are also visually displayed with an l.e.d. digital display.

The "acumonitor" has been used on a subject under stimulation, to measure changes in readings at specific locations. In one test, voltage measurement increased by a factor of five and resistance decreased by 40% during two-minute stimulation of the subject by a 15-mW helium-neon laser.

Ever since the introduction in 1948 of the first solid-state active device, the transistor, there has been a significant impact every few years or so, with the development of more highly sophisticated devices—i.cs, m.s.i., l.s.i. The latest in this line of development is the microprocessor. The term microprocessor (often abbreviated to μP) is used to describe the central processor unit functions of a computing device implemented by one or a few m.o.s./l.s.i. chips. Significant differences between the μP and the minicomputer are the lower cost, reduced power requirements and often, lower speed. An important advantage of the μP over the other forms of l.s.i. is its capability of being programmed.

There were some 19 papers on μP presented in what was called the "microprocessors revolution". M. M. Saba and J. D. Grimes, in their contribution "Microprocessors: a component for all seasons", showed that the μP has really arrived and is now considered a single component characterized by such features as data word sizes of 2, 4, 8 or 16 bits, macro instruction cycle times between 300ns and 60μs, instruction sets between 50–100 items, memory address space ranges from 256 words to 65 kbytes, frequently requiring from ten to 40 s.s.i. or m.s.i. packages to interface them with other sub-systems. The μP presents itself as a powerful, inexpensive computing device, the implications of which upon the electronics and computing industries are not yet appreciated.

The uses to which the μP is now being applied are basically in the areas of calculation and control-type functions. It is often used as an alternative to hard-wired random logic and has been found an inexpensive alteruative to the minicomputer, where speed is not of the essence. Such applications are, for example, point-of-sale and graphic terminals, and credit card verification systems. According to a report by Quantrum Science Corporation there were 100,000 units in the USA at the beginning of 1974; and the number is expected to increase to 800,000 units by the end of 1975. By 1976 the cost of a unit is predicted as either $10 or $130—depending on who you want to believe.

In reviewing the present and future trends of the market for microprocessors, Robert F. Wickham indicated that their role would be in "dedicated" systems such as computer peripheral controllers, office equipment, computer terminals, communications controllers, as well as test and measuring instruments offering programmability and "intelligence".

In the equipment show a remarkable piece of equipment was shown by Perception Technology Corporation. It was "voice entry", a device which provides a direct interface between the human voice and a computer system, making it possible for any person to address a machine in appropriate words chosen from one's own language.

This apparatus could be useful for controlling equipment or machine systems in situations where both hands and feet are already occupied or where there are restrictive physical limitations, such as in the cockpit of a test vehicle or where operations upon micro-components must be made while viewing the device through a microscope. Further uses are in directing materials, handling, sorting and in controlling physical access by personal (voice) identification. As the input is an audio signal, remote control of systems is possible by telephone.

The basic unit, designated the VE-100, is suitable for table top or rack mounting and costs $6,198. This provides an interface to a computer (such as a PDP/8E with 8k of memory) which is necessary for operation of the unit. The vocabulary is normally the digits "zero" to "nine" plus control words "enter", "cancel", "reset", and "function". The machine can be trained to recognize other words.

Machine recognition of speech regardless of the speaker's characteristics is a formidable problem and many systems so far have had a high rate of inaccuracy and speaker dependence. A novel solution is provided by the use of a set of transformations to map speech spectral parameters into a perceptual space.

The problem of accuracy of recognition can be appreciated when it is observed that the variation, in spectral terms, of a given phoneme between different speakers is often greater than the difference between two distinct phonemes. The problem is compounded because, even with a single speaker, monitoring shows that spectral differences occur at different times, contexts and circumstances which are comparable to the differences between speakers.

Speech parameters can be described by spectral distribution and to a general degree may be represented by points in a two-dimensional perceptual space approximating a circle (Fig. 5). A combination of more than one frequency will be indicated by a point within the figure. (This is somewhat similar to the representation of coloured light in the CIE chromacity diagram. However, the speech spectral distribution curve is continuous.) The co-ordinates of the curve approximate to sine and cosine shapes, and are derived from Fourier transformations. In the equipment the functions U_1 and U_2 are reproduced by six active bandpass filters, one at each of the frequencies noted, each with a Q of 1.67 and two filters with slope at 24dB/octave at 300Hz and 500Hz to provide the required shaping.

Phonetic segments are determined by noting changes in energy levels and transitions between voiced and unvoiced states. Then segments are fed to an 8×8 matrix space in the computer and these are compared with stored speech information in matrix form. A number is assigned to each of the comparisons of a given segment with all the stored patterns. The number is related to the closeness of the dominant vowel in the input vs. the stored pattern; the closer the number is to zero, the better the match. In a given word up to four segments will be recognized and

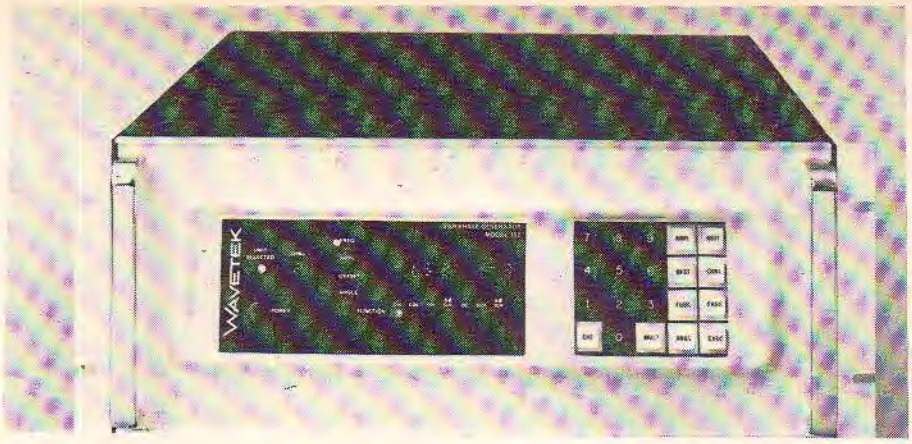


Fig. 6. Wavetek model 152 programmable function generator.

Fig. 7. Tektronix 31/53 data acquisition system.

compared for the matching process.

The system consists of speech processing circuits, a mini-computer and an interface between them. In operation an input word is processed and its identity verified within 160ms of the end of the spoken word. During this interval the spectral distribution of the speech signal is determined by the filters, whose outputs are rectified, smoothed, sampled every 10ms and input to a memory. The computer tabulates them to form the data points of the perceptual space. A comparison is then made with the related, stored pattern and operates on a decision algorithm built upon a broad statistical base, thus gaining a large degree of speaker independence and accuracy.

Regarding this latter aspect, accuracy is claimed to be from 90% to 99%. The higher figure may be achieved by "training" the system, by repeating via the input microphone the desired vocabulary and voice.

A new approach in programmable function and waveform generation was demonstrated by Wavetek. The Model 152 equipment (Fig. 6) allows, either from a manual keyboard on the instrument or remotely by an ASCII code, control of frequency, amplitude, waveform, d.c. offset, and trigger mode, as well as continuous phase variations of functions from 1Hz up to 100kHz, with harmonic distortion of less than 0.1%. (The models 158/159 have frequency ranges from 1Hz to 3MHz and can be programmed for 180° phase changes only.) Sine, triangle, ramp and square waveforms may be generated with output voltages of from 10 millivolts to 10 volts p-p into 50 ohms load impedance.

The programmable function generator has many applications in automated testing, where its output parameters may be controlled remotely from a computer in response to previously set up programmes and to adapt to special conditions. Remote programming is accepted into the unit as 7-bit parallel ASCII coded characters; up to nine instruments may be connected to a common line, controlled from one source. The unit will respond to input up to 1 Mbyte per second; the selected output function becomes stable within 1ms in all cases. With the variable phase feature, this parameter may be controlled with 4-digit resolution referred either to its own sync output or an external sync source.

Tektronix were displaying the DM43, a precision digital multimeter for use with the 465 and 475 portable oscilloscopes. The meter has 3½ digits, five 7-segment l.e.ds and will display voltages from 1V to 1200V, resistance values from 0.1Ω to 20MΩ, temperature from −55°C to +150°C and also differential time delay measurements, which are resolved at an increased factor of ten times compared to the precision delay time dial on the oscilloscope.

Time measurements are made by selecting the first of the two points by means of the oscilloscope's delay time position control. The meter is set to zero at this point. Next the delay time position control is used to select the second point and the delay is read out directly on the meter. This direct time readout capability has application in checking the critical timing of digital systems.

Temperature probing of semiconductor power components can be accomplished while signal waveforms for the device are monitored at the same time. Test leads used for voltage, resistance and temperature are independent of the oscilloscope into which the meter is incorporated. Front panel pushbuttons provide separate selection of function and range.

Tektronix displayed for the first time the 31/53 Calculator-based Instrumentation System, which is capable of data acquisition, transformation and analysis (Fig. 7). Its main feature is its ability to log, compare and analyze measurement data as it arrives. The user can also store the data. The unit has many of the capabilities of the minicomputer, but it is cheaper and easier to use, as there is no need to learn a computer language to operate it. In many existing systems information is gathered by reading meters, strip charts or printed lists. Then it is interpreted or compiled and entered by hand into a calculator or a computer for statistical analysis or for storing on cards or tape. In the 31/53, the process data gathering, data analysis, documentation and permanent storage can be handled by the single calculator system. It combines the concept of a stand-aloue data recorder and data analysis computation.

The system includes the Tektronix 31 calculator, a mainframe power source, an iuterface plug-in, standard software for data acquisition and analysis, and standard options and accessories. The cost is $3,995.

Data acquisition is accomplished by selected instruments from Tektronix's TM 500 line of modular measurement instruments. The system mainframe allows these modules to be plugged-in in any desired configuration.

Circuit Ideas

Electronic changeover switching

The circuit shown in Fig. 1 effects a changeover function when only a single pair of contacts is available. When the switch is open, only input A is admitted to the output via R_4. When the switch is closed, input B is admitted to the output together with an inversion of the input A signal, which cancels the direct sigual A and leaves only signal B present. A gain of two is given to input B by the op-amp circuit, to bring the system gain to unity for both inputs A and B by compensating for the attenuation of signal B through R_5

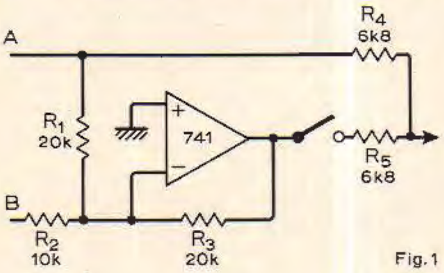


Fig. 1

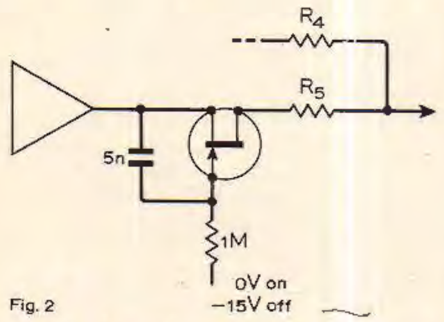


Fig. 2

and R_4 (assuming source impedance at input A$\ll$6.8kΩ. The degree of attenuation of the unselected input depends on the tolerances of R_1, R_3, R_4 and R_5, and if more than about 30dB rejection is required, some trimming may be necessary.

Electronic switching can be accomplished by substituting an f.e.t. to replace the switch, as shown in Fig. 2. The 5nF capacitor prevents the f.e.t. from cutting off during the positive half-cycles above about 100Hz which exceed the f.e.t. piuch-off voltage when in the on state.

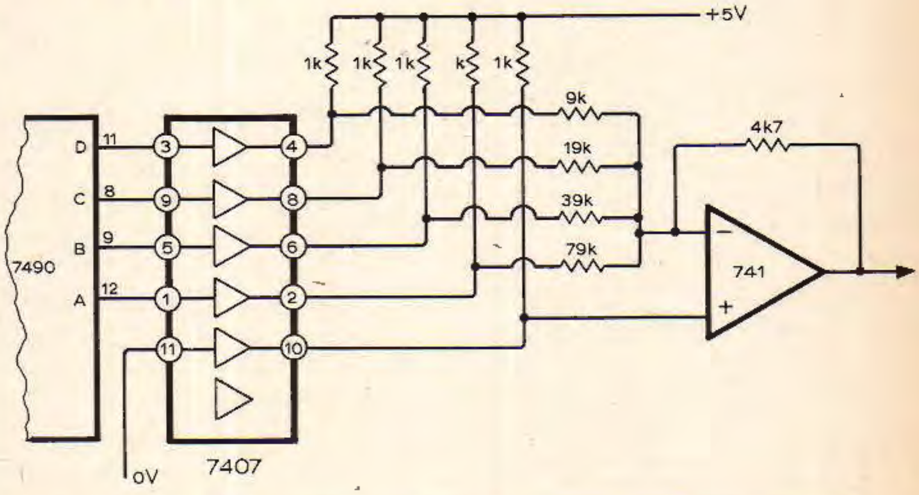
In certain multi-chaugeover switch functions the operational amplifier could be a section of a programmable op-amp.

M. J. Sells,
Reading.

Improved simple d. to a. converter

Readers may have difficulty in getting a satisfactory performance from D. James' digital to analogue converter (*W.W.* June, page 197) over a reasonable temperature range especially if the 7490 is driving other t.t.l. This is because of the necessity for equal logic 1 output voltages from the 7490 as well as matched v_{be} for the transistors. A better performance with similar economy can be achieved by using a 7407 hex buffer as shown in the accompanying diagram. The effect of changes in $v_{ce\,sat}$ with temperature can be minimized by connecting the non-inverting input of the op-amp to the output of an unused buffer at logic 0. The 7407 could be replaced by a 7405 if temperature compensation is not required or for the addition of a less significant digit.

R. J. Chance,
Birmingham.

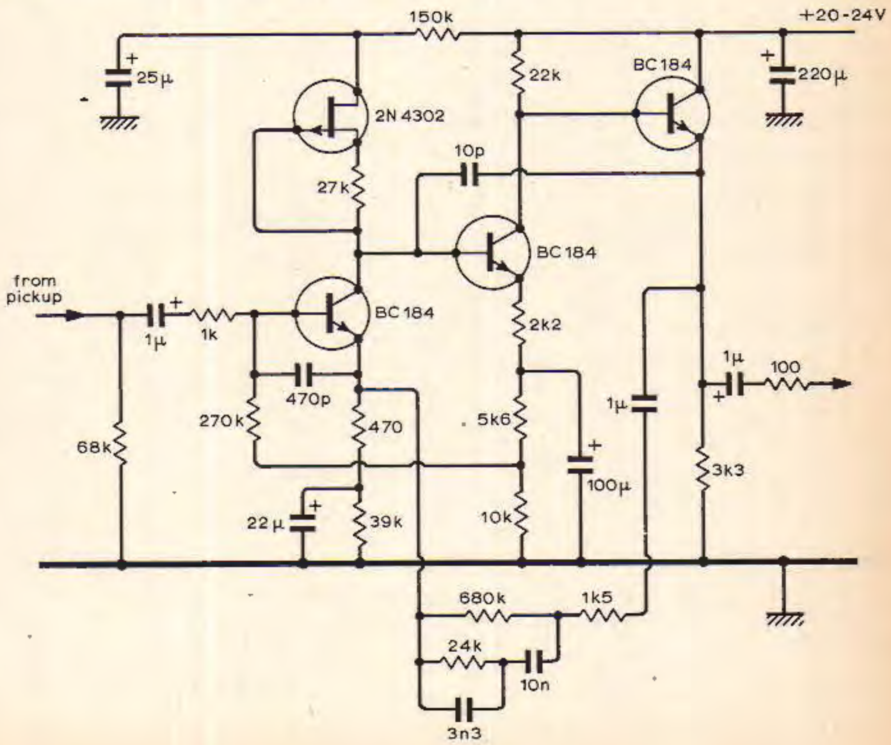


RIAA-equalized pre-amplifier

The amplifier shown in the diagram was designed to combine the advantages claimed by proponents of either side of a recent correspondence in this magazine. It has the low noise (less than −70dB ref. 5mV input) and high overload capability (almost 30dB above 3mV input) of a series feedback-pair design, and the low distortion (0.05% i.m. distortion at 2V r.m.s. output) of the Liniac.

The first stage is basically a Liniac-type circuit with emitter resistors, one of which reduces the d.c. gain, and thus the amount of d.c. feedback applied, improving transient response over the usual feedback pair arrangement. This feeds into a second, ×10 stage, which, contrary to normal practice, has part of its emitter resistance undecoupled, preventing shunting of the first stage high impedance dynamic load by this second stage input impedance.

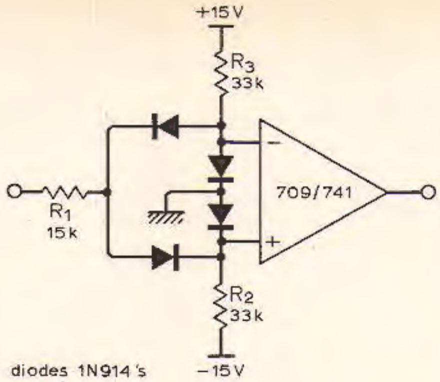
S. F. Bywaters,
University College,
London.



Dual limit comparator using single op-amp

This circuit was designed to give a positive output when the input voltage exceeded plus or minus 8.5 volts. Between these limits the output is negative. The positive limit point is determined by the ratio of R_1, R_2, and the negative point by R_1, R_3. The forward voltage drop across the diodes must be allowed for. The output may be inverted by reversing the inputs to the operational amplifier. The 709 is used without frequency compensation.

K. Pickard,
Otley, Yorks.



Novel power amplifier

This circuit obtains a differential output from a type 741 operational amplifier, by using its power supply pins. These outputs are used to drive power Darlingtons, which use high voltage supplies. This type of differential output is possible due to the op-amp power supply rejection ratio (typically 30μV/V) and its class B output stage. The output pin of the 741 is loaded with R_{11} to obtain maximum current swings at the 741's supply pins.

The ±15 volt supplies required by the 741 are obtained by resistor divider chains R_3, R_4 and R_5, R_6 and transistors Tr_1 & Tr_2 transfer their outputs to the 741's supply pins by their emitter follower action.

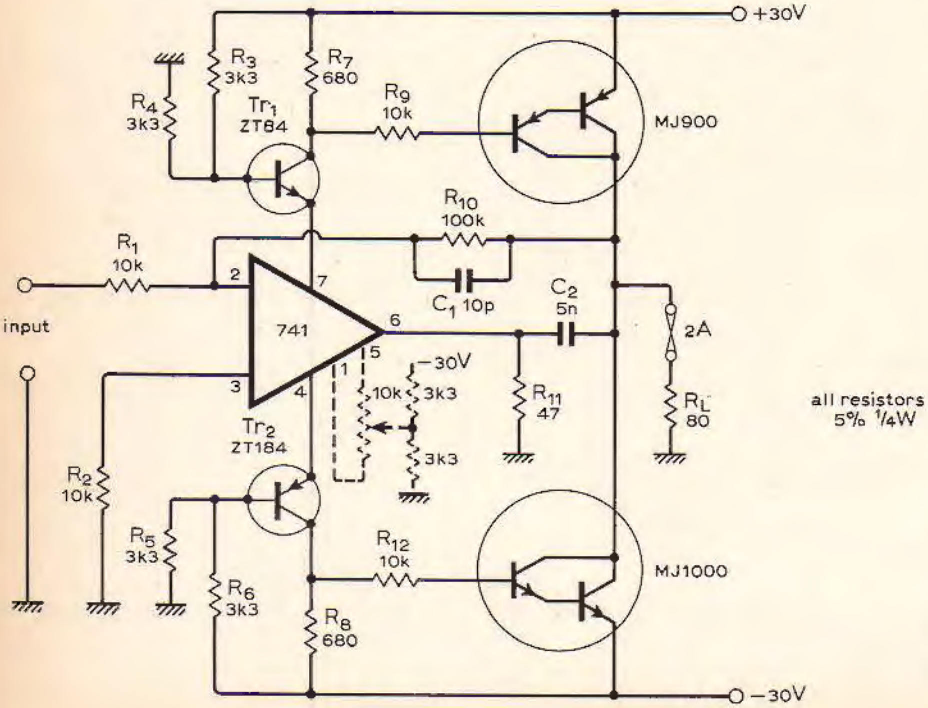
Quiescent current drawn from each high voltage rail by the 741 (typically 1.7mA) flows through the transistors producing a voltage across their collector loads that is fed to the base of the power Darlington output transistors to set their quiescent current. Darlington pairs are used to prevent loading of the voltages developed by the current variations through Tr_1 and Tr_2.

The capacitor connected between the 741's output and the power Darlington's output, supplies stabilizing negative feedback to the last-mentioned. The capacitor across R_{10} provides high frequency roll-off.

For other snpply voltages, change the divider resistors but maintain the 5mA through the divider chain. Any general-purpose transistors for Tr_1 and Tr_2 may be used and the Darlington pairs may be made up from discrete types of transistors. Higher gains can also be used by changing R_1 and R_{10} and C_1 to maintain maximum frequency response with stability.

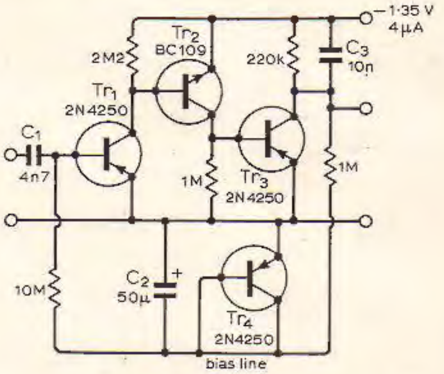
Components shown in broken lines are for optional zeroing of output offset, if the circuit is used in a servo system for example. With component values as shown, 30 watts can be delivered into eight ohms from d.c. to 100kHz (with ×10 gain) with less than 0.2% distortion.

Kenneth Griffiths,
Yatton, Somerset.



Micropower low-noise amplifier

This amplifier has ultra-low power requirements (1.35V, 4μA), low noise (about 10μV pk-pk equivalent input noise with 10MΩ source impedance), 10MΩ input impedance, and a high voltage gain of 2000. It was designed for use in implanted transmitters which detect brain and heart potentials.



High input impedance is attained by current-starving Tr_1, which operates in the 200nA region. The 2N4250 transistor was chosen because its gain remains high ($\beta \times 200$) at very low voltages and currents. It is, in addition, a low-noise transistor. The low current in Tr_1 limits the bandwidth of the amplifier to about 5kHz, but this is acceptable for biological work. The input impedance is determined primarily by the 10MΩ bias feed resistor. The transistors Tr_2 and Tr_3 provide additional gain.

The amplifier had gain constant to within 10% over a −10°C to +100°C temperature range. It is self-biased, with Tr_4 clamping the bias line, to prevent low-frequency instability. The low-frequency roll-off is determined primarily by C_1, but when changing this capacitor C_2 should also be altered in the same ratio. This will prevent another form of low-frequency instability which occurs when C_2 is too small. Capacitor C_3 adjusts the high-frequency cut-off point, and may be omitted if desired. As shown, the amplifier has 3-dB points at 3 and 80Hz, suitable for heart-beat monitoring.

C. Horwitz,
University of Sydney,
Australia.

WW Diary

The Wireless World Diary for 1975 is now available from booksellers price 62p or direct from the publishers, T. J. & J. Smith Ltd, Deer Park Road, London SW19 3UT, at 72p including postage and packing.

Liquid-cooled power amplifier

by I. L. Stefani and R. Perryman

The amplifier to be described in this article was developed as part of a research programme in which it was employed to excite magnetic specimens. The original model was designed to produce peak currents slightly in excess of 10 amperes at frequencies ranging from zero to 5kHz, but operating experience indicated that the equipment was capable of being uprated by a substantial amount, and it is thought that publication of the constructional details might be of use to workers in other fields.

The need to operate with d.c. and at very low frequencies indicated that some form of transistor bridge should be used, and after one or two simple air-cooled arrangements had been tried, it was decided to experiment with liquid cooling. The first tests used power transistors mounted in pairs in two water-filled copper tanks, and while this arrangement enabled the ratings to be raised by some 30%, the onset of thermal runaway was rather sudden and it was felt that the small increase in output was a poor return for the extra complications. The tests proved to be useful, however, as they pointed the way to a more satisfactory form of liquid cooling. The following points were noted:

- Natural circulation was slow and hard to start.
- Stagnant layers of fluid collected round the transistors.
- Relatively large thermal gradients appeared to exist in the transistor cases.

As a result of these observations a new series of tests was undertaken with the output transistors mounted in such a way that each received a turbulent flow of liquid close to the active element. Forced circulation and a fan-assisted heat exchanger were also incorporated, although flow from a tap was found to be very effective.

The electrical circuit was initially designed round two complementary pairs of emitter-followers connected so that each pair formed one half of a bridge, but it was subsequently thought that performance could be improved if the output elements were used as current-boosters assisting emitter-followers of lower rating. A scheme of this type was employed by I. Hardcastle and B. Lane[1] and its success influenced the final decision to adopt this arrangement. Difficulties were encountered with output voltage stabilization and with the design of a gain control which did not cause a shift in the d.c. balance at the output. These points will be taken up later.

Various liquids were considered for the coolant, but the final choice was water with a little "Prestone" inhibitor added.

Output stage

The general layout of the liquid-cooled output stage is shown in Fig. 1. Cool liquid is pumped into a small tank to equalize the pressure applied to the branches and the coolant is then passed through four short lengths of polythene tubing to the transistor bank. After cooling the transistors the warm fluid is returned to another tank from which it flows to a fan-assisted heat exchanger of the type commonly used for car heating. The complete fluid circuit is outlined in Fig. 2. Fig. 3 shows the constructional details of the flow and return tanks which are identical except for the lengths of the inlet and outlet pipes. The transistor mountings are cut from $\frac{1}{4}$in brass plate to sizes given in Fig. 4, which also shows the manner of bending the pins and the construction of the cover plate. The skewing of the bent portions of the pins prevents contact between adjacent transistors when they are mounted in a bank. Before assembly, leads should be soldered to the pins, and the brass surfaces should be sealed with a little "Silcoset" sealing compound. Great care should be taken when sealing the transistors to the mounting blocks for if any seepage occurs in the regions of the base pins, the high current gains will make the booster stage virtually uncontrollable. Normal motor gasket sealing compounds have not been found to be satisfactory.

When the amplifier is operating, cool liquid is pumped into the lower tank where

1. High power amplifier. I. Hardcastle and B. Lane. *Wireless World*, Oct. 1970, p. 477.

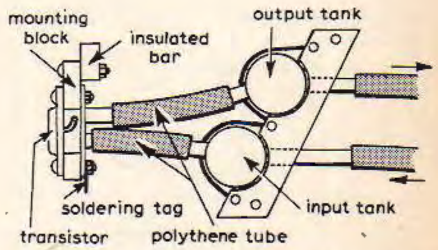


Fig. 1 Mechanical layout of liquid-cooled power output stage

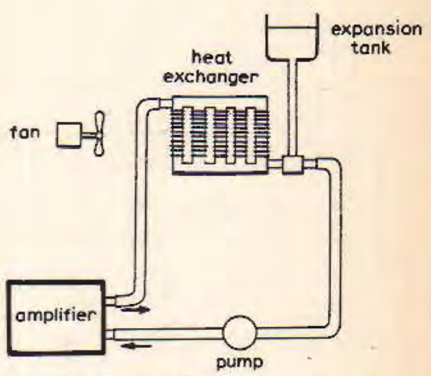


Fig. 2 Complete fluid cooling circuit

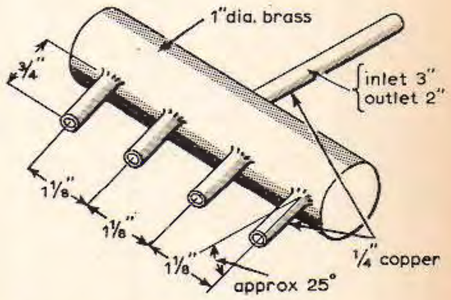


Fig. 3 Dimensions and constructional details of flow and return tanks.

it divides into four streams, each stream passing through a $\frac{5}{16}$in dia. hole in the mounting block to strike the transistor at a point immediately opposite its active element. The water subsequently passes up the $\frac{3}{32}$in wide slot to the $\frac{1}{4}$in diameter exit hole and back to the return tank.

The output circuit

The operation of the output stage may be readily understood by reference to Fig. 5, which shows emitter-followers Tr_2 and Tr_3 supplying a small current to a load. The resistors R_2 and R_3 have little effect on the performance of the transistors other than to cause a slight reduction in their maximum voltage swings, but the voltages developed across these resistors may be used to operate current boosters in the form of complementary power transistors Tr_4 and Tr_5. The collector of each booster acts as a curreut source and forces a large current into the load without substantially altering the voltage drop associated with the emitter-follower. Thus the load current is large and the effective source impedance

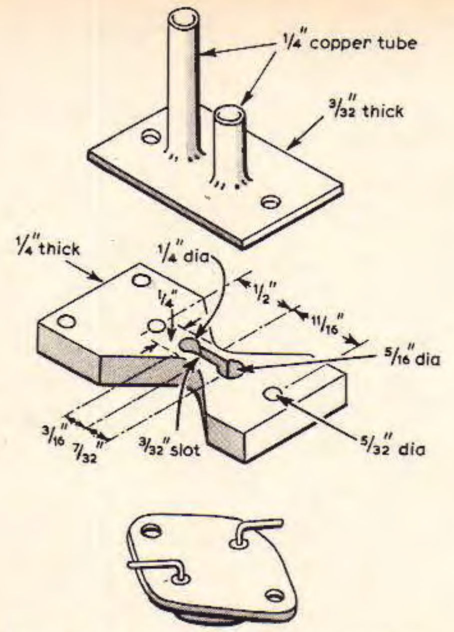


Fig. 4 Dimensions of transistor mountings.

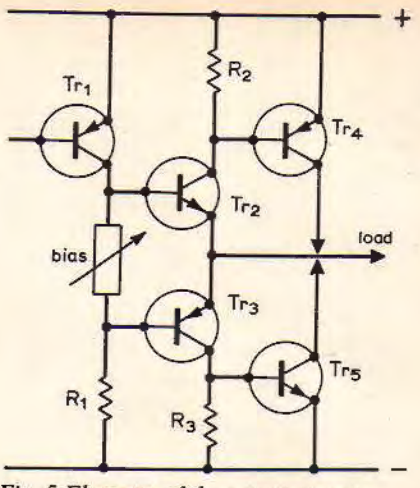


Fig. 5 Elements of the output circuit.

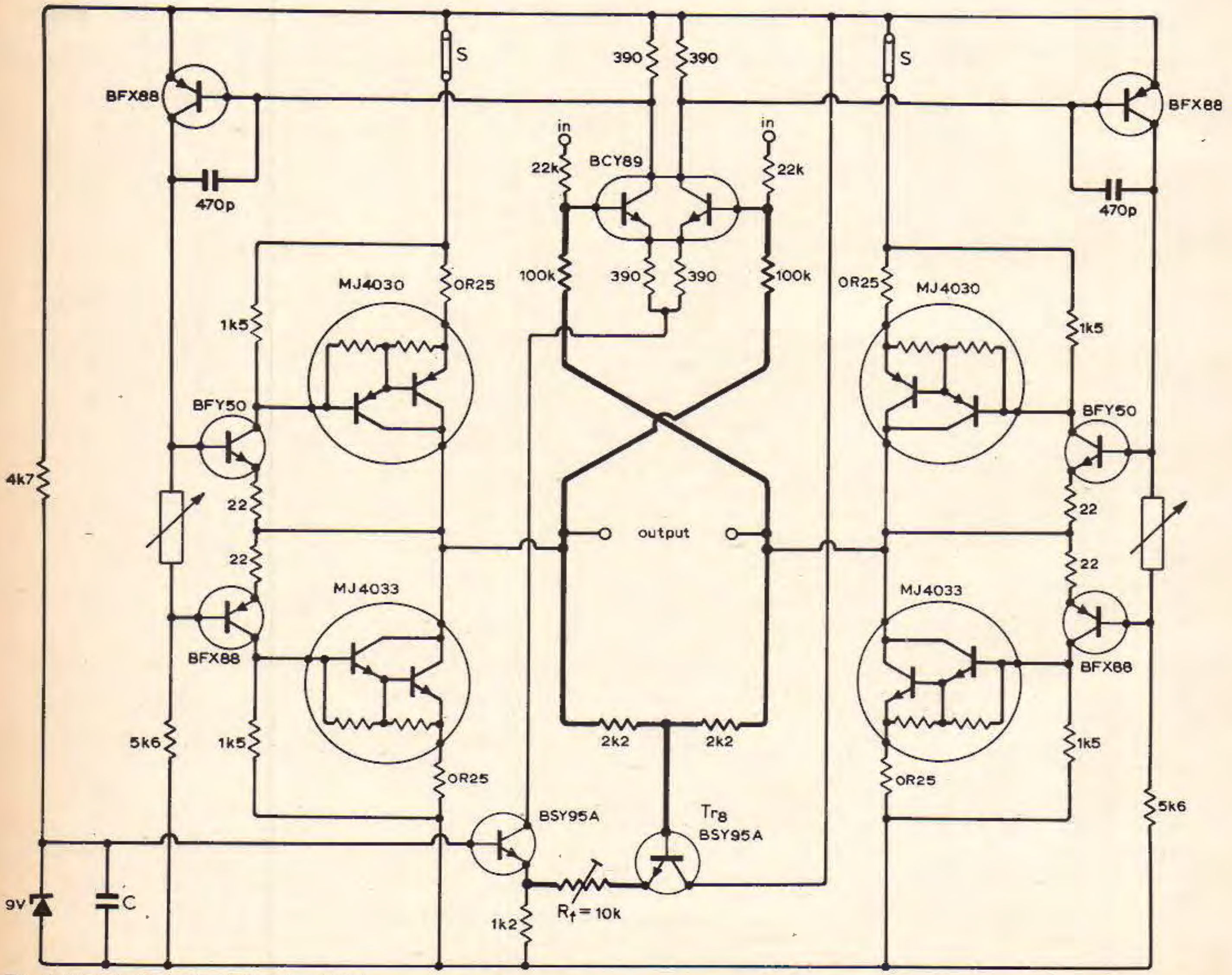


Fig. 6 Circuit of the complete output bridge.

is low. In the actual amplifier the transistors Tr_4 and Tr_5 are replaced by Darlington-pairs mounted in TO3 cases. This raises the sensitivity so that the booster operates directly from low power driver and output stages built into a printed circuit. When two output and booster stages are connected together to form a pair of bridge arms, the biasing of the emitter-follower bases requires the provision of a constant-voltage circuit capable of being preset to give an output between 1.2 and 1.5 volts. This biasing circuit is used to adjust the standing current passing through the power transistors which form the bridge arms. (See Fig. 5.) The complete output bridge is shown in Fig. 6.

The driving stages

The transistors driving the emitter-followers must be operated with their emitters joined to one of the supply busbars or it will not be possible to provide sufficient voltage swing to operate the bridge properly. (See Fig. 5.) This means that the driving stages are prone to drift and some means of correcting this tendency must be devised. The method used is the application of feedback in two separate forms: first, the mid point of the output is stabilized via (Fig. 6) Tr_8 and resistor R_f which regulate the standing current passing through the input stages, and second, conventional voltage or parallel feedback is used. The feedback circuits are drawn in heavy lines in Fig. 6, which shows the basic arrangement of the power stages. The 470pF capacitors connected to the driving stages prevent high frequency instability and emitter resistors in the booster stages produce a certain amount of thermal stabilization. The 0.25Ω resistors have to carry large currents and they are constructed from short lengths of Eureka wire wound into helical coils.

Finally, in order to facilitate setting up, it is advisable to insert manganin shunts or removable links in the bridge arms at S for monitoring the standing currents. The amplifier now in use has small ammeters permanently connected to manganin shunts.

The preamplifier

The duties of the preamplifier are threefold. First, it is required to provide a voltage gain, and second, it should enable this gain to be varied. Finally it must convert the single-ended input to a balanced output. The first and third functions present no difficulties, but the second is a possible source of trouble as the d.c. passing through the gain control produces a voltage drop which alters with the setting and is considerably magnified in passing through the amplifier. Matched f.e.ts were tried out in the controlled stages but the degree of balance did not prove sufficient to prevent severe drift with changes of temperature. The final arrangement used a rheostat to partially short-circuit the output of a carefully balanced double-transistor amplifier stage. The mean voltage drop using this scheme is independent of the control setting. The circuit, with component values, is shown in Fig. 7.

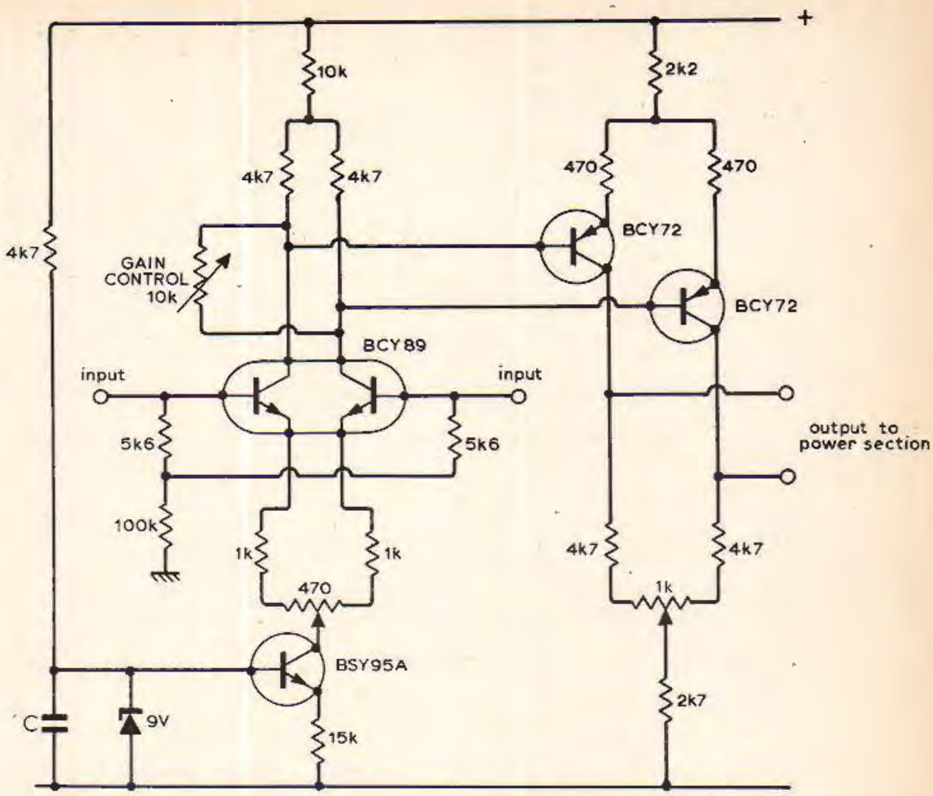


Fig. 7 Preamplifier circuit.

Setting up and testing: With water flowing through the output boosters and the 10kΩ bias trimmers turned right back, the supply voltage should be turned on and the feedback resistor R_f adjusted until the mean output voltage is about 15V for a 30-volt supply. The gain control should then be turned to the short-circuited position and the 1kΩ balance control on the preamplifier adjusted until the voltage between the output terminals shows zero on a d.c. voltmeter. When the gain is turned to a maximum this voltage will usually change and it should be returned to zero by means of the 470Ω balance control. The bias controls should then be carefully turned clockwise until currents of 1 to 2A flow in each of the pairs of bridge arms. After allowing the stage to warm up the trimmers should be rechecked. Exhaustive testing has not been carried out because the amplifier has been in continual use for well over a year, but a few test results are given as an indication of the performance.

Max. open circuit voltage swing when using a 32V d.c. supply: 58V (20.5V r.m.s.)

Max. output current swing (limited by the power unit): 34A (12A r.m.s.)

Max. power: greater than 230W

Output impedance: less than 0.5Ω

Frequency range: approximately 0–110kHz

For general use it is advisable to install some means of protection. Possibly a flow-operated switch and thermocouples on the transistor mounting blocks should be considered.

Finally, it should be recorded that the amplifier in its present form does not heat up very much. This suggests that it might be possible to uprate the design by a substantial margin; the simplest method would appear to be to raise the supply voltage and adjust some of the circuit component values accordingly.

Sixty Years Ago

It always seems a pity when legendary phenomena are explained in terms of modern scientific theories, and many people would ascribe this iconoclastic trend to the last 30 or 40 years. But it seems that we were at it long before that, as witness this extract from the December, 1914 issue of *The Wireless World*, in which W. B. Cole implies that Joshua was a bringer of "bad vibes".

". . . it seems quite clear to the writer that Moses, who was learned in all the wisdom of the Egyptians, imparted to his successor Joshua the knowledge of the principle of resonance, and that Joshua, discovering that the wall of Jericho responded to a certain note, made use of this principle.

"During the week he kept his men busy walking round the city in order to keep the inhabitants within (verse 1). The Israelites were strictly enjoined to maintain silence, so that the priests who blew with the trumpets might make the necessary acoustical experiments, and to tune all their trumpets to the same pitch. The seventh day all was ready. The people completely encircled the city and at a given signal the priests blew with their trumpets, the people shouted, the same note, and the effect of this choir of 40,000 men (Josh. iv, 13) caused the wall to collapse."

Measurement and detection with current differencing amplifiers

Introducing a set of tested circuits presented in cookery-card form

by J. Carruthers, J. H. Evans, J. Kinsler and P. Williams

Paisley College of Technology

Three sets of Circards deal with a new kind of i.c. building brick—the LM3900 current differencing amplifier. Sets 16 and 17 cover signal processing and generation circuits respectively, and set 18 on measurement and detection will be issued shortly.

Pattern recognition is one sign that a technology is reaching maturity. The early stages following new advances are a succession of bright ideas, half-worked-out theories and unrelated developments. This is inevitable as workers in many areas take from the original material that which meets their needs—or appeals to their prejudices.

In circuit design the same configuratious appear under many guises and names, developed quite independently and for different applications. If we cau recognize these similarities and construct the appropriate family tree this is worthwhile in itself.

But we can do more. If two circuits are similar in form because related in function, then by finding any other circuit designed for one of the functions there is a good chance that it can be modified to provide the other. A good designer is one who picks the best brains.*

The present topic is a particularly good illustratiou of this thesis. The problem is to measure some property of the amplitude of an a.c. waveform. Four circuits have their properties listed in the table and circuit diagrams representing a basic feedback form of each are shown in Figs 1 to 4. The configurations are identical, the differences lying only in whether conduction is through a diode or a switch, and whether the load is resistive or capacitive. This identity of form is far from apparent iu practical versions since there are so many additional components and sub-circuits to optimize the response or effect coupling between other circuits/transducers.

The half-wave rectifier uses a diode as does the peak rectifier. It begins conduction through the diode as soon as the input goes positive remaining in conduction for the phase angle range 0 to π for sine-wave input. The mean value of the output is normally required, and a moving-coil meter is suitable as the deflection is proportional to the mean current.

*To quote Tom Lehrer:
Plagiarise Plagiarise
Remember why the good Lord made your eyes
So don't shade your eyes
But Plagiarise Plagiarise Plagiarise
—only please to call it Research

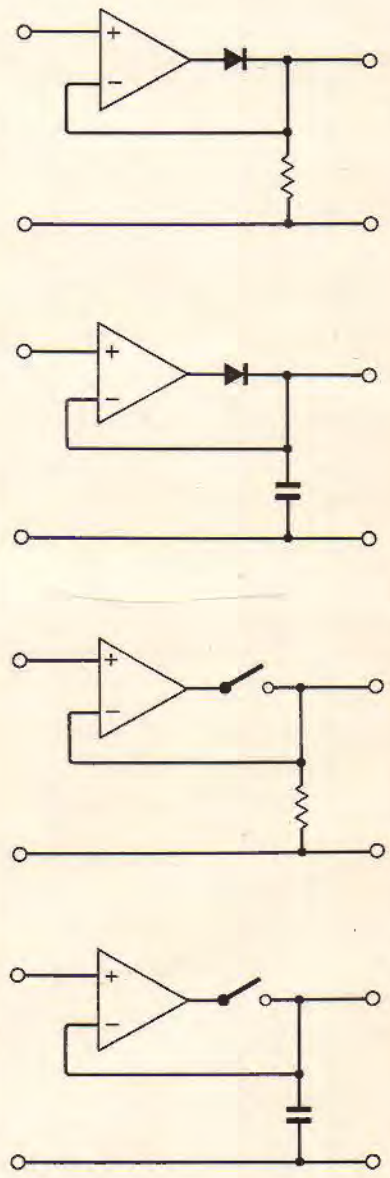
When the resistive load is replaced by a capacitor, conduction of the diode only takes place for those instants when the input voltage exceeds the voltage stored on the capacitor. For a steady-state a.c. signal this corresponds to the positive peak of the input, and assuming no discharge of the capacitor in the intervening period the conduction angle is vanishingly small and is centred on $\pi/_2$. The resulting constant voltage across the capacitor is measurable with any d.c. voltmeter whose input current requirements are so small as to avoid significant capacitor discharge.

To accommodate varying signal amplitudes some discharge must be permitted since a small amplitude would otherwise never be sensed if following a larger input. The resistive path leads to a compromise time constant between maximum holding time of the peak voltage and minimum recovery time after large peaks. Conversely, the half-wave rectifier suffers from capacitive effects at high frequency with stray capacitance leading to partial peak rectification. The resulting output/frequency characteristic often shows a rise of 1 to 3dB prior to the cut-off frequency limits of the amplifier.

The sampling circuit replaces the diode of the half-wave rectifier by a switch which closes for a brief interval at some phase angle determined by external circuits. The output is zero for all instants except the sampling instant. With capacitive loading, provided the switch closure is for a period of time greater than the time constant of the capacitance together with the amplifier output resistance, theu the capacitor volt-

Four types of circuit, listed here, to measure the amplitude of an a.c. waveform—see Figs. 1 to 4.

Circuit	Load	Conduction angles, ϕ_1, ϕ_2	Conduction device	Voltmeter
Sample	R	arbitrary $\Delta\phi \rightarrow 0$	switch	instantaneous
Half-wave rectifier	R	$0, \pi$	diode	mean/d.c. moving coil
Sample and hold	C	arbitrary $\Delta\phi \rightarrow 0$	switch	d.c.
Peak rectifier	C	$\frac{\pi}{2}, \frac{\pi}{2}$	diode	d.c.



Figs. 1–4. Types of circuit used to measure amplitude of a.c. waveforms (see Table). Complete circuits are given in cards 7 and 8 in set 18.

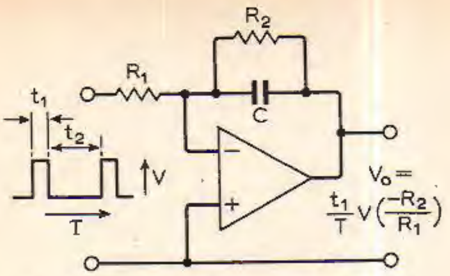


Fig. 5. LM3900 c.d.a. is well-suited to measurement of time period and frequency. An input capacitor can alternatively be charged through a diode to form a "pump" circuit (see card 10).

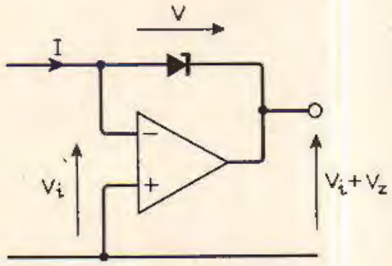


Fig. 6. Defining operating conditions for testing a zener diode with a c.d.a. (see card 5).

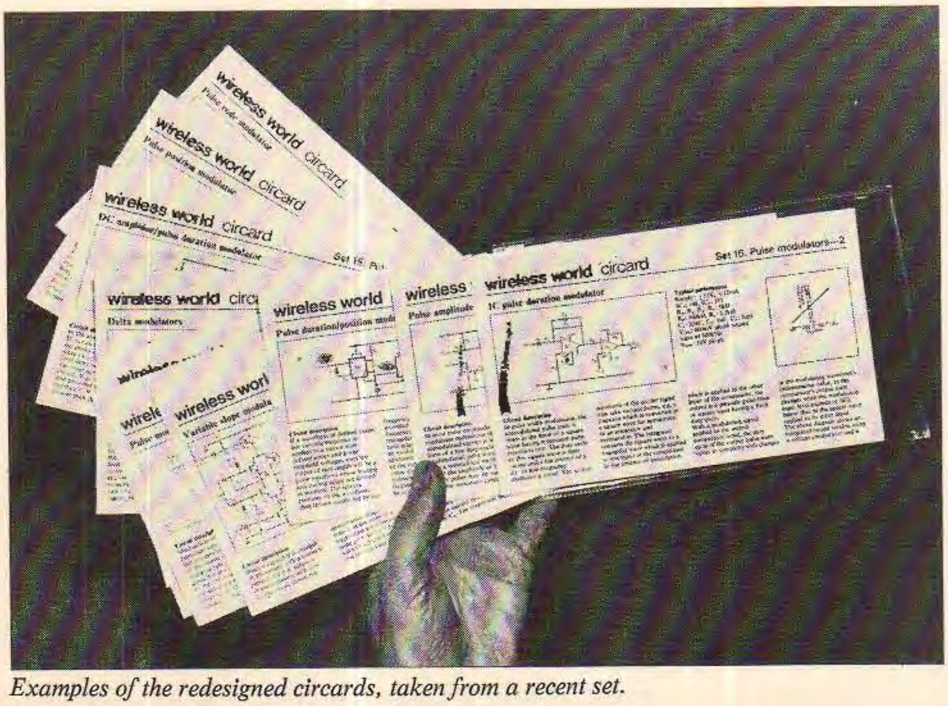
age becomes equal to the input voltage (again a compromise since the sampling period should not be so long as to allow a significant change in the input). If the switch is closed periodically at the same instant in successive cycles then the sampling time may be reduced, with the capacitor voltage increasing to the required level over a number of periods. With the switch open, as it is for most of the time, the capacitor stores or holds the sampled voltage, provided the measuring instrument is suitably buffered.

The sampling circuits are readily constructed with current-differencing amplifiers, and long hold times are possible. With careful adjustment the output drift can be < 5%/hour under controlled conditions which is a good performance from such a general-purpose circuit. The accuracy is less impressive since the current-mirror match is involved, and it cannot compete with standard op-amp circuits iu this respect.

Measuring period and frequency

The measurement of time period and frequeucy is another field to which the circuit is well-suited. A pulse waveform of constant width and height but variable frequency is fed as in Fig. 5 to the amplifier with parallel RC feedback. The mean voltage across the capacitor is then directly proportional to the input frequency. Alternatively frequency and pulse height may be kept constant when the output becomes a measure of pulse width. The availability of two inputs extends this capability to the measurement of frequency difference or sum. Alternatively an input capacitor may be charged and discharged through a diode network to give the equivalent of a diode pump/transistor pump type of frequency meter (tachometer).

The d.c. characteristics of the amplifier can be used to simultaneously define the operating conditions of diodes, zeners etc, while providing a low output impedance point for ease of measurement (Fig. 6). Finally, the circuit may be used in conjunction with an external network of resistors and diodes to perform quite complex logic functions such as exclusive-OR. Though offering no competition for the usual logic families for large-scale applications, they are very convenient for providing a small number of logic functions in an existing system. The wide range of supply voltages particularly commend them for such applications.



Examples of the redesigned circards, taken from a recent set.

Titles of cards in set 18 of Circards are

1 Measurement and detection
2 Logic circuits
3 Phase-locked loop
4 Transducer driving
5 Semiconductor device testing
6 Negative resistance circuits
7 Peak/mean rectifiers
8 Sample and hold circuits
9 High-frequency circuits
10 Tachometers

What are Circards?

Circards are a new method of collating and presenting data about circuits in a compact and easily retrievable way. The sets of 203 × 127mm (8 × 5in) double-sided cards are designed for easy filing in standard boxes and for easy access at the desk or at the bench, where transparent plastics wallets keep the cards in good condition.

Each card normally describes operation of a selected circuit, gives *measured* performance data and graphs, component values and ranges, circuit limitations and modifications to alter performance. Suggestions for further reading are included together with cross references to related circuits. The Circard concept was outlined more fully in the October 1972 issue of *Wireless World*, pp. 469/70.

How to get Circards

Order a subscription by sending £13.50 for a series of ten sets to

Circards
IPC Electrical-Electronic Press Ltd
General Sales Department, Room 11
Dorset House
Stamford Street
London SE1 9LU

Specify which set your order should start with, if not the current one. One set costs £1.50, postage included (all countries). Make cheqnes payable to IPC Business Press Ltd.

Circuits covered so far in Circards are
1 active filters
2 switching circuits (comparator and Schmitt circuits)
3 waveform generators
4 a.c. measnrement
5 audio circuits (equalizers, tone controls, filters)
6 constant-current circuits
7 power amplifiers (classes A, B, C and D)
8 astable multivibrator circuits
9 optoelectronics: devices and uses
10 micropower circuits
11 basic logic gates
12 wideband amplifiers
13 alarm circuits
14 digital circuits
15 pnlse modulators
16 current-differencing amplifiers—signal processing
17 c.d.as—signal generation
18 c.d.as—measurement and detection

Future sets will cover monostable circuits, two-transistor circuits, multipliers and dividers, code converters, d.c. amplifiers and choppers, amplitude modulation and detection, transistor arrays, a.f. oscillators and voltage-to-frequency converters.

Capacitors

A survey of present day capacitor technology and applications

by R. A. Fairs

Rank Radio International

This is a survey of the properties and parameters involved in the construction and use of capacitors and dielectrics. Simple equivalent circuit analysis is also explained. The second half of the survey deals with different types of capacitors: electrolytics, paper, plastic film, mica and ceramic. The construction of each type is described together with particular properties of each type and their circuit application. Finally an applications chart relates the different properties and parameters.

Progress in semiconductor technology has led to an increasing dependence on the role of commercially available capacitors in a circuit. A glance at any electrical network reveals that about 30% of the components used are capacitors; and that about 40% of all failures encountered are due to misuse in circuit application of these capacitors.

The impedance of a capacitor, Z, largely controls its behaviour in any circuit application. The manner in which this impedance deviates from that of a true capacitor requires the construction of an equivalent circuit for practical capacitors. This can be done quite simply and Fig. 1 shows the familiar parallel plate capacitor together with its equivalent circuit.

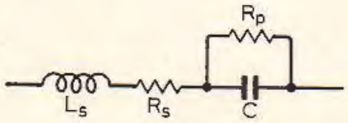


Fig. 1. Equivalent circuit of a typical capacitor: L_s—equivalent series inductance, R_s—equivalent series resistance, R_p—leakage resistance (or parallel loss resistance), C—apparent capacitance.

We can reduce this circuit to a simple resonant circuit (Fig. 2) whose impedance curve (impedance vs frequency) when plotted on log-log. graph paper is a hyperbola whose shape and orientation depends on the values of L_s, R_s, and C (Fig. 3).

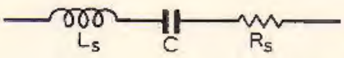


Fig. 2. Simple series resonant circuit where $Z=\sqrt{R_s^2+(X_{Ls}-X_c)^2}$

We can make the following observations:

- f small $Z\approx 1/2\pi fC\approx X_c$
- f resonant $Z\approx R_s$ (20kHz→1MHz)
- f large $Z\approx 2\pi fL_s\approx X_{Ls}$

The resonant frequency of capacitors varies considerably from about 20kHz for electrolytic capacitors to around 1MHz for plastic film types and is even higher for ceramics. Fig. 4 shows the impedance curve of a tantalum electrolytic capacitor. The prime cause of the curve deviating from a hyperbola is temperature differences which affect the parameters of a capacitor in a non-linear fashion, so in some applications manufacturer's data must be consulted.

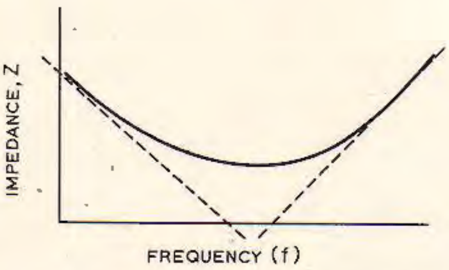


Fig. 3. Impedance versus frequency curve of the simple resonant circuit shown in Fig. 2.

The inductance of the capacitor is largely controlled by the dimensions of the external leads and the method of connection to the capacitor section. In tubular capacitors the ratio of the length of the capacitor section to its diameter is also significant. To minimize the effect of inductance, most electrolytic capacitors have low inductance windings. Fig. 5 shows a reduction in inductance by a factor of 26 by this method.

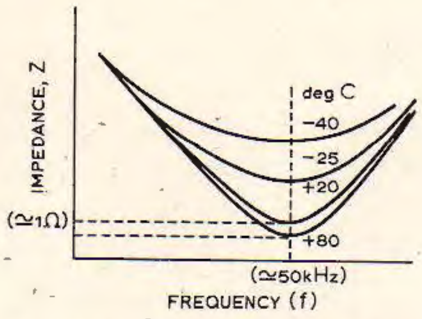


Fig. 4. Impedance curve for a tantalum electrolytic capacitor.

As a rule of thumb the inductance of a normal capacitor, length 1cm, is of the same order as a piece of 22 swg wire of length 1cm.

For capacitance value a temperature coefficient (t.c.) is defined by:

$$\text{t.c.}=\frac{\Delta C\times 10^6}{C.\Delta t}$$

$$=\frac{\text{change in capacitance}\times 10^6}{\text{orig. capacitance}\times\text{change in temp.}}$$

$$=\alpha\text{ppm}/^\circ\text{C}$$

where ppm = parts per million.

By defining the temperature coefficient in this manner it is independent of the units of capacitance.

It is usual to operate capacitors well below their resonant frequency, and thus neglect the effects of inductance. Fig. 2 simplifies to an equivalent circuit which is universally used, that of a "lossy" capacitor in Fig. 6.

By considering this circuit one can develop terms which are extensively used throughout the capacitor industry. From

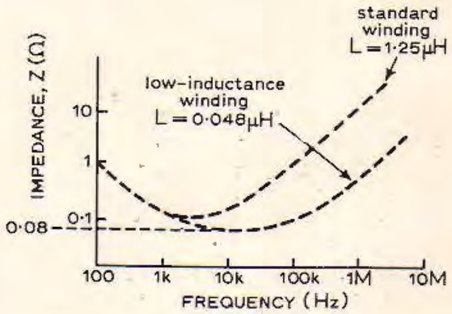
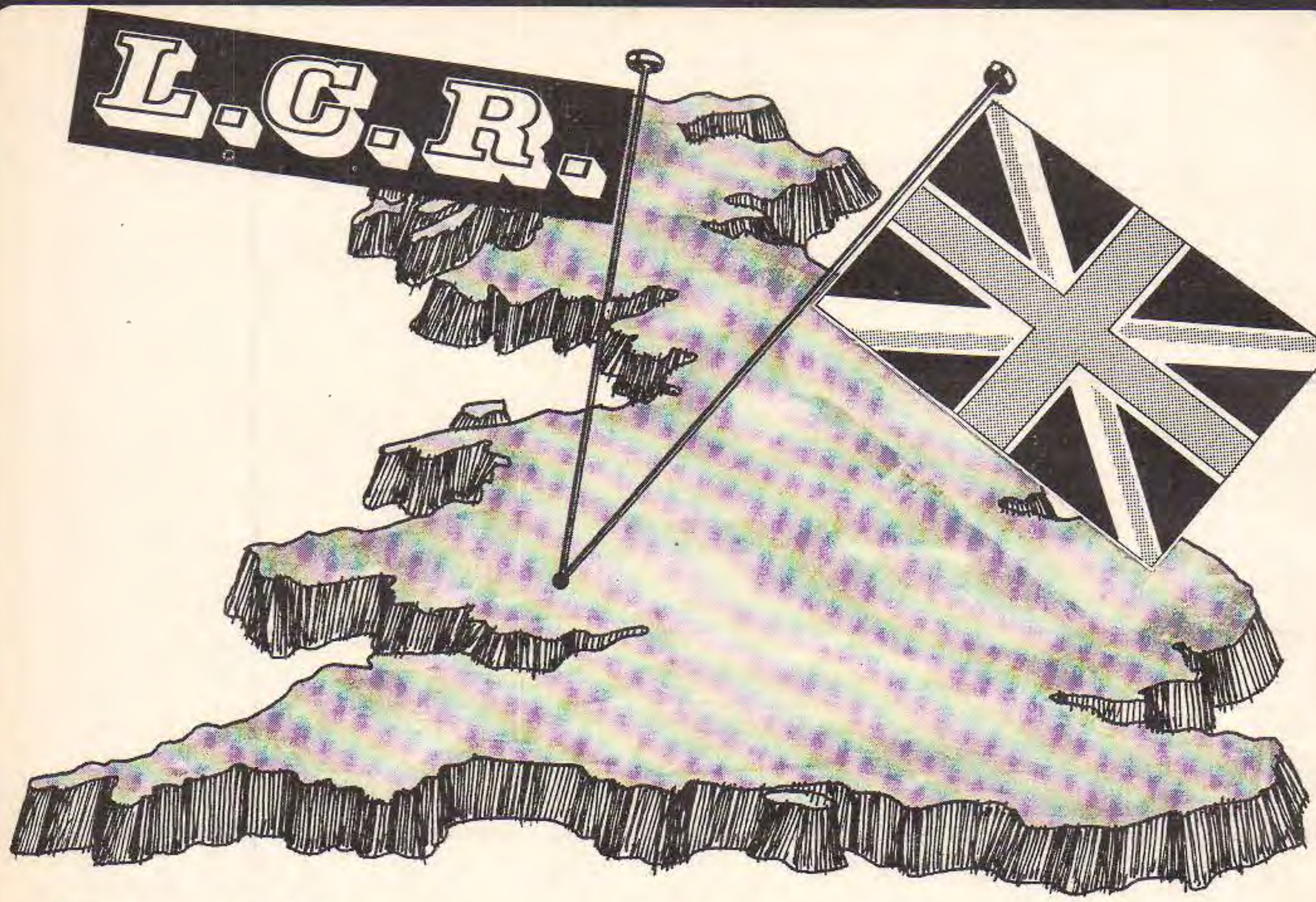


Fig. 5. Impedance reduction obtained by low inductance winding.

Fig. 6. Equivalent circuit of a "lossy" capacitor operated well below the resonant frequency.



We are proud to be practically the last major supplier of POLYSTYRENE CAPACITORS who produce ALL their capacitors in the UNITED KINGDOM.

But in saying this we are not suffering from a severe case of jingoism. We know that many of our customers are trying very hard to keep their component stocks to a minimum, and it is useful in these circumstances to have a supplier who can produce 10,000 capacitors of some odd value at the drop of a hat—or should we say the wave of a flag.

Other products include high-voltage capacitors, high-current capacitors, polyester capacitors, electrolytic capacitors, polypropylene capacitors, polycarbonate capacitors.

Please write or telephone for details.

L.C.R. Components

WOODFIELD WORKS
TREDEGAR MON
Tel 0495-25 3131 Telex 497201

the phasor diagram, Fig. 7, we make the basic definitions:

Loss angle, δ

Phase angle, ϕ

Impedance, $Z=\sqrt{X_c^2+R_s^2}$

$$\text{Power factor (p.f.)}=\frac{\text{true power}}{\text{apparent power}}$$

$$=\frac{P_s}{Z}=\cos\phi=\sin\delta$$

$$\text{Dissipation factor (d.f.)}=\frac{\text{resistance}}{\text{reactance}}$$

$$=\frac{R_s}{X_c}=\tan\delta$$

For small R_s, d.f.$\approx$p.f. (since $\sin\delta\approx\tan\delta$ for $\delta<0{\cdot}15$)

This relation holds for almost all commercially available capacitors.

It is easily seen that for a good capacitor, δ must be small, but exactly what variations occur with frequency and capacitance value will be important in capacitor application and requires some dielectric theory explained in the appendix.

Leakage current

This quantity is dependent on the parallel loss resistivity (R_p) of the capacitor, which has a negligible effect on the equivalent series resistance, R_s, except for low frequencies. It can be shown that

$$R_p=\frac{1}{\omega CR_s}+R_s$$

The relationship can be understood by considering a perfect capacitor discharging through a resistor as shown in Fig. 10. The behaviour of the circuit is described by:

$$\frac{Q}{C}+\frac{dQ}{dt}R_D=0$$

$$\text{i.e.}\ \frac{dQ}{Q}=\frac{-dt}{RC}$$

$$(\log_e Q)_0^t=(-t/RC)_D^t$$

$$\text{or: } Q=Q_o\,e^{-t/RC} \qquad (1)$$

$$I=\frac{dQ}{dt}=\frac{I_o}{RC}e^{-t/RC} \qquad (2)$$

Eqn. (1) shows that the leakage current varies with time, and thus a fixed value of the current, I, is only realized after a fixed time. For electrolytic capacitors this time is usually 15 minutes.

The quantity RC is known as the time constant of the capacitor and is of the order of days for polystyrene capacitors, and several seconds for electrolytics.

Dielectric absorption

The rate at which a capacitor charges is important. A perfect capacitor when connected to a d.c. supply of E volts would charge according to

$$I=(E/R)e^{-t/RC} \qquad (3)$$

In practice, deviation from (3) occurs because if a fully charged capacitor is discharged and allowed to remain open circuit for some time a new charge accumulates within the capacitor showing that a fraction of the original charge has been "absorbed" by the dielectric. A time log therefore exists between the rate of charging and of discharging the capacitor.

Dielectric strength

The voltage at which the dielectric breaks down is a measure of the dielectric strength of the medium. This depends on the test conditions and the thickness of the material. It thus imposes a stress on the medium and is usually measured in volts/metre. Of associated importance is the insulation resistance which will follow approximately eqn (4)

$$R_T=\frac{R_t}{eK(T-t)} \qquad (4)$$

where R_T = insulation resistance at temperature T and R_t = insulation resistance at temperature t. K is a constant (0·1 for paper capacitors and 0·05 for mica and ceramic capacitors).

Energy losses

For a perfect capacitor, C, operating at V volts, the energy stored is given by eqns (5) and (6).

$$E=\int_0^V v\,dQ \qquad (5)$$

$$=\int_0^V v\,d(C.v)=C\int_0^V v\,dv=1/2CV^2 \qquad (6)$$

However, the phase difference between the vectors E and D defined in the appendix causes a hysteresis loop (similar to the B, H curves observed for ferromagnetic materials), between the charge Q, and applied voltage V. The energy dissipated per cycle of the loop will be given by eqn (5) and will vary with the frequency of the applied field, so that the total energy stored in the capacitor will be less than the result predicted by eqn (6).

General considerations

For a parallel plate capacitor working in vacuo, the capacitance, C, between the plates, ignoring edge effects, is given by

$$C=\epsilon_o A/d \qquad (7)$$

where ϵ_o is the permittivity of free space, A is the area of plates, d is the distance between plates.

When a dielectric is placed between the plates the capacitance of the system changes to C' where C' is related to C by

$$\epsilon=\frac{C'}{C}=\text{permittivity of dielectric or dielectric constant.} \qquad (8)$$

From these equations we see that to obtain the highest capacitance in the smallest volume, ϵ must be high, and d must be small. Translated into manufacturing techniques this requires a thin foil of high permittivity capable of withstanding the stresses imposed by the working conditions of the capacitor.

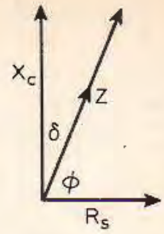


Fig. 7. Phasor diagram related to the equivalent circuit of a "lossy" capacitor.

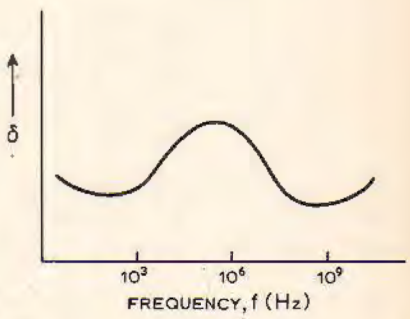


Fig. 8. Loss angle versus frequency for a polar dielectric material.

One has already seen that the cost of obtaining a high permittivity, illustrated by Fig. 8, is its frequency dependence.

The most important considerations in choosing a capacitor for particular applications are: capacity/physical size, and shape; working voltage; frequency characteristics (effect of frequency in impedance and dissipation factor); insulation resistance; environmental conditions (temperature and humidity considerations) and cost.

A brief survey of the types of capacitors available now follows.

Electrolytic capacitors

Capacitors of this type are physically the largest available; their CV product (capacitance value × working voltage) is also large. Typical application of these capacitors is to be seen in power supply circuits and coupling between audio amplifier stages.

The large capacitance evolves from the use of a very thin dielectric film (about 1nm thick). Such a film is realized practically by oxidizing a suitable metal (usually aluminium or tantalum). The method employed is that of anodic oxidation, i.e. by making the metal the anode when immersed in an electrolytic bath.

The resulting dielectric film is extremely strong possessing a dielectric strength of the order of $10^5\,Vm^{-1}$, although imperfections in this film lead to leakage being a typical characteristic.

For aluminium electrolytic capacitors, the oxide is produced on a 99.99% pure aluminium foil at an oxide thickness proportional to the working voltage of the capacitor. This voltage is often called the polarising voltage and its function is to maintain the oxide film at a specified thickness, thus giving consistent capacitance value.

The foil, now known as the anode foil, is then concentrically wound with another aluminium foil (about 98% pure) which acts as a cathode. The two foils are separated by a layer of highly porous paper and the whole assembly immersed in an electrolyte (usually ethylene glycol) which promotes the forming of oxide film when the capacitor is in operation.

The capacitance section is then placed in an aluminium can which is hermetically sealed. A typical arrangement is shown in Fig. 11.

To give an increased capacitance value in the same physical size the aluminium oxide may be etched. This process effectively increases the area of the dielectric and increases its permittivity from about 7 to about 10. However, electrolytics made in this manner are unable to withstand high currents, compared with the plain foil type.

Tantalum capacitors. These capacitors employ tantalum oxide as a dielectric which has a higher permittivity than aluminium oxide (typically up to 25), and as a result give a high capacitance in a relatively small size.

There are three distinct types of tantalum capacitors available: solid tantalum, wet sintered tantalum and tantalum foil (the construction of this is similar to that of an aluminium foil and will not be discussed).

The electrolyte used is solid manganese dioxide used in solid tantalum types or aqueous phosphoric or sulphuric acid used in the latter two types.

Solid tantalum capacitors. Capacitors of this variety are constructed by sintering tantalum powder particles around a tantalum anode, the resulting assembly is rigid after manufacture and is known as a "slug" (Fig. 12).

By controlling the temperature and time of the sintering process one may control the size of the slug, its density and its oxide content. The purity of the tantalum used is also important since it largely controls parameters such as leakage current and power factor.

The cathode of the solid tantalum capacitor is formed by dipping the slug in a solution of manganese nitrate which when passed through ovens at 300°C decomposes to a semiconductor layer of manganese dioxide, this is then coated with graphite and silver.

A schematic diagram of a complete solid tantalum capacitor is shown in Fig. 13.

The final encapsulation of the solid tantalum capacitor can be in several forms, the most commou ones being: polyester sleeve with epoxy end seals, dipped epoxy coated, metal case with resin seal or epoxy resin moulding.

Wet sintered tantalum. The slug used is similar to that employed in the solid tantalum variety; the distinct difference between the two types being in the cathode system. Fig. 14 shows these differences.

Table 1. Comparison of tantalum capacitor types

Parameter	Solid	Wet	Foil
Maximum d.c. voltage rating	100V	125V	450V
CV product	inflexible	inflexible	flexible
Closest capacitor tolerance	±5%	±5%	±10%
Volume efficiency*	2	1	3
D.C. leakage current per *CV* ($AF^{-1}V^{-1}$)	0·02	0·0005	0·01
Temperature stability**	1	2	3
Frequency characteristics**	1	2	2
Reverse voltage	≯1V	0	≯3V
Cost*	3	2	1

* ** 1 indicates highest* or best**
2 indicates intermediate stage between 1 & 3
3 indicates lowest* or worst**

Table 1 provides a general comparison for the three types of tantalum capacitors discussed, however for more precise information it is necessary to consult manufacturer's data.

Reliability. (a) solid tantalum: very reliable, working failures generally due to misuse; intrinsic failure due to oxide crystallisation, (b) wet sintered tantalum: failure due to vapour transmission of the electrolyte through the capacitor seal, causing a fall in capacitance and degradation in the dissipation factor; hence hermetic seals are desirable. Aluminium and tantalum foil types also suffer from the same defect.

Paper capacitors

In this type of capacitor a thin sheet of

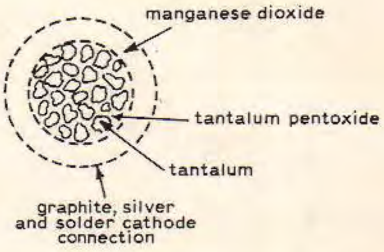


Fig. 12. Solid tantalum capacitor slug formed by sintering tantalum powder particles around a tantalum anode.

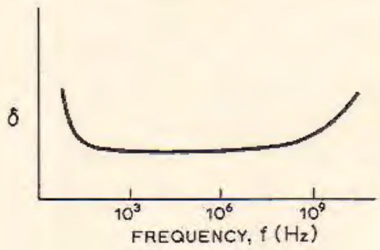


Fig. 9. Loss angle versus frequency for a non-polar dielectric material.

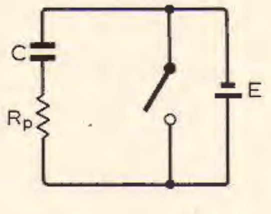


Fig. 10. Perfect capacitor before discharge through a resistor.

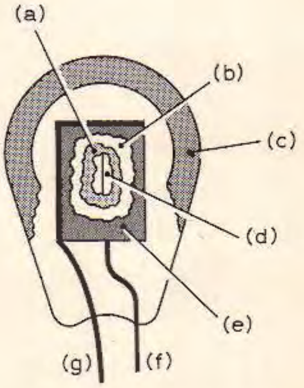


Fig. 13. Schematic of a complete solid tantalum capacitor (a) tantalum impregnated with manganese dioxide (b) graphite layer (c) resin auter coating (d) tantalum shown cut away to indicate anode terminal and tantalum pentoxide layer (e) solder layer completely surrounding cylinder (f) welded anode connection (g) cathode connection.

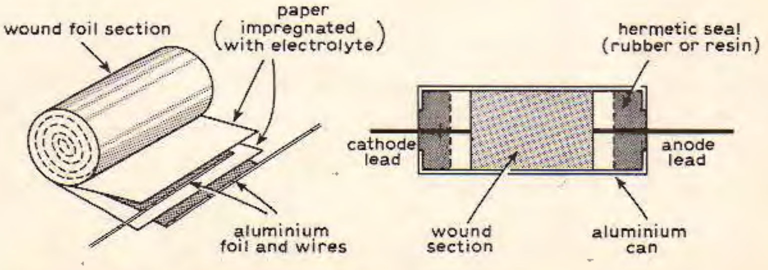


Fig. 11. Construction of an aluminium electralytic capacitor.

now manufacture ELECTROLYTIC CAPACITORS

☐ Tubular . . . wire ended ☐ Tubular . . . solder tag terminals ☐ Professional grade . . . screw terminals

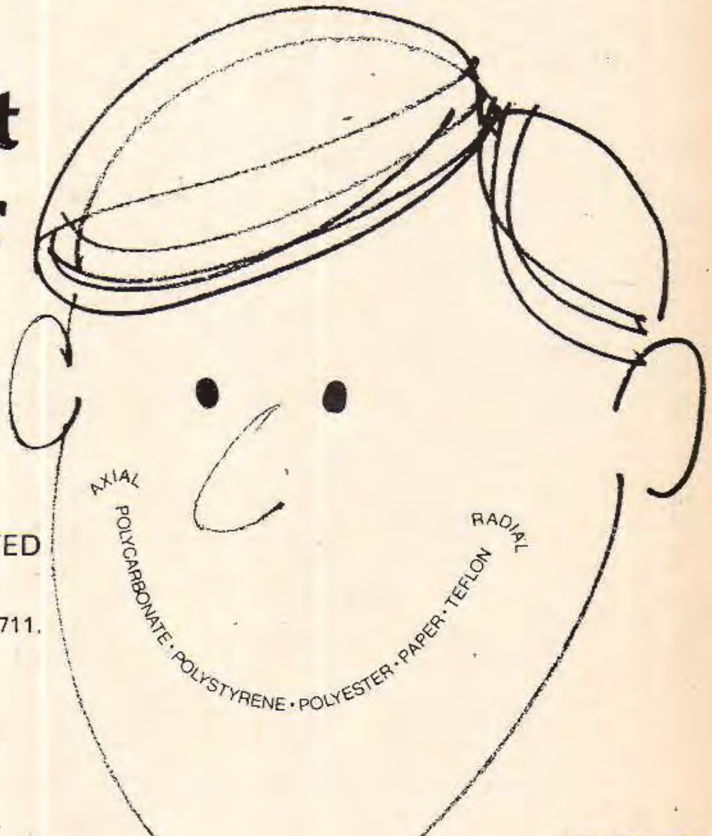
Pye TMC Components Limited, Capacitor Division, Oldmedow Road, Hardwick Industrial Estate, King's Lynn, Norfolk
Telephone: King's Lynn (0553) 3855. Telex: 81182

WW—050 FOR FURTHER DETAILS

SEI capacitors put a smile on your face . . .

. . . and extend that smile with our new range of extended foil polystyrene types for those critical applications where only the best is acceptable.

SALFORD ELECTRICAL INSTRUMENTS LIMITED
Peel Works, Barton Lane, Eccles,
Manchester M30 0HL.
Telephone 061-789 5081 Telex 667711.



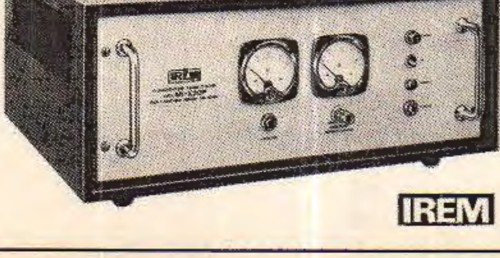
GEC

A member company of
GEC Electrical Components Ltd.

WW—083 FOR FURTHER DETAILS

ELECTRONIC POWER UNITS

FOR XENON ARC AND MERCURY ARC LAMPS



UNITS AVAILABLE FOR LAMPS RANGING FROM 75 TO 6500 WATTS.

Lamp housings and lens systems manufactured as standard off the shelf models or to specific design.

K. T. Manners Design Ltd.
33 Percy Street, London W1P 9FG
Telephone: 01-580 6361. Telex: 28604

LET'S TALK ABOUT CERAMICS!

You would be surprised at the range of ceramic capacitors and piece parts that we can show you.

Supported by the pick of the world's technology there is always something new to interest you in our Stettner range:

Ceramic Plate Capacitors 4mm sq–12mm sq 1pf–0.047uf
Ceramic Disc Capacitors 4mm dia–16mm dia 0.3pf–0.1uf
Ceramic Disc Trimmer Capacitors 4.5mm dia–25mm dia 2.5/4pf–20/150pf
Ceramic Tubular Trimmer Capacitors 0.5/2pf–3/15pf
Ceramic Leadless Disc and Trapezoidal Capacitors 0.4pf–1500pf
Ceramic Feed–thru Capacitors and Insulators
Ceramic High Stability Inductors 16nH–14uH
Ceramic High Frequency Components
Ceramic Metallized Coils
Ceramic Stand-off Insulators

All types of ceramic insulators and piece parts both standard and custom built.

Don't miss out. Why not call our man in to talk about the Stettner range?

STEATITE INSULATIONS LIMITED
Hagley House, Hagley Road, Birmingham B16 8QW.
Telephone 021-454 6961, Telex 33445.

STEATITE INSULATIONS LTD.

MORE CHOICE MORE KNOWLEDGE MORE EXPERIENCE

WW—103 FOR FURTHER DETAILS

paper is impregnated with another suitable dielectric to prevent moisture absorption (see Table 2 for details of typical dielectrics used). The electrode of the capacitors is usually aluminium and two basic types of capacitor exist, one being the metal foil variety which functions at high voltages and currents, the other being the metallized variety where the dielectric is coated with a thin layer of alumininm or zinc; this method of construction leads to a size reduction due to the thinness of the metallized film but has a disadvantage in that pulse handling is bad.

Encapsulation of paper capacitors is usually by moulding the capacitor element in resin or encasing it in metal cans, the latter being hermetically sealed to prevent evaporation of the dielectric.

Reliability. The power factor of paper capacitors is dependent on the type of impregnant used. In some cases it may be large and will always increase rapidly with frequencies above 10kHz.

A defect in the dielectric of a capacitor will cause an electric arc between the electrodes which will destroy more of the surrounding dielectric and result in catastrophic failure.

The disadvantage is not seen in metallized film types because the heat generated by the arcing process will rapidly vaporize the electrode section, this clearing the short. Metallized film construction is thus not confined to paper capacitors but is used extensively in plastic film types. A schematic diagram of the process is shown in Fig. 15.

Plastic film capacitor

Plastic films are used extensively in capacitor manafacture due to their high reliability and low cost. A number of leaves of plastic film are interleaved with aluminium electrodes rolled into a coil and encapsulated by a metal case or plastic encapsulation. A typical plastic film capacitor is shown in Fig. 16.

Historically, the first plastic film capacitor consisted of polystyrene film, which produced a realiable capacitor, although expensive. Nowadays, numerous plastic films are used and Table 3 gives a synopsis of the relative advantage of the four most common types.

It shonld be noted that it is not possible to vacuum deposit a metallized film on polystyrene film due to its low melting point.

Mica capacitors

Mica is a natnrally occurring silicate which due to its platelike crystal structure, can be laminated into thin sheets suitable for capacitor construction. Being chemically inert and possessing a high permittivity (6·5 to 8·7) mica is capable of a precise electrical performance.

The construction of a mica capacitor is shown in Fig. 17, and consists of a number of small parallel capacitors to form the main capacitor.

Metallized film techniques in mica capacitors have led to the silver mica capacitor becoming extensively available in the capacitor market. In this capacitor, silver electrodes are fired directly onto the sheets of mica giving better stability due to the defined distauce of the electrodes and the lack of air pockets in the capacitor (and hence their associated instability).

Encapsulation of the capacitor is commonly by means of a moulded epoxy resin although this does produce a fatigue condition on the capacitor due to the heat of the moulding which affects the reliability of the capacitor. In contrast the dipped mica capacitor, being encapsulated by dipping in resinous material below atmospheric pressures gives better electrical characteristics than the moulded types and high reliability.

Ceramic capacitors

Ceramic capacitors may be divided into two classes; the high permittivity type (high K, $\epsilon \approx 1000$) and low permittivity type (low K, $\epsilon \approx 10$).

Characteristics of the two types are widely different. The low K types possess low power factor, small linear temperature coefficients, and operating frequency capabilities of up to 1000MHz. The high K types have high power factors (dependent on the applied a.c. and d.c. fields due to electrical hysteresis) and non-linear temperature coefficients. By a suitable choice of materials a dielectric can be useful in circuit applications where an otherwise detrimental temperature drift would occur, e.g. tuned circuits and

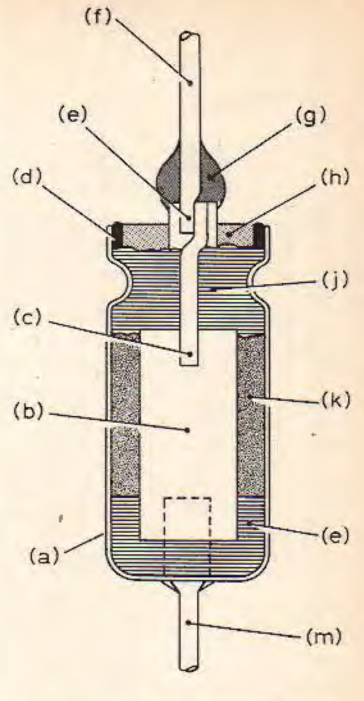


Fig. 14. Schematic of a wet-sintered tantalum capacitor (a) fine silver (b) anodized sintered tantalum anode (c) tantalum wire (d) solder seal (e) tantalum to nickel weld within header (f) nickel wire (g) solder seal between header and external anode lead (h) glass-to-metal seal (j) internal seal (k) electralyte (l) anode boot (m) cathode.

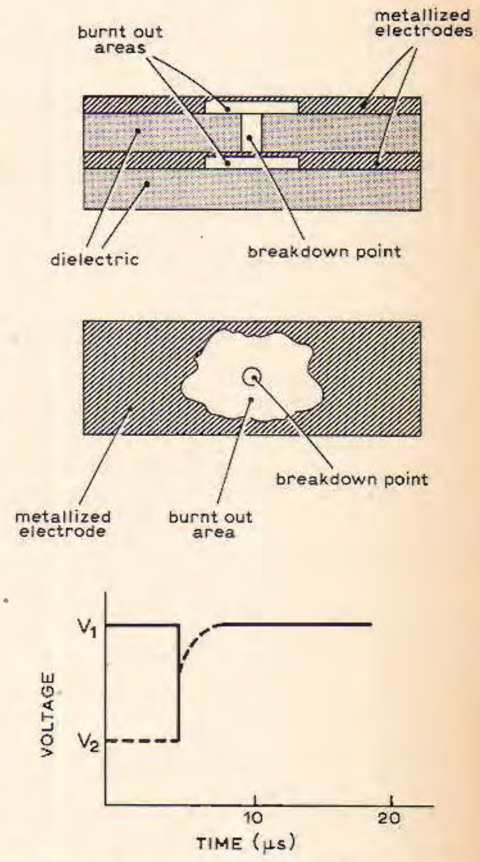


Fig. 15. Process of self healing of a metallized dielectric capacitor. The voltage trace is typical during the process.

Table 2. Dielectrics for paper capacitors

Dielectric	Permittivity (P1)	Permittivity with paper (P2)	Comment
Natural products (oils, waxes, etc)	2·2 to 6·0	≈4	Low dielectric stress due to difference of $P1$ and $P2$
Synthetic halogenated products	5·0	≈5	More even dielectric stress due to equality of $P1$ and $P2$
Plastic polymers	2·5	≈3·5	Possible voids form in polymerisation; low cost

Table 3. Plastic film dielectrics

Characteristic	Polystyrene	Polyethylene terephlalate	Polycarbonate	Polypropylene
Structure	non polar	polar	polar	non polar
*Permittivity	2·4	3·3	2·8	2·25
Production of film	extrusion	melt casting	extrusion or solvent casting	extrusion
Film-thickness (μm)	8	3·5	1·5	8

*decreases with frequency for polar material

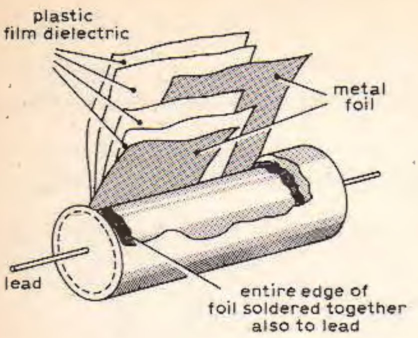
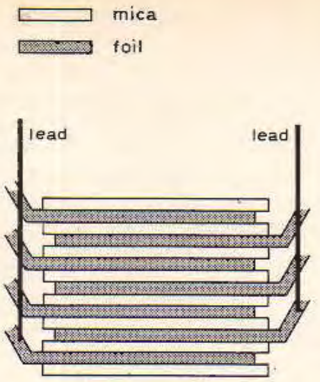


Fig. 16. Constructional features of a plastic film capacitor.



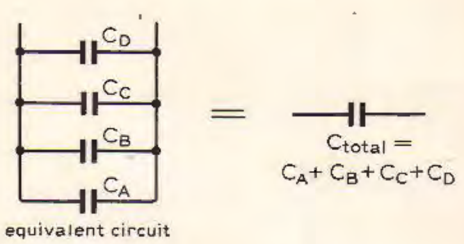


Fig. 17. Construction of a mica capacitor and its equivalent circuit.

filters.

The high *K* ceramic capacitors are able to give a large capacitance in a small space and find application in decoupling and by-pass capacitors.

Manufacture

The ceramic materials used in capacitor manufacture are made from natural minerals such as steatite, titanium dioxide, and alkaline earths. The ingredients, after being finely ground are compressed, heated to 900° C to remove any impurities; then reground and finally recast in a carefully controlled atmosphere of about 1300° C.

Ceramic capacitors are found in either disc or tubular form. The electrodes are a film of silver fired on to both surfaces of the ceramic. Encapsulation is usually by means of a wax impregnated phenolic dip.

Of particular interest is the barrier layer ceramic capacitor. In this type the high *K* thin film ceramic plates are fired in a de-oxidising oven so as to convert the plates into a conducting metal. The capacitor assembly is then fired in a reoxidizing oven so as to restore the external surfaces in the assembly to a dielectric. Normal silvering is now applied resulting in two high capacity capacitors connected in parallel.

This technique enables high capacitance to be obtained in a relatively small space.

Further reading and acknowledgement

Most manufacturers provide excellent information on capacitors, among those of particular interest are technical literature by: Waycom, Philips, Plessey, Lemco and Erie.

Of deeper and of a more theoretical nature are "Fixed Capacitors" by Dummer (Pitman) and "Dielectrics" by P. J. Harrop (Butterworths).

The author wishes to thank the staff of the Components Laboratory, Rank Radio International for their consistent help and enthusiasm.

Appendix

It is known that when a dielectric is polarized the electric field (*E*) within the dielectric is vectorially displaced according to eqn.1.

$$\epsilon_o E = D - P \qquad \text{(A1)}$$

where: ϵ_o = permittivity of free space
D = dielectric displacement of the medium
P = polarization of the medium

This equation can be physically interpreted by considering a dielectric as a collection of atoms, positively or negatively charged, each separated by a small distance, and arranged in some regular pattern to form what is known as a lattice. The dielectric may be fundamentally classified as polar or non-polar according to whether or not it possesses a permanent dipole moment (a dipole consists of two charges equal in magnitude, *q*, but of opposite sign, separated by a small distance, *a*. The dipole moment is the quantity *qa*). Under the action of an electric field, *E*, the lattice of the dielectric is distorted (or displaced) and its dipole moment is altered in magnitude and direction. The dielectric is said to be polarised.

It is also useful to define the "polarizability" of the medium, *X*, from

$$P = X\epsilon_o E \qquad \text{(A2)}$$

hence from (A1) and (A2), $D = (1+X)E$.

This defines the permittivity of the dielectric, ϵ (see general considerations for the physical importance of this parameter) by $\epsilon = (1+X)$.

The loss angle, δ, is defined as the phase angle between *E* and *D*, but is complicated by the fact that *X* is not dependent on a single variable but on four physically distinct mechanisms viz: electronic polarizability (*e*), atomic polarizability (*a*), dipole polarizability (*d*), space charge (*s*)

$$X = \alpha e + \beta a + \gamma d + \delta s$$

where ($\alpha, \beta, \gamma, \delta$ are constants dependent on the dielectric).

Capacitor comparison chart

	Polypropylene		Polyester		Polycarbonate		Mica	Paper		Polystyrene	Ceramic		Electrolytic		
	metallized	film/foil	metallized	film/foil	metallized	film/foil		metallized	film/foil		disc/tube	monolithic	aluminium foil	foil	tantalum solid & wet
Insulation resistance Ω	10^5M	5.10^4M	5.10^4M	10^5M	5.10^4M	10^5M	10^5M	3.10^3M	2.10^4M	10^6M	10^2M	10^4M	practical measurement by leakage current		
Dissipation factor	0.0003	0.0003	0.01	0.005	0.005	0.001	0.02 to 0.0005	0.01	0.005	0.0003	0.002 to	0.02	very poor 0.08	poor 0.01	poor 0.0005 to 0.02
Tolerance (%)	5	2	5	5	5	2	0.5	10	5	0.625	10	20	10	10	5
Temperature range (°C)	−40 to 85	−40 to 100	−55 to 125	−55 to 125	−55 to 125	−55 to 125	−55 to 125	−30 to 100	−30 to 100	−40 to 70	−55 to 125	−55 to 125	−20 to 80	−40 to 125	−40 to 150
Size per CV	small	small	small	small	small	small	small	small	large	large	small	small	very small	small	
Stability	fair	excellent	fair	fair	fair	fair	excellent	fair	fair	excellent	fair	fair	fair	very good	excellent
Cost per CV	low	low	low	fair	fair	fair	fair	fair	fair	high	low	low	fair	high	high
Capacitance range (μF unless indicated)	0.001 to 100	100pF to 0.47μF	0.001 to 10	100pF to 0.01μF	0.001 to 100	5pF to 0.01μF	5pF to 0.01μF	0.01 to 100	0.001 to 100	100pF to 0.6μF	5pF to 1μF	0.001 to 10	typically 1 to 22,000	1 to 1000	*CV* product inflexible (3500 max normally)
Voltage (V) (a.c.)	250 to 440	63 to 500	63 to 400	90 to 160	40 to 250	63 to 160		250 to 630	250 to 630	—	63 to 250	—	—	—	—
Voltage (V) (d.c.)	750 to 1000	100 to 1500	100 to 1500	160 to 400	63 to 1000	100 to 400	63 to 630	500 to 5000	—	63 to 1000	63 to 10000	63 to 450	6.3 to 500	6.3 to 300	1 to 50
Temperature coefficient PPM/°C	−170	−120	400	400 (non linear)	150	−50 to −100	100	300	300	−150	non linear positive to 1000 neg		1500	1000 (non linear)	200 to 1000
Appx. resonance MHz	0.1	1	0.1	1	0.1	1	1.0	0.1	0.1	1	10	100	0.05	0.1	0.1

World of Amateur Radio

The Moscow way of licensing

At a time when the h.f. bands are less frequently open to DX I find that a high percentage of all my contacts seem to be with amateurs in the USSR where activity and standards of operating are high and where many amateurs seem to be using home-built transceivers. Considerable official encouragement is given to amateur radio in the USSR including access to surplus equipment and technical information. But at the same time by British standards the licensing is very much on an "incentive" basis and demands considerable effort on the part of those wanting licences.

A recent survey of Russian licence conditions in *Electronics Australia* shows that the Muscovite's path to a first-class licence is long and arduous. In essence the procedure is: complete a basic electronics course; join a radio club and take a test (including a 10 w.p.m. Morse test) which licenses you to *listen* on the amateur bands and log stations; after six months you can take a "third-class" test (more difficult examination on simple transmitter theory and practice and 12 w.p.m. Morse test). If you pass this you are permitted to operate a 10-watt transmitter on sections of the 3.5 and 7MHz bands c.w. and 28MHz phone. These licences can be renewed only by the operator moving to a higher class. To do this requires another ("second-class") examination and a pass allows operation of a 40-watt transmitter on 3.5 to 420MHz c.w. (phone restricted to 28MHz). Finally to obtain a "first-class" licence requires the applicant to send and receive Morse at 18 w.p.m., be able to design transmitter and receiver circuits, and build and service advanced transmitters and receivers. If he or she (for some 10% of Russian amateurs are "YLs") passes, then permission is given to operate 200 watts on 3.5 to 420MHz c.w. or phone (there are no 1.8, 50 or 70MHz bands available in Russia – I am not certain about microwave bands).

V.h.f. going factory-built

Not so long ago it was common practice for v.h.f. enthusiasts to claim that their bands had become the last refuge of those who liked to build their own equipment (although in practice reception usually depended on a home-built converter in front of a commercially-built h.f. communications receiver). Bnt there is plenty of evidence to show that factory-built equipments are today becoming almost as widely used on 144MHz as on 14MHz. In the last two or three years there has been an influx of v.h.f. transceivers such as the Yaesu FT-2 series, Trio TR7200 and TR2200 and kit units such as the Heathkit HW202, 144MHz transverters, Inoeu and Icom units such as the IC22 and IC210 with its phase-locked v.f.o., the Liner 2 transceiver that has enormously increased the amount of s.s.b. on 144MHz, and a growing number of 144MHz hand-held units for working direct or through repeaters.

One wonders whether, in the face of this invasion, the home-builders will tend to retreat to the u.h.f. bands or subscribe to the growing interest in microwaves.

Ionospheric storms in a quiet year

Recent months have been marked by pronounced 27-day repeats of pretty severe magnetic storms. They start off with a steep rise in maximum usable frequencies, leading on to auroral effects and then followed by several days of disturbed conditions and low m.u.f., particularly on the North Atlantic paths. It has of course long been recognised that the 27-day repetition period of these storms allows them to be predicted with good accuracy during the decreasing phase of the sunspot cycle. But one certainly has the feeling that the storms have been more severe this year than one would expect in what many regard as "a year of the quiet sun".

For example, October 12 saw a high m.u.f. with the 28MHz band opening well to Australia and Japan; this was soon followed by Aurora openings on v.h.f. and then a lengthy period of subdued h.f. conditions.

Clamping down on Citizen's Band violations

The American FCC appears to be taking seriously a series of measures aimed at better regulation and supervision of 27MHz CB operation where in the past the Class D regulations have been honoured mostly in the breach. For example the Commission has recently set up four specially equipped and trained enforcement teams; obtained a well-publicised series of criminal convictions for gross violations; established temporarily some 40 special inspection stations to check the use of CB equipment by lorry drivers (of 36,000 vehicles checked about 7,000 were carrying 27MHz CB equipment, more than half unlicensed and many others exceeding the power regulations). There are current proposals in the United States to prohibit the sale or importation of linear amplifiers in the 20 to 40MHz range as these are being widely used to run high-power CB stations.

However, there are also proposals to increase the number of 27MHz channels (adding 27·23 to 27·54MHz), to permit the use of omnidirectional aerials at heights up to 60ft (20ft will still be the limit for beams) and to relax some of the restrictions on hobby use of Citizen's Band.

Type approval of amateur gear?

One aspect of so much amateur equipment now coming from factories rather than being built on the kitchen table is the question of whether this is likely to lead to the introduction of some form of type approval, type acceptance or recognised "performance standards". Probably the main question is that of the levels of spurious emission outside of amateur bands, a factor that has been emphasised by the more general use of mixing processes rather than straight frequency multiplication in transmitter practice. It is by no means unusual, even in reputable designs, for there to be spuriae of the order of −40dB or so with reference to wanted output. This may or may not result, for example, in interference to television reception or to other communication services; much depends on what additional suppression is provided by the operator in the form of filters or resonant aerials. But there is an argument that if equipment is sold for amateur operation should it not be expected to be suitable, without additional suppression, for use at all normal locations?

One answer might be for the licensing authorities to insist that all equipment conformed to a published performance specification, but where would this leave the amateur who wishes to modify equipment and lacks measuring equipment to ensure that the performance is still within spec?

The ARRL Board of Directors recently decided that if any form of type approval is instituted in the United States the League would urge continuation of the amateur's right to build, to modify and to adapt surplus equipment to his own use.

In brief

The installation of the RSGB president for 1975 (C. H. Parsons, GW8NP) will take place at Cardiff on January 17 . . . Nobel prize winner Sir Martin Ryle holds the amateur callsign G3CY . . . The final RSGB 144MHz contest for 1974 takes place on December 8 . . . Microwave operating awards are issued by the RSGB for the first contact an amateur makes over the following distances: 13-cm band 500km; 9-cm 400km; 6-cm 300km; 3-cm 150km; and 15-mm 150km . . . "I would like to voice my personal firm support of the Amateur Radio Service," from a recent address by Richard E. Wiley, chairman of FCC . . . Over 1,000 repeater stations have been licensed in the United States, making this the fastest growing segment of amateur radio, and it seems likely that restrictions on the linking of repeater stations may be lifted, together with those relating to cross-band operations.

PAT HAWKER, G3VA

New Products

Sweep/function generator

Line, square, triangle and swept waveforms, as well as fixed-amplitude pulses are available from the model 195 generator. A frequency range from 2Hz to 200KHz in three ranges, with a linear/logarithmic frequency control is offered by the instrument which will span three decades on any frequency range. Slow, medium and fast sweep rates are provided, with high- and low-level sine outputs, and a voltage-controlled frequency input permitting remote control of the frequency. The three sweep rates give sweep times of 25s, 250ms and 2.5ms, and the frequency accuracy is claimed to be ±2% of full scale. The instrument measures 18.7 × 21.6 × 7.3cm and costs £79. Dana Electronics Ltd, Collingdon Street, Luton, Beds.
WW300 for further details.

Direct current calibrator

The 609S is a d.c. source for calibration from nanoamp levels up to 100mA in five ranges. An accuracy of ±0.05% of setting ±0.005% of range ±0.2nA is quoted for the instrument, which has a regulation for the load and supply of 5ppm/V. Output noise for the 100, 10, and 1mA ranges is less than 5ppm of full scale, and 10ppm of full scale ±0.1nA for the 100 and 10 μA ranges. The unit, which measures 22 × 16 × 19cm, is powered by ten U2-type batteries, but an interchangeable mains power unit is available. Time Electronics Ltd, Botany Industrial Estate, Tonbridge, Kent.
WW302 for further details

Pulse transformer

The 1060 series of miniature pulse transformers manufactured by Nano Pulse Industries has been designed for use with triac and s.c.r. circuits. Standard types in the range have either two or three windings and ratios of 1:1, 1:1:1 or 2:1:1 respectively. Minimum inductances can be either 1.5 or 5mH with maximum leakage inductances between 0.5 and 2.3μH. Tekdata Ltd, Westport Lake, Canal Lane, Tunstall, Stoke-on-Trent, Staffs ST6 4PA.
WW306 for further details

Cable identification system

A system comprising the model H8030-30TC pulse transmitter, and the model TCD-2 pulse detector is capable of identifying each phase anywhere along cable runs. A series of coded pulses are transmitted by the H8030-30TC on "A" and "B" phases, these pulses combine and return on "C" phase. In three-conductor cables, each phase can be identified by moving a pick-up coil around the cable, and by observing the meter on the TCD-2 detector. Hipotronics Inc, Brewster, NY 10509, USA.
WW311 for further details

Multichannel VU meter

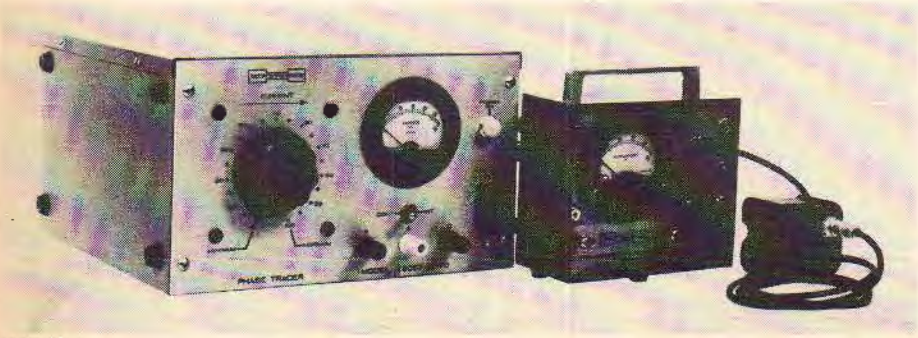
A new instrument called the VUE-SCAN replaces conventional VU meters and accepts up to 28 channels of audio information which are displayed simultaneously as illuminated vertical bars on a television monitor screen. The bars are always present as a background refereuce. The lower two-thirds of the screen has a blue filter and the remaining upper third has a red filter. As the level of a channel increases the bar representing that channel increases in height and intensity. Any channel which moves into the red position is identified as over-modulated. Audio Designs & Manufacturing Inc, 16005 Sturgeon, Roseville, Mich 48066, USA.
WW304 for further details

Digital clock

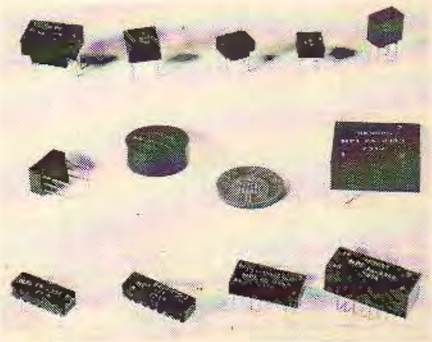
Emihus Microcomponents have designed a universal digital circuit specifically for use in mains driven electronic digital clocks, timers and time-base circuits. The circuit, which uses p.m.o.s. technology, has two designations—EDC6051 and EDC6052. Common features to both are: 50Hz, 60Hz or 100kHz control frequency options; three inputs for setting minutes, tens-of-minutes and hours; stop control feature,

WW300

WW302



WW311



WW306

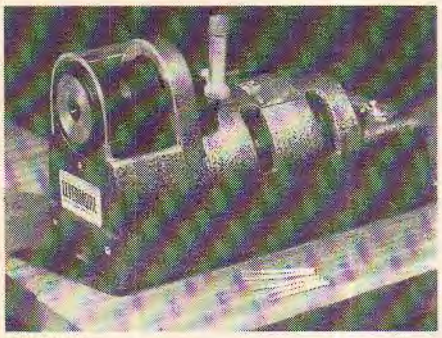
reset facility, 12- or 24-hour display, a.m./p.m. indication, and eight-decade counting in 1, 2, 4, 8, b.c.d. option. The EDC6051, however, includes a 24-hour alarm setting and a "snooze alarm" feature. The circuit is contained in a 28-pin d.i.l. package. Emihus Microcomponents Ltd, Clive House, 12 Queens Road, Weybridge, Surrey.
WW303 for further details

Rotary wire stripper

The model 70 wire stripper has been designed as a production line machine and is capable of handling most types of wire up to 0.201in outside diameter. A solid carbide swing blade is adjusted to suit the wire thickness. The machine is mains-powered, measures $5\frac{1}{4} \times 3\frac{3}{4} \times 10$in and weighs $7\frac{1}{4}$lb. A. Levermore & Co Ltd, 40 The Broadway, London SW19 1SQ.
WW309 for further details

Milliohmeter

The Toneohm 400A is a mains-operated milliohmeter offering five ranges from 30 milliohm to 3 ohm. The readout is indicated on a panel meter, and in the form of a resistance dependent audio tone. Accuracy is quoted as 5% of f.s.d. and the maximum probe voltage is 0.7V. Calibration is by means of a preset control on the front panel of the meter which measures 15.5 × 10 × 10cm and weighs 1.1kg. Polar Electronics, P.O. Box 97, Les Villets Forest, Guernsey, Channel Islands.
WW301 for further details



WW309

WW308

Radio power meter

A mobile r.f. power meter, TF2512, from Marconi is a 50 ohm direct reading absorption power meter having a 10W and 30W full-scale range. Frequency range is from d.c. to 500MHz, with an accuracy of ±5% up to 250MHz and ±7% up to 500MHz. A thermocouple sensing element provides true-mean-power measurements from any applied waveform. Changing the power range is achieved by altering the meter sensitivity, therefore it is impossible to damage the thermocouple by inadvertently switching to the wrong range. Marconi Instruments Ltd, St Albans, Herts.
WW310 for further details

Knobs

Sifam have introduced a range of knobs and accessories which are available in 11, 15, 21 and 29mm base-diameter sizes with or without indicating line. All the accessories are made from nylon except for transparent dials which are made from a polycarbonate. Black and grey shades are standard with green, blue or yellow caps and pointers. Sifam Ltd, Woodland Road, Torquay, Devon TQ2 7AY.
WW308 for further details

Pattern generator

A pocket-sized u.h.f./v.h.f. 625 line pattern generator has been announced by Labgear. The unit produces a blank raster, 12 horizontal/13 vertical lines, and an eight-bar grey scale. Both u.h.f. and v.h.f. outputs are available from the generator which has a mains/battery facility. The instrument measures 4.5 × 10 × 17.5cm and is available from Labgear Ltd, Abbey Walk, Cambridge CB1 2RQ.
WW315 for further details

WW310

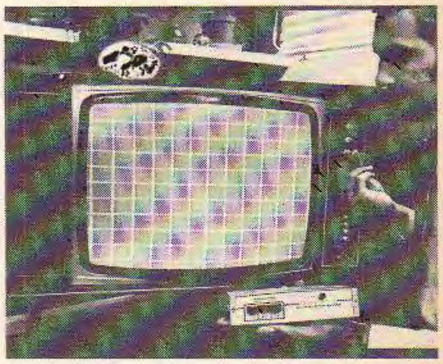
C-band amplifier

A solid-state amplifier for use in line-of-sight communication systems has been introduced by Raytheon. The model VCM-5004 delivers one watt minimum between 7725 and 8275MHz. The design incorporates a power output monitor, self-contained input-output circulators and current regulators. Noise figure rating for the device is 33dB, gain 27dB minimum, phase linearity ±2°/40MHz, and amplitude linearity ±0.2dB/40MHz. The amplifier operates in a temperature range from 0 to +55°C and measures 5.75 × 4.75 × 1.25in. Raytheon Company, 130 Second Avenue, Waltham, Mass 02154, USA.
WW307 for further details

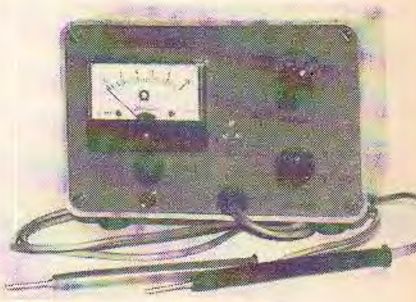
Electronic teleprinter

The ITT-Creed model 2300 is the first teleprinter to feature l.s.i. circuits and first to feature a clutchless print mechanism. It offers a cost reduction of about 20% on the previous ITT machine, at the same time featuring an interchangeable keyboard and a link option board to cater for the different Telex systems. The machine is lighter, smaller and more reliable than its predecessors, as well as being cheaper.

Ability to work into any Telex system is achieved by a plug-in board system that includes a diode matrix board from which



WW315



WW301

selected diodes are clipped out for individual systems (as well as for identification codes). "On the fly" printing is used where a rotating wheel in front of the paper is struck from behind the paper—a technique previously applied to data printers. An impregnated porous wheel (Porlon) resting on the character wheel provides inking and is claimed to have a life six times that of a normal ribbon.

Operating speed can be 50, 75 or 100 bauds and the 5-unit (Telex code) electronics have the potential for conversion to an 8-unit code for data terminals. ITT Creed Ltd, Hollingbury, Brighton BN1 8AL.
WW312 for further details

Graphic equalizer

A graphic equalizer called the Dual 11s comprises two identical 11 band equalizers in one case. Each unit uses overlapping *LCR* filters arranged for boosting and cutting each channel by up to 12dB. The instrument features a noise figure of better than −90dBm and total harmonic distortion of less than 0.01%. The equalizer is available as either a rack-mount unit or fitted in a portable case from Klark-Teknik Ltd, Summerfield, Kidderminster, Worcs DY11 7RE.
WW313 for further details

High voltage capacitors

Perdix Components are now offering a range of high-voltage capacitors for applications where a military grade is not required. Standard types are available from 2kV d.c. working to 150kV d.c. working and capacitances from 500pF to 0.5μF with a tolerance of ±20%, ±10% or ±5% in the operating temperature range −40 to +80°C. Perdix Components Ltd, Perdix House, 31 Green Lane, Chislehurst, Kent BR7 6AG.
WW314 for further details

Capacitance meter

The ESP direct-reading capacitance meter provides measurement in the range 1pF to 10μF. No balancing is required and the value is indicated on a linear scale. The instrument is powered by a 9V battery whose condition is continuously monitored by a l.e.d. which will not light if the battery voltage drops to a level which will affect the performance. The meter is priced at £25 plus v.a.t. and is available from Electronic Services & Products Ltd, 2a Badby Road, Daventry, Northants.
WW319 for further details

TV camera tubes

The latest Mullard television camera tubes for use in surveillance systems are claimed to operate in light levels of 10^{-2} lux, which is equivalent to half moonlight conditions. They consist of Vidicon tubes coupled to image intensifiers by means of fibre-optic plates. Each device contains its own high voltage power supply, a target signal amplifier and an automatic brightness level control. The brightness level control produces a signal that operates the camera iris enabling the tube to operate in varying light conditions. Mullard Ltd, Mullard House, Torrington Place, London WC1.
WW316 for further details

Decade resistance box

The D61/A is a six-decade resistance box offering a nominal accuracy of 1% from 1ohm to 1,111,110ohm in steps of 1ohm. The junction between each decade is brought out to a socket, allowing the box to be used as a potential divider. Metal film 1% resistors are used except for the 1ohm decade which uses a ±0.05milliohm type. Maximum permissible current varies from 700μA at 1Mohm to 2.2A at 1ohm. D. H. Davies, 4 Middleton Drive, Guisborough, Cleveland.
WW317 for further details

Fusible resistor

A new and patented thick-film fusible resistor from Erie is claimed to supersede the conventional wire-wound types in which solder has to melt. The resistor has a "flip top" mechanism which ejects an inert top to provide the fusing action. Two speeds of "flip tops" are available; red types fracture in five seconds at 15W and ten seconds at 9W while blue types fracture in 20 and 30 seconds respectively. Both types are flame retardant and designed to withstand 100% overload for one minute. Erie Electronics Ltd, South Denes, Great Yarmouth, Norfolk.
WW318 for further details

Solid State Devices

Names of suppliers of devices in this sectiun are given in abbreviation after each entry and in full at the end of the section.

Power transistors

International Rectifier have announced a range of discrete and Darlington, high voltage, power transistors. A feature of the new range is the use of glass passivation which allows "on-the-junction" hermetic sealing which in turn prevents the ingress of impurities.
WW350 for further details **International Rectifier**

U.h.f. transistor

The MRF621 has been designed for 12.5V operation between 406 and 512MHz. The transistors will provide 45W at 470MHz from a 12.5V collector supply. Minimum power gain is 4.8dB with a collector efficiency of 55%.
WW351 for further details **Motorola**

Diode bridges

The SCBHO5F-4F series are fast recovery bridges in an "Alpac-T" aluminium package. P.i.v. ratings are from 50 to 400V with an average output current of 10A and a quoted recovery time of 250ns.
WW352 for further details **Bourns**

Regulator

A hybrid i.c. regulator, in a TO-3 package, called the MIVR 42050-055 will deliver up to 5A at 5V ±0.1V without the need for external components. The device incorporates short-circuit protection, voltage shutdown and current foldback. Power rating is 120W at 25°C.
WW353 for further details **GDS**

1GHz decade counters

A new range of decade counters comprises the SP8665B 1GHz, the SP8666B 1.1GHz, and the SP8667B 1.2GHz counters, with guaranteed operation over the temperature range 0 to 70°C. The counters feature a self-biasing clock input, and a clock inhibit input for direct gating capability. The devices have a typical power dissipation of 550mW with a 6.8V supply.
WW354 for further details **Plessey**

Linear i.cs

Recent additious to the RCA range of linear i.cs are the TA6480 tv sound i.f. and audio output system, the CA1352 tv video amplifier, the CA3131 5W audio amplifier, and the CA810 7W audio power amplifier with thermal shutdown.
WW355 for further details **RCA**

1024-bit r.a.m.

Sample quantities are now available of the 2102 1024-bit static r.a.m. which has an access time of 650, 450 or 350ns in the temperature range 0 to 70°C. The devices are constructed using the Fairchild n-channel isoplanar process aud are produced in a 16-pin d.i.l. package.
WW356 for further details **Fairchild**

Suppliers

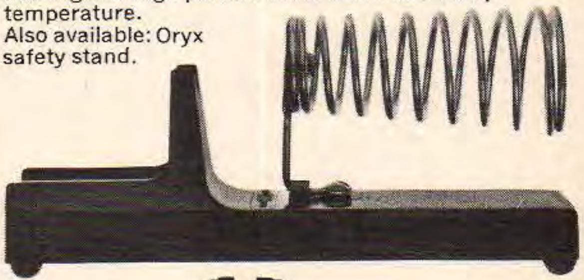
International Rectifier, Hurst Green, Oxted, Surrey.
Motorola Inc., Semiconductor Products Division, European Headquarters, P.O. Box 8, 16 Chemin de la Voie-Creuse, 1211 Geneva 20, Switzerland.
Bourns (Trimpot) Ltd, Hodford House, 17 High Street, Hounslow, Middx TW3 1TE.
GDS (Marketing) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.
Plessey Semiconductors, Sales Office, Cheney Manor, Swindon, Wilts SN2 2QW.
RCA Ltd, Solid State-Europe, Sunbury-on-Thames, Middlesex.
Fairchild Semiconductor Ltd, Kingmaker House, Station Road, New Baruet, Herts.

The Greenwood guide to professional soldering.

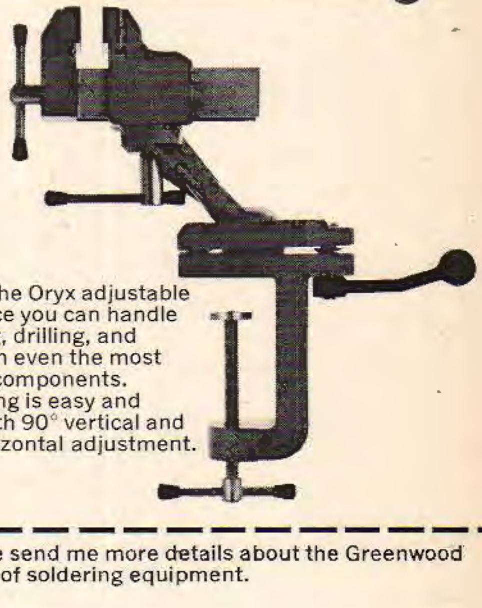
The Ersa Multitip. A top-quality iron that's ultra-light, offering reliability so necessary to achieve constant production flow. A range of different shaped tips simply push onto the stem of the iron. It has the unique advantage that you can change the element in seconds.

The Iso-Tip. A safe, high-powered iron which works anywhere without a mains lead. The breakthrough? Nickel Cadmium cells that are re-chargeable. (A charging stand is included for 240v or 115v A.C.) Each charge gives at least 60 soldering joints. Weight? Only 6oz.

The Oryx 50. A temperature controlled mains soldering iron. (Temperature control within ± 2%.) Adjustment (200°–400°C) can be made whilst iron is operating using the same tip. Light, compact and easy to handle. A large 50W element loading gives rapid heating and high performance with constant tip temperature.
Also available: Oryx safety stand.



The Ersa Sprint. Unique – it heats up to maximum temperature in only 10 seconds, and is the lightest gun on the UK market. Ideal for the service-man. With its lightweight (only 7oz.) and compact construction, it can be manoeuvred in even the most awkward areas.



With the Oryx adjustable bench vice you can handle soldering, drilling, and cutting on even the most delicate components. Positioning is easy and quick, with 90° vertical and 360° horizontal adjustment.

Oryx SR3A desoldering tool. Ideal where components are tightly grouped. Instantly removes unwanted solder from printed circuits etc. Accurate, reliable, speedy, and safe.

Greenwood Electronics offer a range of highly advanced products specifically for professional soldering applications.

For more detailed information about the comprehensive Greenwood range, send us the coupon today.

Please send me more details about the Greenwood range of soldering equipment.

Name ______________________

Address ______________________

______________________ WW3

Greenwood Electronics

21 Germain Street, Chesham, Bucks, HP5 1LL
Tel: 02405 4808 Telex: 83647

Now-<u>two</u> fascinating ways to enjoy saving money!

NEW! Sinclair Scientific kit £19.95 (INC. VAT)

Britain's most original calculator now in kit form
The Sinclair Scientific is an altogether remarkable calculator.

It offers logs, trig, and true scientific notation over a 200-decade range – features normally found only on calculators costing around £100 or more.

Yet even ready-built, the Sinclair Scientific costs a mere £32.35 (including VAT).

And as a kit it costs under £20!

Forget slide rules and four-figure tables!
With the functions available on the Scientific keyboard, you can handle *directly*

sin and arcsin,

cos and arccos,

tan and arctan,

automatic squaring and doubling,

$\log_{10}$, antilog_{10}, giving quick access to x^y (including square and other roots),

plus, of course, addition, subtraction, multiplication, division, and any calculations based on them.

In fact, virtually all complex scientific or mathematical calculations can be handled with ease.

So is the Scientific difficult to assemble?
No. Powerful though it is, the Sinclair Scientific is a model of tidy engineering.

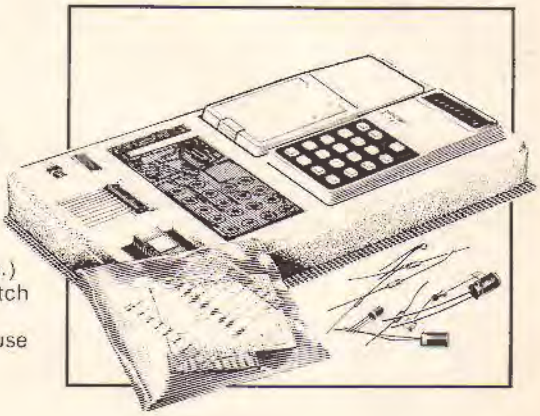
All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our Service Department will back you throughout if you've any queries or problems.

Of course, we'll happily supply the Scientific or the Cambridge already built, if you prefer – they're still exceptional value. Use the order form.

Components for Scientific kit (illustrated)

1. Coil
2. LSI chip
3. Interface chips
4. Case mouldings, with buttons, windows and light-up display in position
5. Printed circuit board
6. Keyboard panel
7. Electronic components pack (diodes, resistors, capacitors, etc.)
8. Battery assembly and on/off switch
9. Soft carrying wallet
10. Comprehensive instructions for use

Assembly time is about 3 hours.



Features of the Sinclair Scientific

● **12 functions on simple keyboard**
Basic logs and trig functions (and their inverses), all from a keyboard as simple as a normal arithmetic calculator's. 'Upper and lower case' operation means basic arithmetic keys each have two extra functions.

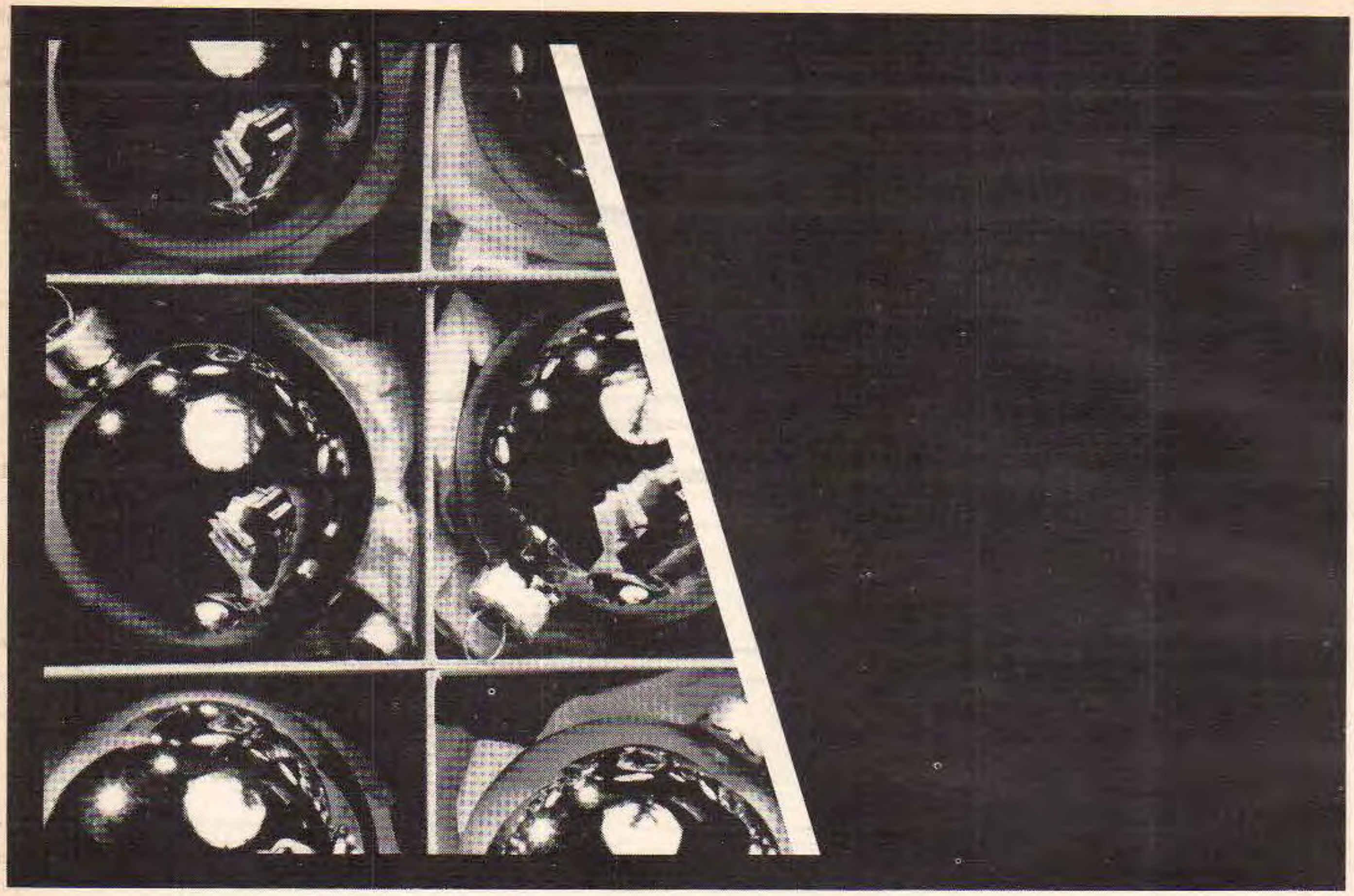
● **Scientific notation**
Display shows 5-digit mantissa, 2-digit exponent, both signable.

● **200-decade range**
10^{-99} to 10^{+99}

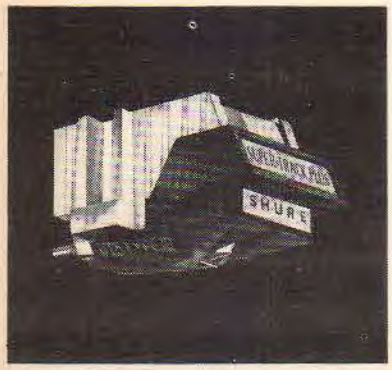
● **Reverse Polish logic**
Post-fixed operators allow chain calculations of unlimited length – eliminate need for an = button.

● **25-hour battery life**
4 AAA manganese alkaline batteries (e.g. MN 2400) give 25 hours continuous use. Complete independence from external power.

● **Genuinely pocketable**
4 1/3" x 2" x 11/16". Weight 4 oz. Attractively styled in grey, blue and white.



A cartridge in a pear tree.



What a superb Christmas Gift a Shure V-15 Type III would be! With it you could hear the true sound of pipers piping, drummers drumming, rings ringing. As the giver, you would make a Hi-Fi enthusiast supremely happy not only at Christmas time but throughout the years to come. As a last resort, if nobody else takes the hint, why not give one to yourself!

Shure Electronics Limited
Eccleston Road, Maidstone ME15 6AU
Telephone: Maidstone (0622) 59881

WW—035 FOR FURTHER DETAILS

SHURE ®

Real and Imaginary

by "Vector"

How quo was my status?

In the October issue the Editor sprang to the stirrup to bring us the good news that active steps are being taken to improve our professional status. As one whose status only departs from the zero line to swing negative I fervently applaud this noble project.

In his communiqué the Editor emphasized the importance of status and, as ever, Sir is so right. I remember one instance at a Farnborough Air Show. I'd been invited to a wining and dining session by a couple of high-powered aviation executives who were under the impression (rightly) that our Chairman was in the market for a private heavier-than-air machine. They were also under the impression (terribly wrongly) that I had some pull with the Old Man. (Actually they'd confused me with another chap of the same name who was a big wheel in our company.) The rendezvous they'd chosen resembled a morgue with waiters, but the food was cordon bleu stuff so I let them stay confused. Not until the coffee-and-liqueurs stage had been reached was the conversation ever-so-delicately steered around to executive aircraft, whereupon the truth was revealed and it wasn't long before I was cast forth into outer darkness.

Upon reflection, this last bit isn't quite true, for the hotel forecourt, like its customers, was well lit. I was halfway across it when my way was barred by a drunken Irishman who was built roughly to the scale of the Giant's Causeway. Without ado he seized my lapel in one massive paw and swept his other arm around in a magnificent arc which encompassed the assembled battalion of Mercs, Jags and Rolls-Royces.

"If yez ask me," he said, thrusting his seven o'clock shadow to within three inches of mine, "if yez ask me, dese are nudding but a bunch of ****** status symbols!" And releasing his grip he lurched off into the night. So did I, but in the opposite direction; I didn't want to be in the immediate vicinity if a Rolls suddenly went off bang. But I couldn't help agreeing with the expressed philosophy. An engineer with a five-year-old Mini doesn't stand a dog's chance with the dollies on the Air Show stands when these counter-jumpers with their hired status symbols are around. So vive le status!

The brisk, ambitious lad who is contemplating entering electronics should have no great difficulty in acquiring a status which is instantly recognizable throughout the profession, but there are short cuts to the top of the tree. As a first step he should hang on at university for as long as the state and his parents can be coerced into subsidizing him. During this foetal phase he should collect as many degrees as possible, including, naturally, a Ph.D. This won't necessarily give him the engineering capability of replacing a busted fuse but it looks very fetching on an application for a job. A word of warning, however. I believe that in the USA Ph.Ds are so thick on the ground (I use the term "thick" to mean a high population level and not in its "thick as two planks" connotation) that only the medical profession uses the word "doctor". So if you do get one, don't emigrate to the States.

If you must go into the electronics industry, join a big firm. Having got a Ph.D. on the payroll they won't know what to do with you, so you can easily get yourself lost in the organization. Join as many learned societies as you can and spend your time in the sanctuary of the firm's library, writing papers for their Proceedings. Provided that you make them completely unintelligible the learned societies will publish them and you'll soon establish an enviable reputation for appearances in the literature. You are now well on your way to becoming a world authority on the sex life of the electron (or whatever your chosen subject is) and invitations to speak at conferences and symposia will flow in. Choose your acceptances with care, selecting those which coincide in venue and timing with the Motor Show, the Boat Show or whatever function forms your particular interest. Many symposia are held abroad, usually in some warm, exotic locality; with care, you can spend nine months of the year overseas, living on your expense account. Your firm will be so bucked at all this they they'll create you a Plenipotentiary Scientific Consultant which merely means that what you've formerly been doing under cover can now be done in the open.

Other forms of status in industry are often more apparent than real. Long ago, firms tumbled to the fact that the tea-boy works better if he's called a Stimulant Provision Officer and that the arrangement operates to some extent in lieu of more pay. It works up to a point, but when everybody in the organization is an admiral you're back to square one, for status is relative, not absolute. There are other, more reliable, guidelines. In any given Product Division there may be a dozen managers; at tea break, eleven will send their secretaries for a cuppa from the automatic dispenser while one will get a pot of tea on a tray brought by a waitress. Guess who's the big wheel?

Offices are another status symbol. Titles who share an office with half a dozen other titles don't rate in the hierarchy, but conversely, the news that you're to be given an office on your own does not necessarily mean that you've arrived. It could merely be that Works and Bricks have discovered a disused store cupboard and you're being bunged in there to get you out of everybody else's hair. Only when you move into a room big enough to house six, with carpet on the floor and a shapely blonde secretary installed in an outside office, can you feel that you're in the big league. From then on, promotion will take you to more and more opulent structures; from the Chairman's doorway, for instance, you can just glimpse his desk on a clear day while, for all you know, a couple of tigers may be lurking in the pile of the carpet.

But as the Editor points out, status-recognition within the profession is relatively straightforward; it's recognition by the public that's the problem. They brush shoulders with us in the street in total unawareness that we're the chaps who've brought fulfilment to their lives. Without us they'd never have known those tender moments with Ena Sharples, neither could they ever go on safari to Mummerset to help the Archers with the carrot harvest. Little do these lesser mortals know that supermen are standing alongside them in the queue. That, if we chose to turn from electronics to some honest form of toil, we would divorce them for ever from sight and sound of Messrs Wilson, Heath, Thorpe, Savile, Blackburn, Waring *et al.* If they did know this, I'm sure they would make due obeisance.

The tragedy is that, away back in the Stone Age of radio, we—at least our forebears—had the adulation of the general public and lost it. If you have access to the early volumes of *W.W.*, take a look at the photographs and you'll see what I mean. There he sits, this superman of old, stonefaced in front of a pile of ironmongery and curly wires; twin-banded earphones are clamped on his head; one hand is adjusting a stud-switch while the other is poised over a morse key. Clearly, matters were at crisis point when the picture was taken; a message from Mars, perhaps? Or an SOS from mid-Atlantic? The general public never saw these wizards in the flesh but gazed in awe at their pictures, knowing that they conversed not in mortal tongues but in an alien dot-dash language of their own. Then along came the loudspeaker and the microphone and killed the mystery stone dead. I think the headphones were the key feature; shorn of those we became indistinguishable from the common herd.

So the problem resolves itself into one of instant recognition; here, I think we might learn from the Armed Services, with their insignia. Couldn't we, for instance, borrow the hand grasping a bunch of straws that the RAF use to distinguish their electronics personnel? On second thoughts, no; it isn't showy enough. Personally, I think something along the lines of Batman's uniform is called for. That really should do something for our public image.

General index

Volume 80, March – December 1974

The general index is followed by classified and authors' sections. The classified index is divided into the following: audio and acoustics; circards; circuit ideas; circuitry and circuit design; communications; constructional designs; editorials; education and instructional; exhibitions and conferences; letters to the editor; measurement and test; news of the month; project; realm of microwaves; research notes and space news.

CLASSIFIED INDEX

AUDIO & ACOUSTICS

CIRCARDS

CIRCUIT IDEAS

CIRCUITRY & CIRCUIT DESIGN

COMMUNICATIONS

CONSTRUCTIONAL DESIGNS

EDITORIALS

EDUCATION & INSTRUCTIONAL

EXHIBITIONS & CONFERENCES

LETTERS TO THE EDITOR

MEASUREMENT & TEST

NEWS OF THE MONTH

VALVES

	£		£
A1065	1.25	ECL80	0.55
AR8	0.55	ECL82	0.35
ATP4	0.50	ECL83	0.70
B12H	3.00	ECL86	0.45
CY31	0.50	EF36	0.65
DAF96	0.50	EF37A	1.20
DF96	0.50	EF40	0.75
DK96	0.70	EF41	0.65
DL92	0.40	EF80	0.30
DL96	0.60	EF83	1.25
DY86/87	0.40	EF85	0.35
DY802	0.40	EF86	0.35
E88CC/01	1.20	EF89	0.30
E180CC	0.70	EF91	0.45
E182CC	1.25	EF92	0.50
EA50	0.40	EF95	0.40
EABC80	0.40	EF183	0.35
EAF42	0.75	EF184	0.35
EB91	0.25	EFL200	0.75
EBC33	1.00	EL33	2.50
EBC41	0.75	EL34	0.70
EBF80	0.40	EL36	0.60
EBF83	0.50	EL41	0.80
EBF89	0.35	EL81	0.60
EC52	0.35	EL82	0.55
ECC81	0.40	EL84	0.30
ECC82	0.33	EL85	0.60
ECC83	0.33	EL86	0.45
ECC84	0.35	EL90	0.45
ECC85	0.40	EL504	0.80
ECC86	0.90	EM31	0.60
ECC88	0.50	EM80	0.55
ECC189	0.70	EM84	0.40
ECF80	0.40	EM84	1.00
ECF82	0.40	EY51	0.45
ECF801	0.75	EY81	0.45
ECH42	0.80	EY86	0.40
ECH81	0.33	EY88	0.50
ECH83	0.45	EZ40	0.70
ECH84	0.45	EZ41	0.75

	£
EZ80	0.30
EZ81	0.30
GY501	0.75
GZ34	0.70
GZ37	1.00
KT66	2.50
KT88	3.00
MH4	0.75
ML6	0.65
OA2	0.45
OB2	0.45
PABC80	0.40
PC97	0.50
PC900	0.50
PCC84	0.40
PCC85	0.40
PCC88	0.60
PCC89	0.50
PCC189	0.60
PCF80	0.40
PCF82	0.40
PCF84	0.60
PCF86	0.60
PCF200	0.75
PCF201	0.75
PCF801	0.55
PCF802	0.50
PCF805	0.90
PCF806	0.75
PCF808	0.90
PCH200	0.80
PCL81	0.55
PCL82	0.40
PCL83	0.65
PCL84	0.45
PCL86	0.50
PCL805	0.60
PFL200	0.70
PFL200	0.70
PL36	0.60
PL81	0.50
PL82	0.45
PL83	0.45
PL84	0.45
PL504	0.80
PL508	1.00

	£		£
PL509	1.35	U191	0.75
PL802	0.95	U801	0.75
PY33	0.60	UABC80	0.40
PY80	0.40	UAF42	0.65
PY81	0.40	UBC41	0.60
PY82	0.40	UBF80	0.40
PY83	0.40	UBF89	0.40
PY88	0.45	UBL1	1.00
PY500	1.00	UBL21	0.70
PY800	0.45	UCC85	0.45
PY801	0.50	UCF80	0.75
QQVO3-10	1.40	UCH42	0.75
QQVO6-40A	8.00	UCH81	0.45
QVO3-12	1.10	UCL82	0.45
R19	0.60	UCL83	0.65
SC1/400	3.00	UF41	0.70
SC1/600	5.00	UF80	0.35
SP61	0.75	UF85	0.45
TT21	5.00	UF89	0.50
U25	0.85	UL41	0.70
U26	0.75	UL84	0.40
U27	0.65	UY41	0.45
		UY85	0.40
		VR105/30	0.45

	£		£		£		£		£
VR150/30	0.45	3D6	0.40	6AK5	0.40	6C6	0.50	6L6G	0.40
X66	0.65	3S4	0.40	6AK8	0.40	6CB6	0.50	6L7G	0.40
Z800U	2.70	3V4	0.85	6AL5	0.25	6CH6	1.45	6SA7	0.50
Z801U	2.70	5B/254M	4.00	6AL5 W	0.55	6CL6	0.75	6SA7GT	0.40
Z900T	1.20	5B255M	3.50	6AM6	0.45	6D6	0.55	6SC7GT	0.40
1A3	0.55	5R4GY	0.90	6AN8	0.45	6EA8	0.55	6SG7	0.50
1L4	0.25	5U4G	0.45	6AQ5	0.45	6F7	1.10	6SJ7	0.55
				6AQ5W	0.70	6F8G	0.75	6SJ7GT	0.35
				6AS6	0.80	6F23	0.90	6SK7	0.55
				6AT6	0.40	6F32	0.75	6SL7GT	0.50
				6AU6	0.40	6F33	3.50	6SN7GT	0.50
				6AV6	0.45	6H6	0.35	6SQ7	0.55
				6AX4GT	0.75	6J4WA	1.25	6V6G	0.15
				6AX5GT	1.00	6J5	0.65	6V6GT	0.50
				6B7	0.70	6J5GT	0.50	6X4	0.40
				6BA6	0.30	6J6	0.30	6X5G	0.40
3A4	0.60	5V4G	0.55	6BE6	0.35	6J7	0.60	6X5GT	0.50
1R5	0.40	5Y3GT	0.55	6BG6G	0.90	6J7G	0.40	6Y6G	0.90
1S4	0.30	5Z3	0.80	6BJ6	0.65	6K6GT	0.80	6Z4	0.65
1T4	0.30	5Z4	0.80	6BQ7A	0.60	6K7	0.55	6-3OL2	0.90
1X2A	0.60	5Z4TG	0.55	6BR7	1.20	6K7G	0.30	7B7	0.80
1X2B	0.75	6AB7	0.60	6BW6	1.00	6K8GT	0.50	7Y4	0.80
2D21	0.50	6AC7	0.60	6BW7	1.00	6K25	1.00	9D6	0.40
2K25	9.00	6AH6	0.70	6C4	0.40	6L6	1.25	9D2	6.00

VAT 8% EXTRA

	£
12AG	0.55
12AT6	0.45
12AT7	0.40
12AU7	0.33
12AV6	0.50
12AX7	0.33
12BA6	0.45
12BE6	0.50
12BH7	0.50
12C8	0.55
12E1	3.50
12K5	1.10
12K7GT	0.50
12K8GT	0.70
12Q7GT	0.70
12SA7GT	0.70
12SG7	0.55
12SJ7	0.55
12Y4	0.40
14S7	1.00
19AQ5	0.65
19G3	8.00
19G6	6.60
19H5	14.00
20P3	0.60
20P4	1.10
25L6GT	0.70
30C15	1.00
30C17	1.00
30C18	0.90

COLOMOR

THE VALVE WITH A GUARANTEE

	£		£
30F5	1.00	957	0.50
30FL1	1.00	1629	0.70
30FL12	1.10	2051	1.00
30FL14	0.90	5933	3.00
30L15	0.95	6057	0.75
30L17	0.95	6060	0.70
30P12	1.00	6064	0.60
30P19	1.00	6065	1.00
30PL1	0.95	6080	2.30
30PL13	1.10	6146	2.25
		6146B	3.25
		8020	5.00
		9001	5.00
		9002	0.50
		9003	0.70
		9004	0.35
		9006	0.35

VIDICON TUBES
EMI types 9677A & 9677C
£20.00 ea.

	£
30PL14	1.10
35L6GT	0.75
35W4	0.50
35Z4GT	0.70
50C5	0.60
5DCD6G	1.10
75	1.00
75C1	0.75
76	0.75
78	0.70
80	0.75
85A2	0.75
723a/b	8.00
803	6.00
805	14.00
807	0.65
813	6.50
866A	1.20
931A	6.00
954	0.50
955	0.50
956	0.50

C.R. TUBES

	£
DG7-5	12.00
DG13-2	18.00
DG13-34	12.00
MW13-35	35.00
VCR139A	8.00
3BP1	4.50
88D	9.00
88J	8.00
88L	9.00

SPECIAL VALVES

	£
CV239	45.00
M503-2J42	42.00
K301	7.00
KRN2A	6.00
725A	23.00

A lot of these valves are imported and prices vary for each delivery, so we reserve the right to change prices for new stock when unavoidable.

TRANSISTORS

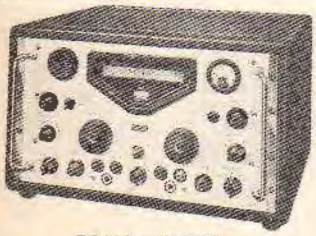
Please write or phone for current price of any of the transistors, diodes shown below.

AC113	AF178	BF167	GET116	OC36	SX754	2N2062
AC126	AF186	BF185	GEX66	OC42	ZR11	2N2147
AC127	AFZ12	BFY51	NKT222	OC44	ZR21	2N2411
AC128	ASY26	BFY52	OA5	OC45	1N23A	2N2989
AC176	ASY27	BFY90	OA47	OC70	1N25	2N3053
ACY18	ASY28	BSY27	OA70	OC73	1N32A	2N3054
ACY19	BC108	BSY38	OA71	OC78	1N38A	2N3055
ACY20	BC118	BSY95A	OA73	OC78D	1N43	2N3390
ACY28	BC119	BYZ16	OA79	OC81	1N70	2N3391
ACY39	BC136	CRS1/10	OA91	OC82	1N277	2N3730
ACY40	BC137	CRS1/20	OA200	OC82D	1N415C	2N3731
AD149	BC148A	CRS1/30	OA202	OC82DM	1N4148	2N3819
AD161	BC172	CRS1/40	OAZ200	OC83	2N456A	2N4038
AD162	BC172A	CRS3/10	OC22	OC139	2N708	2N4058
ADZ11	BC212A	CRS3/20	OC22	OC140	2N918	2N4061
ADZ12	BCY31	CRS3/30	OC26	OC170	2N1304	2N4785
AF114	BCY33	CRS3/40	OC28	OC172	2N1305	2N5295
AF115	BCY72	CRS25/025	OC29	OC200	2N1307	3N128
AF116	BF115	GET115	OC39	OC206	2N1309	3N154
AF117						3N159
AF118						2S303
AF124						404
AF125						2082
AF126						40250
AF127						40251
AF139						40668

VALVES AND TRANSISTORS

Telephone enquiries for valves, transistors, etc., retail 749 3934; trade and export 743 0899.

OTHERS IN STOCK inc. Integrated circuits, CRT & special valves. Min. Mail Order £1. U.K. Postage £1-£2, 17p, £2-3, 22p, over £3 free. C.O.D. 25p extra.



RACAL RECEIVERS
Models RA17, RA17 Mk. II, RA 17L, RA17W, RA117E, in condition from working "as seen" to brand new in cabinets. Prices on application.
DIVERSITY SWITCH TYPE MA168B, solid state, **£45.00.**

TEKTRONIX
OSCILLOSCOPES

571A-600MHz, separate P.S.U. £150 complete.
561A-10MHz, solid state, complete with 3A1 dual trace vert. and 3B3 delay time base plug-ins P.O.A.
541A-33MHz. Choice of plug-ins. P.O.A.
LA265A(545A)-33MHz, separate time bases with delay. P.O.A.
545-15MHz. Separate time bases with delay. Price on application.
PLUG-IN UNITS
CA—24 MHz dual trace 50MV-20V.
G—20 MHz differential 50MV-20V.
L—30 MHz fast rise time 5MV-20V.
D—High gain differential 1MV-50V.
N 600MHz sampling 10MV-cm.
53/54C. Dual trace 33MHz, 60MHz, 0,05-20v.

TEKTRONIX
585 OSCILLOSCOPE

DC to 100MHz. Separate time bases with delay and 5X magnifier. Time base A: 0·05 microsecs to 2 sec/cm in 24 stages also continuously variable between steps. Time base B: 2 microsecs to 10 sec in 18 stages. Delay 1 microsec to 10 sec. Complete with type 81 adaptor enabling use of all letter series plug ins. Type 80 plug-in (less probe) also available.

SOLARTRON

CD 1400 OSCILLOSCOPE with 15MHz vert plug-ins and choice of standard or delay time base P.O.A.
AS 870.3 CURRENT LIMITING POWER SUPPLY 0–30v in steps of 10, 1, 0.1V at up to 3A **£50.**

★ **Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.** ★

TF144H SIGNAL GEN. Freq. range 10 KHz-72 MHz, R.F. output 2µV to 2V at 50 ohms 400 and 1000 Hz internal mod. Limited qty. only available. Full spec. and price on request.

TF 1102 AMPLITUDE MODULATOR Amplitude modulates at up to 80% the C.W. or F.M. output of any signal generator with a frequency range of 100kHz to 500MHz. Input waveforms to the modulator may be: sine, square, pulse or picture at any level up to H1 impedance, Mod level monitored on panel meter. **£40·00**

TF 1258A VHF SPECTRUM ANALYSER for analysis and measurement of Radar Equipment. Frequency range 190 to 230MHz with crystal check points. Sweep width 0·5 to 5MHz, output pulse delay (a) 85-175 µSec, (b) 0·7-1·4 mSec with ×1 and ×2 multiplier and ÷2, ×1, ×2 multiplier. Output 2µV to 20mV with ×10 multiplier. **£200.**

500/250W MEDIUM WAVE BROADCAST TRANSMITTERS. Price and details on application.

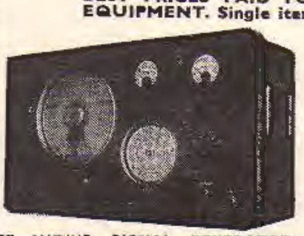
HEWLETT–PACKARD

175A OSCILLOSCOPE with 1750A dual trace vert plug-in and 1781B delay time base plug-in. 50MHz minimum bandwidth at 50mV/CM. T/B modes: main, main single, mixed, main delayed, delaying. Full Spec & P.O.A.
185A SAMPLING OSCILLOSCOPE. 800MHz, complete with 188A 1mV/CM dual trace plug-in, 1GHz probe and manual. Full spec & P.O.A.
524C ELECTRONIC COUNTER/TIMER direct reading to 10MHz, extended to 500MHz depending on converter plug-in, also period and time measurement. 8 digit in-line display on Nixie tubes. **£165** with one plug-in (as below) 524B model, spec as for 524C but display on 6 neon lamp decades and 2 meters **£115** with one of the following plug-ins: 526A Video amp, 525A: 10-100MHz, 525B: 100-220 MHz, (525C: 100–500MHz **£45** extra).
616B SHF SIGNAL GENERATOR Freq 1.75GHz–4.2GHz. Mod: F.M., C.W., Pulse, Ext A.M., output 0.1µV–200mV. Full spec & P.O.A.
200AB AUDIO OSCILLATOR 19kHz, 600ohm balanced or unbalanced, small size, **£25.**
300A HARMONIC WAVE ANALYSER Freq. 0–16kHz. Full spec & P.O.A.

TELEQUIPMENT 543C & D43H OSCILLOSCOPES £80.
KAHN SSB ADAPTOR MODEL RSSB=62=1B. Designed for receivers with 455–500kHz I.F. (eg Collins 51J: AR88D etc) at 100mV (max) input. Features: Electronic A.F.C., carrier frequency diversity to combat fading; 20 sec R.C. memory to maintain tuning during severe fading; individual carrier meters; nuvistors; low distortion product demodulator. Full spec & P.O.A.

TEST EQUIPMENT
for direct line for all enquiries regarding test equipment only, phone 01-748 5496.

BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT. Single items or quantities. Private or Industrial.



TF 801D/1/S SIGNAL GENERATOR. Range 10-485 MHz in five ranges. R.F. output 0·1 µV-IV source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator. 50Ω output impedance. Internal modulation at 1 kHz at up to 90% depth, also external sine and pulse modulation. Built-in 5MHz crystal calibrator. Separate R.F. and mod. meters. P.O.A.

TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. freq. 10Hz to 100kHz, pulse width 0·1 to 100µ sec., delay −1·5 to +3000µ sec., rise time 30N sec. **SPEC. TM 6600/S.** As for TF1400S except pulse width 0·5 to 25µ sec., delay 0 to +300µ sec. **£230.**

TF 526B OSCILLATOR AND DETECTOR UNIT £50·00.

TF 1226B, TF1225A, TF 577A. WHITE NOISE TEST SET £185·00. Full spec. on request.

ROHDE & SCHWARZ

Z-g DIAGRAPH TYPE ZDU. 30–420 MHz, 50Ω. Directly measures multi-terminal networks, phase shift, phase angle etc. with complementary POWER SIGNAL GENERATOR TYPE SMLM High Freq. resolution, internal/external mod., up to 3V out. P.O.A.
POLYSKOP SWOB 1. 0.5–400MHz 75Ω. P.O.A.
VHF WATTMETER & MATCHING INDICATOR 30/80W, 230MHz, 75Ω. P.O.A.
VHF VOLTMETER TYPE UDND P.O.A.
MICROWAVE POWER METER TYPE NRD. 0–3200MHz at 50Ω, 0–200mW in 4 ranges, built-in calibration check with measuring head **£125.**
FREQUENCY SYNTHESIZER TYPE XUA. 30Hz–30MHz with **FREQUENCY INDICATOR TYPE FKM,** 15–30MHz; 30–100MHz. P.O.A.

TECHNICAL MATERIAL CORP:

EXCITER/TRANSMITTING MODE SELECTOR Freq. 2–32MHz. M.O. and 10 crystal positions. Vernier tuning. U.S.B./L.S.B. var carrier insertion etc. **£200.**
F.S.K. EXCITER. Freq. 1–6.5MHz. 0–100Hz continuous frequency shift. Up to ± 600Hz switched frequency correction. Modes F.A.X.: F.S.: M.S.C.: C.W. **£50.**

3 PHASE AUTO TRANSFORMER, wye input 400v, wye output 241.5/230/218.5v 50c 18kVA. Made by Westinghouse of USA. Brand new in original cases **£60.00** including UK transport.

RACAL UNIVERSAL COUNTER/TIMER SA550 (CT488)

8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. on request. **£145.**

PLEASE NOTE

Unless offered as "as seen"

ALL EQUIPMENT

ordered from us is completely overhauled mechanically and electrically in our own laboratories

FOR EXPORT ONLY
TRANSMITTERS:
BC 610 Hallicrafters.
RCA ET 4336 also modified version of increased output to 700w.
COLLINS TYPE 231D 4/5kw., 10 channel, autotone and manual tuning. All above complete installation and spare parts.
TRANSCEIVERS
19, 19HP, 38, 62.
C-13 TRANSMITTERS
RACAL COMMUNICATIONS EQUIPMENT
We are able to offer a comprehensive selection from the range of this modern high class equipment including, receivers, L.F. Converters, SSB adaptors, panoramic adaptors, diversity switches, transmitter driver units, linear amplifiers can be built to customers' requirements. Please send us your enquiries.

AR88 SPARES. We hold the largest stock in U.K. Write for list.
R.F. METER 0-8 amp. 2½" (U.S.A.) **£1·00** P. & P. 15p.
TELEPHONE TYPE "J" (Tropicalised) 10 line **MAGNETO TELEPHONE SWITCHBOARD**
50 line AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD
Price of each of the above on application.

PLEASE ADD 8% VAT

COLOMOR (ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
Tel. 01 - 743 0899

BI-PRE-PAK

SUPPLIERS OF SEMI-CONDUCTORS TO THE WORLD

12 Watt stereo amp

Only **£10** 45p p & p SPECIAL OFFER LIMITED QUANTITY

6 watt music power each channel

This excellent little amplifier is of the latest integrated circuit design, and will work into 4, 8 or 16 ohm speakers. The reproduction is excellent for an amplifier of this size, only 8" × 3½" × 2". The case is made of chromed metal.

Tested and Guaranteed Paks

B79	4	1N4007 Sil. Rec. diodes. 1,000 PIV lamp plastic	50p
B81	10	Reed Switches 1" long ⅛" dia. High speed P.O. type	50p
H35	100	Mixed Diodes. Germ. Gold bonded etc. Marked and Unmarked	50p
H38	30	Short lead Transistors. NPN Silicon Planar types	50p
H41	2	Power Transistors Comp. Pair BD 131/132	50p
H63	4	2N3055 Type NPN Sil. power transistors. Below spec. devices	50p
H65	4	40361 Type NPN Sil. transistors TO-5 can comp. to H66	50p
H66	4	40362 Type PNP Sil. transistors TO-5 can comp. to H65	50p
H69	8	Integrated circuits DTL data supplied. Mixed Types. Flip Flops, Gates, Hex Inverters, etc.	50p

Unmarked Untested Paks

B1	50	Germanium Transistors PNP, AF and RF.	50p
B66	150	Germanium Diodes Min. glass type	50p
B86	100	Sil. Diodes sub. min. IN914 and IN916 types	50p
B83	200	Transistors, manufacturers, rejects, AF, RF, sil and germ.	50p
H26	40	NPN Silicon Trans. 2N3707-11 range, low noise amp.	50p
H34	15	Power Transistors, PNP, Germ. NPN Silicon TO-3 Can. P & P 5p extra.	50p
H67	10	3819 N Channel FET's plastic case type	50p
H68	10	Experimenters Pak of Integrated Circuits data supplied DTL & TTL some marked	50p

Make a rev counter for your car

The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a linear and accurate rev. counter for any car with nomal coil ignition system.

£1·00 each

Telephone dials

Standard Post Office type. Guaranteed in working order only **25p** + P&P 18p each

Electronic Transistor Ignition £6.00

Complete Kit. P&P 11p

Now in kit form, we offer this "up-to-the-minute" electronic ignition system. Simple to make, full instructions supplied, with these outstanding features: transistor and conventional switchability, burglar-proof lock-up and automatic alarm, negative and positive compatibility.

New X-Hatch

Our new, vastly improved Mark Two Cross-Hatch Generator is now available. Essential for alignment of colour guns on all TV receivers. Featuring plug-in ICs and a more sensitive sync. pick-up circuit. The case is virtually unbreakable—ideal for the engineer's toolbox—and only measures 3" × 5¼" × 3".

Ready built unit only **£9·95** Complete kit **£7·95**

(includes P & P, but no batteries)

LM380 AUDIO IC

We have just received a large consignment of LM380 ICs. These are specially selected to a higher grade and are marked with the number SL60745.
This **fantastic** little 3watt audio IC only requires two capacitors and two potentiometers to make an amplifier with volume and tone control. The quality is good and has to be heard to be believed.

Our special price **£1·00** ea complete with data and projects book

Over 1,000,000 Transistors in stock

We hold a very large range of fully marked, tested and guaranteed Transistors, Diodes and Rectifiers at very competitive prices. Please send for Free Catalogue.

Our very popular 4p Transistors

FULLY TESTED & GUARANTEED
TYPE "A" PNP Silicon alloy, TO-5 can.
TYPE "B" PNP Silicon, plastic encapsulation.
TYPE "E" PNP Germanium AF or RF.
TYPE "F" NPN Silicon plastic encapsulation.
TYPE "G" NPN Silicon, similar ZTX300 range.

8 RELAYS FOR £1·00 Various Types. Post & Packing 27p

UHF TV Tuner Units

for 625 line channels 21 to 65

Brand new by a famous manufacturer

Data supplied **£2·50**

Plastic Power Transistors

40 WATT SILICON

Type No.	Gain	VCE	Polarity	Price
40N1	15	15	NPN	20p
40N2	40	40	NPN	30p
40P1	15	15	PNP	20p
40P2	40	40	PNP	30p

90 WATT SILICON

Type No.	Gain	VCE	Polarity	Price
90N1	15	15	NPN	25p
90N2	40	40	NPN	35p
90P1	15	15	PNP	25p
90P2	40	40	PNP	35p

L.E.D's. Complete with mounting grommet Red **25p** Green **40p**

INTEGRATED CIRCUITS
We stock a large range of I.Cs at very competitive prices. These are all listed in our FREE Catalogue, see coupon below.

METRICATION CHARTS now available
This fantastically detailed conversion calculator carries thousands of classified references between metric and British (and U.S.A.) measurements of length, area, volume, liquid measure, weights etc.
Pocket Size **12p**. Wall Chart **18p**.

LOW COST DUAL IN LINE I.C. SOCKETS
14 pin type at **15p** each
16 pin type at **17p** each
Now new low profile type.

BOOKS
We have a large selection of Reference and Technical Books in stock.

BUMPER BUNDLES
These parcels contain all types of surplus electronic components, printed panels, switches, potentiometers, transistors and diodes, etc.

2 LBS in weight for £1·00
Post and Packing 27p.

Our famous P1 Pak is still leading in value

Full of Short Lead Semiconductors & Electronic Components, approx. 170. We guarantee at least 30 really high quality factory marked Transistors PNP & NPN and a host of Diodes & Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.

Please ask for Pak P.1. only 50p

PLEASE ADD VAT AT CURRENT RATE.

Please send me the FREE Bi-Pre-Pak Catalogue.
I enclose a large SAE with 5p stamp.

NAME ....

ADDRESS ....

MINIMUM ORDER 50p. CASH WITH ORDER PLEASE. Add 15p post and packing per order. OVERSEAS ADD EXTRA FOR POSTAGE.

Buy these goods with Access.

BI-PRE-PAK LTD

Co Reg No 820919

Dept. B. 222-224 WEST ROAD, WESTCLIFF-ON-SEA, ESSEX.
TELEPHONE: SOUTHEND (0702) 46344.

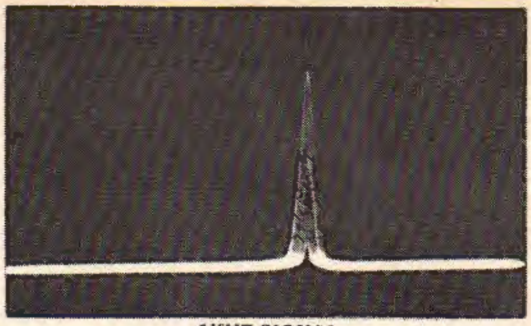
BUILD THIS EXCITING PROJECT

AN AUDIO ANALYZER

IN LESS THAN 2 HOURS

ONLY **£27** p.p. 75p.

YOU CAN BE EXAMINING GENERATORS, FILTERS, ETC., ON YOUR GENERAL PURPOSE OSCILLOSCOPE.
SENSITIVITY 100 MV. FREQUENCY RANGE 100 HZ to 50 KHZ. REQUIRES 24V DC 150MA POWER SUPPLY.
COMPRISES OF: FHACHI VCO FX11; RAMP FX21; FILTER FX31; A FIBRE GLASS PC BOARD ALREADY DRILLED FOR MOUNTING ALL NECESSARY COMPONENTS.



1KHZ SIGNAL

FREE On all orders received before December 31st 1974 all additional components you need (excluding P.U.) to complete the PROJECT. This device is not cased or calibrated.

FHACHI VCO MODULE FX11

Size 2 × 1⅛ × ⅝"H. Input 12V to 24V DC (not centre tapped) 18V input giving 10V constant amplitude output. Requires only a 1 meg ohm potentiometer to tune entire range—or can be swept with a saw tooth input. Enormous possibilities: music; synthesizers; filters; communications; frequency modulation, etc. Detailed application sheet with all purchases. Price **£5.75** P. & P. 15p.

FHACHI RAMP MODULE FX21

24 Volt DC input for 18 volt saw tooth output. Requires only external capacitor and 100K ohm potentiometer to control frequency range up to 100KHZ (eg 50 mfd electrolytic gives sweep of approx 1 cm per second). In or out sync capability. Price **£5.75**. P. & P. 15p.

FREE WITH EVERY PAIR PURCHASED OPERATIONAL AMP TYPE 709

COMPLIMENTARY POWER TRANSISTORS

EACH RATED AT 160 WATTS.

£2.50 pr. pair. P & P 10p.

2N5879 AND 2N5881

MARCONI TF 1041B Vacuum Tube Voltmeter **£35** ea.
MARCONI TF428C Valve voltmeter 100mV to 150V AC; 20Hz to 150 MHZ; DC 40mV to 300V **£8** ea.
MARCONI TF899 Valve Millivolt meter. 20mV to 2V AC; 50Hz to 100mHz detected output for modulation monitoring. **£7** ea.
MARCONI TF912A Power Meter 5 to 25 Watts. Freq. range 80 to 160mHz. **£20.**
MARCONI TF801A/1 Signal Generator 10 to 310mHz **£55** ea.
MARCONI TF91D/3R Carrier Deviation Meter **£100.**
MARCONI TF791B Carrier Deviation Meter **£30.**
MARCONI TF34/2 FM Deviation Meter **£40.**
MARCONI TF142E Distortion Meter **£20.**
MARCONI TF886A Q Meter **£15.**
MARCONI TF142F Distortion Factor Meter **£35.**
MARCONI TF791C Carrier Deviation Meter **£65.**
MARCONI TF455E Wave Analyzer **£60.**
MARCONI TF868B Universal Bridge **£95.**
MARCONI TF995A/5 AM/FM Generator **£295.**
MARCONI TF1020A RF Power Meter 150 and 300 Watts. As new. **£90** ea.
MARCONI TF1020A RF Power Meter 50 and 100 Watts. As new. **£65** ea.
MARCONI TF1094A/S. HF Spectrum Analyzer. Late model **£375.**
MARCONI TF1371 Wideband Millivolt meter **£25.**
MARCONI TF1434/2 Counter Range extension unit 10–100mHz **£30.**
MARCONI TF1102 Amplitude Modulator Carrier inputs up to 500mHz **£20.**
MARCONI TF1073 Variable attenuator 0 to 100dB in 1dB steps. 75 ohm DC to 150mHz **£10** ea.
AVO TRANSISTOR ANALYZER CT446. £35.
UNITED SYSTEM CORPORATION Digital Voltmeter. Digitec. 100mV full scale. Small compact transistorized unit. 240V mains. 4 digit. **£15** ea.
KELVIN & HUGHES Single Channel Recorders with spare paper. **£20** ea.
WAYNE KERR VHF Admittance Bridge B801 **£15;** B901 **£20.**
WAYNE KERR Bridge Detector R161. **£30.**

Hewlett Packard Microwave Power Meter 430C complete with Bolometer **£45.**
Hewlett Packard Power Meter 431B **£85.**
Hewlett Packard Valve voltmeter 19" rack AC or DC 1mV to 300V dB scale. **£20.**
AIRMEC OHM METER 861 £25.
EMI WM8 Oscilloscope Plug-in units. New **£25.**
WM16 Plug-in units type 7/1 Single Trace 40 mHz **£20;** 7/2 Dual Trace 24mHz **£35;** 7/6 High Gain Differential **£30.**
DAWE 10mc/s Digital Frequency Meter. As new. **£25.**
DAWE Digital Voltmeter type 652A. 4 digit up to 1000V DC **£20.**
DAWE Digital Printer type 3094A as new **£40.** ea.
E.H. Pulse Generator Model 123 20mHz 20 nansecs width. **£60.**
GRESHAM LION Waveform Generator 625 line staircase **£45.**
GRESHAM LION Composite Waveform Generator Multi standard Sync/Square/Pulse/Bar. **£45.**
WESTON THERMOPROBE −60 to +100 degree Centigrade. **£100.**
WANDEL & GOLTERMANN Distortion Meter VZM1 For differential gain and differential phase distortion of the colour subcarrier **£120.**
WANDEL & GOLTERMANN TFEK41. Level meter 4–600kHz **£70.**
MUIRHEAD D880A 2 Phase LF Oscillator **£35.**
MUIRHEAD D890A Decade Oscillator **£45.**
PHILIPS GM6020 AC/DC Valve Voltmeter 0.1mV to 1000V. **£25.**
PHILIPS GM6014 AC Valve voltmeter 1000Hz to 30mHz **£30.**
PHILIPS GM6012 Valve voltmeter 1mV to 300V; 2Hz to 1mHz. **£20.**
SINGLE SIDE BAND CONVERTOR CV157/URR. 19" rack mount for use with Collins 390 Receiver. Complete with box of spares **£120** ea.
HEADWAY RESEARCH Photoresist Spinner and Speed Control **£100.**
DUAL TRACE PLUG-IN units for CD1212 Scopes DC–24mHz **£35 ea.**

RACAL RA17 assemblies with film scale **£60** ea.
INFRA RED INDUSTRIES USA Tunable Microvolt meter type 601 **£75.**
TELONIC SWEEP GENERATOR 100–250mHz 4 Watts output **£130.**
PROSSER SCIENTIFIC INSTRUMENTS Model A100 Waveform Generator Multi waveforms **£185.**
POLARAD Spectrum Analyzer TSA 10mHz to 44gHz **£325.**
FENLOW LOW FREQUENCY ANALYZER type SA2 with recorder **£175.**
ROHDE & SCHWARZ UHF Slotted Line Type LMD 300–3000mHz **£45.**
ROHDE & SCHWARZ Field Strength Meter BN15031. 90–470mHz **£60.**
ROHDE & SCHWARZ VHF Test Receiver 280–950mHz USVD-BN1523 **£120.**
ROHDE & SCHWARZ Admittance Meter VLUK-BN3511. As new **£175.**
EDDYSTONE RECEIVER 770A £140.
BRANDENBURG Power Unit SO530/8. 10KV **£40.**
BRANDENBURG Power Unit SO530/10 20KV **£70.**
AIRMEC Modulation Meter type 210 **£75.**
FREQUENCY METERS TS 174 20–250mHz **£30; TS175** 85 –1000mHz **£35.**
SOLARTRON Transistor P.U. type AS758.2 0–30V in o.1V steps 0–10 amps **£30.**
SOLARTRON Precision AC Millivoltmeter VF252. 1.5mV full scale **£30.**
SOLARTRON Resolved Component Indicator VP250. 20c/s–20 kc/s. **£30.**
SOLARTRON Multi purpose stab P.U. type 1904. Standard mains input. Outputs: +250V DC 200MA; +18V DC 2A; +6V DC 8A; −3.5V DC 100MA; −6V DC 8A; −18V DC 4A; 25V AC 150MA. All DC lines will withstand short circuits to earth. With copy of manual **£35** ea.
AMERICAN GENERATOR TYPE TRM3. AM/FM Sweep 15–400mHz. Built in display, markers etc. Full info on request. Brand new. **£250** ea.
TEKTRONIX Pulse Generator type 161 **£10.**
TEKTRONIX Pulse Generator type 163 **£10.**
TEKTRONIX Power Unit type 160A **£10.**
Large range MODULAR P.U. Various voltages etc. S.A.E. for lists.
TEKTRONIX Oscilloscope type 536 with T plug-in **£285.**
TEKTRONIX Oscilloscope type 647 with 10A2 and 11B2 plug-ins **£525.**
TEKTRONIX Oscilloscope type 545A Main Frame only Fine condition **£165.**

TELEPHONES

STANDARD 300
Series. BLACK
only **£1.00** ea.
P & P 50p.

MODERN STYLE 706
BLACK OR TWO-TONE GREY **£3.75** ea. P & P 35p.
STYLE 7006q
TWO-TONE GREEN **£3.75** ea. P & P 35p

HANDSETS—complete with 2 insets and lead **75p** ea. P & P 37p.

DIALS ONLY.
75p ea. P & P 25p.

SCOOP FIRST TIME

MODERN STANDARD TELEPHONES IN GREY OR GREEN WITH A PLACE TO PUT YOUR FINGERS LIKE THE 746.

A CHANCE NOT TO BE MISSED

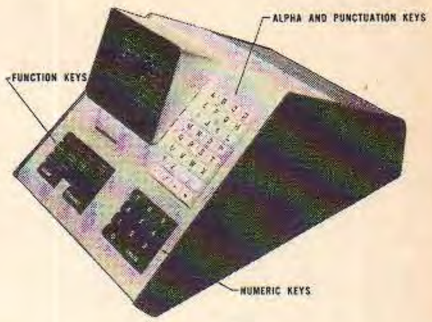
£3.00 ea. P & P 35p.

HIGH VALUE— PRINTED BOARD PACK

Hundreds of components, transistors, etc.—no two boards the same—no short-leaded transistor computer boards. **£1.75** post paid.

EX-BEA VISUAL DISPLAY UNITS

7″ ELECTROSTATIC TUBE
11 × 8 cm VIEWING AREA



MANUFACTURED IN THE USA BY BUNKER-RAMO
STANDARD 240V 50HZ MAINS INPUT

These units are inspected to see that no parts are missing. No circuit diagrams or information is available. We are in the process of obtaining circuits, information, etc, and a copy will be forwarded to all purchasers at the earliest possible time.
Therefore these units are sold as received at **£30** each.

GRATICULES. 12 cm. by 14 cm. in High Quality plastic. **15p** each. P. & P. 5p.

PANEL mounting lamp holders. Red or green. **9p** ea. Miniature. **PANEL** mounting lamp with holders—10V 15MA **5p** ea.

BECKMAN MULTITURN DIAL
Model RB. Brand new.
£1·90. P. & P. 10p.

FIBRE GLASS PRINTED CIRCUIT BOARD. Brand New. Single or Double sided. Any size **1½p** per sq. in. Postage **10p** per order.

LIGHT EMITTING DIODES (Red) from Hewlett-Packard. Brand New. **38p** ea. Information **5p.** Holders **1p.**

METERS. Ernest Turner Model 402. 100 micro amps. BRAND NEW. Lousy scale—hence **£2·25** ea. P. & P. 25p.

METERS by SIFAM type M 42, 25–0–25 micro amp. Scaled 25–0–25 green; 250–0–250 red; linear. As new. **£2·95** ea. P. & P. 37p.

VISCONOL EHT CAPACITORS
0·05mfd 2·5kv **50p** ea. 0·01mfd 5kv **40p** ea.
0·05mfd 8kv **50p** ea. 0·01mfd 10kv **50p** ea.

BLOCK PAPER CAPACITORS AVAILABLE. S.A.E. with requirements.

PHOTOCELL equivalent OCP 71. **13p** ea.

MULLARD OCP70 10p ea.

POTENTIOMETERS
COLVERN 3 watt. Brand new. 25K at **13p** ea.

MORGANITE Special Brand new. 2·5; 10; 100; 250; 500K; 1in. sealed. **17p** ea.

BERCO 2½ Watt. Brand new. 5; 10; 50; 250; ohms: 1; 2.5; 10; 25 at **15p** ea.

STANDARD 2 meg. log pots. Current type **15p** ea.

INSTRUMENT 3in. Colvern 5 ohm **35p** ea.; 50K and 100K **50p** ea.

BOURNS TRIMPOT POTENTIOMETERS. 20; 50; 100; 200; 500 ohms; 1; 2; 2·5; 5; 10; 25K at **35p** ea. ALL BRAND NEW.

RELIANCE P.C.B. mounting. 270; 470; 500 ohms; 10K at **35p** ea. ALL BRAND NEW.

VENNER Hour Meters—5 digit, wall mount—sealed case. Standard mains. **£3·75** ea. P. & P. 45p.

TRANSFORMERS. All standard inputs. Gard/Parm/Part. 450–400–0–400–450. 180 MA. 2 × 6.3v. **£3** ea.

FANTASTIC VALUE
Miniature Transformer. Standard 240V input. 3Volt 1 amp output. Brand New. **65p** ea. P. & P. 15p. Discount for quantity.

CAPACITOR PACK 50 Brand new components only **50p**. P. & P. 17p.

P.C. MOUNT SKELETON PRE-SETS. Screwdriver adjust 10, 5 and 2.5M @ **2p** ea. 1M, 500, 250 and 25K @ **4p** ea. Finger adjust 10, 5 and 2.5M @ **3p** ea. 1M, 500, 250 and 25K @ **5p** ea. Min P. & P. 10p.

1000pf FEED THRU CAPACITORS. Only sold in packs of 10—**30p.** P. & P. 10p.

RECTANGULAR INSTRUMENT FANS. American Ex-equ. Size 4¾ × 4¾ × 1½″. 115 Volt. Very quiet **£3** ea. P. & P. 37p.

DELIVERED TO YOUR DOOR 1 cwt. of Electronic Scrap chassis, boards, etc. No Rubbish. FOR ONLY **£4.** N. Ireland £2 extra.

P.C.B. PACK S & D. Quantity 2 sq. ft.—no tiny pieces. **50p** plus P. & P. 20p.

FIBRE GLASS as above **£1** plus P. & P. 20p.

TRIMMER PACK, 2 Twin 50/200 pf ceramic; 2 Twin 10/60 pf ceramic; 2 min strips with 4 preset 5/20 pf on each; 3 air spaced preset 30/100 pf on ceramic base. ALL BRAND NEW **25p** the LOT. P. & P. 10p.

ALMA precision resistors 200K; 400K; 497K; 998K; 0·1% **27p** ea.; 3·25K, 5·6K, 13K–0·1% **20p** ea.

RELAYS
Varley VP4 plastic covers 4 pole c/o 15K—**33p**; 5·8K—**40p** ea.

BRAND-NEW 12in.
LONG PERSISTENCE TUBES
New stocks—new price. Only **£6·50**
(whilst stock lasts)
Ideal for SSTV; educational purposes. Type 12DP7A, connections, voltages etc. Price includes carriage & VAT.

Large quantity LT, HT, EHT transformers and chokes.

Vast quantity of good quality components
—NO PASSING TRADE—so we offer
3 LB. of ELECTRONIC GOODIES
for £1·50 post paid.

CRYSTALS. Colour 4.43MHz. Brand New. **£1·25** ea. P. & P. 10p.

Beehive Trimmer 3/30 pf.
Brand new. Qty 1–9 **13p** ea, P. & P. 15p; 10–99 **10p** ea, P. & P. 25p; 100–999 **7p** ea, P. & P. free.

HF Crystal Drive Unit. 19in. rack mount. Standard 240V input with superb crystal oven by Labgear (no crystals) **£5** ea. Carr. £1·50.

ROTARY SWITCH PACK—6 Brand New switches (1 ceramic: 1–4 pole 2 way etc.). **50p.** P. & P. 20p.

CONSTANT VOLTAGE TRANSFORMERS
1 Kilowatt etc.
S.A.E. with requirements.

LOW FREQUENCY WOBBULATOR

Primarily intended for the alignment of AM Radios; Communication Receivers; Filters, etc., in the range of 250 KHZ to 5 MHZ, but can be effectively used to 30 MHZ. Can be used with any general purpose oscilloscope. Requires 12V AC input. Three controls—RF level; sweep width and frequency. Price **£8·50.** P. & P. 35p.
A second model is available as above but which allows the range to be extended down in frequency to 20 KHZ by the addition of external capacitors. Price **£11·50.** P. & P. 35p.
Both models are supplied connected for automatic 50 HZ sweeping. An external sweep voltage can be used instead. These units are encapsulated for additional reliability, with the exception of the controls (not cased, not calibrated).

DON'T FORGET YOUR MANUALS S.A.E. WITH REQUIREMENTS

MAKE YOUR SINGLE BEAM SCOPE INTO A DOUBLE WITH OUR NEW LOW PRICED SOLID STATE SWITCH. 2 HZ to 8 MHZ. Hook up a 9 volt battery and connect to your scope and have two traces for ONLY **£6·25.** P. & P. 25p.
STILL AVAILABLE our 20 MHZ version at **£9·75.** P. & P. 25p.

20HZ to 200KHZ SINE AND SQUARE WAVE GENERATOR

In four ranges. Wien bridge oscillator thermistor stabilised. Separate independent sine and square wave amplitude controls. 3V max sine, 6V max square outputs. Completely assembled P.C. Board, ready to use. 9 to 12V supply required. **£8·85** each. P. & P. 25p. Sine Wave only **£6·85** each. P. & P. 25p.

LARGE QUANTITY OF OSCILLOSCOPE & DISPLAY TUBES FROM 1″ to 24″
S.A.E. FOR COMPREHENSIVE LIST
All of our tubes can be supplied with nu-metal shields or Telcon nu-metal tape.

WIDE RANGE WOBBULATOR

5 MHZ to 150 MHZ (Useful harmonics up to 1·5 GHZ) up to 15 MHZ sweep width. Only 3 controls, preset RF level, sweep width and frequency. Ideal for 10·7 or TV IF alignment, filters, receivers. Can be used with any general purpose scope. Full instructions supplied. Connect 6·3V AC and use within minutes of receiving.
All this for only **£5·75.** P. & P. 25p. (Not cased, not calibrated.)

TRANSISTOR INVERTORS

TYPE A
Input: 12V DC
Output: 1.3kV AC 1.5MA
Price **£3.45**

TYPE B
Input: 12V DC
Output: 1.3kV DC 1.5MA
Price **£4.70**

TYPE C
Input: 12V to 24V DC
Output: 1.5kV to 4kV AC 0.5MA
Price **£8.35**

TYPE D
Input: 12V to 24V DC
Output: 14kV DC 100 micro amps at 24V.
Progressively reducing for lower input voltages
Price **£11**

Postage & Packing 36p

Unless stated – please add £2.00 carriage to all units.

VALUE ADDED TAX not included in prices—please add 8%

Official Orders Welcomed, Gov./Educational Depts., Authorities, etc., otherwise Cash with Order

Open 9 am to 6.30 pm any day (later by arrangement.)

Buy it with Access

CHILTMEAD LTD

BARCLAYCARD

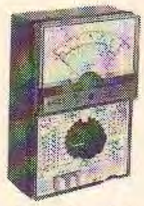
7/9 ARTHUR ROAD, READING, BERKS. (rear Tech. College, Kings Road) Tel.: Reading 582605/65916

TAUT SUSPENSION MULTIMETERS

Made in USSR

For ex-stock delivery*

U4312 £10.25
U4313 £12.50
U4315 £9.00

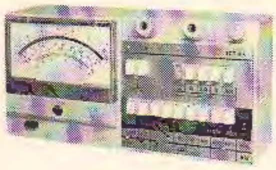


U4324 £9.25

U4341 £10.50

U4317 £16.50

U4323 £7.70



F4313 £22.00

TRADE ENQUIRIES INVITED
PLEASE WRITE FOR FULL DETAILS

SPECIAL OFFER OF L.E.D.s

Twelve Light Emitting Diodes Type HP5082/4850. 0.20 mm dia., bright diffused red light. Operating current 20mA at 1.65V. ONLY £1.75 incl. P.P. and VAT

1-AMP SILICON RECTIFIERS

20 pieces	1N4001	50 p.i.v.	£1.12
"	1N4002	100 p.i.v.	£1.25
"	1N4003	200 p.i.v.	£1.35
"	1N4004	400 p.i.v.	£1.45
"	1N4005	600 p.i.v.	£1.55
"	1N4006	800 p.i.v.	£1.85
"	1N4007	1000 p.i.v.	£2.10

This is a special offer and minimum quantity of 20 pcs must be ordered. These prices are inclusive of P.P. and VAT.

11.5 AMP THYRISTORS

BTX47-1200R P-GATE Reverse blocking Thyristors. Peak reverse voltage 1200V. Trigger voltage 3.5V £2.00* Specials offer of 10 pcs £12.00 Inclusive of P.P. and VAT.

PHOTO-CONDUCTIVE CELLS

ORP12	£0.60*	ORP69	£0.60*
ORP60	£0.60*	ORP90	£1.10*
ORP61	£0.45*	ORP93	£1.10*

Please write for full catalogue and Price List of Valves, Semi-conductors, Test Equipment and Passive Components.

Minimum Account Order & Charge £10.00 + VAT, otherwise cash with order. Prices are exclusive of VAT unless indicated. When remitting cash with order please add £0.50 per Multimeter or £0.15 in £ for other items.

MINIMUM ACCOUNT ORDER CHARGE £10.00 PLUS VAT. OTHERWISE CASH WITH ORDER PLEASE

***Prices are exclusive of VAT**

Z & I AERO SERVICES LTD

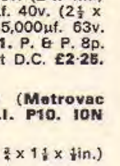
Tel. 727 5641 44A WESTBOURNE GROVE, LONDON W2 5JF Telex 261306

WW—038 FOR FURTHER DETAILS

E.H.T. POWERUNIT. 110/240v. 50Hz giving 5 K.V. at 50 m/a. METERED OUTPUT. **£17·50.**

COPPER LAMINATE P.C. BOARD
11 x 3½ x 1/16 in. **12p** sheet. 5 for **50p.**
10 x 4 x 1/16 in. **12p** sheet. 5 for **50p.**
10½ x 5½ x 1/16 in. **15p** sheet. 4 for **50p.**
10 x 7 x 1/16 in. **18p** sheet. 3 for **50p.**
Offcut pack (smallest 4 x 2 in.) **50p** 300 sq. in.
P. & P. single sheet **4p.** Bargain packs **20p.**

TELEPHONE DIALS (New) £1 ea.



RELAYS (G.P.O. '3000'). All types, Brand new from **37½p** ea. 10 up quotations only.
EXTENSION TELEPHONES (Type 706) Various Colours **£3·50.** P.P. 25p. Excellent condition.
RATCHET RELAYS. (310 ohm) Various Types **85p.** P.P. 5p.
UNISELECTORS (NEW) 25 way 12 Bank (Non Bridging) 68 ohms. **£6.** P.P. 30p.

PRECISION A.C. MILLIVOLTMETER (Solartron) 1·5m.v. to 15v: 60db to 20db. 9 ranges. Excellent condition. **£22·50.** P.P. £1·50.

HIGH CAPACITY ELECTROLYTICS
2,200µf. 100v. (1½ x 4in.) **75p.** 3,150µf 40v. (1½ x 4in.) **60p.** 10,000µf. 25v. (1½ x 4½in.) **60p.** 12,000µf. 40v. (2 x 4in.) **75p.** 16,000µf. 16v. (2 x 4in.) **60p.** 21,000µf. 40v. (2½ x 4in.) **£1.** 2,800µf. 100v. (4 x 2in.) **80p.** 15,000µf. 63v. (4½ x 2½in.) **£1.** 35,000µf. 40v. (3 x 4½in.) **£1.** P. & P. 8p.
H.D. ALARM BELLS. 6 in. Dome 6/8 volt D.C. **£2·25.** P.P. 50p.

HIGH VACUUM DIFFUSION PUMPS (Metrovac 093C). New condition. **£40.** P.P. £2. **A.E.I. P10. ION Pump Control Units. £17·50.**

OVERLOAD CUT-OUTS. Panel mounting (1¾ x 1½ x ⅛in.) 800 M/A/1·8 amp/10 amp. **35p** ea. P.P. 5p.

BULK COMPONENT OFFER. Resistors/Capacitors. All types and values. All new modern components. Over 500 pieces **£2.** (Trial order 100pcs. 50p). We are confident you will re-order.

REGULATED POWER SUPPLY. Input 110/240v. Output 9v. DC. 1½ amp. 12v. D.C. 500 m/a. **£4.** P.P. 30p.

U.K. ORDERS 8% V.A.T. SURCHARGE

TRANSFORMERS

ADVANCE "VOLSTAT" TRANSFORMERS. Input 242v. A.C.

CV50. 38v. at 1 amp: 25v. at 100 m/a. 75v. at 200 m/a. **£2** ea. P.P. 40p.

CV75. 25v. at 2½ amp. **£2·50.** P.P. 50p.

CV100. 50v. at 2 amp: 50v. at 100 m/a. **£3.** P.P. 50p.

CV250. 25v. at 8 amp: 75v. at ½ amp. **£5.** P.P. £1.

CV500. 45v at 3 amp: 35v. at 2 amp: 25v. at 3 amp. **£7.** P.P. £1.

L.T. TRANSFORMER. Prim. 240v. Sec. 13v. at 1·5 amp. **75p.** P.P. 15p.

L.T. TRANSFORMER. Prim. 240v. Sec. 24v. at 1½ amp. **£1·20.** P.P. 20p.

L.T. TRANSFORMER. Prim. 110/240v. Sec. 0/24/40v 1½ amp. (Shrouded). **£1·50.** P.P. 30p.

L.T. TRANSFORMER. Prim. 200/250v. Sec. 20/40/60v. at 2 amp. (Shrouded). **£2·25.** P.P. 40p.

L.T. TRANSFORMER (H.D.) Prim. 200/250v. Sec. 18v. at 27 amp: 40v. at 9·8 amp: 40v. at 3·6 amp: 52v. at 1 amp: 25v. at 3·7 amp. **£15.** P.P. £2.

H.T. TRANSFORMER. Prim. 110/240v. Sec. 400v. 100 m/a. **£2.** P.P. 50p.

E.H.T. TRANSFORMER. 240v. Sec. 1800v. 50 mA. **£2·50.** P.P. 50p.

L.T./H.D. TRANSFORMER. 210/240v. output 17v. at 60 amp. **£12·50.** P.P. £1.

L.T. TRANSFORMER. 110/240v. ('C. Core). Secs. 1/3/9/27v. at 10 amps. **£6·50.** P.P. 75p.

L.T. TRANSFORMER. Prim. 240v. Sec. 16/0/16v. at 2 amp. **£1·60.** P.P. 20p.

L.T. TRANSFORMER. Prim. 110/240v. Sec. 23/0/23v. at 1·8 amp: 50v. at 300 m/a: 3·15/0/3·15v. at 300 m/a. **£1·75.** P.P. 20p.

L.T. TRANSFORMER. Prim. 200/240v. ('C' Core). Secs. 1v./3v./8v./9v. all at 1.5A: 50v. at 1 amp. **£2.** P.P. 25p.

L.T. TRANSFORMER. 110/240v. ('C' Core). Sec. 13.5v. 4A.: 39v. at 2A. **£2·50.** P.P. 25p.

L.T. TRANSFORMER. 110/240v. ('C' Core) 1v./3v./9v./20v./20v. all at 2 amp. **£3.** P.P. 35p. Same Secondaries but at 4 amp. **£4·25.** P.P. 40p.

L.T. TRANSFORMER. 110/240v. ('C' Core). Secs. 1v./3v./9v. all at 10 amp: 35v. at 1 amp: 50v. at 750 m/a **£5·25.** P.P. 50p.

HIGH-SPEED MAGNETIC COUNTERS. 4 digit (non reset) 24v. or 48v. (state which) 4 x 1 x 1 in. **40p.** P.P. 5p.

5 digit (Non-reset) 24v. **75p.** P.P. 5p.

3 digit 12v. (Rotary Reset) 2¼ x 1¾ x 1½ in. **£1** each.

3 digit 12v. (Reset) 3½ x 1 x 1 in. **£2·25.** P.P. 5p.

6 digit (Reset) 240v. A.C. **£3·50.** P.P. 10p.

MULTICORE CABLE (P.V.C.)
6 core (6 colours) 3 screened, 14/0048. **15p.** yd. 100 yds. **£12·50.**
20 core (2 screened) **17½p** yd. 100 yds. **£15.**
24 core (24 colours) **20p** yd. 100 yds. **£17·50.**
30 core (15 colours) **22½p** yd. 100 yds. **£18·50.**
Minimum order 10 yds.

RIBBON CABLE (8 colours)
£1·25 10m. **£10** 100m.
8 cores. 7/·mm. bonded side by side in ribbon form.

SMALL MOTOR (1/50 H.P.) 900 R.P.M. 230/250v. A.C. **£1·50.** P.P. 30p.

RELAYS

SIEMENS/VARLEY PLUG-IN. Complete with transparent dust covers and bases. 2 pole c/o contacts **35p** ea.; 6 make contacts **40p** ea.; 4 pole c/o contacts **50p** ea. 6-12-24-48v. types in stock.

12 VOLT H.D. RELAYS (3 x 2 x 1 in.) with 10 amp. silver contacts 2 pole c/o **40p** ea.; 2 pole 3 way **40p.** P.P. 5p.

24 VOLT H.D. RELAYS (2 x 2 x ½ in.) 10 amp. contacts, 4 pole c/o. **40p** ea. P.P. 5p.

240v. A.C. RELAYS. (Plug-in type), 3 change-over 10 amp. contacts. **75p** (with base). P.P. 5p.

P.A.R. BISTABLE RELAY (Latching) 24v. D.C. 4 c/o contacts **65p.** P.P. 5p.

SILICON BRIDGES. 100 P.I.V. 1 amp ⅝ x ⅝ x ⅜ in.) **30p.** 200 P.I.V. 2 amp. **60p.**

24 VOLT A.C. RELAYS (Plug-in).
3 Pole Change-over **60p.**
2 Pole Change-over **45p.**

WE REGRET THAT ALL ORDERS VALUE UNDER £5 MUST BE ACCOMPANIED BY REMITTANCE.

PATTRICK & KINNIE

191 LONDON ROAD · ROMFORD · ESSEX
ROMFORD 44473 **RM7 9DD**

Wilkinsons

RELAYS P.O. TYPE 3000 AND 600

BUILT TO YOUR SPECIFICATION. HIGHEST QUALITY AT COMPETITIVE PRICES WITH A QUICK DELIVERY SERVICE. QUOTATIONS BY RETURN HOME AND OVERSEAS.

PO type **MINIATURE UNISELECTOR** including JACK 12 outlet, 2 bridging 1 non-bridging wipers. This compact ratchet-driven 3-level Uniselector is of unique design and occupies no more space than a standard 3000-type Relay **£8·50 each.**

PO type 2 UNISELECTORS all 25 outlet 8 level non bridging wipers 300 ohms **£14** ea. 11 level 1 bridging 10 non bridging 65 ohms **£17** ea. 4 pole 50 way all non bridging 75 ohms **£11** ea.

PRECISION PORTABLE VOLTMETER 0 to 160 volts AC/DC 8 inch scale in polished wood case with hinged flap **£10** each. Resistance supplied to extend range to 320 volts (scale reading × 2) £1 extra.

N.S.F. LEDEX DC SOLENOID OPERATED WAFER SWITCHES 24 Pole 11 Way and Off commutating switch, continuous duty voltage 23.9 volts **£15** each.
54 Pole On/Off, 9 Wafers, continuous duty voltage 4.77 volts **£12** each.
According to duty cycle, operating voltages can be up to 3 times those given.

MINIATURE DIGITAL INDICATOR size of digits ⅝ inch illuminated by 28 volt midget flanged lamps, weight 3½ ozs, reading 0 to 9 with decimal points, quick disconnect rear of unit for easy lamp replacement **£4·50** ea.

ALL BRITISH MOVING COIL RECTIFIER AC METERS

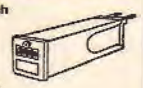
2 inch flush square		**3½ inch flush round**	
20 Volts	**£3·25** ea.	100 Microamps	**£4·75** ea.
50 Volts	**£3·25** ea.	200 Microamps	**£4·50** ea.
100 Volts	**£3·25** ea.	500 Microamps	**£4·25** ea.
200 Volts	**£3·25** ea.	10 Milliamps	**£3·50** ea.
2½ inch flush round		10 Volts	**£3·50** ea.
100 Microamps	**£4·25** ea.	20 Volts	**£3·50** ea.
200 Microamps	**£4·00** ea.	50 Volts	**£3·75** ea.
500 Microamps	**£4·00** ea.	100 Volts	**£3·75** ea.
200 Volts	**£3·25** ea.	200 Volts	**£3·75** ea.

VALVE SCREENING CANS B7G 1¾ inch long 13,000 available sold in one lot only **2p** each.

BRIDGE MEGGERS series 1, 1,000 volts range 0/100 meg—ohms/infinity with resistance box **£85.**

MINIATUREBUZZERS 6–12 volts, with tone adjuster **50p** each as illus. **15p** each for lots of 100.

HIGH SPEED COUNTERS £1·75 each 3½in. × 1in. 10 counts per second with 4 figures. The following D.C. voltages are available 6 v., 12 v., 24 v., 50 v., or 110 v. Auxiliary contacts, normally open, **40p** extra.



SPECIAL OFFERS

BERCO ROTARY STUD SWITCHES 3 Bank 3 Pole 20 Way with control knob **£4** each.

ELCOM WINKLER SWITCHES 3 Bank 12 Pole 2 Way **£4** each.

ROOM THERMOSTAT Adjustable between 45–75 degrees F 10 amp 250 volt bakelite case with control knob **£2** each.

IMMERSION THERMOSTAT Adjustable between 70–190 degrees F 20 amp 0 to 440 volt 11 inch stem complete with one hole fixing sheath Satchwell **£2** each.

PUSH BUTTON UNIT Twin S.P.D.T. Red and Green Buttons in metal frame size 4¾ in. × 2 in. × 2½ in. **£2** each.

SWITCHES FOR MODEL RAILWAYS, ETC. Single Pole On/Off 4 hole fixing with locking device **50 pence** each, Single Pole 3 Way, suitable for use as SP Change Over with Off position **50 pence** each., BANK OF 5 SWITCHES ON/OFF 6 hole fixing, flush mounting bakelite case **80 pence** each.

PACK OF ONE EACH OF 8 SPECIAL OFFERS DESCRIBED ABOVE FOR ONLY **£10.**

All prices shown are carriage paid UK only but subject to VAT at the standard rate.

STOCKISTS OF ALL STUART TURNER PUMPS, CENTRIFUGAL TYPES 10 AND 12 AVAILABLE NOW.

L. WILKINSON (CROYDON) LTD., LONGLEY HOUSE, LONGLEY RD., CROYDON, CR0 3LH. Phone 01-684 0236. Grams: WILCO CROYDON

WW—066 FOR FURTHER DETAILS

NEW PRACTICAL PAPERBACKS FROM FOULSHAM-TAB

BASIC TV COURSE
by George Kravitz **£1.50**

NEW SKILL-BUILDING TRANSISTOR PROJECTS AND EXPERIMENTS
by Louis E. Gardner Jr. **£1.45**

RADIO CONTROL HANDBOOK
by Howard G. McEntee **£1.90**

TRANSISTORS: THEORY AND PRACTICE
by Rufus P. Turner **£1.40**

WORKING WITH SEMICONDUCTORS
by Albert C. W. Saunders **£1.50**

CASSETTE TAPE RECORDERS—HOW THEY WORK—CARE & REPAIR
by Walter Salm **£1.60**

ELECTRONIC MEASUREMENTS SIMPLIFIED
by Clayton Hallmark **£1.70**

SOLID-STATE CIRCUITS GUIDEBOOK
by Brice Ward **£1.75**

10 MINUTE TEST TECHNIQUES FOR PC SERVICING
by Art Margolis **£1.60**

TV BENCH SERVICING TECHNIQUES
by Art Margolis **£1.65**

MINIATURE PROJECTS FOR ELECTRONIC HOBBYISTS
by Ken W. Sessions Jr. **£1.45**

FM STEREO/QUAD RECEIVER SERVICING MANUAL
by Joseph J. Carr **£1.55**

TROUBLESHOOTING SOLID-STATE WAVE GENERATING AND SHAPING CIRCUITS
by Ben Gaddis **£1.55**

THE 2-METRE FM REPEATER CIRCUITS HANDBOOK
by Ken W. Sessions **£1.90**

PINPOINT TRANSISTOR TROUBLES IN 12 MINUTES
by Louis E. Gardner Jr. **£2.50**

FOULSHAM-TAB LTD.
YEOVIL ROAD. SLOUGH. BUCKS.

INSTRUMENTS

Not new but in good condition most believed in working order. Definitely repairable—any not so would be replaced or refunded. Offers invited for any or all of these instruments.

Valve Voltmeter. Type 613C by Dawe.
Wave Analyser. Type 853 by Airmec.
Noise Receiver. TF1225A by Marconi.
Pulse Generator. 301A by Kasama.
Decade Oscillator. D695A by Muirhead.
Stabilized Power Supply. R2030 by Edison.
BFO. 1014 by Bruell & Kyoer.
Phase Meters. D729 AM & D729 AS by Muirhead.
Video Transmission Oscilloscope. PTC1205 by Pye.
Oscillator. C0546 by Solatron.
Noise Generators. TF1106 & 1226A & 1226B by Marconi.
Crystal Calibrator. TF 7273A by Marconi.
Static Megger. TM1739 by Marconi.
Frequency Charger. Ref. 203 by Airmec.
Inductance Bridge. TF301E by Marconi.
Frequency & Time-Measuring Equipments. Ref. TSA 1035, TSA 3436 and TSA 836, all by Venner.
Megometer. Ref. 350 by Myria.
Valve Voltmeters. TF1041, TF428B/2 & TF428C, all by Marconi.
Ditto. Ref. E13556 by Mullard.
Sensitive Valve Voltmeters. TF1100 & TF1041/C by Marconi. V200A by Furzehill.
RF Tuning Units. STU1A & STU2A by Polarad.
Carrier Frequency Oscillators. 65296D & 65642 by GEC.
Inductance Comparator. 655665A by GEC.
Laboratory Amplifier. Ref. AWS51A by Solatron.
Band Stop Filter Unit. TM5774 by Marconi.
Stop Frequency Generator. CTD 32343 by Marconi.
Carrier Deviation Meter. TF791D by Marconi.
Counter Timer. Ref. 34101 by Cintel.
Delayed Sweep & Pulse Generator. 3352.
Signal Generators. TF1058, TF867/2 & TF144H by Marconi.
Chronotron. Model 25A by Electronic Instruments.
LF Oscillator. 652297B by GEC.
Diode Tester Mark IV. EST1217 by Marconi.
Electron Sweep Generators. E/C2 by Polarad.

MULLARD UNILEX STEREO SYSTEM

There is no doubt that it is a good system, we believe that for the money it is without comparison. We demonstrate gladly at our Tamworth Road depot. Prices of the individual items for this:

1 Unilex Amplifier Ref. EP.9000 **£1.60**
1 Unilex Pre-Amp Ref. EP.9001 **£1.80**
1 Unilex Power Unit Ref. EP.9002 **£2.30**
1 Control panel kit with spun-aluminium-faced knobs **£3.30**. Or the complete outfit—**£11.30** post paid.

Pair of 15 ohm speakers made by EMI are also available if required, **£3.30** the pair. No extra postage if ordered with the above, otherwise add 25p.

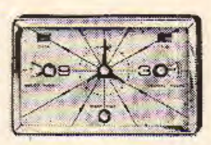
TANGENTIAL HEATER UNIT

This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW element and 1kW element allowing switching 1, 2 and 3kW and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs control switch. **£3.85**. 2kW Model as above except 2kW **£2.75**. Don't miss this. Control Switch **44p**, P. & P. 40p.

THIS MONTH'S SNIP

SOUND TO LIGHT UNIT Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450w). Unit in box all ready to work. **£7.95** plus 95p VAT and postage.

15A ELECTRICAL PROGRAMMER



Learn in your sleep: Have radio playing and kettle boiling as you awake—switch on lights to ward off intruders—have warm house to come home to. All these and many other things you can do it you invest in an electrical programmer. Clock by famous maker with 15-amp. on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours. Independent 60-minute memory jogger. A beautiful unit. Price **£2.15** + 20p p. & p. or with glass front chrome bezel **83p** extra.

TAPE DECK

In metal case with carrying handle, heavy fly wheel and capstan drive. Tape speed 3¾. Mains operated on metal platform with tape head and guide. Not new but guaranteed perfect. Price **£1.95** plus £1 post and insurance.

J. BULL (ELECTRICAL) LTD.

(Dept. W.W.)

102/3, TAMWORTH ROAD, CROYDON CR0 1XX

NEW ITEMS

Car Cassette Power Kit. With a stabilized output of 6v, 9v or 12v. The kit comprises transistors, zener diode, resistors and condensers. Price **£2.10**. Suitable plastic case 40p extra.

Black Light as used in discotheques and for stage effects, etc. Virtually no white light appears until the rays impinge on luminous paint or white shirts, etc. We offer 12" 8w tubes complete with starter, choke, lamp-holders and starter-holder. Price **£2.75** + 30p post. Tubes only **£2** + 30p post.

8kV Rectifiers. For replacements in colour TVs or for experimenting with really high voltage for doublers and triplers, etc. Famous maker. **45p** each. Quantity prices available.

15-way Screen Cable. Suitable for equipment wiring, multi-way telephone installations, etc. Each core has seven strands copper, PVC insulated and colour coded differently from every other core. These are then laid together encased first by a metal screen and then grey PVC. Price **30p** metre or 10 metres **£2.50.**

Touch Switch. This switch suitable for up to 10 amps mains voltage. Stands up approximately ½" rather like a joystick and no matter which direction it is pushed, it makes contact. Base size approximately 2¼" × 2". Price **25p** each.

Light Switch. Automatically switches on lights at dusk and off at dawn. Can also be used where light and dark is a convenient way to stop and start an operation. Requires only a pair of wires to the normal switch. In bakelite box, normal switch-plate size. 1 amp model **£2.95.**

Meters. All flush mounting with chrome-plated surround. 0–2 amp **40p**, 0–3 amp **45p**, 0–4 amp **65p**, 0–10 amp **95p.**

Rectifiers. All 24v full wave (bridge) with cooling fins. 1½–2 amp **25p**, 3–4 amp **85p**, 5–7 amp **£1.25.**

Constant-voltage Transformer. American-made 500w loading. Input voltage can be either 115 + or − 20% or 220 + or − 20%. For 50 c.p.s. mains output 115v 50 c.p.s. A real quality transformer, probably cost well over £100. Not new but guaranteed perfect. Our price **£45** plus carriage.

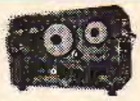
AM/FM TUNER unit made by the American GEC company, 8-transistor, all wired ready to work. Complete with tuner condenser, needs only scale and pointer. Tunes AM range 540 to 1620 KHz, FM range 88 to 108 MHz. Switches for on/off and AFC. Output for MXP or direct. Special snip price **£6** plus 30p post. Three or more post free.

TERMS: Add 8% VAT. Send postage where quoted—other items, post free if order for these items is £6, otherwise add 30p.

P. F. RALFE

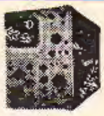
10 CHAPEL ST. LONDON NW1.
Phone 01-723 8753

SIGNAL GENERATORS



MARCONI TF801D/1S. 10-480 mHz P.O.A.
MARCONI TF801B/2S. 10-480 mHz **£225.**
MARCONI TF144H 10kHz—72 mHz P.O.A.
MARCONI TF1370 RC Oscillator 10kHz-10mHz. Sine/Square.
ROHDE & SCHWARZ SMAF (illustrated) AM/FM 4-300 mHz.
ROHDE & SCHWARZ SMLR 15-30mHz power generator. P.O.A.
RACAL/AIRMEC 201A. 30kHz-30mHz. As new. P.O.A.
ADVANCE SG21 VHF Square-wave generator 9kHz-100mHz. **£25.**

OSCILLOSCOPES



TEKTRONIX 555 (Late model) with two 'L' plug-ins and '21A' and '22A' plug-ins.
TEKTRONIX 545A with CA unit. DC-30mHz. Price only **£295·00.**
TETRONIX 531 DC-15mHz with L type plug-in
TETRONIX 535 DC-15mHz with L typa plug-in
ITT METRIX miniature portable scope. DC-10mHz. Brand new. **£50.**
NB: Due to the fragile nature of CRTs we regret that these oscilloscopes cannot be despatchsd by post. Collection only or delivery could be arranged.

MISCELLANEOUS TEST EQUIPMENT

MARCONI TF1400S double pulse generator with TM6600/S secondary pulse unit. **£105.**
MARCONI TF791D deviation meter. 4-1024mHz. 0-100kHz deviation.
MARCONI TF1342 low-capacitance bridge 0·002pf-1,111pf. Resistance 1-1000M.ohm. **£85.**
ROHDE & SCHWARZ USVD calibrated receiver 280-4, 600mHz.
ROHDE & SCHWARZ A.F. Wave Analyser type FTA 0-20kHz plus log/lin AF meter incorporated. Excellent condition.
ROHDE & SCHWARZ URV milli-voltmeter BN10913 (late type) 1mV-10V. With 'T' type insertion unit, free probe and attenuator heads. 1kHz-1,600mHz. **£175.**
COSSOR 1453 True RMS milli-voltmeter. Excellent. **£75.**
ADVANCE PG54 Pulse generator. AS NEW.
SOLARTRON EM1006 production-line resistance tolerance check-set. 0-15Mohm digital read-out.
AIRMEC TYPE 210 modulation meter. Excellent condition.
WAYNE KERR B521 LCR Bridge. Excellent condition. **£55.**
EDDYSTONE 770R VHF Receiver covering 19-165mHz. As mew. **£125**

MUFFIN INSTRUMENT FANS
Dimensions 4·5 x 4·5 x 1·5 ins. Very quiet running, precision fan specially designed for cooling electronic equipment, amplifiers etc. For 110V. AC operation—(practise is to run from split primary of mains transformer or use suitable mains dropper). CC only 11 Watts. List price over £10 each. Our price, in brand new condition, is **£3·50.**

POLARAD Model SA84WA SPECTRUM ANALYSER
10MHz-63GHz. I.F. Markers. Spectrum calibrator. Log/Lin scale. NB. This is not the instrument with the expensive TWT to replace. Supplied in full working, excellent condition. Guarantee.

MANY TYPES of RF plugs and sockets in stock:—

BNC plugs 50Ω. **30p.** BNC sockets 50Ω. **25p.** N. Type plugs 50Ω. **50p.** Burndept plugs. **40p.** Burndept sockets. **40p.** Miniature PYE. **20p.** Miniature sockets. **20p.**

All connectors are brand new. Immediate delivery. Please add appropriate postage.

DURATRAK VARIACS type 100L. 230V. AC Input. 0-230V. AC Output, at 8 amps. Brand new units, less control knobs. Price only **£15·00.** Carriage £1.

MINI HELIPOTS
500 Ω Beckman Linearity Tolerance 0.075% (10 Turn). 1K Ω Beckman Linearity Tolerance 0.25% (10 Turn). 20 Ω Colvern CLR 26/6310/9S (3 Turn). 5K Ω Colvern (10 Turn).

AVO VALVE TESTERS
Brief-case type 160. Full working condition throughout. **£65.**

AERIAL CHANGE/OVER RELAYS
of current manufacture designed especially for mobile equipments, coil voltage 12v., frequency up to 250 MHz at 50 watts. Small size only. 2 in. × ⅞ in. Offered brand new, boxed. Price **£1·50,** inc. P.&P.

RACAL/AIRMEC VHF/UHF Millivoltmeter type 301A. Frequency range 50Hz-900mHz. Voltage range 300µV-3V in eight ranges. Co-axial input 50 and 75 ohms BNC connectors. DC Ranges 100µV-10V in ten ranges. Light-weight mains operated instrument in as new condition with handbooks. Other makes of voltmeter also available from stock.

HEWLETT-PACKARD RF POWER METER
Type 432A. Power range 1µW-10mW in 7 ranges. Frequency range 10mHz-10GHz. Automatic zeroing. With 478A co-ax mounts and carrying case. In excellent condition.

HEWLETT PACKARD/ BOONTON TYPE 8900B
Peak-power calibrator. Measures true peak power ±.6 db absolute. Frequency range 50-2000Mhz. RF power range 200mW peak, full-scale. RF Impedance 50 ohms. P.O.A.

POLARAD MICROWAVE RECEIVER
Model 'R' with tuning unit type RMT. Frequency range 4.2GHz-7.65GHz. AM/FM. In working condition. Price **£75.**

PLEASE ADD 8% V.A.T. TO THE TOTAL AMOUNT WHEN ORDERING. INCORRECT AMOUNTS WILL CAUSE DELAY IN DESPATCH. THANK YOU.

Do you know anyone who may need EEIBA's help?

The help provided by EEIBA takes many forms. Last year more than 800 people who are, or had been, employed in the electrical and electronics industries received urgently needed money totalling £94,000.

It provided new homes in the EEIBA flats in Birmingham, an automatic invalid chair at the Lady Nelson Home, a new sewing machine for a disabled woman, a cooker for an elderly pensioner—and a brand new minicar as a prize for those contributing more funds for the continuation of EEIBA's work.

More important than any of these items was the friendship and reassurance given to people in need by the Association's voluntary workers all over the country.

This active and growing benevolent association helps people who are in need through illness, disability, accident or general hard times. Many employers already know about EEIBA and support it generously. But we need the support of many thousands of employees who can give small regular contributions.

If you would like to receive more details about EEIBA, or if you know of any employee or former employee whom you feel should be helped by the Association, please write straight away to Tom Killick, the Director and Secretary.

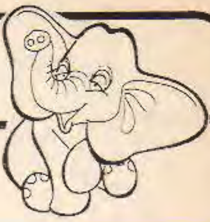
EE IBA

The Electrical and Electronics Industries Benevolent Association
8 Station Parade, Balham High Road, London SW12 9BH.
Telephone: 01-673 0131.

305P5a

Henry's

LARGEST SELECTION OF ELECTRONIC COMPONENTS AND EQUIPMENT. LOW PRICES MEAN LESS VAT.



You can build the Texan and Stereo FM Tuner

TEXAN 20 + 20 WATT IC STEREO AMPLIFIERS

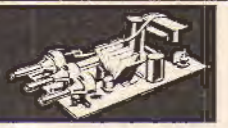
Features glass fibre PC board, Gardeners low field transformer, 6-ICs, 10 transistors plug diodes etc. Designed by Texas Instruments engineers for Henry's and P.W. 1972. Supplied with full chassis work, detailed construction handbook and all necessary parts. Full input and control facilities. Stabilised supply, overall size 15¼ in. × 2¾ in. × 6⅝ in. mains operated. Free teak sleeve with every kit **£28.50** (GB post paid)
Built and tested **£35.00**

STEREO FM TUNER

Features capacity diode tuning, led and tuning meter indicators, stabilized power supply—mains operated. High performance and sensitivity with unique station indication IC stereo decoder. Overall size in teak sleeve 8 in. × 2¾ in. × 6⅝ in.
Complete kit with teak sleeve **£21.00** (GB post paid). Built and tested **£24.95**

JOIN THE LARGE BAND OF HAPPY CONSTRUCTORS!

TRANSISTORISED MODULES
Tuners - Power Suppliers - Amplifiers



Amplifiers (All single channel unless stated)

4-300	9 volt	300 MW	£1.75
2004	9 volt	250 MW	£2.70
104	9 volt	1 watt	£3.10
304	9 volt	3 watt	£3.95
555	12 volt	3 watt	£4.10
555ST	12 volt	1½ × 1½ watt	£5.95
E1208	12 volt	5 watt	£5.10
608	24 volt	10 watt	£4.95
410	28 volt	10 watt	£4.95
620	45 volt	30 watt	£9.95
Z40	30/35 volt	15 watt	£5.45
Z60	45/50 volt	25 watt	£6.95
SA6817	24 volt	6+6 watt	£10.20

Amplifiers with controls

E1210	12 volt 2½+2½ watts 8 ohms	£8.25
R500	Mains 5 watts 4–16 ohms	£6.30
SAC14	Mains 7+7 watts 8 ohms	£11.75
SAC30	Mains 15+15 watts 8 ohms	£14.95
CA038	9 volt 1½+1½ watts 8 ohms	£6.95
CA068	12 volt 3+3 watts 8 ohms	£10.50

FM Modules

Mullard LP 1186 FM tuner (front end) with data 10.7MHz o/p	£4.85
Mullard LP 1185 10.7MHz IF unit	£4.50
Gorler Permability FM tuner (front end) 10.7MHz o/p	£4.20

FM and AM tuners and decoders

FM 5231 (tu 2) 6 volt FM tuner	£7.95
TU3 12 volt version (FM use with decoder)	£7.95
SD4912 Stereo Decoder for Tu 3.12 volt	£7.95
SP62H 6 volt stereo FM tuner	£14.95
A1007 9 volt MW–AM tuner	£4.80
Sinclair 12/45 volt FM tuner stereo recorder for above	£7.45
A1018 9 volt FM tuner in cabinet	£13.95
A1005M (S) 9–12 volt stereo decoder FM for above	£7.50
1062 12 volt stereo decoder. General purpose	£6.50

Preamplifiers

Sinclair	Stereo 60 Preamplifier	£6.75
E1300	CART/TAPE/MIC INPUTS 9 volt	£2.85
E1310	Stereo 3–30mV mal cart 9 volt	£4.75
FF3	Stereo 3mV tape head 9 volt	£4.95
3042	Stereo 5–20mV Mag. cart. mains	£5.95
EQ25	Mono 3–250mV Tape/cart/flat. 9 volt	£1.95

Power Supplies—Mains input (*chassis-rest cased)

470C 6/7½/9V 300mA with adaptors		£2.25
P500 9 volt 500mA		£3.20
HC244R 3/6/7½/9 volt 400mA stabilised		£5.50
*P11 24 volt ½ amp **£3.30**.	*P15 28 volt ½ amp	£3.30
*P1080 12 volt 1A **£4.70**.	*P1081 45 volt 0.9A	£7.80
P12 4½–12 volt 0.4–1 amp		£7.15
SE101A 3/6/8/12 volt 1 amp stabilised		£12.75
P1076 3/4½/6/7½/9/12 volt ½ amp		£4.20
SE800A 1–15 volt 0–½A stabilised		£17.50

QUALITY CASSETTE TAPES

"Living Sound" made specially for Henry's by EMI Tapes Ltd.

5 screw type with library case. Post paid (GB)

	3 for	6 for	10 for	25 for
C60	£1.10	£2.00	£3.15	£7.50
C90	£1.47	£2.85	£4.65	£11.37
C120	£1.83	£3.54	£5.60	£14.00

EMI SPEAKERS
Special Purchase

13×8 chassis speakers (carr/packing 30p each or 50p pr)
★150 TC 10 watt 8 ohm twin cone **£2.20**
★450 10 watt 4, 8, 15 ohm with twin tweeters and crossover **£3.85** each
FW 15 watt 8 ohm with tweeter **£5.25**
350 20 watt 8, 15 ohm with tweeter **£7.80** each
*Polished wood cabinet **£4.80** carr., etc., 35p each or 50p pair

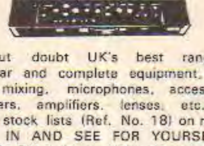
EXCLUSIVE 5 WATT IC AMPLIFIERS

Special purchase 5 watt output 8–16 ohm load. 30 volt max DC operation complete with data.
Price **£1.50** ea. or 2 for **£2.85**.
Printed Circuit Panels **50p**.

UHF TV TUNERS

625-line receiver UHF transistorised tuners FM. UK operation. Brand new.
(Post/packing 25p each)
TYPE C variable tuning **£2.50**
TYPE B 4-button push-button (adjustable) **£3.50**

PA-DISCO-LIGHTING EQUIPMENT



Without doubt UK's best range of modular and complete equipment. Lighting, mixing, microphones, accessories, speakers, amplifiers, lenses, etc. etc. FREE stock lists (Ref. No. 18) on request CALL IN AND SEE FOR YOURSELF at Henry's Disco Centre, 309 Edgware Road, 01-723 6963.

NEW 1975 CATALOGUE 75p WITH VOUCHERS AVAILABLE DECEMBER

TEST EQUIPMENT
MULTIMETERS
(carr/packing 35p)

U4324 20KV with case	£9.25
U435 20KV with steel case	£8.75
U4313 20KV with steel case	£12.50
U4317 20KV with case	£16.50
U4341 33KV plus transistor tester steel case	£10.50
U4323 20KV plus 1KHz 465KHz OSC with case	£7.70
ITI-2 20KV slim type	£5.95
THL33D (L33DX) 2KV robust	£7.50
TP5SN 20KV (Case £2.00)	£8.25
TPS10S 2KV	£6.25
TW20S 20KV	£10.00
TW50K 50KV	£11.25
EP10KN 10KV	£9.95
AF105 50KV De-luxe (Case £1.90)	£12.50
S100TR 100KV plus transistor tester	£22.50

GENERAL TEST EQUIPMENT

(* carr/packing 30p + carr/packing 50p) unless stated

New Revolutionary Supertester 680R Multi-tester	£18.50
Accessories:	
Transistor tester	£11.00
Electronic voltmeter	£18.00
Ampclamp	£11.95
Temperature probe	£11.95
Gauss meter	£11.95
Signal injector	£5.95
Phase Sequence	£5.95
EHT Probe	£5.95
Shunts 25/50/100A	£4.50
† 3100 IMA strip chart recorder	£44.00
† Tk40 AC multivoltmeter	£19.75
* TE15 Grid dip meter 440KHz–28MHz	£19.95
† Tk65 28 range valve voltmeter	£22.50
† Tk200 RF generator 120KHz–500MHz	£18.95
† Tk220 AF generator 20Hz–200KHz	£19.95
* HM350 In circuit transistor tester	£19.50
* C3025 De-luxe meter 1–300 MHz	£6.95
* TT145 Compact transistor tester	£14.75
† G3-38 R/C osc. 20Hz–200KHz	£19.75
* C3042 SWR Meter	£5.75
* SE350A De-luxe signal tracer	£12.95
* SE400 Mini-lab all in one tester	£15.50
C1–5 Scope 500,000KHz (carr £1.00)	£43.00
* C3043 5 CH F/A meter 1–300MHz	£5.75
Resistance sub box (Post etc 20p)	£2.40
Capacitator (Post etc 20p)	£2.10
2 amp variable transformers (carr £1)	£6.66
Radio activity counter 0–10r (carr £1)	£9.97
Mains unit for above (carr 50p)	£3.75

1250-watt Light Dimmer
£3.50 pp 20p
MANUFACTURED BY ULTRA LTD.

Denshi Board Kits

SR-2A	£7.70
SR-3A	£14.95
ST-45	£10.50
ST-100	£13.20

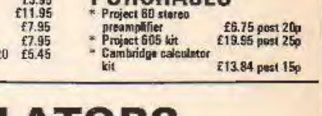
Radionic Kits

X20	£6.20
X40	£13.85
X40A	£11.35

Turner Kits

10 in 1	£6.80
50 in 1	£15.45
150 in 1	£23.65

SINCLAIR MODULES AND KITS



Sinclair Project 80

ST80 stereo pre-amplifier	£11.95
Audio filter unit	£6.95
Z40 15 watt amplifier	£5.45
Z60 25 watt amplifier	£6.95
PZ5 power supplies for 1 or 2 Z40	£4.98
PZ6 power supplies (S. Tab) for 1 or 2 Z40	£7.98
PZ8 power supplies (S. Tab) for 1 or 2 Z60	£7.98
Transformer for PZ8	£3.95
FM tuner	£11.95
Stereo decoder	£7.95
IC20 power amp kit	£7.95
PZ20 power supply for 1 or 2 IC20	£5.45

All above post paid (GB only)

PACKAGE DEALS
(Carriage/packing 35p)

2×Z40, S780, PZ5	£25.00
2×Z60, S780, PZ6	£27.75
2×Z60, S780, PZ8 + Trans.	£34.40

SINCLAIR SPECIAL PURCHASES

* Project 60 stereo preamplifier £6.75 post 20p
* Project 605 kit £19.95 post 25p
* Cambridge calculator kit £13.84 post 15p

CALCULATORS

Sinclair Cambridge Kit	£13.50
Sinclair Cambridge Kit (built)	£17.50
Sinclair memory	£22.50
Sinclair scientific	£26.95
Sinclair scientific kit	£18.50
Hanimax BC817	£18.30

HENRY'S HOME ENTERTAINMENT CENTRES LTD

London

354/6 Edgware Rd. W2	01-402 5854
376/8 Edgware Rd. W2	01-723 0818
372 Edgware Rd. W2	01-402 8140
120 Shaftesbury Ave. W1	01-437 9692
230 Tottenham Court Rd. W1	01-580 1785
144 Burnt Oak B'way, Burnt Oak, Edgware	01-952 7402
190/4 Station Rd. Harrow, Middlesex	01-863 7788

Out of Town

256 Banbury Rd. Summertown, Oxford	(0865) 53072
55 Gloucester Rd. Bristol 7	(0272) 45791

FREE STOCK LISTS

No 36 Transistors/valves/semiconductors.
No 18 Disco lighting high power sound.
No 17 Hi-Fi, TV-tape equipment.
Send large stamped addressed envelope with all enquiries.

Henry's RADIO
EDGWARE ROAD, W2

Electronic Centres
404-406 Electronic Components & Equipment 01-402 8381
309 PA-Disco-Lighting High Power Sound 01-723 6963
303 Special offers and bargains store
All mail to 303 Edgware Road, London W2 1BW

Hi Fi and Electronics Centres Open 9 am - 6 pm

Prices correct at time of preparation. Subject to change without notice. E.&O.E.

Samson's

(ELECTRONICS) LTD.

9 & 10 CHAPEL ST., LONDON, N.W.1

01-723 7851 01-262 5125

ADJACENT TO EDGWARE ROAD MET LINE STATION

STEP DOWN 240/110v AUTO TRANSFORMERS

3000 watts. Built into steel case with two American 2 pin grounded socket outlets. Carry handle. 6 ft. mains lead. **£29·50,** carr. £2. Without case and fittings **£22·00,** carr. £1·50.
Other Types Available. 80-1500 watts, fully shrouded, with American socket outlet and 6 ft. mains lead. Let us know your requirements. Send S.A.E. for list.

AUTO TRANSFORMERS

Partridge. Tapped 0-220-230-240-250v 500 watts unshrouded table top connections **£2·50** carr. 40p. Lemark tapped 0-240 115v 500 watts unshrouded table top connections **£5·00** carr. 80p. 300 watts **£3·50** carr. 50p.

STEP DOWN TRANSFORMERS. ISOLATION TYPES

Drake Pri. 10-0-200-220-240v Sec. 110v 400 watts. Shrouded type. **£8·50.** Carr. 75p. Gresham Pri. 200-220-240v Sec. tapped 100-110-115v 150 watts. Open type. Terminal block connections **£3·75,** P.P. 40p. Drake Pri. 200-220-240v Sec. 110v 50 watts. Open type. Table top connections **£2·25.** P.P. 40p.

HOWELLS "C" CORE TRANSFORMERS

Pri. 200-220-240v. screen. Sec. 70-0-70v. 10 amp. table top connections, size 7×7×7 inches, **£15·00,** carr. **£2·00.** Pri. 220-240v Sec. 18-0-18v 12·5 amps conservatively rated. Table top connections **£10·00,** carr. **£2·00.**

STEWARTS HEAVY DUTY L.T. TRANSFORMERS

Pri. 220-240v. Sec. one. Tapped 4-5-6·3v 12 amps. Sec. two 2·5v 35 amps. 10KV AC WKG **£15·00,** carr. **£2·00.**

PARMEKO ISOLATION STEP DOWN TRANSFORMERS

Pri. 200-220-240v Sec. 90-100-110-120v 7·5 amps conservatively rated. Size 8×8×8 inches. Enclosed type. Table top connections. **£18·50,** carr. **£2·00.**

PARMEKO ISOLATION 1-1 TRANSFORMERS

Pri. 190-260v in 10v steps. Sec. 240v 10 amp conservatively rated. Size 12×10×8 inches. Enclosed type. Table top connections. **£29·50,** carr. £3·00.

TRANSFORMERS FOR LINSLEY HOOD AMPLIFIERS

Fully shrouded, terminal block connections. Pri. 220-240v. Screen tap. Sec. 30-25-0-25-30v., 2 amps. **£4·75,** carr. 40p. Heavy duty type 36-25-0-25-36v. 5 amps. **£8·75,** carr. 50p.

PARMEKO POTTED L.T. TRANSFORMERS

Pri. 115-230v SCR. Sec. tapped 40-45-50v 5 amps. **£8·50,** carr. 75p.
Pri. 110-220-240v. Sec. 2·5v-0-2·5 v 30 amps. Twice. Will give 5v CT 60 amps or 10v CT 30 amps. **£10·00,** carr. £1·00.
Pri. 220-230-240-250v. Sec. 32-0-32v 5 amps. **£10·00,** carr. £1·00.
All types conservatively rated. Brand new. Fraction of maker's price.

PARMEKO

Open types: Pri. 110-200-220-240v. SCR. Sec. 30v 5·5A and 12v 2·2A. Table top connections **£4·95,** carr. 75p. Pri. 240v. SCR. Sec. 26v 10A and 12v 0·1A. Table top connections **£5·50,** carr. 75p.
Pri. 220-240v Sec. 24-30-32v 2A. Potted type **£2·50,** P.P. 40p.
Pri. 220-240v Sec. 13v 6A or 6·6v 12A and 5v 6A. Potted type. **£4·75,** P.P. 75p.

HILGER AND WATT L.T. TRANSFORMERS

Pri. 200-210-220-230-240-250-260-310-320v Sec. 12v 20 amps. Open type. Terminal block connections **£8·50,** carr. 75p.

WODEN C CORE L.T. TRANSFORMER

Pri. 115-230v Sec. Tapped 15-20 25-30v 30 amps. **£12·00,** carr £1·00.

G.E.C. Open frame. Terminal Block Connections Primaries 220-240v. No. 1 Sec. Tapped 51-61 65-67-69v. 10a. **£8·00,** carr. £1·00. No. 2. Sec 58 63-69-74v 3a. and 6v 3a. **£3·75,** P.P. 50p.

GARDNERS C CORE L.T. TRANSFORMERS

Table top connections. Pri. 200-220-240v. No. 1. Sec. 24v 3 amps **£3·00,** P.P. 40p. No. 2. Sec. 25-0-25v 154 M/A and 7v 1·35A **£1·75,** P.P. 25p. No. 3. Sec. 6·3v 3A 4 times, 6·3v 1·5A 5v 3A. **£3·00,** P.P. 50p. No. 4. Sec. 66-73v 0·6A and 6v 1A. **£3·00,** P.P. 50p.

PARMEKO H.T. TRANSFORMERS

C core types. Pri. 220-240v. Sec. 250-0-250v. 50 M/A. 6·3v 1A. 6·3v 0·7A. 6·3v 0·6A **£1·50,** P.P. 40p. Table top connections. Pri. 220-240v. Sec. 300v 210 M/A and 400v 262 M/A. 6·3v 3A. 6·3v 2A. 6·3v 1A **£4·50,** carr. 75p. Pri. 220-240v. Sec. 370-390-410v 6 M/A **75p,** P.P. 25p.

H.T. TRANSFORMERS BY FAMOUS MAKERS

No. 1 Pri. 110-210-230-250v Sec. 230v 200 M/A and 6·3v 7A. potted type **£3·00,** P.P. 50p.
No. 2 Pri. 110v-220-240v Sec. 250v 80 M/A. 15v 1·2A 6·3v 4·5A. Open type **£2·00,** P.P. 35p.
No. 3 Pri. 220-240v Sec. 250-0-250v 75 M/A 6·3v 3A **£1·75,** P.P. 35p.
No. 4 Pri. 200-220-240v Sec. 400-375-350-0-350-375-400v 150 M/A 6·4v 7A twice 6·4v 3A. 6·4v 2A 6·4v 1A 6·4v 0·5A potted type **£5·00,** carr. 75p.
No. 5 Pri. 110-220-240v Sec. 70v 1A and 30v 1A potted type **£3·75,** P.P. 75p.
No. 6 Pri. 220-240v Sec. 1875v 60 M/A and 500 31 M/A potted type **£4·75,** P.P. 75p.
No. 7 Pri. 220-240v Sec. 630-0-630v 105 M/A. 5v 4A 5v 2A **£4·50,** P.P. 75p.
No. 8 Pri. 220-240v Sec. 140v 195 M/A 6·3v CT 1·25A. 50v potted type 1A **£3·50,** P.P. 50p.
No. 9 Pri. 220-240v Sec. 385v 175 M/A and 218v 175 M/A potted type **£3·50,** P.P. 50p.
No. 10 Pri. 220-240v Sec. 480-0-480v 150 M/A 6·3v 2·8A. 6·3v 1·2A twice open type **£4·50,** P.P. 75p.

H.T. SMOOTHING CHOKES

GARDNER 'C' core types. 10H 250 M/A **£2·00,** post. 40p. 20H 180 M/A **£2·00,** post. 40p. 12H 100 M/A **85p,** post. 25p. 50H 25 M/A **85p,** post. 25p. **PARMEKO** Potted types, 10H 180 M/A **£2·00,** post. 40p. 5·2H 350 M/A **£2·50,** post. 50p. 10H 300 M/A **£2·50,** post 50p. 5H 100 M/A **75p,** post. 25p. 15H 75 M/A **75p,** post 25p. 50H 25 M/A **75p,** 25p.

L.T. SMOOTHING CHOKES

C core types 140 M/H 5A **£3·00,** P.P. 75p. 10 M/H 25A **£8·75,** carr. £1·00. 15 M/H 3·8A **£1·75,** P.P. 35p. Potted types 4-6 M/H 11A **£3·00,** P.P. 50p. 100 M/H 2A **£2·50,** P.P. 50p. 130 M/H 1·15A **£1·00,** P.P. 25p. Open type 150 M/H 3A **£3·00,** P.P. 50p. 50 M/H 2A **£1·50,** P.P. 35p. 20 M/H 1A **£1·00,** P.P. 25p. 4·8 M/H 10A **£2·50,** P.P. 40p. Swinging types. C core. 7·5 M/H 6A-75 M/H 0·5A **£3·75,** P.P. 50p. 10 M/H 4A-100 M/H 0·5A open type **£2·50,** P.P. 25p. 50 M/H 5A-100 M/H 0·5A C core **£2·25,** P.P. 35p.

CONSTANT VOLTAGE TRANSFORMERS

Input 240v + 20% — 10% output 240v + or — 0·5% 30 watts enclosed in metal case, 5½×4×4 ins **£2·00,** P.P. 50p.

PLEASE ADD 8% VAT TO ALL ORDERS INC. CARR.

GENTS ALARM BELLS

6 volt DC 6 inch dia. Gong. Overall size 4½×6×6 inches. **£3·58,** P.P. 50p.

DORMAN LOADMASTER S.P. CIRCUIT BREAKERS

Type M3 250/440v 20 amps **£1·00,** P.P. 25p.

ITT LEVER SWITCHES

Type 601 AAO 72-42 4 CO contacts, overall size 1¾×2×½ ins. White lever gold flash contacts, **60p.** Three for **£1·50,** post paid.

PLESSEY MINIATURE MICRO SWITCHES

Type LIC 7134. One CO one break. Gold flash contacts. Size ⅞×¾×¼ in. Three for **50p,** post paid.

SANGAMO SYNCHRONOUS A.C. 240v MOTOR TYPE 7

4 rev. per hour. Size 1½ plus ½ spindle. 1¾ inch dia. **£1·25,** P.P. 25p.

SPECIAL OFFER OF OMRON RELAYS

Type Mk. 2, 24v. AC. 12v. DC. Two 7 amp CO contacts, S hole fixing. **60p,** post 5p.
Type Mk. 2 plug in octal base type. 12v. DC. Two 7 amp. CO contacts, **75p,** post 5p.

RELAY CONTROL CO. American Miniature relays 6v. DC. 1 CO contact. Size 1½×1×¾ ins. **35p,** post. 5p.

OIL-FILLED BLOCK CAPACITORS

MFD	DCV WKG	PRICE
8	2500	£3·00
8	800	75p
8	600	60p
8	350	40p
6	750	80p
6	600	50p
4	2000	£1·00
4	1000	80p
4	600	40p
4	350	30p
1	600	20p
1	200	10p

P.P. Add 5p each 1-4 MFD.
10p each 6-8 MFD.
25p each 8 MFD 2500v.
Plessey 2+2+2 MFD 1500v. WKG 70°C. **75p,** P.P. 10p.
TCC block electrolytic capacitors 1000 MFD 100v DC WKG **50p,** P.P. 15p.

MOTOR START CAPACITORS TUBULAR TYPES

4 MFD 250v AC. 2·6 MFD 500v DC. 2·5 MFD 380v AC. 2·2 MFD 250v AC. All at **50p,** P.P. 10p. Eire Miniature 2·2 MFD 400v Size 1½×1×½ inches. **25p** post paid. TCC 8 MFD 800v DC WKG electrolytics **75p,** P.P. 15p.

MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: ±1% at 1 Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52·5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements 29 × 12¼ × 10 in. Secondhand condition. **£27·50** each, Carr. £2·00.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7·50** each, Carr. £2·00.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3·50** each, post 50p.

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. **£1·25,** post 30p.

VARIAC TRANSFORMERS: Input 115V, output 0-135V at 2 Amps. **£3** each. 75p post.

RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high × 21 in. wide × 16 in. deep, with rear door. **£12** each, Carr. £2·50.

CLASS "D" WAVEMETER NO. 1 MK. II: Crystal controlled heterodyne frequency meter covering 2-8MHz. Power supply 6V d.c. Good secondhand cond. **£7·50** each. Post 60p.

ROTARY INVERTERS: TYPE PE.218E—input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1 Ph. P.F.9. **£17·50** each. Carr. £2·00.

REDIFON TELEPRINTER RELAY UNIT NO. 12: ZA-41196 and power supply 200-250V a.c. Polarised relay type 3SEITR. 80-0-80V 25mA. Two stabilised valves CV 286. Centre Zero Meter 10-0-10. Size 8in. × 8in. × 8in. New condition **£7·50,** Carr. 75p.

TS 15C/AP FLUXMETER: Used to provide qualitative measurements of flux densities between pole faces of magnets. Range 1200-9600 gausses. ±2%. S/hand good cond. **£25** + 60p post.

AUTO TRANSFORMER: 230V 50c/s, 1000 watts. Mounted in strong steel.case 5in. × 6½in. × 7in. Bitumen impregnated. **£10** each, Carr. £1.

UHF ASSEMBLY: (suitable for 1000MHz conversion) incl. UHF valves; 2C42, 2C46, 1B40. Complete with associated capacitors and screening; 3 manual counters 0-999. Valves 6AL5 and 8 × 6AK5. **£10** each, 60p post.

TELEPRINTER TYPE 7B, Pageprinter 24V d.c. power supply, speed 50 bauds per min. 'as new' cond. in original packing case, **£25** each; or second hand cond. (excellent order) no parts broken, **£15** each. Carriage either type £3·00.

INSULATION TEST SET: 0-10 kV negative, earth with amplifier provision for checking ionisation. 110/230V a.c. input. S/hand good cond. **£30** + £1 carr.

AUTOMATIC VIBRATION EXCITER CONTROL UNIT TYPE 1016: Manufactured by Bruel & Kjoer. 5-5000c/s per sec. S/hand V. good cond. **£90,** Carr. £2.

VRC 19X MOBILE TRANS/REC: 152-174 mc F.M. Power o/put 25 watts. Input voltage 24v. d.c. Weight 80lbs. **£35·00** each, carr. £3·00.

BRIDGE MEGGER: 250V. (Evershed Vignoles) series 2. **£30** each. Carr. £1.

BRIDGE MEGGER: 2,500V., series 1. **£30** each. Carr. £1.

CRYSTAL TEST SET TYPE 193: used for checking crystals in freq. range 3000-10,000KHz. Mains 230V 50Hz. Measures crystal current under oscillatory conditions and the equivalent resistance. Crystal freq. can be tested in conjunction with a freq. meter. **£15.** Carr. £1·50.

RACAL OSCILLATOR: 1-100,000KHz in 1KHz steps with digital readout, BFO, CWN, FSK, CWW, LSB, USB, ISB, DSB. Line 1 and 2. **£200** each. Carr. £5.

50-LINE TELEPHONE SWITCHBOARD: Complete with all plugs etc., excellent cond. **£40** each. Carriage £5.
10-WAY TELEPHONE SOCKET STRIPS: 3 connections and 10 jack-plugs to suit. Similar to PL68. Complete with 6ft. cord. Ex-equipment, good cond. **£4** each. Post 50p.
10-WAY TELEPHONE LAMP STRIP: Suitable for use with the above. **£2** each. Post 30p.
10-WAY TELEPHONE MAGNETIC INDICATOR: 50V. For use with the above items. **£2** each. Post 40p.
10-WAY TELEPHONE SOCKET STRIP: 3 connections. Takes standard P.O. Jackplugs; 201 or 316; and **10-WAY TELEPHONE LAMP STRIP.** **£3** the pair. Post 50p.

DELPENA RF GENERATOR TYPE E.15: 15kW at 500Hz; input 440V 3 ph. 50Hz. **£275.** Carr. at cost.

H.V. TRANSFORMER: 8000/8000. Output 300mA. rms. Size: 12in. × 12in. × 36in. 230V input. **£35,** Carr. £4·00.

TELEPHONE CABLE: (Twin) 1,300ft. on metal reel. **£5** per reel. Carr. £1.

ANTENNA MAST 30ft. consisting of 10 × 3ft. tubular screw sections (⅞" dia.) with base, guyropes and stays etc. **£5** each, Carr. £2.

APN-1 ALTIMETER TX/RX: Freq. approx. 410MHz. Complete wit.. 28V dynamotor, 3 relays, precision resistors, 11 valves. Useful breakdown for parts. **£4** each, Carr. £1·50.

AVO VALVE TESTER CT.160: (Portable) similar to Avo Mk. 3 Characteristic Meter. Good cond. **£35** each, Carr. £1·50.

MODULATOR UNIT: Complete with mod. transformer and 2 × 807 Valves. Mounted 19" chassis, 8" × 8". "As new" cond. **£8** each; or secondhand **£5** each. Carr. both types £1·50.

FIRE-PROOF TELEPHONES: £25·00 each, carr. £1·50.

TF.2000 A.F. SIGNAL SOURCE: £175·00, carr. £1·00.

WESTON INDUSTRIAL THERMOMETER MODEL 221: 0-100° 3 inch. dia. scale. Accuracy 1%. **£3·00,** post 30p.

POWER UNIT: 110/230 volts a.c. input. 28 volts d.c. at 40 amps output. **£30·00** each, carr. £3·00.

SMOOTHING UNIT (for the above): **£10·00** each, carr. £2·00.

SOLARTRON PLUG-IN UNIT TYPE C X-1251: Wideband 40MHz. **£30** ea., 75p post.

SOLARTRON DUAL TRACE CX-1252: 24MHz. **£35** ea., 75p post.

X-BAND MODULATOR CALIBRATOR TYPE MC-4420-X: Mnfr. James Scott. **£125** ea., Carr. £1.

HP-766D DUAL DIRECTIONAL COUPLER: 940-1975MHz. **£35** ea., 75p post.

BACKWARD WAVE OSCILLATOR TYPE SE-215: 6.3 heater, 105V Anode, 7.9mA. Mnfr. Watkins & Johnson. **£85** ea., Carr. £1.

LISTS OF EQUIPMENT AVAILABLE: MOTORS; TELEPRINTERS; AR88 SPARES; TEST EQUIPMENT ETC. Send 10p for above lists.

ALL CARRIAGE QUOTES GIVEN ARE FOR 50 MILE RADIUS OF LONDON ONLY.

ALL U.K. ORDERS SUBJECT TO 8% VALUE ADDED TAX. THIS MUST BE ADDED TO THE TOTAL PRICE (including post or carriage).

If wishing to call at stores, please telephone for appointment.

W. MILLS

3-B TRULOCK ROAD, LONDON, N17 0PG

Phone: 01-808 9213 and Bedford 740605 (STD 0234).

Also see following pages

SEW PANEL METERS

SEW PANEL METERS ARE STOCKED AT OUR 3 LISLE ST., 311 EDGWARE RD., & 152 FLEET ST.. BRANCHES or order by post.

USED EXTENSIVELY BY INDUSTRY, GOVERNMENT DEPARTMENTS, EDUCATIONAL AUTHORITIES ETC.

Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

*Items with asterisk are Moving Iron type, all others are Moving Coil

CLEAR PLASTIO MODEL SD640
Size: 85 x 64mm

50uA	£3.80	10V DC	£3.65
100uA	£3.75	20V DC	£3.65
200uA	£3.70	50V DC	£3.65
500uA	£3.65	300V DC	£3.65
50-0-50uA	£3.75	15V AC	£3.75
100-0-100uA	£3.70	300V AC	£3.75
1mA	£3.65	VU Meter	£3.90
5mA	£3.65		
10mA	£3.65		
50mA	£3.65		
100mA	£3.65		
500mA	£3.65		
1A DC	£3.65		
5A DC	£3.65		
10A DC	£3.65		
5V DC	£3.65		

CLEAR PLASTIC MODEL SW100
Size: 100 x 80mm

50uA	£4.60	150V AC	£4.45
100uA	£4.50	300V AC	£4.45
500uA	£4.30	VU Meter	£4.90
50-0-50uA	£4.50		
100-0-100uA	£4.45		
1mA	£4.30		
1A DC	£4.30		
5A DC	£4.30		
20V DC	£4.30		
50V DC	£4.30		
300V DC	£4.30		

EDGWISE MODEL PE70
Size: 90 x 34mm

50uA	£4.15
100uA	£4.10
200uA	£4.05
500uA	£3.90
50-0-50uA	£4.10
100-0-100uA	£4.05
1mA	£3.85
300V AC	£3.95
VU Meter	£4.30

MODEL ED107 EDUCATIONAL METER
Size: 100 x 90 x 150mm including terminals

A range of high quality moving coil instruments ideal for school experiments and other bench applications. 3" mirror scale. The meter movement is easily accessible to demonstrate internal working.

50uA	£8.50	20V DC	£7.60
100uA	£7.90	50V DC	£7.60
50-0-50uA	£7.90	300V DC	£7.60
1mA	£7.60	500mA/5A DC	£8.60
1-0-1mA	£7.60	5V/50V DC	£8.60
1A DC	£7.60	5V/15V DC	£8.60
5A DC	£7.60	1/5A DC	£8.60
5V DC	£7.60	1A/15A DC	£8.60
10V DC	£7.60		
15V DC	£7.60		

CLEAR PLASTIC MODEL MR 85P
Size: 120 x 110mm

50uA	£5.45	300V DC	£5.20
100uA	£5.40	15V AC	£5.30
200uA	£5.35	300V AC	£5.30
500uA	£5.25	S Meter 1mA	£5.20
50-0-50uA	£5.40	VU Meter	£5.55
100-0-100uA	£5.35	1A AC	* £5.20
500-0-500uA	£5.20	5A AC	* £5.20
1mA	£5.20	10A AC	* £5.20
1-0-1mA	£5.20	20A AC	* £5.20
5mA	£5.20	30A AC	* £5.20
10mA	£5.20		
50mA	£5.20		
100mA	£5.20		
500mA	£5.20		
1A DC	£5.20		
5A DC	£5.20		
15A DC	£5.20		
30A DC	£5.40		
10V DC	£5.20		
20V DC	£5.20		
50V DC	£5.20		
150V DC	£5.20		

CLEAR PLASTIC MODEL SD830
Size: 110 x 83mm

50uA	£4.30	10V DC	£4.10
100uA	£4.25	20V DC	£4.10
200uA	£4.20	50V DC	£4.10
500uA	£4.15	300V DC	£4.10
50-0-50uA	£4.25	15V AC	£4.20
100-0-100uA	£4.20	300V AC	£4.20
1mA	£4.10	VU Meter	£4.40
5mA	£4.10		
10mA	£4.10		
50mA	£4.10		
100mA	£4.10		
500mA	£4.10		
1A DC	£4.10		
5A DC	£4.10		
10A DC	£4.10		
5V DC	£4.10		

CLEAR PLASTIC MODEL MR 45P
Size: 50 x 50mm

50uA	£3.20	300V AC	£3.05
100uA	£3.15	S Meter 1mA	£2.95
200uA	£3.10	VU Meter	£3.40
500uA	£3.00	1A AC	* £2.95
50-0-50uA	£3.15	5A AC	* £2.95
100-0-100uA	£3.10	10A AC	* £2.95
500-0-500uA	£2.95	20A AC	* £2.95
1mA	£2.95	30A AC	* £2.95
5mA	£2.95		
10mA	£2.95		
50mA	£2.95		
100mA	£2.95		
500mA	£2.95		
1A DC	£2.95		
5A DC	£2.95		
10V DC	£2.95		
20V DC	£2.95		
50V DC	£2.95		
300V DC	£2.95		
15V AC	£3.05		

CLEAR PLASTIC MODEL MR 38P
Size: 42 x 42mm

50uA	£3.10	20V DC	£2.80
100uA	£3.05	50V DC	£2.80
200uA	£3.00	100V DC	£2.80
500uA	£2.85	150V DC	£2.80
50-0-50uA	£3.05	300V DC	£2.85
100-0-100uA	£3.00	500V DC	£2.85
500-0-500uA	£2.80	750V DC	£2.90
1mA	£2.80	15V AC	£2.90
1-0-1mA	£2.80	50V AC	£2.90
2mA	£2.80	150V AC	£2.90
5mA	£2.80	300V AC	£2.90
10mA	£2.80	500V AC	£3.00
20mA	£2.80	S Meter 1mA	£2.80
50mA	£2.80	VU Meter	£3.20
100mA	£2.80		
150mA	£2.90		
200mA	£2.80		
300mA	£2.80		
500mA	£2.80		
750mA	£.280		
1A DC	£2.80		
2A DC	£2.80		
5A DC	£2.80		
10A DC	£2.80		
3V DC	£2.80		
10V DC	£2.80		
15V DC	£2.80		

CLEAR PLASTIC MODEL SD460
Size: 59 x 46mm

50uA	£3.50	10V DC	£3.30
100uA	£3.45	20V DC	£3.30
200uA	£3.40	50V DC	£3.30
500uA	£3.35	300V DC	£3.30
50-0-50uA	£3.45	15V AC	£3.45
100-0-100uA	£3.40	300V AC	£3.45
1mA	£3.30	VU Meter	£3.85
5mA	£3.30		
10mA	£3.30		
50mA	£3.30		
100mA	£3.30		
500mA	£3.30		
1A DC	£3.30		
5A DC	£3.30		
10A DC	£3.30		
5V DC	£3.30		

POSTAGE & PACKING 15p

CLEAR PLASTIC MODEL MR 65P
Size: 85 x 78mm

50uA	£3.95	300V DC	£3.70
100uA	£3.85	15V AC	£3.80
200uA	£3.80	50V AC	£3.80
500uA	£3.75	150V AC	£3.80
50-0-50uA	£3.85	300V AC	£3.90
100-0-100uA	£3.80	500V AC	£3.80
500-0-500uA	£3.70	S Meter 1mA	£4.10
1mA	£3.70	VU Meter	£3.70
1-0-1mA	£3.70	1A AC	* £3.70
5mA	£3.70	5A AC	* £3.70
10mA	£3.70	10A AC	* £3.70
50mA	£3.70	20A AC	* £3.70
100mA	£3.70	30A AC	* £3.70
500mA	£3.70	50mA AC	* £3.70
1A DC	£3.70	100mA AC	* £3.70
5A DC	£3.70	200mA AC	* £3.70
10A DC	£3.70	500mA AC	* £3.70
15A DC	£3.70		
20A DC	£3.80		
30A DC	£3.85		
50A DC	£4.05		
5V DC	£3.70		
10V DC	£3.70		
15V DC	£3.70		
20V DC	£3.70		
50V DC	£3.70		
150V DC	£3.70		

BAKELITE MODEL S80 Enlarged Window
Size: 80 x 80mm

50uA	£4.50
100uA	£4.45
500uA	£4.20
50-0-50uA	£4.45
100-0-100uA	£4.40
1mA	£4.20
1A DC	£4.20
5A DC	£4.20
20V DC	£4.20
50V DC	£4.20
300V DC	£4.20
300V AC	£4.30
VU Meter	£4.70

CLEAR PLASTIC MODEL MR 52P
Size: 60 x 60mm

50uA	£3.70	S Meter 1mA	£3.30
100uA	£3.50	VU Meter	£3.80
500uA	£3.35	1A AC	* £3.30
50-0-50uA	£3.50	5A AC	* £3.30
100-0-100uA	£3.45	10A AC	* £3.30
1mA	£3.30	20A AC	* £3.30
5mA	£3.30	30A AC	* £3.30
10mA	£3.30		
50mA	£3.30		
100mA	£3.30		
500mA	£3.30		
1A DC	£3.30		
5A DC	£3.30		
10V DC	£3.30		
20V DC	£3.30		
50V DC	£3.30		
300V DC	£3.30		
15V AC	£3.40		
300V AC	£3.40		

BAKELITE MODEL MR 65 Size: 80 x 80mm

25uA	£5.25	300V DC	£3.60
50uA	£4.00	30V AC	* £3.60
100uA	£3.95	50V AC	* £3.60
500uA	£3.65	150V AC	* £3.60
50-0-50uA	£3.95	300V AC	* £3.60
100-0-100uA	£3.90	500V AC	* £3.60
500-0-500uA	£3.60	VU Meter	£4.10
1mA	£3.60	1A AC	* £3.60
1-0-1mA	£3.60	5A AC	* £3.60
5mA	£3.60	10A AC	* £3.60
10mA	£3.60	20A AC	* £3.60
50mA	£3.60	30A AC	* £3.60
100mA	£3.60	50A AC	* £3.60
500mA	£3.60	500mA AC	* £3.60
1A DC	£3.60	50mV DC	£3.75
2A DC	£3.60	100mV DC	£3.75
5A DC	£3.60		
10A DC	£3.60		
15A DC	£3.60		
30A DC	£3.60		
50A DC	£3.80		
5V DC	£3.60		
10V DC	£3.60		
15V DC	£3.60		
20V DC	£3.60		
50V DC	£3.60		
150V DC	£3.60		

240° Wide Angle 1mA METERS

MW1-6 60 x 60 mm £6.50 P & P 15p

MW1-8 80 x 80mm £6·90 P&P 15p

YAMABISHI VARIABLE VOLTAGE TRANSFORMERS

Excellent quality at low cost. Input: 230V 50/60Hz. Output 0—260V.

MODEL S260 BENCH MOUNTING

		P&P
1A	£10.50	50p
2.5A	£12.00	60p
5A	£17.50	50p
8A	£30.35	£1.00
10A	£33.75	£1.00
12A	£35.40	£1.00
20A	£85.00	£1.50
25A	£95.00	£1.50
40A	£120.00	£1.50

MODEL S260B PANEL MOUNTING 2.5A £12.00 50p

ALL PRICES EXCLUDE VAT

ASK LASKYS

FOR MAIL ORDER

We offer a speedy and efficient service by mail order. Remember to add 8% VAT to total value of goods including post and packing.

TO LASKYS CUSTOMER SERVICES DIVISION
Audiotronic House, The Hyde, London NW9 6JJ. Tel: 01-200 1321

Please send me the following items ....

TOTAL PURCHASE PRICE .... (inc. P&P and VAT)

16 Page HI-FI PRICE LIST — TICK HERE

I enclose cheque / postal order / money order

I wish to pay by Barclaycard/Access and my number is

NAME ....

ADDRESS ....

Signature ....

Registered in England No. 347947 at 12 Lower Grosvenor Place, London SW1 0EX WW12

ASK LASKYS about Hi Fi

CALL INTO YOUR NEAREST LASKY.S BRANCH OR SEND COUPON BELOW FOR NEW 16 PAGE HI-FI PRICE LIST

CENTRAL LONDON

481 OXFORD ST.	01-493 8641
3 LISLE ST. WC2	01-437 8204
34 LISLE ST. WC2	01-437 9155
118 EDGWARE RD. W2	01-723 9789
193 EDGWARE RD. W2	01-723 6211
207 EDGWARE RD. W2	01-723 3271
311 EDGWARE RD. W2	01-262 0387
346 EDGWARE RD. W2	01-723 4453
382 EDGWARE RD. W2	01-723 4194
109 FLEET ST. EC4	01-353 5812
152/3 FLEET ST. EC4	01-353 2833
10 TOTTENHAM CT. RD.	01-637 2232
27 TOTTENHAM CT. RD.	01-636 3715
33 TOTTENHAM CT. RD.	01-636 2605
42/45 TOTTENHAM CT. RD.	01-636 0845
257/8 TOTTENHAM CT. RD.	01-580 0670

ESSEX

86 SOUTH ST. ROMFORD 20218

205/206 CHURCHILL WEST, VICTORIA CIRCUS, SOUTHEND 0702 612241

KENT

53/57 CAMDEN RD., TUNBRIDGE WELLS 0892-23242

LEICESTERSHIRE

45 MARKET PLACE, LEICESTER 0533-537678

NORTHAMPTONSHIRE

73 ABINGTON STREET, NORTHAMPTON (Opening November)

STAFFORDSHIRE

30 WULFRUN WAY, WOLVERHAMPTON Now Open

SURREY

1046 WHITGIFT CENTRE, CROYDON	01-681 3027
27 EDEN ST. KINGSTON	01-546 7845
38/40 EDEN ST., KINGSTON	01-546 1271
32 HILL ST. RICHMOND	01-948 1441

WARWICKSHIRE

116 CORPORATION ST., BIRMINGHAM 021-236 3503

ALL BRANCHES OPEN FROM 9am to 6pm MON. TO SAT.

West End Service Centre for Personal Callers 87 Tottenham Court Rd. W.

BARCLAYCARD & ACCESS

Phone your order to 01-200 0037 or call into any branch

OUR CUSTOMER SERVICES DIVISION at head office will answer all your enquiries—just ring 01-200 1321

EXPORT Personal exports arranged for overseas visitors. Goods specially packed insured and despatched to all parts of the world at minimum cost exclusive of VAT. Payment by bank transfer, certified cheque, postal order or money order in any currency.

NO DEPOSIT TERMS available on most goods for personal callers

CHEQUES TO THE VALUE OF £30, ACCEPTED FROM PERSONAL SHOPPERS WITH BANKERS CARD. IN OTHER CASES AND FOR AMOUNTS IN EXCESS OF £30. PLEASE ALLOW TIME FOR CLEARANCE. BANKERS DRAFTS ACCEPTED.

All prices correct at 11/10/74 but subject to change without notice E.&O.E.

A member of the Audiotronic Group of Companies

FROM THE SPECIALISTS - POWERTRAN ELECTRONICS

WIRELESS WORLD AMPLIFIER DESIGNS

Component packs for a choice of three outstanding amplifiers are stocked together with packs for a regulated power supply suitable for use with a pair of any of them. Also stocked are packs for a very well-established pre-amplifier—the Bailey-Burrows design which features six inputs, a scratch and rumble filter and wide range tone controls which may be either rotary or slider operating.

30W BAILEY	
Pk. 1 F/Glass PCB	£0.80
Pk. 2 Resistors, capacitors, pots	£1.75
Pk. 3 Semiconductor set	£4.70
30W BLOMLEY	
Pk. 1 F/Glass PCB	£0.85
Pk. 2 Resistors, capacitors, pots	£2.15
Pk. 3 Semiconductor set	£5.60
20W LINSLEY-HOOD	
Pk. 1 F/Glass PCB	£0.85
Pk. 2 Resistors, capacitors, pots	£2.40
Pk. 3 Semiconductor set	£3.35
60V REGULATED POWER SUPPLY	
Pk. 1 F/Glass PCB	£0.75
Pk. 2 Resistors, capacitors, pots	£1.40
Pk. 3 Semiconductor set	£3.10
BAILEY-BURROWS PRE-AMP	
Pk. 1 F/Glass PCB	£2.05
Pk. 2 Resistors, capacitors, pre-sets, transistors	£4.95
Pk. 3R Rotary potentiometer set	£1.60
Pk. 35 Slider potentiometer set (with knobs)	£2.70

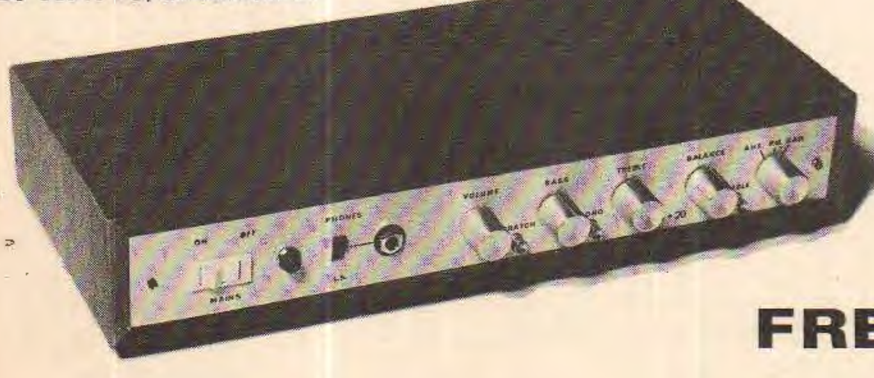
STUART TAPE RECORDER

A set of three printed-circuit boards has been prepared for the stereo integrated circuit version of this high-performance Wireless World published design.

TRRP Pk. 1	Reply amplifier F/Glass PCB	£0.90
TRRC Pk. 1	Record amp./meter drive cct. F/Glass PCB	£1.40
TROS Pk. 1	Bias/erase/stabilizer cct. F/Glass PCB	£1.00

For details of component packs for this design please write for free list.

20 WATTS/CHANNEL



TOROIDAL T20 + 20

Developed from the famous Practical Wireless Texan

Designed by Texas engineers and published in a series of articles in **Practical Wireless**. The TEXAN was a remarkable breakthrough in delivering true Hi-Fi performance at exceptionally low cost. Now further developed to include a true Toroidal transformer, this slimline integrated circuit design, based upon a single F/Glass PCB, features all the normal facilities found on quality amplifiers, including scratch and rumble filters, adaptable input selector and headphones socket.

FREE TEAK CASE and HANDBOOK with full kits

KIT PRICE only **£28.25** post free (U.K.)

Pack		Price
1	Set of all low noise resistors	£0.80
2	Set of all small capacitors	£1.50
3	Set of 4 power supply capacitors	£1.40
4	Set of miscellaneous parts including DIN sockets, fuses, fuse holders, control knobs, etc.	£1.90
5	Set of slide and push-button switches	£0.90
6	Set of potentiometers and selector switch	£1.45
7	Set of all semiconductors	£8.25
8	Special Toroidal Transformer	£4.95
9	Fibreglass PC Panel	£2.50
10	Complete chassis work, hardware and brackets	£4.20
11	Preformed cable/leads	£0.40
12	Handbook	£0.25
13	Teak Cabinet	£2.75

ACTIVE FILTER CROSSOVER

An essential and critical component in a high-quality speaker system is the crossover unit conventionally comprising of a series of passive networks which unfortunately, though introducing reactive impedances between the amplifier and the speakers, result in the loss of the advantage of high amplifier damping factor and renders the speakers prone to overshoots and resonances. An elegant solution to this problem, described by D. C. Read in **Wireless World**, involves the use of a series of active filters splitting the output of the pre-amplifier into three channels, of closely defined bandwidth, each of which is fed to the appropriate speaker by its own power amplifier. A design for a suitable 20-watt amplifier, based on a proven Texas circuit, was also described by Mr Read. The printed-circuit board for this has been designed such that three amplifiers may be stacked and mounted together on a common heat sink to achieve a conveniently compact module.

ACTIVE FILTER

Pack		
1	Fibreglass PCB (accommodates all filters for one channel)	£1.05
2	Set of pre-sets, solid tantalum capacitors, 2% metal oxide resistors, 2% polystyrene capacitors	£4.20
3	Set of semiconductors	£2.65

2 off each pack required for stereo system

SUITABLE ALSO FOR FEEDING ANY OF OUR HIGH-POWER DESIGNS

READ/TEXAS 20w amp.

Pack		
1	Fibreglass PCB	£0.70
2	Set of resistors, capacitors, pre-sets (not including O/P coupling capacitors)	£1.10
3	Sets of semiconductors	£2.40

6 off each pack required for stereo system

4	Special heat sink assembly for set of 3 amplifiers	£0.85
5	Set of 3 O/P coupling capacitors	£1.00

2 off packs 4, 5 required for stereo system

POWER SUPPLY

FOR 20W/CHANNEL STEREO SYSTEM

Pack		
1	Fibreglass PCB	£0.50
2	Set of rectifiers, zener diode, capacitors, fuses, fuse holders	£2.60
3	Toroidal transformer	£4.95

ENQUIRIES WELCOME
For quality sets of speakers

SEMICONDUCTORS AS USED IN OUR RANGE OF QUALITY AMPLIFIERS

2N699	£0.25	2N4302	£0.60	BC182L	£0.10	MJ481	£1.20	TIP29C	£0.71
2N1613	£0.20	2N5087	£0.42	BC184L	£0.11	MJ491	£1.30	TIP30C	£0.78
2N1711	£0.25	2N5210	£0.54	BC212L	£0.12	MJE521	£0.60	TIP31A	£0.60
2N2926G	£0.10	2N5457	£0.45	BC214L	£0.14	MPSA05	£0.30	TIP32A	£0.70
2N3053	£0.15	2N5459	£0.45	BCY72	£0.13	MPSA12	£0.55	TIP33A	£1.00
2N3055	£0.45	2N5830	£0.30	BD529	£0.85	MPSA14	£0.35	TIP34A	£1.50
2N3442	£1.20	40361	£0.40	BD530	£0.85	MPSA55	£0.35	TIP41A	£0.74
2N3704	£0.10	40362	£0.45	BDY56	£1.60	MPSA65	£0.35	TIP42A	£0.90
2N3707	£0.10	BC107	£0.10	BF257	£0.40	MPSA66	£0.40	IN914	£0.07
2N3711	£0.09	BC108	£0.10	BF259	£0.47	MPSU05	£0.60	IN916	£0.07
2N3819	£0.23	BC109	£0.10	BFR39	£0.25	MPSU55	£0.70	IS920	£0.10
2N3904	£0.17	BC125	£0.15	BFR79	£0.25	SN72721P	£0.58	5B05	£1.20
2N3906	£0.20	BC126	£0.15	BFY50	£0.20	SN72748P	£0.58		
2N4058	£0.12	BC182K	£0.10	BFY51	£0.20	TIP29A	£0.50		
2N4062	£0.11	BC212K	£0.12	BFY52	£0.20	TIP30A	£0.60		

*for further information please write for FREE LIST **NOW!***

V.A.T. Please add 8%* to all U.K. orders

(*or at current rate if changed)

U.K. ORDERS—Post free (mail order only)

OVERSEAS—Postage at cost + 50p special packing

Dept. WW12

POWERTRAN ELECTRONICS

PORTWAY INDUSTRIAL ESTATE
ANDOVER, HANTS SP10 3NN

-the lowest prices!

74 Series T.T.L. I.C'S

BI-PAK STILL LOWEST IN PRICE FULL SPECIFICATION GUARANTEED. ALL FAMOUS MANUFACTURERS

Type	1	25	100+
SN7400	0·18	0·17	0·16
SN7401	0·18	0·17	0·16
SN7402	0·18	0·17	0·16
SN7403	0·18	0·17	0·16
SN7404	0·22	0·21	0·20
SN7405	0·22	0·21	0·20
SN7406	0·39	0·34	0·31
SN7407	0·39	0·34	0·31
SN7408	0·25	0·24	0·23
SN7409	0·25	0·24	0·23
SN7410	0·18	0·17	0·16
SN7411	0·28	0·27	0·26
SN7412	0·30	0·29	0·28
SN7413	0·32	0·31	0·30
SN7416	0·40	0·39	0·38
SN7417	0·40	0·39	0·38
SN7420	0·18	0·17	0·16
SN7422	0·30	0·29	0·28
SN7423	0·40	0·39	0·38
SN7425	0·40	0·39	0·38
SN7426	0·40	0·38	0·36
SN7427	0·40	0·38	0·36
SN7428	0·45	0·42	0·40
SN7430	0·18	0·17	0·16
SN7432	0·40	0·38	0·36
SN7433	0·42	0·40	0·38
SN7437	0·45	0·42	0·40
SN7438	0·45	0·42	0·40
SN7440	0·18	0·17	0·16
SN7441	0·74	0·71	0·64
SN7442	0·74	0·71	0·64
SN7443	£1·20	£1·15	£1·10
SN7444	£1·20	£1·15	£1·10
SN7445	£1·98	£1·95	£1·90
SN7446	£1·20	£1·15	£1·10
SN7447	£1·10	£1·07	£1·05
SN7448	£1·10	£1·07	£1·05
SN7450	0·18	0·17	0·16
SN7451	0·18	0·17	0·16
SN7453	0·18	0·17	0·16
SN7454	0·18	0·17	0·16
SN7460	0·18	0·17	0·16
SN7470	0·32	0·29	0·27
SN7472	0·32	0·29	0·27
SN7473	0·41	0·39	0·35
SN7474	0·41	0·39	0·35
SN7475	0·60	0·58	0·56
SN7476	0·44	0·43	0·42
SN7480	0·74	0·71	0·64
SN7481	£1·30	£1·25	£1·20
SN7482	0·90	0·85	0·80
SN7483	£1·20	£1·15	£1·05
SN7484	£1·10	£1·05	£1·00
SN7485	£2·00	£1·90	£1·80
SN7486	0·35	0·34	0·33
SN7489	£4·00	£3·75	£3·50
SN7490	0·74	0·71	0·64
SN7491	£1·10	£1·05	£1·00
SN7492	0·74	0·71	0·64
SN7493	0·74	0·71	0·64
SN7494	0·85	0·82	0·75
SN7495	0·85	0·82	0·75
SN7496	0·96	0·93	0·86
SN74100	£1·50	£1·45	£1·40
SN74104	0·70	0·68	0·66
SN74105	0·70	0·68	0·66
SN74107	0·44	0·42	0·40
SN74110	0·60	0·55	0·50
SN74111	0·95	0·92	0·90
SN74118	£1·10	£1·05	£1·00
SN74119	£1·50	£1·40	£1·30
SN74121	0·50	0·48	0·45
SN74122	0·88	0·86	0·84
SN74123	£1·58	£1·54	£1·50
SN74141	0·85	0·82	0·79
SN74145	£1·58	£1·54	£1·50
SN74150	£2·50	£2·40	£2·30
SN74151	£1·10	£1·05	£1·00
SN74153	£1·20	£1·10	£1·00
SN74154	£1·98	£1·90	£1·75
SN74155	£1·20	£1·15	£1·10
SN74156	£1·20	£1·15	£1·10
SN74157	£1·20	£1·15	£1·10
SN74160	£1·73	£1·70	£1·65
SN74161	£1·73	£1·70	£1·65
SN74162	£1·73	£1·70	£1·65
SN74163	£1·73	£1·70	£1·65
SN74164	£2·20	£2·10	£2·00
SN74165	£2·20	£2·10	£2·00
SN74166	£2·35	£2·30	£2·25
SN74174	£2·00	£1·95	£1·90
SN74175	£1·40	£1·35	£1·30
SN74176	£1·60	£1·55	£1·50
SN74177	£1·60	£1·55	£1·50
SN74180	£1·60	£1·55	£1·50
SN74181	£5·00	£4·50	£4·00
SN74182	£1·50	£1·45	£1·40
SN74184	£2·40	£2·30	£2·20
SN74190	£2·15	£2·10	£2·00
SN74191	£2·15	£2·10	£2·00
SN74192	£2·15	£2·10	£2·00
SN74193	£2·15	£2·10	£2·00
SN74194	£1·90	£1·80	£1·70
SN74195	£1·80	£1·60	£1·40
SN74196	£1·78	£1·70	£1·65
SN74197	£1·73	£1·70	£1·65
SN74198	£3·45	£3·35	£3·20
SN74199	£3·10	£3·00	£2·90

Devices may be mixed to qualify for quantity price. (TTL 74 Series only) data is available for the above series of I.C.'s in booklet form. Price 35p.

INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price
UIC00=12±7400	0·55
UIC01=12×7401	0·55
UIC02=12×7402	0·55
UIC03=12×7403	0·55
UIC04=12×7404	0·55
UIC05=12×7405	0·55
UIC06=8×7406	0·55
UIC07=8×7407	0·55
UIC10=12×7410	0·55
UIC20=12×7420	0·55
UIC30=12×7430	0·55
UIC40=12×7440	0·55
UIC41=5×7441	0·55
UIC42=5×7442	0·55
UIC43=5×7443	0·55
UIC44=5×7444	0·55
UIC45=5×7445	0·55
UIC46=5×7446	0·55
UIC48=5×7448	0·55
UIC50=12×7450	0·55
UI351=12×7451	0·55
UIC53=12×7453	0·55
UIC54=12×7454	0·55
UIC60=12×7460	0 55
UIC70=8×7470	0·55
UIC72=8×7472	0·55
UIC73=8×7473	0·55
UIC74=8×7474	0·55
UIC76=8×7476	0·55
UIC80=5×7480	0·55
UIC81=5×7481	0·55
UIC82=5×7482	0·55
UIC83=5×7483	0·55
UIC86=5×7486	0·55
UIC90=5×7490	0·55
UIC91=5×7491	0·55
UIC92=5×7492	0·55
UIC93=5×7493	0·55
UIC94=5×7494	0·55
UIC95=5×7495	0·55
UIC96=5×7496	0·55
UIC100=5×74100	0·55
UIC121=5×74121	0·55
UIC141=5×74141	0·55
UIC151=5×74151	0·55
UIC154=5×74154	0·55
UIC193=5×74193	0·55
UIC199=5×74199	0·55
UICXI=25 Assorted 74's	1·55

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

LINEAR I.C.'s—FULL SPEC.

Type No.	Case		1	25	100+
72702	DIL	14	0·50	0·48	0·45
72709P	DIL	8	0·33	0·31	0·29
72709	DIL	14	0·35	0·33	0·30
72710	DIL	14	0·45	0·43	0·40
72741	DIL	14	0·40	0·38	0·35
72741C	TO-5	8	0·45	0·43	0·40
72741P	DIL	8	0·38	0·36	0·34
72748P	DIL	8	0·38	0·36	0·34
SL201C	TO-5	8	0·50	0·45	0·40
SL701C	TO-5	8	0·50	0·45	0·40
SL702C	TO-5	8	0·50	0·45	0·40
TAA263	TO-72	4	0·80	0·70	0·60
TAA293	TO-74	10	£1·00	0·95	0·90
TAA350A	TO-5	10	£1·85	£1·80	£1·70
µA703C	TO-5	6	0·28	0·26	0·24
µA709C	TO-5	8	0·35	0·33	0·30
µA711	TO-5	10	0·45	0·43	0·40
ZN414	TO-18	4	£1·20	—	—
TBA800	DIL	14	£1·50	—	—

DTL 930 SERIES LOGIC I.C's

Type	1	25	100+
BP930	0·15	0·14	0·13
BP932	0·16	0·15	0·14
BP933	0·16	0·15	0·14
BP935	0·16	0·15	0·14
BP936	0·16	0·15	0·14
BP944	0·16	0·15	0·14
BP945	0·30	0·28	0·25
BP946	0·15	0·14	0·13
BP948	0·30	0·28	0·25
BP951	0·70	0·65	0·60
BP962	0·15	0·14	0·13
BP9093	0·45	0·43	0·40
BP9094	0·45	0·43	0·40
BP9097	0·45	0·43	0·40
BP9099	0·45	0·43	0·40

DUAL-IN-LINE SOCKETS

14 & 16 Lead Sockets for use with DUAL-IN-LINE I.C's. TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No. 1–24 25–99 100up

555 i.c. 65p each

LOW COST No.			
BPS 14 " "	16p	14p	12p
BPS 16 " "	17p	15p	13p
BPS 8 pin type	15p	13p	11p

NUMERICAL INDICATOR TUBES

Type	Description	
3015F	Minitron 7 Segment Indicator ..	.. £1·50
MAN 3M	L.E.D. 7 Segment Display 0.127" High Characters ..	.. £1·90
CD 66	Side Viewing 'Nixie Type' Tube 16 mm.	£1·87
GR 116	Side Viewing 'Nixie Type' Tube 13 mm.	£1·70

3 TERMINAL POSITIVE VOLTAGE REGULATORS

TO.3 Plastic Encapsulation

µA7805/L129 5V (Equv. to MVR5) £1·76
µA7812/L130 12V (Equv. to MVR12V) £1·76
µA7815/L131 15V (Equv. to MVR15V) £1·76

BI-PAK

CATALOGUE & LISTS

Send S.A.E. and 10p

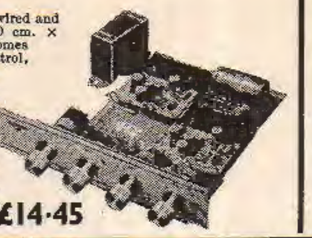
EDSR 3166 TRIPLE 66 BIT DYNAMIC SHIFT REGISTER TTL Compatible. Low Clock Capacitance, High Speed Diode Protected Inputs Wired 'OR' Capability SPECIFICATION SHEET AVAILABLE £2.50

TEAK VENEERED CABINET for: STEREO 20

TC 20. £3.95 p&p 30p

E.M.I. LEK 350 Loudspeaker System Enclosure kit in teak veneer, including speakers. Rec. retail price £45.50 per pr. OUR SPECIAL PRICE £30 per pair P.& P. £1. ONLY WHILE STOCKS LAST!

The STEREO 20



The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm. × 14 cm. × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls, Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20 has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz-25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble con. ±14dB at 14kHz. **£14·45**

SHP80 STEREO HEADPHONES, 4-16 ohms impedance. Frequency response 20 to 20,000 Hz Stereo/mono switch and volume controls £4.95

TRANSFORMERS

T461 (Use with AL10) £1·60 P. & P. 15p.
T538 (Use with AL20 & AL30) £2·30 P. & P. 15p.
BMT80 (Use with AL60) £2·75 P. & P. 25p

POWER SUPPLIES

PS 12. (Use with AL10, AL20 & AL30) 88p
SPM 80. (Use with AL60) £3·25

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridge while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm

PRICE £4·35

Frequency response—
20Hz–50KHz (—3dB
Bass control—
± 12dB at 60H
Treble control—
±14dB at 14KHz
*Input 1. Impedance
1 Meg. ohm
Sensitivity 300mV
†Input 2. Impedance
30 K ohms
Sensitivity 4mV

FRONT PANELS FP12 50p

NOW WE GIVE YOU 50w PEAK (25w R.M.S.) *PLUS* THERMAL PROTECTION! The NEW AL60 Hi-Fi Audio Amplifier FOR ONLY £3.95

- Max Heat Sink temp. 90°C.
- Frequency Response 20Hz to 100KHz
- Distortion better than 0.1% at 1KHz
- Supply voltage 15-50 volts
- Thermal Feedback
- Latest Design Improvements
- Load—3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm × 105mm .. 13mm

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

FULLY BUILT—TESTED and GUARANTEED

STABILISED POWER MODULE SPM80 £3·25

SPm80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BmT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2·15 p. & p. 25p

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL60 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages. Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB
Harmonic distortion	better than 0·1%
Inputs: 1. Tape head	3·25mV into 50KΩ
2. Radio, Tuner	75mV into 50KΩ
3. Magnetic P.U.	3mV into 50KΩ
Bass control	±15dB at 20Hz
Treble control	±15dB at 20kHz
Filters: Rumble (high pass)	100 Hz
Scratch (low pass)	8kHz
Signal/noise ratio	better than +65dB
Input overload	+26dB
Supply	+35 volts at 20mA
Dimensions	292×82×35 mm

All input voltages are for an output of 250mV. Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20kHz.

only £13·15

MK 60 AUDIO KIT

Comprising: 2×AL60, 1×SPM80, 1×BTM80, 1×PA 100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets. Complete Prices: £28·75 plus 30p postage.

TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16½"×11¼"×3¾", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets etc. Kit price: £9·95 plus 30p postage.

AL10/AL20/AL30 AUDIO AMPLIFIER MODULES

The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power device has resulted in a range of output powers from 3 to 10 watts R.M.S.

The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po=3 WATTS f=1KHz	0·25%
LOAD IMPEDANCE	—	8–16Ω
INPUT IMPEDANCE	f=1KHz	100 kΩ
FREQUENCY RESPONSE ± 3dB	Po=2 WATTS	50 Hz–25KHz
SENSITIVITY for RATED O/P	Vs=25V. Rl=8Ω f=1KHz	75mV. RMS·
DIMENSIONS	—	3"×2½"×1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL=8Ω f=1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.
PRICE	£2·50	£2·85	£3·20

All prices inclusive of V.A.T. Giro No. 388 - 7006
Please send all orders direct to warehouse and despatch department

BI-PAK

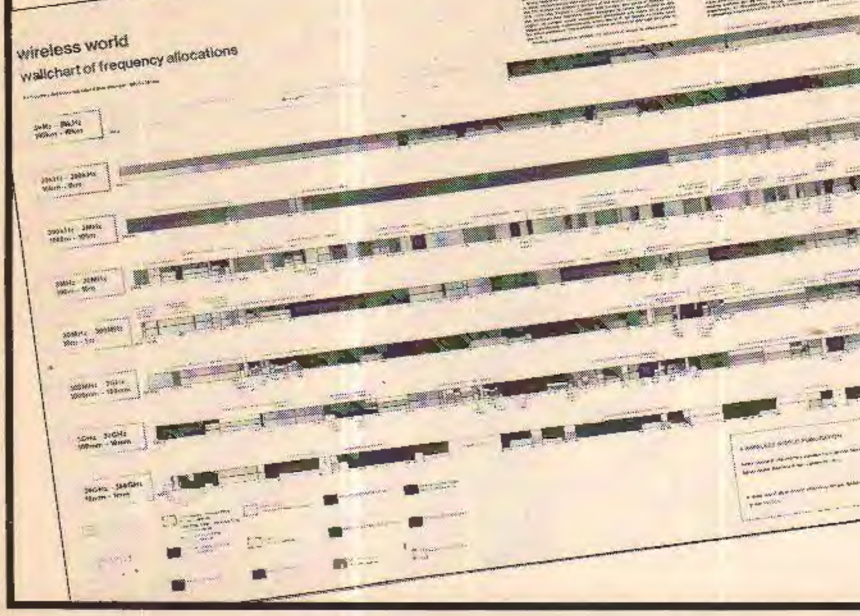
P.O. BOX 6, WARE · HERTS

Postage and packing add 15p. Overseas add extra for airmail Minimum order 55p. Cash with order please

Guaranteed Satisfaction or Money Back

Wireless World
FULL COLOUR WALLCHART OF FREQUENCY ALLOCATIONS
80p

The wallchart shows the allocation of frequencies within the radio spectrum ranging from 3 kHz to 300 GHz and is scaled on eight logarithmic bands contriving 15 main categories of transmissions which are identified by colours. All the important spot frequencies and 'special interest' frequencies are marked. The information is taken from the ITU and has been condensed into easily read chart form. Measures 2′ 11″ × 1′ 11″.



ORDER FORM

To: IPC Electrical-Electronic Press Ltd., General Sales Dept., Room 11, 32 Stamford Street, London SE1 9LU

Please send me .... copies of the Wireless World Wallchart of Frequency Allocations at 80p each inclusive.

I enclose remittance value £ .... (cheque/p.o. payable to IPC Business Press Ltd.)

Name ....
(please print)
Address ....

....

....

Registered in England No. 677128
Regd. office: Dorset House, Stamford Street, London SE1 9LU

Electronic Brokers a Happy Christmas and

FABULOUS Marconi

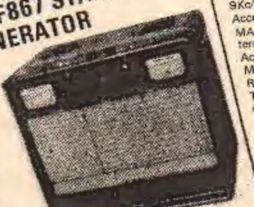
MARCONI Type TF144H STANDARD SIGNAL GENERATOR

Frequency range: 10kHz–72MHz. Crystal Check: 400kHz and 2MHz crystals. Stability: 0.002% in 10 minute interval.

Full specification available on request

£245

MARCONI TF867 STANDARD SIGNAL GENERATOR



Carrier Frequency Range: 15Kc/s–30Mc/s in 11 bands. Calibration Accuracy: ± 1%. Output Voltage: 0.4µV-4V. Impedance: 75 ohms nominal for outputs from 2-4V. 75 ohms for outputs from 4µV-2V. 13 ohms for outputs from 0.4µV-0.4V. Accuracy: below 3Mc/s ± 0.25dB to ± 0.1µV. 3–10Mc/s ± 0.5dB or 00.2µV. 10–30Mc/s ± 1.0dB or ± 0.5µV. Power Supply: 100–125V, 200–250V, 40–100c/s. Dimensions: 18 in. high x 21in. wide x 14½in. deep.

£139.50

ADD 8% VAT TO ALL PRICES

ADVANCE SQUARE WAVE GENERATOR SG21

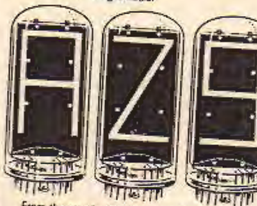
Frequency Range 9Kc/s to 100Mc/s. Rise time less than 1nS Ex-Demonstration. New condition in manufacturer's original carton.

9Kc/s to 100Mc/s continuously variable.
Accuracy ± 4%, ± 1% F.S.
MAIN OUTPUT 20mV–1V into 50 ohm external termination continuously variable.
Accuracy ± 5%.
Maximum output on open circuit 2V.
RISE TIME less than 1nS up to 500mV.
TRIGGER OUTPUT
0.2, 0.4, 1.0, 2.0V into 50 ohm external termination maximum output on open circuit 4V.
Rise time nominally 1.5nS.
Fall time nominally 3.5nS.
Size: 11inW, 5½inH, 9inD.
Wt. 7.1 lb.
LAST LISTED PRICE £95

OUR PRICE £35 P/P £1.50
Also available SG21A 100Kc/s–30Mc/s.

ALPHANUMERIC NIXIE TUBES B7971

The Alphanumeric NIXIE tube has the ability to display all the letters of the alphabet, numerals 0 thru 9 and special characters in a single tube.



From the standpoint of both readability and electrical characteristics, the Alphanumeric NIXIE tube provides many unique benefits including
★ 170V–21mA
★ All DC operation ★ Uniform, continuous line characters of equal height
★ Memory with simple solid state drive circuits ★ Readability in high ambient light . . . 200 footlamberts brightness
★ Long life with no loss of brightness
★ Character height 2½ins.

Price only **99p** each plus 16p

Bases for above 50p each.

HERE! NOW! FOR IMMEDIATE DELIVERY!

AVO7 £19.50

Fully tested and checked, guaranteed 12 months with one free calibration.

Leads and batteries extra. Leather cases for above £3.50. Ever-ready case enables the meter to be used while in its case £5.

THE REVOLUTIONARY SUPERTESTER 68OR

FOUR INTERNATIONAL PATENTS – SENSITIVITY 20,000 Ohms per Volt 10 FIELDS OF MEASUREMENT AND 80 RANGES. ACCURACY 1% in D.C. 2% in A.C.

OUTSTANDING FEATURES: 20,000 Ohms per Volt sensitivity ● Fully screened against external magnetic fields ● Scale width and small case dimensions (128 × 95 × 32mm) ● Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading ● Simplicity and ease of use and readability ● Full range of accessories ● 1.000 times overload ● Printed circuit board, is removable without de-soldering ● More ranges than any other meter. VOLTS A.C. = 11 ranges: 2–10–50–250–1000–2500. Volts and **4–20–100–500 and 2000 Volts.** VOLTS D.C. = 13 ranges: 100mV–2V–10–50–200–500–1000 **Volts 200 mV–4V–20–100–400 and 2000 Volts** AMP D.C. = 12 ranges: 50µA–500µA–5 mA–50 mA–500 mA–50 Amp and **100µA–1 mA–10 mA–100 mA–1 Amp and 10 Amp.** AMP. A.C. = 10 ranges: 250µA–2.5 mA–25 mA–250 mA–2.5 Amp and **500µA–5 mA–50 mA–500 mA–5 Amp.** OHMS REACTANCE = 6 ranges: **x1–x10–x100–x1000–x0.000 and Low Ohms.** DETECTOR = 1 range: from 0 to 10 Megaohms. FREQUENCY = 2 ranges: from 0 to 500 and from 0 to 5000Hz. V. OUTPUT VOLTAGE = 9 ranges: 10–50–250–1000–2500 V and **20–100–500–2000 Volts.** DECIBELS = 10 ranges: from −24 to +70 db. CAPACITY = 6 ranges: from 0 to 50,000 and from 0 to 500,000 pF using the mains and from 0 to 20, from 0 to 200, from 0 to 2,000 and from 0 to 20,000 Micro farad using the incorporated 3 Volts battery. **Bold figures indicate depress button.**

£18.50 with shockproof case

Accessories available to convert Supertester 68OR into following: SIGNAL INJECTOR, GAUSS METER, ELECTRONIC VOLTMETER, AMPERCLAMP, TRANSISTOR TESTER, TEMPERATURE PROBE, PHASE SEQUENCE INDICATOR— Send for details.

TOP VALUE AC/DC MULTI-METER

With taut band suspension movement Sensitivity 20.000 ohms per volt on DC and 4.000 ohms per volt on AC.
Technical Data:
0.06-0.6-6-60-600mA-3 Amps DC. 0.3-3-30-300mA-3 Amps AC. 0.6-1.2-3-12-30-60-120-600 DC. 1200 Volts. 3-6-15-60-150-1300-600-900 Volts AC. 45 to 20,000 Hz.
500Ω. 5-50-500kΩ resistance. Decibel range −10 to −12dB. Accuracy (% of F.S.D.):—DC and resistance measurements −2.5. Price with test leads, and storage case **£8.85**

UNIQUE MULTI-METER/ SIGNAL GENERATOR

Taut suspension movement. Simple multimeter combined with audio/I.F. Test Oscillator providing AC and DC Voltage ranges. D.C. current ranges and resistance ranges. 1kHz and 465kHz oscillator output makes the instruments suitable for general tuning of receivers etc.
Scale length: 65mm. D.C. voltage ranges: 0.5, 2.5, 10, 50, 250, 500, 1000V. A.C. voltage ranges: 2.5, 10, 15, 250, 500, 1000V. D.C. current ranges: 0.05, 0.5, 5, 50, 500mA. Sensitivity: 20,000Ω/V. Resistance ranges: 5–1000Ω mid-scale reading 50Ω 50Ω 10k; mid-scale reading 500Ω, 500Ω-100kΩ; mid-scale reading 5kΩ 5kΩ-1mΩ mid-scale reading 50kΩ.
Accuracy: 5% of F.S.D. Internal battery: 3V dry cell.
Oscillator output: 1kHz squarewave. 465kHz sinewave modulated by 1kHz squarewave signal. Output voltage: 1V minimum.
Overall dimensions: 160 × 97 × 40mm. in carrying case, complete with test leads.

AMAZING VALUE £7.50

SPECIAL OFFER OF COLOUR T.V. AND F.M. MEASURING EQUIPMENT BY WANDEL AND GOLTERMANN

VZM1 Measuring set for measuring phase and amplitude modulation distortion for Colour T.V. Sub carrier (PAL Systems)

£495.00

VZM2 Measuring set for measuring phase and amplitude modulation distortion for Multichannel FM radio systems with base bands up to 12 Mc/s.

£295.00

VZM83 Generator and Receiver used to measure transmission distortion on FM radio link systems. Superimposed signal 52/304/556kHz.

£275.00

PROGRAMME BOARDS BY SEALECTRO

These boards are basically a multi-pole multi-throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either, shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 2 planes. 24 × 50 **£29.** 20 × 11 **£15.**

Pins now available at 15p each.

Stop Press

TEKTRONIX 453A Listed at over £1300.
Special Offer this month £795.

SPECIAL OFFER OF TELEPHONE CARRIER TEST EQUIPMENT

An unusual offer of a system up to 15 Mc/s for the measurement of level attenuation on telephone carrier equipment and wide band radio relay systems.
SIEMENS sweep frequency system consisting of: 3W518 Level Oscillator 10 Kc/s–17 Mc/s; 3D335 Level Selective Meter 10 Kc/s–17 Mc/s; 3W933 Sweep Attachment; 3D346 Large Screen Level Tracing Receiver. Offered as a complete system as a 32M701.
Special Offer less than Half-Price
Enquire for individual items P.O.A. **£1950.00**
Also available manual point to point system consisting of:
3W518 Selective Level Oscillator 10 Kc/s–17 Mc/s
3D335 Selective Level Meter 10 Kc/s–17 Mc/s
Price Per Pair **£950.00**

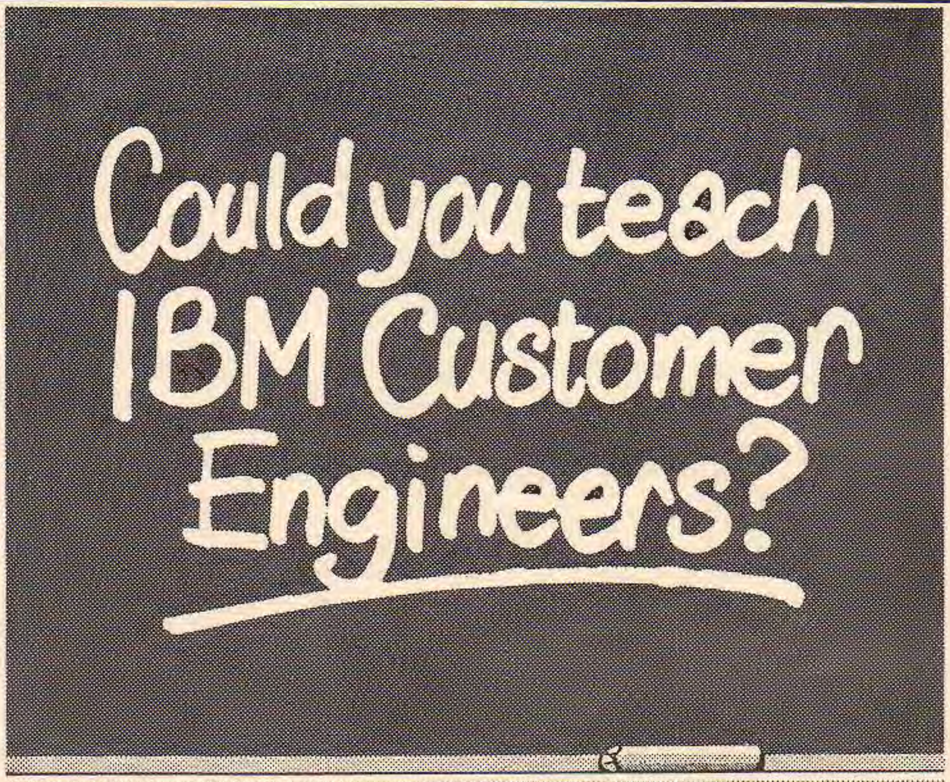
JUST ARRIVED!! NUMERIC INDICATOR TUBES

ultra-long life, high quality, 0-9 and 2 independent decimal points. Supply voltage 200V D.C. Current 14mA. Pulse duration 100µs. Characture height 0.51, overall size 1.4. Brand new, guaranteed. Surplus to manufacturers requirements. Type B5853st. Price 1–25 **£1.00**, 25+ **90p**, 100+ **80p**, 1000+ price on application.

APPOINTMENTS VACANT

DISPLAYED APPOINTMENTS VACANT: £4.68 per single col. centimetre (min. 3cm).
LINE advertisements (run-on): 66p per line (approx. 7 words), minimum two lines.
BOX NUMBERS: 30p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.)
PHONE: Allan Petters on 01-261 8508 or 01-261 8423.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Advertisements accepted up to 12 noon Wednesday, December 4th for the January issue subject to space being available.



We have a number of opportunities for instructors to train our customer engineers to service and maintain data processing equipment including the latest 370 Systems and Software.

If you're an experienced or potential instructor with a background in software and/or electronics, educated to HNC, C & G standard or perhaps you've had similar service experience – now's the chance to find out more about these secure, well paid positions, offering excellent salaries, career development prospects and in depth training.

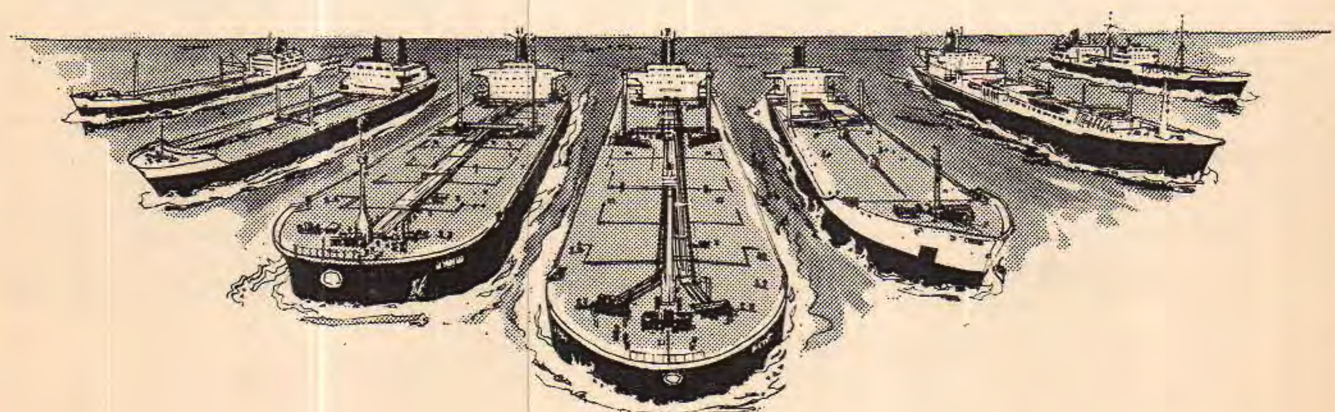
If you are interested please write to:
Anne Dare, IBM United Kingdom Limited,
389 Chiswick High Road, London W4 4AL.
Quoting ref: WW/92414.

IBM

14276

Radio/Electronics Officers

Does it make sense to settle for second best?



When you're thinking about your career and your family's future, it would be wise to think of Shell. Whether you're in the service now or ashore for the time being, you will already know a lot about us. Our British flag fleet of about 80 ships (with more on the way) is widely diversified, carrying many different cargoes—bitumen, luboils, crude, LNG, chemicals and black and white products. That means that you don't have to be stuck in one particular kind of tanker for long periods. You can move up and move around with equal familiarity. Our large and increasing investment in training underwrites our determination to ensure that we will achieve our intended service periods of 4½ months, and underlines our confidence in the future of the Fleet.

When it comes to pay, you'll find our salaries are highly competitive. You can earn between £2,972 (with general certificate and DTI radar certificate) and £6,156 (including MNTB electronics certificate). Your experience and qualifications will determine the point at which you can enter this scale. Leave too is generous—at the rate of 183 days per year served. All officers are members of the company pension scheme and certificated officers can take their wives to sea whenever they wish, which includes two free air fares a year. If you are returning to the service after a spell ashore or already in service, we'll be pleased to tell you all about the extra benefits that Shell can offer you as a Radio/Electronics Officer in our fleet. Write or phone, reversing the charges:

Shell Tankers (UK) Limited,
STP/13, (WW/12/74)
Shell Centre,
London SE1 7PQ.
Tel: 01-934 4172 or 3968.

T.V. Test Engineers & Technicians

As one of the largest manufacturers of T.V. and audio equipment, ITT can offer excellent opportunities to experienced Test Engineers as a result of continuing expansion of the colour T.V. Test Department at their Radlett Works.

These are responsible positions involving diagnosis of faults on colour T.V. chassis; assessing performance of chassis against specifications and standards; maintaining fault records and reporting quality trends.

ONC Electronics or C & G Final Certificate with colour endorsement is desirable coupled with several years' experience in a T.V. Test or Service Department. The ability to supervise and co-ordinate the work of a team of Test Technicians and assist in their training would be an advantage.

Test Technicians are also required to carry out testing, alignment and fault finding on chassis.

A good salary will be offered together with generous additional benefits including assistance with relocation, where appropriate.

Write with details of your experience to Mrs. J. D. Calnan, ITT Consumer Products (UK) Limited, Radlett Works, Colney Street, St Albans, Herts, AL2 2EG.

Colour Television **ITT**

4206

Radio Operators. How to see more of your wife without losing sight of the sea.

Join the Post Office Maritime Service. We have openings for Radio Operators at several of our coastal stations.

The work is just as interesting, just as rewarding as aboard ship, but you get home to see your wife and family more often. You need a United Kingdom General or First Class Certificate in Radiocommunications, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting pay for a man of 25 or over is £2,270, plus cost of living allowance with further annual increases after that. Though we're happy to take people from 19 up.

In addition to your basic salary, you'll get an average allowance of £450 a year for shift duties and there are opportunities for overtime.

Other benefits include a good pension scheme, sick pay and prospects of promotion to Senior Management.

For more information, write to: ETE Maritime Radio Services Division (L529), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London, EC1A 1AS.

Post Office Telecommunications

193

Customer Engineers

As one of the largest and most successful computer manufacturers, we place particular importance on the maintenance of a high level of customer service. Our equipment is among the most advanced in the world today. Highly sophisticated hardware used by top companies and organisations in commerce, industry, science and government.

Our Customer Service organisation is, therefore, immensely important to us if we are to maintain the high standards we have set ourselves over the years, during which we have pioneered much of the advanced technology in use today throughout the industry.

We're looking for Customer Engineers to carry out, to a high professional standard, all electronic and electro-mechanical work concerned with installation, modification, refurbishing, preventive and remedial maintenance on Sperry Univac equipment in the UK.

We require men with a knowledge of electronic or mechanical fault-finding techniques. In addition to technical competence, essential requirements are a pleasant personality and the ability to maintain a good relationship with customers. Full product training will be given.

To Engineers looking for the best in salaries, vacancies exist in most parts of the country. Conditions and fringe benefits are what you would expect when you join a company within the international Sperry Rand organisation. Future career prospects in the computer field are excellent.

For vacancies in London or the South write with full personal and career details to Personnel Manager, Ref. WW, Sperry Univac, Univac House, 160 Euston Road, London NW1. Telephone 01-387 0911. For vacancies in the Midlands and North write with full personal and career details to Personnel Manager, Ref. WW, Sperry Univac, Lynnfield House, Church Street, Altrincham, Cheshire. Telephone 061-928 7731.

SPERRY UNIVAC

PROFIT FROM EXPERIENCE

13733

Test Gear Engineers

Consumer Electronics

ITT, one of Europe's leaders in the field of consumer electronics, has achieved an enviable reputation for the high quality of its range of audio products and monochrome and colour TV.

At Hastings we can offer excellent scope to Test Gear Engineers within the Industrial Engineering Department.

Assistant Chief Engineer

To deputise for the Chief Engineer – Test Gear and co-ordinate the Test Gear Department in respect of appraisal of test gear requirements for new R & D designs; design, development and manufacture of all test gear and its installation in the factory and at sub-contractors. In addition, he will be responsible for budgeting and project appropriation and all maintenance activities on test gear installations.

This position calls for an HNC and at least five years' experience in the organisation and design of complex test equipment in the consumer electronics industry.

Senior Test Gear Engineer

Reporting to the Chief Engineer –Test Gear, he will be responsible for supervising a team of test gear engineers engaged in installation and both routine preventative and emergency breakdown maintenance of all test equipment at Hastings and satellite locations.

Essential requirements are HNC coupled with several years' experience at senior level maintaining electronic equipment, covering audio to UHF frequencies and pulse techniques.

Attractive salaries will be offered together with a wide range of benefits including pension/sickness schemes and assistance with relocation expenses, where appropriate, to this particularly pleasant area. The Company is situated close to the sea with some of the most attractive countryside in the South East on the doorstep.

Write with details of your qualifications and experience to David Harris, Personnel Officer, ITT Consumer Products (UK) Limited, Theaklen Drive, Hastings, Sussex.

The heart of Hastings **ITT**

[4278

SONY®

V.T.R. Service Engineers

Our expanding Video Tape Recording business creates vacancies for experienced V.T.R. Service Engineers.

Based at our Central Service Division, Ascot Road, Bedfont, near Ashford, Middlesex, successful applicants will carry out service repairs in the workshop to Video Recorders, Video Cameras and Professional Microphones. Preference will be given to those with previous V.T.R. experience, but, alternatively, we would be interested in top quality Colour TV Engineers with Tape Recorder experience.

Attractive salaries will be commensurate with experience and qualifications. Interested service engineers are invited to apply with details of past experience and current salary, or ask for an application form, to:

The Personnel Officer, SONY (U.K.) LIMITED, Pyrene House, Staines Road West, Sunbury-on-Thames, Middlesex. Tel: Sunbury 87644.

[4218

SENIOR TELEVISION ENGINEER

for

OB Unit for horseracing

We need a qualified and experienced TV Engineer to take engineering charge of a travelling OB Unit employed on the surveillance of horseracing. Must be familiar with broadcast standard OB practice and VTRs.

Salary £3,600-£4,200 p.a. depending on experience plus expenses on location.

Write or telephone for application form to:

Frank Dixon,
Racecourse Technical Services Limited,
88 Bushey Road, Raynes Park SW20 0JH
Tel: 01-947 3333

[4251

ELECTRONIC ENGINEERS

Ferranti in Edinburgh have a variety of vacancies for Electronic Engineers involving work on avionic systems. This includes production testing and maintenance, quality and test engineering and environmental testing.

Candidates with Services or industrial experience and knowledge of some of the following areas of technology would be particularly relevant:
Digital and Analogue Techniques
Microwave Engineering
Servo Techniques
Lasers and Optics
Electronic Displays

We are particularly interested in people with the following qualifications:
O.N.C., H.N.C.
City & Guilds Telecommunications Technician Course, Intermediate or Final Certificates, or Acceptable Services equivalent.

Those recently qualified with H.N.D. (Mechanical or Electrical) but who lack industrial experience should also apply. These posts are based in Edinburgh which offers an attractive living environment with many recreational activities within easy reach.

The Company operates a contributory Pension and Life Assurance Scheme and will assist with relocation expenses where necessary and priority will be given to incoming workers for Scottish Special Housing.

Salary negotiable £1800—£3000.

Apply in writing giving particulars of qualifications and experience to the
STAFF APPOINTMENTS OFFICER
FERRANTI LIMITED
FERRY ROAD
EDINBURGH EH5 2XS.

FERRANTI

4239

ELECTRONIC VACANCIES

Engineers
Draughtsmen ● Designers
Service and Test Engineers
Technicians ● Technical Authors
Sales Engineers

£1,600-£5,000 pa

Permanent or Contract

01-387 0742
MALLA TECHNICAL STAFF LIMITED
376 Euston Rd., London NW1 3BG

95

Radio Technology
TELECOMMUNICATIONS OFFICER

. . . to work in the Broadcasting Branch of the Directorate of Radio Technology, Central London which gives technical advice on the development of TV, sound and wired broadcasting systems, carries out the technical appraisal of new broadcasting stations' characteristics, prepares frequency plans and negotiates frequency assignments for broadcasting stations. It also participates in the work of the International Radio Consultative Committee and international conferences.

Candidates (aged at least 23) must have ONC in Engineering (with a pass in Electrical Engineering 'A') or in Applied Physics, or an equivalent qualification. In addition they should normally have had at least 5 years' relevant experience.

Salary starting between £2,700 and £3,230 (according to age) and rising to £3,450. Good prospects of promotion. Non-contributory pension scheme.

For full details and an application form (to be returned by December 10, 1974), write to Civil Service Commission, Alencon Link, Basingstoke, Hants, RG21 1JB, or telephone BASINGSTOKE 29222 ext 500 (or, for 24-hour answering service, LONDON 01-839 1992). Please quote reference T/8796.

HOME OFFICE

4254

Papua New Guinea

Radio Technical Officers

Applications are invited from suitably qualified and experienced personnel for the posts of Technical Officer (Radio) and Senior Technical Officer (Radio) with the Civil Aviation Agency of the Department of Transport. There are twelve positions available working on the installation and maintenance of a variety of electronic communications equipment and appointments will be made at three levels of seniority based on experience and qualifications.

Candidates should have successfully completed City and Guilds Technician Courses, Part III Full Technological Certificate or HNC. A minimum of 6 years' relevant experience is required, with at least 3 years' involvement in a field of radio work closely related to civil aviation communications.

Conditions of service

Period of engagement is for two years (renewable in most instances). General entitlements are very attractive and include a generous gratuity (approx. 25% of salary combined with attraction allowance), education allowance for dependent children attending school overseas, return air passages with personal effects and luggage allowance, low cost married and single accommodation, and generous leave conditions.

Pay per annum

Expressed in $A. Current rate of exchange $A1.76 = £1.00 approx.

Level	*Salary*	*Attraction Allowance*	*Gratuity*
TO1	2385	4460	1910
TO2	2625	5205	2230
STO1	3105	5225	2230

Please write or telephone immediately for an application form and full details of the posts. The Papua New Guinea Public Service Board Representative, 22 Garrick Street, London W.C.2. Telephone: 01-240 1780.

Papua New Guinea

Papua New Guinea

[4277

T.V. Engineers for New Zealand

Are you dissatisfied with your present position, feeling like a change of scene? Do something about it now! Be our guest—come down under and join the Tisco Team, N.Z.'s largest service organisation.

We are in service only and our engineers are all important people, every one of our 30 managers is an ex engineer.

We are now selecting staff to sponsor under the Immigration Scheme to arrive in N.Z. mid 1975.

If you,

- Have 5 years experience, preferably some in colour.
- Single or married with 3 children or less.

write now enclosing a photograph and details of past experience to:- **The Technical Staff Supervisor, Tisco Ltd, Private Bag, Royal Oak, AUCKLAND, NEW ZEALAND.**

[4070

CHELSEA COLLEGE

University of London

ELECTRONICS TECHNICIAN GRADE 2B required for the construction and maintenance of equipment and apparatus and to assist in the running of Electronics Undergraduate Teaching Laboratory. Day release for approved courses. Salary scale (under review) £1,752—£2,022 per annum including London Allowance, plus payments under a Threshold Agreement (at present approximately £146 per annum). 37½ hour week, generous holidays. Application forms and further details from Mr. M. E. Cane (2B. ET) Chelsea College WW, Pulton Place, Fulham, London SW6 5PR.

[4230

ANGLIAN WATER AUTHORITY

Lincolnshire River Division

ELECTRONIC INSTRUMENT TECHNICIAN

Grade T7 (£2,715—£3,018)

Plus Threshold Payments

Applicants should have a recognised qualification in electronic engineering preferably registered as a Technical Engineer and have obtained experience in workshop techniques, servicing and design practice. Experience in experimental work and a knowledge of measuring techniques would be an advantage.

Local Government Conditions of Service apply. Removal expenses and lodging allowance in appropriate cases. Application forms from the undersigned to be returned by 2nd December, 1974.

50 Wide Bargate, Boston, Lincs. — D. I. Rollett, Divisional Manager

[4269

BRUSSELS

The Technical Centre of the European Broadcasting Union is seeking an

EDITORIAL ASSISTANT

for duties entailing the processing of English editions of the E.B.U.'s technical periodicals from source material to publication.

This post with good prospects would suit a young Engineer or Technician of English mother-tongue, with experience in telecommunications—preferably broadcasting—and the ability to produce documents in faultless English from English and French material, as well as translations of technical reports and correspondence. A higher-than-average proficiency in the French language is evidently essential.

The starting salary will be not less than 400.000 Belgian francs per annum, depending upon age and experience. Candidates should write giving details of education and experience to:

The Director
Technical Centre of the
European Broadcasting Union,
Avenue Albert Lancaster 32
B-1180 Brussels (Belgium)

[4236

LEEDS CITY COUNCIL
Department of Education

AUDIO ENGINEER

(Ref. 13/20)

T3 £2187–£2538

Plus £3.20 per week Threshold

Leeds Polytechnic
Educational Technology Unit

To work with production team in the operation of the colour television studio and related recording facilities and to assist with the maintenance of equipment.

Application forms (quoting (Ref. No.) together with further details from the

ADMINISTRATION OFFICER
LEEDS POLYTECHNIC
CALVERLEY STREET
LEEDS LS1 3HE

to whom the forms should be returned.

[4243

Electronics Engineers up to £5000

Many jobs which would suit you down to the ground – either in the U.K. or overseas – are never advertised. Yet it will cost you nothing whatever to give yourself the opportunity to be considered for them.
Join the Lansdowne Appointments Register – used by hundreds of employers to select electronics engineers. You have nothing to lose, everything to gain – and it's all conducted in strict confidence. So post the coupon – find out exactly how you can make use of a service which is all the more valuable for being free!

To: Stuart Tait, Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 6585 (anytime – 24 hour answering service).

Please send me further details.

Name ....

Age (20-45 only) ....

Address ....

.... WW/18/11

lansdowne Appointments Register

97

Electronics Test Engineers: career openings that affect all sorts of people...

. . . you most of all, naturally. Mainly because, by joining the world's largest exporter of radio-telephone equipment you will inevitably open up for yourself career advantages that very few companies can provide. Pye Telecom is growing at an ever-increasing rate – and the potential for its products has as yet been only fractionally utilised.

But the work you do will also be vital to an incredible number of others. Very frequently, life itself depends on the efficiency of the UHF and VHF equipment you'll be working on. Police, firemen and ambulance staff are a small sample of the extensive range of users. Which explains the exacting specifications of the test procedures in operation – and why previous fault-finding and testing experience is an essential requirement. If it relates to communications equipment, so much the better, but this is not absolutely essential. More important is practical proficiency, which may well have been gained in the armed forces. Relocation assistance is available and there is the possibility of Local Authority Housing being available.

Find out more right now by phoning or writing to Mrs Cath Dawe at:

Pye Telecommunications Ltd
Colne Valley Road, Haverhill, Suffolk CB9 8DU
Telephone: Haverhill 4422

A member of the Pye of Cambridge Group

[4249

BBC

ENGINEERING DESIGNS DEPARTMENT

A number of posts are available in Central London for enthusiastic and forward thinking young students to train as

TECHNICIANS

in the laboratories of the BBC's Designs Department. Their work will include assisting engineering and laboratory staff in the development, construction and testing of units of sound and television broadcasting equipment.

The successful candidates will probably be aged 18-20 and have a keen interest in, and possibly some experience of, electronics. They will have some 'O' levels—two preferably will be scientific—and they will be either recently qualified to O.N.C. or City & Guilds Part II standard, or have recently commenced the final year of such a course. Day release to complete the course will be given. Subsequent training to I.E.E.T.E. standard is by full time BBC courses at its Engineering Training Centre.

The salary offered would depend upon experience and qualification on appointment and would be between £1,872 p.a. and £2,064 p.a. It would rise by £96 p.a. to a maximum of £2,352 p.a. Satisfactory trainees could expect to be selected within two years for more senior Laboratory Technician posts whose salaries can progress to £2,697 p.a. £3,054 p.a., or £3,507 p.a. (These figures include £120 p.a. London Weighting, which is under review.)

Request for application forms to The Engineering Recruitment Officer, BBC, Broadcasting House, London, W1A 1AA, quoting reference 74.E.4092/WW and enclosing self addressed envelope at least 9in. x 4in. Closing date for completed application forms is 14 days after publication.

[4211

COUNTY OF SOUTH GLAMORGAN
DEPARTMENT OF ENVIRONMENT AND PLANNING

Senior Assistant ENGINEER

SO/PO(1) £3201–£3729 p.a.

Plus Threshold Payment

This senior post is in the County Surveyor's Division and applicants will be required to assist in the design of an Area Traffic Control Scheme for the City. Applicants should preferably be familiar with computer systems, data transmission and closed circuit television, and must hold an appropriate qualification in this field in accordance with the National Scheme.

A contribution of up to £500 toward removal and associated expenses will be considered in appropriate cases.

Application forms are obtainable from: The Personnel and Management Services Officer, Floor 9, County H.Q., Newport Road, Cardiff. (0222 499022). Closing date 2nd December, 1974 and applicants should quote reference S212.

[4221

FOREIGN AND COMMONWEALTH OFFICE

COMMUNICATIONS DIVISION

Has a continuing commitment for

BROADCAST RELAY ENGINEERS

To serve a one year (unaccompanied) tour of duty on the island of Masirah (off the coast of Oman). Applications are invited from engineers with experience of the operation and maintenance of high-powered radio transmitters, and who hold a third year City and Guilds Certificate in Telecommunications or its equivalent.

SALARY: £6,563 per annum, plus a tax free allowance of £480 per annum for a single officer, or £985 per annum for a married unaccompanied officer.

Free furnished accommodation and passages are available.

For an application form and further details, please write to:

Recruitment Section
Foreign and Commonwealth Office
Hanslope Park, Hanslope
Milton Keynes MK19 7BH

[4215

CHIEF ENGINEER

The North West State of Nigeria requires a chief engineer, based in Sokoto, for a new Colour Television Service.

Candidates should have experience in the operation and maintenance of P.A.L. Colour Television Studio, Outside Broadcast, Microwave Link and VHF Transmitters equipment.

Apply in writing to:

DWA

DAVID WHITTLE ASSOCIATES
Communications, Electronics & Television Consultants

Grays Redlynch Salisbury Wiltshire UK

[4227

VID-COM LTD

VIDEOTAPE EDITOR

Vid-Com, New Zealand's rapidly growing independent video facility require an additional VTR Editor.

Facilities include four Ampex 1200c VTRs, Mark I Editec, an EECO Time Code system, HS-100 Video Disc, Fernseh studio and hand-held cameras, a Grass Valley N1600 Vision Mixer and a self-contained mobile OB VTR unit. Present staff size—26 people.

Major activities involve production of commercials and programmes for broadcast as well as various CCTV projects.

The applicant must be a fully trained skilled VTR operator/editor and experience as a technician would be helpful though not essential.

Salary is negotiable in the range of $NZ 7,000 per annum and overtime and meal allowance will apply.

As an independent facility we are not subsidized by Government or advertising revenue and it is the end result of our production efforts that counts.

The successful applicant must be willing to offer a sense of responsibility and service to our customers as well as providing technical ability. The applicant, if qualified, will also have the opportunity to assume the position of Deputy Chief Engineer.

Enquiries should be directed to:

The General Manager,
Vid-Com Ltd.,
P.O. Box 1409, Auckland, New Zealand.

4209

TONGA SUPERVISING BROADCASTING TECHNICIAN

required by the Tonga Broadcasting Commission to be responsible for the operation and maintenance of the Commission's two 10 Kilowatt sound transmitters, to install and maintain studio equipment, to run a radio retail store involving technical supervision in purchasing, selling and repairing of receivers and other equipment.

Candidates, under 55 years of age, MUST have a City and Guilds Telecommunications Technician Final Certificate Course 271 or equivalent with ten years' experience in the operation of studio and transmitter equipment as well as in all aspects of a small broadcasting station with particular emphasis on sound transmitters. Salary in scale £2,125 to £3,400 pa which includes an allowance normally tax free in scale £504 to £1,404 pa and 20% Cost of Living Allowance. Gratuity 20% of Local Salary. Tour of two years.

Benefits include free passages, Government housing at moderate rental. Holiday visit passages and generous paid leave. An appointment Grant of £300 and Car Loan of £600 may be payable.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Ministry of Overseas Development.

For further particulars you should apply, giving brief details of experience to

crown agents

M Division, 4 Millbank, London SW1P 3JD, quoting reference number M2K/740928/WF.

[4258

CHELSEA COLLEGE
University of London

TECHNICIAN GRADE 4

required to run Physics Second and Third Year Undergraduate Teaching Laboratory. Duties include the development, construction and maintenance of Physics teaching apparatus and a good knowledge of electronics is required.

Salary (under review) £2,076 to £2,391 including London Allowance, plus payments under a Threshold Agreement (at present £167 per annum).

Application forms and further details from Mr. M. E. Cane (4.PT), Chelsea College, WW, Pulton Place, Fulham, London SW6 5PR.

[4250

FIELD SERVICE ENGINEER

required for the Electronics Department of Lithographic Printers. Good rates and prospects of promotion for the right man.

KINGPRINT LTD.
Electronics Division,
ORCHARD ROAD, RICHMOND,
SURREY. Tel: 876 1091

[4265

Public Address Engineer

Experienced man with high standards required in the Public Address and Sound Recording field, capable of organising and operating temporary P.A. Systems covering conferences etc. Basic knowledge of electronics, tape editing and recording useful. Smart appearance (conventional dress) essential. Reliable driver—living central London—Age 24-40. Salary negotiable—Full details to:

G. HANSEN,
Griffiths Hansen (Recordings) Ltd,
12 Balderton Street,
London, W1F 1TF.
Telephone 01-499 1231/2.

[4225

DEVELOPMENT ENGINEER

required for an expanding company servicing the printing industry. First class rates of pay. Pension scheme and good prospects for the right man.

KINGPRINT LTD.
Electronics Division,
ORCHARD ROAD, RICHMOND,
SURREY. Tel: 876 1091

[4266

TELEVISION ENGINEER

A vacancy occurs for an additional TV. Engineer with an expanding Rental and Retail company. Applicant will preferably have some colour experience. Large s/c flat available after trial period. Salary according to experience.

Hydes of Chertsey Ltd.,
56/60 Guildford Street, Chertsey 63243

[39

£2,000—£2,500

p.a. BASIC to

REPAIR ENGINEER

ACCORDING TO ABILITY

for servicing audio and photographic (electronic flash) equipment, etc.

AXCO INSTRUMENTS LTD.

(Tel: 01-346 8302)

228, Regents Park Road, Finchley N3 3HP

[4210

INTEROFFICE TELEPHONES LIMITED

An opportunity exists to join our Sound and Time Section to maintain in London/H. Counties various types of Radio/Amplifiers. Some knowledge of Impulse Clock Systems and direct speech installations would be an advantage.

Please telephone for an appointment.

01-274 3214/5
01-274 5091 [4275

REQUIRED—EXPERIENCED ENGINEER

for high quality tape recorders as well as sound projection equipment. Salary negotiable.

Apply:
AV DISTRIBUTORS (London) LIMITED,
26 Park Road, London NW1 4SH
Phone: 01-935 8161.

[4213

APPOINTMENTS

ELECTRONIC EXPERIENCE WANTED. Engineers, technicians or testers required to assist teams preparing electronic equipment manuals. Writing experience preferable but not essential. Interesting work on sites in London and Home Counties. Impex Publications, 37, Alexandra Street, Southend-on-Sea, Essex. [4273

REDIFON TELECOMMUNICATIONS LTD., London, SW18, have a vacancy for an enthusiastic, practical man with some experience of Volume Production Testing in the electronics industry. Phone: 01-874 7281 and ask for Len Porter. [4212

SITUATIONS VACANT

HI-FI AUDIO ENGINEERS. We require experienced Junior and Seniors and will pay top rates to get them. Tell us about your abilities. 01-437 4607. [19

TV FILM Dubbing Theatre requires experienced engineer, professional sound recording techniques. Write stating experience and salary expectations. Box No. W.W. 4226.

WANT A PAID HOBBY? We are a London T.A. Regiment with vacancies for morse operators. Telephone 01-247 5594 or 8749. [4217

ARTICLES FOR SALE

AARVAK ELECTRONICS, 3-channel sound-light converters, from £18. Strobes, £25. Rainbow Strobes, £132.—98A West Green Road (Side Door), London N15 5NS. 01-800 8656. [23

BRADLEY BAND pass filters. No. 4 450-650MHz. No. 5 650-1000MHz 2 each. Coax switch type 256 6 way 50Ω'N'. Offers. Finch, 6 Cherry Tree Way, Penn, Bucks. Penn 4483. [4247

COLOUR T.V.'s—Bush CTV25 displayed working £90+VAT. Large discounts for 3-up. Non-workers available. Rediffusion wired Mono T.V.'s all screen sizes, new condition. Sumiks, 1532 Pershore Road, Birmingham, 30. Tel. 021-458 2208. [12

FOR SALE Racal 100Mhz Universal counter timer type 5A 550 and handbook, good working order, only £80. Smith, "Cracknells", Hempstead, Nr. Saffron Walden, Essex. Telephone Radwinter 493 evenings or weekends. [4264

WE SELL CONSTRUCTION PLANS

Phonevision, Television Camera, Police Radar Detector, Voice typewriter, Scrambler, Answering machine, Wireless quarter mike. Plans; $7.50 each.

COURSES

Detective-Electr, $36.50. Security-Electr, $43.50. Telephone Eng, $59.

OVER 750 ITEMS

Ask for Catalogue—Airmailed $0.75

T. STRIK,
Postbox 618, Rotterdam, Holland.

[44

Classifieds continued on page 106

Find your place in British Gas

COMMUNICATIONS AND INSTRUMENTATION MAINTENANCE

Eastern Gas wish to recruit a Maintenance Technician to be based at their Communications and Instrumentation Workshop at Hertford.

The duties, which are both varied and interesting, involve all aspects of maintenance on their Region's Integrated Communications System which incorporates the use of microwave radio, telemetry and electronic pneumatic instrumentation.

ONC or equivalent qualification plus a knowledge of one of the above is desirable but not essential for applicants with proven ability in Communications or Instrumentation.

The salary will be in the range £2,025–£2,532 per annum and there are excellent opportunities for promotion on merit to a salary grade rising to £2,865 per annum; in addition to these figures a weekly supplement will be paid in accordance with the pay code under the Industry's Threshold Agreement.

Considerable travelling within the Eastern Region of British Gas will be necessary and a current driving licence is therefore essential.

Please write with full details of age, qualifications and experience to J. M. Pinney, Recruitment Officer, Eastern Gas, Star House, Potters Bar, Herts or telephone Potters Bar 51151.

EASTERN GAS

4262

RADIO TECHNICIANS

Are you a Radio Technician with a City & Guilds, Intermediate Telecommunications Certificate or equivalent? If so then why not join the Home Office. There are vacancies in Central London (near Waterloo Station) but you may also be liable for employment at the Home Office Laboratory at Canons Park, Stanmore.

PAY: Inclusive of an interim addition is £1,695 at 19 rising to £2,575 plus a cost of living supplement which is at present £12.18 a month. In addition a London Weighting Allowance of £228 which at present is subject to review.

A SECURE FUTURE with a good pension scheme, prospects of promotion and a generous leave allowance. Five day week of 41 hours.

EXPERIENCE: Two years practical workshop experience of maintenance and the use of radio/electronic gear.

INTERESTED: Then telephone or write for an application form (to be returned by 29 November, 1974) to:

Miss C. S. E. Phillips, Home Office, Whittington House, 19-30 Alfred Place, London WC1EA 7EJ.

Telephone 01-637 2355 Extn. 87.

[4253

Join the EMI Service Team at Hayes

We urgently require

Electronic Repair & Calibration Engineers

required for the repair and calibration of a wide range of electronic instrumentation, including oscilloscopes, DVMs, pulse generators, power supplies etc.

Applicants should be aged at least 18 years and should have had at least two years background iu electronics. Further training will be given in appropriate cases.

Close Circuit Television Engineers

for the servicing and commissioning of CCTV, VTRs etc.

Applicants should be aged at least 19 years, and must have had some experience in television receiver servicing.

For both of these positions, starting salary will be up to £2,300 per annum according to age, experience and ability.
37½ hour week, plus paid overtime.

Don't delay, for further details telephone or write to M. Ford, 01-573 3888 Ext. 2268, EMI Service, 254 Blyth Road, Hayes, Middlesex.

EMI

The international music, electronics and leisure Group.

4271

BRUNEI
TELEVISION ENGINEER

- ★ Posting Bandar Seri Begawan.
- ★ Engagement for three years initially.
- ★ Gratuity 25% of total salary drawn.
- ★ Free Family passages.
- ★ Furnished quarters at reasonable rental.
- ★ Children's education allowances and holiday visit passages.
- ★ Interest free car loan.
- ★ There is NO INCOME TAX PAYABLE in Brunei at present.

The Brunei Television Service require a Supervisory Engineer (Transmitters) to be responsible to the Superintending Engineer for the efficient operation and maintenance of all transmitting equipment; also routine inspection and maintenance of aerials and feeders on towers 400/450ft. high and to undertake the training of local staff. Candidates, preferably under 55 years of age, *must* hold a recognised qualification in colour television engineering, and have spent at least 5 years in a supervisory position in a PAL colour television transmitting station. Experience should include parallel operation of Band III transmitters of 5 KW and higher output towers and the installation, operation and maintenance of microwave link equipment.

Salary, according to qualifications and experience, in the scale £3,166 to £5,750 approximately.

For further particulars you should apply, giving brief details of experience, to:

crown agents

M Division, 4 Millbank, London SW1P 3JD, quoting reference number M2K/740804/WF. [4222

Classifieds continued from page 105
Articles for Sale continued

PRESSURE SENSITIVE RESISTORS

Disks Squares Strips

75p each. Min. Order £5+30p P&P+VAT
Trial Pack — 3 disks, 3 squares, 1 strip, £5.73 inc. P&P and VAT, or £5.25 CWO.

LOGIC APPLICATIONS LIMITED
6 Swan Close, St. Paul's Cray, Orpington, Kent. Tel. Orpington 30908

[4259

COLOUR. UHF and TV SPARES. Colour and UHF lists available on request. 625 TV. If unit, suitable for Hi-Fi amp or tape recording, £6.75, P/P 35p. Bush CTV25 colour, new power units complete, incl. mains TX, Electrolytics, rectifiers, etc., £2.50, carr. 80p. New convergence panels plus yoke and blue lat., £3.85, P/P 40p. New Philips single standard convergence panels complete, incl. 16 controls, coils, P.B. switches, leads and yoke £5.00, P/P 40p. New Colour Scan Coils, Mullard or Plessey plus convergence yoke and blue lateral, £10.00, P/P 40. Mullard AT1025/05 Convergence Yoke, £2.50, P/P 35p. Mullard or Plessey Blue Laterals, 75p P/P 20p. BRC 3000 type Scan Coils, £2.00, P/P 40p. Delay Lines DL20, £3.50, DL1E, DL1, £1.50, P/P 25p. Lum. Delay Lines, 50p, P/P 15p. EHT Colour Quadrupler for Bush Murphy CTV 25 111/174 series, £8.25, P/P 35p. EHT Colour Tripler ITT TH25/1TH suitable most sets, £2.00, P/P 25p. KB CVC1 Dual Stand. convergence panels complete incl. 22 controls, £3.75, P/P 35p. CRT Base Panel, £1.75, P/P 15p. Makers Colour surplus/salvaged Philips G8 panels part complete; Decoder, £2.50, IF incl. 5 modules, £2.25. T. Base, £1.00, P/P 25p. CRT base, 75p, P/P 15p. GEC 2040 panels, Decoder, £3.50, T. Base, £1.00. RGB and Sound, £1.00, P/P 35p. CRT Base 75p, P/P 20p. B9D valve bases 10p, P/P 6p. VARICAP TUNERS. UHF ELC 1043 NEW, £4.50, Philips VHF for Band 1 and 3, £2.85 incl. data. Salvaged VHF and UHF Varicap tuners, £1.50, P/P 25p. UHF TUNERS NEW, Transistorised, £2.85 or incl. slow motion drive, £3.85. 4 position and 6 pos. push-button transistorised, £4.95. All tuners P/P 35p. MURPHY 600/700 series complete UHF Conversion Kits incl. tuner, drive assy., 625 IF amplifier, 7 valves, accessories housed in cabinet plinth assembly, £7.50 P/P 50p. SOBELL/GEC 405/625 Dual standard switchable IF amplifier and output chassis incl. cct., £1.50 P/P 35p. THORN 850 Dual standard time base panel, £1.00 P/P 35p. PHILIPS 625 IF amplifier panel incl. cct., £1.00 P/P 30p. VHF turret tuners AT7650 incl. valves for K.B. Featherlight, Philips 19TG170, GEC 2010, etc., £2.50. PYE miniature incremental for 110 to 830, Pam and Invicta, £1.00. A.B miniature with UHF injection suitable K.B, Baird, Ferguson, 75p. New fireball tuners Ferguson, HMV, Marconi, £1.90 P/P all tuners 30p. Mullard 110° mono scan coils, new, suitable all standard Philips, Stella, Pye, Ekco, Ferranti, Invicta, £2.00, P/P 35p. Large selection LOPTs. FOPTs available for most popular makes. PYE/LABGEAR transistd. Masthead UHF Booster, £5.75, Power Unit, £4.65 P/P 30p or Setback battery operated UHF Booster, £4.65 P/P 30p. 200+200+100 Microfarad 350v Electrolytic, £1.00 P/P 20p. MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No. 28, 59, 159 Buses or W. Hampstead Bakerloo and Brit. Rail). MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON, N. W. 11. Tel. 01-794 8751. [60

OVERNIGHT SERVICE

for Printed Circuit Prototypes
Also production runs, photography, gold plating, roller-tinning etc.
Rigid board and flexible film.

Electronic & Mechanical Sub-Assembly Co. Ltd.
Highfield House, West Kingsdown, Nr. Sevenoaks, Kent.
Tel: West Kingsdown 2344.

[40

CONSTRUCTION AIDS—Screws, nuts, spacers, etc., in small quantities. Aluminium panels punched to spec. or plain sheet supplied. Fascia panels etched aluminium to individual requirements. Printed circuit boards—masters, negatives and board, one-off or small numbers. Send 9p for list. Ramar Constructor Services, 29 Shelbourne Road, Stratford on Avon, Warwks. Tel. Stratford on Avon (std 0789) 4879. [28

DIGITAL CLOCK CONSTRUCTORS! The price barrier is broken! AY-5-1224 clock chip plus four 0.3" seven segment L.E.D. displays type 707: £10.46 plus VAT, post free. For the short sighted: as above, but 0.6" high displays type 747: £12.66 plus VAT. Clock chip alone is £3.66 plus VAT. Circuit diagram supplied. Details S.A.E. GREENBANK ELECTRONICS, 94 New Chester Road, Wirral, Merseyside L62 5AG. [4232

HI FIDELITY MODULES made and tested.

Linsley Hood, Class A	£7.25*
Linsley Hood, D.C. coupled 75W	£14.00*
Linsley Hood, pre-amp (75W)	£13.50
Bailey Quilter, pre-amp	£8.50
Toshiba I.C. Stereo, pre-amp	£12.00

*Excl. Heat Sinks.

TELERADIO HIFI, 325 Fore St., London, N9 0PE. 01-807 3719. (Closed Thursday.) [33

Classifieds continued on page 107

SURPLUS BARGAINS
KLEINSCHMIDT S.C.M. TELEPRINTER OUTFITS

Comprising. Teletypawriter (page printer) type TT-271B/FG (known as Kleinschmidt 160) Reperforator-Transmitter (tape printer) type TT-272A/FG with table FN-65/FG. Both units are supplied with change wheels, the whole equipment operates on 115 or 230V 50 cycles in very choice condition £55. (carr £4).
ELECTRONIC TIMER KITS 0·8 sec to 100 sec comprises A.E.I. Transistorised Module, Relay and all electrical components for 115 or 240V AC operation £1·75 (25p) VAT 20p. Veeder root 4-digit resettable counters 115V £1·25 (8p). Printed Circuit Kits. £1·25 (25p) total with VAT £1·65. AMPEX VIDEO TAPE 2 in. × 1670 NEW £9 (50p). AVO CT38 Electronic Test Meters £18 (£1). FERRIC CHLORIDE 25p a lb. (16p). 10 lb £2·50 (paid). Kent Chart recorders 115V AC £20 (1·50). Multipoint Kent Chart recorders £30 (£1·50). TELEPRINTER Papers and Tape. 8½ in. rolls 3-ply, carbon/buff manilla 60p per roll (32p). 8½ in. rolls 7-ply NCR no carbon required, white, £1 (32p). ⅞ in., 2 in. core, white, £2 per box of 8 rolls (52p). 11/16 in., 2 in. core, buff, £2 per box of 10 rolls (52p). Friden Tape £2 per box of 6 rolls (52p). Loads of surplus to clear. Large SAE for List.

ALL PLUS VAT 8%

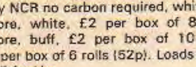
CASEY BROS.
233-237, Boundary Road, St. Helens, Lancs. 86

Classifieds continued from page 106
Articles for Sale continued

MULLARD ferrite cores, LA3 100 to 500 k Hz, 50p; LA4 10 to 30 k Hz, 75p; LA2100 3 to 200 k Hz, 50p. Enquires invited for other ferrites, rings, beads, rods, etc. Mc. Murdo PP10 edge plugs ex brand new equipment, 12p; also 10 ways Ps 10 sockets ex brand new equipment, 14p; covers for sockets with cable clamps and screws, 3p each. Mc. Murdo B11A relay sockets ex new equipment, 10p each; 100 for £7.00; 1000 for £50. Ceramic formers length 23mm O.D., 13mm internal bore, 1 end 8mm internal bore, other end 4mm, 100 for £1.50. Very large quantities of all above components ex stock. Also available large quantities of Polyester ceramic, Polystyrene and electrolytic capacitors relays, key switches, etc. Add 8% VAT to all orders. Mail order only. Xeroza Radio, 1 East Street, Bishop's Tawton, Devon. [4233

MARX-LUDER
STACKABLE EPICYCLIC GEARED ELECTRIC MOTORS

A range of high efficiency reversible D.C. motors are now offered complete with stackable epicyclic gears giving all the gear ratios: **3, 4, 5, 6, 12, 15, 18, 20, 24, 30, 60, 72, 90, 120, 360** by combining them as shown. Extra



gear sets extend the range to fit most requirements. Four sizes of motor each with pile gears and **6v** windings are available as under

	£
EM136P 1½ watts; 5000rpm; size 24×24×74mm Max. gearbox torque **2kg.cm**	**5.65**
EM136P/1 Spare gear set with 3,4,5,6 ratios	**1.70**
EM141P 8 watts; 5000rpm; size 35×35×109mm Max. gearbox torque **5kg.cm**	**6.45**
EM141P/1 Spare gear set with 3,4,5,6 ratios	**1.80**
EM145P 20 watts; 7000rpm; size 52×52×180mm Max. gearbox torque **10kg.cm**	**8.25**
EM146P 30 watts; 4000rpm; size 52×52×200mm Max. gearbox torque **10kg.cm**	**10.20**
SPECIAL OFFER 'Gearbox pack'. All items above	**30.00**

MOTORS without gearboxes:

EM131 0.8 watts; 20g.cm; 8000rpm; Ø17mm	**3.95**
EM136 1.2 watts; 40g.cm; 5000rpm; Ø21mm	**3.80**
EM139 4.2 watts; 160g.cm; 5000rpm; Ø30mm	**3.60**
EM141 8 watts; 320g.cm; 4500rpm; Ø30mm	**4.20**
SPECIAL OFFER "Motor pack". All motors above	**14.00**

Suggested applications. Laboratory equipment, stirrers, pump drives, servo systems, positioning of aerials, dampers, doors, power for models trains, boats, drills, cutting wheels etc.

S.A.E. for DATA SHEETS

"Motivator" Curtain Cord Controllers

A few of these new units have just become available. Ultra slim design, e.g. size 40×185×185mm. Screws flat on wall behind curtains without showing. Can be connected directly to existing corded curtains. Incorporates internal auto limit switches and power supply. May be operated remotely by 3-way switch (supplied).

Motivator Model B with 2 year battery pack. Kit	**18.00**
Fully assembled and tested as above	**24.00**
Motivator Model M with mains power supply. Kit	**22.00**
Fully assembled and tested as above	**30.00**

Additional information gladly supplied on request. All prices are inclusive in U.K. only.

MAIL ORDER ONLY FROM
AID-US PRODUCTS
Dept. WW3, 8 Hillview Rd., Pinner HA5 4PA, Middlesex [4274

Classifieds continued on page 108

NEW JOBS IN STEVENAGE

Dixserve is the servicing division of Dixons Photographic, the biggest camera and hi-fi retail chain in the world. And Dixserve is looking for Audio Engineers & Electronic Calculator Engineers to work at their Service Centre in Stevenage.

We'll give you a 5-day week, 3 weeks annual holiday, a pension scheme, a full and comprehensive range of modern test equipment, plus stunningly beautiful offices with a subsidised restaurant and bar, a social club and rest rooms. And, of course, a very good salary scale.

Contact: **Pat Rowley, Dixons Photographic Ltd., Cartwright Road, Stevenage. Tel: Stevenage 4371 (reverse the charges).**

DixSERVE LTD

[4260

Workshop Engineers
Audio and Colour Television

Our recently opened U.K. service centre is in Slough. The workshops are modern and lavishly equipped to undertake the servicing of our wide range of sophisticated colour T.V. and audio equipment.

Audio/Tape

Applicants must have at least a years' relevant experience with a service organisation.

Colour Television

A minimum of 2 years' colour T.V. experience in a workshop servicing organisation is essential.

Benefits include ✻ 5 day week ✻ heavily subsidised staff restaurant ✻ 4 weeks holiday ✻ pension schemes ✻ free life assurance ✻ and a special discount scheme on all our quality products.

Write, call in or phone **Mrs. A. Ward, Personnel Officer, AEG-TELEFUNKEN (U.K.) LTD., Bath Road, Slough SL1 4AW. Telephone: Slough 33311.**

AEG TELEFUNKEN

[4280

MARTIN ASSOCIATES

ELECTRONIC TEST EQUIPMENT

ANALYSERS General Radio 1556-B Impact Noise Analyser. 5Hz–20kHz. Solid state. **£65.00.** Marconi TF2330 Wave Analyser BFO. 20Hz–50kHz. C/w handbook. Almost new condition. **£495.00.**

BRIDGES Gambell 2091M NEW. 4 Decade DC Resistance Bridge. Balance indication by 5–0–5 uA Meter. Total resistance 11,110 ohms. **£35.00.** Gambell 2086 NEW. Switch bridges. 4 decade. Accuracy ratio coils 0.02%. **£30.00.** Gambell 2082 NEW. 4 decade resistance boxes. DC–10kHz. 0.1%. 1–11, 110 ohms. **£25.00.** These units are ideal for schools and colleges.

DIGITAL VOLTMETERS Solartron LM1420.2 4 Digit 2 uV–1000V. 6 ranges. Accuracy ±0.05%. Auto polarity. C/w handbook and 1/P leads. **£250.00.** LM1420.2BM As above plus Mean Sensing Unit. 10Hz–100kHz. 200mV–500V. 5 ranges accuracy 0.1%. C/w handbook and 1/P leads. **£275.00.** LM1440.3 5 Digit 0–2000V. 5 ranges. Accuracy 0.003%. C/w handbook and 1/P leads. **£295.00.**

METERS Hewlett Packard 430C Power Meter. 10 u W–10mW. C/w 477B Thermistor 10mHz–10gHz. **£125.00.** 412A DC Volt-Ohmeter. **£120.00.** 411A RF Millivoltmeter. **£120.00.** Booton 91D RF Value Voltmeter. **£85.00.** Airmec 284 Phase Meter 50kHz–100mHz. C/w leads and 4 probes. **£75.00.** Marconi TF1300 DC/AC/ohms Value Voltmeter. 20Hz–300mHz. C/w probes. **£30.00.**

OSCILLOSCOPES Tektronix 545B DC-33mHz Dual Beam Delay sweep main frame only **£250.00**, with CA plug-in. C/w handbook. **£31.00.** 547 DC–50mHz Dual Beam Automatic display switching. Main frame only **£425.00**, with 1A1 plug-in. C/w Handbook. **£600.00** S.E. Labs EM102 DC-30mHz Dual Beam Trigger Delay plus E530 plug-in. Almost new condition. C/w handbook. **£210.00.** Solartron CD1642 DC–15mHz Dual Beam Portable c/w handbook. Above average condition. **£115.00.**

SIGNAL SOURCES Advance J-1 AF Generator 15Hz–50kHz. O/P 25V. Imp 600 ohms. C/w handbook. **£25.00.** Airmec 201A 30kHz–30mHz. Built-in Crystal Calibrator. C/w handbook. Almost new condition. **£135.00.** E.H. Labs 132L Pulse Generator Var. Pulse Width 100nS–100mS O/P 0–50V. C/w handbook. **£50.00.** Marconi 801D/8S Signal Generator 10mHz–485mHz O/P 0.1 uV to 1V Emf. Source Imp: 50 ohms. **£400.00.** Philips PM5162 Sweep Generator 0.1Hz to 100kHz Sine Triangular Sq. Wave O/P 0–3V. **£150.00.**

This is a selection of our INSTRUMENTATION. Send or telephone for a free list. Each instrument is sold to makers specification and carries a 3 MONTHS WRITTEN GUARANTEE.

MARTIN ASSOCIATES, GREENSWARD LANE, ARBORFIELD, NR. READING, BERKS.
TEL: ARBORFIELD CROSS (0734) 760610. [4240

Classifieds continued from page 107
Articles for Sale continued

DATAPOINT V.D.U. (Keyboard + C.R.T.), Logic fault only, £200. E.M.I. "Starlight" intensifier vidicon W/scan coils £100 (or offer). Mini-Computer boards (complete) £200. Brighton (0273) 554992 eves.

LADDERS 8ft 10in closed—21ft extended, £23.54, delivered. Home Sales Ladder Centre (WW2), Haldane (North) Halesfield (1) Telford, Shropshire. Tel: 0952-586644. [32

LEON Television sound tuners. Completes your Hi-Fi system channels 21-68UHF self contained unit. Output Audio 200HV 36-50 inc. VAT. Leon Electronics 14, Aintree Road, Crawley, Sussex. Crawley 20536. [4263

CRYSTALS

Fast delivery of prototype and production military quality crystals. Competitive prices all frequencies: LF crystals a speciality. Details from

INTERFACE INTERNATIONAL
29 Market Street, Crewkerne, Somerset
Tel: (046031) 2578. Telex: 46283. [35

NEW COMPONENTS Post Free, 8% VAT included. 2N 3702, 2N 3704, 9p. Guest UPM 050 $\frac{1}{4}$W Carbon Film resistors 1p each. Siemens B32540 250V Polycarbonate 0.01, 0.015, 0.022, 0.033, 0.047, 4p; 0.068, 0.1 μF, 5p. Triac TAG 250 400v/8A, 75p. D32 diac 25p. GREENBANK ELECTRONICS (Dept. 323), 94 New Chester Road, Wirral, Merseyside. L62 5AG. [4268

NEW unused digital multimeter mains or battery all normal A/C D/C ranges. Four digits 0.1% accuracy over 25 ranges. Cost £98 accept £72. Phone after 7.00 p.m. 01-560 1084. [4184

SUPERB Instrument Cases by Bazelli, manufactured from heavy duty P.V.C. faced steel, hundreds of Radio, Electronic, and Hi-Fi enthusiasts are choosing the case they require from our range of over 200 models, generous trade discount, prompt despatch, free literature, Bazelli Dept 22, St. Wilfreds, Foundry Lane, Halton, Lancaster 1A2 6LT. [4223

CARBON FILM RESISTORS—E12 SERIES
High Stab. $\frac{1}{4}$W OR $\frac{1}{2}$W 5%. 1p. 75p/100. £5·50/1000 (22Ω-1MΩ).

RESISTOR KITS 22Ω-1MΩ E12 SERIES
10E12 KIT 10 of each value (Total of 570) $\frac{1}{4}$W, £3·65; $\frac{1}{2}$W, £3·85; .25E12 KIT 25 of each value (Total of 1425) $\frac{1}{4}$W, £8·35; $\frac{1}{2}$W, £8·45.

METAL FILM KITS ALSO AVAILABLE.

CATALOGUE No. 3 (Approx. 2000 Parts) 20p.

C.W.O. P. & P. 10p on orders under £5. Overseas at cost.

B.H. COMPONENT FACTORS LTD
Dept. WW, 61 Cheddington Road, PITSTONE, Nr. Leighton Buzzard, Beds. LU7 9AQ. Cheddington (0296) 668446 (32

NELSON-JONES tuner built from Integrex Kit. Push button varicap tuning, Portus and Haywood decoder. Performs to specification. I. G. Bowman, 35 Park Hill Road, Torquay, S. Devon. [4248

TEKTRONIX 545A Scope D.C. to 30MHz. Type CA plug-in, dual-beam (105V to 20v/div). Very good condition, recently factory serviced. Manuals for both. X10 voltage probe. Offers please. Box No. WW 4252.

EXPRESS

Prototype Printed Circuits
Fastest in London Area
Also medium production runs, call-offs, etc.
Electronic & Mechanical Sub-Assembly Co. Ltd.
Highfield House, West Kingsdown, Nr. Sevenoaks, Kent.
Tel: West Kingsdown 2344 [40

UNBEATABLE Prices BT106 Branded Product £0.85 exclusive of VAT. CWO plus p.p. 10p. Pace Electronics Limited, 138 Glebe Road, Deanshanger, Milton Keynes MK19 6NB. [4208

VACUUM is our speciality. New and second-hand rotary pumps, diffusion outfits, accessories, coaters, etc. Silicone rubber or varnish outgassing equipment from £40. V. N. Barrett (Sales) Ltd., 1 Mayo Road, Croydon. 01-684 9917. [24

ENAMELLED COPPER WIRE

S.W.G.	1lb reel	½lb reel
10 to 14	£1.90	£1.05
15 to 19	£2.00	£1.10
20 to 24	£2.05	£1.15
25 to 29	£2.10	£1.20
30 to 34	£2.20	£1.28
35 to 40	£2.35	£1.35

All the above prices are inclusive in U.K.

COPPER SUPPLIES
102 Parswood Rd., Withington, Manchester 20
Telephone 061-224 3553 [85

24V BATTERY CHARGERS. Basic 6 amp Charger £36. Automatic Trickle Charge, £48. 12 amp Charger for charging two battery banks simultaneously with independent automatic trickle charge, £62. Prices+VAT+Del. Send for leaflet or send cheque or PO to Lark Electronics Ltd., 33 Western Road, Lymington, Hants. Tel. Lym 3822 or 5806. [4142

60 KHz MSF Rugby and 75 KHz Neuchatel Radio Receivers. Signal and Audio outputs. Small, compact units. Two available versions. Toolex, Bristol Road, Sherborne (3211), Dorset. [21

BUILDING or PURCHASING an AUDIO MIXER

pre-amp, autofade, V.U. or audio monitor, V.E. mixer, driver or power supply etc . . . First consult:

PARTRIDGE ELECTRONICS
Ref. W.W.
21-25 Hart Road, Benfleet, Essex
Established 23 years [43

DOUGLAS For Transformers

★ Comprehensive stock range
★ Rapid prototype service
★ Quantity production orders.

Douglas Electronic Industries Ltd.,
Eastfield Road, Louth, Lincolnshire LN11 7AL.
Tel: Louth (05-07) 3643 Telex: 56260 4007

ARTICLES WANTED

CASH paid for new valves, transistors, C.R.T. test equipment, tape recorders, amplifiers, Hi-Fi equipment, T.V. sets, large or small quantities. Stan Willetts, West Bromwich. Tel: 021-553 0186. [4216

GRAMPIAN or B.B.C. type Cutterheads complete or in parts. Any condition accceptable. Box No WW 4029.

QUANTITY of NKT 301 or NKT 302 Transistors required, singles or hundreds. Details please to WASCO ELECTRONICS, Queen Street, Lancaster, Lancs. [4234

RADIO TELEPHONES required, ITT type M5 (UHF). Price and quantity available to: WASCO ELECTRONICS, Queen Street, Lancaster, Lancs. [4235

WANTED, all types of communications receivers and test equipment.—Details to R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [63

TOP PRICES PAID

for semiconductor and component redundant or excess inventories

P.R.S. ELECTRONICS
126 Headstone Road
Harrow, Middlesex
Tel: 01-965 6864 [34

ELECTRO-TECH COMPONENTS LTD.

Are buyers of all types of electronic components and equipment. They will be pleased to view clearance stocks anywhere in Great Britain at one or two days notice
and negotiate on the spot!

ELECTRO-TECH COMPONENTS LTD.
315/317 Edgware Road, London, W.2
Tel: 01-723 5667. 01-402 5580 [37

BOOKS

TV and Electronic Publications, TV repair manuals, £3.35, as used by the experts. Stamps for brochure due on ents Grange Farm, Wyaston, Ashbourne, Derby. [4237

ESSENTIAL BOOKS!

Radio Book Catalogue

Mobile Radiotelephone Equipment Handbook. Gives circuits, data and illustrations plus some valuable modifications for amateur use for commercial radiotelephone equipment including PYE and other popular makes. Available mid-November. £4.75, p.p. 35p.
How to Make 2M and 4M Convertors for Amateur Use. Fully comprehensive. Contains circuits, lay-outs, components lists, diagrams and full instructional notes. 60p, p.p. 15p.
How to Make Walkie-Talkies for Licensed Operation. 40p, p.p. 15p.
The Theory of Guided Electromagnetic Waves. The most comprehensive book yet written about waveguides, transmission lines, cavity resonators. Over 500 pages. Ideal for anyone interested in RADAR and UHF. Published at £11.50. Special offer £4.50, p.p. 50p.
Radio Book Catalogue. Send for this fully comprehensive catalogue of radio books. Free.
The Bargain Book Gazette. Contains thousands of interesting new and out of print books at bargain prices. Subjects include all types of hobbies, collecting, 1001 interests. Published regularly and sent free on request.

GERALD MYERS (Publisher & Bookseller),
138 Cardigan Rd., Headingly, Leeds 6. (Callers welcome.) [4278

CAPACITY AVAILABLE

AIRTRONICS LTD., for Coil Winding—large or small production runs. Also PC Boards Assemplies. Suppliers to P.O., M.O.D., etc. Export enquiries welcomed. 3a Walerand Road, London, SE13 7PE. Tel. 01-852 1706. [61

BATCH Production Wiring and Assembly to sample or drawings. Deane Electricals, 19B Station Parade, Ealing Common, London, W.5. Tel: 01-992 8976. [20

CAPACITY available to the Electronic Industry. Precision turned parts, engraving, milling and grinding both in metals and plastics. Limited capacity available on Mathey SP33 JIG BORER. Write for lists of full plant capacity to C.B. Industrial Engineering Ltd., 1 Mackintosh Lane, E9 6AB. Tel. 01-985 7057. [14

Classifieds continued on page 109

We've got prices to put power in your profits

TOSHIBA VALVES Type	Goods Price (p)	Type	Goods Price	Type	Goods Price	Type	Goods Price	Type	Goods Price	Type	Goods Price
DY87	30.0	PL508	67.0	AF115	23p	BC147A	08p	BF173	25p	BU108	£2.10
DY802	30.0	PY88	35.5	AF116	23p	BC148	08p	BF178	35p	BY126	11p
ECC82	28.0	PY500A	85.0	AF117	23p	BC149	12p	BF179	40p	BY127	12p
EF80	29.5	PY800	29.0	AF118	50p	BC153	20p	BF180	35p	E.1222	30p
EF183	34.5	**SEMI-CONDUCTORS**		AF139	42p	BC154	22p	BF181	35p	IN60	05p
EF184	34.5	AC127	17p	AF178	45p	BC157	12p	BF184	21p	MJE340	45p
EH90	31.5	AC128	15p	AF180	45p	BC158	10p	BF185	21p	OA202	7.5p
PC900	24.5	AC141K	30p	AF181	45p	BC159	14p	BF194	15p	OC71	15p
PCC89	40.0	AC142K	30p	AF239	45p	BC173	18p	BF195	15p	OC72	15p
PCC189	41.0	AC151	20p	BA145	14p	BC178B	20p	BF196	20p	BU105/02	£2.40
PCF80	31.5	AC154	18p	BC107	11p	BC182L	12p	BF197	17p	2SC1172B	£2.40
PCF86	39.0	AC155	18p	BC108	11p	BC183L	12p	BF198	23p	R2008B	£2.00
PCF801	42.0	AC156	20p	BC109	12p	BC187	28p	BF200	25p	R2010B	£2.00
PCF802	40.0	AC176	22p	BC113	25p	BC214L	15p	BF218	30p	**INTEGRATED**	
PCL82	39.0	AC187	19p	BC116	25p	BD124	70p	BF224	35p	**CIRCUITS**	
PCL84	34.0	AC187K	30p	BC117	20p	BD131	45p	BF258	40p	TAA550	49p
PCL85	39.5	AC188	20p	BC125	25p	BD132	45p	BF336	28p	TBA120AS	£1.00
PCL86	41.0	AC188K	30p	BC132	25p	BD235	49p	BF337	35p	TBA120SQ	£1.00
PFL200	55.5	AD142	45p	BC135	20p	BD237	52p	BFX86	28p	TBA540Q	£1.75
PL36	55.5	AD149	40p	BC137	25p	BDX32	£2.40	BFY50	22p	TBA560CQ	£2.40
PL84	25.0	AD161	38p	BC138	40p	BF115	20p	BFY52	20p	TBA920Q	£2.90
PL504	60.5	AD162	38p	BC142	26p	BF160	20p	BSY52	35p	TBA990Q	£2.90
		AF114	24p	BC143	30p	BF167	20p	BT106	£1.40	SN76013ND	£1.50

EHT RECTIFIER TRAY ASSEMBLIES

Type	Goods Price	Type	Goods Price
ITH Decca Col.	£4.50	11TAM Philips G8	£4.50
ITN GEC/Sobell	£4.50	TCQ Pye/Ekco	£3.50
2TQ 1400 + 950 Mk II	£1.85	11 TAQ ITT/KB	£4.50
2TAK 1500 5 Stick	£2.00	3 TCU BRC 3000	£5.00
2DAF 1500 3 Stick	£1.85	11 TAZ GEC 2010	£5.35
2HD 950 3 Stick	£1.70		

12 MONTHS GUARANTEE

COLOUR TUBES

Type	Goods Price
19" A49/191X	48.00
20" 510DJB22	49.75
22" A56/120X	53.25

FULLT GUARANTEED

PRICES SUBJECT TO 8% VAT. All goods subject to settlement discount of 5% 7 days and 2% monthly. New Price List from 1st. May 1974.

COMBINED PRECISION
COMPONENTS (PRESTON) LIMITED
194-200 North Road, Preston PR1 1YP
Telephone: 55034 Telex: 677122.

The Theory and Practice of PAL Colour Television in three important Sound Colour Films

Part 1. The Colour Signal
Running time 30 mins.

Part 2. The Receiver Decoder
Running time 25 mins.

Part 3. Receiver Installation
Running time 25 mins.

For purchase or hire in 16mm. and Philips VCR.

Send SAE for precis details.

ZAAR COLOUR VIDEO LTD.

339 CLIFTON DRIVE SOUTH,
ST. ANNES-ON-SEA, LANCS FY8 1LP
TELE. (0253) 721053

Film-to-Video tape transfers specialists

4228

ECONOMIZE ON SEMICONDUCTORS

All prices include VAT

- ★ Special low prices on 741C
- ★ Plastic 3 terminal Regulators
- ★ Economical Digital Clock IC
- ★ Low-price DIL Sockets

	1+ p	10+ p	25+ p
709C Op Amp 8 pin DIL	34	32	30
723C Reg. + data 14 DIL	65	63	59
741C Op Amp 8 pin DIL	32	30	29
748C Op Amp 8 pin DIL	39	37	35
NE555 Timer + data 8 DIL	76	73	69
CA3046 Array 14 pin DIL	76	73	69
TDA1405 Reg. 5V 650mA	100	92	85
TDA1412 Reg. 12V 500mA	100	92	85
TDA1415 Reg. 15V 450mA	100	92	85
BC107, 108, 109	10	9.5	9
BC182, 184	11	10.5	10
BC212, 214	12	11.5	11
H-P Red ⅛" LED	18	16	15
H-P Red 0.2" LED	19	18	17

	p		p		p
BC109C	11	BZY88C—		1N914	5
BC177	18	3V3—15V	11	1N4001	5
BC178	18	2N3702	12	1N4002	5
BF244	24	2N3704	12	1N4004	7
BF244B	27	2N3708	10	1N4148	5
BFY51	17	2N3055	48		

TTL Mixed Prices

	1+ p	10+ p
7400	19	18
7402	19	18
7403	19	18
7404	20	19
7405	20	19
7410	19	18
7413	19	18
7420	19	18
7430	19	18
7442	80	76
7447	120	110
7473	42	40
7474	40	38
7476	46	43
7486	40	38
7490	65	60
7492	65	60
7493	65	60
74121	50	46

AY-5-1224 Digital Clock IC, 12 or 24 hr operation, 7 segment or BCD ouputs. Drives LED, Minitron, Neon displays, simple interfacing, 16 DIL pack + circuits. IC + data **£4.65**. H-P 5082-7740 0.3" digits **£2.20**. IC + 4 0.3" digits **£12.50**. IC, 4 0.3" digits, transistors and transformer **£15.00**.

TCA940 Audio Power Amplifier 10W + data + circuit **£2.60**

TAD100 Radio IC + IF filter + circuit **£1.60**

DIL Sockets 8 pin **11p**; 14 pin **12p**; 16 pin **13p**

Carbon film High Stability ¼W 5% Resistors, 10 ohm–2M2 **1p** ea, 10 **9p**, 100 **80p** same value.

By return service. Prices include VAT. P & P 8p (UK), overseas at cost. All items new. TI, Motorola, Mullard, SGS, etc. SAE lists, enquiries. Colleges, etc., supplied.

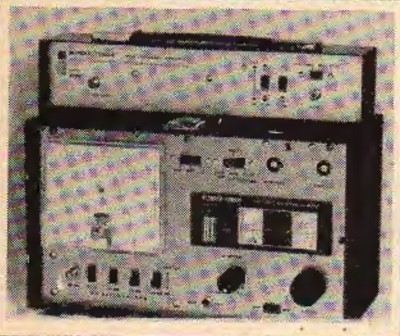
SILICON SEMICONDUCTOR SERVICES

41 Dunstable Road, Caddington, Luton, Beds LU1 4AL

40

Classifieds continued on page 113

Quality Products Made in America



Blonder-Tongue
Field Strength Meter - FSM2
Superb quality and performance. Complete line of MATV and CATV products available.

Astatic - Choose from over 60 different microphones for public address, studio, commercial sound and recording microphones. Quality sound reproduction since 1930. Complete line of Astatic cartridges, needles and arms.

Atlas Loudspeaker - complete line of public address speakers and microphone stands.

Trusonic - speaker systems to meet every indoor and outdoor requirement.

Irish Tape - premium quality tape available in cassette, 8-track, open reel and video.

Gromes Precision - public address amplifiers

Consolidated Wire and Cable

AVA - coaxial connectors

Teleco - telephone answering instruments

Perma Power - portable PA Systems

Utah - complete line of hi-fi speakers and accessories

Automatic Garage Doors, TV Tube Brighteners, Remote Controls

Write for illustrated catalog and specifications for these products.

Morhan Exporting Corp.
270-278 Newtown Road
Plainview, N.Y. 11803
Cable Address: Morhanex, N.Y.
Telex: 96-7880

WW—052 FOR FURTHER DETAILS

QUARTZ CRYSTAL UNITS from

- 1.0-60.0 MHZ
- FAST DELIVERY
- HIGH STABILITY
- TO DEF 5271-A

WRITE FOR LEAFLET AT - 1
McKNIGHT CRYSTAL Co.
HARDLEY INDUSTRIAL ESTATE, HYTHE, SOUTHAMPTON SO4 6ZY.
TEL. HYTHE 8961
STD CODE 042 14

SPECIAL NOTICE
TO ALL MANUFACTURERS
in the
ELECTRONIC, RADIO, TELEVISION and ALLIED TRADES.

Please note that we will purchase any redundant and surplus stocks which you may have available after stocktaking, or wishing to make space for more important items. We are particularly interested in large quantities of components, raw materials, etc.

BROADFIELD & MAYCO DISPOSALS LTD.
21 Lodge Lane, N. Finchley, London, N12 8JG.
Telephone:
01-445 0749 01-445 2713 01-958 7624

SYNTHESISER SOUNDS SUPREME
BY DEWTRON—THE UP-FRONT PEOPLE
YOU can build professional standard synth. equipment from our modules if you can read and solder! E.g. pitch-to-voltage enables your creation to play itself from sound of voice, sax, clarinet, guitar etc. Send 15p NOW for full catalogue. 10 years experience from—
D.E.W. LTD.,
254 Ringwood Road, Ferndown, Dorset.

EXPRESS
PRINTED CIRCUITS – ROLLER TINNING – GOLDPLATING – FLEXIBLE FILMS, ETC.
Electronic & Mechanical Sub-Assembly Co. Ltd
Highfield House, West Kingsdown
Nr. Sevenoaks, Kent
Tel: West Kingsdown 2344

SOWTER TRANSFORMERS
FOR SOUND RECORDING AND REPRODUCING EQUIPMENT
We are suppliers to many well-known companies, studios and broadcasting authorities and were established in 1941. Early deliveries. Competitive prices. Large or small quantities. Let us quote.
E. A. SOWTER LTD.
Transformer Manufacturers and Designers
7 Dedham Place, Fore Street, Ipswich IP4 1JP
Telephone 0473 52794

COLOUR TV's
Bush CTV 25 displayed working **£90** plus VAT
Large discount for 3 up non-workers available.
REDIFFUSION WIRED MONO TV's. all screen sizes, new condition.
SUMIKS
1532 Pershore Road, Birmingham 30
Tel: 021-458 2208

Grampian

'SERIES 7' – *Studio Monitor Version*
One of the world's finest Amplifiers.

GRAMPIAN REPRODUCERS LIMITED
Hanworth Trading Estate, Feltham, Middlesex.
Telephone: 01-894 9141.

Guide to Broadcasting Stations

17th Edition

A new edition of a title which has sold more than 250,000 copies. The bulk of the book is devoted to lists of stations broadcasting in the long, medium, short and v.h.f. bands in both frequency and geographical and alphabetical order. The book also contains useful information on radio receivers, aerials and earth, propagation, signal identification and reception reports.

1973 206 pp., illustrated
0 592 00081 75p

Illustrations in Applied Network Theory

F. E. Rogers

A hundred numerical and algebraic illustrations designed to exemplify practical circuit problems and introduce, in analysis, principles consistent with studies of synthesis that may be pursued later.

1973 240 pp., illustrated
0 408 70425 X cased £5.00
0 408 70426 8 limp £2.50

Obtainable through any bookseller or from

Newnes-Butterworths
BOROUGH GREEN, SEVENOAKS, KENT TN15 8PH
TEL. BOROUGH GREEN 2247

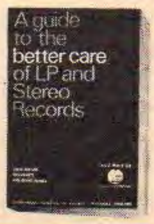
SINTEL

Data and circuits supplied with orders, or available separately (4½p stamp each).

Calculator Keyboard (to order)—Ideal for C500, suitable for CT5001 .... £4.85 + 8% VAT=£5.23
6 Minitron displays for only .... £6.00 8% VAT=£6.48
MK50250N Alarm Clock IC .... £6.90 + 8% VAT=£7.45
SP352 2 digits .55" .... £4.00 + 8% VAT=£4.32
CT 7001 Calendar Alarm Clock IC £9.80 + 8% VAT=£10.58
Minitron 3015F 9mm 7 seg. display £1.20 + 8% VAT=£1.29
Soldercon IC socket pins 1,000 for £4.00 + 8% VAT=£4.32

Add 10p p&p for orders under £2
SINTEL, 53c ASTON STREET, OXFORD

THE ONLY COMPREHENSIVE RANGE OF RECORD MAINTENANCE EQUIPMENT IN THE WORLD!

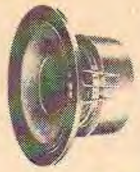


Send P.O. 15p (plus 4p postage) for 48 page booklet providing all necessary information on Record Care.

CECIL E. WATTS LIMITED
Darby House
Sunbury-on-Thames, Middx.

Wilmslow Audio

THE firm for speakers!



Baker Group 25, 3, 8 or 15 ohm	£7.75
Baker Group 35, 3, 8 or 15 ohm	£8.50
Baker Deluxe, 8 or 15 ohm	£10.75
Baker Major, 3, 8 or 15 ohm	£8.50
Baker Regent, 8 or 15 ohm	£7.75
Baker Superb, 8 or 15 ohm	£14.50
Celestion PST8 (for Unilex)	£2.55
Celestion MH 1000 horn, 8 or 15 ohm	£10.95
EMI 13 × 8, 3, 8 or 15 ohm	£2.25
EMI 13 × 8, 150 d/c 3, 8 or 15 ohm	£2.50
EMI 13 × 8, 450 t/tw 3, 8 or 15 ohm	£3.75
EMI 13 × 8, 350, 8 or 15 ohm	£8.25
EMI 13 × 8, 20 watt bass	£6.60
EMI 2¼" tweeter 8 ohm	£0.65
EMI 8 × 5, 10 watt, d/c, roll/s 8 ohm	£2.50
Elac 59RM 109 15 ohm, 59RM114 8 ohm	£2.80
Elac 6½" d/cone, roll/s 8 ohm	£3.50
Elac TW4 4" tweeter	£1.21
Fane Pop 15 watt 12"	£4.80
Fane Pop 25/2 25 watt 12"	£6.95
Fane Pop 40, 10" 40 watt	£8.50
Fane Pop 50 watt, 12"	£11.00
Fane Pop 55, 12" 60 watt	£12.50
Fane Pop 60 watt, 15"	£13.00
Fane Pop 100 watt, 18"	£22.50
Fane Crescendo 12A or B, 8 or 15 ohm	£29.00
Fane Crescendo 15, 8 or 15 ohm	£36.00
Fane Crescendo 18, 8 or 15 ohm	£49.95
Fane 807T 8" d/c, roll/s, 8 or 15 ohm	£3.85
Fane 801T 8" d/c, roll/s, 8 ohm	£7.00
Goodmans 8P 8 or 15 ohm	£5.00
Goodmans 10P 8 or 15 ohm	£5.30
Goodmans 12P 8 or 15 ohm	£12.95
Goodmans 12P-D 8 or 15 ohm	£16.75
Goodmans 12P-G 8 or 15 ohm	£15.75
Goodmans Audiom 100 8 or 15 ohm	£12.00
Goodmans Axent 100 8 ohm	£7.25
Goodmans Axiom 401 8 or 15 ohm	£17.25
Goodmans Twinaxiom 8" 8 or 15 ohm	£8.25
Goodmans Twinaxiom 10" 8 or 15 ohm	£9.00
Kef T27	£5.25
Kef T15	£6.00
Kef B110	£7.25
Kef B200	£8.25
Kef B139	£14.75
Kef DN8	£2.00
Kef DN12	£4.95
Kef DN13	£3.30
Richard Allan CG8T 8" d/c roll/s	£6.35
STC4001G super tweeter	£6.19
Wharfedale Super 10RS/DD 8 ohm	£9.80
Fane 701 twin ribbon horn	£23.00
Baker Major Module each	£10.75
Fane Model One each	£9.90
Goodmans DIN 20 4 ohm each	£9.75
Helme XLK25 (pair)	£22.00
Helme XLK30 (pair)	£14.95
Helme XLK50 (pair)	£39.95
Kefkit 2 each	£24.75
Kefkit 3 each	£36.75
Peerless 3–15 (3 sp. system) each	£15.00
Richard Allan Twinkit each	£8.95
Richard Allan Triple 8 each	£13.75
Richard Allan Triple each	£19.95
Richard Allan Super Triple each	£23.75
Wharfedale Linton 2 kit (pair)	£19.25
Wharfedale Glendale 3 kit (pair)	£34.50
Wharfedale Dovedale 3 kit (pair)	£52.50

PRICES INCLUDE VAT

Cabinets for PA and HiFi, wadding, vynair, etc.

Send stamp for free booklet "Choosing a Speaker".

FREE with orders over £7—"HiFi loudspeaker enclosures" book.

All units guaranteed new and perfect.

Prompt despatch.

Carriage: Speakers 38p each, tweeters and crossovers 20p each, kits 75p each (pair £1.50).

WILMSLOW AUDIO

Dept WW
Swan Works, Bank Square, Wilmslow, Cheshire SK9 1HF Tel. Wilmslow 29599
(Discount HiFi, PA and Radio at 10 Swan St, Wilmslow.)

WW—063 FOR FURTHER DETAILS

The Young Generation Relay

Flatform Relay AZ 535

1 changeover,
high dielectric strength between coil and contact stack for reliable insulation between signal and heavy duty circuits.

Contact material: Silver cadmium oxide, fine silver.

Switching capability	3 A 240 V 50 Hz 500 VA
Operating power	ca. 360 mW
Coil voltage	maximum 110 V
Surface area	32.5 x 20 mm
Height	11 mm

ZETTLER

Zettler UK Division

Equitable House,
Lyon Rd., Harrow,
Middx. HA1 2DU
Tel. (01) 863 6329

WW—022 FOR FURTHER DETAILS

THE TEXAN

HI QUALITY AMPLIFIER BY TEXAS

Booklet & Parts List 35p Post Incl.

AVAILABLE IN PACK FORM

RESISTORS & CAPACITORS	pp 20p	£4.15
SWITCHES	pp 20p	£1.25
CONTROLS & SELECTOR	pp 20p	£1.45
SEMICONDUCTORS	pp 15p	£8.25
TRANSFORMER	pp 30p	£6.95
P.C. BOARD	pp 20p	£2.50
CASE	pp 38p	£3.00

POST & TAX EXTRA *NOW ON DEMONSTRATION*

LINSLEY HOOD 75W AMP
D.C. COUPLED LOW DISTORTION

PACK	1. RES. & CAPS	pp 15p	£2.30
	2. SEMICONDUCTORS	pp 20p	£6.75
	3. P.C. BOARD & DATA	pp 20p	£1.00
P.S.U.			
	5. RES. & CAPS	pp 20p	£2.25
	6. RECTIFIERS	pp 20p	90p
	7. P.C.B. & SUNDRIES	pp 20p	£3.30
	8. 50 WATT TRANSFORMER	pp 35p	£5.00
	18. (TOROIDAL TRANSFORMER	pp 55p	£8.95)
PRE-AMP			
	11. RES/CAPS	pp 20p	£3.00
	12. CONTROLS	pp 25p	£1.00
	13. SWITCHES	pp 20p	£2.00
	14. SEMICONDUCTORS	pp 20p	£1.90
	15. P.C.B. & DATA	pp 20p	£1.00

POST & V.A.T. NOT INCLUDED

Article reprint 40p + post.
Also available Chassis, Teak Sleeve
S.A.E for further information

TELERADIO ELECTRONICS
325–7, FORE ST., LONDON N9 0PE
01-807 3719 (Closed Thursdays)

At three ha'pence a pint you gotta pick a packet, or two!

Around 1780 Sarah Oliver kept the colourful Bay Horse Inn in North Shields - the haunt of sailors, labourers, thieves and gentlemen who settled to her much-loved brew, said by many to 'preserve the wind'.

Times change, but good things don't.

Now from the same building on Horse Ferry Landing, Geordie Home Brews bring you all the natural, wholesome ingredients you need to brew a strong, natural beer like the one Sarah Oliver served. And still at a ridiculous 1½p per pint!

MAKES 40 SATISFYING PINTS FOR 60p

Sarah Oliver's Home Brew

BY GEORDIE HOME BREWS

from your usual Geordie Stockist
Enquiries to: VIKING BREWS LTD.
CLIVE STREET NORTH SHIELDS

WW—004 FOR FURTHER DETAILS

EX-COMPUTER STABILISED POWER SUPPLIES

RECONDITIONED, TESTED AND GUARANTEED

Ripple <10mV. Over-voltage protection 120-130v. 50 c/s input. Stepdown transformer to suit about **£3.**
Post & Packing **£1·70**

5-6v. 8A.	£12	5-6v. 16A.	£16
5-6v. 12A.	£14		

PAPST FANS 4½ x 4½ x 2in. 100 cfm. 240v. 50/60 Hz. **£3·50** (30p).

PAPST FANS 6in. dia. x 2$\frac{3}{16}$in. deep Type 7576 **£5·00** (30p).
Few only 6in. PAPST **£4** (30p)

TRANSISTORS p & p 10p
BC107/8/9 BC147/8/9 BC157/8/9 all **9p**
BF180 **25p** BF182/3/ **40p** BF184 **17p** BC167 **13p**
BFW10 **55p** BF336 **35p** 741 8 DIL **34p**
2N3771 **£1·10**, 2N3441 **50p**, BD131 **40p**

ELECTROLYTICS
30,000µ 25v, 68,000µ 16v, 15,000µ 30v **65p** (20p)
4000µ 70v., 3,600µ 40v., 4½×2in. dia. **55p** (15p)
5,000µ 35v., **40p** (12p)

EX-COMPUTER PC PANELS 2 x 4in. 25 boards for **£1** (30p).
QH Bulbs, 12v. 55w. 50p (7p)
150 mixed HI-STABS 60p (11p)
250 Mixed Resistors 60p (13p)
250 Mixed Capacitors 60p (11p)
200 SI Planar Diodes 50p (8p)
Microswitches.............. 8 for 50p (10p)
Min. Glass Neons .... 8 for 50p (7p)
2N3055 EQUIV..............4 for £1 (10p)

Postage and packing shown in brackets

Please add 8% VAT to TOTAL

KEYTRONICS

Mail Order only.

44 EARLS COURT ROAD, LONDON, W.8
01-478 8499

SEMICONDUCTOR DATA HANDBOOK

by General Electric

Price £3.40

ELEMENTS OF TRANSISTOR PULSE CIRCUITS by T. D. Towers. Price **£3.70**

UNDERSTANDING IC OPERATIONAL AMPLIFIERS by R. Melen. Price **£2.20**

RECEIVING PAL COLOUR TELEVISION by A. G. Priestley. Price **£5.25**

ELECTRONIC EQUIPMENT RELIABILITY by J. C. Cluley. Price **£2.70**

DIGITAL ELECTRONIC CIRCUITS AND SYSTEMS by N. M. Morris. Price **£2.45**

OPERATIONAL AMPLIFIERS DESIGN AND APPLICATIONS by Tobey. Price **£4.20**

DIGITAL LOGIC BASIC THEORY AND PRACTICE by J. H. Smith. Price **£1.65**

GE TRANSISTOR MANUAL. Price **£1.30**

TRANSISTOR FUNDAMENTALS AND SERVICING by B. Larson. Price **£8.00**

SERVICING ELECTRONIC ORGANS by M. H. Applebaum. Price **£2.00**

★ALL PRICES INCLUDE POSTAGE★

THE MODERN BOOK CO.

SPECIALISTS IN SCIENTIFIC & TECHNICAL BOOKS

19-21 PRAED STREET, LONDON, W2 1NP

Phone 723 4185
Closed Sat. 1 p.m.

PEAK PROGRAM METERS TO BS4297

also 200KHz version for high speed copying.

Drive circuit, 35 x 80mm, for 1mA L.H. zero meter to BBC ED1477. Gold 8-way edge con supplied.

		4 off	10 off	50 off
Complete kit	£10.00	£9.50	£9.00	£8.50
Built and aligned	£14.00	£13.30	£12.60	£11.90

ERNEST TURNER PPM meters, scalings 1/7 OR-22/+4. Type 642, 71 x 56mm **£10·90**; 643, 102 x 79mm **£12·90**.
Twin movement, scale 86 x 54mm **£31.00**

FREQUENCY SHIFTER

FOR HOWL REDUCTION

PUBLIC ADDRESS : SOUND REINFORCEMENT

In any public-address system where the microphones and loudspeakers are in the same vicinity acoustic feedback (howl-round) occurs if the amplification exceeds a critical value. By shifting the audio spectrum fed to the speakers by a few Hertz the tendency to howling at room resonance frequencies is destroyed and an increase in gain of 6–8dB is possible before the onset of feedback. The 5Hz shift used is imperceptible on both speech and music.
SHIFTERS IN BOXES with overload LED, shift/bypass switch, BS4491 mains connector and housed in strong diecast boxes finished in attractive durable blue acrylic. Jack or XLR audio connectors.

Type	A	B	C
Input impedance	200Kohm	200Kohm	10Kohm BALANCED
Output impedance	2Kohm	20 or 600 ohm	20 or 600 ohm BAL
PRICE	£58.00	£68.00	£84.00

SHIFTER CIRCUIT BOARDS FOR WW July 1973 article
Complete kit and board **£21.00** *Including p.s.u. and* DESIGNER
Board built and aligned **£28.00** *mains transformer* APPROVED

SURREY ELECTRONICS

The Forge, Lucks Green, Cranleigh, Surrey GU6 7BG. (STD 04866) 5997
CASH WITH ORDER, less 5% UK post free, add VAT

Classifieds continued from page 109
Capacity Available continued

COMPONENT ASSEMBLY, Wiring and Test of, P.C.Bs, Electronic panels and Chassis, Prototypes designed, Batch production undertaken. DAVANT ELECTRONICS, 11 Ellesmere Road, Shrewsbury. Tel. Shrewsbury 50550 or Bomere Heath (Shrews) 682. [4080

COMPLETE printed circuit documentation including artwork masters, assembly drawings, mechanical drawings, circuit diagrams, etc., prepared from your basic design details. Single and double sided P.C. boards. Assembled prototypes supplied. J.T. Electronics. Box No. WW 4244.

CONSULT US for all Electronic and Telecommunications projects. High quality work by qualified staff at very favourable rates. Quotes free. D.C. Electronics. Tel: 0534 31814. [4238

ENGINEER makes anything unusual. Inventors models, displays. Special tools and equipment. Seymour, 30 Devonshire Drive, Stapleford, Nottingham. [4229

ELECTRONIC and Electro-Mechanical design and development services offering one off design or developments to production. Single circuits or complete systems. D.C.A. Electronics, 19 Church Street, Warwick. Tel. Warwick 44992. [4235

SMALL Batch Production, wiring assembly, to sample or drawings. Specialist in printed circuit assemblies. D. & D. Electronics, 42 Bishopsfield, Harlow, Essex. Harlow 33018. [17

COURSES

RADIO and Radar M.P.T. and C.G.L.I. Courses. Write: Principal, Nautical College, Fleetwood, FY7 8JZ. [25

BUSINESS OPPORTUNITIES

MAKE MONEY FROM YOUR HOBBY

Sell a range of nationally advertised Hi-Fi speakers from home and make some real money fast. The range has already become well-known and very favourable reviews have been carried out. You sell only a brand-new fully guaranteed product with full support from the manufacturer. Your mark up is 67% and maximum investment is £140. This is a direct selling opportunity and not part of any pyramid scheme.

Write for full details to:

ELBAR INDUSTRIES,
Dept. 6,
2 Greystones Close,
Kemsing, Sevenoaks, Kent

[4214

NEW GRAM AND SOUND EQUIPMENT

GLASGOW HI FI, Recorders, Video, Communications Reciever always available we buy sell and exchange for photographic equipment. Victor Morris Audio Visual Ltd., 340 Argyle Street, Glasgow, G.2; 31 Sauchiehall Street, Glasgow, G.1; 8/10 Glassford Street, Glasgow, G.2. Tel: 041-221 8958. [11

Hair Transplant

For free brochure, clip this ad. and send to:
Room 6
HAIR TRANSPLANT INTERNATIONAL
502 Eccleshall Road, Sheffield

[4224

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

EDDYSTONE EC10 MK11 Transistorised battery operated, mint condition, cost new £86 bargain at £55. Phone Newmarket 3871 evenings. [4256

HRD Rx5s, etc., AR88, CR100, BRT400, G209, S640, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [65

SIGNAL generators, oscilloscopes, output meters, wave voltmeters, frequency meters, multi-range meters, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [64

SERVICE AND REPAIRS

SCRATCHED TUBES. Our experienced polishing service can make your colour or monochrome tubes as new again for only £2.75, plus carriage £1. With absolute confidence send to Retube Ltd., North Somercote Louth, Lincs, or 'phone 0507-85 300. [27

TAPE RECORDING ETC.

RECORDS MADE TO ORDER

DEMO DISCS MASTERS FOR RECORD COMPANIES	VINYLITE PRESSINGS

Single discs, 1-20, Mono or Stereo, delivery 4 days from your tapes. Quantity runs 25 to 1,000 records PRESSED IN VINYLITE IN OUR OWN PLANT. Delivery 3-4 weeks. Sleeves/Labels. Finest quality NEUMANN STEREO/Mono Lathes. We cut for many Studios UK/OVERSEAS. SAE list.

DEROY RECORDS
PO Box 3, Hawk Street, Carnforth, Lancs.
Tel. 2273

[82

IF quality, durability matter, consult Britain's oldest transfer service. Quality records from your suitable tapes. (Excellent fund raisers for schools). Modern studio facilities with Steinway Grand.—Sound News, 18 Blenheim Road, London, W4. Tel. 01-995 1661. [4009

TENDERS

FOR SALE BY TENDER

SURPLUS RADIO & TELEPHONE EQUIPMENT

70 STORNO TYPE CQM 39
6 STORNO TYPE CQM 39
1 STORNO TYPE CQF 31
2 STORNO TYPE CQF 31
25 SINGLE CHANNEL TRANSCEIVERS
25 3 CHANNEL TRANSCEIVERS
3 BASE EQUIPMENT
14 BASE EQUIPMENT

For further details write to: **The County Surveyor, Northumberland County Council, Phoenix Street, Queen Street, Newcastle upon Tyne. NE1 3AT.**

[4272

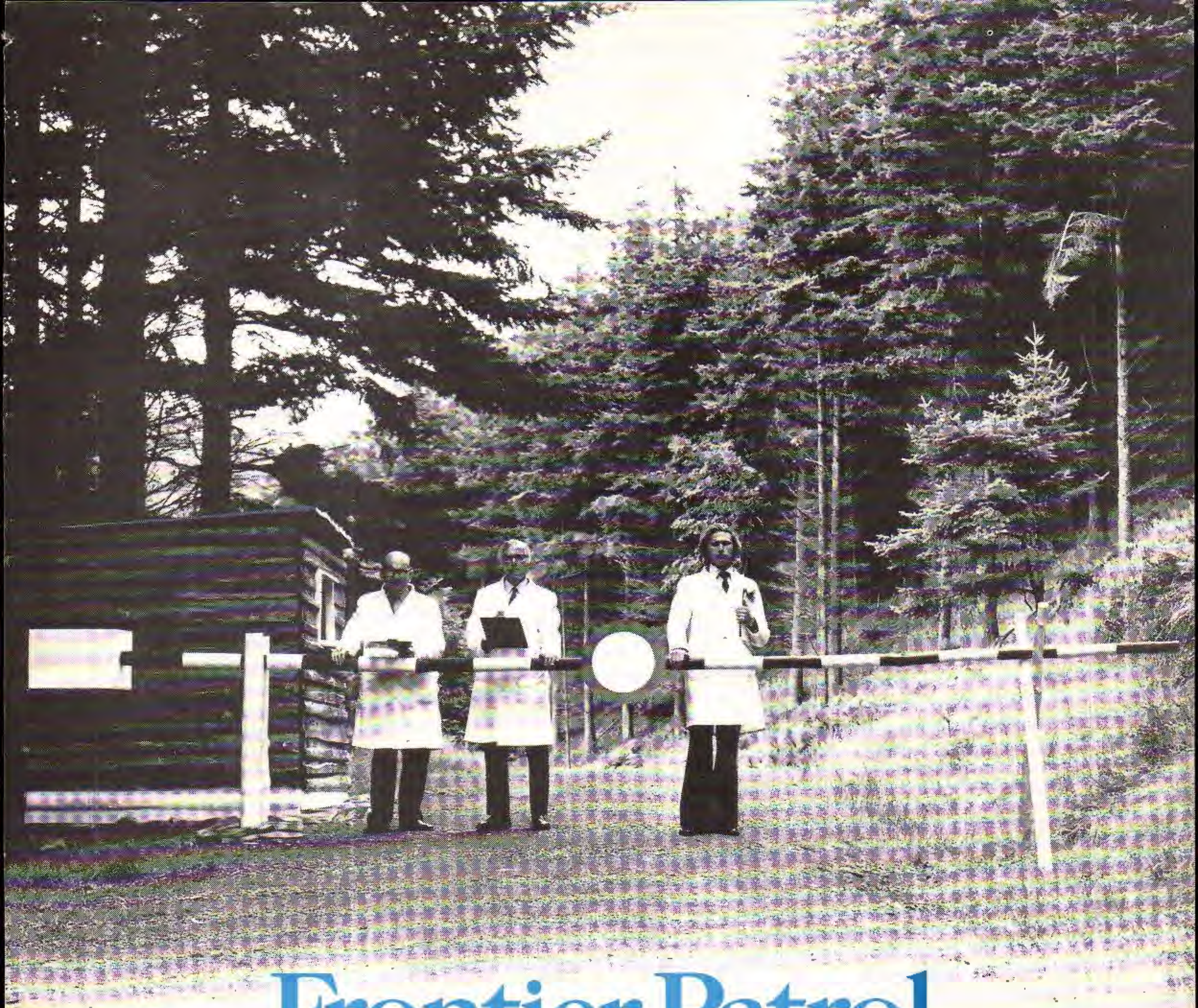
VALVES WANTED

WE buy new valves, transistors and clean new components, large or small quantities, all details, quotation by return.—Walton's, 55 Worcester St., Wolverhampton. [62

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 94-109

Printed in Great Britain by Hazells Offset Ltd., Leigh Road, Slough, Bucks., and Published by the Proprietors I.P.C. 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. 155 West 15th Street, New York, N.Y. 10011.



Frontier Patrol

Spy-trapping? Smuggler-scotching? That's no work for the scores of designers in our 150-strong engineers' brigade.

They're on frontier duties just the same, though. For sometimes they're operating on the very frontiers of human knowledge – as with our remarkable new spectrum analyser, in which they've combined the latest digital storage technology and television display with semi-automatic operation to produce a new generation instrument.

Sometimes, on the other hand, they're helping you to economise – as when they produce a signal generator able to give the performance you need without the cost of the performance you don't.

There are times, too, when – as a result of free-ranging, exploratory probing – they come up with a revolutionary instrument that was not originally on the agenda at all. An example? The X–Y Memory, a definitive solution to the irritating problem of clear oscilloscope display of very low frequency waveforms.

The fact is: **mi** maintains what is Europe's largest operation devoted exclusively to electronic test and measuring instruments. And it has the resources, the research facilities, the development potential to match.

mi : THE INNOVATORS

MARCONI INSTRUMENTS LIMITED

Longacres · St. Albans · Hertfordshire AL4 0JN · England · Telephone: St. Albans 59292 · Telex: 23350

A GEC–Marconi Electronics company.