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50MHz oscilloscope

EXCLUSIVE DOLBY KIT (Part 1)

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10p

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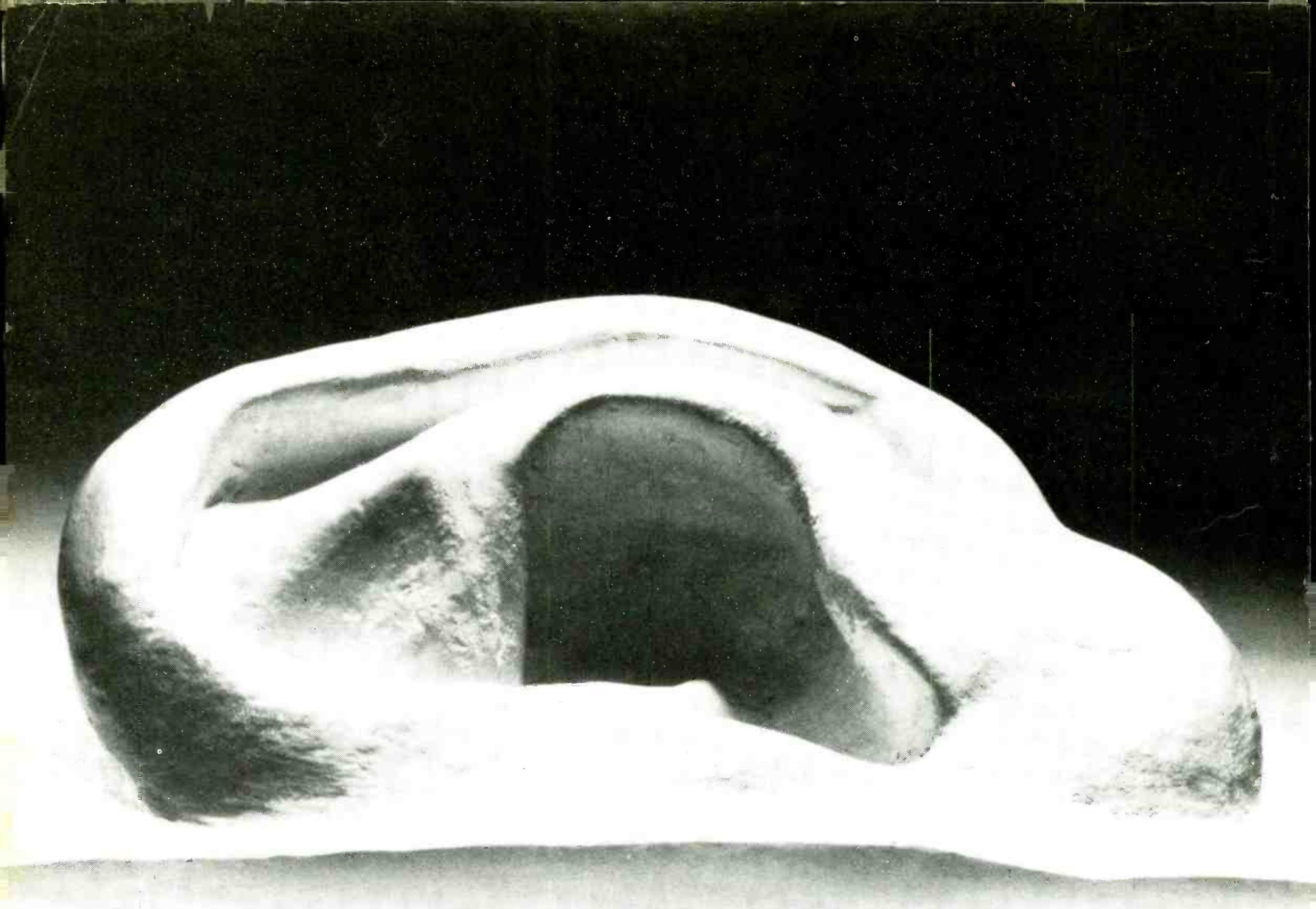

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The human ear must be one of the oldest research instruments in the business. Yet many of the ultra-modern Marconi instruments used in today's most advanced research projects owe a debt to it.

At **mi**, you see, we don't believe in Ivory Towers. So we ponder the constant feedback of information from you through our sales engineers far and wide, and keep our ear to the grounds of component technology and measurement trends throughout the world.

Requests, suggestions, remarks, ideas . . . they all lead us to what you are going to need – or they reveal possible new approaches to the solutions of those needs.

We have our ears in all the national and international committees of measurement standards and recommendations too.

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LOW COST VOLTMETERS

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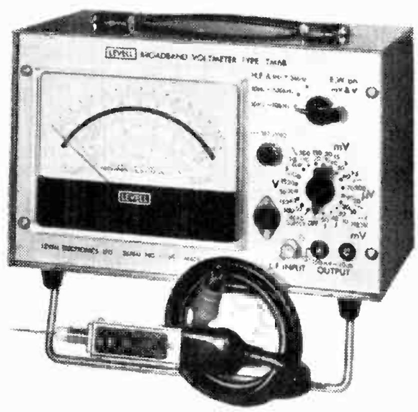
PORTABLE INSTRUMENTS

These highly accurate instruments incorporate many useful features, including long battery life. All A type models have 3¼″ scale meters, and case sizes 5″ x 7″ x 5″. B types have 5″ mirror scale meters and case sizes 7″ x 10″ x 6″.

A.C. MICROVOLTMETERS

VOLTAGE & db RANGES: 15μV, 50μV, 150μV ... 500V f.s.d. Acc. ± 1% ± 1% f.s.d. ± 1μV at 1 kHz. – 100, – 90 ... + 50dB, scale – 20dB/+ 6dB rel. to 1 mW/600Ω.
RESPONSE: ± 3dB from 1 Hz to 3MHz, ± 0·3dB from 4Hz to 1 MHz above 500μV. Type TM3B can be set to a restricted B.W. of 10Hz to 10 kHz or 100 kHz.
INPUT IMPEDANCE: Above 50mV : > 4·3MΩ < 20pf. On 50μV to 50mV : > 5MΩ < 50pf.
AMPLIFIER OUTPUT: 150mV at f.s.d.

type TM3A **£65** type TM3B **£80**



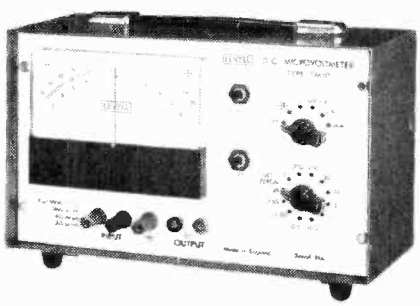
BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV ... 3V f.s.d. Acc. ± 4% ± 1% of f.s.d. at 30MHz. – 50dB, – 40dB, – 30dB to + 20dB. Scale – 10dB/+ 3dB rel. to 1mW/50 Ω. ± 0·7dB from 1 MHz to 50MHz. ± 3dB from 300kHz to 400MHz.

L.F. RANGES: As TM3 except for the omission of 15μV and 150μV.

AMPLIFIER OUTPUT: Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

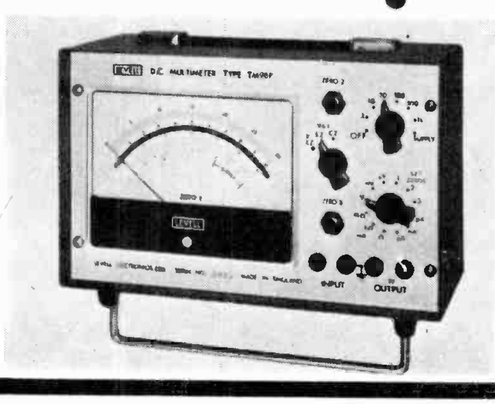
type TM6A **£110** type TM6B **£125**



D.C. MICROVOLTMETERS

VOLTAGE RANGES: 30μV, 100μV, 300μV ... 300V. Acc. ± 1%, ± 2% f.s.d., ± 1μV. CZ scale.
CURRENT RANGES: 30 pA, 100 pA, 300 pA, 300 mA. Acc. ± 2%, ± 2% f.s.d., ± 2 pA. CZ scale.
LOGARITHMIC RANGE: ± 5μV at ± 10% f.s.d., ± 5 mV at ± 50% f.s.d., ± 500 mV at f.s.d.
RECORDER OUTPUT: ± 1V at f.s.d. into > 1kΩ

type TM10 **£67**



D.C. MULTIMETERS

VOLTAGE RANGES: 3μV, 10μV, 30μV ... 1kV. Acc. ± 1% ± 1% f.s.d. ± 0·1μV. LZ & CZ scales.

CURRENT RANGES: 3pA, 10pA, 30pA ... 1 mA (1A for TM9BP) Acc. ± 2% ± 1% f.s.d. ± 0·3pA. LZ & CZ scales.

RESISTANCE RANGES: 3 Ω, 10 Ω, 30 Ω ... 1kM Ω linear. Acc. ± 1%, ± 1% f.s.d. up to 100M Ω.

RECORDER OUTPUT: 1V at f.s.d. into > 1k Ω on LZ ranges.

type TM9A **£95** type TM9BP **£114**

LEVELL ELECTRONICS LTD.
Moxon Street, High Barnet, Herts. EN5 5SD
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Prices include batteries and U.K. delivery. V.A.T. extra. Optional extras are leather cases and mains power units. Send for data covering our range of portable instruments.

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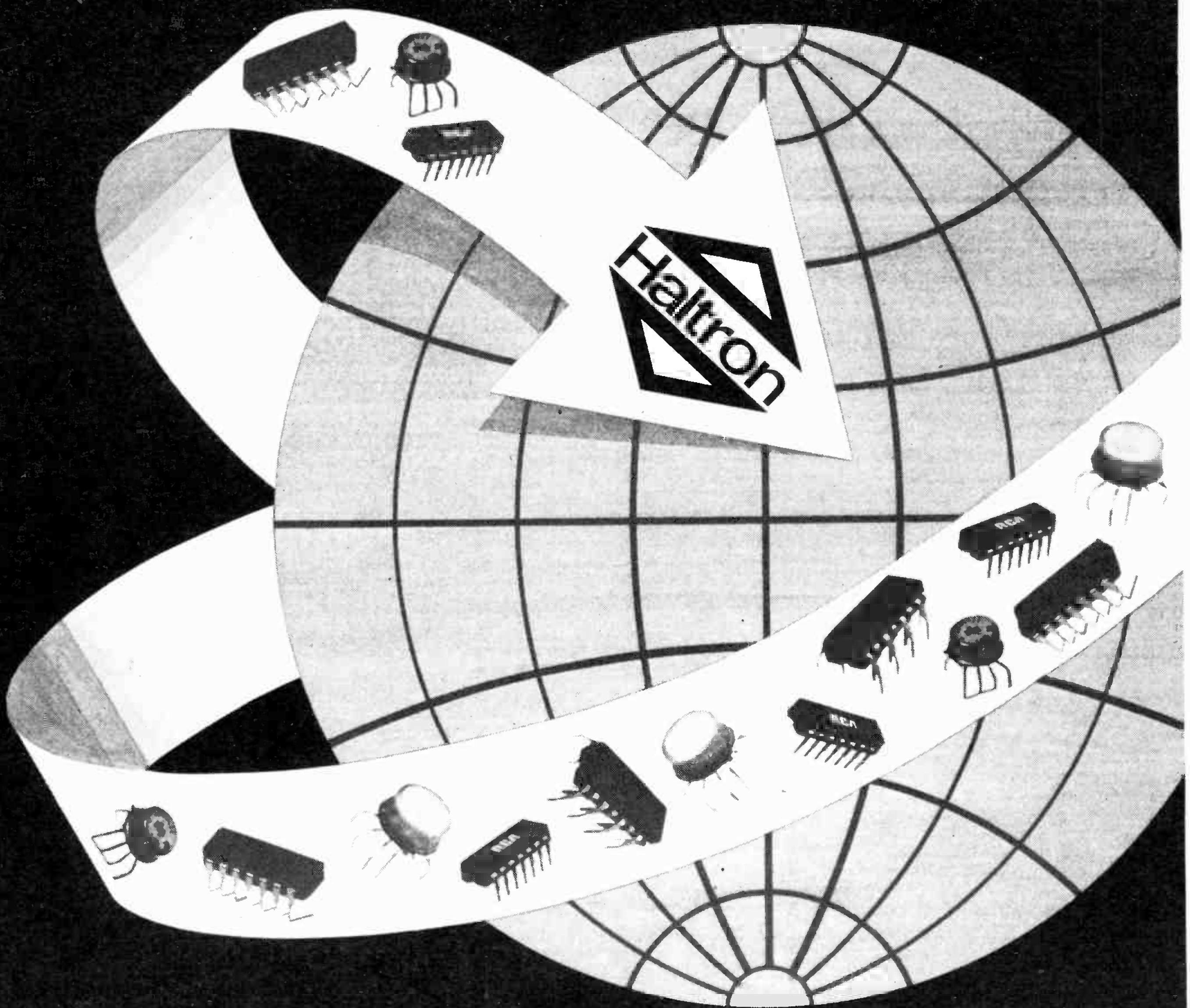
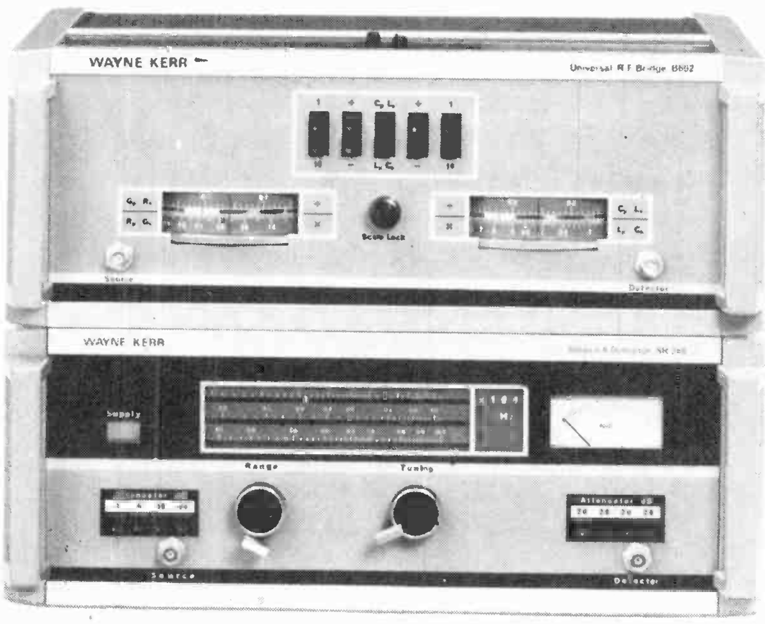

Haltron

Stable companions

Wide-range universal bridge **B602**
0.1-100MHz source/detector **SR268**
from Wayne Kerr



SPECIFICATION

B602

Frequency range:	100kHz to 10MHz
Accuracy:	1% up to 3MHz. 1pF to 10nF 10Ω to 100kΩ 1μH to 10mH
Overall impedance range:	1fF to 1mF 100μΩ to 100MΩ (10n℧ to 10k℧) 10pH to 10H

SR268

Frequency Range:	100kHz to 100MHz in 9 bands (SR268L 46·5kHz to 46·5MHz)
Frequency accuracy:	2–3% according to band used.
Short Term Frequency Stability:	0·01%
Output level:	0·5–2·0V according to band used.
Output attenuator:	3, 6, 10, 20 dB additive steps, 75Ω
Input sensitivity for 10% meter deflection:	1 to 30μV according to frequency setting
Input attenuator:	4 steps of 20 dB, 75Ω
Detector bandwidth.	2–3% according to band used

For more information, either phone Bognor Regis (02433) 25811 or write to the address below:

WAYNE KERR
Durban Road, Bognor Regis, Sussex
Telex: 86120. Cables: Waynkerr, Bognor
A member of the Wilmot Breeden group

The B602 transformer ratio arm bridge measures impedance in all four quadrants of the complex plane over the frequency range 100kHz to 10MHz. Because of novel features incorporated in the design, values from virtually a short circuit to an open circuit can be measured. This bridge has established a standard of performance and flexibility which is unobtainable from any other radio frequency bridge.

A standard inductor is included in the bridge network in addition to standards of capacitance and resistance enabling a periodic calibration of the scales which are correct at any frequency between 100kHz and 10MHz.

There are only two balance controls. One is direct reading in resistance and conductance, the other in capacitance and inductance and there is no interaction between them.

The stability realised allows a discrimination of 0·1% to be obtained for all types of measurement with a general accuracy of 1% over most of the impedance and frequency range.

The bridge is shown together with the SR268 Source and Detector which can also be used with other bridges in the Wayne Kerr range over the frequency band 100kHz to 100MHz. Nine frequency ranges are provided by this instrument and a single tuning control adjusts both source and detector to the exact frequency required.

Meticulous screening between the two sections provides freedom from bridge measurement errors due to leakage of the source signal into the detector. Common mode rejection transformers are incorporated in the input and output networks to reduce interference from unwanted signals, and push button attenuators are included to assist the logarithmic detector circuit to indicate approach of the bridge balance point.

WW—223 FOR FURTHER DETAILS

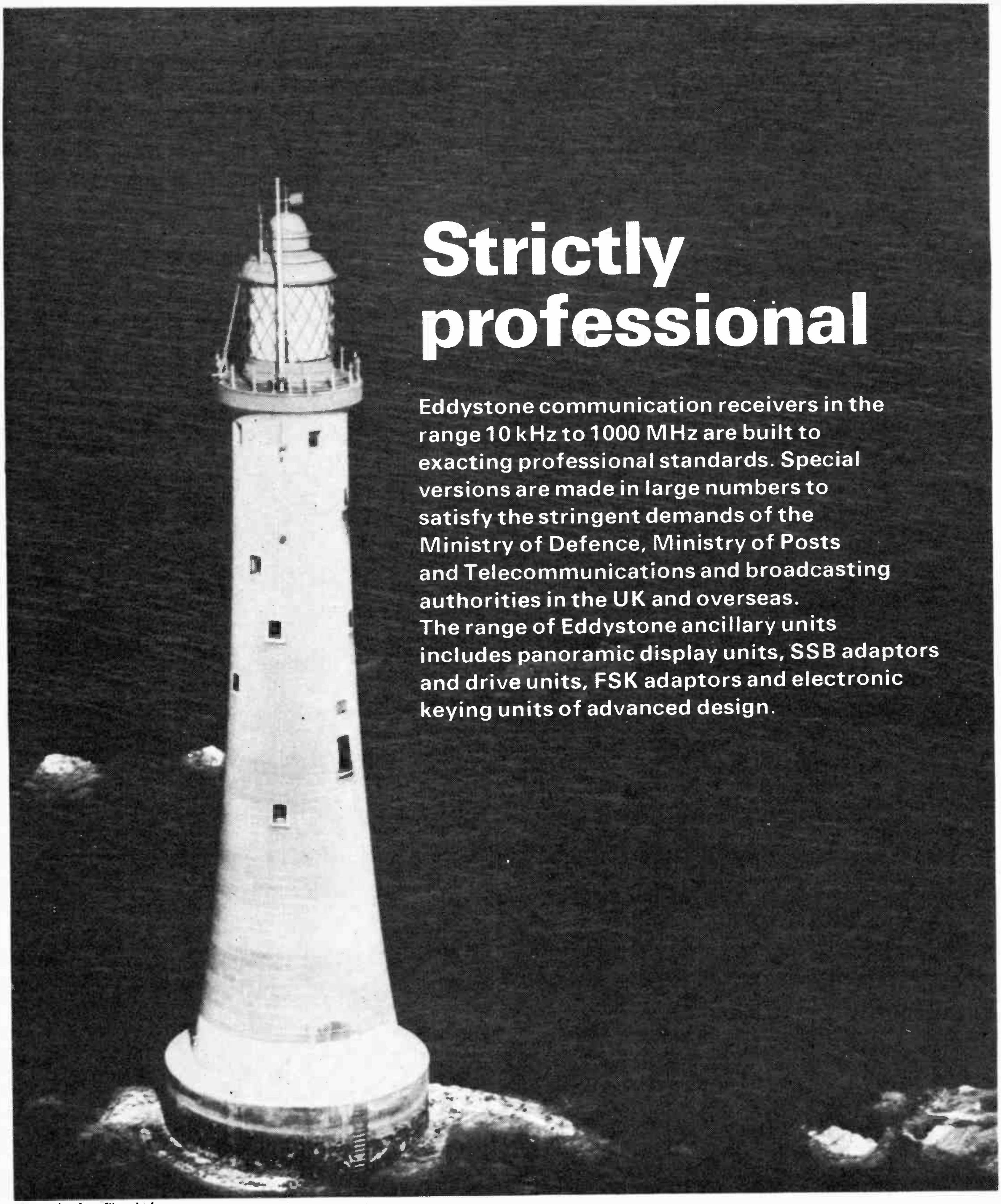


Photo by Aerofilms Ltd.

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Member of Marconi Communication Systems Limited

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Telephone: 021-475 2231 Telex: 337081

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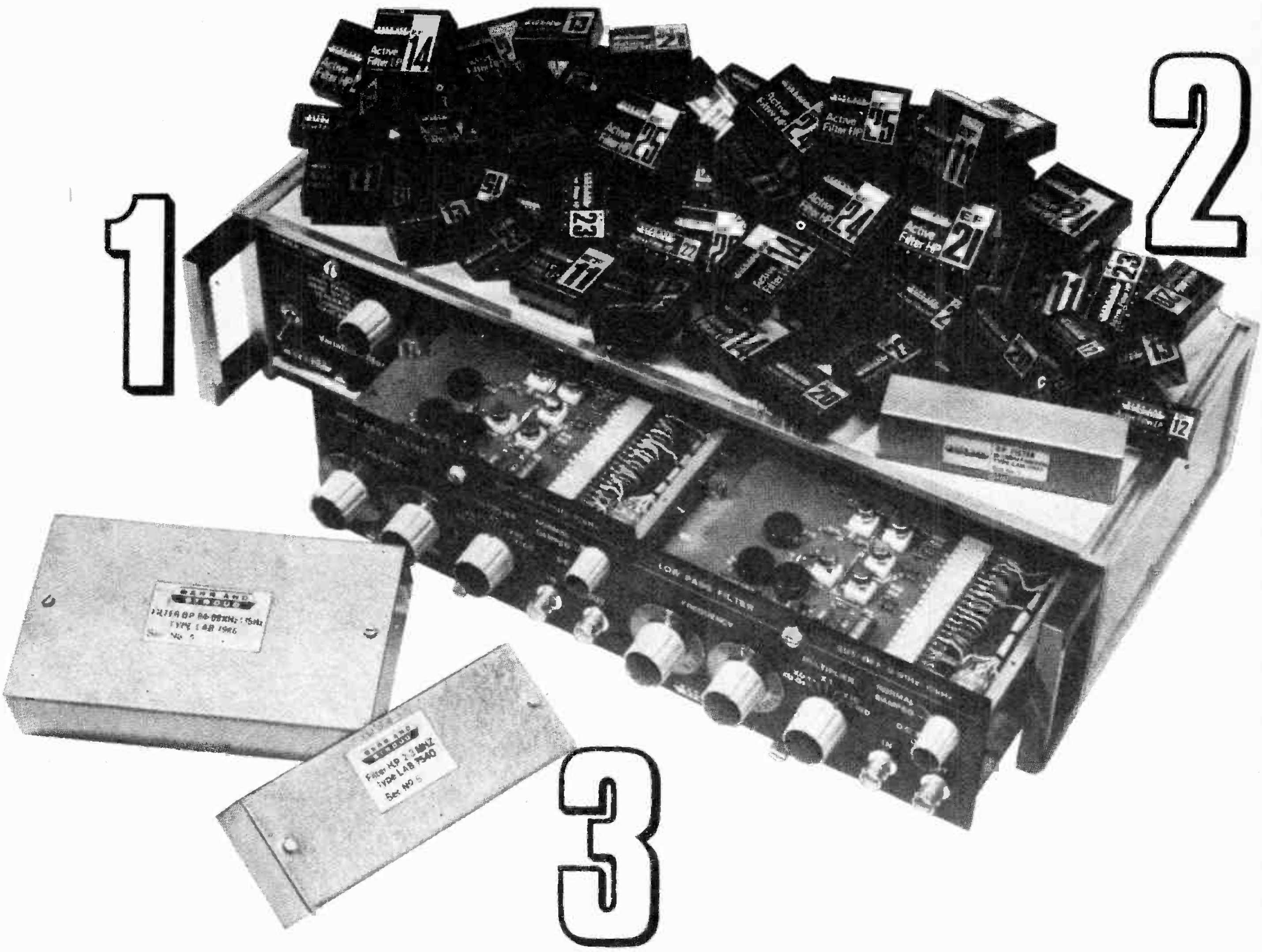
WW—191 FOR FURTHER DETAILS

BARR & STROUD ELECTRONIC FILTERS

The 3 aspects of our service



1. System EF3

A flexible system of filter instrumentation using a modular approach to give plug-in interchangeability. The mainframe carries a power unit and accepts up to two filter units of either Low Pass or High Pass function. Integral switching allows individual or cascade operation and can give Band Pass, Band Stop, Band Separate or Band Combine modes.

2. Active Filter Modules

These are compact, solid state, encapsulated units providing basic filter functions to be customer set for cut-off frequency and characteristic. The present range contains Low Pass and High Pass types with cut-off frequency coverage from 1.0Hz to 30kHz in overlapping ranges, with attenuation rates up to 24dB/octave/module. Universal modules specifically for Band Pass and Band Stop operation are part of the range.

3. Custom Build Service

If our standard filter range does not meet your specification we welcome the opportunity to study your requirement. Broadly our capability stretches from d.c. to 25MHz with experience in passive and active designs. We can work to normal commercial standards or strict defence requirements and construction can be as dictated by the environmental conditions of your application.

BARR & STROUD LIMITED
London Office: 1 Pall Mall East, London SW1Y 5AU
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BARR AND STROUD
Glasgow and London

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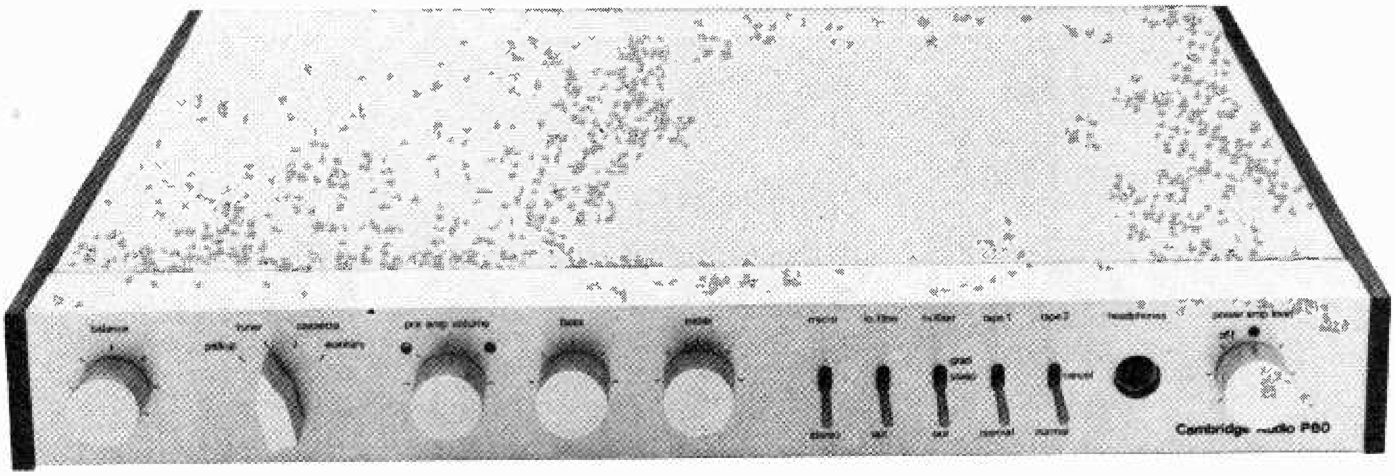
A WORLD FIRST* FROM CAMBRIDGE AUDIO



THE NEW P60 INTEGRATED STEREO AMPLIFIER

Low profile design only 2″ high.

Recording with or without tone correction.

*Peak level indicator for tape recording.

Suitable for continual high power operation.

Dual independent tape operation.

*Light Emitting Diodes for level monitoring in main and pre-amplifiers.

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WW 25

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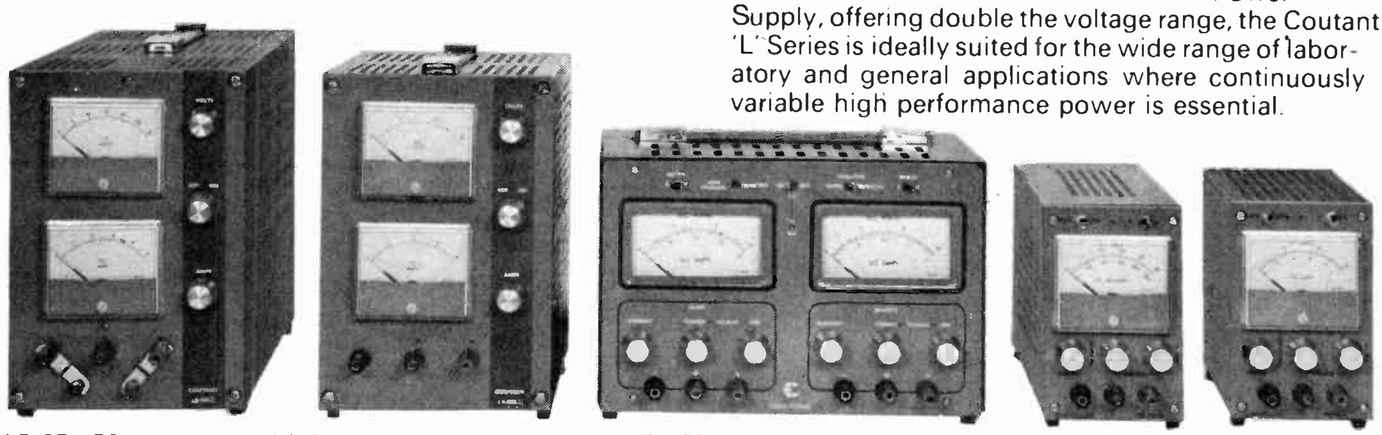
With the addition of the new LQT Twin Power Supply, offering double the voltage range, the Coutant 'L' Series is ideally suited for the wide range of laboratory and general applications where continuously variable high performance power is essential.



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

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

LQT SERIES
LQT 100 : 0 to ± 30V " 0 to 1A x 2
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 4A
or 0 to 30V " 2A

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

LM SERIES
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provides power when no power exists!

Now you can be totally independent of a mains power supply. The Electrotech 'Standby' provides up to 500 W of power instantly when connected to a 24V source. If linked to two ordinary 12V car batteries the unit will deliver 240V 50Hz power for at least 2½ hours.

- Open circuit on low battery condition
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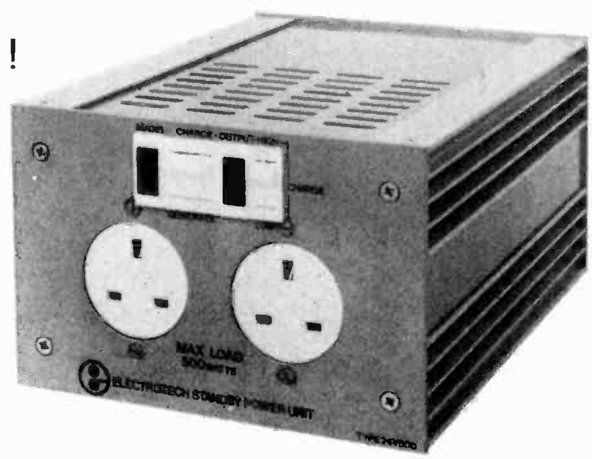

Electrotech 'Standby' supplied by:

LEKTROKIT LIMITED
Trafford Road, Reading, Berkshire.
Tel: Reading (0734) 55394

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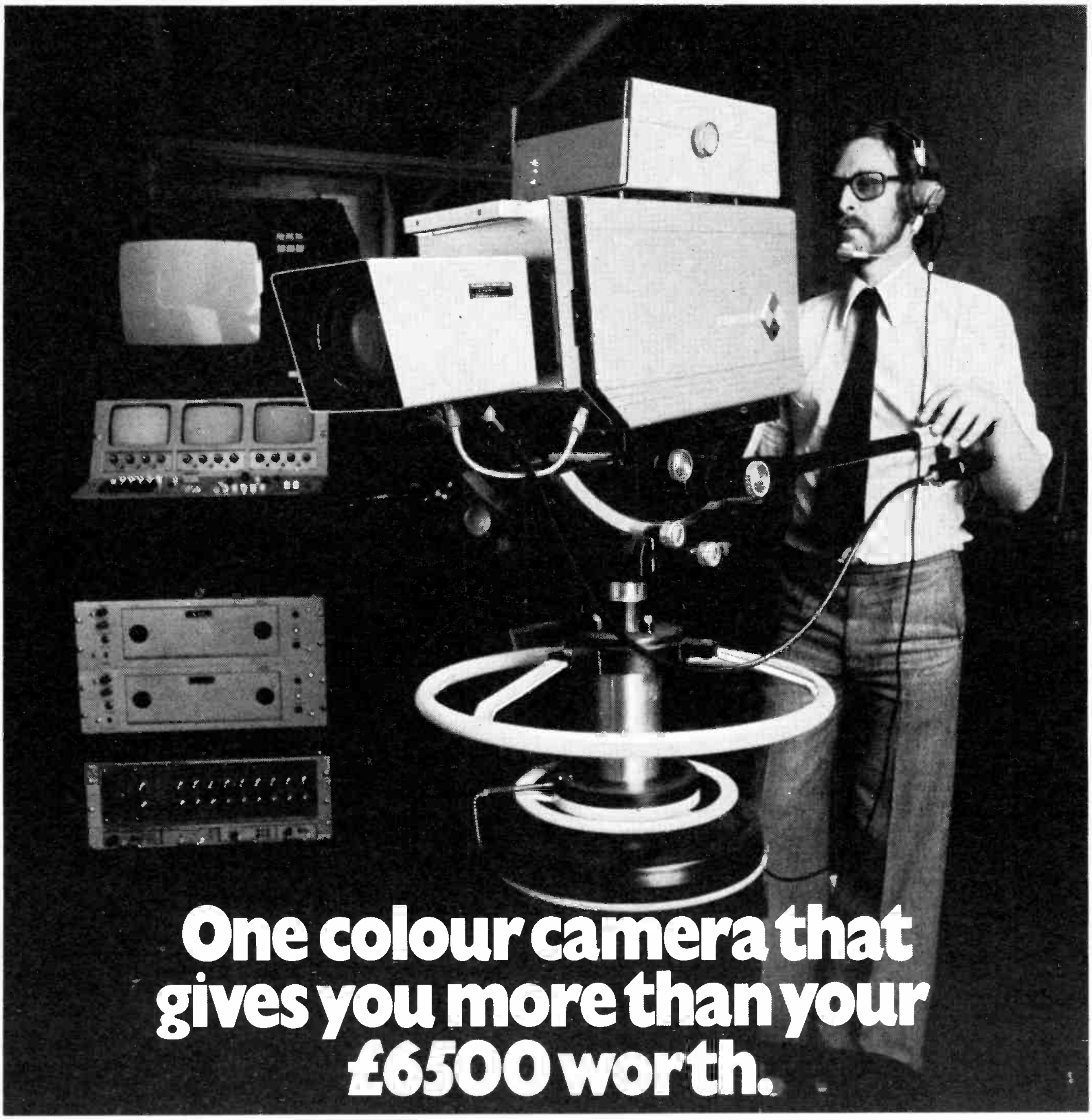

The ITC CTC-3X is a lot of camera for the money. £6500 buys you a high performance colour television camera, that can be used in studio, telecine, mobile or remote colourcasting.

It comes complete with f1.8 10:1 zoom lens, servo and cable controlled.

A view-finder monitor which can be easily removed or tilted both upward and downward.

A camera control unit which gives you remote controls including colour balance, iris, R.B. channel positions and gain, and on-off power and beam.

A separate mains lead that allows camera to be operated without CCU.

Plus features such as turret colour temperature correction filters.

A built-in colour bar generator.

A set of matched vidicon tubes. A waveform colour sampler for easy colour balance adjustment.

That's the ITC CTC-3X. A lot of camera for £6500.

If you want it fitted with Plumbicon® Tubes with extended red, it will cost you £8125.

Also available is the SC 701P Genlock colour sync. generator at £1265.

Plus the MEA 7100P six channel special effects generator at £2415.

At Dixons Technical, of course.

Prices subject to VAT.

To: Dixons Technical,
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Please send me full details of the ITC CTC-3X colour camera and ancillary equipment.

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Dixons Technical Ltd

WW/39a/5

Also available from our agents. Southern Counties: Action Video. In the north: Holiday Brothers Ltd.

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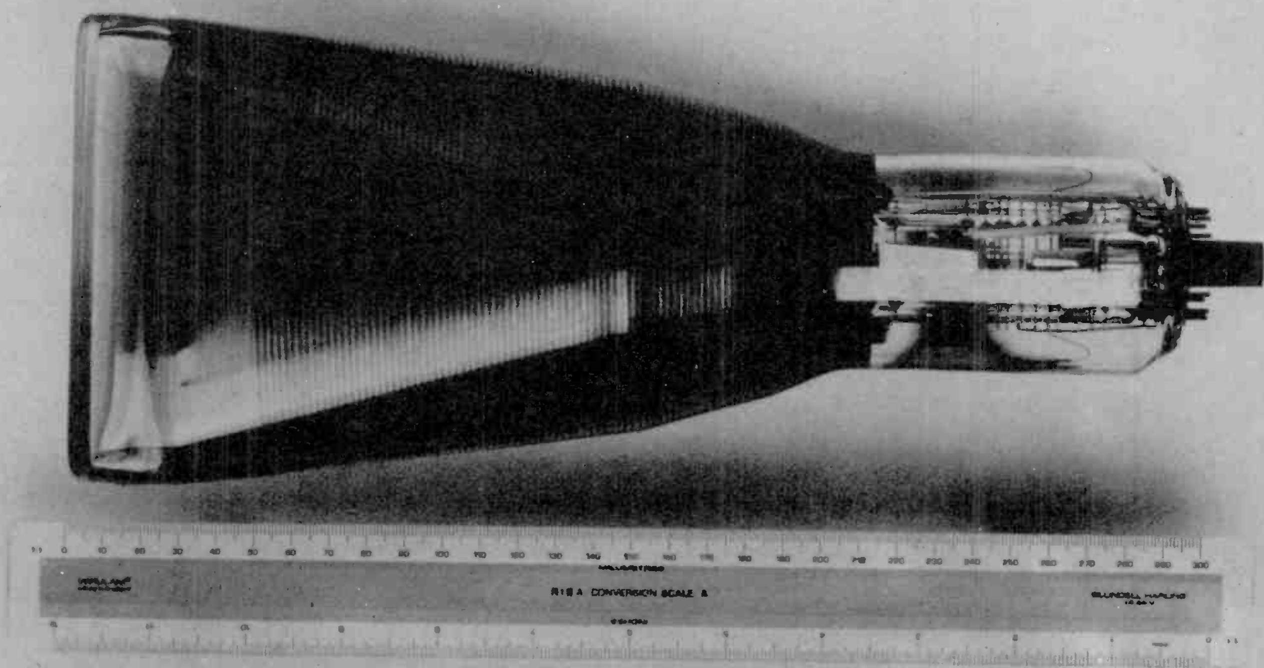
There's only one thing the new Brimar D18-130 tube is short on: length.



More space on the screen with less for the tube – that's what the new Brimar **D18-130** offers you for your next portable display instrument design.
With a useful display area of 12.3 cm. x 10 cm. its overall length is only 310 mm. And that's the shortest length for its screen size of any electrostatic focus industrial tube available.
The tube has a high brightness and good focus performance (under typical operating conditions a line width of 0.25 mm. can be expected.)
The new **D18-130** can be supplied with internal graticule and various phosphors to special order. The standard phosphor is GH, which gives a medium-short persistence green trace. A magnetic shield and twist coil are available.
We'll gladly send you a descriptive leaflet on request.

BRIMAR

Thorn Radio Valves and Tubes Limited
Mollison Avenue, Brimsdown, Enfield, Middlesex, EN3 7NS. Telephone: 01-804 1201.

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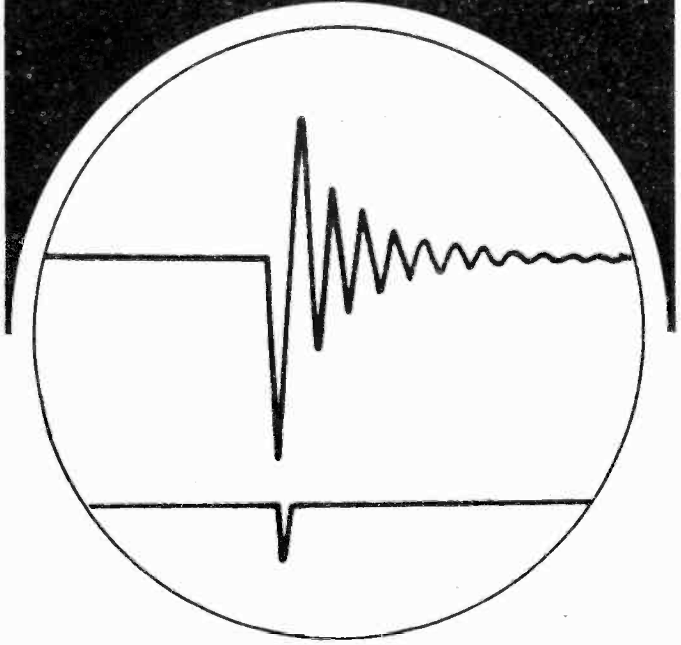
WW—240 FOR FURTHER DETAILS

SEND FOR THE FACTS ON FIBRE OPTIC RECORDING!



Medelec Limited, with a firmly established reputation earned in the exacting field of medical instrumentation, have developed a range of equipment combining the facilities of conventional oscilloscopes, strip chart and X-Y recorders, to provide unique capability.

Fibre Optic Recording increases the clarity and efficiency of data recording, gives low cost records and extends the field of application to new areas of industrial research and development.

To learn more about Fibre Optic Recording and Medelec equipment send today for a new publication "Medelec Fibre Optic Recording". This gives full information on development, comparisons, economics, case histories and general applications.

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Leaders in Fibre Optic Recording

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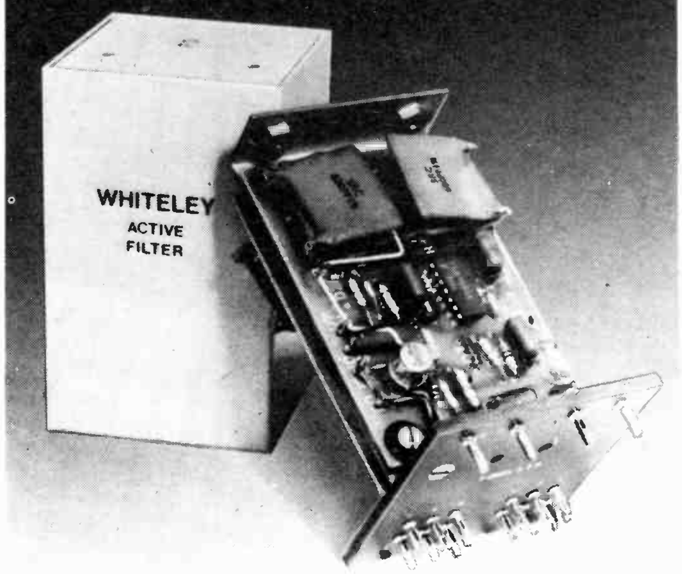
New active filter takes over from passive networks



These active filters are designed to take over the functions of passive filter networks in audio telecommunications systems. They offer several advantages, in space-saving, economy and reliability.

As a size comparison, one active filter will take up the same space as two Post Office Type 3000 relays. By using the same fixing and terminal holes as the relays, it offers an extra convenience when baseboards are being prepared. By replacing inductive components with solid state devices, filter characteristics have been obtained at less cost, without insertion loss, and with increased flexibility and economy. These new active filters have B.P.O. approval, and have wide applications, in the audio area and in signalling and control systems.

Whiteley *versatility...*

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elektor

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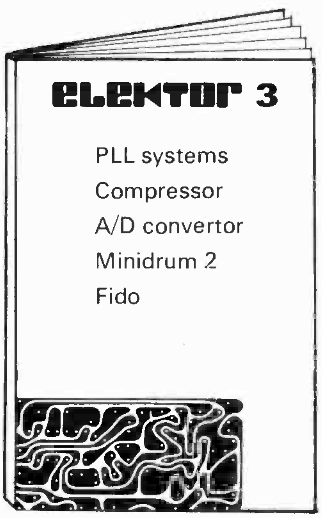

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Touch control audio preamp.
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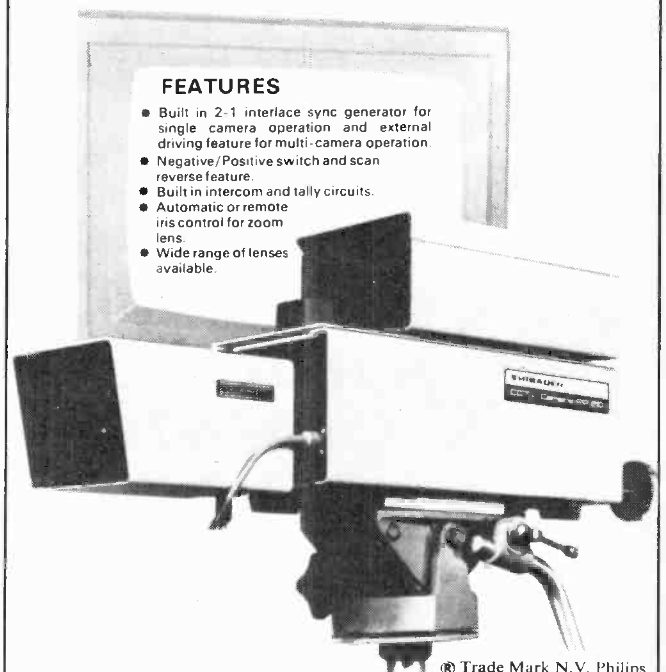
3

The FP 210K, Shibadens popular 1" Plumbicon® Camera



® Trade Mark N.V. Philips

This is the camera that will operate anywhere – in the studio or on outside location – and guarantee excellent results for a wide range of T.V. requirements in the fields of industry, education and commercial applications.

Equipped with a 5" electronic viewfinder for accurate picture composition and focus, the FP 210K is automated to ensure all major functions are easily handled.

If you prefer, a separate mesh type vidicon tube can be used, which, like the 1" Plumbicon ® gives high definition picture reproduction.

To see the FP 210K in action, or for complete technical information, contact Shibaden's Technical Service Department at 01-203 4242/6 or write to:

Hitachi Shibaden (UK) Limited
BROADCAST & CCTV EQUIPMENT MANUFACTURERS
Lodge House · Lodge Road · Hendon · London NW4 4DQ. Telephone: 01-203 4242/6

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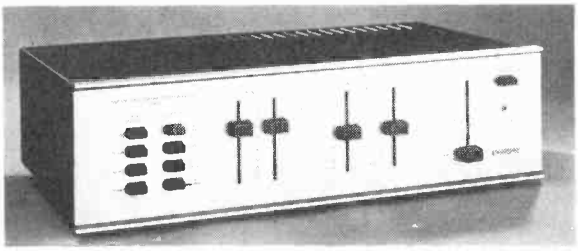
A NEW STANDARD FOR SOUND REPRODUCTION

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. (Cannot be identified or measured as it is below inherent circuit noise.)
Power amplifier. at rated output: at 25w output:	Less than 0.02% (typically 0.01% at 1kHz).

Overload margin.

Disc input	40 dB min.

Hum and noise output

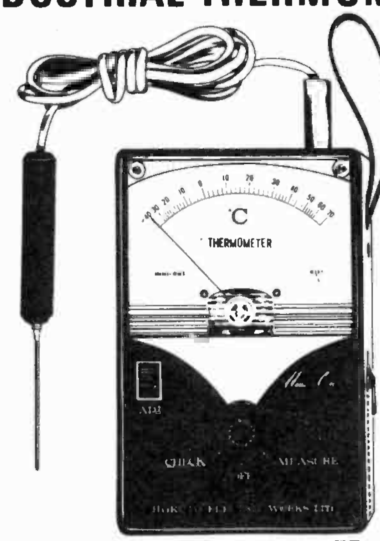
Disc:	—83dBV Measured flat with noise band-width of 23kHz (ref. 5mV.)
	—88dBV Measured with 'A' weighted characteristic (ref. 5mV.)
Line:	—85dBV Measured flat (ref. 100mV.)
	—88dBV 'A' weighted (ref. 100mV.)
Size:	17 inches × $4\frac{3}{4}$ inches × 11 inches deep overall.
Weight:	21 lb.

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

ELECTRONIC INDUSTRIAL THERMOMETER



THE MODERN WAY TO MEASURE TEMPERATURE

A Thermometer designed to operate as an Electronic Test Meter. Will measure temperature of Air, Metals, Liquids, Machinery, etc., etc. Just plug-in the Probe, and read the temperature on the large open scale meter. Supplied in zippered vinyl case with transparent front and carrying loop, Probe, and internal $1\frac{1}{2}$ volt standard size battery.

Model "Mini-On 1" measures from − 40°C to + 70°C, price £17.50
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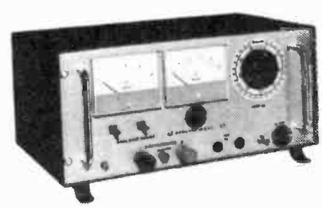

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Input 200–250V. 50Hz
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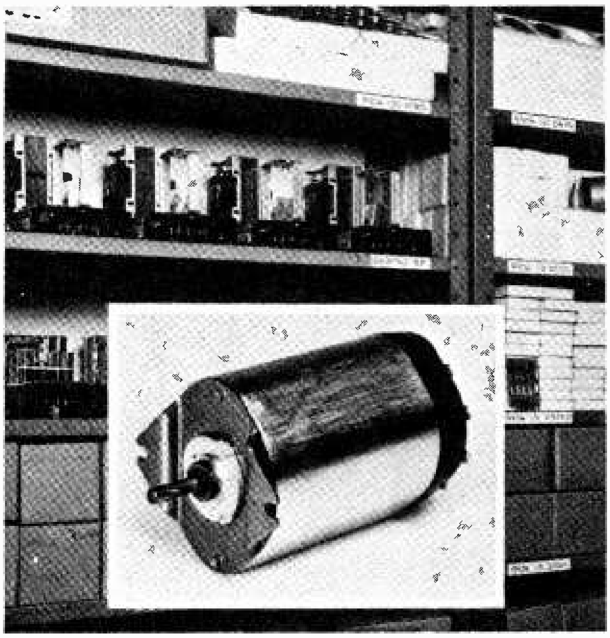

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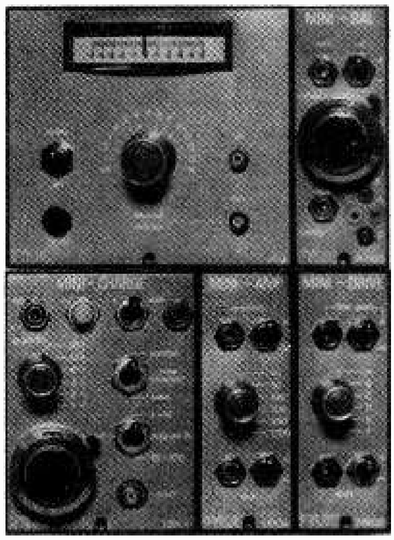

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Power bandwidth	DC to 20 kHz +1 db, −0 db, 600 W into 8Ω
Phase response	+0 db, −15 db DC—20 kHz
Slew rate	16 V/μsecond
Damping factor (8Ω)	greater than 400 DC—1 kHz
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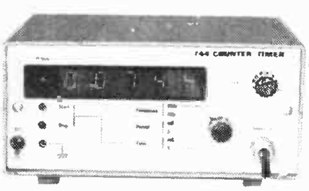

744 COUNTER TIMER

£74 + £1.50 p.&p. + VAT

Measures frequency, period and time
30MHz frequency range (DC coupled)
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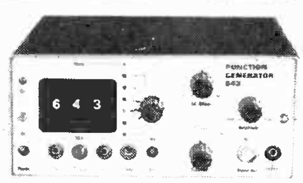

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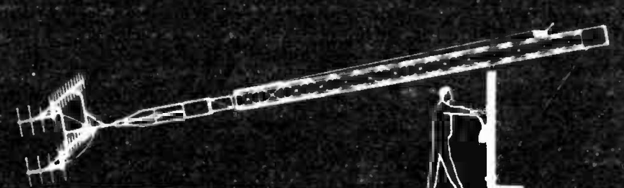

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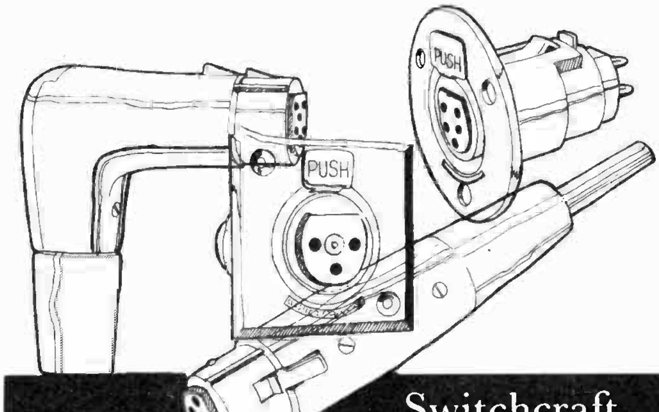

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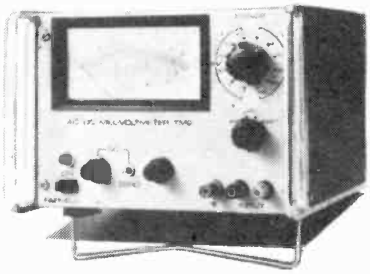

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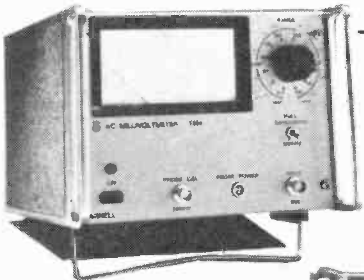
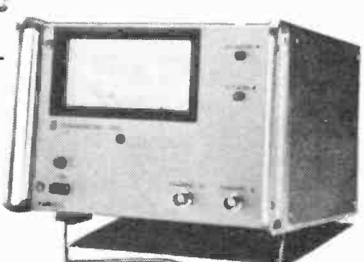
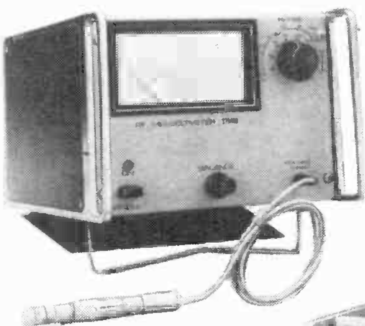
A.C./D.C. MILLIVOLTMETER
1mV to 300V f.s.d.
10Hz to 5MHz frequency range
10M Ω input impedence
Mains or battery operated



TM4
A.C. MILLIVOLTMETER
300 µV to 100V f.s.d.
20Hz to 18MHz
10MΩ input impedence via probe
H.F. spurious and noise filter



PM1
PHASEMETER
Meter indicates phase difference 0-180°. Lamps indicate leading or lagging phase 10Hz to 100kHz
PM1/B operates from mains or rechargeable batteries



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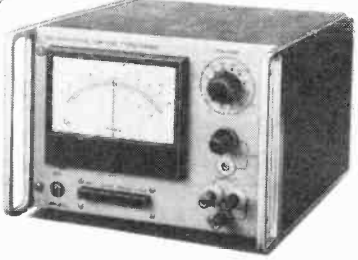

TM39
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TPA SERIES – D

integrated circuit power amplifier

TPA 50 - D Specification

Power Output	100 watts rms into 4 ohms 65 watts rms into 15 ohms
Freq Response	±0·1dB 20Hz to 20KHz into 15 ohms. -1dB at 150KHz
Total harmonic distortion	Less than 0·04% at all levels up to 50 watts rms into 15 ohms
Input sensitivity	OdBm
Noise	-100dB
Rise time	2 u seconds
Price	£70 plus V.A.T.

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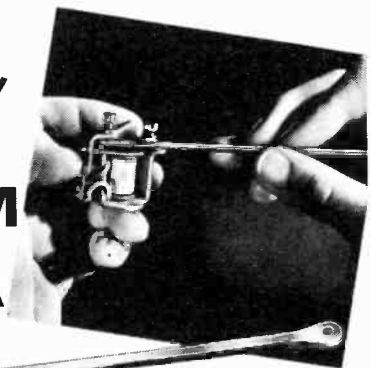
Keep those Contacts CLEAN

BY USING A

DIACROM SPATULA



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No other cleaner has all these advantages:—

1. Only 100% pure, natural diamond grains are utilised.
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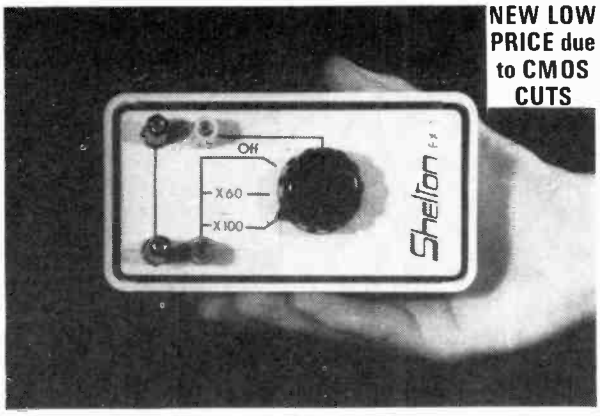

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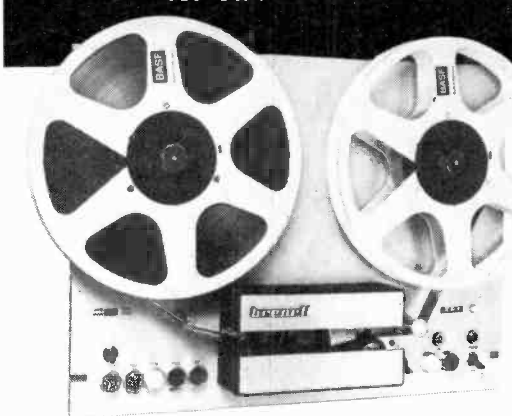
and multi-channel electronics for studio and industrial use



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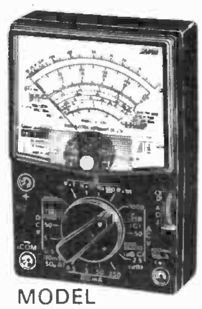

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1 (a) Equivalent input noise at the exceedingly low figure of 0.5 μV.
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(c) An input dynamic range of close on 100dB, 30dB better than the finest recordings now available.
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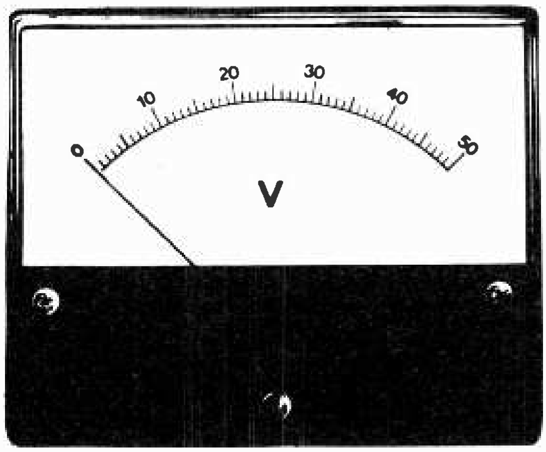

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Type Number	Output Voltage	Output Current Amps	Short Circuit Current mA (Typical)	% Regulation Line and Load (Typical)
PU01	5 ± 0.1	0.5	370	0.3
PU02	5 ± 0.1	1.0	770	0.5
PU03	15 - 0 - 15 ± 0.2	0.10	37	0.1
PU04	15 - 0 - 15 ± 0.2	0.20	84	0.1
PU05	12 - 0 - 12 ± 0.2	0.12	45	0.1
PU06	12 - 0 - 12 ± 0.2	0.24	120	0.2
PU11	18 - 0 - 18 ± 0.2	.15	50	0.1
PU10	15 ± 0.2	.10	37	0.1
PU12	12 ± 0.2	.10	45	0.1
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Input voltage ranges 103 - 126V, 200 - 240V. 210 - 250V. Frequency 50 - 400 Hz all types.

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"Worldwide Market is our aim," says Vitavox MD . . .

Reporting that the 1975 export order book of Vitavox Limited was the biggest in their 44-year history, the Company's Managing Director, Mr. Neil Young, said: "The expansion and strength of our export programme has always been a top priority with us. In today's industrial and economic climate this priority is more vital than ever".

Getting his priorities right has always been a first essential with Neil Young. On leaving school, where he studied modern languages, he joined the Royal Electrical and Mechanical Engineers: "To see if I had any technical ability". From here he went to English Electric, carrying out research work on technical literature with their Technical Publications Department. He moved on to the EWS Technivision Publications Division and then to Elliott Aviation, in both cases working on technical instruction literature for the Services.

In 1962, at the age of 25, Neil Young joined Vitavox, the firm his father founded in 1931. He then became an Associate of the Institution of Works Management. Seven years later, after a period during which, among other projects, he and his brother David helped to develop the costing and production control systems of the Company, he succeeded his father, the late Mr. Len Young, as Managing Director; Mr. Young senior becoming Chairman of the Company, the post he held until his death in 1974.

"My policy has been to streamline production wherever possible, to continue to up-date production and, of course, to develop our export markets—all policies very much in tune with my father's beliefs."

With a turnover 100 times that of the Company's founding year, a home market as healthy as that for overseas and with the export market currently covering 34 countries across the world, Vitavox today is living proof that Neil Young's priorities are spot on.

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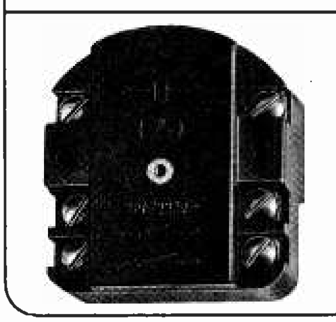

Impulse Latching Relay AZ 340

Make contacts:
Resistive load: 10 A/240 V AC.
Lamp load: 8 A/240 V AC.
Compensated fluorescent tubes: 3.7 A/240 V AC.

Break contacts:
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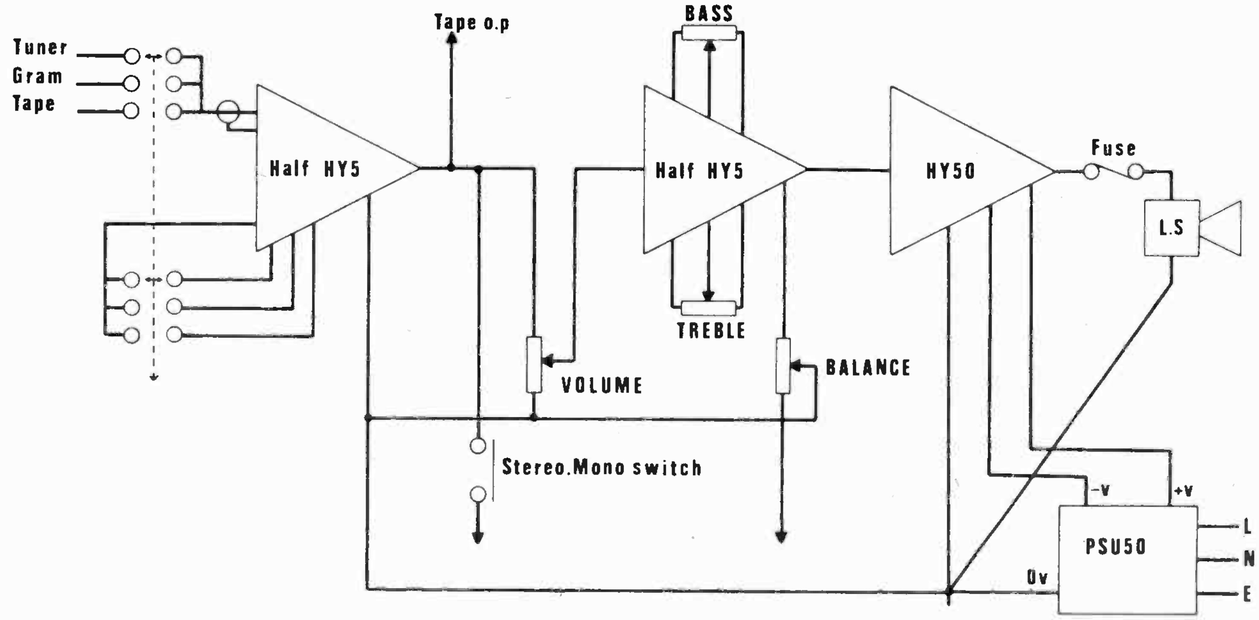
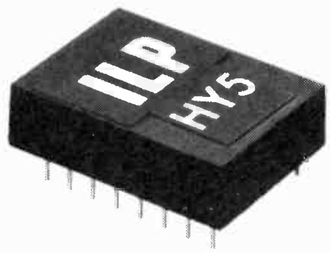
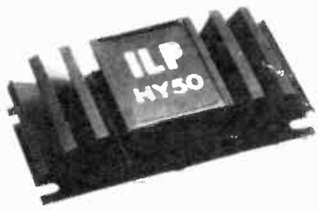
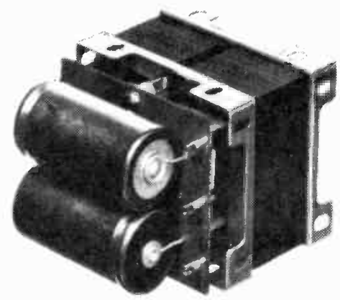


Mono electrical circuit diagram with interconnections for stereo shown







The HY5 is a complete mono hybrid preamplifier, ideally suited for both mono and stereo applications. Internally the device consists of two high quality amplifiers—the first contains frequency equalisation and gain correction, while the second caters for tone control and balance.

TECHNICAL SPECIFICATION

Inputs
- Magnetic Pick-up 3mV.RIAA
- Ceramic Pick-up 30mV
- Microphone 10mV
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- Auxiliary 3-100mV
- Input impedance 47kΩ at 1kHz

Outputs
- Tape 100mV
- Main output Odb (0.775 volts RMS)

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- Treble ±12db at 10kHz
- Bass ±12db at 100Hz

Distortion 0.05% at 1kHz
Signal/Noise Ratio 68db
Overload Capability 40db on most sensitive input
Supply Voltage ±16—25 volts.

PRICE £4.50 + 0.36 V.A.T. P & P free.

The HY50 is a complete solid state hybrid Hi-Fi amplifier incorporating its own high conductivity heatsink hermetically sealed in black epoxy resin. Only five connections are provided: Input, output, power lines and earth.

TECHNICAL SPECIFICATION

Output Power 25 watts RMS into 8Ω
Load Impedance 4—16Ω
Input Sensitivity Odb (0.775 volts RMS)
Input Impedance 47kΩ
Distortion Less than 0.1% at 25 watts typically 0.05%
Signal/Noise Ratio Better than 75db
Frequency Response 10Hz—50kHz ±3db
Supply Voltage ±25 volts
Size 105 x 50 x 25 mm.

PRICE £5.98 + 0.48 V.A.T. P & P free.

The PSU50 incorporated a specially designed transformer and can be used for either mono or stereo systems.

TECHNICAL SPECIFICATIONS

Output voltage 50 volts (25–0–25)
Input voltage 210–240 volts
Size L.70. D.90. H.60 mm.

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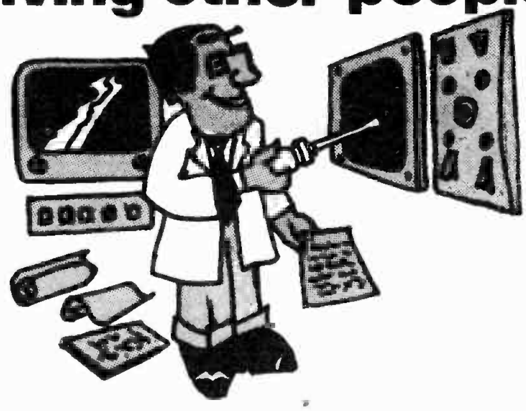

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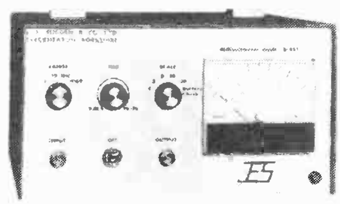

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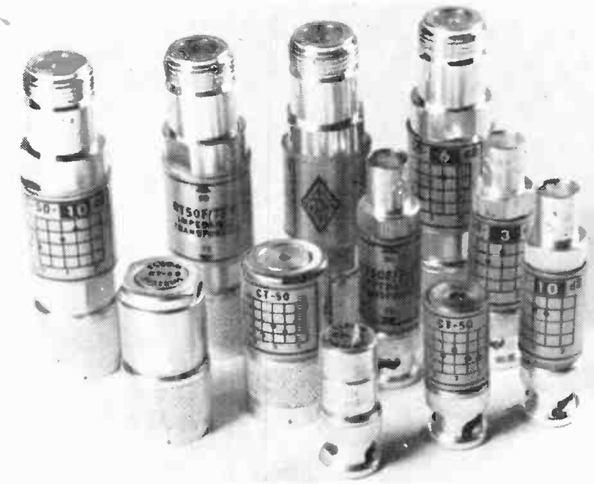

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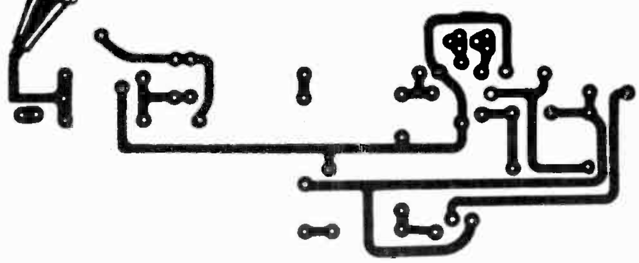

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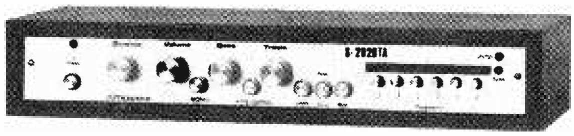
S-2020TA STEREO TUNER/AMPLIFIER KIT

NEW PRODUCT

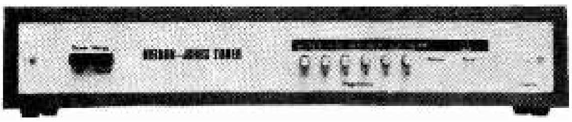


SOLID MAHOGANY CABINET

A high-quality push-button FM Varicap Stereo Tuner combined with a 20W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier: Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc), THD less than 0.1% at 20W into 8 ohms. All sockets, fuses, etc, are PC mounted for ease of assembly. Tuner section: uses Mullard LP1186 module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88–104MHz. 30dB mono S/N @ 1.8μV.THD typ. 0.4%.

PRICE: £47.95 + 99p p&p + VAT.



NELSON-JONES STEREO FM TUNER

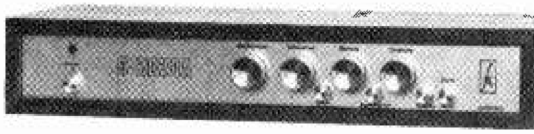
A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

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

PRICE: Mono £25.46 + 85p p&p + VAT;
With Portus-Haywood Decoder £31.96 + 85p p&p + VAT;
With ICPL Decoder £29.73 + 85p p&p + VAT.

NEW PRODUCT

S-2020A AMPLIFIER KIT



Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring.

Typ. Spec. 20 + 20W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc). Toroidal mains transformer.

PRICE: £29.95 + 99p p&p + VAT.

STEREO MODULE TUNER

A low-cost Stereo Tuner based on the Mullard LP1186 RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC. Variable INTERSTATION MUTE. PLL stereo decoder IC.

Typ. Spec. Sens. 30dB S/N mono @ 1.8μV. Tuning range 88–104MHz. LED sig. strength indicator. LED Stereo indicator. THD typically 0.4%.

PRICE: Stereo £26.32 + 85p p&p + VAT. Mono £22.40 + 85p p&p + VAT.

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

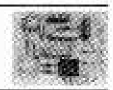
SUB ASSEMBLIES

BASIC NELSON-JONES TUNER
Supplied as a printed circuit board with all components and screening box to build a varicap tuner module. Performance spec as above for complete N-J Tuner. For suitable stereo decoders see below. (Illustrated without screening box.)
PRICE: £12.88 + 25p p&p + VAT.

BASIC MODULE TUNER
Supplied as a printed circuit board with all components and screened Mullard LP1186, to build a mono or stereo tuner module. Performance spec as above for Stereo Module Tuner complete kit.
PRICE: Mono £11.11 + 25p p&p + VAT; Stereo £13.89 + 25p p&p + VAT.

PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER
Mk II version of this design (WW Sept. 1970). The lowest distortion phase-locked stereo decoder kit available (Typ. 0.05% @ N-J Tuner O/P level). Separation 40dB up to 15KHz.
Complete kit comprises PCB and all components, inc. stereo LED.
PRICE: £7.68 + 25p p&p + VAT.

PHASE-LOCKED IC DECODER
Integrated circuit phase-locked stereo decoder based on the MC1310. THD typically 0.3%. Separation 40dB @ 1KHz.
PRICE: £4.27 + 20p p&p + VAT.



PUSH-BUTTON UNIT
The six-position push-button unit used in our tuners and tuner/amp. Each track has the required diode law for stability of tuning. There are approx. 40 turns on each button and there are six separate moving pointers. An AFC disable switch is incorporated with each button. The unit is finished in black with red pointers.
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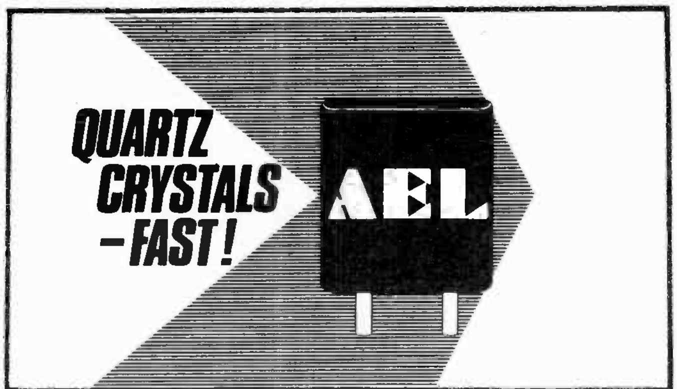

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STEREO IC DECODER

HIGH PERFORMANCE PHASE LOCKED LOOP
(as in 'W.W.' July '72)

MOTOROLA MC1310P EX STOCK DELIVERY

SPECIFICATION

Separation: 40dB 50Hz-15kHz. Distortion: 0·3%
I/P level: 560mV rms O/P level: 485mV rms per channel.
Input impedance: 50kΩ. Power requirements: 8-16V at 16mA
Will drive up to 75mA stereo 'on' lamp or LED.

KIT COMPRISES FIBREGLASS PCB (Roller tinned), Resistors, I.C., Capacitors, Preset Potm. & Comprehensive Instructions — **ONLY £3·98** — **WHY PAY MORE?** post free.

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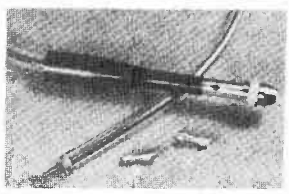

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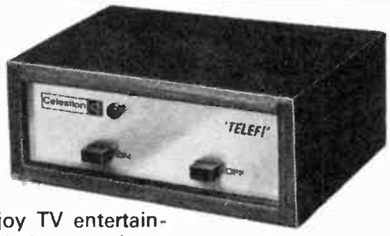

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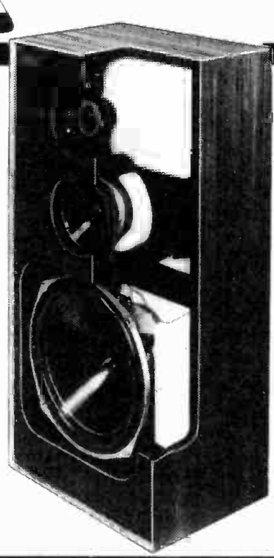

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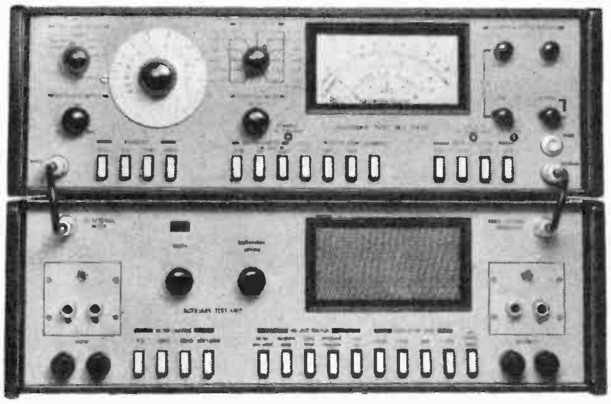

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100mm × 150mm	27p	24p	29p	26p	15p	14p	19p	15p	33p	30p	29p	26p	15p	14p
150mm × 200mm	53p	48p	56p	51p	30p	27p	37p	30p	66p	60p	60p	54p	30p	27p
200mm × 250mm	88p	80p	92p	84p	51p	45p	63p	51p	£1·10	£1·00	£1·02	92p	51p	45p
250mm × 250mm	£1·10	£1·00	£1·15	£1·05	65p	55p	80p	65p	£1·38	£1·25	£1·30	£1·15	65p	55p
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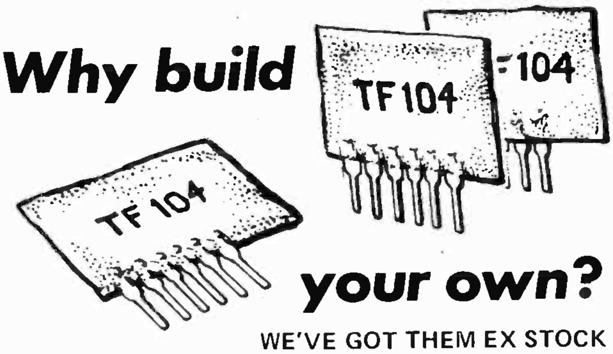

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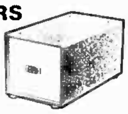

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0-6	0-6	1000	1000	212	1.90	0.47
9-0-9	—	100	—	13	1.40	0.25
0-9	0-9	330	330	235	1.50	0.25
0-8-9	0-8-9	500	500	207	1.93	0.34
0-8-9	0-8-9	1000	1000	208	2.75	0.47
15-0-15	—	40	—	240	1.35	0.25
0-15	0-15	200	200	236	1.38	0.25
20-0-20	—	30	—	241	1.35	0.25
0-20	0-20	150	150	237	1.38	0.25
0-15-20	0-15-20	500	500	205	2.73	0.56
0-20	0-20	300	300	214	1.93	0.47
0-20	—	3500	No Screen	1116	3.30	0.64
20-12-0-12-20	—	700 (D.C.)	—	221	2.20	0.47
0-15-20	0-15-20	1000	1000	206	3.50	0.56
0-15-27	0-15-27	500	500	203	3.00	0.56
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4	2	18	2.96	0.56
6	3	70	4.18	0.56
8	4	108	4.56	0.64
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12	6	116	5.51	0.72
16	8	17	7.00	0.80
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3	125	7.52	0.80
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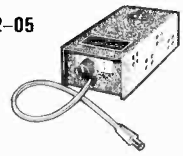

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200	65	7.04	0.20	4.95	0.64
300	66	8.00	0.20	5.81	0.72
500	67	10.99	0.20	8.85	0.88
750	83	13.82	0.85	10.80	0.95
1000	84	17.27	0.85	13.68	1.13
1500	93	21.87	0.85	18.31	0 A
2000	95	33.11	1.60	24.25	0 A
3000	73	47.94	2.10	35.10	0 A

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0–10 mA	6	0–10 mA	6
0–50 mA	0·5	0–50 mA	0·5
0–100 mA	0·5	0–100 mA	0·5
0–500 mA	0·5	0–500 mA	0·5
0–1 AMP	0·5	0–1 AMP	0·5
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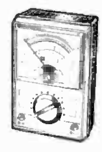

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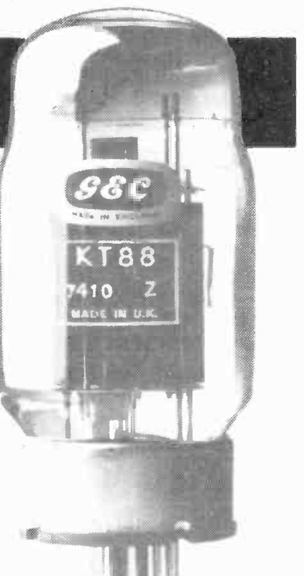

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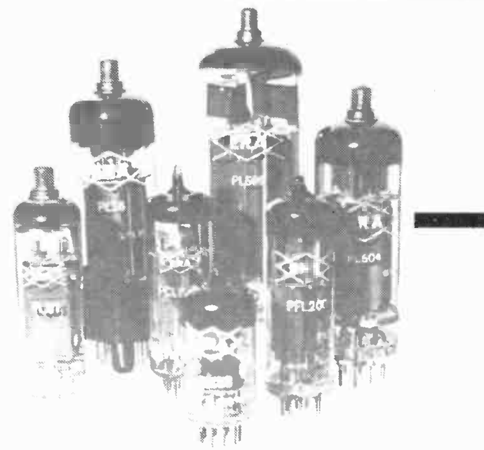

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MAY 1975 Vol 81 No 1473

Contents

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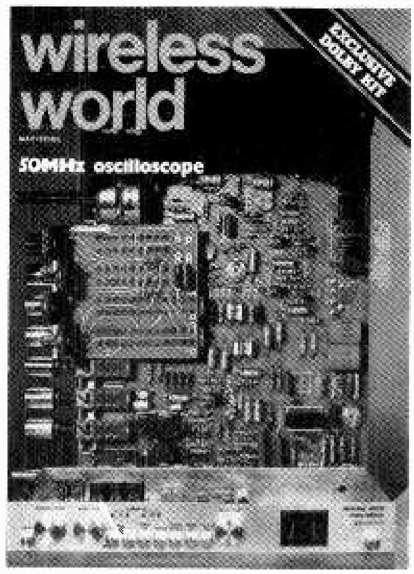

This month's front cover shows the chassis and printed circuit board of the Wireless World Dolby noise reducer. Principle of operation is described in this issue.

IN OUR NEXT ISSUE

Time by radio
A digital clock synchronized to the atomic frequency standard broadcast at 60kHz on MSF Rugby

Wireless World Dolby noise reducer
The second article will deal with the circuitry and construction of this unique audio project

Circuit calculations simplified
Quite sophisticated design can be done with simple arithmetic. Part 1 is on calculating resistance values

SIXTY-FIFTH YEAR OF PUBLICATION

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wireless world

Computers and us

The "computer on a chip" that we used to talk about ten years ago has now arrived. It is, of course, the integrated-circuit "microprocessor", which, in the space of a cubic centimetre or so and at the cost of a few pounds, provides the central functions of a stored-programme digital computer. Before long this device will be a familiar object in our lives. No doubt we shall see it in cars and washing-machines, in cash registers and petrol pumps, and in a great variety of "distributed processing" applications in industry and commerce. What will its impact be? The average citizen will accept this minor revolution with bland indifference, unaware that once again his mode of life is being subtly changed by technology. The engineer or technically-informed person, though more aware of the potentialities, will display a different form of complacency. Secure in the knowledge that he understands how these things work, how they are designed, manufactured and applied, he will believe that everything is under control. Computers can never exceed the capabilities of those who design and programme them and therefore they can never get out of hand.

These are naive attitudes. Technology has modified the surface pattern of our lives, and hence by introjection our inner selves, since the beginning of man. The Industrial Revolution in Britain changed the mode of life and work drastically and irrevocably. Today the changes tend to creep up and take us unawares. With the computer, for example, while we were worrying that it might usurp human brain power and lead to mass unemployment we did not notice that in one field of use, business and administration, it was subtly changing from a calculating machine into an automated filing system. Suddenly there were "computer banks" that held personal information on us—information we had supplied in tax returns, census answers, and records to do with health, insurance, credit-worthiness, military service and the like. While this information stays distributed in separate computers the threat to privacy and freedom remains a threat. But the danger is that the scattered data could be collated into dossiers. An "identikit" picture of each citizen based purely on data could be used to make decisions about him, without anybody actually speaking to him or telling him that a decision had been made. Remember that this is *technologically* quite possible. To what extent it becomes reality depends on the ability of our ethics to restrain our technology.

Information collated by computers is also being used to make decisions on a national level. Theoretically the administrators' ability to get more data, quicker, should result in better decisions. But there is the hidden danger of the increasing isolation of the decision maker from his sources of data and his decreasing ability to check their validity.

As engineers and technicians we cannot take refuge in the limitations of computers as we see them now. There are certainly inherent limitations to the capabilities of the conventional stored-programme digital computer in its present form, but there are no inherent limitations to computer technology as a whole—consider, for example, the work that is being done on artificial intelligence. At some point we must realize that we are not mere instruments of technological progress. We must stop and ask ourselves what we want to do with these machines and what effect these technological aims will have on the shape and quality of our lives.

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Wireless World Dolby noise reducer

1—An introduction to the Dolby noise reduction system

by Geoffrey Shorter

This noise-reducer design is intended mainly for hiss reduction in magnetic-tape recording machines. The unit can be switched to decode commercially available Dolby B-encoded cassette tapes, Dolby B-encoded f.m. radio transmissions (as in the USA), or to encode blank tapes from any source. As an alternative, it can be used in trading some of the noise improvement for reduced distortion at peak recorded levels. The *Wireless World* processor can be aligned without any additional test instruments, the circuit board being arranged to provide the necessary alignment and calibration tones. This article gives background to the B system and to the functioning of the noise reducer and subsequent articles describe construction, alignment and calibration of the unit. A complete kit is available only through *Wireless World* (see panel on page 205)

In audio systems dynamic range can be defined as the ratio of the largest to the smallest programme signal. Dynamic range is typically limited at the high-level end by tape saturation or amplifier signal handling problems: there is usually a fairly well-defined level beyond which compression occurs and distortion rises at a rapid rate. At the other extreme there is a limit on the lowest signal that can be handled, set typically by the noise level of electronic circuits, tape noise, surface noise on discs, or granularity on optical soundtracks.

In concerts, dynamic range can be as high as 90 to 100dB, but once such programme material has been recorded, dynamic range is reduced to 60 or 70dB. (When broadcast the range can be as low as 20 to 40dB.) In this situation there are three options—lose that part of the programme below noise level, distort the peaks, or distort the range by compression either manually or automatically. None of these options is altogether acceptable in itself, all distort the original in some way. What is needed is a way of getting round this limitation of dynamic range without the distortion of overmodulation, without losing programme in noise and without distortion of range. Before discussing various techniques that have been proposed and tried, we will be more specific about what is required.

As well as not introducing any perceptible non-linear or dynamic range distortion of both steady-state and transient signals, any proposed technique for high quality use should not perceptibly alter the signal in respect of frequency response and transient response. Any signal processors must be able to operate to the normal constraints of audio channels, i.e. operation should not depend on freedom from phase and amplitude versus frequency errors or changes, nor on a linear phase-frequency response; channel overload characteristics should not be worsened. In addition to compatibility with transmission channels, there must be compatibility between processors to the extent that recordings can be interchanged. In reducing perceptibility of noise, there should be no noticeable noise modulation effect and ideally all noises should be reduced by a similar amount, otherwise reducing one kind might unmask another.

Noise-reducing techniques

"Static" methods. The most well-established methods of avoiding the constraints imposed by high noise levels are "static" ones. Examples are the high-frequency pre-emphasis, and subsequent de-emphasis, applied to f.m. broadcasts and gramophone records and the low-frequency pre-emphasis used in tapes. They are static because the amount of emphasis given is fixed and does not take account of the signal in any way. At some frequencies, there is thus an intrusion into the possible range of levels that signals can occupy which may mean that some lower than normal limit must be placed on the programme level.

Single-ended methods. An alternative approach is the dynamic one of altering the level of a signal by an amount that depends on the signal level, at either the sending/recording end or at the listening end. In examining such dynamic techniques it is expedient to look at the possibilities from a steady-state signal level point of view, with the thinking that frequency and time-dependent variations can be seen as special categories within a level classification. In practice, however, the success of each kind will undoubtedly depend on how well complicated time-varying multi-frequency signal patterns are responded to by the processing circuitry; and to whatever psychoacoustic, or perceptual, effects such as auditory masking, can be discovered and made use of.

The simplest kind of device, within our terms of reference, is the low-level noise gate, depicted graphically in Fig. 1(a), which eliminates signals below a certain threshold level. More useful is a stepped noise gate, where signals and noise below a certain threshold are attenuated by a finite amount rather than an infinite amount—Fig. 1(b). There are a host of variants on this theme, Fig. 1(d) showing another possibility.

A number of commercially-available expanders have used the general approach of Fig. 1(b), including H. H. Scott's "dynamic noise suppressor" and R. Burwen's "dynamic noise filter", operating only at low and high frequencies and with a passband that varies according to signal level. The Philips "dynamic noise limiter" is another example, though its operation is restricted to high frequencies. With these devices, the bandwidth restriction at low signal levels must inevitably cause some loss of programme. Further, any reduction of noise level that can be achieved is likely to be modulated by intermittent mid-frequency signal components, giving rise to what is called breathing. Because they are "single-ended" these techniques must result in a distortion of dynamic range. Thus you can either have the original dynamic range plus on reduced noise, or a distorted dynamic range and loss of some low-level information with a reduced noise level—but not both at the same time.

Besides altering the level of low-amplitude signals, a similar expansion can be achieved by expanding high-amplitude signals, Fig. 2(c), but as well as exhibiting the two major disadvantages already mentioned, this would suffer a third. By having a variable-gain element operating at a high level there are obviously greater risks of generating intrusive unwanted signals as a result of overshooting, high non-linear distortion and a high circuit noise level.

Dynamic processing is often carried out prior to recording or transmission. The low-level compression characteristics of Figs. 1(c) and (e) and the high-level characteristic of Figs. 2(a) and (b) both enable average signal level to be increased relative to the noise level. But in themselves they suffer from the same disadvantage as do the expanders. Clearly, single-ended methods are inappropriate to normal high quality reproducing systems.

Complementary methods. The only way of avoiding the difficulty of alteration to dynamic range is by the complementary method—the dynamic equivalent of static "equalization". In complementary systems, signal processing before transmission and recording, normally compression, is followed by an equal degree of complementary processing, normally expansion, prior to audition so that the original dynamic range is restored. Noise added by the medium after compression is reduced by the degree of expansion used. In the expander of Fig. 1(b) the complementary compressor characteristic would be (c) and the complement of (d) would be (e). Likewise, the transfer characteristics of Figs. 2(b) and (c) form another compander system.

Another kind of diagram makes it easier to visualize what happens so far as levels are concerned. Fig. 3(a) is a typified high-level compander characteristic, showing both the compression and expansion curves. Its equivalent level diagram of Fig. 3(b) shows the reduced dynamic range (indicated by arrows) where the maximum level to be handled by the interposing medium is assumed to be the same—the region marked "overload margin" giving an increased margin against overload and thus lower distortion. Fig. 3(a) shows the same reduced dynamic range produced by the characteristic of Fig. 3(a), but with the intermediate gain shifted so that the low signal levels can be increased in relation to the noise level.

Fig. 4(a) shows low-level compander characteristics, with the level diagram of Fig. 4(b) illustrating the use of the compressed dynamic range to bring up the low-level signals relative to the noise. Fig. 4(c) shows how, by reducing the levels by a constant amount, increased overload margin can be obtained. (Notice the similarity between Figs. 3(b) and 4(c) and between Figs. 3(c) and 4(b), the

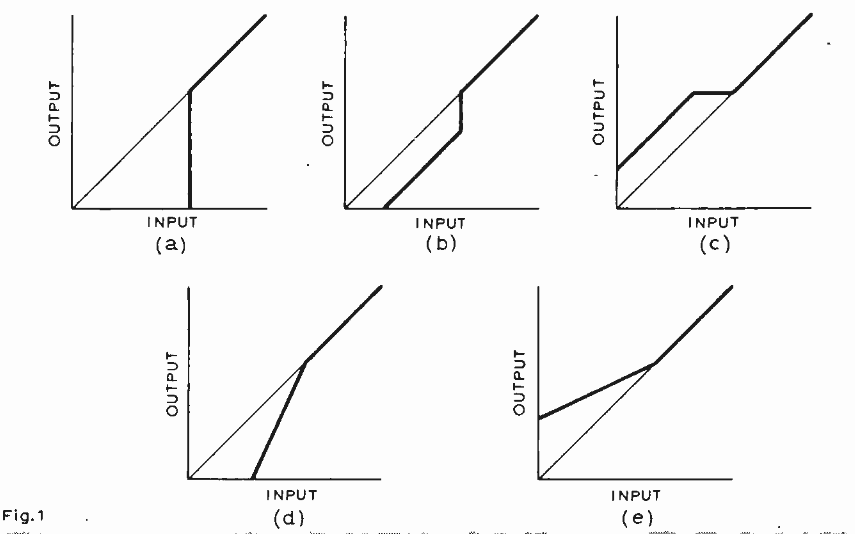


Fig.1

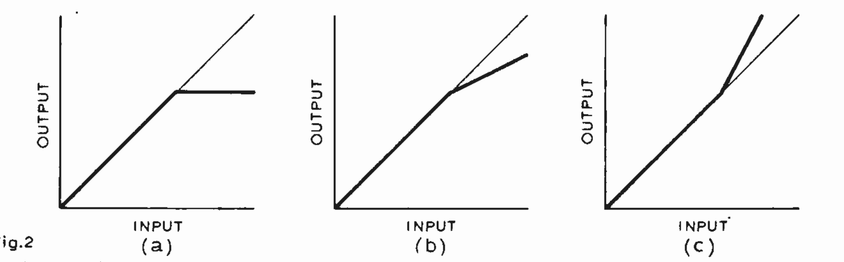


Fig.2

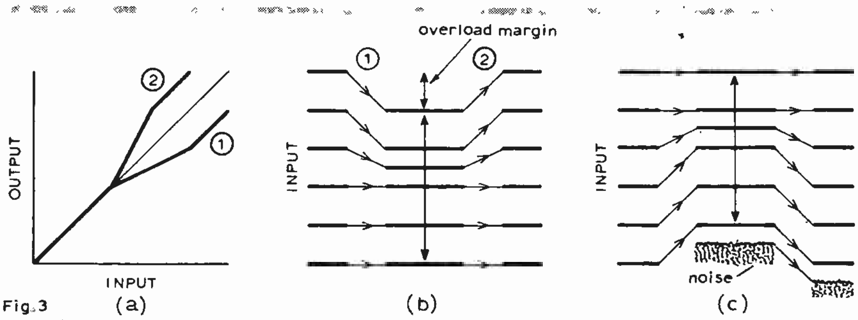


Fig.3

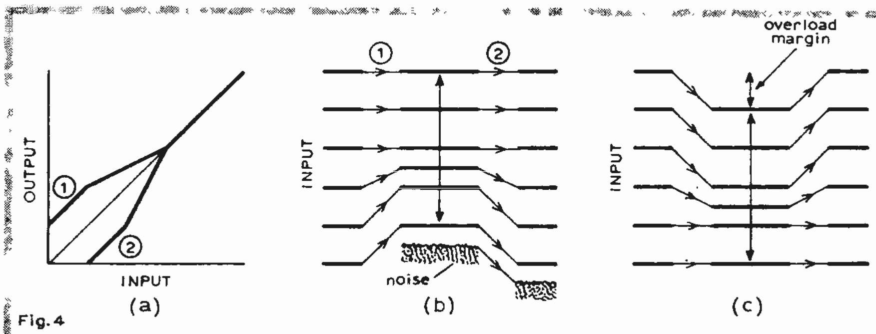


Fig.4

Fig. 1. Low-level noise gate (a) simply loses both noise and signal below a certain threshold level. Finite attenuation of low-level signals is achieved with the expansion transfer characteristics of (b) and (d). Such "single-ended" expanders reduce noise at the expense of distorting dynamic range. Compressors at the signal source end can raise low level signal above noise levels, but similarly distort range (c) and (e).

Fig. 2. High-level limiter and compressors (a) and (b) and expanders (c) suffer an additional disadvantage because of processing at a level where distortions would be more obvious.

Fig. 3. Complementary high-level system (a) is able to reproduce original dynamic range while either reducing maximum level to give more overload margin (b), reducing noise (c), or giving a combination of both.

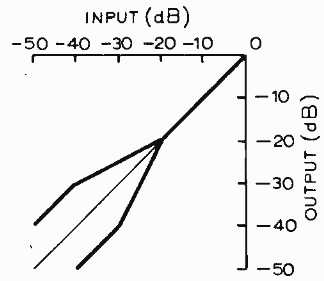
Fig. 4. Low-level complementary system (a) has the advantage that any distortion products are at a low level where they are less likely to be audible.

difference being the siting of the region of "linear" operation at either a high level or a low level. Despite the immediate visual contrast between Figs. 3(a) and 4(a) there is clearly a close resemblance between curves 1.)

In practice the characteristic curves do not have the discontinuities shown, corners being rounded to prevent objectionable noise modulation. The curves should be capable of easy realization, be readily reproducible and the two complementary curves must be matched to within the required tolerance.

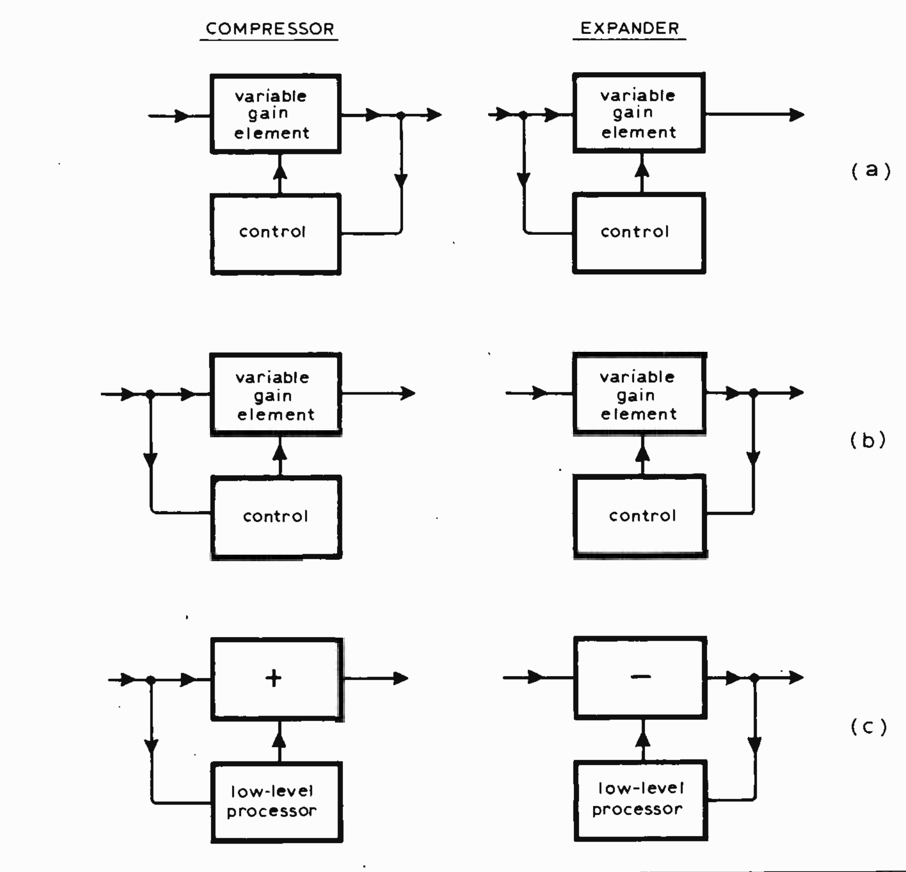
Two recently-introduced studio companders use the general approach of Fig. 2(b) and (c), but with a threshold that is much lower than indicated. The dbx Inc. compander uses a square-law curve above a certain threshold (−60dBm), which in logarithmic terms is a 2:1 compression ratio. The Burwen "noise eliminator" uses a cubic law (logarithmically, a 3:1 compression ratio) above a certain threshold. (A fixed h.f. pre-emphasis and a level-independent bandwidth are also features of these systems.)

In general, such high level companding techniques suffer from a number of drawbacks: poor tracking between the two processors, high sensitivity to errors in gain in-between processors, overshooting and a risk of overmodulation, both of which could lead to compression in the transmission medium that would go uncorrected on expansion, noise modulation by signals, modulation-product formation as a result of rapid gain changes, all of which are undesirable in a high quality link. High level companders can be very useful however in telephone circuits for example and the Post Office's Lincompex scheme is an example of a compander in which dynamic range is reduced to zero. (Subsequent expansion would not be possible were it not for the fact that information on signal amplitudes is contained in separate pilot or control channel.)



In most electronic signal processing systems there is usually some maximum level beyond which the signal must not be allowed to go and to which levels are frequently referred. Transfer characteristics are therefore usually given in the quadrant shown in which the point of reference is made to be some arbitrary maximum level, rather than the zero signal level of Figs. 1 to 4. (A zero at the axes intersection would represent 0dB and not an origin as in cartesian coordinates.) In practice such curves are not discontinuous but are smoothly connected to prevent unwanted modulation and to permit easy realization and matching.

Fig. 5. Conventional companders use the equivalent complementary systems of (a) or (b) whereas the Dolby system (A and B) uses an additive to method (c) enabling processing circuitry to be separated from the main signal path.



The low-level method (Fig. 4) has a high tolerance of channel gain errors, produces modulation distortion at low signal levels rather than high levels, and there is less risk of overloading the medium. It seems a good idea anyway because one might expect the ear to be less sensitive to low-amplitude effects than to the same effects at high level. This then is the basic companding technique chosen for the Dolby system.

Dolby low-level compander

In conventional companding systems there are two equivalent ways of achieving compression and expansion. One is to derive a control signal, after subjecting the input signal to a variable-gain element (compressor); expansion or "decoding" would then be achieved by the converse process—the control signal being derived prior to a variable-gain element (expander), Fig. 5(a). The equivalent, alternative, way is to derive the control in the compressor part before the variable-gain element and to subsequently expand by using a control obtained after the variable-gain device, Fig. 5(b). (The first-mentioned method is used in the dbx and Burwen high-level companders and in the JVC a.n.r.s. low-level compander.)

The Dolby technique makes use of a different approach—with an important difference; compression is achieved by deriving a special low-level signal that is added to the main signal, and expansion is obtained by subtracting a low-level signal from the main one, Fig. 5(c). (Within the low-level processor block, compression is achieved with method (a).)

Of course, the required compander characteristics could have been derived in the normal way, i.e. by direct action of a compressing circuit on the main signal path Figs. 5(a) and (b); but in the low-level approach the whole range need not be subjected to processing. It is obviously in the interests of quality that low-level signals be processed separately, leaving the main signal to a linear path whose quality is not restricted by that of the variable-gain path.

Tracking at high levels becomes easier using this low-level approach, and a tracking error due to channel gain variation would occur at an unobtrusively low level. Additionally with this technique, it is found that sufficiently accurate tracking can be maintained using a control derived from peak and average signal values. Thus the elaboration of an r.m.s.-derived control, which would strictly be necessary for channels having a non-linear phase-frequency response, is avoided.

Notice that in the subtractive part of Fig. 5(c), a negative feedback loop is effectively formed in the low-level "contribution" to the main path. Advantage of this is taken in the Dolby system (and in the JVC a.n.r.s. system) in that an identical network to that used to produce the additive low-level signal at the encoder, can be used in forming the subtractive component at the decoder, merely by inserting the network in the negative feedback loop of a main path amplifier. Among other things this means a single processor can be used for both encode and decode functions by a suitable switching arrangement.

In a wideband compander of this kind having the kind of characteristic at Fig. 4, a low-amplitude signal below the operating threshold would result in the maximum amount of low-level boost being applied, and on decoding the noise level will be appropriately reduced; a high-amplitude signal would result in no noise reduction. Thus an intermittent high-amplitude signal could modulate the noise level, producing breathing (unless high-level signals were present in the same frequency band as the noise. This breathing can occur in any kind of wideband compander, of course).

In the Dolby A system this effect is overcome by splitting the audio band into sections in the additive signal path, each section having its own compression and control circuitry. A high-amplitude signal in one band will not then prevent noise reduction being obtained in bands above and below. Within each band, the presence of a high-amplitude signal is relied on to mask, that is reduce the perceptibility of, noise components close to that signal. Studies of auditory masking show a shift in the hearing threshold in the presence of a (masking) tone, which effect can extend upward in frequency to a considerable extent; downward to a much lesser extent, the amount depending on the level of the masking tone.

When the economics of band splitting are judged against the extent of this masking effect, the amount of noise reduction required, and the value of threshold level in relation to the benefits of the additive technique, it turns out that four bands give a satisfactory compromise of cost versus performance. Splitting the band with 12dB per octave filters in the ranges 80Hz low pass, 80Hz to 3kHz band pass, 3 to 9kHz band pass, and 9kHz high pass would give a uniform 10dB boost (and hence noise reduction) to low-level signals, as determined by setting compression threshold at 40dB below peak operating level. By making the 3 to 9kHz bandpass filter into a high-pass filter, an additional boost is obtained, gradually increasing from about 5kHz to a maximum at 15kHz. The lowest band provides reduction in the hum and rumble range, the second reduces mainly broadband noise, tape print-through and cross-talk, while the upper bands reduce hiss.

Dolby B-type system

The cost and complexity of the A system is not really appropriate to consumer products. Moreover, in slow-speed tape machines in particular the noise spectrum has a different distribution to that occurring in the studio situation, on account of the slower tape speed and thin

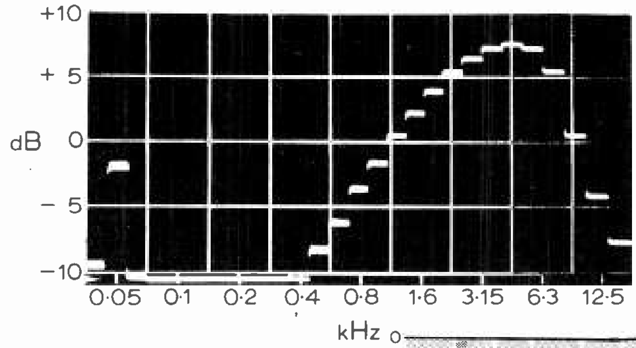


Fig. 6. Noise spectrum of low-noise ferric oxide cassette tape shows problem is a mid- to high-frequency one, rather than a broadband one for which the Dolby A system was developed.

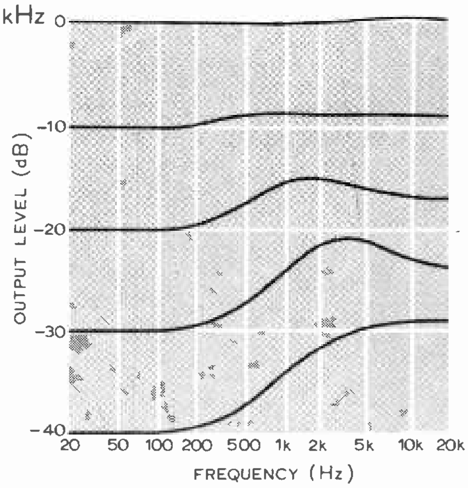


Fig. 7. In the Dolby B and JVC a.n.r.s. systems, low-level high-frequency signals are boosted during encoding by 10dB at low levels, the amount of boost decreasing as input level increases. Characteristics shown are amplitude-frequency response curves, with input level as a parameter, for the encoding process.

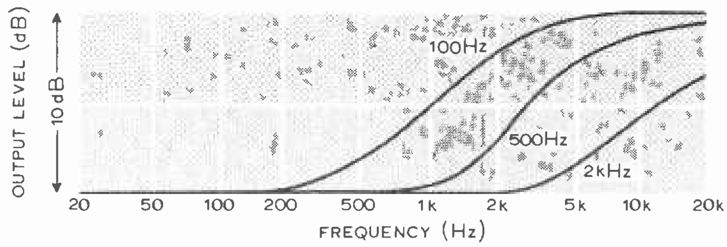


Fig. 8. Because the compressor circuit is made frequency sensitive in B-type processors, frequency at which boost, and hence noise reduction, occurs rises with increasing input level. Thus noise reduction is preserved in the presence of mid-frequency signals at high amplitude, which would otherwise reduce or prevent noise reduction. Curves show response below threshold level in presence of 0dB tones.

oxide layers used in tape cassettes. Fig. 6 gives a typical DIN-weighted noise spectrum taken from a low-noise ferric oxide tape cassette, showing the noise problem is mainly a mid- to high-frequency one. Noise reduction in the B-type system is therefore limited to this frequency range and Fig. 7 shows the amount of boost (hence noise reduction) applied at various input levels; a fixed high-pass filter placed in the subsidiary signal path, as is done with the JVC a.n.r.s. system, would achieve this end. What, then, about noise modulation which in the A system was reduced to imperceptible amounts by the multiband feature?

In the B system, such a filter prevents high-level low-frequency tones from activating the compression circuit, so there is no noise modulation by l.f. components. But there could still be modulation by high-level signals close in frequency to the filter cut-off. The trick to avoid this, unique to the Dolby B circuit, is to move the filter passband higher in frequency, so that the high-level signal would then be below the filter passband. The curves of Fig. 8 show the effect of the variable-frequency filter under the influence of a high-level tone at three different frequencies; the lowest-frequency curve representing the lower limit of the combined filter's translation in frequency. As the figure shows, with a high-amplitude tone of 500Hz applied, there is some 8 or 9dB of noise reduction at 10kHz; even with a tone at 2kHz there is still some noise reduction obtained. Had the filter passband remained fixed, these high-level tones would have caused the variable-gain element to operate, resulting in reduced or zero contribution from the subsidiary path, and hence little or no noise reduction.

Fig. 9 shows a simplified block diagram

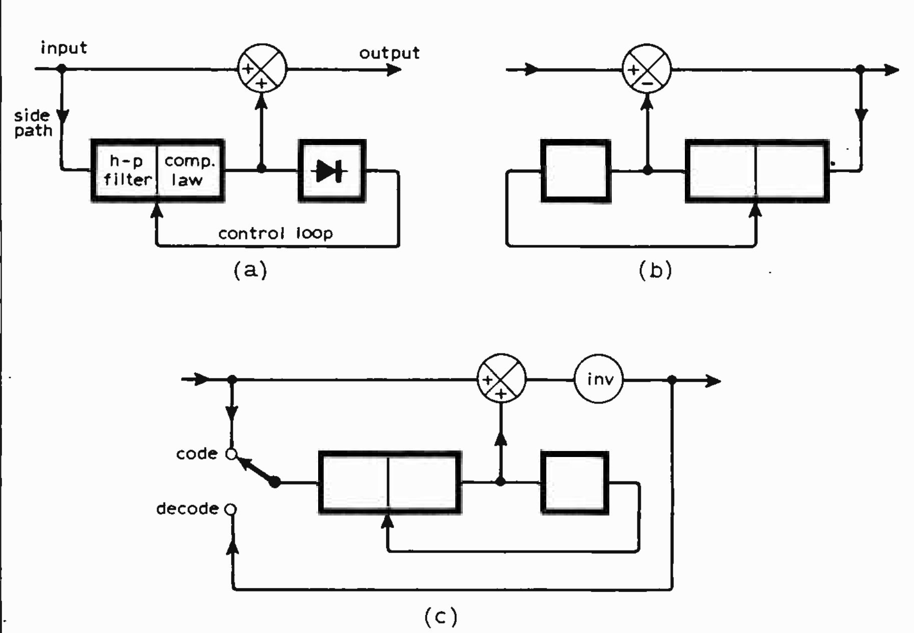


Fig. 9. Characteristics of Fig. 8 are realized by a voltage-controlled filter and compressor which adds up to 10dB of subsidiary signal to the main path during encoding (a). In decoding, a similar network is used to subtract from the main path (b), the network forming part of a negative feedback loop. This loop means that identical networks can be used for encoding and decoding. By placing the phase inversion in the main signal path, as shown (c), it can be left permanently in-circuit, simplifying encode-decode switching.

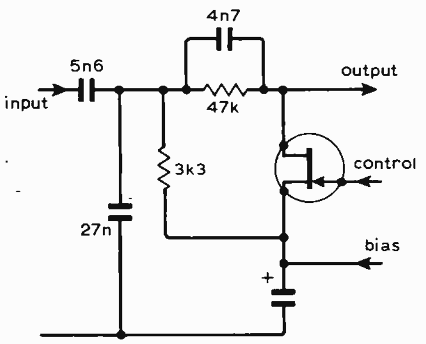


Fig. 10. Output of high-pass filter decreases after the compression threshold, set by gate bias, has been exceeded by the control signal. Response curve of combined fixed and variable filter sharpens when the two turnover frequencies coincide.

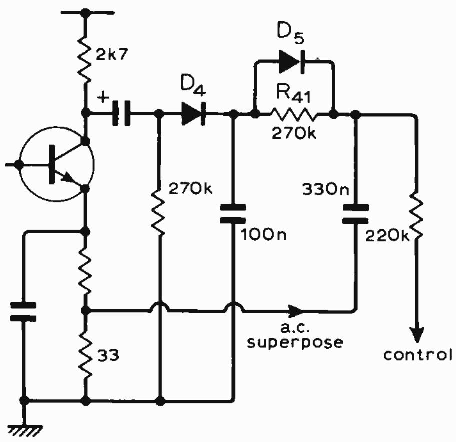


Fig. 11. Control-loop integrator has variable attack and decay times depending on speed and amplitude of signal changes. Large transients cause D_5 to conduct, shortening loop response time. Superposition of a.c. signal on control loop is to allow f.e.t. to operate symmetrically, thus keeping second harmonic distortion to a low level.

of B-type processors, the encoder at (a), and the decoder at (b) with the same filter and compressor circuitry now in a negative feedback loop. In (b) a phase inversion is clearly required, which in (a) it is not. A simple dodge, that leads to a simplified encode/decode switching arrangement, is to re-site this phase inverter in the main signal path after the summing amplifier. The inverter can now remain in-circuit permanently, forming part of the feedback loop only during decode, Fig. 8(c).

Circuit operation. The way in which the voltage-variable filter and compressor operates is interesting. A fixed high-pass filter, formed by the parallel combination of the 5.6 and 27-nF capacitors (fed from a low impedance source, they are effectively in parallel) and the 3.3kΩ resistor determines a turnover frequency of 1.5kHz (Fig. 10). Imagine that a simple compressor then follows, i.e. a variable attenuator formed by a fixed resistor and the f.e.t. voltage-variable resistor (ignoring the 4.7nF capacitor). The f.e.t. is to be controlled by a direct voltage obtained after rectification of the signal passed by the filter/f.e.t. combination. Without any direct voltage applied to the f.e.t. gate, as would be the case for inputs of any level below the filter passband and for low-level inputs within the passband, the f.e.t. resistance is nominally infinite. The filter circuit would thus give minimum attenuation of h.f. signals and pass them to the main path, allowing h.f. noise reduction to be obtained. When an h.f. input is of sufficiently high level for the control signal to overcome the f.e.t. bias (this determining the compression threshold), the direct voltage to the gate would cause the f.e.t. resistance to fall, attenuating the signal, and reducing the amount passed to the main path. As the h.f. signal increased, a progressively smaller amount would be returned to the main path. Operation of this principle is shown by the curves in Fig. 7(a), which in fact apply to the Dolby B and a.n.r.s. circuits.

By replacing the fixed resistor with a capacitor (4.7nF) in series with the f.e.t. resistance a second, variable, high-pass filter is formed. With increasing f.e.t. gate voltage, actioned by an increasing signal frequency and/or level, the filter characteristic rises in frequency, "overtaking" the fixed filter curve to largely determine a new, higher, passband (after equilibrium between signal level control and filter is reached). Thus the frequency at which a significant signal is returned to the main path is raised, as depicted in Fig. 8, preserving some h.f. noise reduction in the presence of mid-frequency signals. In the region where the two filter curves are close, the combined filter shape is sharpened to around 10dB/octave, so the effect of the filter action is heightened in this region, and the immunity of the circuit to noise modulation therefore improved.

Dynamic operation

To avoid modulation products being generated by rapid changes of gain in the compressor, which may or may not be cancelled in the complementary expansion process, a long attack time is desirable in the rectifier circuit providing the f.e.t. control voltage. On the other hand, a short attack time is needed to minimize the effect of overshoots, which could have an amplitude equal to the amount of compression.

The extremely elegant solution chosen is to use a time constant that depends on the rate of change of signal. Referring to Fig. 11, the 2.7-kΩ collector resistor and the 100-nF capacitor allow rapid following of a slowly changing input signal. But the time constant of the 270kΩ (R_{41}) and 330-nF component gives an attack time for the control signal of 100ms—long enough to prevent audible modulation products being formed. Diode D_5 is not brought into conduction because the voltage drop across it is never large enough (the discharge time of the 100-nF path being shorter than through the 330-nF capacitor). For large transient changes of input signal the potential across the 100-nF rises faster than that at the 330-nF capacitor so D_5 conducts, reducing

Noise reducer kit

Complete kits for the *Wireless World* Dolby B noise reducer are available through the address given below. The two-channel design features:

- a noise reduction of 10dB at 5kHz and above
- switching for both encoding (low-level h.f. compression) and decoding
- a switchable f.m. stereo multiplex and bias filter
- provision for decoding Dolby f.m. radio transmissions (as in USA)
- no equipment needed for alignment
- suitability for both open-reel and cassette tape machines

The kit includes:

— complete set of components for a stereo processor
— regulated power supply components
— board-mounted DIN sockets and push-button switches
— fibreglass board designed for minimum wiring
— solid mahogany cabinet, chassis, two meters, front panel, knobs, mounting screws and nuts

Price is £37.10 inclusive.

Calibration tapes are available, costing £1.94 inclusive for 9.5cm/s open-reel use and for cassette (specify which).

Send cash with order, making cheques payable to IPC Business Press Ltd, to:

Wireless World noise reducer
General sales department
Room 11, Dorset House
Stamford Street
London SE1 9LU

attack time to around 1ms or less. Between these two extremes charging of the 330-nF capacitor is shared by D_5 and R_{41}, as determined by the p.d. across them.

While the effects of transients are limited by the variable attack time, high amplitude transients require more rigorous treatment. Overshoots, as a result of the control loop not operating quickly enough, are limited to a maximum amplitude of 2dB by two silicon clipper diodes. When added back to the main path the clipped subsidiary signal can result in a momentary distortion of 1%, lasting for around 1 or 2 ms, but this occurs at a time when, because of the casual transients in the main path, the ear is least susceptible to it.

As with attack time, recovery time is as much a problem—it must be so short that noise reduction immediately following a high amplitude signal is restored within the time the ear takes to recover its normal hearing threshold, but not so short that low-frequency or modulation distortion results. The circuitry ensures a 100-ms decay time normally, but for large sharp reductions in signal level this value is reduced.

In Fig. 11 there is a proportion of a.c. signal from the emitter resistors superimposed on to the direct control voltage. This is to maintain symmetry of operation in the f.e.t. and thus keep second harmonic distortion to a low level by ensuring that $v_{gd}=v_{gs}$. Therefore an a.c. signal is applied to the gate that is half the value of that at the drain. By this means, and by keeping the signal voltage at the f.e.t. low by the capacitance divider prior to the f.e.t., distortion is reduced from a peak of 0.5% to 0.05% (at 1.5kHz and – 15dB).

This simplified introduction to noise-reducing systems should help in understanding operation of the B-type circuit, to be given in next month's issue in full.

To be continued.

Acknowledgement. We wish to thank Dolby Laboratories Inc. for their co-operation in developing this *Wireless World* design and particularly Ian Hardcastle for his valuable assistance.

Books Received

The latest editions of the D.A.T.A. book series are now available, covering **transistors, semiconductor diodes, digital integrated circuits, linear integrated circuits** and **semiconductor applications notes.** Other annual publications in the series include those on semiconductor heat sinks, sockets and associated hardware, discontinued integrated circuits and **discontinued transistors.** Each book lists the majority of devices currently available, throughout the world, together with their relevant parameters. London Information (Rowse Muir) Ltd, Index House, Ascot, Berks SL5 7EU.

Radar Precision and Resolution by G. J. A. Bird is aimed at providing the practising engineer with an understandable treatment of the radar uncertainty function together with a foundation of the underlying transform theory. Chapters include signal processing methods, Laplace and Fourier transforms, Hilbert transforms and complex analytical signals. Much of the book comprises mathematical treatments and worked examples with diagrams and graphs where necessary. The text concludes with a series of appendices which define terminology used in the book. Price £5.80, cloth. Pp.160. Pentech Press Ltd, 8 John Street, London WC1N 2HY.

Tidal-wave warnings from the ionosphere?

Tidal waves have nothing to do with tides. They are generated by undersea earthquakes: a sudden fall in sea-floor level due to an earth slip transfers energy to the water above. This propagates as a long-wavelength high-speed water wave. In a ship on the ocean the wave may pass unnoticed because, even if the amplitude is great, the gently sloping wavefront makes no impact. When the wave strikes the shore, however, there is a devastating inrush of water. Nowadays geophysicists call this type of wave by its Japanese name, tsunami ("harbour wave").

The islands which form the state of Hawaii are at great risk from tsunamis since they lie in the middle of the Pacific Ocean, which is ringed by earthquake zones. A tsunami warning system for such an area is very desirable, provided that it is reliable and does not give a lot of false alarms. For some time seismologists have attempted to give tsunami warnings, making use of the fact that the earth slip which causes the wave also sets up a Rayleigh surface wave through the sea floor. This travels about 20 times as fast as the tsunami and in principle, with the distance involved, could give the people of Hawaii at least a few hours warning.

Unfortunately the Rayleigh wave is small and of very long period. This makes it difficult to pick out from all the seismic noise which seismometers register all the time. For this reason a new, indirect method of detecting the Rayleigh wave is of great interest since it seems to offer a cheap and reliable way of doing the job. It has been developed by workers at the department of electrical engineering at Hawaii University and in principle involves little more than the monitoring of standard frequency transmissions in the area.

The method is possible because the Rayleigh wave on the sea floor disturbs the water above. The change of sea-floor level in effect lifts the sea surface over a wide area. The sea surface then acts as a huge piston or diaphragm and sends a very-low-frequency acoustic wave (period 30–200 seconds!) upwards into the atmosphere. When this wave reaches the ionosphere it causes a change in the refractive index to *radio* frequencies. The corresponding changes in the path length of reflected radio wave causes phase delays which are detectable, when the reflected radio waves return to earth, as Doppler frequency shifts. The shift may be small (1Hz for a 5 or 10MHz transmission) but detectable if the transmitted frequency and receiver local oscillator are stable enough. In the Hawaii experiments the local standard frequency transmitter WWVH was used, with monitoring receivers on three islands. Observed Doppler shifts were found to correlate well with seismic records of known earthquakes.

The beauty of this indirect method of tsunami detection lies in the fact that the atmosphere both amplifies the acoustic wave and filters out short-period noise. Amplification is the result of decreasing air pressure with altitude, which lengthens the wavelength, and also of the fact that a small change of refractive index of the ionosphere makes a big difference to the path length of a reflected radio wave. Low-pass filtering happens because acoustic waves do not propagate well if the mean path of air particles is comparable with the acoustic wavelength. In the thin air of the ionosphere this discriminates in favour of very-long-wavelength acoustic waves.

Meetings

LONDON

1st. IEE—Discussion on "Engineering management decisions in the current economic climate", at 17.30 at Savoy Pl., WC2.

1st. RTS—"Methods of digital coding for television transmission," by I. F. Macdiarmid, at 19.00 at London Weekend Television South Bank TV Centre, Upper Ground, SE1.

6th. IEE/I.Phys.—Colloquium on "Laser instrumentation", at 10.30 at Savoy Pl., WC2.

6th. IEE—"Motor car performance: acquisition and analysis of road vehicle service data," by Dr M. T. G. Hughes, at 17.30 at Savoy Pl., WC2.

7th. IERE—Colloquium on "Millimetric wave propagation", at 14.00 at 9 Bedford Sq., WC1.

7th. IEE/IERE—"Electromagnetic flowmeter design," by Dr D. Wyatt and Dr J. Hemp at 17.30 at Savoy Pl., WC2.

8th. IEE/IERE—Colloquium on "Patient monitoring", at 10.30 at Savoy Pl., WC2.

9th. IEE—Colloquium on "Breakdown phenomena and influence of electrode surfaces in high pressure gases", at 10.00 at Savoy Pl., WC2.

9th. IEE—Colloquium on "Handling information in the day-to-day running of large service organisations", at 10.30 at Savoy Pl., WC2.

9th. IEE—"Motor car performance: acquisition and analysis of road vehicle service data", by Dr M. T. G. Hughes, at 17.30 at Savoy Pl., WC2.

12th. IEE/IERE—Colloquium on "Computer simulation of communication systems", at 10.30 at Savoy Pl., WC2.

13th. IEE—Discussion on "Transducers for measuring electrical alternating quantities", at 14.00 at Savoy Pl., WC2.

13th. IEE—Colloquium on "Civil applications of underwater acoustics", at 14.30 at Savoy Pl., WC2.

13th. AES—"Measurement of loudspeaker dynamic performance", by Roger C. Driscoll, at 19.15 at the IEE, Savoy Pl., WC2.

14th. R.I.Nav.—"Navigation for fishing craft", by Gregory Haines, at 17.00 at the Royal Institution of Naval Architects, 10 Upper Belgrave St, SW1.

14th. IEE—"Spark ignition in the automobile", by C. Bowden, at 18.30 at Savoy Pl., WC2.

15th. IEE—"The INTELSAT system after 10 years", by D. J. Withers, at 17.30 at Savoy Pl., WC2.

15th. RTS—"Television cameras—how light, how small?" by W. P. Vinten at 19.00 at London Weekend Television South Bank TV Centre, Upper Ground, SE1.

20th. IEE—Colloquium on "Solid state scanning", at 14.30 at Savoy Pl., WC2.

21st. IERE—Colloquium on "The CEI Examination and the Colleges", at 14.30 at 9 Bedford Sq., WC1.

21st. IEE—"Electronic aids for the detection and prevention of crime", by G. Phillips, at 17.30 at Savoy Pl., WC2.

22nd. IERE/IEE—Colloquium on "Distributed information systems", at 14.30 at 9 Bedford Sq., WC1.

28th. IERE—Colloquium on "Recent developments in high quality sound", at 14.00 at the Engineering Lecture Theatre, University College, Gower St, WC1.

28th. IEE—"Electronics in medicine," by Dr D. W. Hill at 17.30 at Savoy Pl., WC2.

BEESTON

6th. IEE—"Feedback—the history of an idea," by Prof A. G. J. Macfarlane, at 19.00 at The Nurseryman, Derby Rd.

LIVERPOOL

9th. IEETE—"Modern trends in sound reproduction," by speaker from the GEC at 19.30 at MANWEB Social Club, Thingwall Road.

BRIGHTON

13th. IEE—Discussion on "I am an engineer", at Sussex University.

GLASGOW

8th. SERT—Section AGM and "The certificate of competence in colour television servicing," by A. J. Kenward at 19.30 at Weir Hall, Institution of Engineers and Shipbuilders in Scotland, Rankine House, 183 Bath St.

BIRMINGHAM

21st. SERT—"Modern technology in the service of the police, including the new Birmingham computerized command and control system," by A. T. Burrows at 19.00 at the Byng Kenrick Suite, University of Aston, Gosta Green.

NEWCASTLE

19th. IEE—"Electronics in the service of music", at 17.45 at the University.

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

Announcements

Bib Hi-Fi Accessories Ltd have moved to new premises in Wood Lane End, Hemel Hempstead and the new address is: PO Box 78, Hemel Hempstead, Herts HP2 4RH. Telephone Hemel Hempstead 61291.

"Industrial Instrumentation" is the title of a one-week course which is being organised by the Electronics Division of the Institution of Electrical Engineers (IEE) to take place at the University of Sussex, Brighton, between July 21 to 25, 1975.

A one-day seminar organised by Sira Institute and devoted to **"The role of market research in product planning in the instrument industry"** will be held at The City University, London EC1 on May 7, 1975. The seminar is designed to interest staff within companies manufacturing instruments and other high-technology products, who are new to market research techniques or who want to brush up their knowledge of them.

The proceedings of the 2nd **European Electro-Optics Conference** are now available on application to the publishers and organisers, Mack-Brooks Exhibitions Ltd, 62–64 Victoria Street, St. Albans, Herts. The 400-page hard-covered publication contains 50 papers and 18 abstracts of papers first presented at Montreux, Switzerland in April 1974.

Waycom Ltd, Wokingham Road, Bracknell, Berkshire RG12 1ND has successfully concluded negotiations for an exclusive UK marketing agreement with the AVX Corporation of America, manufacturers of monolithic ceramic capacitors.

Tony Chapman Electronics Ltd, 80 High Street, Epping, Essex CM16 4AE, have been appointed exclusive representative, in the UK, of the Vari-L Company, Inc. of Denver, Colorado, USA. Vari-L manufacture wideband signal processing components such as double balanced mixers, transformers, hybrid power dividers/combiners and variable inductors.

Audio Engineering Society 50th Convention

A report on the papers heard and products seen by two of our editorial staff

Part 1: by W. E. Anderton

Not a great deal of equipment on view at the exhibition was new to visitors, but the majority was of exceptionally high quality, reflecting the standard of modern technology in the field of audio engineering. Among the new items, Quad were showing a prototype of their power amplifier—to be launched during the autumn. No specification is available yet, but the continuous output power is rated at 100W per channel. The output stage of this power amplifier was the subject of a paper presented at the convention, "Current Dumping Audio Amplifier", by P. J. Walker and M. P. Albinson of the Acoustical Manufacturing Co. The paper described the operation of an output stage design in which linearity of the main current-carrying output transistors has no bearing on the overall amplifier performance, hence the need for biasing and allied problems associated with crossover are eliminated. "The solution presented in this paper relies on the fact that a low-powered amplifier of one or two watts does not have the same restrictions as one of higher power. It can be simple class A, for example, and the higher cut-off frequencies enable a wide bandwidth to be obtained. Thus we start by providing a low-powered, high-quality amplifier of well defined mutual conductance capable of the full output voltage swing but with limited current capability. Next we arrange that current drawn by the load turns on heavy-duty current-dumping transistors which then carry the major part of the output current. This dumping current is separately monitored and fed back to the common input. The amount of feedback is such that the mutual conductance is the same whether or not the current dumpers are operating."

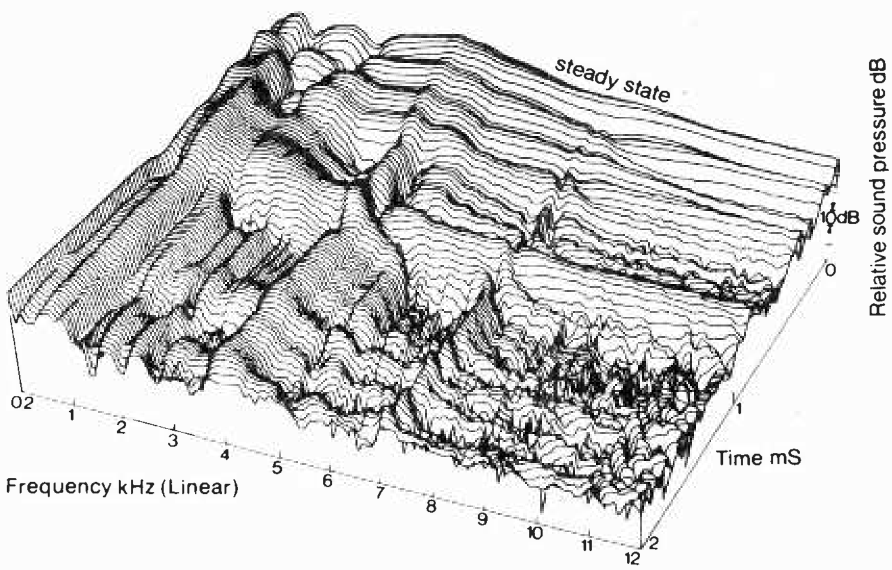
The Dolby cinema units, 364 Cinema Noise Reduction Unit and E2 Cinema Equalizer were on view. Used together, the two permit cinemas to reproduce Dolby-encoded optical sound tracks with high accuracy. The model 364 contains accurate electrical reproducing characteristics for all optical and magnetic sound tracks, selected by push-buttons. The E2 provides four independent types of adjustment: gain adjustment to match projector output to the 364 and to match input requirements of the theatre power amplifier; high-frequency adjustment to correct sound-head aperture loss; separate high-frequency and low-frequency adjustments for the overall theatre sound system; and 27 independently adjustable level controls for narrow-band filters.

The Bruel & Kjaer phase meter type 2971 was on demonstration. This instrument, released several months ago, gives direct phase indication from a digital display in degrees and radians or an analogue meter display in radians. Triggering can be achieved on positive or negative going waveform slopes. The instrument's frequency range is 2Hz to 200kHz and signal voltage range is 10mV to 15V with "out-of-range indication". A d.c. output proportional to phase angle is available and there is also a digital output for use with tape punch or computer systems. If the meter is to be used for relative phase measurements as, for example, in measuring the phase response of a loudspeaker, it is necessary to use the meter in conjunction with a delay line. Other uses include checking the phase characteristics of filters, amplifiers and transformers, mechanical impedance measurement, determination of loss factor and hence the complex modulus of material samples, trim-balancing aircraft jet engines and general phase measurement of electrical signals.

The latest professional Ampex video recorder was on demonstration during the week. This is the AVR-2 which has an extended range, digital timebase corrector to eliminate drift and offer a wider correction window and contribute to a fast lock-up time—one second in NTSC, two seconds in PAL/SECAM. Ampex credit the fast lock-up time to the timebase corrector, a direct-coupled printed-circuit capstan drive, the new Mark XV video head and the digital servo systems. All the electronic sub-systems are constructed on a modular basis for easy maintenance.

Lecture notes

An all-day session on loudspeakers revealed several interesting and controversial papers. "Loudspeaker evaluation using digital techniques", by J. M. Berman, and "Loudspeaker system simulation using digital techniques", by L. R. Fincham, presented a method of testing loudspeakers to obtain amplitude and phase responses derived from a unit impulse input. Automatic Fourier analysis is necessary for the system to be practical in terms of the length of time taken for measurements. By



Example of a loudspeaker's cumulative display amplitude spectrum—see text.

using an averaging and correlation technique to eliminate noise, the testing can be done without the need of an anechoic chamber. It is also possible to display cumulative display spectra. Similar analysis to that in obtaining the amplitude frequency response can also be carried out but measured at narrow intervals of time after the initial impulse has been received by the measurement microphone. The result, which can be displayed on a visual display unit, has x- and y-axis of amplitude versus frequency, but also a third z-axis representing time to show the pattern of build-up and decay of resonances in the loudspeaker. We hope to publish more details on this system in the near future.

Still on the subject of loudspeaker testing and performance, R. C. Driscoll in his lecture "Narrow-band transient test function", described the development of a test signal whose frequency spectrum can be defined within definite limits that can be varied to order. The idea is to view a selected, limited frequency spectrum produced by the loudspeaker under test so that effects within a single, or between two or more, bands can be observed. The test signal was derived from the observation that the transform from time to frequency domain of a square pulse produced a spectrum envelope $\sin\omega/\omega$. By using the notion of Fourier pairs and producing a function $\sin\omega/\omega$ in the time domain (not easy!), and then transforming this, a frequency spectrum whose "shape" is that of a square "pulse" is obtained. Refining the system allows the width of this defined spectrum pulse to be varied and also the repetition rate. We look forward to hearing the results of this research work, which overcomes the problems of swept sine-wave testing (individual frequencies tested only) and noise measurements (*fixed* bands of frequencies tested only).

In his lecture "Influence of loudspeaker cabinet walls", H. D. Harwood revealed that doubling the thickness of a cabinet material to reduce colouration could often, surprisingly, make the colouration worse. Several materials used for cabinet construction had been examined during a period of research.

A presentation entitled "Loudspeakers—the Missing Link", by E. Baekgaard, stirred up a discussion on the audibility of phase distortion. The problem has not yet been resolved.

Several papers on digital techniques in audio were presented. "A multiplex stereo decoder with automatic phase error correction", by M. J. Hawksford, described a sub-system which continually monitors and corrects inherent phase errors whether these are generated at source, during reception or within the decoder. "Digital on-line audio processing", by K. Bäder, B. Blessar and R. Zaorski, gave an introduction to the techniques behind the design of digital equipment used in audio processing.

Two interesting papers were presented during the so-called Pop Forum. "Pop Music studios in German Radio; acoustics and recording techniques", by E. J. Volker and F. Moehrke, examined four studios—Norddeutscher Rundfunk in Hamburg, Südwestfunk in Baden-Baden, Westdeutscher Rundfunk in Köln and Hessischer Rundfunk in Frankfurt. "Multitrack recording techniques", by P. E. Brown, was a retrospective talk on the historical development of this subject up to the present day.

Government sponsors

Strathearn Audio is a new company which has been established on a major scale by the Northern Ireland Finance Corporation (a government body) providing production facilities in Belfast and international marketing headquarters in London. Two papers presented by this company described the theory behind the first product launches planned for later this year. The first paper entitled "A novel planiform loudspeaker system", by R. C. Whelan, described a mid-range and high-frequency transducer operating an electrodynamic motor system as applied to a plane radiator (in this case a thin, flat strip of mylar is used as the plane radiator). A conductive ribbon is attached along the centre of the diaphragm and has a series of permanent magnets assembled along its length. It was shown that the strip dimensions could be made consistent with the required sound pressure levels and efficiency. Further, if the unit were operated with its long axis vertical, acceptable dispersion could be achieved.

The second paper, "A new direct-drive turntable with parallel tracking arm", by K. D. Ridler and J. H. Pope, contained several new developments. We are hoping to publish detailed information on this system in a future issue. The prototype appears to be true "state of the art" but two novel features include a ring of l.e.ds for observing fine-speed adjustment and a system of Helmholtz coils and magnet coupled to the short pickup arm whereby tracking weight can be adjusted without any clumsy mechanical operation and can be done while a record is actually playing. The motor and suspension of this turntable are both worthy of explanation in detail but space does not permit.

All in all an excellent convention—our congratulations to exhibitors, lecturers and especially the organizers.

Part 2: by B. Lane

As mentioned previously, there was little new equipment on view in the exhibition (except perhaps the Playboy Bunnies on the AKG stand!) but one particular item noticed, directly related to an unannounced paper by P. A. Fryer of Rank Radio International. This was a signal gating system used for delay gating the output of a measurement microphone. This device is used to examine the output of a loudspeaker for a specific period of time, after a precise interval timed from the cessation of the electrical input to the loudspeaker under test.

The measurement technique is designed to provide an amplitude versus frequency plot of a loudspeaker output, for different intervals of time delay. Dr Fryer's findings indicated that delayed resonances with a Q of between one and five were considerably more noticeable than those of high values of Q.

In a paper entitled "The elimination of scratch noise from 78 r.p.m. recordings", and read by Dr Peter G. Craven of the University of Oxford, an electronic system, using the vertical component of the record groove modulation, is used to identify the presence of scratches. This information is then applied to a sample and hold circuit which will switch the lateral information which contains the wanted information. Records are tracked with a stereo pickup cartridge and the output decoded, using a matrix to provide the required information for the sample and hold circuit. Dr Craven pointed out that the system was most effective on early electrical recordings rather than on the more complex acoustic versions.

Duplicating musicassettes

A particularly intriguing paper was jointly read by G. W. R. Taylor and D. L. Watson. Mr Taylor heads the development laboratory at EMI tape and Mr Watson is associated with the development laboratories of EMI records. The two presentations related to the improvement of high-speed duplicated musicassettes.

The introduction related to improvements in the quality of duplicating tapes produced by EMI, namely Type 152 for C60 and Type 161 (C90). It was demonstrated that with the improvement in performance, a reduction in intermodulation distortion occurred and it was possible to make use of the improved high-frequency short-wavelength performance to offset duplicating losses.

Complementing this performance improvement, Mr Watson pointed out that getting the best out of cassette duplication involved considerable care and expertise. In this he particularly referred to the problem of dynamic range and noise. Dangling a "carrot" before his audience, Mr Watson announced that EMI Records had been able to effect significant improvements in this direction by the development of a new electronic circuit which was the subject of a patent application. The demonstration that followed was a comparison between disc and duplicated cassette using the same original recording. Differences were negligible, indicating that the claims made are of quite a remarkable nature.

As a final note, further information concerning the availability of a bound book containing the papers presented at the convention can be obtained from the society's secretary at 1 Crown Close, Orpington, Kent VR6 6JP.

News of the Month

Video first

The video disc player developed by AEG-Telefunken, Teldec of Hamburg and Decca (London) was launched on the West German market on March 17. The machine, which is now known as TeD (Telefunken Decca), was originated in 1965 and first demonstrated in Berlin on June 24, 1970. It uses a thin, flexible plastic disc with hill-and-dale recording at a pitch of around 280 grooves per mm and revolving at 1500 r.p.m. A diamond stylus and ceramic transducer detect the vision and sound signals, which are then modulated on a u.h.f. carrier and passed to the aerial socket of an ordinary receiver. TeD has been developed to the PAL colour standard for sale in German-speaking areas at first, but NTSC and SECAM versions have also been produced. Fifty programmes are available on discs costing as little as £2 and lasting up to ten minutes. It is claimed that by the end of the year, there will be more than 350 programmes. Handling of the discs will not be a problem, as they are "posted" into the machine still in their sleeves, the record being extracted and inserted again automatically, so that the disc itself is not under attack by dust or greasy finger marks. The discs are 0.1mm thick, 21cm diameter and weigh 5g.

The price of the machine in Germany is around DM.1500 (£266). In comparison with other disc systems and video tape machine it suffers from the short playing time, but scores heavily on the cost. The programme material at £12 per hour is not much cheaper than unrecorded video tape at £14–£18 per hour (recorded tape will be much more than this) but the machine cost is only half that of the cheapest video tape machine. The chief limitation is that no recording by the user is possible, a snag shared by optical disc systems (Philips VLP, Thomson-CSF, etc.) although the MDR, by Erich Rabe, will overcome this restriction by means of its magnetic recording principle.

A detailed description of TeD was given in *Wireless World*, August 1970, although development has continued since then.

TeD video player (UK version shown by Decca), now on sale in Germany. The centre push switch selects repeated playing of single frames.

Bristol community TV experiment concluded

The local community cable television experiment in Bristol closed down on March 14 (see leader, April issue). The experiment provided a considerable amount of valuable information on the role of locally originated television programmes in a city community. Although the licence in theory could have run for another four years, Rediffusion, who conducted the experiment, say they did not consider that any further useful information could be obtained by continuing the experiment.

Bristol Channel was launched in May 1973 as part of an experiment in local television authorized by the Government. It has cost over £200,000 and been available to 23,000 subscribers to the Rediffusion cable network in the city, at no extra charge. Under the rules of the licence, practically all the programmes presented had to be made in the locality about the locality and by the people of the locality. Rediffusion could see no reason for continuing Bristol Channel within the restrictions of its present licence for what would be several years before the government of the day decided in which way cable television was to develop.

The Greenwich community TV experiment closed several months ago. This now leaves only Sheffield, Swindon and Wellingborough of the original five stations licensed.

Rescue radio system

An experimental radio communication system which provides two-way speech contact between underground workers and the surface was successfully used in operations at the Moorgate Tube disaster in London. The equipment consists of mobile base station and a number of special waistcoats containing portable transmitter-receivers, all of which may be rushed to the scene of a fire or other disaster. Each waistcoat contains an integral loop antenna and the three-channel transceiver is designed to leave the operator's hands completely free. Total weight of each transceiver is about 5lb while the base station equipment, with a weight of 30lb, is also portable. With this equipment communication can be fully maintained from within steel-framed buildings, cellars, tunnels, caves, mines and similar locations. Each rescue worker is permanently in two-way contact with the base station and a talk-through facility is available which permits person-to-person contact. The transmitter is voice operated. There is no press-to-talk or similar transmit/receive switching. Only two controls are fitted, an on/off switch combined with a volume control and a channel selector. The life of a battery is two hours, the same as that of an oxygen cylinder.

The system, known as Fire Ground radio, is in the early development stages and is not yet generally available. It is being developed by Plessey Avionics and Communications under a contract from the Home Office Directorate of Telecommunications for use by fire fighting services.

Memory store for coloured weather display

A data memory system forms a significant part of an automated weather radar network being developed for the Meteorological Office by the Royal Radar Establishment of Malvern. So far, seven weather radar display stores have been supplied for various stations. The RRE had experimented previously with other forms of storage but all were abandoned through economy or limitations of display or speed.

The memory store is built from Jasmin Electronics' range of digital logic modules. Basically, the system stores digital rainfall data transmitted by radar signals. This data is then converted into a colour code for clear grid type display on a colour television set. Alternatively, it can be logged or further processed by computer. Data is continually updated every 15 minutes and an ordinary tape recorder can be used as a back up store so that recorded data can be displayed at any time.

The system has sufficient capacity to store up to nine different area pictures or one composite picture covering the entire country. Precipitation data in six degrees from light rain to thunderstorm with large hail is held for a period of two hours. The user can immediately view rainfall distribution in his selected area at any one of nine different times almost instantaneously. Alternatively he could play back the nine pictures in sequence to give a true picture of weather developments both in and outside his own area which in turn would enable him to anticipate conditions hours ahead.

Symposium on broadcasting satellites

The European Space Research Organization held a symposium on broadcasting by satellite at Frascati, Italy from February 12–14. The expressed purpose of the symposium was to bring the technical and operational possibilities and the economic features of this new method of broadcasting sound and television to the notice of potential users. Attendance was by invitation and included demonstrations and presentations by research establishments and industrial companies active in the field.

The first day was devoted to various systems aspects including a presentation by Dr G. J. Phillips (BBC) who expounded on the principles of assigning frequency channels and satellite orbit positions with particular reference to a plan for broadcasting national programmes to European countries. He described trial plans and explained the limitations imposed by technical requirements. The second day was devoted to discussion of receiver design problems of which Mr E. Alder (S.E.L., Germany) described and demonstrated a method of transmitting two sound signals as digital modulation in an extended back-porch period of the line blanking. The method requires modification of the video signal waveform in reduction and displacement of the line-synchronizing pulse and colour burst periods. The final day was devoted to satellite systems.

Whether the conference achieved its purpose is hard to say. Certainly it brought together many of those in Europe concerned respectively with satellite technology, broadcasting and receiver design and some aspects of the subject were discussed ad nauseam. However, attendance by representatives from developing countries seemed disappointingly low and perhaps insufficient attention was given to their problems.

Satellite navigator helps food search

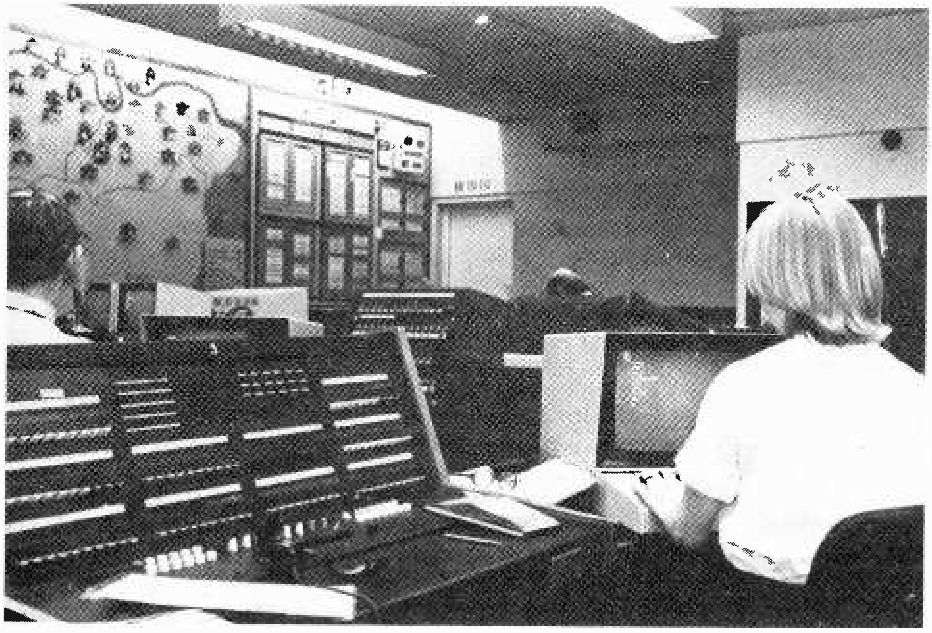
Positional accuracy to within 20 feet is claimed to be obtainable from the RSN2 Satellite Navigator in use by the captain of a scientific research vessel which recently left Southampton on a seven-month voyage prospecting for new food resources.

This first fitting of an RSN2 aboard an ocean going surface vessel was made in $3\frac{1}{2}$ hours by Redifon Telecommunications engineers. Direct readout of latitude, together with GMT, is given on an illuminated display on the front of the unit which occupies $3\frac{1}{2}$ cubic feet of space.

Operation is automatic—an inbuilt computer does all the work using information transmitted by six orbiting satellites (see "Navigation by satellite" by W. Blanchard, *Wireless World*, February 1975, pp.52–57). The ship—*Profesor Siedlecki*—is a Polish research vessel working for the International Sea Fisheries Institute and partly financed by the Food and Agriculture Organization of the United Nations.

It will explore the open ocean for new fishing areas, of which maps will be made, and also look for krill, small crustaceans which are the main food of the balin whale and a possible new source of nutritious food.

All three of London Fire Brigade's new control room v.d.u. installations are now operational. At Croydon, pictured here and controlling the entire Greater London area south of the Thames where there are about 965,000 dwellings, 100 emergency calls are handled each day and passed to the 45 stations in that 420 square mile area.



Communications 76

With enlarged terms of reference, Communications 76 promises to be the largest and most important event in the field of international telecommunications. Subtitled "communications equipment and systems," it now takes in radio, civil, public and private and defence communications interests. The four-day "exposition" is being sponsored by six authorities (Ministry of Defence, Home Office, British Overseas Trade Board, Electronic Engineering Association, Telecommunications Engineering and Manufacturing Association, and the Institution of Electrical Engineers) and will feature an enlarged exhibition, three-tier conference with parallel sessions devoted to the theme subject, user topics and technical matters, and a number of "inward missions". There will be at least four of these, in which the British Overseas Trade Board subsidize parties of senior buyers having specific interests in the four themes.

Each of the four days of the conference, under the chairmanship of Dr D. M. Leakey, will be devoted to a single theme—radio communications, sponsored by the EEA (first day); civil communications, sponsored by the Home Office (second day); public and private telecommunications, sponsored by TEMA (third day); and defence communications, sponsored by the Ministry of Defence (fourth day). Communications 76 will be held June 8–11, 1976 at the Hotel Metropole, Brighton.

The first quadraphonic Nowell

The BBC's second experimental quadraphonic broadcast, with a seasonal message this time, will start at midnight on December 23 and will last for about an hour. It will be a nativity play "The First Nowell", based on medieval pageantry to music by Vaughan Williams. As with the first quadraphonic broadcast last July, two groups of v.h.f. stereophonic transmitters will be used. Radio 3 transmitters will carry the front left and right signals and Radio 4 the rear left and right. In the absence of a second stereo receiver, some interesting, though not completely representative effects could be obtained by using a mono receiver, preferably v.h.f., tuned to Radio 4, to provide the rear information from a central position.

A 50MHz oscilloscope

An advanced design using semiconductor techniques
1—Y amplifier and X amplifier

by C. M. J. Little, B.A.

Department of Electronics, Southampton University

The oscilloscope design presented in this article is the final result of five years' development and construction work carried out in my spare time. The project started with the purchase of a new Brimar cathode ray tube, the large cash outlay ensuring that an oscilloscope of some sort would eventually be built. From the first rather crude instrument, I became afflicted with a desire for perfection, and the present design is the result of continual improvement. To give an example of the amount of development work that I have done: three versions of the Y amplifier have been built, two of the e.h.t. inverter, two of the Y attenuator, two of the ramp generator, and no less than five of the X amplifier.

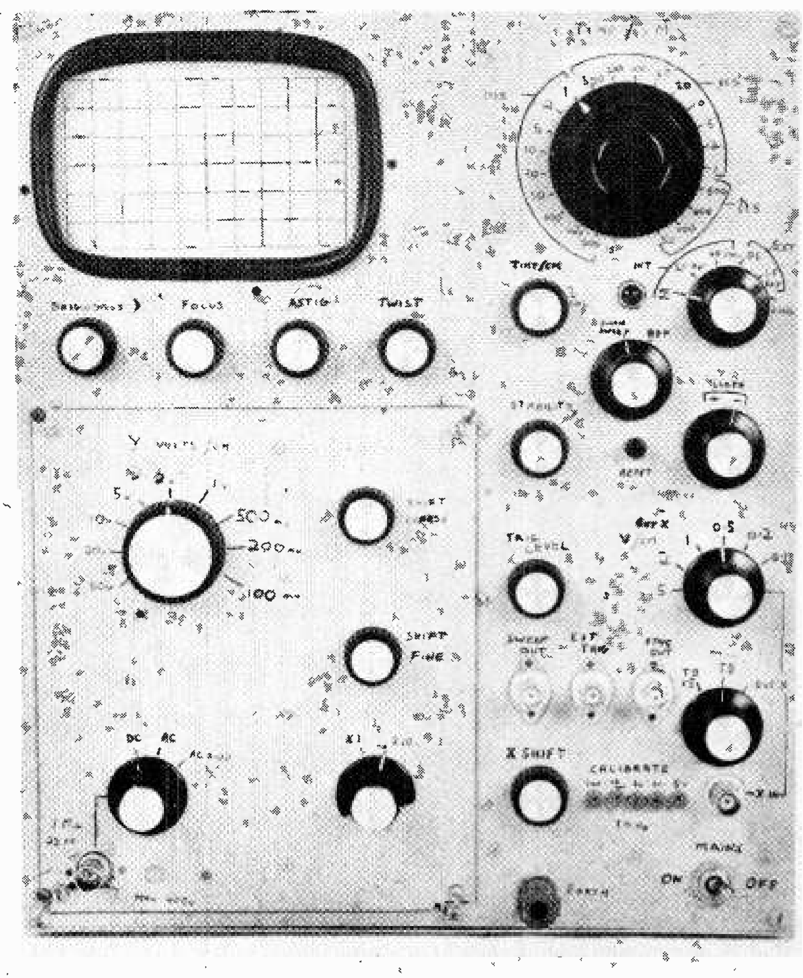
The oscilloscope offers all the usual facilities to be found in high quality commercial instruments, such as directly-coupled amplifiers, stabilized e.h.t., calibrated triggered timebase, and wide bandwidth. It lacks dual-trace operation, Y signal delay, and delayed timebase. The performance can be judged from the specification and some waveform photographs which will show the limits of the performance in some respect or other. Although I cannot guarantee these performance figures for all examples built, I am confident that the circuits are repeatable and will work well without further development.

I should point out that this design is complicated and that its construction should only be attempted by those readers with considerable practical experience. It is also expensive, costing at least £80, which is probably sufficient deterrent to those who are not wholly confident of their ability. However, the finished result is as useful and as easy to use as commercial instruments costing much more. It also seems to be reliable, having survived six months in the hands of the Southampton University Radio Club! It is recommended that the full series of articles is read and digested before starting work on the oscilloscope, as they will be published in the order considered best for description, not for construction. The list of components will, for this reason, be printed with the final article.

Y amplifier

The Y amplifier is a general purpose wide band amplifier, directly-coupled throughout, and with a bandwidth of 50MHz, although the attenuator degrades this. The basic sensitivity of 100mV/cm, and all other lesser sensitivities are obtained by switching a 1MΩ compensated attenuator in front of the fixed gain amplifier. A switch increases the basic amplifier sensitivity to 10mV/cm, maintaining the direct coupling but decreasing the bandwidth to 17MHz. A capacitor-coupled pre-amplifier with a gain of 100 may be switched in front of the attenuator to increase the maximum gain to 100μV/cm, but use of this degrades the bandwidth to 10Hz–600kHz. The input impedance is constant at 1MΩ, 25pF on all ranges to allow the use of a "divide-by-ten" probe.

The Y amplifier is divided into two parts, one of which, the pre-amplifier, is mounted in a removable plug-in unit, while the output amplifier is in the main unit next to the tube base. The removable Y plug-in unit facilitates the construction of alternative Y pre-amplifiers. More will



be said about this in the section on modifications.

The Y output amplifier circuit is shown in Fig. 1. The basic configuration is a differential cascode amplifier with Tr_3 and Tr_4 as the common-base pair, and Tr_5 and Tr_6 the common-emitter amplifiers. The base voltage of Tr_3 and Tr_4 is held at a constant d.c. potential of +14V, adjustable with R_2. The common-mode input voltage is 11V, this voltage and the emitter resistors R_{13} and R_{14} defining the current through each half of the cascode to be 26.5mA. The mean Y plate potential is therefore about 30V. The gain of the stage is defined by R_{15} to be 13 times. L_3, L_4, C_7 and R_{16} compensate for a fall in gain due to capacitive loading at the collectors of Tr_3 and Tr_4. These components are adjusted to give a good pulse response. L_1, L_2, R_8, R_9 and R_4 reduce the effect of mismatch and reflections in the wires connecting the output amplifier with the plug in. They were adjusted experimentally to give a reasonable pulse shape. Tr_2 provides a low impedance feed to the trigger generator.

The Y pre-amplifier circuit is shown in Fig. 2. The main active component is a μA733 integrated circuit, which is a differential wideband amplifier, and could almost have been designed especially for the present application. Fixed gains of 10, 100 and 400 can be selected by shorting various pins on the TO5 package, with a bandwidth of 100MHz, or the gain may be varied between 10 and 400 with a preset between pins 4 and 9. The maximum supply voltage is ±8V so R_{47} is used to drop the 18V rail to 15V. The output common mode voltage is 10.4V and the input common mode voltage 7.5V.

The minimum gain of the 733 is 10, so the total gain of the output amplifier and the 733 is 130. With a deflexion sensitivity of 8V/cm, this gives a final sensitivity of 60mV/cm. The input stage, therefore, has a gain of about 0.5.

The input stage is a differential amplifier using two junction f.e.ts in common-drain, and two n-p-n transistors in common-emitter. The input stage provides firstly a high input impedance and secondly, a voltage shift from the 0V input to the 7.5V input to the 733. The collector loads of Tr_{11} and Tr_{13} are 500Ω in order to ensure a wide bandwidth. At one stage in the design I thought that the Y amplifier might be made fully differential, with two input terminals. This was not done, but explains R_{28} to adjust the common mode rejection to a maximum, and also the current sources Tr_{12} and Tr_{14}. R_{30} adjusts the gain of the whole amplifier, and R_{23} adjusts the common mode input voltage of the 733 to exactly 7.5V.

The Y shift voltage is applied to the gate of Tr_{15} from a network which provides fine and coarse shift controls. The coarse control acts as a balance adjustment in the ×10 gain position. The shift network is fed from the ±11V rails. Input protection is provided by D_1, D_2 and R_{20}.

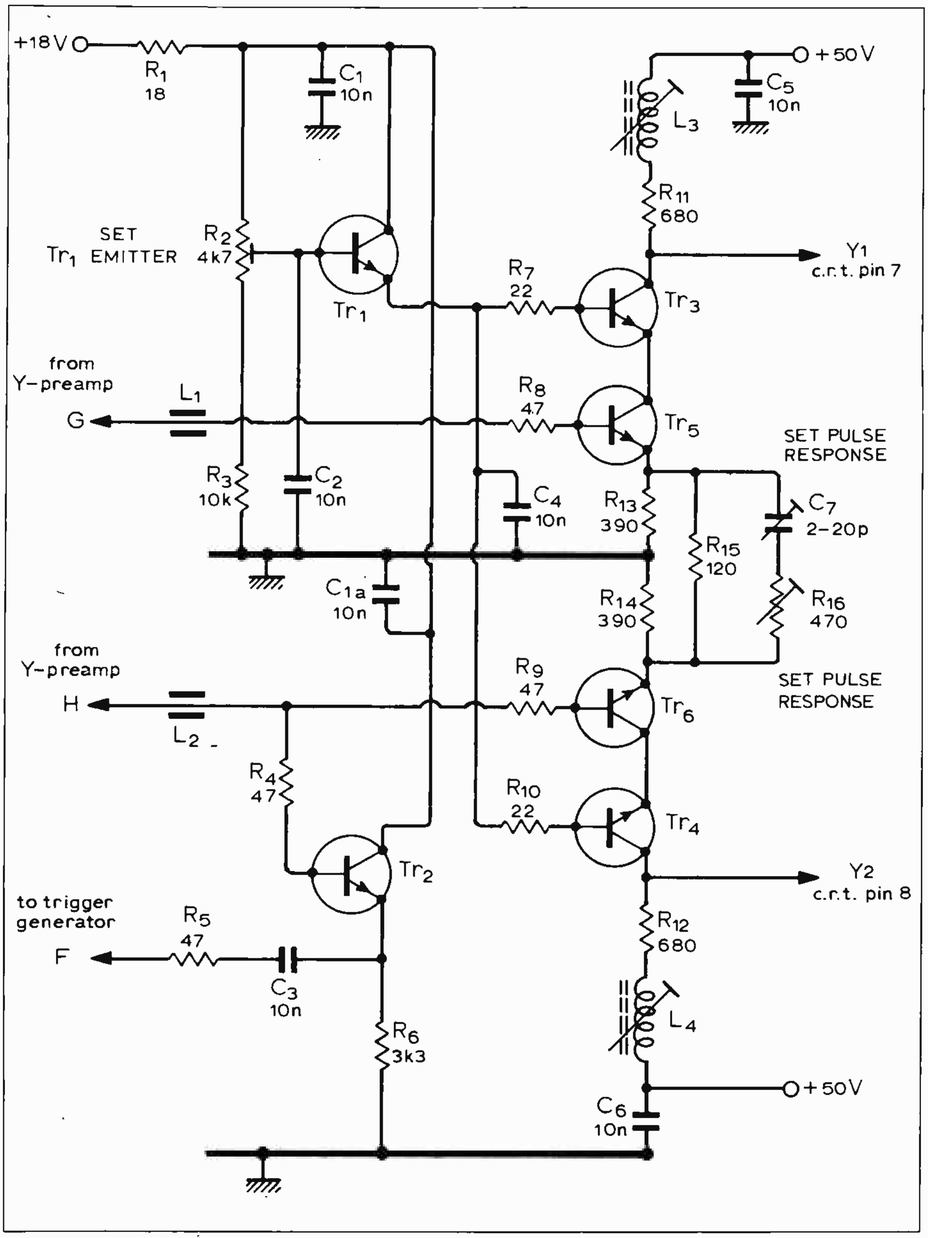
The ×10 gain switch operates RL_1, which switches R_{46} across the gain control pins of the 733, increasing its gain to 100×. A reed relay is used here to avoid long leads to the pins of the 733. The capacitance from pins 4 and 9 to earth must be as small as possible.

The final parts of the Y amplifier are shown in Fig. 3 and Fig. 4. The Y attenuator switches a separate section for each gain position. Each section is compensated and has a capacitor to standardize the input impedance. A further discussion of the Y attenuator will be given in the construction section.

The a.c. pre-amplifier has a gain of 100, and is placed between the attenuator and the input socket. This means that noise generated in the pre-amplifier will be attenuated as the sensitivity of the main amplifier is reduced. The circuit has zero phase shift between input and output, maintaining the convention that up is positive on the screen. The prototype showed instability due to capacitive coupling between the input and output. C_{21} was added to eliminate this, and could be removed if the screening was made more efficient. In particular, S_{2b} and S_{2c} could be on separate wafers, with a screen in between. It was not anticipated that the "÷ 10" probe would be used with the "AC × 100" gain position.

This concludes the circuit description of the Y amplifier.

Fig. 1. The Y output amplifier. L_1, L_2 are ferrite beads.



X amplifier

This part of the oscilloscope gave easily the most trouble, and about four completely separate versions of the X amplifier have been built and rejected. At this point I have to admit that I looked at the circuits of various commercial oscilloscopes to see how to overcome the problems I had experienced. The present circuit, shown in Fig. 5, is based on one used by Solartron.

The problem is that the circuit has to provide very fast slew rates with very fast recovery from overload. Consider the X amplifier operating from the 50ns/cm sweep. The total deflexion voltage required is about 170 volts peak to peak, which corresponds to a slew rate of 340V/μs. Now the problems really begin when the ×5 expansion switch is operated. The slew rate is now 1700V/μs! Worse than this, the amplifier will be overloaded for about three-quarters of the sweep, as it is trying to produce a sweep voltage of 850 volts, when it has a maximum voltage swing of about 200 volts. The result of all this is to produce an impossibly non-linear sweep, sometimes even doubling back on itself! The secret is to ensure that all collector-base junctions remain reversed biased during overload, as a saturated transistor takes too long to recover. It is also equally important to avoid base-emitter junction reverse breakdown for the same reasons. The degree to which the circuit avoids these troubles may be judged from a photograph of a 100MHz sine wave displayed at 50ns/cm with ×5 expansion.

The basic configuration of the output stage is again a differential cascode amplifier. This is operated between the −50V rail and the +130V rail in order to obtain sufficient voltage swing. The mean output voltage with no spot deflexion is 50V, which gives a current of 24mA in each half of the differential amplifier. The bases of Tr_{36} and Tr_{37} are held at −24V by D_{14} and D_{15}. D_{16} to D_{19} prevent the collector voltages from falling below −11V, thereby avoiding saturation of Tr_{36} and Tr_{37}.

The emitter voltages of Tr_{34} and Tr_{35} are at −39V, requiring collector voltages

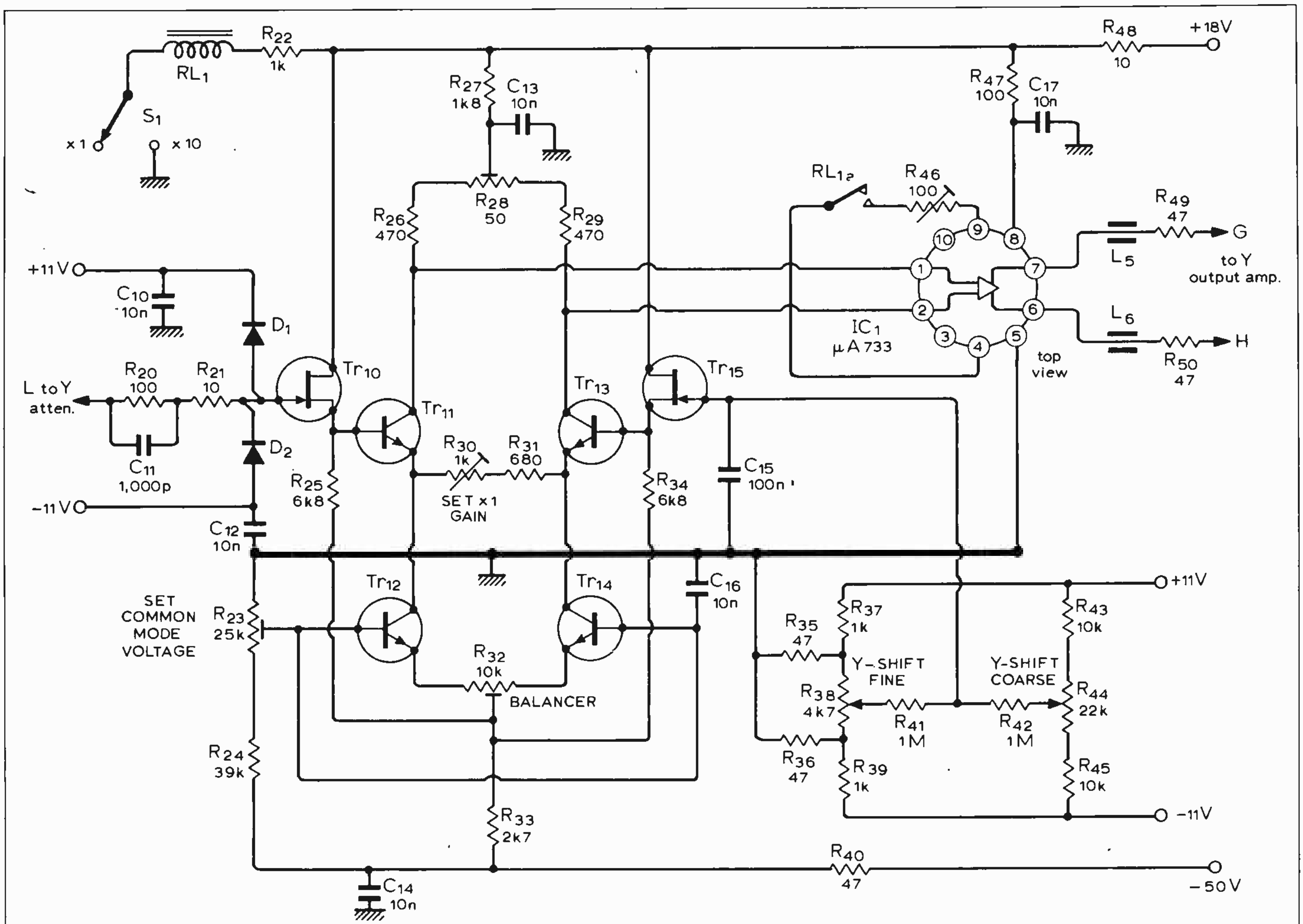
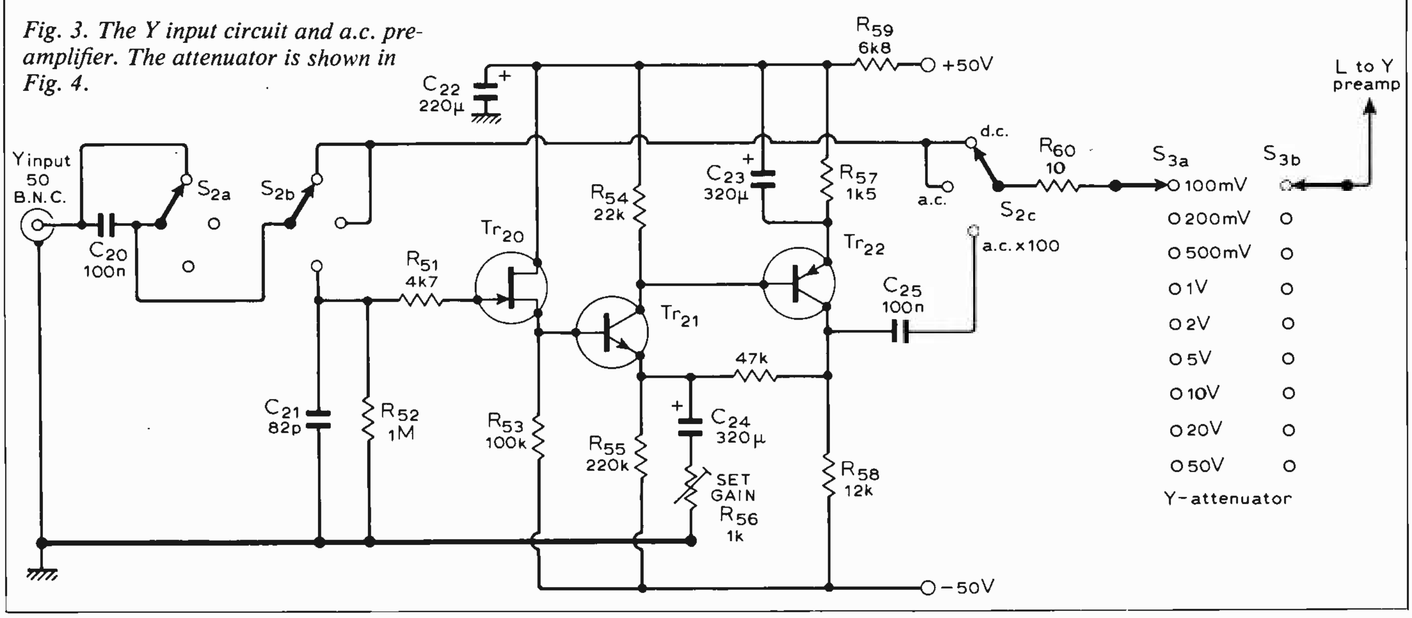


Fig. 2. Circuit diagram of the Y pre-amplifier.

Fig. 3. The Y input circuit and a.c. pre-amplifier. The attenuator is shown in Fig. 4.

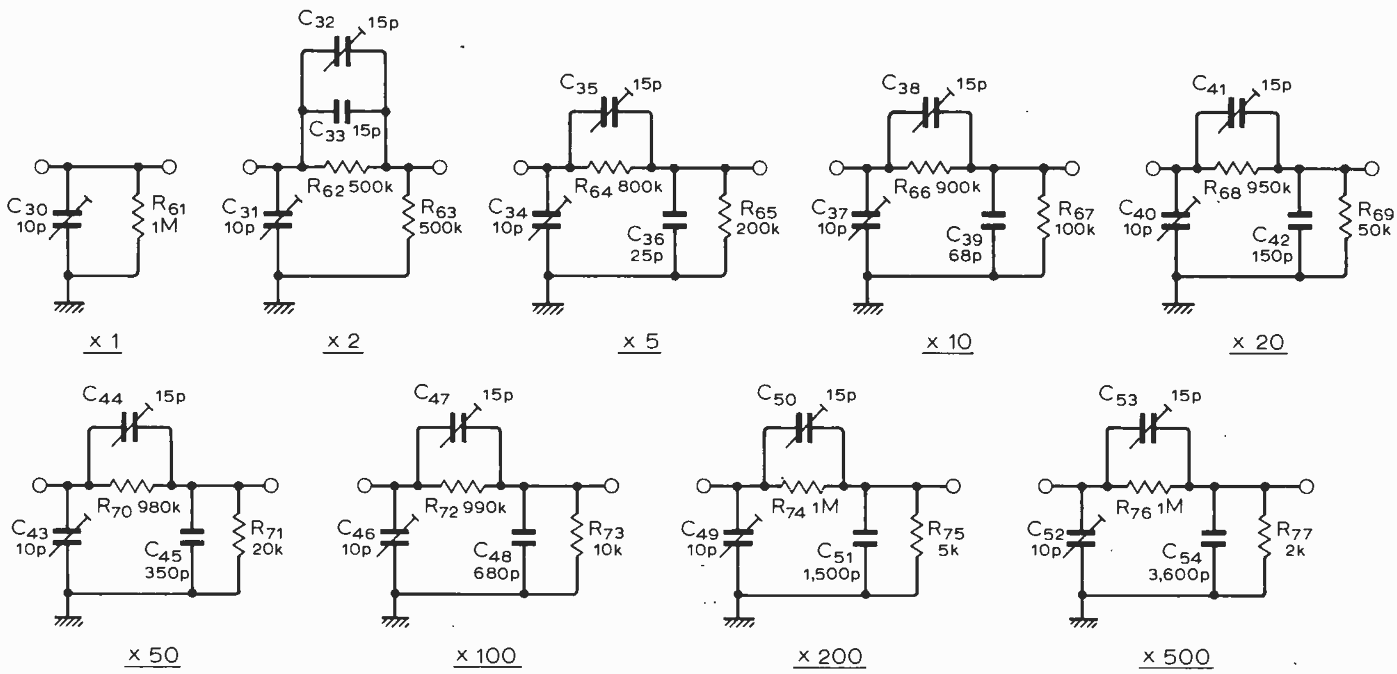


of about −27V on Tr_{32} and Tr_{33}. This p-n-p input stage will accept the full 20V peak-to-peak sweep voltage without overloading. The constant-current source Tr_{31} prevents saturation of Tr_{32} or Tr_{33}, and sets the overall working point of the amplifier. D_{10} and D_{11} prevent breakdown of the base-emitter junctions of Tr_{32} and Tr_{33}. The gain of the amplifier is adjusted to give a sensitivity of 2V/cm with R_{93}. When the ×5 expansion switch is operated, R_{90} is switched into circuit via relay RL_2 and the sensitivity increases to 400mV/cm.

To summarize the horizontal deflexion system, Fig. 6 shows the interconnexion of the various horizontal sub units, and also shows the circuit of the external X preamplifier. This has a fixed gain of 4, and is protected in the same way as the Y amplifier. A switched attenuator provides sensitivities from 100mV/cm to 5V/cm. The ×5 gain relay RL_2 is operated in the external X position of S_5. Although the external X preamplifier is a negative feedback amplifier no compensation seems to be necessary. *(To be continued)*

Fig. 4. Y attenuator sections, selected by S_3 in Fig. 3.

Fig. 5. The X amplifier for both timebase and external signals. Letter symbols refer to Fig. 6.



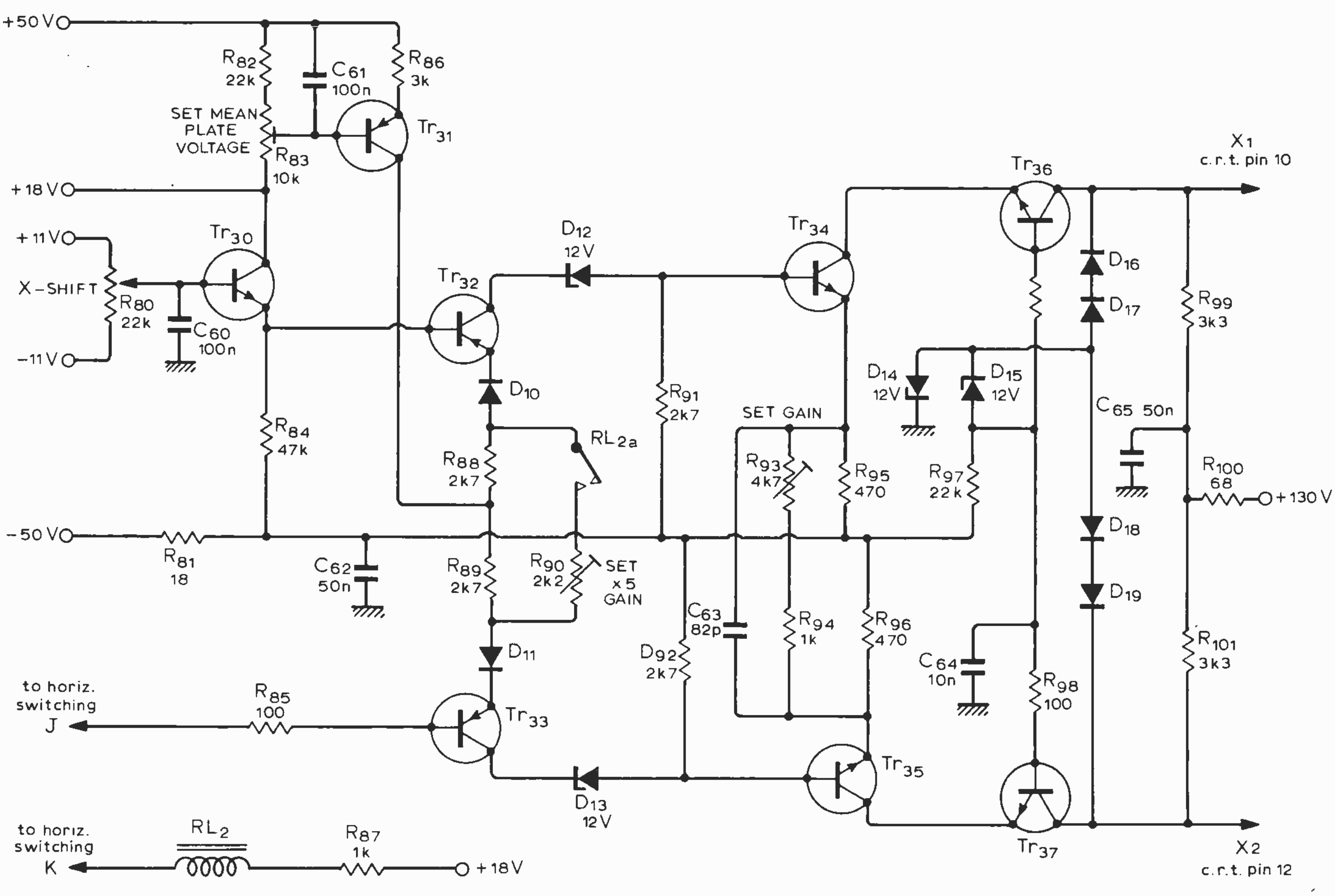
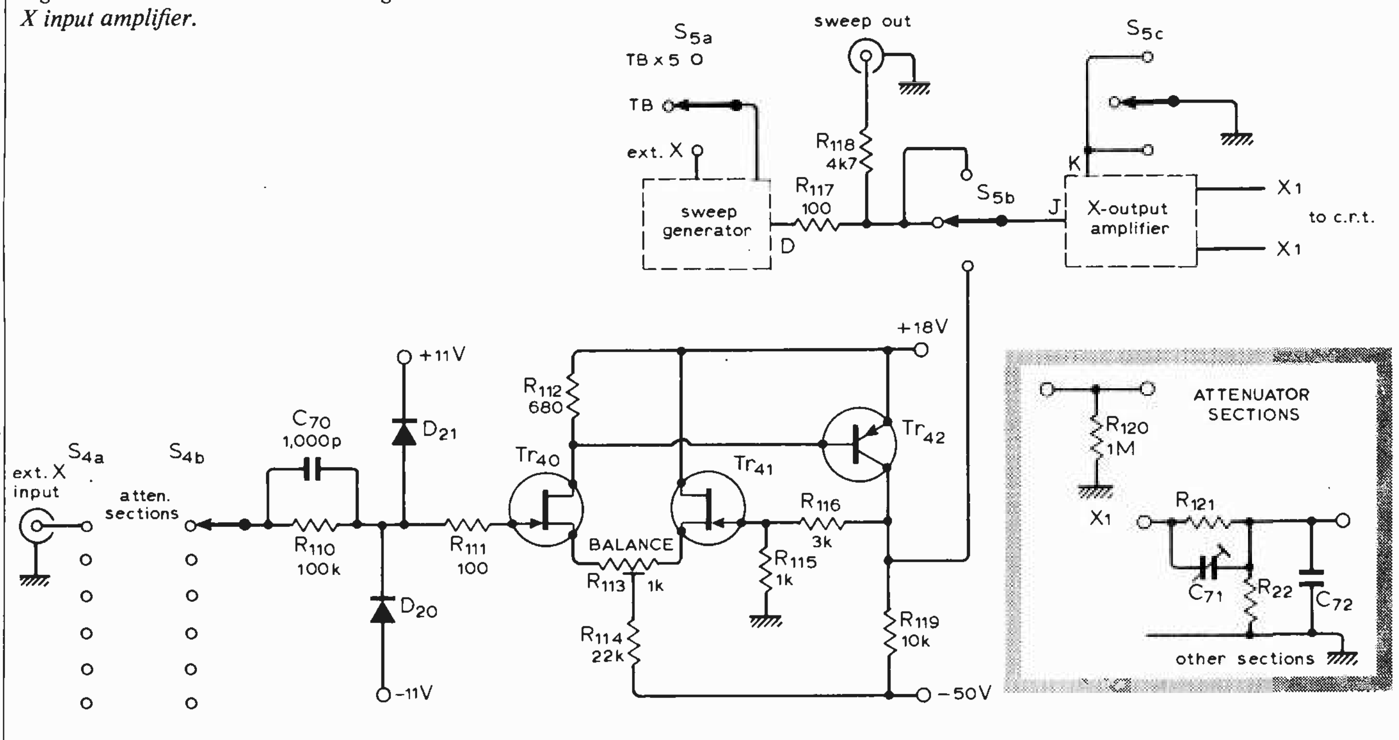


Fig. 6. The horizontal axis switching and X input amplifier.



Specification of the oscilloscope

C.r.t.
Spiral p.d.a. tube operated at 4kV. E.h.t. derived from feedback-stabilized inverter. Built-in graticule inside tube face. Screen area 10cm × 6cm. Directly-coupled retrace blanking.

Calibrator
1kHz square wave calibrator giving voltage outputs of 5 volts, 1 volt, 0.1 volt, 10mV, 1mV to sockets on front panel. Voltage accuracy ±1%. Time accuracy ±0.5%.

Y amplifier
1MΩ, 25pF input impedance. Nine-position switch giving vertical sensitivities of 100mV/cm to 50V/cm in 5, 2, 1 sequence. Switch giving gain increase of 10× on all ranges. A.c. preamplifier giving gain increase of 100× for a maximum sensitivity of 100μV/cm.

Bandwidths (at −3dB points)

gain ×1	d.c.—50MHz, rise time 7ns
gain ×10	d.c.—17MHz, rise time 20ns
gain ×1000	10Hz—600kHz, rise time 0.5μs

Hum and noise
0.5cm peak to peak at 100μV/cm

X amplifier
External input with input impedance of 1MΩ. Six sensitivities of 100mV/cm to 5V/cm in 5, 2, 1 steps. Bandwidth d.c.—5MHz.

Sweep generator
23 switch-selected ranges from 1s/cm to 50ns/cm in 5, 2, 1 sequence. Uncalibrated fine adjustment with 3:1 range. Linearity of sweep better than 0.1% except on 50ns range, when 0.5%. Accuracy of all ranges ±2%. Expansion switch giving X expansion of 5×. Usable on all sweep ranges giving a maximum rate of 10ns/cm.

Single sweep facility

Triggering
Trigger level control with +/− slope switch. Trigger selector switch giving the following positions:
"Int." A.c.-coupled signal taken from Y amplifier.
"L.f. rej." As int. but via high-pass filter.
These two positions provide stable triggering up to 10MHz. The minimum signal level is 0.3cm.
"H.f. sync." Stable synchronization up to 100MHz with 0.2cm signal.
"Ext. d.c." External triggering. Minimum level 50mV at 1kHz.
"Ext. l.f. rej." Input impedance 1MΩ.
"Line." Triggering from 50Hz mains.

Cost to build using mainly new components £80.

Literature Received

ACTIVE DEVICES
Burr-Brown have sent us a leaflet on the Model 3660 i.c. instrumentation amplifier, which features a voltage drift of less than 2.5μV/°C and a bias current drift of less than 2nA/°C. Common-mode rejection ratio is at least 110dB and the input impedance is 20GΩ. Burr-Brown International, 25A King Street, Watford, WD1 8BT WW401

A booklet from Micro Electronics gives design and applications information on the MEU21/22 programmable unijunction transistors. Applications include oscillators, a TV deflection circuit, delays and s.c.r. control. Micro Electronics Ltd, York House, Empire Way, Wembley, Middlesex . WW402

An eight-page leaflet giving connexions and application notes for several manufacturers' audio integrated circuits is available from Chromasonic Electronics, 56 Fortis Green Road, London N10 3HN. The cost is 10p, or free with more than £1 of components.

PASSIVE DEVICES
We are informed by Plessey that they have published a brochure setting out full information on a range of c.r.t. deflection components for professional use. The publication, which is in English, French and German, is obtainable from Plessey Windings, Abbey Works, Titchfield, Fareham, Hants PO14 4QA WW403

MATERIALS
A brochure entitled *Adhesive on both sides* describes the uses of double-sided adhesive tapes in various industries. There is a page of characteristics of 14 types of tape made by Tesa Tapes Ltd, Ascot Road, Bedfont, Feltham, Middlesex TW14 8QP. WW404

EQUIPMENT
Appliance Components Ltd tell us that they have available a leaflet on the ETA series of electronic delay timers for the range 3s to 20m. Appliance Components Ltd, Cordwallis Street, Maidenhead, Berks SL6 7BQ WW405

Crystal oscillators, compatible with c.m.o.s. circuitry, are available from Lyons Instruments and the Vectron CO-236 range, which covers frequencies from 0.01Hz to 10MHz, is described in a leaflet available from Lyons at Ware Road, Hoddesdon, Herts WW406

Cambion say that they have issued a brochure of Euro-Card component mounting boards and Euro-Rack assemblies. Cambion Electronic Products Ltd, Castleton S30 2WR WW407

Transducers using strain gauge, piezo or differential transformer techniques for the measurement of pressure, force, acceleration and displacement are described in a new short-form catalogue from Bryans Southern Instruments Ltd, Willow Lane, Mitcham, Surrey CR4 4UL WW408

A 64-character, 16-column alphanumeric printer from Gay of Milan, named the Printina, is briefly described in a leaflet from Claude Lyons Ltd, Hoddesdon, Herts WW409

Digital frequency-synthesis—a new approach

by D. C. Ayre, Dip. Tech. (Eng.), and K. G. Woodard, B.Sc.
Farnell Instruments Ltd

Although the idea of the phase-locked loop synthesizer has been in existence for some time, it has never been possible to use the type of phase comparator having infinite pull-in range with a resolution of six digits and still produce a signal with very low residual f.m. This article shows how the residual f.m. can be greatly reduced while retaining a fast response time and high resolution.

In the last few years there has been a vast expansion in semiconductor technology, and in particular in integrated circuits, which has done much for digital circuit design by providing many new building blocks of great internal complexity and overall versatility. It is the introduction of this type of device, and notably high speed dividers up to 1GHz, that permits a new look at old techniques. One area that has benefited is digital frequency synthesis, using a phase-locked loop, a technique which has been in existence for over forty years.

Fundamentally, the phase-locked loop is a means of controlling the frequency of a voltage-controlled oscillator so that its frequency is equal to a reference frequency or some multiple or sub-multiple of it. For this purpose a phase comparator is required. An elementary phase-locked loop is shown in Fig. 1. This is a first-order system, the error being in phase only. It is this phase error that is used to control the v.c.o. to the correct frequency. As the output of the phase comparator contains oscillator frequency components of high relative level, a low-pass filter is used—Fig. 2. Components of this filter are carefully selected to produce a good phase margin in the loop characteristic. As the bandwidth of the loop is usually very much smaller than the oscillator frequency, there is virtually no r.f. fed back to the frequency control of the oscillator.

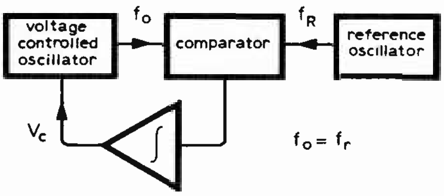


Fig. 1. Elementary phase-locked loop.

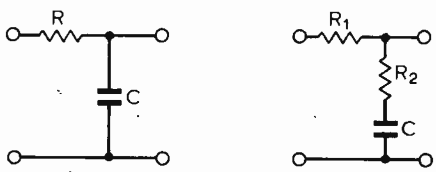


Fig. 2. Typical low-pass filters.

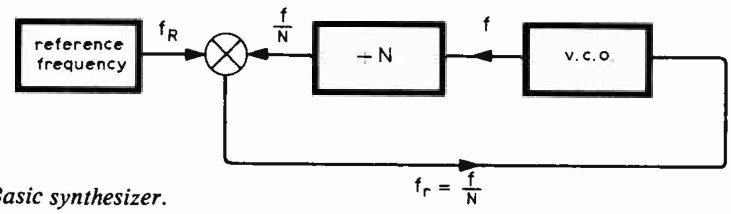


Fig. 3. Basic synthesizer.

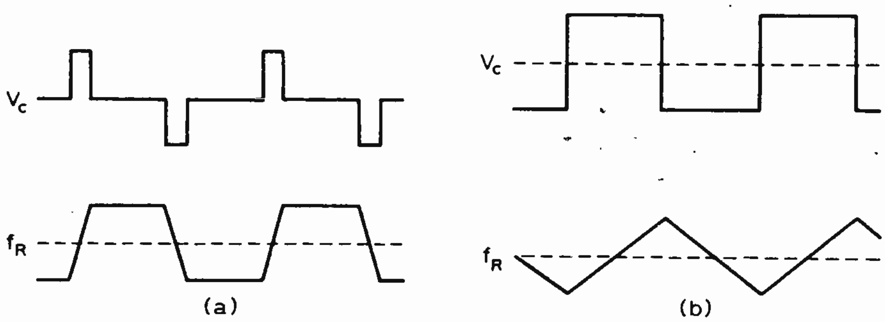


Fig. 4. Comparator waveforms and their effect.

To make this loop into a basic synthesizer a programmable divider is added—Fig. 3. If the divide-down ratio is very large, then the comparison frequency becomes very low. This frequency may now be getting into the region of the control bandwidth, in which case it will be fed directly on to the frequency control line causing frequency modulation. This has been a limiting area ever since the devices made this type of synthesizer possible. The resolution must therefore be kept relatively low if the residual f.m. and the settling time of the loop are also to be kept low.

Originally, the phase comparator was an analogue circuit using diodes and transformers, similar to a mixer, but with the advent of complex integrated circuits the comparator has become digital, at frequencies that can be reached by digital integrated circuits. The output from these comparators tends to be of a digital nature which is easily filtered if the comparison frequency is high.

The comparator waveforms of Fig. 4, with their inherent problems, are easily produced using modern integrated circuits. The advantages gained by these circuits, such as logic level outputs that indicate the lock condition or the ability to search over a very wide frequency range to allow lock to be obtained, make it worthwhile finding a way to overcome the major disadvantages. A phase comparator of this type but with a ripple-free output would make it possible to build a synthesizer with up to six decades of frequency control and to restrict the unwanted f.m. to negligible proportions.

The area for greatest improvement is in the waveshape of the correction pulses. The present comparators tend to produce a wide energy spectrum with the maximum power in the lower frequency components.

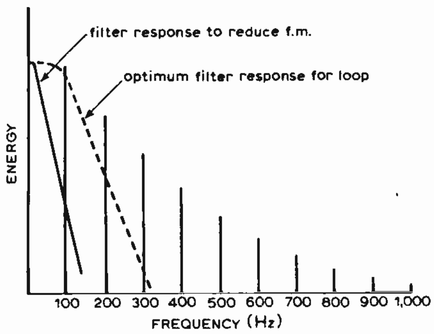


Fig. 5. Comparator energy spectrum.

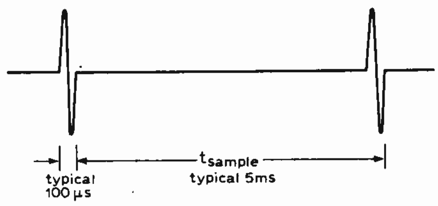


Fig. 6. Ideal waveform.

Filters that attenuate these components would badly affect the phase response and settling time of the control loop. This means that to be able to effectively remove the unwanted components without altering the loop parameters, it will be necessary to concentrate the more powerful components to higher frequencies as in Fig. 5. Such a waveform would tend to concentrate all of its correction power into a very short time, compared with the time between such pulses.

An ideal waveform is basically a single cycle of a sinewave at a frequency far in excess of the repetition rate—Fig. 6. The energy of this waveform is concentrated in the spectral lines corresponding to the frequency of this sinewave and its harmonics, see Fig. 7(a). In practice, the energy of the low frequency components will increase if the loop is compensating for oscillator drift, see Fig. 7(b). To obtain the best results, it will be necessary to use a very low drift oscillator for the v.c.o.

Frequency-locked signal generator

The prescaler, in Fig. 8, is needed to reduce the maximum input frequency to the presettable dividers to the maximum clocking speed of the logic used which is approximately 20MHz in the case of t.t.l. Thus if a resolution of 1kHz is required of a 100MHz signal, the comparison frequency will be 1kHz divided by the prescaler—200Hz in this example. The programmable divider is shown with six digits, representing a division ratio of up to 10^6, and is typical of modern telecommunications equipment. The comparator output of the system will suffer from the faults previously mentioned; in particular any jitter from the comparator will be magnified by a factor of up to 10^6, the value of the programmable divider. To overcome this fault some extra circuitry needs to be added. Fig. 9 shows the system in more detail with the extra blocks.

The output of the v.c.o. and reference lines both drive monostables whose outputs alternatively set and reset the flip-flop to produce a square wave when the frequencies are equal. Once the v.c.o. pulse has set the flip-flop, the output is NAND-ed with the v.c.o. line to see if another pulse appears before the reference pulse resets the flip-flop. If a pulse appears, then the v.c.o. is too high in frequency and the NAND gate produces a "go-down" pulse.

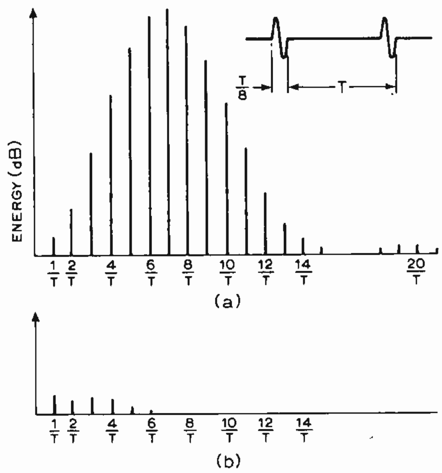


Fig. 7. Energy spectrum of (a) ideal waveform, (b) practical system with two stage filter.

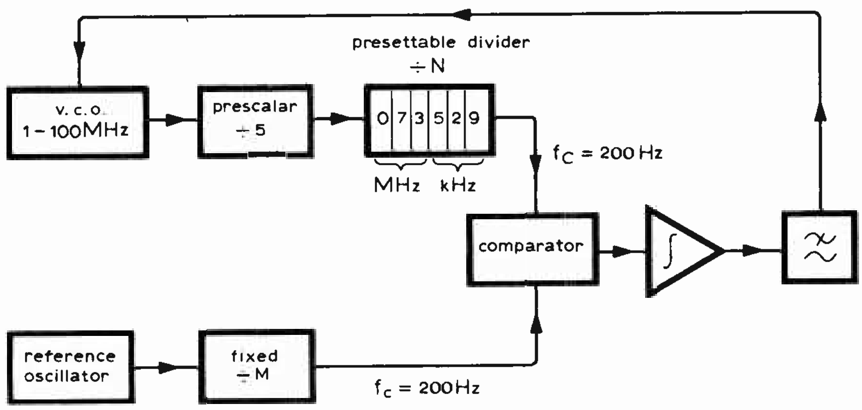


Fig. 8. Frequency-locked signal generator.

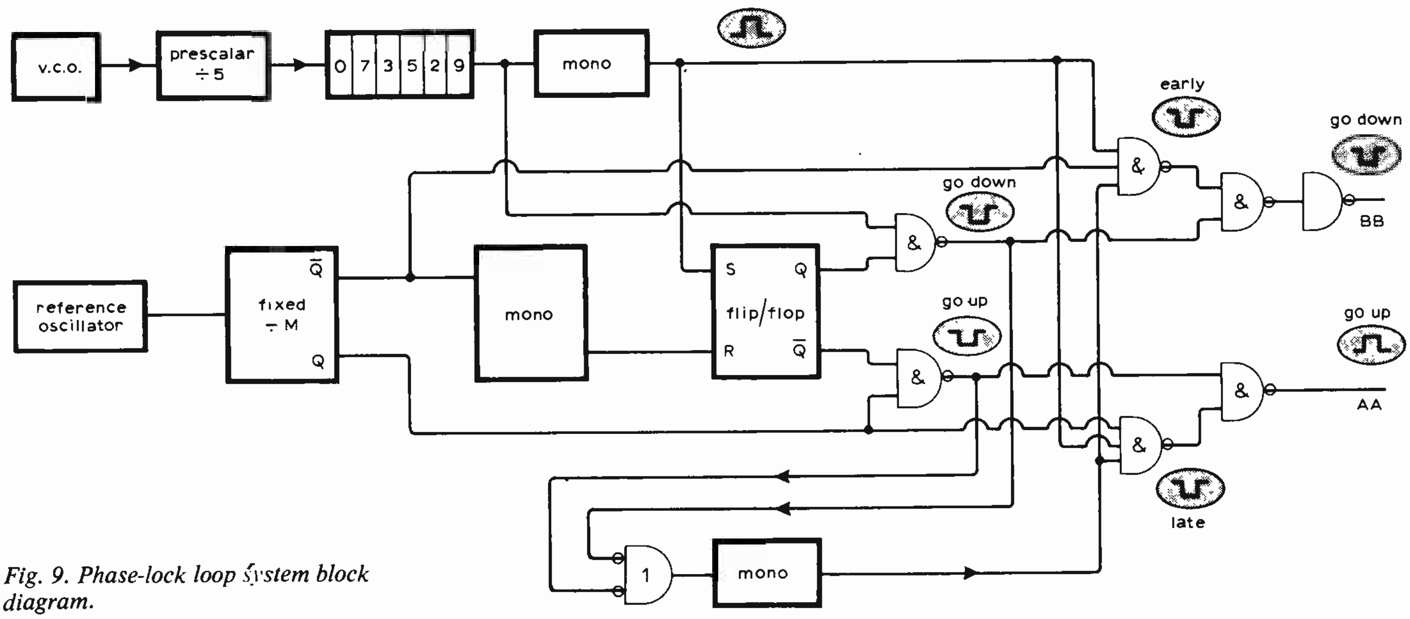


Fig. 9. Phase-lock loop system block diagram.

The same function is performed with the flip-flop's other output and the reference oscillator pulse to produce a "go-up" pulse when the v.c.o. is too low in frequency. The monostables on the v.c.o. and reference lines provide a delay so that the flip-flop output cannot be combined with its own set or reset trigger which would give false up and down pulses. This method is preferred to relying on propagation delays.

There is now a series of go-up and go-down command pulses. When the two frequencies are equal the flip-flop output has an equal mark/space ratio square wave and there are no up or down pulses. In this condition the v.c.o. is free to drift in either direction until a correction pulse returns it to equality. Ultimately, the drift would be balanced against up or down pulses at the sampling rate of 200Hz. These pulses constitute the residual frequency modulation.

Phase lock

The method of reducing this 200Hz f.m. is to carry out a phase-lock operation which produces "late" and "early" pulses as soon as the flip-flop output departs from an equal mark/space square wave.

The set pulse and the divider Q output, NAND-ed, produce a "late" pulse, the $\overline{Q}$ output and the set pulse giving an "early" pulse. These are referenced to earth and summed to produce a composite signal. An effect of the summation is to round off the composite signal to form a complete cycle of sine-wave, with a period of typically 100µs. If the v.c.o. drifts low with respect to the reference oscillator the width of the late pulse increases by a small amount, and vice-versa if the v.c.o. drifts high. Thus the balance between the areas contained in the late and early pulses gives an extremely sensitive fine-tuning control of the v.c.o. Moreover, this control is instantaneous in its action since it is an "on-line" control.

This complete cycle of sine-wave is an extremely important point and is the basis of the reduced f.m. system. When the two frequencies are locked, the two areas of the halves of the sine-wave are equal except for a small amount to balance the v.c.o. drift. As can be seen from Fig. 7(a), the cycle is very narrow, typically 100µs or less, corresponding to a frequency of 10kHz. This means that the only f.m. produced by this phase-lock technique is at a frequency of 10kHz or more, and not at the comparison frequency of 200Hz, because there are no up or down pulses when locked. This absence of up or down pulses when near phase lock is used to inhibit the phase-lock section during "search" to prevent locking onto harmonics.

Performance of a synthesized signal generator

When this system of synthesis is applied to a signal generator it is possible to produce accuracy and stability figures comparable with those produced by a full synthesizer. However, the noise performance of the system cannot be better than that of the unstabilized oscillator for the spectrum outside the bandwidth of the phase-locked loop.

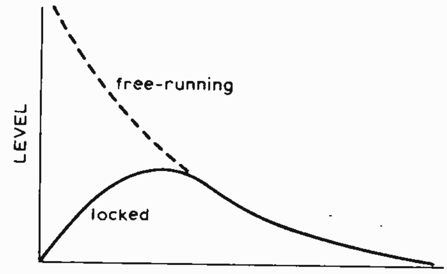


Fig. 10. Typical sideband noise spectrum of a synthesized signal generator.

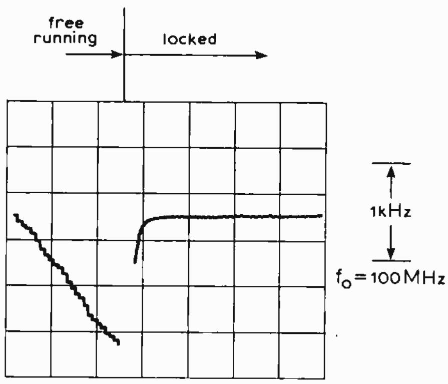


Fig. 11. Typical X-Y plot of frequency stability.

The lower components of noise are very much attenuated compared with those of the unstabilized oscillator, while the outer components are hardly affected —Fig. 10. Another factor which will compare unfavourably with the full synthesizer is resolution, which in the case of this synthesized generator is only 1kHz. This figure is arrived at by a compromise concerning cost, complexity and speed of operation, speed being another factor that compares unfavourably with the more expensive system.

To consider some of the advantages, one has first to consider what is required of the synthesized signal generator. The disadvantages of a standard signal generator are drift and inaccuracy of frequency setting. To overcome these factors several manufacturers have produced add-on synchronizers which solve the problem of inaccuracy and drift but are very inconvenient to use, requiring the frequency to be set manually to a high degree of accuracy before locking can take place. Also if this is done only a short time after the unit is switched on, it is likely to lose lock again.

This add-on synthesizer, however, has none of these disadvantages, being capable of finding and locking on to any frequency dialled up on the thumbwheel switches, even if this means changing range. No external frequency counter is required and no digital display for confirmation of frequency as it is not possible for the system to settle on the wrong frequency and also indicate that it has locked.

This ability to move to a frequency that has been set-up digitally means also that external digital programming is possible, including a digital sweep.

The frequency stability of a system using an "unovened" crystal in and out of lock is shown in Fig. 11.

The time taken in practice for the frequency to be altered from 10MHz to 100MHz (four range changes required) is around 5 seconds. The time taken to move 1kHz is in the order of milliseconds.

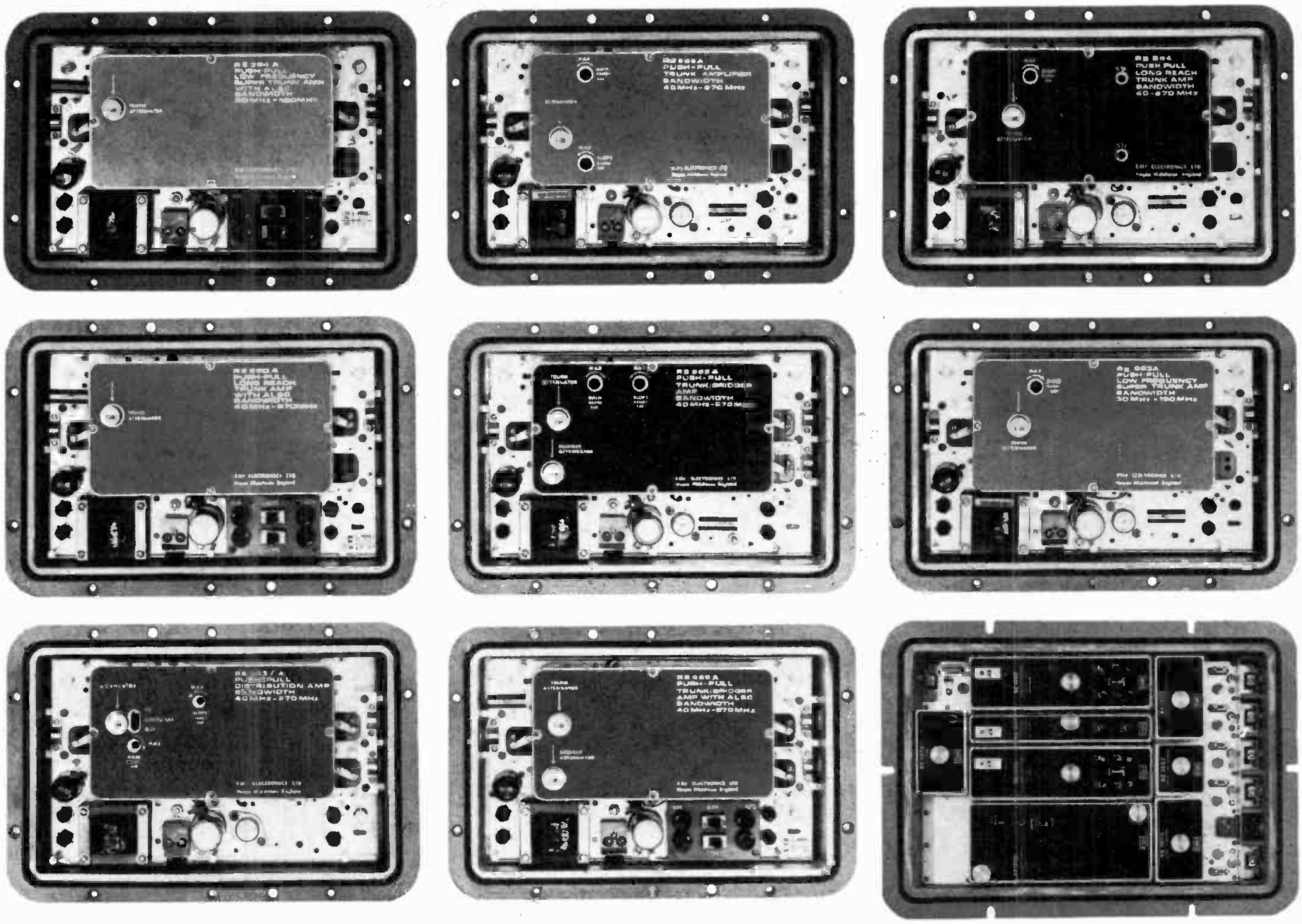
Resolution is considered to be of no problem in general as there is little real requirement for the frequency to be set any more accurately than 1kHz, this being about the practical limit with standard signal generators.

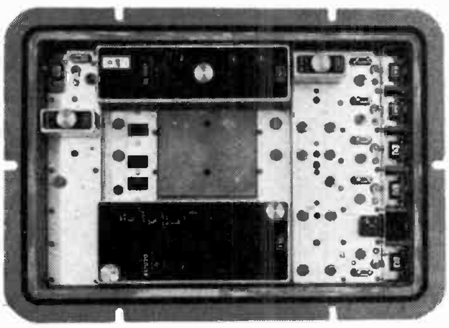
New m.o.s. centre

At a cost of DM 20 million, a plant for the production of m.o.s. components has been set up in Munich. The new facilities comprise six diffusion ovens for doping the semiconductor crystals with impurities and three ion implantation systems for i.cs with particularly low operating voltages. The new plant has been set up by Siemens.

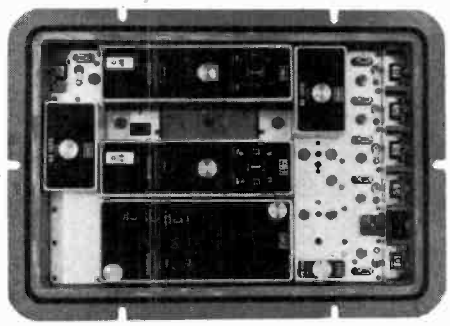
Integrated metal oxide semiconductor circuits require fewer fabrication steps than bipolar circuits, have smaller structures and consume less power. It is therefore possible to accommodate a particularly large number of transistors on a limited area. Engineers were discussing possible methods of manufacturing such circuits as early as 1961; five years later the first samples were on the market. Over the next few years m.o.s. sales are expected to increase at a rate of 30%, a figure well above the average for the components sector.

The new production centre takes the place of a number of widely scattered production locations. Its overall isolation from the environment allows a previously unattainable, but now obligatory freedom from dust during the production processes. The dust content of the rooms does not exceed 150 particles/cubic metre. Water with a purity of 10^{-9} ions/litre is available for the photographic masking processes that precede each individual diffusion step. The high degree of purity of the air in the centre with its area of over 1000 square metres is achieved despite the fact that 80 persons are directly involved in the manufacturing processes.





EMI offers a wider choice of options in cable TV.

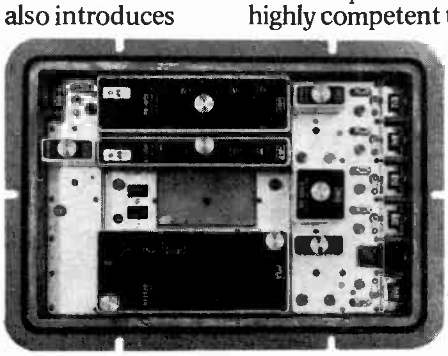


The quality of EMI Colorline cable television equipment is proved daily in systems bringing high quality television to hundreds of thousands of people—particularly in Europe.

Now EMI introduces a new range of modular VHF network amplifiers offering full two-way facilities.

The new range—the Colorline RE1000 series—has a basic forward bandwidth of 40-300 MHz with optional reverse band-widths of 5-30 MHz or 5-100 MHz. At the same time EMI also introduces a unique multi-channel VHF/UHF Distribution Converter. It enables up to seven channels to be converted from a VHF trunk network into the UHF bands for local distribution.

This new equipment, complemented by our Colorline RE900 series of VHF push-pull equipment and by the ME 690 modular series of VHF/UHF MATV equipment provides the systems designer with an even greater variety of options to meet virtually every requirement of VHF and UHF cable distribution.



As pioneers in the development of high definition television, EMI has accumulated nearly forty years experience in every aspect of television broadcasting—embracing hardware, software and practical operating 'know-how.' This unique breadth of experience makes us highly competent to help you. Contact us at the planning stage.

That's what we're in business for.

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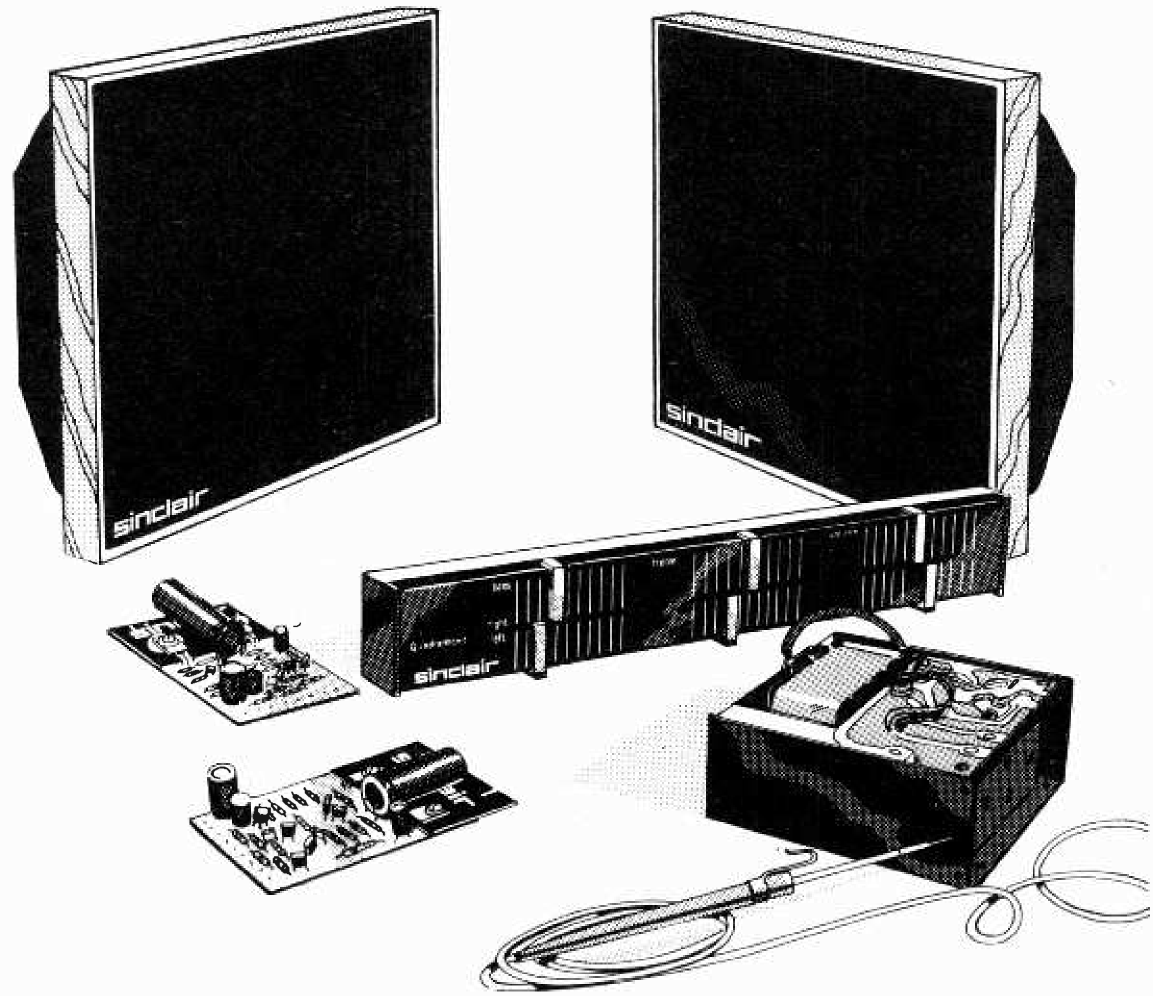
WW—181 FOR FURTHER DETAILS

Go quad for around £50

(including the speakers!)



Sinclair Project 80 hi-fi modules

If you've thought of switching to quad, you've probably found it an expensive process. Do you part with your existing stereo amp – which probably cost you a lot in the first place – and replace it with an even more costly quad amp? Or do you buy an expensive add-on kit – often costing as much as £90 even *without* the extra speakers?

With Sinclair Project 80 hi-fi modules, you can keep your existing amplifier ... add a quad decoder, two power amps and a power supply unit ... a couple of Sinclair Q16 speakers and you've got a high-quality, true quad system which will have cost you only £50 or so to convert!

How does Sinclair Project 80 work?

Project 80 is a comprehensive set of hi-fi modules or sub-assemblies. Amps ... pre-amps ... FM tuner ... quad decoder ... control units ... everything you need to assemble hi-fi units. They're all designed to look alike and are all completely compatible with each other. Simply decide on the specification of the unit (stereo or quad) you want to build ... buy the necessary modules ... connect them up and house them.

You can even build a quad amp entirely from Project 80 modules. Two power amplifiers, a control unit and a power supply give you a stereo amp for as little as £31.80 plus VAT. The necessary add-on quad modules cost only £36.80 + VAT. Together, they make up a true hi-fi quad amp for only £68.60 + VAT!

And whenever you choose, you can add extra Project 80 refinements. An FM tuner ... a scratch/rumble filter ... higher-output power amps – Project 80 is an enjoyable way to develop your own hi-fi system!

Is it difficult to build?

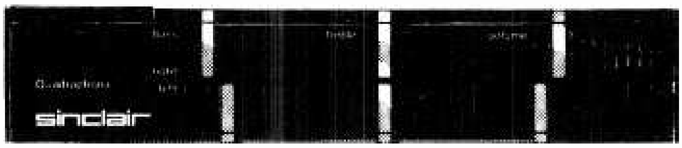
Not at all. All Project 80 module circuitry is complete in itself – all you have to do is connect the external wiring to numbered solder points.

And if you're not so hot with a soldering iron? Use Project 805 kits. Project 805 uses Project 80 modules, but provides special clip-on tagged-wire connections – positively no soldering! There are two Project 805 kits – the basic 805 stereo amplifier kit, and the 805Q quad conversion kit.

805Q can be used to convert a Project 80 or 805 stereo system, or your existing stereo system.

You'll find more details and some system suggestions opposite.

Project 80 hi-fi modules – the easy way to true quadraphonics.



Project 80 SQ quadraphonic decoder

Combines with and exactly matches Project 80 control unit for true quadraphonics. This unit is based on the CBS SQ system and is a complete quadraphonic decoder, rear channel pre-amp and control unit.

Specification
(9½ in x 2 in x ¾ in.) Connects with tape socket on Project 80 control unit or similar facility on any stereo amplifier. Separate slider controls on each channel for treble, bass and volume. **Frequency response**: 15 Hz to 25 kHz±3 dB. **Distortion**: 0.1%. **S/N ratio**: 58 dB. **Rated output**: 100 mV. **Phase shift network**: 90±10, 100 Hz to 10 kHz. **Operating voltage**: 22 V–35 V.

Price: £18.95 + VAT

Project 80 power amplifiers

Two different amplifiers, designed to be used separately or combined, with Project 80 modules or as add-ons to existing equipment. Protected against short circuits and damage from mis-use.

Z40 Specification
(2¼ in x 3 in x ¾ in.) 8 transistors. **Input sensitivity**: 100 mV. **Output**: 12 W RMS continuous into 8 Ω (35 V). **Frequency response**: 30 Hz – 100 kHz ± 3 dB. **S/N ratio**: 64 dB. **Distortion**: 0.1% at 10 W into 8 Ω at 1 kHz. **Voltage requirements**: 12 V – 35 V. **Load imp**: 4 Ω – 15 Ω; safe on open circuit. Protected against short circuit.

Price: £5.95 + VAT

Z60 Specification
(2¼ in x 3¾ in x ¾ in.) 12 transistors. **Input sensitivity**: 100 mV – 250 mV. **Output**: 25 W RMS continuous into 8 Ω (50 V). **Frequency response**: 10 Hz to more than 200 kHz ± 3 dB. **S/N ratio**: better than 70 dB. **Distortion**: less than 0.1% at 12 W into 4 Ω at 1 kHz. **Voltage requirements**: 12 V – 50 V. **Load imp**: 4 Ω min; max safe on open circuit. Protected against short circuit.

Price: £7.45 + VAT

Project 80 power supply units

Range of power supply units to match desired specification of final system.

PZ5 Specification
Unstabilised. 30 V output. Including mains transformer.

Price: £5.95 + VAT

PZ6 Specification
Stabilised. 35 V output. Including mains transformer.

Price: £8.95 + VAT

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Stabilised. Output adjustable from 20 V to 60 V approx. Re-entrant current limiting makes damage from overload or even shorting virtually impossible. Without mains transformer.

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Project 80SQ quadraphonic add-on kit

Converts your existing stereo hi-fi system to quad using solderless connections

Contains following Project 80 units:

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PZ5 power supply unit
Masterlink unit
On/off switch
plus pre-cut wiring loom with clip-on tagged wire connections, nuts and bolts, instruction manual.

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Original and uniquely designed speaker of outstanding quality.

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(10⅜ in square x 4¾ in deep.) Pedestal base. All-over black front. Teak surround. Balanced sealed sound chamber. Special driver assembly. **Frequency response**: 60 Hz to 16 kHz. **Power handling**: up to 14 W RMS. **Impedance**: 8 Ω.

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Quad system suggestions from Sinclair

1. Add-on quad to existing system:
12 W per rear channel RMS
Quadraphonic decoder + 2 x Z40 amps + 1 x PZ6 power supply + (existing stereo amplifier) + 2 x Q16 speakers + (2 existing speakers) + (turntable). Total Project 80 cost: £57.70 + VAT.

2. Add-on quad to existing system:
25 W per rear channel RMS
Quadraphonic decoder + 2 x Z60 amps + 1 x PZ8 power supply + (mains transformer) + (existing stereo amplifier) + (2 x equivalent speakers) + (2 x existing speakers) + (turntable). Total Project 80 cost: £42.30 + VAT.

3. Quadraphonic system built from scratch:
12 W per channel RMS
Pre-amp/control unit + quadraphonic decoder + 4 x Z40 amps + 2 x PZ6 power supply + 4 x Q16 speakers + (turntable). Total Project 80 cost: £110.40 + VAT.

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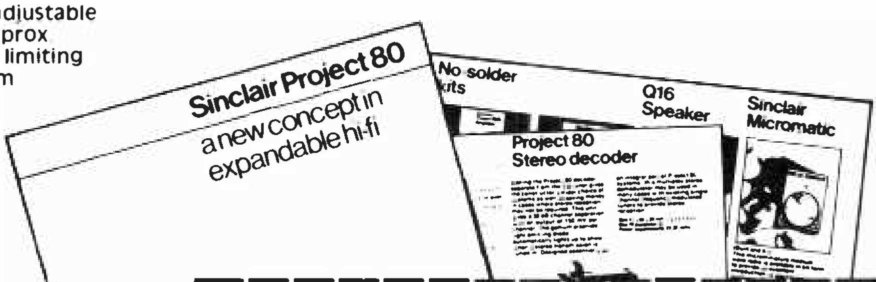

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WW/5/75

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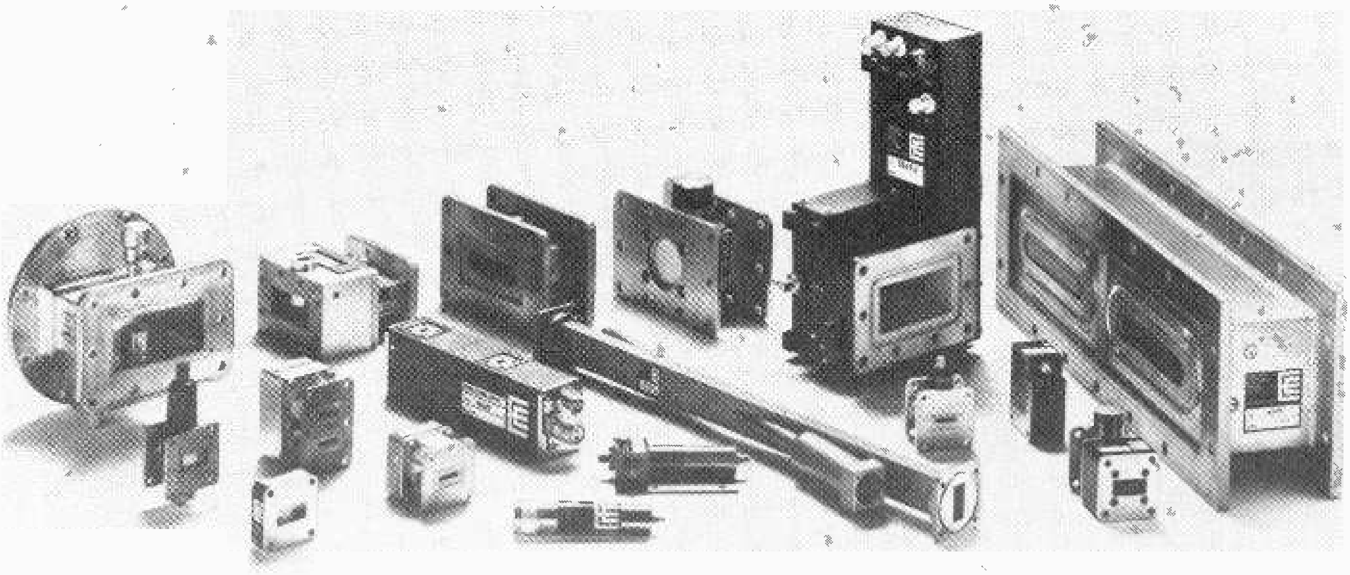

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WW—239 FOR FURTHER DETAILS

Letters to the Editor

INTERFERENCE FROM POCKET CALCULATORS

Widespread use of the pocket calculator is creating interest in the levels of its radiated interference especially in certain electromagnetically critical environments such as aircraft. Instances have been recorded of interference with radio navigation equipment as a result of the operation of pocket calculators within several metres of aircraft radio direction-finding equipment. I hasten to add that for commercial aircraft, however, tests have indicated that passenger use of pocket calculators has not affected flight deck instrumentation.

As a related example I observed severe interference in the measurements obtained from an electro-encephalograph (e.e.g.) as the result of the operation of a hand-held calculator in the vicinity of the e.e.g. pick-up unit. Needless to say, the results of measurements performed under such circumstances would be useless.

It must be pointed out that the signal levels emanating from pocket calculators are not their "exclusive property". Any operating digital processing system suffers from the same malady, and at most computer installations great pains are taken to provide adequate shielding of electro-magnetically sensitive components (magnetic tapes, memory unit, etc.).

As a final item of possible interest I would like to quote from an issue of *Approach*, the naval aviation safety review of the US Navy, December 1974:

"A Word To The Wise

Recent tests by the Canadian Department of Communications have established that hand-held electronic calculators cause a degree of interference in ADF signals when the calculator is operated in close proximity to the ADF antennas. It is not necessary that operations be performed on the calculator, only that the calculator be turned on. Pilots should be aware of this and use ADF indications cautiously when hand-held calculators are being used in the cockpit."

Charles Thomas Ristorcelli,
US Navy Postgraduate School,
Monterey,
California, USA.

Later this year we shall be publishing an article by Lt Ristorcelli on radio interference from pocket calculators.—Editor.

CAPACITORS AS TRANSMISSION LINES

I found Mr R. A. Fair's article on capacitors in the December 1974 issue of your magazine interesting and useful. However, this article, as well as many others I had read, omits an equivalent circuit of greatest importance to designers of v.h.f. and u.h.f. circuits.

Tubular and flat ceramic capacitors, especially with high-K dielectric, often exhibit a behaviour of open-ended, lossy transmission line stubs, with periodic impedance peaks and valleys of decaying amplitude *v.* frequency.

This transmission line effect can be easily demonstrated by using a grid-dip meter in the oscillating mode. For example, if a 5nF bare disc capacitor is inserted in the cut inductance for the 100 to 250MHz band (thus completing the interrupted loop of the inductor), one will observe at least two oscillator drop-out frequencies when tuning through the band, with strong fluctuations of the meter reading between these points. The frequencies of high impedance where oscillator activity ceases depend on many factors: physical dimensions of the capacitor (length of stub) including the location of coil connections to the capacitor's plates, dielectric constant of the ceramic material (propagation constant), etc.

I have seen occasional references in technical periodicals to some "mysterious" and erratic behaviour of bypass capacitors at very high frequencies. I am certain that there is no mystery if one considers such capacitor as a transmission line, and the erratic behaviour of some capacitors of same value can be explained by differences in physical dimensions, in the value of K, location of lead connection to the plates, and losses of the dielectric material, even if capacitance is the same.

Alex Azelickis,
Morton Grove,
Illinois, USA.

SINGLE LAMP F.M. TUNING INDICATORS

Having let several letters on the above subject go unchallenged, I now feel that it is time to speak.

The challengers have in general all fallen into the same trap, which stems from the fact that they have all been intelligent, technical people! The emphasis here is on the "technical", in the electronic meaning, which is not a virtue when trying to understand the requirements of the non-technical, who, almost by definition, do not read *Wireless World.*

I was recently visiting a friend who had just purchased a new tuner-amplifier. The friend in question is not unintelligent, being well up the ladder in civil engineering, but qualifies as non-technical in the electronic meaning. During conversation I was asked to explain the legend "contour" against one of the push-buttons of his amplifier. I leave to your readers' imagination the trouble I had.

My friend can cope with his two-lamp system, after it has been explained to him. A person with less intelligence (unfortunately the vast majority) will have trouble even when it has been explained. For instance, both lamps are lit when there is no station tuned at all! Confusion right away.

I agree that the two-lamp system displays more information, if we know how to read it, but is it really useful? It is human nature, I submit, to converge onto the correct point with a less than critically damped oscillation. Once tuned, the a.f.c., which can make use of the extra information, should eliminate the need to readjust, or it is not worth having. Let the inter-station mute circuit mute the indicator lamp also, as in our design (June 1974 issue, p.173), and the lamp becomes a "station" indicator rather than a "tuning" indicator proper.

It is hard for people who have been brought up with a soldering-iron in their hand to understand that others have not been blessed likewise, and it is a pity that so much of what is made for the general public has to be designed by these informed ones. Perhaps all design labs should have a "standard idiot" on the payroll to test our efforts. I think we would all get a shock.

J. A. Skingley,
Icon Design,
Purton,
Wilts.

EASIER TO BECOME A RADIO AMATEUR?

Cyril Parsons, 1975 President of the RSGB, will get a great deal of advice on how to run things in Doughty Street but I hope he doesn't take too much notice of the hints dished up by Pat Hawker in your January issue.

There are very good reasons why we should have expansion of amateur radio by making it easier to become an operator. If we don't fill up some of those wide open spaces on the 21 and 28 MHz bands with "operators" the consequences could well be worse than a possible devaluation of the amateur licence. A listen around 21 and 28 on Sundays at local midday will show just how active the real c.w. operators are: the hush is deafening, but not because of "conditions".

Pat Hawker is concerned about mode and band rivalries. Surely they are the same thing and stem from the one cause, that is, the technically competent operator limited to short distance communications due to a lack of a c.w. capability who would give his ears to work s.s.b. dx.

There is a simple and perfectly logical answer to the problem, and that is to remove the requirement for a Morse test from the amateur radio exam conditions. By all means let those of us who would rather use c.w., and I am one of these, do so. The exam is an anachronism; a bad operator need not be listened to or communicated with.

Having freed our amateur operator from the rigours of the Morse code let us now take the next bold step and emulate the American FCC by getting rid of the requirement to keep a log of communications. Basically there is no logical reason why an amateur operator should keep a log; who he contacts and at what times are of absolutely no interest to anyone but himself. The only constraint placed on amateur operating is on message content and this is not logged anyway, so away with the log book; contest operators and certificate claimants will have to make their own arrangements.

Maybe the reason Japan outsells Britain in electronic products by almost ten to one is because the amateur radio operators in the respective countries are in the same proportion.

J. F. Dunglinson, G4CGW, ex 5Z4JX,
Blantyre,
Malawi.

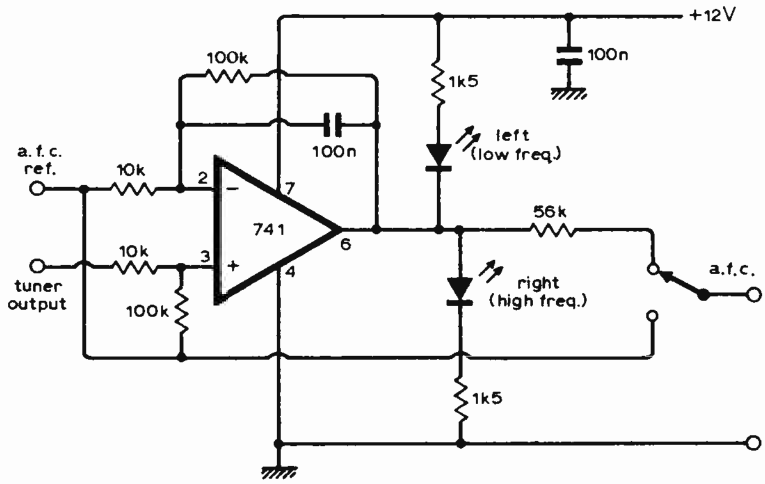
F.M. TUNING INDICATOR

In Circuit Ideas in the July 1974 issue, J. S. Wilson contributed a d.c. op-amp circuit for general a.f.c. applications in f.m. tuners. I have built a Nelson-Jones tuner and found that the author's "winking l.e.d." tuning indicator extinguished asymmetrically under off-tune conditions.

I have used the contributor's op-amp circuit to provide extra gain in the a.f.c. feedback loop and I have added two l.e.ds, driven by the output (which is limited to 25mA on short circuit), as a tuning indicator, as shown in the diagram.

The gain of 100 (1MΩ feedback) was too strong for use during tuning but lowering the gain too far reduced the sensitivity of the indicator. The compromise adopted is a gain of 10 (100kΩ feedback) but a higher gain could be employed for l.e.d. sensitivity with a larger series resistor to buffer the local oscillator, although its effect on the audio filter (1MΩ decoupled by 100nF) should be taken into account.

R. D. Post,
London, W10.



DOPPLER EFFECT

I note the comments made by Mr J. Moir (October 1974) and "Cathode Ray" (December 1974) concerning Doppler effect and respect their views, but I still require convincing that this effect is responsible for the distortion measured, despite the correlation of actual and predicted results. There is no question concerning the existence of phase modulation in loudspeakers, due to the imperfect piston action of the cone.

Although it would seem to be a "red herring" the controversy concerning the simultaneous existence of carrier and sidebands in an electromagnetic propagating medium is elegantly resolved by considering the practical working and results obtained from such devices as the threshold extension demodulator, where we suppress our tendency to think of the signal transformed by the use of Bessel's functions and consider the physical actuality of instantaneous frequency. However, we are handicapped by the elusive nature of the propagating medium and final judgement on this issue must wait for future developments.

There is no such handicap when considering sound propagation in air. The physical properties of the medium are well known. The nature of sound propagation is accepted as the devolution in wave fashion of the adiabatic expansion and contraction of adjacent volumes of air in a periodic manner. The periodic motion is only sinusoidal when the medium is propagating a single frequency. "Cathode Ray" is therefore incorrect when he writes concerning one "small amplitude high frequency wave being carried by that *sinusoidally* moving air" (my italics). We may resolve the wave into its sinusoidal components, but, as I tried to explain in my letter published in the August 1974 issue, the conception of the propagating medium, whether it is a loudspeaker cone or air vibrating at two sinusoidal frequencies simultaneously, requires parts of the medium to be in two places at the same time. The physics of the medium preclude this conception which, I stress, is a mathematical transform of the reality.

Finally, can Mr Moir explain how he eliminates the supposedly present Doppler effect from his measuring device? If it exists in loudspeakers then it must be present in microphones and all similar transducers. The problems in deciding whether it is additive or cancelling should take some fairly strenuous analysis to resolve! Of course, the ear, as the final arbiter of good sound, would prove an even more difficult topic for consideration.

David H. Edgar,
Suva,
Fiji.

LIQUID-COOLED POWER AMPLIFIER

I have studied with great interest Messrs Stefani and Perryman's liquid-cooled power amplifier design (December 1974 issue) and have come up with a few questions.

Have they experienced problems with the power output short-circuiting through the water coolant? (I would assume the "Prestone" inhibitor is to increase corrosion resistance, not decrease conductivity.)

Why have they used MJ4030 and MJ4033 transistors, which can dissipate up to 150 watts each at 25°C? When using water cooling they could probably have used lower power and therefore probably cheaper Darlington pairs (e.g. MJ900 and MJ1000s which, incidentally, have an h_{FE} of about 6000 at I_C=3A d.c. as opposed to 3500 at 10A d.c.).

What is the input sensitivity to the preamplifier for the rated output?

Apart from possibly changing one or two transistors (such as the BSY95A) for higher voltage equivalents (for example BSY54), would any other components need to be changed to run at (say) 50 volts supply?

Paul Lenartowicz,
Hounslow,
Middlesex.

Dr Perryman and Mr Stefani reply:

No problems have been experienced with leakage currents through the water. The resistance of the water will be of the order of 1kΩ and this provides only a slight additional load. However, if any water escapes near the input pins of the transistors the whole stage becomes inoperative and damage may result. Mr Lenartowicz is correct in assuming the purpose of the "Prestone" is to act as an inhibitor of corrosion and organic growth.

The MJ4030 and MJ4033 transistors were selected for their very high peak collector currents, because the amplifier was required to supply large current pulses to saturated iron specimens. If lower currents are needed there may well be more suitable types of output transistor.

The input to the preamplifier for full output of 230W is approximately 150mV.

Finally, if the voltage is to be raised substantially it will be necessary to use transistors of higher rating and also to raise the load resistors of the driving stages (marked R_1 in Fig. 5). For a 50V supply it is suggested that 10kΩ resistors should replace the 5.6kΩ ones used in the original circuit. It will also be necessary to increase the signal handling capacity of the preamplifier, and if this is done by raising the voltage to 50 then the 4.7kΩ load resistors at the output of the preamplifier should be increased to 10kΩ.

SOLID STATE DIGITAL CLOCK

Several readers have asked whether it is possible to use a larger display in my digital clock (Feb. and Mar. 1975). I used a Texas TIL360 in the original design to reduce to a minimum the printed board area taken up by the display. A larger display can easily be used if required. The procedure is as follows:

1. In place of the TIL360 on the p.c. board mount a 16 pin dual-in-line i.c. socket.
2. Mount the selected displays on a small piece of Veroboard or p.c. board fitted with 16 wire pins and plug it into the i.c. socket on the main p.c. board.
3. The displays used must be common cathode GaAsP displays. Suitable types are Litronix Data-Lit 4 or Data-Lit 44, or Monsanto Man-4.

These displays give a useful increase in display size without any circuit changes. The peak segment current is about 15mA; this represents a peak digit current of 120mA. The segment current may be increased by reducing the value of R_{24} to R_{30} and R_{16} from 680 ohms. I would not advise an increase in segment current above about 20mA ($R_{24} - R_{30}$ and $R_{16} >$ 470 ohms).

Some of the large seven-segment displays require quite large peak currents, particularly the green GaP displays; also, due to saturation effects in gallium phosphide these displays are often unsuitable for high-brightness multiplexed displays of more than four digits.

David D. Clegg,
London SW10.

SDS Components Ltd have told us that they do not handle the MOSTEK clock chip used in the digital clock.

Having read Mr Clegg's articles in the February and March issues with interest I would like to offer some constructive criticism based on my own experiences.

Basically, I cannot accept his argument for the rejection of mains as the frequency standard. If, as the article suggests, one assumes that the clock will be used mainly for recording off-air programmes then it will most likely be built into or near to any existing radio and recording equipment and thus portability will be of little consequence.

The frequency stability of the mains is sufficiently accurate for the recording of off-air programmes since the BBC uses electro-mechanical time-switches to switch on Open University programmes and the accuracy of these is only a couple of minutes.

If the mains fails you are unlikely to be able to make a recording either!

The use of a crystal controlled frequency standard may be technically more aesthetically pleasing but I feel that in this instance it is unnecessary.

Having accepted the premise that the clock will be closely associated with any existing recording hardware, a better clock chip to use is the Emihus EDC 6051. This is cheaper and as a bonus has full stopwatch facilities which are invaluable when timing programmes or elapsed recording time, etc. Another possibility with this chip would be to combine it with the Emihus ETT 6016 touch tuner and so provide "touch control" of the logic functions.

R. M. Sinden,
East Sheen,
London, SW14.

Mr Clegg replies:

I can only agree with Mr Sinden's statement that the mains frequency stability is sufficient for the recording of the Open University Programmes in the early morning, since, as he points out, the BBC uses electro-mechanical time switches. The use of the mains as a frequency standard is also ideal for a four digit domestic clock displaying only hours and minutes; it is not suitable, however, for a six digit clock which also displays seconds, there being little point in a seconds display which is incorrect by more than a few seconds!

The problem of off-air recording *in absentia* provided the initial incentive to design this clock and I felt that a small, self-contained clock would have many additional uses.

I designed this clock between July and September 1973; were I to start the design today I would probably use the same chip.

ELECTRODYNAMICALLY INDUCED E.M.F.

Only the tip of an electromagnetic iceberg is indicated by C. P. J. Meade's letter in your February issue. Argument as to the true source of electrodynamically induced e.m.f. has continued since Faraday's time. A relativistic hypothesis which seems to have attracted little notice until recent times advances the idea of relative motion between a conductor system and an observer as being a fundamental requirement for such induction[1]. This would appear to be substantiated by simple experiment[2], albeit for non-uniformity of magnetic field and motoring behaviour.

Further disputation on this subject may appear futile to your readers; but there is strong personal opinion that each bout of controversy advances our knowledge a little further; and with an intuition akin to that displayed by "Cathode Ray's" reply to Mr Meade, I feel that the hidden portion of our iceberg contains profound secrets relating to the true nature of electricity, magnetism and gravity.

John Gray,
College of Technology,
Belfast.

References

1. "Unipiece Electrodynamic Rotating Machines". J. Gray, *Marine Engineers Journal*, September 1968, pp.4–6.
2. Various letters throughout 1970 in *I. E. E. News*, J. Gray, with particular reference to issues dated February 23, 1970 (p.4) and October 12, 1970 (p.4).

TRANSISTOR CIRCUIT DIAGRAMS

We have had the transistor since 1948 but have not yet reached a satisfactory standard method of drawing transistor circuits. The matter is brought to mind by the article "The monostable . . ." in the January issue.

The authors' Fig. 9 contains a complementary pair of transistors and a negative supply line at the top of the diagrams. What then is the meaning of the sketch which indicates the triggering pulse? Does it mean that the base potential of Tr_1 is to be driven in the direction of the emitter, as indicated by a glance at the diagram? Or does it mean that this is the appearance of the waveform as viewed on the screen of an oscilloscope as normally operated? Had I not known the answer before examining this diagram I would not know it now.

In a circuit where all transistors are of the p-n-p type there does exist an argument (in my opinion a very poor one) for having the negative line at the top of the diagram, but what is the argument for so doing when the circuit contains an equal number of p-n-p and n-p-n transistors, and even, as I have seen in some examination questions, only n-p-n transistors?

It is a pity that Mr Amos did not mention this subject in his November 1974 article on diagrams. (Incidentally, I do not like the technique employed elsewhere by Mr Amos of mixing the two conventions in one diagram.)

Bearing in mind the facts that the "positive-upwards" convention has been standardized for so long, and that we must all work with conventionally connected oscilloscopes, should we not retain the positive-up convention as our standard?

Roy C. Whitehead,
Cape Town,
South Africa.

75 years of magnetic recording

3—From steel to plastic

by Basil Lane, Assistant Editor, Wireless World

From 1939 the Magnetophone entirely supplanted other methods of master recording in German broadcast studios. It was this unique state of affairs, discovered by the Allied forces after World War II, that was to revolutionize design in Europe and America from 1945 and sound the death knell for steel tape and wire.

The national political situation in Germany was explosive and international relations were deteriorating fast, the dark years of World War II were drawing in on the Western World. For those outside Germany it was as if the Magnetophone had never been; very few reports on the machine had been written and fewer engineers had heard it. The war was to reduce information on the Magnetophone to nothing and it was not until 1945 that the world (that is the recording world) was to be rocked by the progress made during the war.

In America, progress was slow, probably due to the early embargo on published information about the Telegraphone set by Rood, the President of the American Telegraphone Company some years earlier. Bell Laboratories developed experimental steel tape machines,[38] and in 1939 made the first ever stereo recording on a magnetic recorder. In this instance the machine used steel tape on two reels locked in synchronism on the same machine. In 1937 the Brush Development Company produced its Soundmirror, a steel tape-loop machine designed for laboratory investigation of transient phenomena. By 1939 they had also introduced a black oxide paper tape, presumably for the Soundmirror.

In 1941 Brush, General Electric and the Armour Research Institute went into production with wire recorders for the armed services.[13] A young man with a brilliant career ahead, Marvin Camras, developed the long-forgotten a.c. bias method and Armour Research applied for a patent on it. In 1942 Camras designed the Model 50 wire recorder, bought for use by the BBC[39] and used extensively in airborne service, followed by the Webcor wire recorder used by the US Navy.

Just before the end of World War II, Brush asked Minnesota Mining (3M) to develop better tapes and under Dr Ralph Oace, work commenced in 1944.

The revelation—1945

With the war over and the Allied Forces occupying Germany it became possible to see just how much tape recording had progressed. There are many quite amazing and fascinating accounts of those who studied the German recording techniques, some quite official, forming part of Government committees such as the British Intelligence Objectives Sub-Committee (BIOS) and FIAT the American equivalent, others being quick private investigations by those who had a fascination for these things. Many post-war companies specializing in the production of tape recorders or tape were started by these men, including the Mincom division of 3M, initially Crosby Enterprises, and Rangertone run by Col. Ranger, one of the American Army engineers in Germany at the end of the war.

The first surprise for those who investigated broadcasting in Germany was the extent to which magnetic recording had been adopted. All broadcast stations had Magnetophones and in addition they were in use in the signals sections of the German Army, the Intelligence and in some cases in use in the telephone system. Almost none of the radio station output was live, since tape was used as a method of censoring the programmes. This idea was developed way back in 1939 as an expediency for political broadcasts, all of which were carefully vetted.

The really surprising feature of those machines at the radio stations was the quality of the output. This had been due to the development by Dr Braunmühl and his colleague Weber of the a.c. bias system, first applied experimentally to the K4 Magnetophone. In fact the variety of machines had proliferated and just to give an idea of what had become available the following is a list of those for which the author has documentary record. The K4, also designated R.24 by the RRG was made with d.c. bias but converted in some instances to a.c. bias by RRG and called the R22. It was originally introduced in late 1938. There was a dictating machine, the FT-3 few details of which are available. The Tonschreiber b: portable field unit used by the Wehrmacht for signals, fitted with a rotating pitch restoring lead. Tonschreiber c: spring-driven lightweight signals recorder. Tonschreiber d: conversion of the Tonschreiber b for use by war correspondents. Tonschreiber f: dictating machine used as a successor to the FT-3. The A1000—L40 naval communications recorder also known as the RE-3. The R-26: spring driven portable for war correspondents. The model HTS: a high quality studio recorder with a.c. bias, also designated the R122a by RRG.[40] The K7: studio machine developed in 1945, produced in immediate post-war period.

A stereo Magnetophone had been developed by RRG starting about 1942 using the R22 version of the K4. Approximately four machines were made with stacked stereo record and replay heads.[41]

The Magnetophone

One of the most remarkable features of the Magnetophone machine produced by AEG was how little it differed, in mechanical detail, from those studio and high-quality domestic machines we see today.

Fig. 1 is an early K4 Magnetophone showing how the tape is spooled on open platters with a large hub of similar dimensions to the now commonly known NAB reel. In this, and all other machines up to about 1948, the tape is reeled with the oxide out, thus siting the head block, which is interchangeable, on the near side of the machine facing to the back.

On the left of the head block, which contains erase, record and playback heads, is a heavy guide roller designed to reduce longitudinal flutter in the tape to a minimum. To the right of the heads under the cover is the drive capstan and pinch-wheel assembly from which the tape feeds directly to the take-up spool.

The transport arrangements also included a lifting device which allowed the tape to be moved away from the heads during fast rewind. Three, or in some cases four, motors were used to transport the tape, two being used as reel motors. These motors had an inverse torque versus speed characteristic and were originally commutator-type, series wound. Later versions used a.c. motors without commutators.

Constant-speed tape drive was achieved with a two-phase capacitor-type of synchronous motor. Solenoid-operated brakes were fitted to each reel motor and an interlock was provided on the record and play button, reducing the chance of accidental erasure of the tape. The K4 mechanism and subsequent machines to the end of World War II, all followed this arrangement but differed in detail from model to model.

After the general adoption of the K4 by the Reichs Rundfunk-Gesellschaft (RRG) in 1939, there was considerable co-operation between them and AEG in the development of further models. In fact in late 1939, Dr Hans Joachim Braummühl and Dr Walter Weber of the Research Department of RRG developed the a.c. bias system for use in the K4 types in broadcast service[21]. The broadcast version of the K4 was designated R22 or R22a and the subsequent modified versions with a.c. bias were redesignated R122 or R122a.

One of the novel features of all of the Magnetophone models was the use of ring-core heads and longitudinal recording instead of the previous arrangements used on steel-tape machines. A parallel development seems to have been made by British Thompson-Houston in December, 1933, since they made an application for a patent[42], granted in 1935, which describes various configurations of ring-core heads, including the notion of cross-field biasing* and the use of compressed iron powder cores for erase heads.†

Several non-broadcast tape recorders were also produced by AEG during the war years, one of the most remarkable being the version known as the Tonschreiber b. This machine was used principally by the Wehrmacht to record high-speed telegraph signals from a radio[43]. A secondary playback head could then be brought into use to "slow down" the replayed signals without loss of pitch. The head was a rotating drum assembly, shown on the left of the main head block in Fig. 2 and marked with the number 11.

It consisted of four reproducing heads equally spaced around the periphery and a commutator which connected each head to the replay amplifier for 90 degrees of the revolution. This complete assembly could be driven by a separate variable-speed motor which would revolve the drum in the same direction as the tape. This effectively reduced the head-to-tape speed and thus the pitch of the tone without reducing the rate at which the total signal could be transcribed.

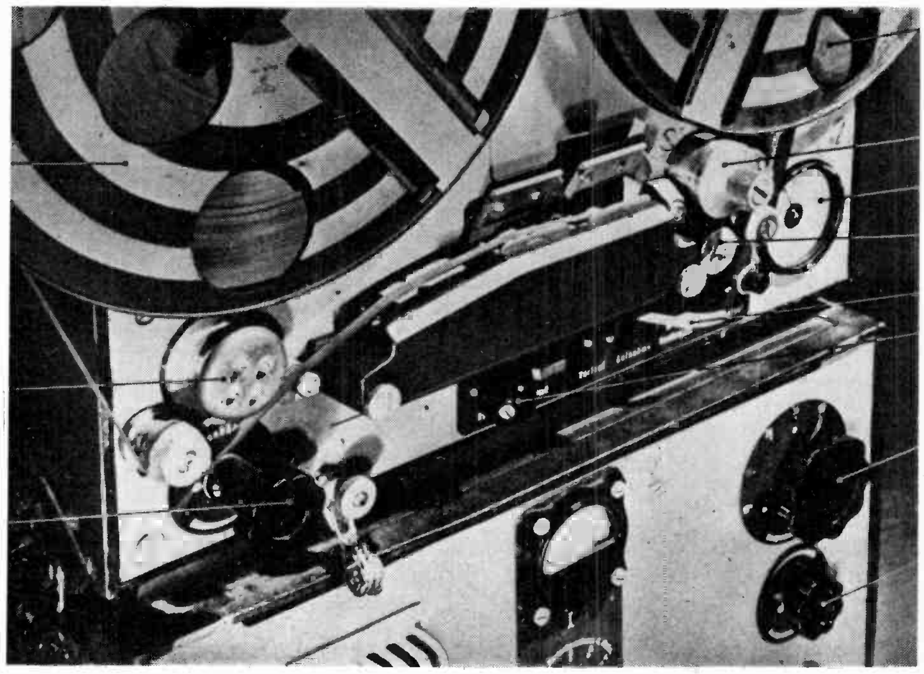


Fig. 1. An early K4 Magnetophone. The amplifier and speaker were contained in two other separate boxes. (Courtesy AEG Telefunken.)

Fig. 2. A close-up of the transport arrangements of a Tonschreiber b. The picture is taken from a BBC Research Department Report and carries their legends. (Courtesy BBC.)

The Tonschreiber b had the facility of being operated at any one of nine tape speeds from 9cm/s up to 120cm/s, this being achieved by altering the frequency of the master oscillator supplying the speed-regulating synchronous control motor. This low-powered motor was directly coupled to a more powerful non-synchronous motor which provided most of the torque required to transport the tape. Using this double-motor arrangement thus reduced the power requirement from the oscillator.

The BBC carried out some voice tests using this recorder, and which the author has heard. The effect on playback is quite peculiar, being somewhat akin to the sound of someone talking down a long length of metal pipe. Obviously not intended for high-quality recording, the Tonschreiber b was, however, a very clever device designed for pure signals use.

Stereophonic recording

Although P. O. Pederson had described a method of multiplexing two audio signals on to a telegraphone wire in 1903 and Bell had succeeded in making binaural trans-

* See concluding part of this series.

† In practice, BTH may have had some sort of co-operative agreement with AEG since a later patent was taken out by BTH on behalf of AEG.

missions[44] by telephone in 1892, there had been few attempts to record a genuine binaural or stereophonic signal by the time of World War II starting.

There had been one classic example of a stereo magnetic recording made at the American World's Fair in 1939 by Bell Laboratories[4], but this used a steel-tape machine with two reels of tape of a new alloy called Vicalloy, clamped in parallel on the same transport and driven by a common shaft. The tape speed for this new type of tape had dropped to 16 inches per second, a cut of more than half the speed of the Blattnerphone machines.

However, as far as magnetic recording is concerned, this is where the matter seems to have rested—except for Germany. The broadcast organization RRG had, in 1942, commenced experiments with some prototype models of stereo tape recorders. These were adapted from the model K4 (R122 type) by RRG Laboratories and fitted with the first known examples of a multiple ring-core head with the tracks in the same vertical alignment[41].

No record pre-emphasis appears to have been applied, the entire equalization being achieved in the replay chain. This was not an entirely satisfactory state of affairs and in the immediate post-war period suggestions made by the BBC to divide equalization between the record and replay amplifiers was adopted.

By the end of the war the Magnetophone had become quite highly developed. The broadcast versions then in use, type HTS, were capable of a very good performance at a tape speed of 77cm/s—relative, that is, to the steel-tape and wire machines in use elsewhere. Frequency response was ±4dB from 60Hz to 10kHz with a signal-to-noise ratio of 35dB, which improved to 50dB when the excessive hum in the replay chain was filtered out. The replay amplifier was not particularly well designed since it had a signal-to-noise ratio of only 55dB[45].

At the end of the war a new type of Magnetophone was being developed, called the K7. Parts for the first 16 production models were found in the French sector of occupied Germany and an arrangement was made for these to be assembled and divided between the French, British and Americans[46]. This machine had several improvements made in the transport, and the bias frequency had been raised to 150–200kHz, but the erase frequency remained at 60kHz.

Before passing on to note the tape developments in Germany in the period 1939–45, mention should perhaps be made of other interesting machines[49]. The first, called the Kassetengerät, was a playback-only machine using a continuous loop cartridge of 9 × 5 × 0.25in. Inside the cartridge was 300 metres of tape, a free loop of which was brought across a rectangular hole cut in the cartridge case. The loop of tape would be slipped over the replay head and capstan and the tape driven at 28cm/s. The high-frequency cut-off point was said to be about 4kHz.

The second idea was a proposal for recording signals on a sheet of magnetic material in the shape of a quarto sheet of paper. No models of this seem to have been made.

Tape manufacture

Mention has been made of the experimental tapes first produced by Fritz Pfleumer and his subsequent co-operation with AEG and IG Farben. By 1936 steel-tape recording had become quite popular in broadcast applications, even to the extent that AEG felt it had to maintain a foothold by patenting a novel thin layer steel foil mounted on a paper backing tape[47] However, the two companies had by then formulated several satisfactory forms of tape[46]. The earliest of these consisted of spherical particles of iron of 10–15 micrometres diameter, glued to a paper or cellulose tape with an organic compound[48]. Shortly after, in 1934, it was realized that an improvement in the structure of the coating could be obtained by using a film-casting technique[49]. Here the magnetic powder was mixed with cellulose or p.v.c. and a solvent, and was then cast on to a continuous travelling metal band having a highly polished surface. When set, this layer would be affixed to a paper of cellulose base and slit into tape form.

Fig. 3. The pitch-restoring head from a Tonschreiber b shown dismantled. (Courtesy BBC.)

Although this was a big improvement there were still problems in obtaining a good high-frequency performance, due to the large size of the magnetic particles used. The search for suitable alternatives led the chemists of IG Farben to the magnetic oxides of iron Fe_3O_4 and gamma Fe_2O_3. Thus, by 1935 the company registered an application describing suitable preparations of these two oxides, for use as magnetic powders on tapes[50]. It would appear that little further development on oxides was to occur from this date until after the war, since it had not yet been realized that there was an advantage to be gained from adopting an acicular (needle-like) form of magnetic particle.

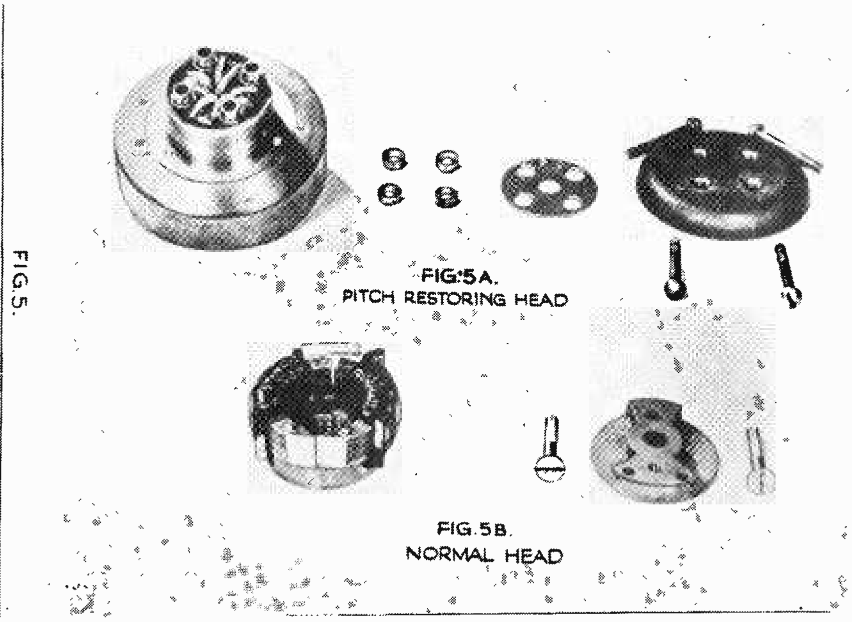
Had this happened the tapes found by the Allies might have been much better as in one patent published, IG Farben had clearly discovered the advantages of using magnets to improve particle packing in the still-liquid casting film, and they would have also therefore discovered the advantages of particle orientation.

Historically, therefore, by the end of the war, three types of tape had been developed by IG Farben. The first of these, based on the old film-casting techniques described above, was type C manufactured at Wolfen using a cellulose acetate base. A later, rather odd type was then developed called type L. This was a homogeneous p.v.c. tape in which the oxide and base material were mixed together, plasticized and then rolled into a single-layer film. The finished product was finally stretched to reduce the possibility of deformation on the tape machine. This tape was not too successful for a variety of reasons and its manufacture appears to have ceased in 1945 or 1946. The original plant, manufacturing type L tape, was at Gendorf which was taken as part of the Russian reparations.

The last development right at the end of the war, was type LG manufactured at Wald-Michebach and Ludwigshaven. This was a coated tape using pre-stretched p.v.c. (Luvithermed) as the base material and a coating of the same sort as type C, which used γ Fe_2O_3 spherical particles as the oxide.

A comment by an investigating official on the quality of these tapes, was that batch uniformity of type C was poor and that, owing to the low elasticity of the base foil, breakage was common[46]. Type L appeared to be quite uniform but suffered from print-through and finally type LG proved a considerable improvement over both types.

During the period 1939 to September 30, 1944, a total of 174,890km of tape had been sold from the Wolfen and Ludwigshaven factories together with 3,332 tape machines. This against a nil return from the rest of the world for this type of tape machine!



EXPLODED VIEWS OF PITCH RESTORING & NORMAL HEADS.
FIG.5.

Reparations and recovery

After the war the Allies developed a policy of breaking some of the very large monopolistic companies into smaller units and this was to happen to IG Farben. The factory at Wolfen, which specialized in type C magnetic tape and photographic film, became the now well-known Agfa company and the main Ludwigshaven plant became part of Badische Anilin & Soda-Fabrik (BASF). As for the Magnetophone, it was regarded as quite a novel idea—so much so that many still believe that AEG and IG Farben had deliberately kept its early development secret as part of the initial war and propaganda effort of politicians in Germany before 1939.

Certainly the Allies were not slow to make use of the Magnetophone, a large number of examples being officially and unofficially "exported" to Britain and America. They were also kept in service in the broadcast stations of occupied territories where some were quick to see the same advantages that Hitler had seen—that the tape recording could be used to pre-record political propaganda for simultaneous repeat broadcasts.

This gave rise to one rather amusing incident illustrating a vagary of Magnetophones. It would seem that one of the Allied war chiefs, probably Eisenhower, had to make a broadcast from Radio Luxembourg shortly after its capture and chose to make a tape recording prior to the occasion which would then be transmitted. This was done, and the transmission was well under way, when to everyone's horror Hitler's voice suddenly broke in on the recording. The tape was an old one which had been inadequately erased! The close of this apocryphal tale is that a prompt order came from a furious Eisenhower that fresh tapes were to be used on all future similar occasions.

From here on, the threads representing the development of magnetic recording become much more intertwined, since the rest of the world still had to be convinced that plastic-based tape was better than wire or steel tape.

There had been no development in magnetic recording to speak of in the UK during the period 1939–45; the BBC were sticking to their complement of Marconi-Stille machines and a few dozen model GE 50 American wire recorders imported some time late in the war years. In fact eight of these were installed in a mobile unit called the "Octopus" and used during the 1947 Olympic Games. However, there was a strong preference for disc recording and their use was extremely limited.

In America the story was somewhat different with two main areas of development almost competing with each other in the search for more versatile means of magnetic recording. Some time in 1940, Marvin Camras, subsequently responsible for a flood of inventions associated with magnetic recording, joined the Armour Foundation and developed a wire recorder using a.c. bias which was then produced by General Electric as the GE 50 and also by the Brush Development Company. A version found its way into USAF service and as a result of a US Navy contract, Brush went on to develop a steel-tape version.

In 1941 Marvin Camras applied, through Armour Research, for a patent on his a.c. bias method, and in 1942 completed the design for the USAF recorder. During 1943 another American company, Webcor, produced wire recorders for the US Navy and in 1944 Minnesota Mining (later 3M) started its first hesitant steps towards developing powder-coated tapes[13].

This occurred as a result of Brush Development asking Dr Oace of Minnesota Mining to develop a thin tape, coated with magnetic powder. Results were slow in coming, partly because Minnesota had no test gear and had to return samples to Brush for testing. It seems that Minnesota did not even know what they were supposed to be producing until it became obvious, with other developments appearing elsewhere.

In 1946 Brush brought out a new Soundmirror machine quite different from its predecessor, but seemingly entirely developed without reference to the Magnetophone, which by then was well known. The first broadcast use of this machine and its paper tape, coated with spherical particles of Fe_3O_4, was during the 1946 New York State political conventions when CBS recorded continuously for 24 hours and then used the material to edit into a "highlights" programme broadcast at the end of the day[51].

This and later machines and their paper tapes were marketed in the UK from 1949 by Thermionic Products—now Racal Thermionics—who are still firmly in the business of producing magnetic tape recorders.

The birth of an industry

Although tape machines using paper-based tapes were beginning to appear in America during 1946 and 1947, it was the "liberated" Magnetophone arriving in Britain and America that was to lend a tremendous impetus to a totally new industry. Here in Britain, EMI went to work and by November, 1947 announced its first-ever tape recorder for studio use, the BTR1 console machine. Although much was owed to the Magnetophone, there were many modifications which produced a very creditable performance.

By 1948 the Abbey Road studios of EMI were using the BTR1, and some machines had entered service in the BBC. In America two men, Colonel Richard H. Ranger and John T. Mullin, had returned from Europe with samples of Magnetophones and were busily lecturing on their finds. In May, 1946, Mullin demonstrated his machines to a meeting of 250 members of the IRE, and the following day received a visit from Alex Poniatoff and others from Ampex, who showed much interest in the German machines. This meeting led to a fascinating chain of events that started the production of the first Ampex 200 in 1948. John Mullin joined forces with Crosby Enterprises to produce a taped version of the Philco-sponsored Bing Crosby Show for NBC in 1947, an event which was to do much to promote the use of tape in broadcasting. Much later Crosby Enterprises were to become what is now known as the Mincom Division of 3M.

Ranger had also been busy, since he had formed a company called Rangertone, marketing first machines and later tape. Most importantly, tape was a big problem because the German product was far from being completely satisfactory.

By a curious coincidence parallel work by Dr W. W. Wetzel, H. K. Smith and R. Herr of 3M versus Marvin Camras at Armour resulted in the production of an acicular form of $\gamma\ Fe_2O_3$ which Camras was first to patent.

The first practical tape from 3M was called type 100 and was a paper-based black-oxide type produced in 1947. It was followed in the same year by type 110, coated on a plastic base and using the new red oxide.

The world had at last woken up to the tape recorder and if at times the allegiance to the Magnetophone was obvious as in our own RGD domestic console type, much research and development was to ensue, resulting in a vast variety of professional and domestic products by the year 1949.

(To be continued)

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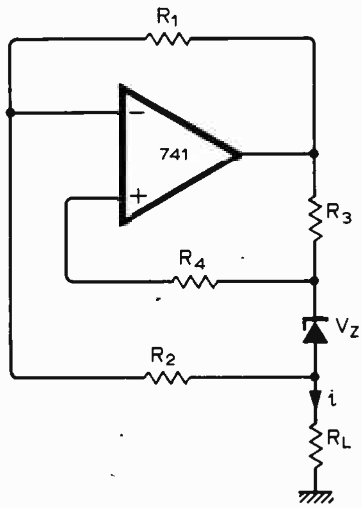
Circuit Ideas

Accurate current generator

Most operational amplifier constant-current circuits suffer from the disadvantage that they require a load isolated from ground. The circuit shown uses a grounded load and, using the 741 op-amp, can achieve a Norton equivalent of an ideal current source in parallel with a resistor of greater than 100MΩ when delivering one milliamp of current.



The output impedance of the current source is primarily decided by the common-mode rejection of the amplifier used. As current through R_2 is also approximately constant it does not affect the output impedance.

In the diagram

$$i=\frac{R_1}{R_2}\cdot\frac{V_z}{R_3}+\frac{V_z}{R_2}$$

(the second term may be neglected if R_2 is large) and

$$R_4=\frac{R_1R_2}{R_1+R_2}.$$

Normally $R_L<R_1=R_2$ and $i=V_z/R_3$.

R. Morcom,
Glenrothes,
Fife.

Voltage stabilizing a symmetrical power supply

The following description of a stabilized symmetrical power supply with overload protection may be useful to readers interested in L. D. Thomas's circuit* idea in the October 1973 issue. Voltage stabilization is by adding two transistors.

Considering the positive rail, stabilization is performed by D_1 cutting off Tr_1 and Tr_2 when the output voltage exceeds the zener voltage minus V_{be} of Tr_1. Current through R_1 is kept constant due to the constant negative rail voltage.

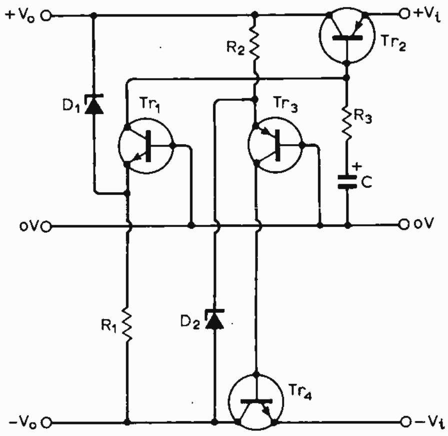
In the case of heavy overload of the positive rail, the protection acts as follows. Maximum rail current is determined by R_1 and the current gain of Tr_2. When D_1 ceases to conduct, the positive rail voltage will drop rapidly, which in turn will decrease the current through R_2 to the negative rail so that D_2 will cease conduction too. Then the negative rail voltage rises, switching Tr_1 and Tr_2 off, followed by Tr_3 and Tr_4.

The power supply is not necessarily self-starting when connected to the proper load. A suitable C–R_3 combination should then be used to switch Tr_2 on. If unconnected, the leak currents of Tr_2 and Tr_4 will normally activate the circuit.

The circuit has been an adequate protection of my transformer-coupled 20-watt Bailey amplifiers since 1967. It has not been possible to blow the output fuses or destroy the output transistors.

Ole Holmskov,
Hørning,
Denmark.

*In L. D. Thomas's circuit, a 2.2kΩ resistor should be inserted between the junction of the upper zener diode and R and the reset push button and series RC components.



Wobbulator

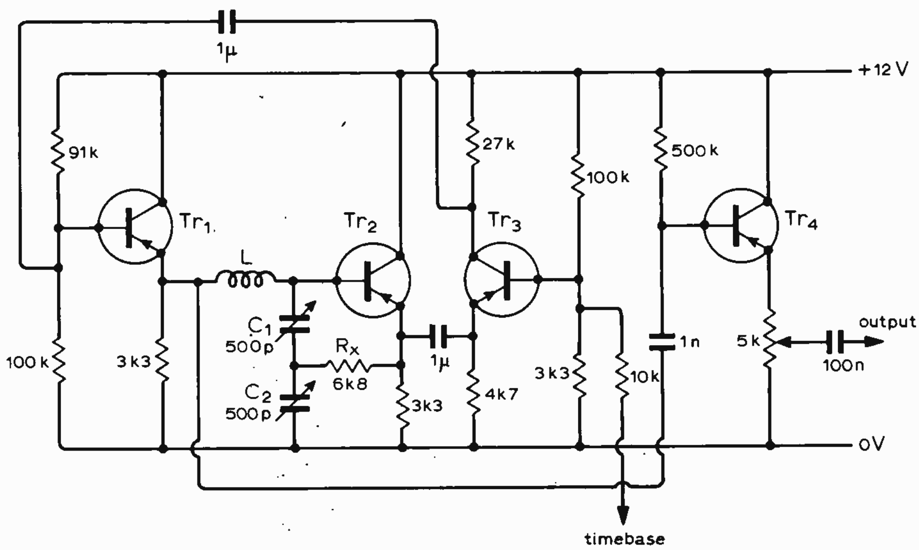
The circuit to be described is derived from a voltage-controlled oscillator mentioned by F. Butler in a *WW* article of December 1965, page 602. In this the effective inductance of the coil is controlled by the amount of feedback.

The circuit shows how this has been modified to produce a wobbulator circuit which is cheap, and simple to set up. Feedback is now taken, without phase change, via Tr_3. This transistor can vary the feedback in accordance with a control voltage at its base. If this is derived from the ramp output of the oscilloscope timebase the frequency of the oscillator will follow the variations in the timebase sweep voltage.

The centre frequency of the sweep may be varied readily by adjustment of C_1 and C_2. The circuit as described is used at 450 to 500kHz, but there seems no reason why, with a change of coil, it should not operate at 1.6 or 10.7MHz. Versions using BC107s, BF115s and BF194s have been made. Resistor R_x may need to be varied to give the best waveform with different transistors and probably for use on different frequency bands.

When the ramp voltage, which can be derived from the timebase, cannot be used directly at low impedance it is suggested that an emitter follower should be used and a suitable proportion of the output tapped off the emitter resistor.

E. C. Lay,
Eastbourne.



London Electronic Component Show 1975

Exhibitors and exhibition details

The 24th international component show to be held at Olympia, London, from May 13 to 16, will this year have well over 300 participant companies with many of these exhibitors coming from abroad. The show will be open daily from 9.30 to 17.30. Admission is by complimentary ticket but is free to overseas visitors. Sponsor of the show is the Radio and Electronic Component Manufacturers' Federation and it is organized by Industrial Trade Fairs Ltd. The following is a list of exhibitors at the show.

Exhibitors

AB Electronic Components
Abbott Transistor Labs.
Advance Electronics
AEG-Telefunken UK
Aktiebolaget Rifa
Aladdin Components
Albol Electronic & Mechanical Prods.
Allen-Bradley Electronics
Allotrope
Alma Components
Alston Capacitors
Altoflex
Amphenol
Anglosid
Anglo Weld Equipment
Antiference
Ariel Pressings
Astralux Dynamics
Avel-Lindberg

Bailey, Stamp & Sons
Batchelor Robinson Group
Bauch, F. W. O.
BDO Products
Bell Industries
Belling & Lee
Bepi (Electronics)
Berger Lahr
Bernhard Beyschlag Apparatebau-GmbH
Bianchi, Spain
BICC-Burndy
British Insulated Callender's Cables
Bonnella, D. H., & Son
Bourns (Trimpot)
Brandauer, C. & Co
Britimpex
British Brown-Boveri
British Central Electrical Co
British Physical Laboratories
British Standards Institution
Bulgin, A. F. & Co
Burgess Micro Switch Co
Burr-Brown International

Cambion Electronic Products
Cannon Electric (GB)
Cannon-MIT (UK)
CB Transformers
Celdis
C.E.M.R.E.P., France
Centralab
Centre Engineering Inc.
Cerme Electronique
CGS Resistance Co
Cherry Electrical Products (UK)
Chomerics
C & K Components
Clare, C.P., Electronics
Cole Electronics
Coline
Colvern
Comite Permanent des Foires
Computer Metal Reg'd
Comway Electronics
Concordia Electric Wire & Cable Co
Connollys (Blackley)
Constanta of Canada
Contraves Industrial Products
Copal Electronics
Coutant Electronics
Critchley Bros
Crouzet
Crystalonics
CSM (Engineering)

Danbridge (GB)
Darstan
Datel (UK)
Daturr
Dau (UK)
Davall, S., & Sons
Davu Wire & Cables
DEK Printing Machines
Delta Metal Electronics
Dial Engineering Co
Diamond H Controls
D. J. Instruments
Doduco

East Grinstead Electronic Components
Eaton's Anodising
Eberle & Co. Elektro GmbH
Edicron
Efco Composants
Egen Electric
EGM Solders
Elecktor Publishers
Electrical & Electronic Trades Directory
Electron
Electronic Engineering
Electronic Visuals
Electronics Weekly & *Wireless World*
Electrothermal Engineering
Elektrim (Electrical Equipment)
Elektromodul
Ellenberger & Poensgen GmbH
Emme
Erie Electronics
Erma
Ernst Roederstein GmbH
Ero-Tantal GmbH
Erwin Sick Optic-Electronic
Euchner & Co
Europa Components & Equipment
Europartners
Evans, Frederick W.
Every Ready (Special Batteries)

Ferranti
Fielden Electronics
Filhol, S. J.
Fischer Elektronik
Flightgrade
Foss Fasteners
FR Electronics
Fried Krupp GmbH
Friedrichsfeld GmbH
Fulmer Components
FW Components

Gardners Transformers
GEC Electrical Comps
GEC Semiconductors
GE Electronics (London)
General Instrument (UK)
Gore, W. L., & Associates UK
Gorman Machine Corporation
Gould Incorporated
Gresham Lion Electronics
Guest Components Group

Habia KB
Hartmann, Fritz Geraetebau
Hellermann Electric
Hesto (Henkels-Stocko)
Heyco Manufacturing Co
Highuol Connectors
Hinchley Engineering Co
Hird Brown Electronics
Holeywell
Holsworthy Electronics
Hunter Equipment Sales
Hybrid Systems GmbH

Imhof-Bedco
IMI Components Division
IMO Precision Controls
Imperial Metal Industries
Industrial Science
Inselek
Insuloid Manufacturing Co
International Rectifier
Ipar, Spain
Israel Company for Fairs & Exhibition
Ivo Counters

Jackson Brothers (London)
Jermyn Manufacturing
Jungbecker, Germany
Juniper Journals

Keithley Instruments
Klar & Beilschmidt, Germany
Klippon Electricals
Kofod Anchersvej
Krystinel Corp.

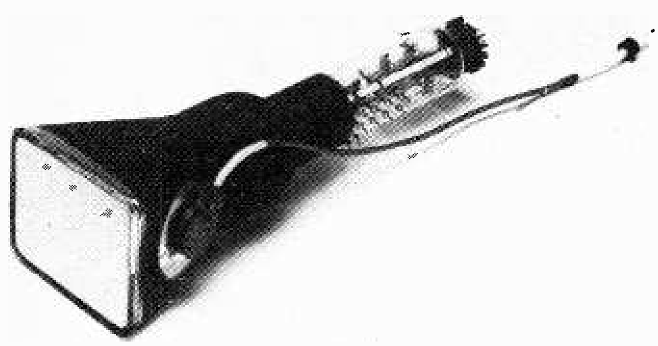
Lan-Electronics
LCR Components
Lektrokit
Lemo (UK)
Lerc
Licon Electronics
Limit Tools & Gauges
Lipa and Isostat (GB)
Littelfuse (GB)
Littex
Livingston Hire
Lloyd, J. J., Instruments
Lloyds Bank
Logik A/S
Londex
London Telephones
Lorlin Electronic Co
Lucas, J.

3M United Kingdom
Magic Dot
Magnetic Devices
Marconi Communications Systems
Markovits, L.
Marston Excelsior
Marquardt, J. & J.
Mechanical Enterprises Inc.
Medelec
Mepco Electra Inc.
Mercury House Business Publications
Metway Electrical Industries
Micrometals
Microsystems International
Milton Ross Co
Monsanto
Mullard

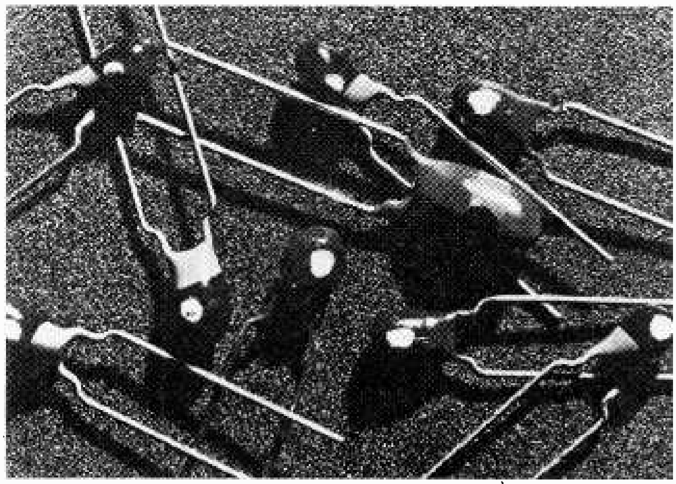
National Semiconductors
Nea-Lindberg A/S
Neosid
Newbury Electronics
Newport Instruments
NSF Switches & Controls

Oscilloquartz S.A.
Ostby & Barton Co

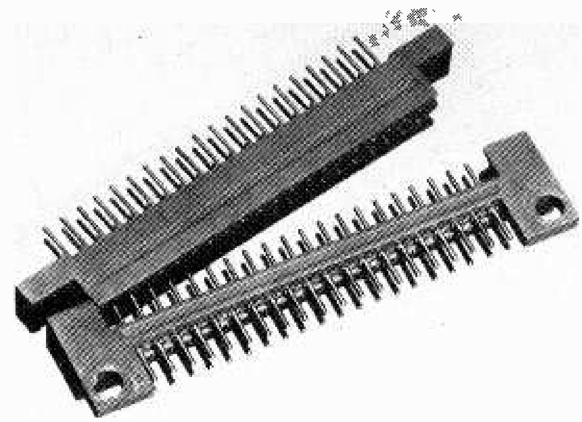
Papst Motoren Kg
Parmeko
PCB Piezotronics
Pedoka
Pell, Oliver, Control
Perdix Components
Perivale Controls Co



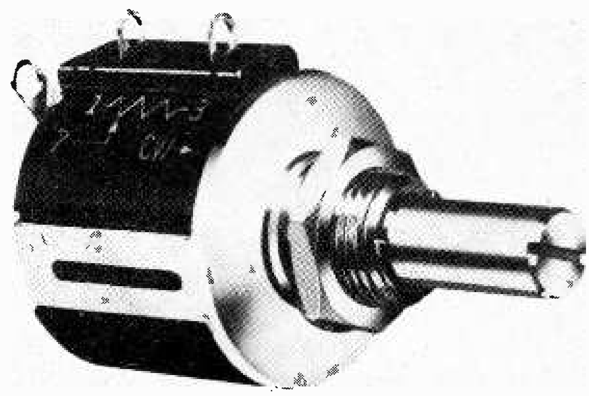
This rectangular-faced instrument cathode-ray tube, type D14-240GH/37, is one of a new range of 14cm-diagonal tubes being shown by Mullard. For use at bandwidths from 100 to 250MHz, it has a minimum writing speed of 1.5ns. Overall length is 385mm.



A selection of "E" series capacitors produced by Union Carbide UK at its Aycliffe factory. Twelve case sizes are included in the range, covering 0.1 to 680 microfarads in voltages from 3 to 63 volts.



This new Smiths Industries Hypertac 40-way two-part p.c.b. connector, type HPE, has parallel 0.63mm diameter contacts set in a 2.54mm grid. The free connector, containing the pin contacts, is designed for double-sided daughter board mounting while the fixed connector, containing the socket contacts, is designed for mother board mounting.



Model 3540, one of Bourns precision potentiometers to be shown at LECS.

Permanoid
Pickering Electronics
Plasmoulds
Plastic Capacitors
Plastic Screws
Plastic Seals
Plessey Interconnect
Portescap UK
Preh Werke
Pressac
Pudenz, Germany
Pye of Cambridge

Quality Audio Supplies (Q.A.S.)
Quebec Dept. of Ind. & Commerce

Racal Group Services
Radiall Microwave Components
Radiatron Components
Rafi, Faimund Finsterhoelzl,
Raytheon-Tag Components
RCA
RCL Electronics
Redpoint
Rendar Instruments
Research Instruments
Resista GmbH
Resistances
Rilton Electronics
RKB Precision Products
Roederstein & Tuerk GmbH
Ropel, France
Rosenthal China (London)
Roxburgh Electronics
Ryetronic Suppressors

Saarlaendische Kondensatoren-
fabrik
Saft (UK)
Sakae Tsushin Kogyo
Salford Electrical Instruments
Scanbe Manufacturing Corp
Schoeller & Co
Scopex Instruments
Sealectro
Seddon & Bramhall
S.E.E.M.
Sellotape Products UK
Semiconductor Specialist
Semikron (UK)
Siemens
Sifam
Silco, France
Silicon Transistor Corporation
Siliconix
Smith Industries (Rugby)
Smiths Industries (Cricklewood)
Sogie
Sonnenschein Accumulatoren-
fabrik GmbH
Souriau (UK)
South London Electrical Equipment Co
SP Elettronica SpA
Special Products Distributors
Spectrol Reliance
Spectrum Controls
Sprague Electric UK
Standard Pneumatic Motor Co
Stanley Palmer, G.A.
Steatite Insulations
Stettner & Co

Stocko Metallwarenfabriken
Stolec
Suhner Electronics
Surrey Steel Components
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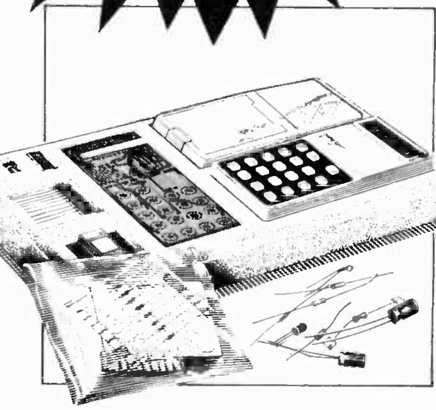
Components for Scientific kit
(illustrated)
1. Coil
2. LSI chip
3. Interface chips
4. Case mouldings, with buttons, windows and light-up display in position
5. Printed circuit board
6. Keyboard panel
7. Electronic components pack (diodes, resistors, capacitors, etc.)
8. Battery assembly and on/off switch
9. Soft carrying wallet
10. Comprehensive instructions for use

Assembly time is about 3 hours.



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- **12 functions on simple keyboard**
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- **Scientific notation**
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4 1/3" x 2" x 11/16". Weight 4 oz. Attractively styled in grey, blue and white.

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1. Coil
2. LSI chip
3. Interface chip
4. Thick film resistor pack
5. Case mouldings, with buttons, window and light-up display in position
6. Printed circuit board
7. Keyboard panel
8. Electronic components pack (diodes, resistors, capacitors, transistor)
9. Battery clips and on/off switch
10. Soft wallet

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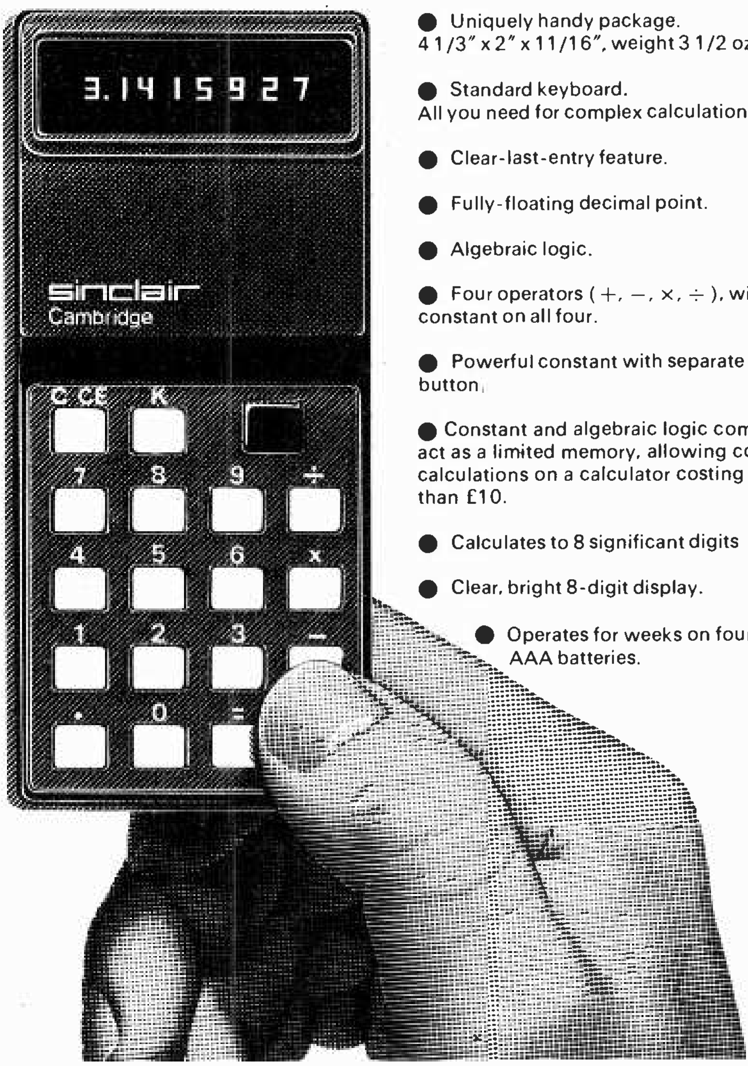
Features of the Sinclair Cambridge



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Display devices

Survey of techniques and types on the market

The increasing use of digital techniques in measurement and information processing has, of course, demanded digital methods of displaying the information produced. As a result we have seen the emergence of a variety of electrical devices for displaying numerals, letters of the alphabet, arithmetical signs and other symbols—the general term for these being alphanumeric display devices. A typical device takes the form of a small panel on which any of the numerals 0 to 9 may be shown—particular numerals being selected by switching voltages to appropriate terminals. Several of these panels may be assembled in a row to permit a display of numbers consisting of multiple digits with a decimal point and perhaps plus and minus signs—as, for example, in a digital voltmeter.

There are various ways of generating the characters, and the methods dealt with in the separate sections of this survey are: incandescent filaments, gas-discharge devices, light-emitting semiconductor diodes, electroluminescent panels and liquid crystals. These methods also involve different techniques for constructing the shape of the characters—either forming them in continuous lines, for example with bent wires in gas-discharge tubes, or by patterns of dots or bars. A very popular "bar" technique is that seen in the so-called "seven-segment" display; this has seven bars, arranged like a "square" figure eight, from which any of the ten numerals may be built up by activating individual bars or "segments".

L.e.d. displays

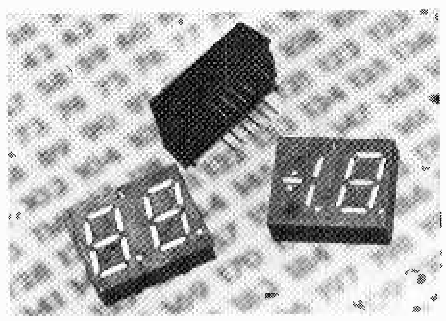
Light-emitting diodes were the first of a new breed of devices to break the hold of displays using gas discharge tubes and filament light sources. Early l.e.d. devices used gallium arsenide phosphide (GaAsP) material and normally emitted red light. To construct a single-digit seven-segment display, a large rectangular slice or several smaller slices of GaAsP would form each segment. The segments were bonded on to a ceramic substrate by epoxy and then the complete assembly was encapsulated in clear epoxy. The problems with the early devices were—large quantities of GaAsP used, misalignment of segments, optical mismatching between the l.e.d. and clear epoxy, and bubbles forming in the epoxy.

More modern displays use much less l.e.d. material for the same size characters. For small displays, around 0.040in, fabrication is normally carried out by diffusing seven junction regions, forming the segments, into a monolithic chip of l.e.d. material. A plastic lens with good optical matching can be bonded to the chip to increase the effective digit size with little light loss. The normal magnification of the lens is ×2 with ×2.8 being a maximum, beyond which point lens aberrations become too great and viewing angle too small. For medium size displays, such as calculator types, segments of l.e.d. material are mounted on a glassfibre or plastic board and protected by a plastic cover which can also be a lens and/or a filter.

For larger displays, magnification is provided by light-pipes or, in the case of transparent gallium phosphide displays, reflector cavities can be used. In the light-pipe method of fabrication the top of a metal pin is used as a support/base as well as the electrical contact. A small piece of l.e.d. material is bonded to the pin and the narrow end of a cone-shaped "pipe" is placed over the l.e.d.—the wide end, which has the shape of a complete segment, goes to the top of the display. This surface can have 20 times the surface of the l.e.d. Glass-impregnated epoxy fills the light pipe and holds the complete assembly in place. When the l.e.d. is illuminated light is reflected off the side walls of the pipe and off the glass particles, giving uniformly diffused light at the surface of the pipe and a bigger and better-shaped segment. The reflective cavity method of construction is used in displays manufactured from gallium phosphide, GaP, because unlike GaAsP, GaP is transparent to red light which is emitted from the sides and bottom of the chip as well as the top. This extra light is reflected to the visible segment area.

L.e.d. materials

The first l.e.ds were produced by epitaxially growing a mixture of 60% gallium arsenide, 40% gallium phosphide on a gallium arsenide substrate. The mixture is in the form of a vapour under pressure and high temperature in a reactor. Diodes made with the 60/40 mixture emit red light at a wavelength of 650nm. If the mixture is altered to 80% GaP, 20% GAs the emission is yellow and at reduced efficiency. GaAsP absorbs its own radiation and light is emitted from only the top of the material. This produces well-defined displays which are inefficient by comparison with other materials, maximum efficiency, for red types, being 2%. One important advantage of GaAsP as a l.e.d. material is its non-linear current/light-output curve—the light output increases faster than the current until a thermal limit is reached. This effect is useful in multiplexed systems where short, high-current pulses are used, because it allows a reduction in total current without sacrificing brightness. Single digits can also be pulsed to achieve the same effect. Non-linearity is also apparent in GaAsP l.e.ds of different colours from red through yellow to green.



Seven-segment numeric l.e.ds.

A more recent material used in the construction of l.e.ds is gallium phosphide, GaP. Devices using this material are manufactured by epitaxially growing 100% GaP on a GAs substrate. Yields are not yet as high as for GaAsP devices and costs are higher. The main advantage of this material is greater efficiency, due to light emission from all sides of the junction. This type of material needs a dopant to provide emissions in the visible portion of the spectrum. If the GaP is doped with nitrogen green emission occurs at 565nm; zinc oxide gives a wavelength of 700nm (red); to obtain yellow the green can be filtered. Doping with both nitrogen and ZnO will also give yellow if the device is operated at medium current levels. As with GaAsP the efficiency drops for colours other than red but not to the same extent. One disadvantage of GaP is the lack of non-linearity, and saturation of light emission at a certain current. This makes GaP unsuitable for multiplex systems or pulsed applications.

Types of display

The most popular l.e.d. display is the seven-segment type which produces ten numerals. These are available in many sizes and four colours with the segments being single/double bars or dots. Another format called a hexidecimal display has the appearance of a seven-segment display with each segment composed of at least

MANUFACTURERS

Bowmar:	Single 7-segment; 3½- and 4½-digit displays; 9- and 14-digit miniature calculator displays, all red.
Contraves:	7-segment panel meter, red. Decode and drive logic.
IEE:	7-segment, with or without decode and drive logic, red. Dot-matrix, red.
Opcoa:	7-segment, red, green, and yellow.
Fairchild:	7-segment, red; 6- and 9-digit calculator displays, red.
Eldema/Genisco:	7-segment, red.
Hewlett-Packard:	7-segment, red; dot-matrix 3-, 4- or 5-digit, red; 3- or 5-digit miniature calculator display, red. Limited alphanumeric, red (hexadecimal).
Sanyo:	7-segment, red; 6- and 11-digit dot-matrix panels.
Litronix:	7-segment, red; dot-matrix, red; 2-, 3-, 4- and 9-digit miniature calculator displays, red.
Monsanto:	7-segment, red, yellow, green, orange; dot-matrix, red; hexadecimal, red.
National Semiconductor:	7-segment, red; 6-, 8- and 9-digit miniature calculator displays, red.
Norbain:	7-segment, red.
Diode-Lite:	7-segment, red. Decode and constant-current drive; dot-matrix, red; hexadecimal with decode and c.c. drive, red.
FM:	7-segment, red; panel meter.
Marconi:	l.e.d. arrays to customer's specification.
EEP:	7-segment, red and green.
Siemens:	7-segment, red, yellow, green or orange.
Spectra-Tek:	7-segment, red; panel meter, decode and drive logic.
Texas:	7-segment, with and without decode and drive; 3- and 4-digit dot-matrix, red; hexadecimal, with decode and drive, red.
Toshiba:	7-segment, red.
Xciton:	7-segment, red, green, yellow, with and without decode and drive.
Oki:	7-segment, red; dot-matrix, red.
TEC:	7-segment, red, green, yellow, with decode and drive; dot-matrix, red, with ROM, drive and clock; hexadecimal, red, with drive.
Plessey:	l.e.d. arrays to customer's specification.
Oshino:	7-segment, red.

four dots, producing ten numerals and six letters, A to F. For alphanumeric displays providing ten numerals and 26 letters, 14/16 segment displays or 7 × 5 dot-matrix types are used: the latter is generally preferred.

New devices

Much development is still taking place. Blue emission is one aim, and one method which has been tried is the coating of infra-red devices with a suitable phosphor. This has not been very popular because of low efficiencies. Other materials have been investigated such as silicon carbide, gallium nitride and zinc sulphide—all with little success, the main problem being that semiconductors with the large band gap necessary are very difficult to grow. Recent compounds to be studied for blue emission are indium-gallium phosphide, indium aluminium phosphide and aluminium gallium arsenide, but at the time of writing no commercial device has been announced.

A new material recently developed for general l.e.ds is manufactured by epitaxially growing a GaAsP layer on a GaP substrate. This produces a material with the advantages of both current types—a transparent substrate which improves efficiency, generally an order better, and a non-linear characteristic making it suitable for multiplexing. Doping of the material with oxygen/nitrogen produces colours also of better efficiency.

Although there have been new devices such as the "thyropter"—a latching GaP device which, by optical feedback, stays illuminated until switched off—most development seems to be in reducing consumption for increased efficiency, and reducing the amount of l.e.d. material used for lower costs. Another area of development is in displays with integral current limiting and built-in decoder/driving chips. Several dot-matrix and seven-segment types are already available and the next two years should see a significant reduction in the cost of these devices.

Liquid crystal displays

The liquid-crystal effect is a "maverick" in the display field because light is not generated but modulated. A display operates by either reflecting light from its surface or controlling light that is passing through it; in the latter mode the device has been referred to as a light valve. As shown in Fig. 1 a display is basically a glass cell with electrodes across two surfaces of a liquid-crystal material. The electrodes are etched, in mirror images, to form characters, such as seven separate segments, and a voltage is applied across the cell. This alters the optical characteristics of the l.c. material between opposite electrodes and results in a character being displayed against unaltered l.c. material.

Liquid crystal is the name given to an organic compound which is a physically mobile fluid having a molecular order similar to that of a crystalline solid. If the temperature is raised to a certain point

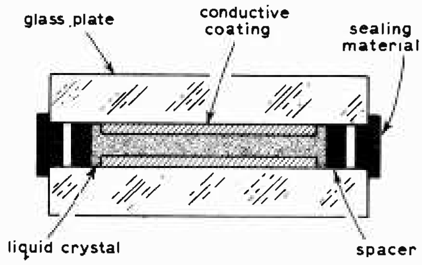


Fig. 1. Basic liquid crystal cell.

the compound will transform into a normal liquid; conversely if the l.c. is cooled it reverts to a crystalline solid. Three classes of liquid crystal have been identified and are named smectic, nematic, and cholestric. The smectic structure has parallel orientation of molecules in discrete layers, the nematic structure also has parallel orientation but no layers, and the cholestric structure has parallel orientation within the plane of a layer but the axial direction of each layer is twisted slightly, thus forming a helix through the layers. One characteristic which is common to all l.cs is the long rod-shaped molecules.

Up to date more than half a dozen electro-optical effects in l.cs have been observed but only two of these are used in displays.

Dynamic scattering

The first l.c. display, produced in 1967, used the dynamic scattering effect—Fig. 2(a), (b). In this mode the l.c. is doped with an electrolyte producing a resistivity in the order of $10^{10}\Omega$ cm. As a result of the doping the l.c. solution conducts current. Under non-energized conditions the molecules align themselves perpendicular to the treated electrodes, and in this condition light can pass through the liquid. When the electrodes are energized the light is scattered due to microscopic variations in the refractive index and disruptions of the molecular alignment. These disruptions are caused by turbulence in the liquid which is a phenomenon that is not well understood, but occurs at a threshold voltage of around 5–10kV/cm.

Dynamic scattering displays can be used in either the reflective or transmissive mode. Fig. 2 shows a transmissive cell with both electrodes transparent but the rear electrode may be made to reflect light to produce a reflective display. In this mode a contrast ratio of 20:1 is possible and the ratio is almost independent of the ambient light level. The appearance is whitish digits on a specular background but the display is not visible in darkness.

In the transmissive mode the appearance is whitish digits on a transparent background and the characters may be viewed in darkness using an auxiliary light source behind the display.

Field effect

The field effect display, often referred to as a twisted-nematic type, was first suggested in 1970. A twisted nematic l.c. structure occurs when the molecules on the two surfaces of a l.c. film are constrained to lie mutually at 90° so that as light traverses the film the optical axis of the liquid rotates by 90°. This alignment of molecules is achieved in a display cell by treating the electrode surfaces which then produce forces at 90°. To complete the display linear polarizing plates are bonded to the cell with their planes of polarization at 90°. When light passes through the cell it is polarized. The plane of polarization is then twisted through 90° and the light passes out of the cell which appears transparent—Fig. 3(a). When an electric field is applied across the cell the molecules tend to orientate themselves with their long-axis normal to the field. If a threshold voltage necessary to overcome the intermolecular forces, typically 1.5–10V, is applied the net effect is an untwisting of the helix. In this energized state polarized light traversing the cell will not be twisted and hence is absorbed by the back polarizer plate—Fig. 3(b). When the field is removed the molecules twist back through 90°. Some molecules twist to the right, others twist to the left, causing a mottled appearance on the display. This problem was overcome at the Royal Radar Establishment by adding optically active materials to produce a "memory".

The appearance of the display is dark characters on a bright background. This can be reversed by positioning the polarizer plates parallel to one another. Coloured displays can be created by adding dyes to the l.c. material or selecting special polarizers. Field effect displays can also be used in the reflective mode by adding a diffuse reflector behind the back polarizer. In this mode a contrast ratio of 40:1 is possible but, as with the dynamic scattering types, the display cannot be seen in darkness.

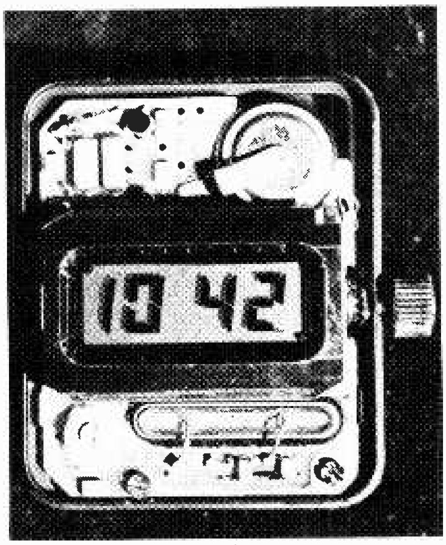
The general trend in l.c. technology is towards field-effect types because of several advantages, as follows:

	field effect	dynamic scatter
Lower drive voltage	1–10V	15–20V
Lower current/cm²	10–500na	1μA
Longer life	10,000+	10,000 h

The main problems of field effect displays are, first, alignment of the glass plates, which is critical otherwise the light rotates through the wrong angle, and second, a 50% light loss in the polarizer plates.

Liquid crystal displays have several advantages over other types in current use but they also have their own problems. These are dealt with briefly below.

Liquid crystals have relatively small temperature ranges, which makes them unsuitable for use in certain environments. The normal range is from −10 to +60°C; this can be raised or lowered by selecting the nematic compound. If the l.cs should be subjected to temperatures outside of their normal range they will transform to a solid or liquid, in which case no display will appear. The electronics will still operate, e.g. in the case of a watch, and when the l.cs return to their normal temperature the display will also return.



Liquid-crystal watch display.

Switching speeds of l.cs are comparatively slow; the turn on and off times are given by:

$$t_{on} \propto \frac{\eta}{\Delta\epsilon\, V^2}$$

$$t_{off} \propto \eta\, d^2$$

where η = viscosity, $\Delta\epsilon$ dielectric anisotropy of l.c., V = applied voltage. The switching speed is dependent on temperature cell thickness, frequency of drive voltage and l.c. material. Typical switching times for both types of display are t_{on} = 2–10ms, t_{off} = 50–300ms.

Liquid crystal displays should be driven by an alternating voltage to prevent electrochemical reaction in the cell, such as electrolysis. Any d.c. component in the drive voltage will shorten the life of the display.

Most a.c. drives are a square wave in the frequency range 25Hz to 1kHz. This type of drive is very difficult to multiplex so each segment of the display requires a separate drive circuit—this extra cost is normally offset by the lower current required.

Developments of liquid crystals

Liquid crystal displays, if you will excuse the pun, have a bright future. Much R & D work is being carried out in order to solve some of the shortcomings of the l.c., such as the susceptibility to hydrolysis by absorbed water vapour and decomposition by exposure to u.v. light. One major breakthrough was in 1973 when a team of chemists led by Dr George Gray of Hull University produced a family of l.cs which are exceptionally stable and almost immune to water vapour contamination and exposure to u.v. light.

Several types of multiplexing have been proposed to overcome the switching limitations of l.c. materials. One of the most promising is a 3:1 a.c. coincident addressing scheme that is continually updated at a rate faster than the natural decay of the electro-optic effect.

Other developments include a small flat-panel TV screen based on a 128 × 128 matrix of twisted nematic displays. The TV operates at 25 frames per second with eight shades of grey. Another project is Xerox's "electronic note paper". This system uses a l.c. that changes from transparent to opaque and persists until it is erased by a high frequency field.

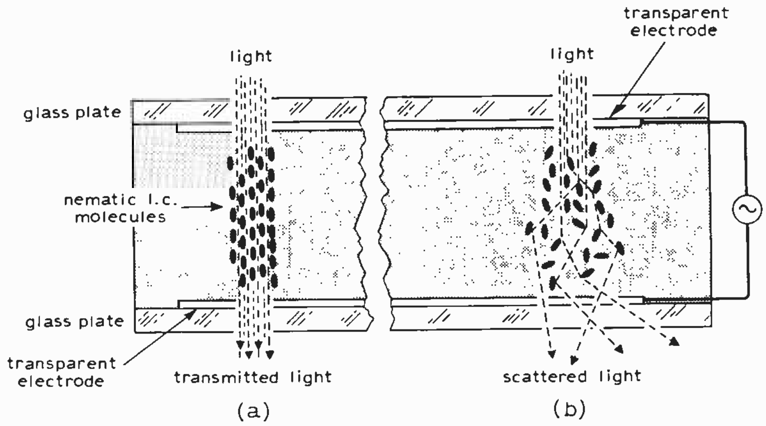


Fig. 2

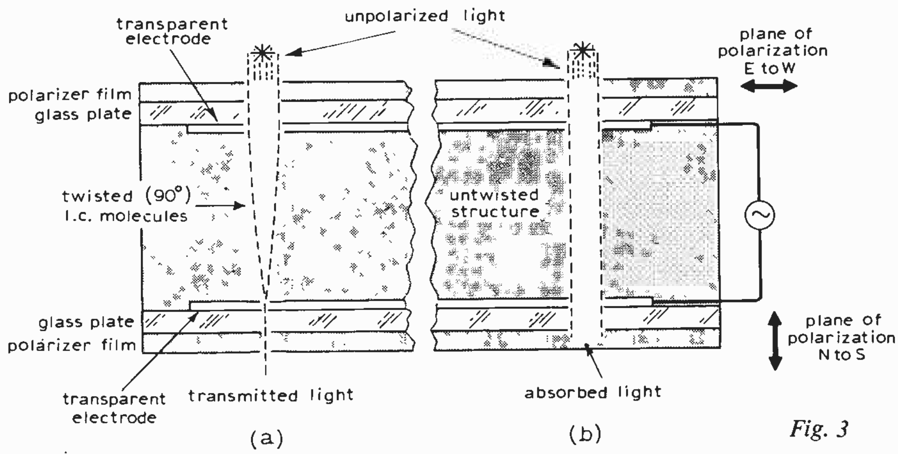


Fig. 3

RCA scientists have developed a simple technique for observing electron pulses flowing through i.cs by placing some nematic l.c. on the surface of the device. The minute electric fields produced by the i.c. cause the l.c. to react thus indicating where a pulse is.

The Royal Radar Establishment have developed an electro-optically controlled colour-switch by placing a thin birefringent layer, such as cellophane, between linear polarizers. A l.c. cell then rotates the light and switches a colour or colours on or off.

MANUFACTURERS

AEG Telefunken	FE/R:W,I,C; FE/T:I,C.
American Microsystems:	FE/R:C.
British Brown Boveri:	FE/R:I,W.
Hamlin:	FE/R:W; DS/R:W,C,I & 8-digit CA; DS/T:C,I & 8-digit CA.
IEE:	FE/R:I; FE/T:I.
LXD:	FE/R:W,C.
Marconi:	DS/R; DS/T (for special applications).
Norstron:	DS/R:C,I; DS/T:C,I.
Princetown:	FE/R:W; (FE/T:W to special order)
Rank:	FE/R:C,I; FE/T:C,I.
RCA:	FE/R; FE/T.
Walter Scott:	FE/R:W,C,I; FE/T:W,C,I.
Siemens:	FE:8-digit CA; DS/R:C,I; DS/T:C,I.
Swarovski:	FE/R:W,C,I; FE/T:C,I; DS/T:C,I; DS/R:C,I.
Tekelec:	FE/R:panel meter.
Thomson CSF:	FE/R:C,I; FE/T:C,I; DS/R:C,I; DS/T:C,I.
Toshiba: (in development)	FE/R:W,C; DS/R:8-digit CA; DS/R:I.

Code

FE—field effect; DS—dynamic scattering; R—reflective; T—transmissive; W—watch; C—clock; I—instrument; CA—calculator.

Gas discharge displays

Perhaps the most familiar gas-discharge display is the Nixie tube, made by Burroughs and by many others under different names. As an indicator for counters and many earlier types of digital instrument, it was almost unchallenged for many years. It is easy to use, reliable, and gives a very bright display, but suffers from the drawbacks of an anode voltage which is high in relation to voltage levels used in modern equipment and of a stacked array of cathodes, some of the rear ones being partially obscured by those nearer the front. It is still widely used, however, and looks likely to continue for some time.

It takes the form of a common anode with ten cathodes, each cathode being a wire shaped to form one of the characters, the whole contained in a neon-filled envelope. The application of a voltage of 160V or over between a selected cathode and the anode causes a discharge to be established between the two electrodes. The selected cathode glows red and is viewed through the glass, either from the side or the end. Numerical characters and a few signs are available.

Neon gas discharges are used to great advantage in the more recently developed "plasma panel". In essence, the panel consists of a large number of neon "cells" arranged in a matrix in a flat panel. The rows and columns are bussed and each cell is thereby addressable. For instance, the cell at the intersection of row x and column y will, when the row bus and column bus are connected to V volts, have impressed across it $2V$ volts, which will fire it. All other cells in row x and column y will have V volts across them and will not fire, assuming that the cell firing requirement is between V and $2V$. The electrodes and cover are transparent and the glow is seen as a point of light. In many cases the applied voltage is at high frequency and ignition takes place at each reversal of voltage, giving two illuminations per cycle.

These displays are extremely flexible and not restricted in size. For instance, a device named Plasmar and made by National Electronics, is a clock and calendar display exhibiting a six-digit time readout, a six-digit calendar and three letters (WED, etc.) to show the day of the week. Additionally, there are 21 "message blocks" which illuminate a stencil to indicate any fixed indicator such as am, pm, hours, seconds, etc. The displays can be multiplexed.

The use of a.c. discharge possesses several advantages over the d.c. type also in use. The construction of the panel is such that the applied voltage effectively "sees" a capacitance, as the electrodes are separated from the gas by a dielectric casting. The effect of this is to ensure that all areas of the panel are displayed equally brightly, the current being shared by capacitors in parallel on the basis of area. In a d.c. panel, current would not be equally shared; the emissivity of each area of electrode being different with area leads to an effect known as "hogging". D.c. panels also allow the gas to be in contact with the electrode, with consequent limitations in cathode life. There is one advantage of d.c. or unipolar-pulsed panels in that there is an inherent memory, rendering external memory devices redundant. In a.c. types the discharge is continually "refreshed" at a frequency high enough to avoid flicker.

Single-character neon displays are also fabricated in a flat format by, for example, Telefunken. An array of stainless-steel strips in a 14-segment formation is connected to input pins and faces a common transparent anode. Application of 130V to any segment causes a discharge between that segment and the common anode in the normal way. The advantage, of course, is that the display is planar, with no obstruction of cathodes.

The phenomenon of fluorescence is used in alphanumeric displays by several firms, mainly in multi-digit tubes, although Tung-sol make single-digit devices. In these, a filament produces an electron cloud, which is attracted to a selected, fluorescent anode by an arrangement of grids and anode voltage selection. The multi-digit tubes are multiplexed and the discharge is a blue-green colour.

MANUFACTURERS

Mullard:	Neon indicator tubes for numeric, limited alpha and sign information. Side or end viewing. Pins or wire ended. Orange.
ITT:	Neon indicator tubes for numeric, limited alpha and sign information. Side or end viewing. Pins or wire ended. Orange.
Burroughs:	Neon indicator tubes for numerals 0 to 9 ("Nixie" tubes). "Self-Scan" alphanumeric dot-matrix panel displays including drive electronics and memory. Up to eight rows of information. "Panaplex II" single row, numeric panel display, 9 or 16 digits.
Nippon Electric:	Dot-matrix plasma panels for the display of characters, numerals, graphics and permanent message blocks. Refresh driven. Multiplexed.
National Electronics:	"Plasmac" plasma panel for use as digital calendar and clock display. Six 7-segment, 1.25in digits for time; six 0.5in digits for date; three 14-segment 1in alpha characters for day of week; 21 message blocks. A.c.-driven.
Ferranti:	D.c.-driven plasma panel. Dot-matrix characters in 7 × 5 format. 32 rows of 40 characters. Memory.
Cherry:	Single row numeric panels. 7-segment, 0.4in characters, with decimal points, commas and operational signs.
Elesta:	Indicator modules with neon tubes, decode and drive electronics. Modules match Contraves edge switch housings.
Contraves:	Indicator modules with neon tubes, count, decode and drive electronics. Modules match edge switch housings.
AEG-Telefunken:	"Varisymbol" flat, 14-segment, neon indicator modules, with decimal point.
Beckman:	Seven-segment neon modules with t.t.l.-compatible decode and drive electronics.
TEC:	Neon indicator tube module with counter, latch, decoder and drive electronics.
Spectra-Tek:	Panel meter with neon tubes, decode and drive electronics.

Fluorescent indicators

Toshiba:	Multiple, single row, fluorescent tubes for up to 12 digits. Filament voltage 3 to 5.5V a.c. Seven-segment characters.
Futaba:	Multiple, single-row fluorescent tubes for up to 17 digits. Filament voltage 2.6 to 4.7V a.c. Seven-segment characters.
Tung-Sol:	Single-digit, seven-segment, side-viewing fluorescent indicators. Filament voltage 1.6V a.c.

Electroluminescent displays

An electroluminescent panel is basically a layer of phosphor, similar to that used in television tubes, sandwiched between two electrodes which may be shaped to produce a seven-segment format. When energized, phosphor between the electrodes emits light and a shape/character is illuminated against passive phosphor.

Electroluminescence will occur when electrons in a semiconductor solid are excited—in the case of phosphor, luminescence is from the excitation of impurity centres to a high energy state which, when returning to the normal energy state, emit photons. The impurity centres are created by doping the phosphor material.

At present there are two categories of electroluminescent displays—a.c. and d.c. energized.

A.c. panels

There are two methods of constructing a.c. panels depending on the application. The first type is called a ceramic panel which is normally the easiest and cheapest to produce. A metal plate is shaped to the required format then a white-enamel reflective-coating is fused to the plate. Powdered phosphor, normally zinc sulphide doped with manganese, is mixed with a binding material and fused on to the enamel surface. While the coating is still hot stannic oxide is sprayed onto the phosphor which forms a transparent conductive electrode. The complete assembly is then glazed with a protective insulating coating apart from a small area where the leads are bonded. An alternating current is applied between the electrode and metal plate and causes electroluminescence. This type of construction is suitable for mass production displays such as exit signs.

The second type of a.c. display is called an organic panel. A glass plate has a transparent conductive film of tin-oxide bonded to it, this film is then coated with a phosphor layer followed by a reflective layer. A back electrode is applied to the panel which is then sealed with a moisture-proof layer. Characters can be formed by etching either the front or back electrodes across which is applied the alternating current. This type of display is suitable for special panels with characters such as a seven-segment display or a dot matrix.

A new type of panel which is constructed similarly to the organic type uses a transparent flexible plastic encapsulation for the front window; this produces a semi-flexible panel about 1mm thick.

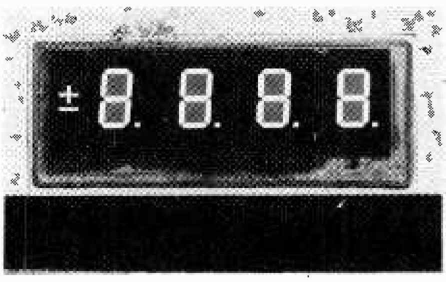
These displays all operate at voltages between 50 and 300V and at frequencies between 50Hz and 5kHz to produce green, blue and yellow light dependent upon the type of phosphor used. By using a fluorescent paint other colours can be produced. The phosphor powder is in a binding material and particles do not touch each other so most of the current flow is capacitive.

The luminance, and to a certain extent colour, is dependent on the frequency of the applied voltage because excitation occurs once every half cycle; above 10kHz the light output decreases due to electrical loss in the panel. Luminance also increases with voltage; a typical display will emit $8cd/m^2$ at 240V 50Hz. The life of a panel is inversely proportional to the frequency and also dependent on the voltage but generally an exponential decay occurs over several thousand hours of continuous use. The panels can be driven from transistor inverters and can be dimmed to extinction by varying the applied voltage.

D.c. panels

These panels are newer and have a higher luminance/voltage ratio with outputs up to $500cd/m^2$ possible. The efficiency is, however, comparable with the a.c. types being around 0.1%. Construction of a d.c. panel is more difficult because a barrier layer has to be formed in the phosphor coating. Zinc sulphide doped with manganese is again used which emits yellow light at 580nm; colours from red to green can be obtained by filtering. The construction of a d.c. panel is similar to that of an organic a.c. type. A glass plate has a transparent conductive coating bonded to it and this is etched to produce the required characters. An insulating layer then covers the leads adjacent to the display; next the phosphor layer is applied. In the case of phosphor powder types a mixture of powder and bonding material is applied by spraying or silk-screen. With thin-film types a layer is deposited by evaporation. Finally, a metal back-electrode is applied also in the shape of required characters. The complete panel is then encapsulated.

Before the display will work an irreversible treatment called "forming" has to be carried out to produce the correct characteristics. The untreated panel has a low resistance and does not emit light. A



Seven segment d.c. electroluminescent display.

suitable voltage is applied which causes a decrease in current slowly at first then rapidly as a barrier layer is formed leaving the panel in a high impedance light-emitting condition. The process is completed by raising the voltage to the normal level.

The powder construction produces panels that operate at around 100V d.c. with a life-time of up to several thousand hours dependent on the way it is operated. Thin-film panels, however, operate at 10 to 20V d.c. but with reduced efficiency and life-time. Both types of d.c. panel operate in a resistive mode and suffer from a gradual ageing due to an increase in resistance. The phosphor is specially prepared for each application, the main parameters being brightness, voltage and current. Normal current densities are between 0.5 and $2mA/cm^2$ dependent on brightness, but the mean brightness can be increased by driving the panel with overvoltage pulses although the efficiency remains the same. Pulsed operation can extend the life of d.c. panels and makes multiplexing possible.

Developments of displays

Because electroluminescent panels can be made in almost any format and size, with single areas of up to $500cm^2$ and over being prepared, they have an advantage in mimic displays.

Most of the development will be in extending the life of panels, reducing power consumption and drive voltages, and making larger display areas. Westinghouse Electric Co have built a prototype a.c. panel consisting of 12,000 elements suitable for alphanumeric displays or, because the brightness of each element is independently variable, a flat television display is possible.

MANUFACTURERS

GEC:	D.c. 4- and 9-digit, 7-segment, yellow: and user specified.
Phosphor Products:	D.c. displays to user's specification.
Saunders-Roe:	A.c. displays to user's specification.
Thorn:	A.c. panels to user's specification.

Incandescent filament displays

Although these displays are considered old-fashioned, incandescent filament (i.f.) devices still have advantages over other devices. Bulbs emit a bright white-yellow light which may be filtered to produce colours. The bulbs are individually replaceable, have a life of around 10,000 hours and can be driven from t.t.l. logic devices. The main disadvantages of i.f. displays are: if there is a failure it is complete; and when a bulb is switched on there is a current surge due to the low cold resistance of the filament. In addition to conventional bulbs there are filament indicator tubes and seven-segment filament displays.

With i.f. lamp displays there are two modes of operation. The most common is to distribute the emitted light over a character/segment area; the other mode of display uses direct viewing of the lamps. For seven-/sixteen-segment displays an equal number of bulbs is used, the light from each bulb being directed, by means of a light pipe or lens, to the surface of the display. Projection types of display have a number of bulbs corresponding to the number of complete characters required; the light shines through a stencil of the character and is focused onto the surface of the display. A variation of this system is a single bulb with a rotating stencil.

Directly viewed displays are normally in the form of a matrix of 5 × 7 individual lamps, the required characters being formed by lighting particular groups of the lamps. These types are very bright and can be used in outdoor displays such as score-boards. To make the display more visible in daylight lenses can be placed over the lamps, but this also restricts the viewing angle.

Stencil displays are the simplest method of conveying information. When a bulb is illuminated behind a transparent film a message or character is displayed. Fibre optic and optical plastic (edge-lit) displays are easily read because the characters can be formed precisely in the required shape. Each bulb in the package directs light along a number of optical fibres or plastic plates which go to the surface of the display. The fibres can either form complete characters or segments of a character, by dots of light. The plastic plates have dots on the surface, in the shape of the characters, which are illuminated; a separate plate is used for each character and the plates stand vertically behind one another.

Indicator tubes use filament wires either shaped to form individual characters or seven segments from which characters can be assembled. The tube is evacuated and when a low voltage, typically 5V, is applied to a filament/s the character glows. The seven-segment principle is also used in a flat-package display which resembles the seven-segment l.e.d. type.

Even though many solid-state/gas-discharge displays are on the market, i.f. types continue to find applications. Very little development is taking place but, because of the advantages mentioned, these types of display will not be replaced until some significant improvements are made in other types.

MANUFACTURERS

Bulgin:	Illuminated stencil. Any message can be displayed.
Conrac:	Matrix of bulbs to form characters.
IEE:	7- and 16-segment fibre optics. Projection types. 7-segment lamp.
Davy:	Matrix of bulbs to form characters.
Apollo:	Filament tubes.
FR:	7-and 16-segment filament.
Shelly/Datatron:	7- and 16-segment fibre optics. Projection types.
Hird-Brown:	Matrix of bulbs to form characters.
Neill:	7-segment lamp.
NEC:	7-segment lamp and illuminated stencil.
Fuji:	7-segment filament.
Diode-Lite:	7-segment lamp.
Setpoint:	Matrix of bulbs to form characters.
Tung-Sol:	7- and 16-segment lamp. Illuminated stencil.
Master	7- and 16-segment.
Specialities:	fibre optic.
TEC:	7-segment lamp with logic. Projection.
RCA:	Filament tube.
Siemens:	Filament tube.
KGM:	Edge lit. Matrix of bulbs to form characters.
Okaya:	7-segment filament. Filament tube.
Itoka:	7-segment lamp.
Spectra-Tek:	Filament-tube panel meter with drive/ decoder logic.

Manufacturers' addresses with UK agents where applicable.

AEG Telefunken UK Ltd, Bath Road, Slough, Berks.

American Microsystems Inc, Adrian Electronics Ltd, 28 High Street, Winslow, MK18 3HF.

Beckman Instruments Ltd, Queensway, Glenrothes, Fife.

Bowmar Instruments Ltd, 1 Ormond Avenue, Hampton, Middx.

British Brown Boveri Ltd, Albany House, 41 High Road, Brentford, Middx.

Bulgin, A. F. & Co Ltd, Bye Pass Road, Barking, Essex IG11 0AG.

Burroughs Electronic Brokers, 49 Pancras Road, London NW1 (neon indicators); Walmore Electronics Ltd, 11 Betterton Street, Drury Lane, London WC2 (self-scan types).

Cherry Electrical Products, Lattimore Road, St. Albans, Herts.

Conrac Ltd, 346 Kensington High Street, London W14.

Contraves Industrial Products Ltd, Times House, Station Approach, Ruislip, Middx.

Davy & United Instruments Ltd, Darnall Works, Sheffield S9 4FA.

Diode-Lite Pye TMC Components Ltd, Controls Division, Roper Road, Canterbury, Kent.

EEP Rastra Electronics Ltd, 275 King Street, Hammersmith, London W6 9NF.

Eldema/Genisco, **Shelly/Datatron** } Fieldtech Ltd, No. 2 Maintenance Area, Heathrow Airport, Hounslow, Middx.

Elesta Britec Ltd, 17 Devonshire Road, London SE26.

FM Kynmore Engineering Co, 19 Buckingham Street, London WC2.

Fairchild Semiconductor Ltd, Kingmaker House, Station Road, New Barnet, Herts.

Ferranti Ltd, Special Components Department, Gem Mill, Chadderton, Oldham, OL9 8NP.

Fuji Perdix Components Ltd, Perdix House, 31 Green Lane, Chislehurst, Kent.

GEC Ltd, Hirst Research Centre, East Lane, Wembley, Middx.

Hamlin Electronics, 14 New Road, Southampton, Hants.

Hewlett Packard Ltd, 224 Bath Road, Slough, Berks.

Hird-Brown Electronics Ltd, Lever Street, Bolton, Lancs.

IEE Counting Instruments Ltd, 5 Elstree Way, Borehamwood, Herts.

ITT, **Sanyo** } ITT Ltd, Brixham Road, Paignton, Devon.

Itoka, **Futaba**, **WalterScott** } Walter Scott Industries, Imp House, 35 Malden Way, New Malden, Surrey.

KGM, **Okaya** } KGM Electronics Ltd, Clocktower Road, Isleworth, Middx.

LXD Inc, Transworld Scientific Ltd, Short Street, High Wycombe, Bucks.

Litronix, Bevan House, Bancroft Court, Hitchin, Herts.

Marconi Communication Systems Ltd, Radford Crescent, Billericay, Essex.

Marconi Company Ltd, Research Laboratories, West Hanningfield Road, Gt. Baddow, Essex.

Master Specialities Co, Waycom Ltd, Wokingham Road, Bracknell, Berks.

Monsanto Ltd, 10 Victoria Street, London SW1H 0NQ.

Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

NEC, **Norstron** } Nimrod Electronics Ltd, Vann Lane, Chiddingfold, Surrey.

National Electronics Inc. Magnus Electronics Ltd, 23 King Street, London W3.

National Semiconductor, The Precinct, Broxbourne, Herts.

Neill Controls Ltd, Neills Road, St. Helens, Merseyside.

Nippon Electric Co, Impectron Ltd, Impectron House, 23 Kings Street, London W3.

Norbain Electronics Ltd, Norbain House, 44 London Street, Reading RG1 4SQ.

Oki Twentieth Century Electronics Ltd, King Henry's Drive, New Addington, Croydon CR9 0BG.

Opcoa, **Apollo**, **FR** } F. R. Electronics Ltd, Wimborne, Dorset.

Oshino Seatronics Ltd, 22 Finsbury Square, London EC2A 1DT.

Phosphor Products, 100 Drawkins Road, Hamworthy, Poole, Dorset.

Plessey Co Ltd, Optoelectronics & Microwave Unit, Wood Burcote Way, Towcester, Northants.

Princetown Material Science. Sprague Ltd, 159 High Street, Yiewsley, West Drayton, Middx.

RCA Ltd, Electronic Components Division, Lincoln Way, Sunbury-on-Thames, Middx.

Rank Research Laboratories, PO Box 33, Phoenix Works, Great West Road, Brentford, TW8 9AG.

Saunders Roe Developments Ltd, North Hyde Road, Hayes, Middx.

Setpoint Ltd, Ingate Place, London SW8.

Siemens Ltd, Great West House, Great West Road, Brentford, Middx.

Spectra-Tek, Kirbymoorside, York.

Swarovski Bywood Electronics, 181 Ebberns Road, Hemel Hempstead, Herts.

TEC West Hyde Developments Ltd, Ryfield Crescent, Northwood, Middx.

Tekelec Euro Electronic Instruments Ltd, 27 Camden Road, London NW1 1YE.

Texas Instruments Ltd, Manton Lane, Bedford.

Thomson CSF UK Ltd, Ringway House, Bell Road, Deneshill, Basingstoke, Hants.

Thorn Electrical, Bond Road, Mitcham, Surrey.

Toshiba UK Ltd, Toshiba House, Great South West Road, Feltham, Middx.

Tung-Sol Walmore Electronics Ltd, 11 Betterton Street, Drury Lane, London WC2.

Xciton Tranchant Electronics Ltd, Tranchant House, 100A High Street, Hampton, Middx.

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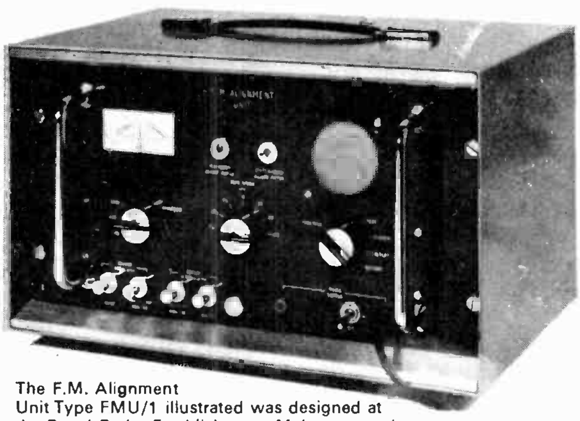

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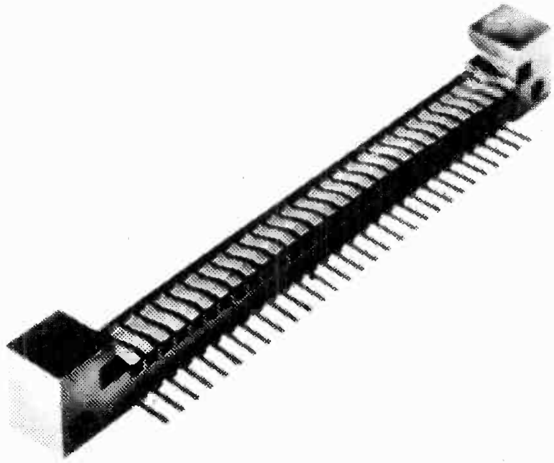

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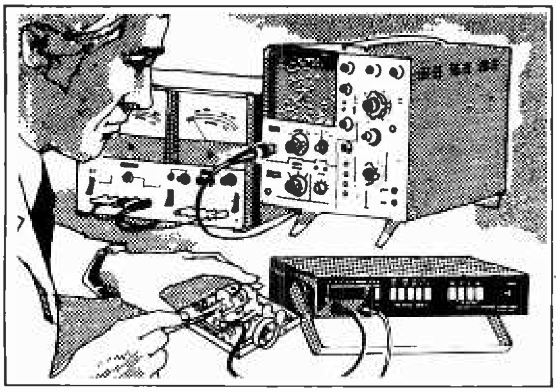

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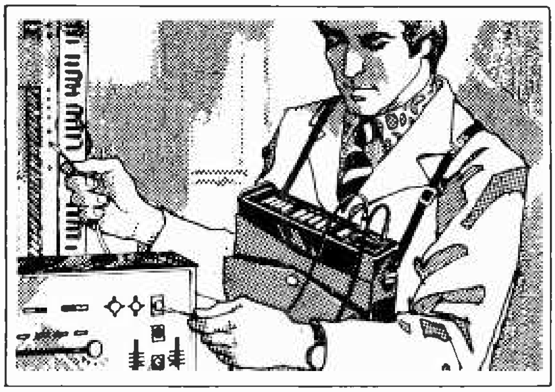

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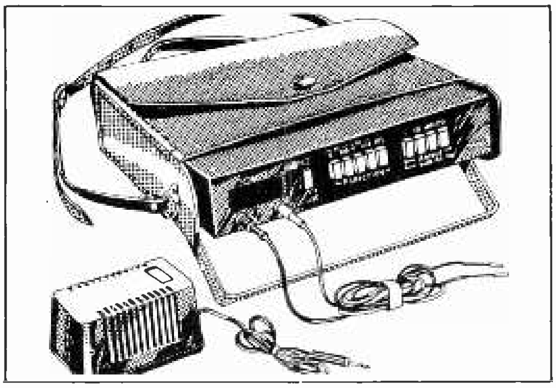

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DC Volts

Range	Accuracy	Input Impedance	Resolution
1 V	0·3% ± 1 Digit	> 100 MΩ	1 mV
10 V	0·5% ± 1 „	10 MΩ	10 mV
100 V	0·5% ± 1 „	10 MΩ	100 mV
1000 V	0·5% ± 1 „	10 MΩ	1 V

Maximum overload – 350 V on 1 V range
1000 V on all other ranges.

AC Volts

Range	Accuracy	Input Impedance	Frequency Range
1 V	1·0% ± 2 Digits	10 MΩ/40 pF	20 Hz–3 KHz
10 V	1·0% ± 2 „	10 MΩ/40 pF	20 Hz–3 KHz
100 V	2·0% ± 2 „	10 MΩ/40 pF	20 Hz–3 KHz
1000 V	2·0% ± 2 „	10 MΩ/40 pF	20 Hz–1 KHz

Maximum overload – 300 V on 1 V range
500 V on all other ranges.

DC Current

Range	Accuracy	Input Impedance	Resolution
100 μA	2·0% ± 1 Digit	10 KΩ	100 nA
1 mA	0·8% ± 1 „	1 KΩ	1 μA
10 mA	0·8% ± 1 „	100 Ω	10 μA
100 mA	0·8% ± 1 „	10 Ω	100 μA
1000 mA	2·0% ± 1 „	1 Ω	1 mA

Maximum overload – 1A (fused).

AC Current

Range	Accuracy	Frequency Range
1 mA	1·5% ± 2 Digits	20 Hz–1 KHz
10 mA	1·5% ± 2 „	20 Hz–1 KHz
100 mA	1·5% ± 2 „	20 Hz–1 KHz
1000 mA	2·0% ± 2 „	20 Hz–1 KHz

Maximum overload – 1A (fused).

Resistance

Range	Accuracy	Measuring Current
1 KΩ	1·0% ± 1 Digit	1 mA
10 KΩ	1·0% ± 1 „	100 μA
100 KΩ	1·0% ± 1 „	10 μA
1000 KΩ	1·0% ± 1 „	1 μA
10 MΩ	2·0% ± 1 „	100 nA

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WW/5/75

Noise—confusion in more ways than one

3—Microwave noise generators and aerial temperature

by K. L. Smith
University of Kent at Canterbury

Techniques for measuring noise temperature in the microwave region are discussed in this article, together with interesting and in some ways unexpected effects on the performance when attenuation is present at the front end of receivers. Noise from external and sometimes distant sources is considered and its effect on the idea of aerial temperature.

I find that the upper end of the frequency spectrum offers many interesting techniques, as we have seen from the recent series of articles by M. W. Hosking in *Wireless World*. The main point to bear in mind about microwaves is that distributed techniques are used and lumped circuit components as well as definite voltages and currents, are no longer in evidence. For example, a matched load on the end of a transmission line (waveguide) is not a small resistor, but is often a wedge of lossy material tapered for a number of wavelengths. Certainly the thermionic diode noise sources are out and the distributed circuit ideas have to be exploited for noise generation. The easiest microwave noise source is one of the matched loads heated to a known temperature in an oven (T_{hot}). For measurements on low-noise receivers, instead of being heated, the load is often cooled by solid carbon dioxide or liquid nitrogen, for instance. This yields a known T_{cold} value. ("T_{hot}" is then usually room temperature.)

I will now describe the gas discharge tube as a most useful noise source for the microwave region. The tubes are usually similar to a small fluorescent lamp, with heater, the positive column of which is coupled into a microwave system by passing the tube diagonally across a waveguide, as shown in Fig. 9. The noise temperature seen by a receiver connected to the gas discharge source is constant and related to the electron temperature in the plasma, in a way that can be calculated. It is virtually independent of the current through the tube, but it does depend to some extent on the type of gas and the pressure in the tube, and on the diameter of the discharge. Tubes containing argon have temperatures 9900K to 11000K. As an example, tube type N1067 has a temperature of 11000K.

The custom in specifying noise tube sources usually involves the excess noise ratio in decibels, so that an argon tube whose noise temperature is 10000K has an excess noise ratio of

$$10 \log_{10} \left(\frac{10000-290}{290}\right) = 15.25\text{dB}$$

The gas tube source has a limitation and that is once the tube has been made and put into operation, the noise temperature is fixed (as we have seen, it is always at about 10000K). This temperature is rather high and you might think that it would produce a very large A in the ratio method for measuring T_e. So it would, but with a bit of manoeuvring based on the discussion in the next section, we can get over this.

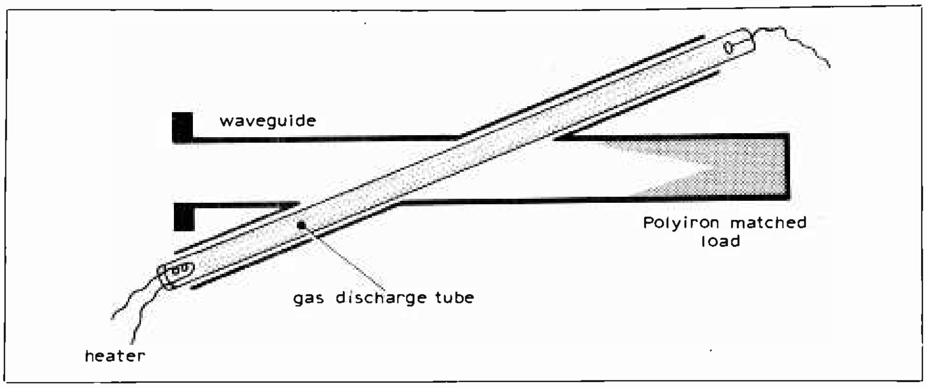


Fig. 9. Electron noise temperature inside an ionized gas tube is surprisingly constant. Tube is placed diagonally across the waveguide to couple or match into the system efficiently.

Effect of attenuation on noise temperatures

At first sight, it might appear that an attenuator with a loss L placed between the output of a source of noise power and the input terminals of an amplifier, could be handled as a stage having a gain of less than one. If this was true the first two terms of the cascading formula could be used directly. The situation is not quite so simple as this in practice, because the attenuator is a lossy passive circuit which contributes thermal noise according to its physical temperature, T_L. The use of the excess temperature simplifies the arguments somewhat, at the expense of always having to remember that 290K has to be added to get the true temperature.

I will now go on to consider how one deals with a lossy network in a system. The problem can be looked at from two points of view. The first considers the output terminals of the attenuator. The attenuator is bracketed in with the source, as it were. The discussion then deals with the question of the source temperature seen by the receiver (whose effective input temperature is, say, T_{eR}) considering the original source and attenuator together forming the new source. The other way is to bracket the attenuator in with the receiver to give a new receiver (with new T_e) with which to face the original source. Of course, both points of view amount to the same thing, it is just the position in the cascade at which we refer to the noise temperature which differs.

The first requirement is for us to consider the effective input temperature of the attenuator alone. Think of an attenuator of loss L, with a matched source resistance, all in a box at a physical temperature T_L. After a little thought, you should see that the available noise power from the output terminals of the whole thing is kT_LB. The available noise power at the input of the attenuator is $k(T_L + T_{eL})B$, where T_{eL} is the effective input temperature of the attenuator. This power multiplied by the gain, i.e. $1/L$, must be equal to the output power

$$\frac{k(T_L+T_{eL})B}{L}=kT_LB \text{ or } T_{eL}=(L-1)T_L \quad (8)$$

Now we can go ahead and use the equation for T_e on page 172 (April issue) to get the overall effective input noise temperature of a receiver with an attenuation of L between its input terminals and the source terminals

$$T_e=T_{eL}+\frac{T_{eR}}{\left(\frac{1}{L}\right)}=(L-1)T_L+LT_{eR} \quad (9)$$

Fig. 11 shows diagrammatically a few steps to assist in arriving at this last equation. You will see that attenuation not only increases the receiver's effective input temperature by L, but adds noise of its own, amounting to $(L-1)T_L$. A typical example of where you will get this kind of thing is an aerial connected to a receiver via a lossy feeder.

We are now in a position to look at the problem in the other way I mentioned. Suppose the aerial temperature is T_a and is connected to the attenuator input terminals, as shown in Fig. 12. The available power coming out of the attenuator is $k(T_a+T_{eL})/L$, so the temperature seen by the receiver is

$$T_{a(eff)}=\frac{T_a}{L}+\left(1-\frac{1}{L}\right)T_L \quad (10)$$

by using equation (8).

This means that the effective aerial temperature is not only reduced to $1/L$ of the actual value, but a spurious or masking noise $(1-1/L)T_L$ is added by the attenuator. Whichever way one looks at it, attenuation between aerial and receiver has a nasty effect on the noise performance of a low noise system.

Just to check that equations (9) and (10) are ways of saying the same thing, you might like to calculate the output noise power, P_{NO}, in both cases.

From (9) and Fig. 11

$$P_{NO}=k(T_a+T_e)\frac{BG}{L}$$

$$=k(T_a+[L-1]T_L+LT_{eR})\frac{BG}{L}$$

and from (10) and Fig. 12

$$P_{NO}=k(T_{a(eff)}+T_{eR})BG$$

$$=k\left(\frac{T_a}{L}+\left[1-\frac{1}{L}\right]T_L+T_{eR}\right)BG$$

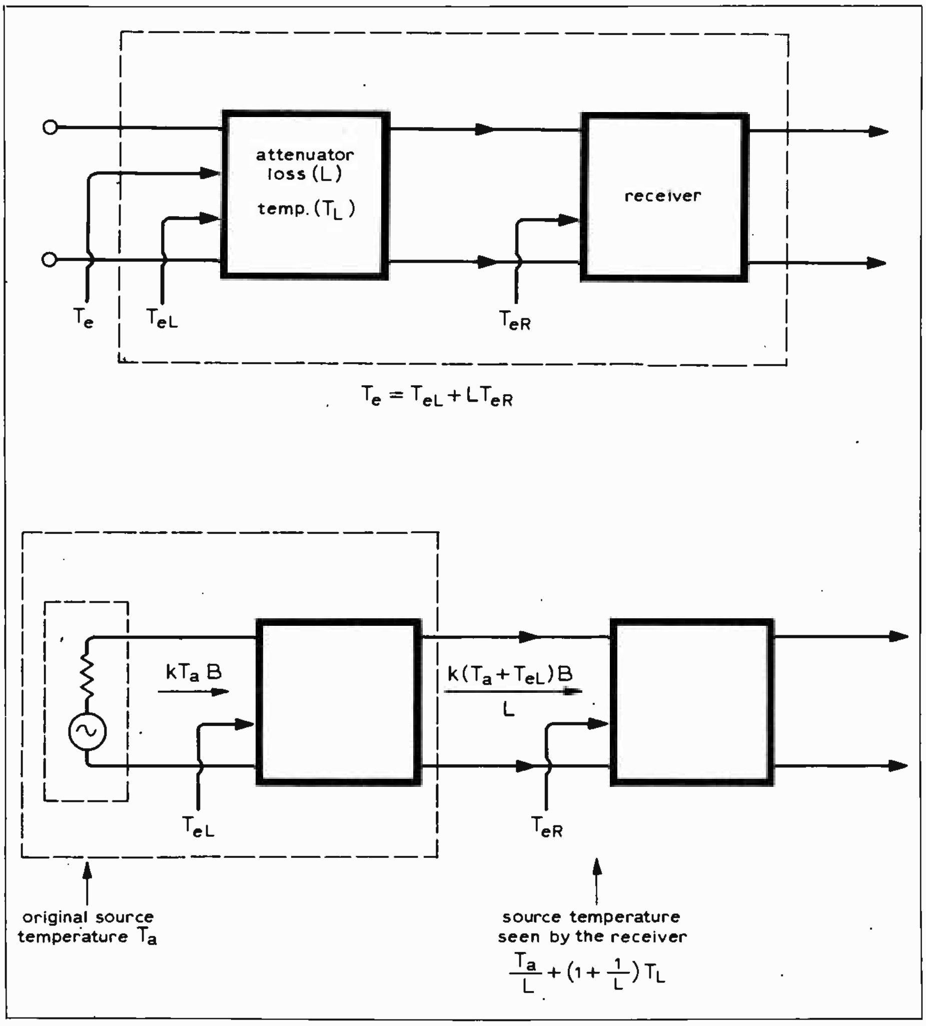


Fig. 11. Including the attenuator in with the receiver gives a new receiver complete with new overall T_e with which to face source.

Fig. 12. Same system as Fig. 11 but now considered from the point of view of attenuator bracketed in with source to form a new source . . . feeding the original receiver.

Factorizing out $1/L$ in the second equation shows it to be exactly the same as the first.

There is one situation in which an attenuator is useful when dealing with noise. If you have a noise source which has a known fixed, but high noise temperature, you can obtain a lower noise temperature by exploiting equation (10). Of course the attenuator must be a highly accurate calibrated one to give a known value of L. From equation (10) you can see that with no attenuation, $(L=1)$, the temperature seen is that of the source. If L is very large, the first term in the equation becomes negligibly small, so does $1/L$ in the bracket and the noise temperature seen by the receiver is simply T_L, no matter how high T_a is—if L is large enough. In most situations, $T_L=T_o$ or nearly so and if we deal in terms of excess temperatures then equation (10) can be rewritten

$$T_{a(eff)}-T_o=\frac{T_a}{L}+\left(1-\frac{1}{L}\right)T_o-T_o$$

which is

$$T_{a(eff)}-T_o=\frac{T_a-T_o}{L}$$

This argument shows that the effective excess noise temperature of a source is just the actual excess temperature divided by L. L must be a numerical ratio and as virtually all attenuators are calibrated in decibels, you must do a conversion back first. This is easy to do and I will finish this section with a simple example.

Suppose you have a gas tube noise source whose excess noise temperature is 10000K. If a 10dB attenuator at room temperature is placed between it and a receiver, then L is 10 and the result recorded by the receiver is an effective excess noise temperature of 1000K. If 20-dB attenuation is inserted, you would observe 100K. 30dB would give 10K excess temperature and so on. This technique is useful when using gas tube noise sources for measuring performances of low noise receivers and sensitivity of radiometers.

Aerial temperatures

My earlier discussion attempted to highlight the distinction between T_a and T_e. It underlined the fact that T_a measures the noise coming in with the signal. You might be tempted to think that we cannot do anything about a naturally occurring T_a and have to put up with it. That is not the whole picture and a much closer look is required.

One of the first questions you might ask is where does the noise external to the receiving equipment originate? We already have partial answers. The sun radiates at noise equivalent temperatures of about 6000K near the infra-red end of the spectrum, up to hundreds of thousands of degrees at longer wavelengths. Occasionally the sun produces bursts of noise which are orders of magnitude greater than the "quiet" sun value. The earth radiates at about 300K over much of its surface away from the poles. The moon and planets radiate at their characteristic temperatures and there is a general background hubbub (especially at long wavelengths) from the galaxy. At millimetre wavelengths the atmosphere radiates and absorbs, together with acute and rapidly changing effects by rain and clouds—all very much under scrutiny by many observers.

A summary of these effects is illustrated in Fig. 13, where the main curve shows the variation of aerial temperature over the radio spectrum. It is not surprising that S band (10cm wavelength) and X band (3cm) figure prominently in space mission communications and radar, because the value of T_a in this region is very low, around 10K. The rise to millions of degrees at long and medium waves is clearly seen. Time spent on careful low noise design of communications receivers at this end of the spectrum would be time wasted. Other considerations, such as good cross modulation and low spurious response performance, become prominent.

From the beginning of the v.h.f. region upwards in frequency, low-noise design for minimum T_e becomes important as can be inferred from the parts of Fig. 13 where aerial temperatures lower than room temperature occur. Moving to higher frequencies still, we see a rising T_a as water molecules in the atmosphere produce a peak in atmospheric absorption at about 23GHz. This overlaps another rise at 60GHz which is explained by the existence of a cluster of molecular oxygen spectral lines around this frequency. The small dip between the peaks near 35GHz is a window at Q band (8mm wavelength).

At higher frequencies the atmospheric gases have more and more resonances and propagation becomes impossible, except for very short distances. The atmosphere is virtually opaque until the visible light window at 600000GHz, except for a few rather foggy windows in the near infra-red region. The effective temperature of the atmosphere varies with its physical temperature as well as its opacity. In turn, the opacity varies with the fogginess at any frequency and the physical thickness. The distance to the outer edge is obviously much less looking upwards than along towards the horizon. One would expect the noise from the atmosphere to be greater looking horizontally than vertically, as borne out by the curve on Fig. 13.

The natural production of noise giving high aerial temperatures is not always looked upon as an annoying and expensive interference. Radio astronomers and experimenters who carry out work on atmospheric absorption mechanisms look for and measure changes in T_a for their bread and butter. Radio link, radar and space communication engineers on the other hand look on high aerial temperatures as a bugbear. This is a very good example of the saying, "One man's meat is another man's poison."

Radio aerials have quite wide beam widths, although extremely large microwave dishes are built to reduce the pattern width and give a directivity more like a searchlight beam. There are always the side lobes to consider. The aerial temperature recorded by a receiver is the average value

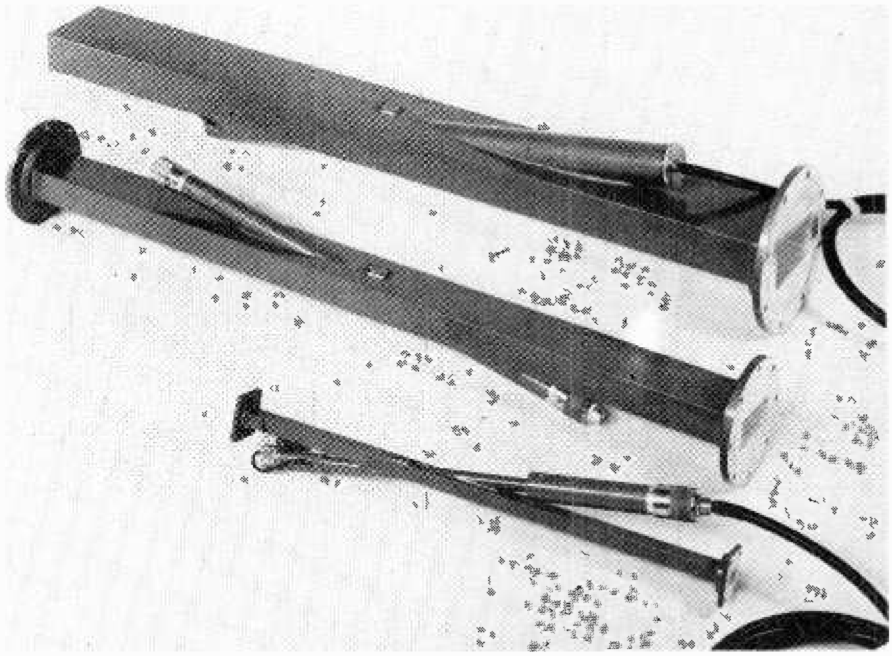
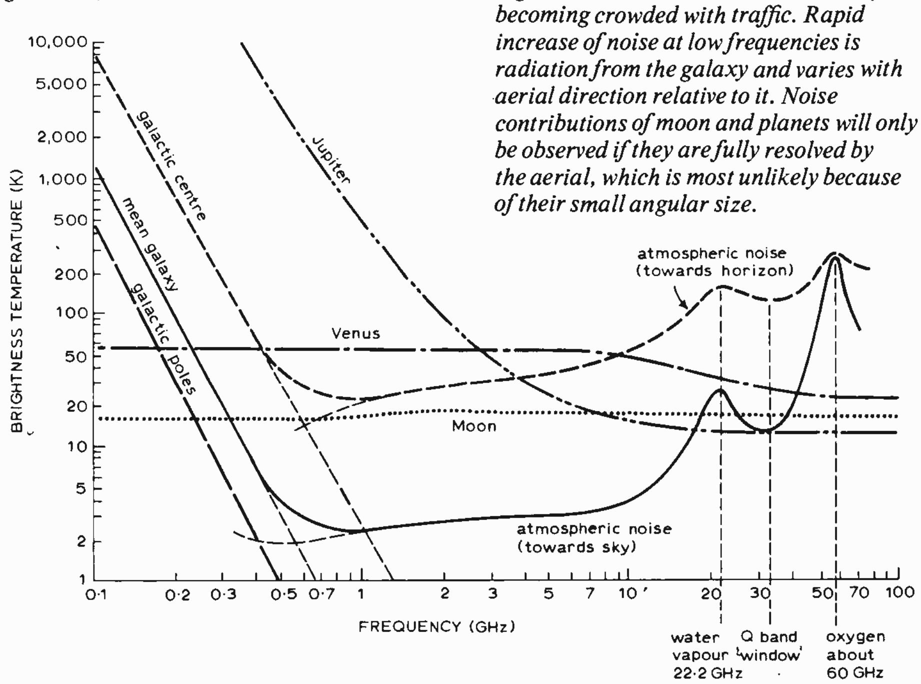


Fig. 10. Typical waveguide gas tube noise sources. Tube is struck by impulse from power supply and operates at 150mA until switched off. (Mid-century Microwavegear Ltd.)

Fig. 13. Atmosphere does not transmit equally well across the whole radio spectrum. Molecular absorption begins to set in above 10GHz. High transparency region between 0.8 to 10GHz is already becoming crowded with traffic. Rapid increase of noise at low frequencies is radiation from the galaxy and varies with aerial direction relative to it. Noise contributions of moon and planets will only be observed if they are fully resolved by the aerial, which is most unlikely because of their small angular size.



seen by the aerial beam. Any peaks in the temperature distribution in space (a "point" source like a planet, for instance) will be missed with a broad beam. It is a matter of resolving power as in any other telescope problem.

I briefly discussed this kind of idea in reference 12 under the heading convolution. What this means is that the averaging over the large aerial beam area dilutes the effect of a small hot source and it fades into insignificance. If the aerial beam is small and covers the source, the hot source will be seen at its full or "brightness" temperature.

A very important effect is the possibility of the aerial beam, and certainly the side lobes looking at the earth, especially in radar or horizontal point to point communication systems. A large contribution to the T_a of a low noise receiver can arise from this source. The sun and moon have already been mentioned, but they are small in size and can be avoided with care. The operating frequency, chosen for the lowest T_a and available signal power at the receiver, finally gives us the information, which enables the value of T_{op} to be worked out, thus yielding the signals to noise ratio expected at the output of the system.

(To be continued)

Oscilloscope capacitance meter

Simple measurement technique utilizes the timebase sawtooth waveform to obtain an accuracy better than 5%

by H. v. Z. Smit, B.Sc., B.Eng.(Elec.)

From time to time various methods of measuring the value of a capacitance by means of an oscilloscope have been published[1, 2]. Many of these methods depend on the determination of the shape of a phase ellipse and therefore a sine-wave source is essential. Also, the value of the capacitance has usually to be calculated from the readings taken. Thus such methods tend to be of academic interest rather than useful in practice.

In the method described here, which can also be used to determine the capacitance/voltage characteristic of tuning diodes, use is made of only one selected resistor to convert the oscilloscope into a direct-reading capacitance meter covering a range between about 1pF and several μF. The accuracy of measurement is sufficient for most practical purposes. It is necessary for the timebase sawtooth of the oscilloscope to be available externally.

The vertical shift control is first set to fix the zero line on the lowest line of the graticule. The unknown capacitance C and the resistor R are then connected as shown in Fig. 1. Next the vertical deflection control is set for maximum d.c. sensitivity and the horizontal (time scale) is adjusted to give a display such as that shown in Fig. 2. The capacitance value is directly proportional to the vertical deflection after steady state conditions have been reached. This value can be easily read off the vertical centre line of the graticule.

In accordance with the expression given (derived in the Appendix), the value of R should be chosen to give the desired vertical scale factor (pF per cm or μF per cm).

$$R = TV/vF$$

where V is 1/sensitivity of y-input in volts/cm; T is the timebase setting in μs/cm; v is the sawtooth slope in volts (vertical) per cm (horizontal); and F is the required vertical scale factor in μF/cm.

For example if: $V = 20$mV/cm, $v = 0.92$ volts per horizontal cm and $F = 1000$pF/cm (required). Choose $T = 1$ms/cm and the equation gives $R = 21.7$kΩ. The display shown in Fig. 2 was obtained with this value of R and for the above conditions. The value of the unknown can be read off as 6700pF.

Accuracy of measurement depends on the accuracy of the vertical and time scales, the accuracy with which R is known, the accuracy with which the slope of the sawtooth can be determined, the linearity of the sawtooth and finally the reading accuracy which in turn depends on line thickness, graticule quality and parallax. Errors attributable to these factors are negligible in practice.

The method has the advantage that the limits of valid measurement are immediately apparent in the display. The minimum capacitance which can be measured is limited by stray capacitances to earth and at the input of the oscilloscope. These capacitances do not introduce errors of measurement but make

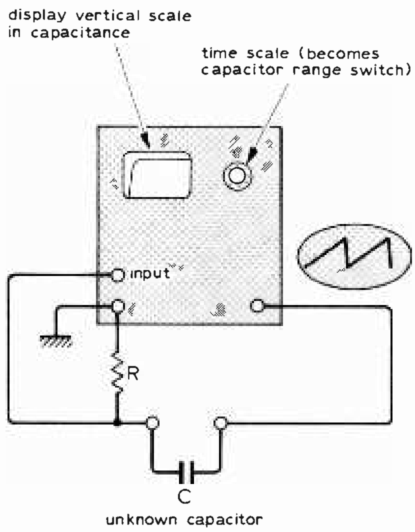
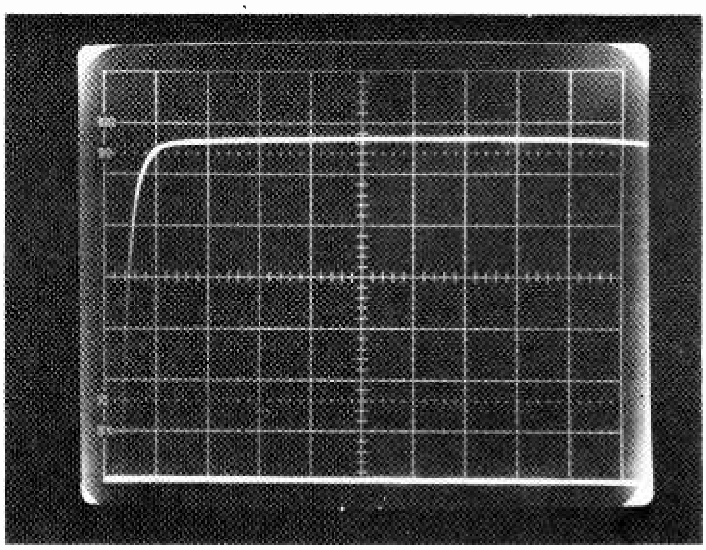


Fig. 1. Circuit used for measuring the value of capacitor C.

Fig. 2. Measurement of a 6700pF capacitor. Time scale is 1ms/cm (corresponding to 1nF/cm). Voltage setting is 20mV/cm.



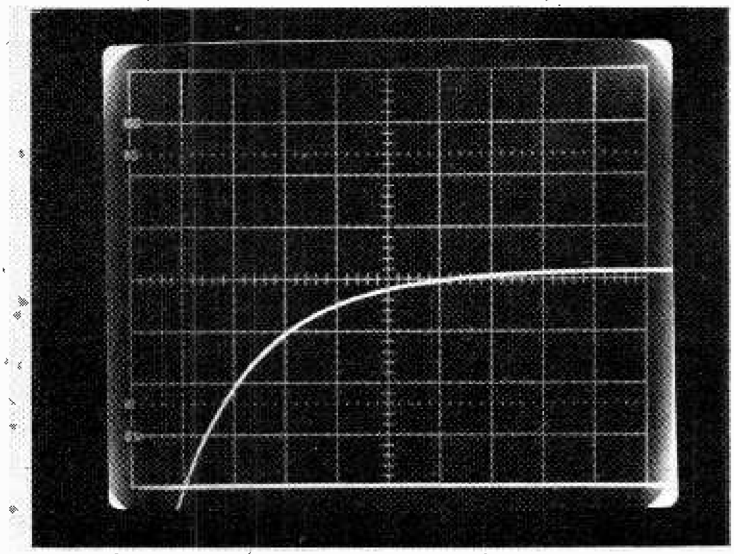
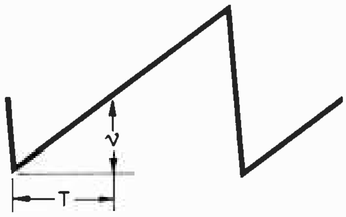
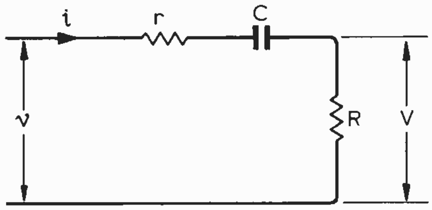


Fig. 3. Measurement of a 2.1pF capacitor. Time scale is 0.5μs/cm (corresponding to 0.5pF/cm). Voltage setting is at 20mV/cm and the oscilloscope input capacitance is 30pF.



(a)



(b)

Fig. 4 (a). Timebase sawtooth waveform and (b) the circuit to which it is applied—see appendix.

accurate reading of the display difficult, as shown in Fig. 3.

It is possible to measure capacitances an order smaller than the stray capacitance. Fig. 3 shows a 2.1pF capacitor being measured although the input stray capacitance is 30pF. Theoretically there is no upper limit to the value of the capacitance which can be measured. In practice, however, the time consumed in taking a reading eventually becomes unrealistic, 100s/cm corresponding to 100μF/cm, for instance. On the other hand the practical range can be extended by a factor of 20 to 100 by decreasing the value of R. A lower limit to R is reached when the time constant rC (where r is the sawtooth generator output resistance) becomes so great that it "distorts" the waveform on the oscilloscope and a trace similar to that shown in Fig. 3 results.

If reasonable care is taken during the measurement procedure, results can be accurate to well within 5%. Accuracy can be optimized by a suitable choice of R and use of a standard capacitor C whose value is accurately known.

Appendix

Refer to Fig. 4 (a) which shows the timebase sawtooth waveform. Quantity T, represented by 1cm horizontal deflection, is by definition the time in μs at which the vertical deflection voltage is v. At any time t voltage is v_t and therefore

$$v_t=vt/T$$

This voltage is applied to the series circuit of Fig. 4 (b) where r is the output impedance of the sawtooth generator, R is the resistance of the calibrating resistor and C is the unknown capacitance. By summing voltages,

$$v_t=vt/T=iR+ir+(1/C)\int i\,dt$$

Differentiating with respect to t

$$v/T=(R+r)\,di/dt+i/C$$

As $t\rightarrow\infty$, $di/dt\rightarrow 0$ and thus $i\rightarrow vC/T$.

The voltage V across R, as applied to the vertical input of the oscilloscope, is equal to iR, therefore

$$V=vCR/T$$

$$\text{or } C=VT/vR$$

By a suitable choice of R and T, any given value of V can be made to correspond with a convenient value of C. Thus if C is replaced by F (μF per cm) then $F=VT/vR$, where V is now in volts per cm.

References

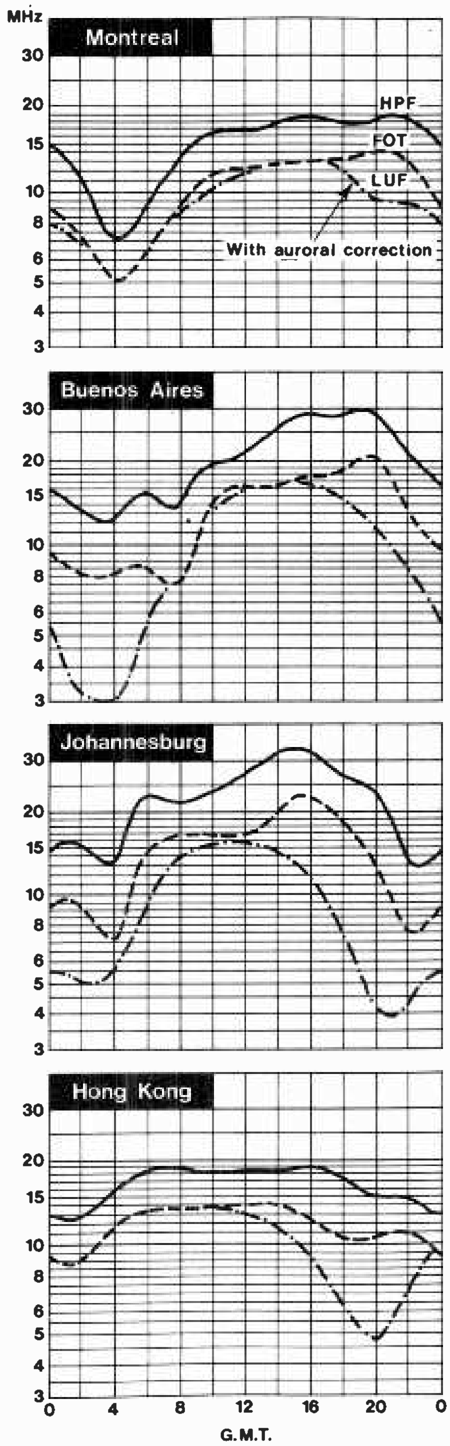
1. Rider & Uslon, "Encyclopaedia on cathode-ray oscilloscopes and their uses", 1959 edition, pp.14–4 to 14–7.
2. Millay, J., "Progress in semiconductor testing", *Tekscope*, Nov. 1972, p.3.

HF predictions

Frequency predictions are the expected monthly mean values of HPF, FOT and LUF for a given state of the ionosphere. Since the charts below refer to a specific future period the given state must also be predicted in terms of ionospheric index. A commonly-used index is the 12-month running-mean sunspot number given by

$$R_{12}=\frac{1}{12}\left[\sum_{n=-5}^{n=5} R_{k+n}+\frac{1}{2}(R_{k+6}+R_{k-6})\right]$$

where R is the mean of daily sunspot numbers for a month represented by its subscript and R_{12} is the smoothed index for the month represented by $k=0$. Hence a prediction of R_{12} requires an extrapolation of the series at least six months ahead of the last available value.



Coastguard v.h.f. repeaters

System in Scotland using solar power

by J. B. Tuke

National Air Traffic Services

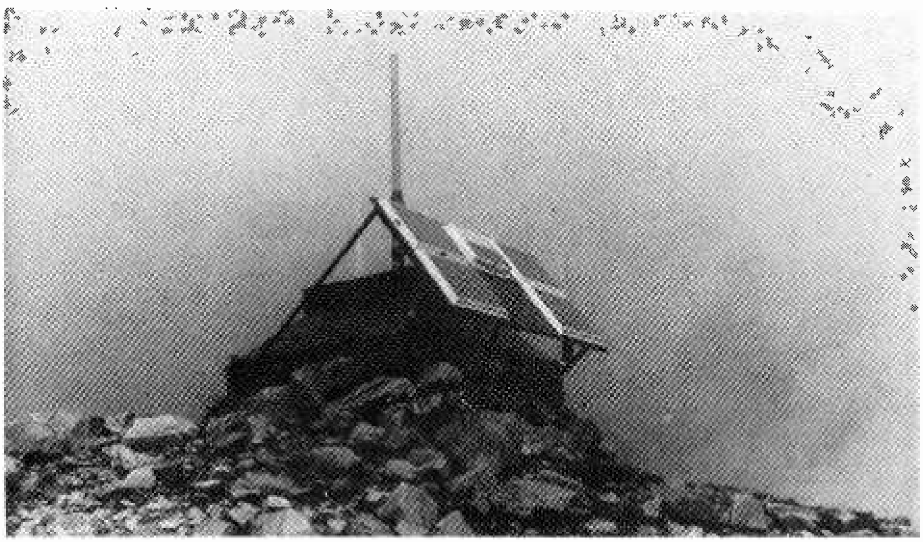
When the Civil Aviation Authority assumed responsibility for aspects of HM Coastguard radio communication services one of the difficulties which had to be studied was the problem of communication between coastguard teams, carrying out routine patrol or rescue work, and their base station. The base may be situated some miles from the scene of action, and the rugged terrain of the Scottish coast makes v.h.f. "walkie-talkie" communication more difficult than usual. By its very nature, a coastguard station is unlikely to be situated on very high ground so that practical v.h.f. range is often restricted to no more than a few miles. In the event of an incident it is essential that any coastguard mobile parties are kept in communication with their base, no matter where in their area they are operating. This can only be arranged by the use of "talk-through" repeaters. The indented coastline with high hills between posed the initial problem, but it also provided the solution since a repeater could be set up on a strategic hilltop having line of sight along the coast.

Unfortunately the most suitable sites are often the most remote and it was soon evident that if the best site was to be used in most cases there could not possibly be an access road or any form of external power supply for the kind of money HM Coastguard could afford.

After consideration, a design formula was evolved which solved both engineering and economic aspects of the problem, reasoning along the following lines. The capital cost of an outside power supply and a road to a remote high site is heavy, likewise the maintenance costs. A self-contained power supply together with highly reliable equipment, on the other hand, could eliminate the need for a road and outside electricity provided that the installation could operate for, say, a year without attention. Further substantial capital and revenue savings could be achieved if the whole station were no more than a weatherproof container capable of being delivered by tracked vehicle or helicopter. In theory the total capital and running costs of such a device would be very small when compared with the cost of a conventional installation, provided that a solution could be found to the engineering problems. The essential parameters are:

- Total reliability.
- Attention, say, only once a year.
- 24-hour capability.
- Ability to withstand extreme climatic conditions.

Attention was given to obtaining a repeater which had minimal current drain in the receive mode, and looking for a suitable power supply. There was something of a "chicken and egg" situation here as the choice of one was dependent on the other.



Repeater station on Beinn Bheigar in Islay, showing solar panels.

After study of a number of repeater specifications it appeared that the CQF series manufactured by Storno might well fill the bill. These sets are in themselves weatherproof, having been made in the form of a hinged box where the receiver is in the lid and the transmitter in the box, the two folding together with a weathertight joint. The company were enthusiastic to assist and modify a CQF 612 to reduce the standing receiver current to under 50mA at 24V. The transmitter remained unmodified and delivered 10W output for 24V, 1 amp input. An attractive property of the set is its ability to work well with reduced input—the receiver performance remaining virtually unchanged down to 21V and the transmitter still delivering a good 5W at this figure. In fact the equipment was found to operate—though with some degradation of performance, of course—down to as little as 16V input. This meant that if some form of battery power supply were decided upon a fair amount of latitude existed with regard to input voltage.

Discovery of a suitable battery came about to some extent by chance. A magazine article described extremely long-life cells which at one time were used to operate point motors on railway tracks, and some amateur sleuthing, together with the assistance of the advertising department of the magazine *Electron*, eventually provided the name of Le Carbone—a company in Sussex manufacturing very-long-life, high-capacity alkaline primary cells. The total life capacity of these cells (type AD 608) is over 2,000 ampere-hours, and it was calculated that this would be sufficient to run the repeater for some 400 days for a capital outlay of some £130 assuming the receiver to be on continuously and the transmitter to be operating for not more than one hour daily. Thirty of these cells would be used to power the repeater (nominal voltage 1.2V per cell) with a simple series regulator reducing the initially high battery voltage to 24. As the end-of-life voltage is around 0.8V, a figure approaching 24V total could be expected even a year after installation.

The next question was the physical form of the container. There were severe environmental problems if any sort of portable building were to be considered.

A "hut" on a Scottish hilltop should either be a substantial brick building which simply cannot blow away, or should be something minimal in size and wind resistant—and this latter was decided upon. A metal box 4ft 6in square, 2ft 6in high with a slightly domed roof was constructed. Internally, a two-storey partition was fitted, the batteries to be housed in the lower portion of the box and the radio equipment in the upper. The weight of the batteries (nearly 900lb) would surely keep the box immovable even in the worst of gales, as wind resistance is very low compared with its weight. The container would be completely weatherproof, but with adequate ventilation for the battery compartment (essential for the particular cells used as they are air-depolarized), aided in the unlikely event of calm weather by the natural "breathing" of the device due to daily warming and nightly cooling of the environment.

Consideration had been given to using a short end-fed vertical dipole on the roof of the box for an aerial (in fact this has been used as will be described later) but the first installation was to use a conventional mast with end-fed dipole at the top. A small 25-ft mast was decided upon—this is in fact one section of CAA's standard non-directional beacon mast and has four wire guys to hold it in place.

For purposes of field trials, the North Minch was selected as being most in need of improved communication and typical of the other problem areas in Scotland. The area included the coasts of the Outer Hebrides, the islands of Harris and Lewis, the north-west coast of the Scottish mainland and the northern half of the Isle of Skye. There is a centrally disposed coastguard station in this area situated in the north of Skye at Duntulm, but v.h.f. communication from here was quite impossible to the south and only a limited range could be expected round an arc between approximately 200 and 080 degrees true. Surveys showed that a repeater on top of Meall Nan Suireamach, just south of Duntulm near the Quirang, would "see" almost all of the area to be covered.

Next came the question of transportation. Since reconnaissance showed the site access to be rock-free and with slopes not exceeding 30 degrees, it was decided to use a tracked vehicle (Sno-Trac), which is used elsewhere by the Authority to gain access to some of the more remote Scottish hilltop radio stations in winter. It is a light tracked vehicle, capable of being transported on a three-ton lorry, and makes its way happily over any soft, boggy or heather-covered ground. Because of its very low gear ratio it can carry quite a considerable weight over quite difficult countryside.

The repeater was duly installed in Skye in the summer of 1972. The ascent of the hill proved relatively simple and the station was established without any real problem. Results were excellent from the start, coverage being from Barra right round through Stornoway and down almost to Kyle of Lochalsh. As expected, the power supply lasted just over the year, and an "expedition" last year and again this year to replace the battery has found the equipment in good order, both electrically and physically.

A further station was installed in 1973—this time on top of Beinn Bheigar in Islay. As part of an "exercise" the Royal Naval Air Service at Prestwick agreed to position the repeater by helicopter, the entire station being installed and commissioned on the hilltop in about an hour. In this case the end-fed dipole was built on to the top of the equipment container, as the site chosen falls away rapidly on all sides; thus an aerial only some 3ft high at the base provides adequate cover over the southern area of the Inner Hebrides and right across to Northern Ireland.

Having successfully operated the Skye repeater for over two years, and the Islay one for over a year, we turned our attention to further economies, the battery power supply being the most obvious subject for attack. There were three alternative sources of power for study, wind power, atomic power and solar power. The first was ruled out on mechanical grounds—while there is no shortage of wind on the Scottish west coast, no proven windmill system exists capable of withstanding the wind speeds and icing conditions which would be experienced. Atomic power cells suitable for this application do exist, but require prohibitively expensive installation works due to safety restrictions. This left solar power as the only line of enquiry worth following.

The firm of J. Lucas are actively engaged in this field and a comprehensive study was made by them of our requirements. A hilltop site in the west of Scotland may not appear to be the ideal spot for sunshine, but in fact the study showed that the small requirements of our repeater system could be met without undue difficulty, and for a total cost of about £900. With battery and transport costs escalating rapidly, we could expect to "break even" financially in about three years, even at present levels of expenditure.

A solar panel array delivering something over 1 amp at 24V in bright daylight is used to charge a bank of secondary cells, and after relating weather conditions which determine charging, battery efficiency and power consumption, it was decided to use 14 Lucas heart pacemaker batteries of 50 ampere hour capacity in a series-parallel arrangement. This number was based on the worst-case premise that there would be no charging at all during the six weeks either side of the winter solstice. In fact there will, of course, be some small amount of charging, so that all calculations have been made with a good margin for error.

Theoretically the system should go on for ever, the only attention required being the topping up of the batteries. It was for this reason that pacemaker models were chosen, as their topping up requirements are minimal. To reduce this still further special oil has been added to the electrolyte, as floating this on top will reduce losses by evaporation.

The solar panel measures $3\frac{1}{2}$ft square and is mounted on the side of the equipment box facing due south and angled at 55 degrees. As with the primary cells, the batteries are placed in the lower compartment and the system is at present on a year's trial at the Islay site. Indications so far are most encouraging.

There will still be a yearly visit to the site, but as there is no need to transport a large stock of heavy batteries, it will be a simple hill walk to top up the batteries and generally look over the installation, and under these conditions the costs will be only a small fraction of that entailed when the Sno-Trac has to be used.

If all continues to go well two further sites, in Arran and Mull, are to be fitted with solar power systems as they are installed, and the remaining station in Skye will be converted this year when the routine primary battery change becomes due. It is hoped that with reliable radio equipment and solar power, major visits at only three- to five-year intervals will be necessary when the secondary cells themselves have completed their useful life. Visits of this frequency should ensure a reliable and very cost-effective system for many years to come.

Sixty Years Ago

The editorial leader of the May, 1915, issue of *The Wireless World* in its philosophical attitude towards the essence of wireless telegraphy has not grown outdated in the passing of 60 years. "At such a time as this when the thoughts of the whole world are directed to war, the fact that looms largest in the attention of the general public is that wireless telegraphy is daily proving its utility as a means of establishing communication with ships at sea, both naval and mercantile, with aeroplanes and aircraft, with submarines and on the battlefield. The public imagination has been fired by the revelation of what it can do in regions hitherto untouched, somewhat to the exclusion of recognition of its utility in familiar fields. . . . In fact, it is immaterial whether we look at the manifold activities of the civilized world or let our vision range geographically over the various parts of the globe: whether we confine our attention to the earth or extend it to the air or to the sea—we still feel that a stage has been reached in the development of wireless telegraphy which justifies our contention that ubiquity forms its most striking characteristic."

World of Amateur Radio

End of "BERU"

The 38th BERU contest, held on March 8–9, was the last under the traditional scheme of the old "British Empire Radio Union" although the RSGB has stated that a new form of British Commonwealth contest will be introduced in 1976. Fittingly, BERU bowed out in a burst of good h.f. conditions with even 28MHz opening to Africa, with Australian and New Zealand stations heard at good strength on 7MHz and with stations towards the west of Canada providing good signals on 14MHz. This, perhaps more than any other h.f. contest, has always provided something rather better than a point-slogging frenzy, requiring considerable knowledge of the times at which various paths are likely to be open on the different bands to obtain high scores. Many British amateurs would have been prouder to claim they had finished ahead of the field in a BERU contest than, for example, to have won one of the trendy contests such as those providing free holidays to the winner!

Low-cost s.s.b. generation

In the first enthusiasm for single-sideband operation, many amateurs in the fifties and sixties used phasing-type s.s.b. generation, mostly with wideband networks such as the Dome and "s.s.b. Jr" or commercial units based on similar configurations. The problem was the need for precise values of components that were not too readily affected by temperature or changes in operating frequency. A few amateurs eliminated the need for accurate wideband quadrature networks by adoption of the "third method" though this requires good balance in one pair of mixers to prevent the radiation of a continuous audio tone. Because of these problems and the difficulties of pre-set adjustment amateurs turned increasingly to filter systems based on h.f. or m.f. bandpass crystal filters or m.f. mechanical filters. For the past decade these have been almost universally used both in factory-built and home-built s.s.b. transmitters and transceivers, even though good s.s.b. filters are significantly more expensive than phasing or third method techniques. Filters have proved reliable in operation and maintain good sideband suppression over long periods without adjustment.

Recently, however, there have been signs that the introduction of digital methods of obtaining 90° phase shifts on r.f. signals (see *Wireless World*, September 1973) has opened the way to low-cost s.s.b. generators that are much easier to set up and require little adjustment over long periods. A number of amateurs have in the past few months successfully implemented both phasing and "third method" systems based on standard integrated circuits as balanced modulators and digital phase-shifters.

But possibly still unique is the work of Peter Martinez, G3PLX of Gosport who is now using on 144MHz a 10.7MHz s.s.b. generator based on the polyphase technique described and patented by M. J. Gingell of STL (*Electrical Communication*, vol. 48, No 1–2, 1973) for use in connection with line telecommunications. Some time ago Peter Martinez designed a six-stage polyphase network based entirely on preferred value components (*Amateur Radio Techniques*, 5th edition, page 181). He has now completed an exciter based on this network in association with a Schottky-clamped 74S74 digital phase shifter, two MC1596 double-balanced modulators, with the "clock" input on 42.8MHz and s.s.b. output on 10.7MHz. Sideband suppression has been adjusted to better than 50dB and he believes that using 1% tolerance resistors it would be quite possible to achieve 40dB.

It seems likely that this is the first time that the polyphase approach has been successfully used in a v.h.f. transmitter—and it is the first reported use of this system in an amateur station. The polyphase network is, in effect, a new way of making a wideband audio phase-shift network and is more tolerant of component values.

Licence trends

The Home Office statistics for licences issued at December 31, 1974 show the continuing trend towards Class B (v.h.f. phone-only) licences which now account for virtually one quarter of British amateur licences, having increased by 638 during 1974 compared with an additional 374 Class A licences. All classes of licence continue to show increases during the year with the total now exceeding 25,000. Fastest rising class of licence is the Class B mobile permit, reflecting the large number of 144MHz n.b.f.m. equipment now in use and the growing number of "repeaters" to extend their range of operation. Since "mobile" licences are usually held by amateurs having also a Class A or Class B permit the total number of British amateurs is now in the region of 20,500.

Amateur licences

	end-1971	end-1972	end-1973	end-1974
Class A	14,065	14,462	14,930	15,304
Class B	3,012	3,718	4,328	4,966
Class A/M	2,666	2,854	3,081	3,424
Class B/M	545	826	1,176	1,549
Television	214	227	254	277
Totals	20,502	22,087	23,769	25,520

Mixed grill

An interesting 20-page account of the development of the original "radio microphone" (at first called a "telesonic" microphone to disguise the fact that a miniature transmitter was involved before the time when the Post Office introduced licences for this application) has been published by Reg Moores of 117 Horton Road, Brighton, who made the first unit in 1947. He is a former professional ice-skater and amateur radio enthusiast (one-time G3GZT I believe) and conceived the idea in the thirties. The first model worked on about 28MHz and later units about 70MHz using three valves. First operational use was for the 1949 Christmas season ice show "Aladdin" at the Brighton Sports Stadium, with the microphone hidden in the clothes of the skater-performers, transmitting signals via a closed loop aerial to an R1481 surplus receiver with the output amplified by a 120-watt Vortexion amplifier. Less happily Reg Moores also believes that this was, in effect, the first "radio bug".

An amateur who has held amateur licences for nearly 50 years is H. E. F. Taylor, G6HT of Torquay who was first licensed as 6FZ in January 1926 (although he had previously operated on 400 to 1000 metres using ex-trench sets of the Felsted OTC) but who, from 1928 to 1956, operated in India under the call-signs VU2FS and VU2AT and during the war in the wireless sections of an Indian Auxiliary Force unit and the Royal Signals.

The RSGB 21st National VHF Convention is being held at the Winning Post Hotel, Whitton, Twickenham, Middlesex on May 10–11 with lecture sessions on the Saturday afternoon and Sunday morning, a dinner-dance on the Saturday evening, trade show and exhibition of home-constructed equipment and with an anticipated attendance of over 700 (details from "VHF Convention", RSGB, 35 Doughty Street, London WC1).

The h.f. beacons ZL2MHF (28.170MHz) at Mount Climie, New Zealand and PY1CK (28.160MHz) at Rio de Janeiro, Brazil, are now in operation but a recent hurricane has put 3B8MS, Mauritius, temporarily out of action. Incidentally, does any reader know the location of the single-letter "beacons" that operate around 20,995kHz and in the 3.5MHz band? I believe they are part of the American Military Affiliate Radio System. Their considerable value as a guide to 21MHz conditions would be enhanced by knowing even roughly where they are located!

R. W. Addie, G8LT recently had a 20-minute r.t.t.y. contact with W2LFL over the Oscar 7 satellite. Battery conditions on the Oscar 6 satellite could mean another year of operational life—it was launched in October 1972 and still going strong.

The Amateur Radio Mobile Society's rally, due to be held on May 18 at Northwick Park Hospital, has had to be cancelled.

PAT HAWKER, G3VA

New Products

100MHz counter-timer

A new 100MHz multifunction counter-timer, known as the model 9838, has been added to the range of counter-timers manufactured by Racal Instruments Ltd. The instrument has a basic sensitivity of 10mV throughout its range, and will directly measure frequency, single and multiple periods or ratios, single and double line time intervals including positive or negative pulses or contact closures and also multiple events. A six-digit filament tube display is provided with gate and overflow l.e.ds to ensure unambiguous measurement in all modes of operation. The counter-timer, which is fully portable, measures 96.5 × 240 × 268mm and conforms to BS4743 safety recommendations. Racal Instruments Ltd, Duke Street, Windsor, Berks SL4 1SB.

WW315 for further details

Heat Pipe

A forced-cooled heat pipe system uses four 18in pipes with a fan-cooled condenser section 6in cubed. The thermal resistance from the pipes to ambient air is 0.05°C/W which allows, say the makers, a dissipation of up to 1.2kW. The system, which may be used to cool fluids or banks of power semiconductors, will operate at temperatures up to 150°C. Solek Ltd, 16 Hollybush Lane, Sevenoaks, Kent.

WW314 for further details

Wire stripper

A pneumatic gun that will cut and strip up to five p.v.c. wires in one operation is now available from ITT. The tool has been designed for fast precision work on cable forms in telecommunication-wiring type operations. Wires from 0.3 to 0.8mm can be cut and stripped at a speed of around 6,000 per hour. ITT Components Group Europe, Equipment Products Division, Thornton Industrial Estate, Milford Haven, Dyfed.

WW316 for further details

Electroplated p.t.f.e. microstrip

Polyplate microstrip substrates in electroplated p.t.f.e. offer low interface losses due to the absence of discontinuity and chemical adhesives between metal electrode deposit and substrate, as well as good machinability, mechanical strength and adhesion. The makers, Polyflon Resine, of Milan, claim a high pulse propagation speed, high dielectric strength and a dielectric constant essentially unchanging with frequency, making them suitable for L-, S-, C- and X-band wavelengths. Polyflon Resine, Via Mezzago, 20050 Sulbiate, Milan, Italy.

WW322 for further details

Camera tubes

The XQ1410 series of Plumbicon television camera tubes features a resolution of better than 700 TV lines and a typical sensitivity of 400μA/lumen. The tubes have a 30mm diameter lead-oxide photoconductive target and use magnetic focusing and deflection. The tubes, which are directly interchangeable with the less sophisticated XQ1020 series, have a range of matched deflection coil assemblies available to ensure optimum performance. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

WW318 for further details

Temperature alarm

The Digilimit 205 is a temperature indicator which operates from thermocouples or resistance thermometers, and has two independent alarm points. The alarms are digitally set to any point in the temperature range and digital circuitry compares the actual and selected temperatures. The output from each alarm is via a solid-state switch which is isolated from the signal input. Control and Readout Ltd, Burrell Buildings, Churchill Industrial Estate, Lancing, Sussex BN15 8TZ.

WW310 for further details

Coil set

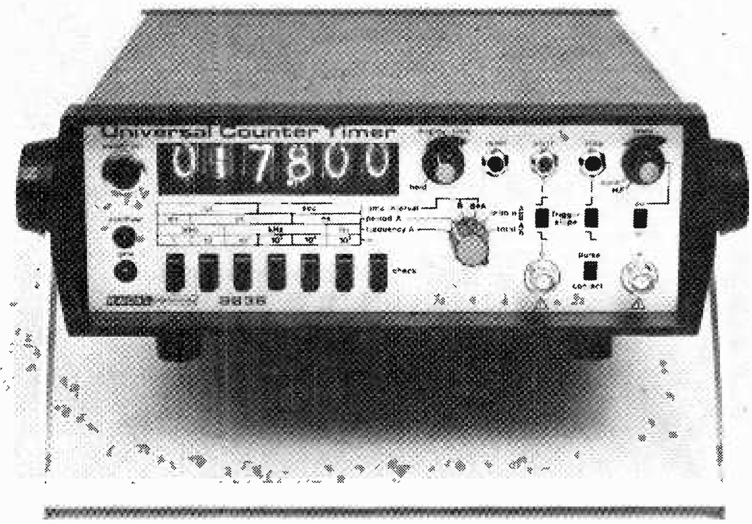
A set of coils for the Motorola MVAM1 varicap diode tuner is announced by Toko. They are medium-wave coils, and the set comprises aerial, r.f. oscillator, detector coils and ceramic filters for use with the μA720/CA3123E integrated circuit series. The set is designated the 6a/3123 and is obtainable from Ambit International, 37 High Street, Brentwood, Essex.

WW320 for further details

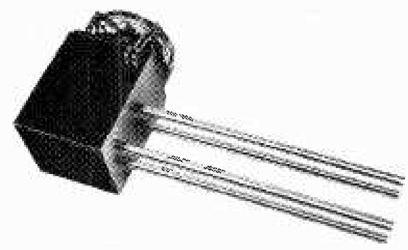
Thermostats

The 28030 series of bi-metal thermostats by Electrovac will switch 4A at 25V, 50Hz. It is said to be capable of 10^5 switching operations and is obtainable with several lead arrangements. Body dimensions are 11mm diameter × 7.5mm and there is a mounting lug. Joseph Electronics Ltd, Westminster House, 188–190 Stratford Road, Shirley, Solihull, West Midlands.

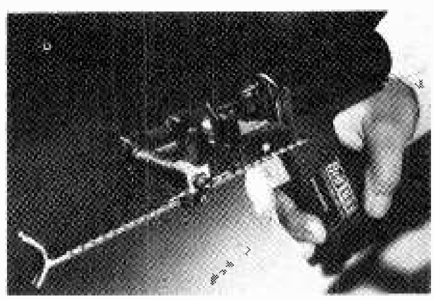
WW321 for further details



WW315



WW314



WW316

Oscillator

Type TG200DMP is a sine/square-wave RC oscillator with a frequency range from 1Hz to 1MHz in 12 semi-decade ranges. The instrument incorporates a fine control calibrated from 0 to +1%, and an output voltage variable from 200μV to 7V r.m.s. Sine-wave distortion is less than 0.1% below 5V output and between 10Hz and 100kHz. Square-wave rise time is less than 150ns at all frequencies. Levell Electronics Ltd, Moxon Street, Barnet, Herts.
WW308 for further details

Ribbon cable

A new range of ribbon cables includes bonded and extruded types with solid or stranded copper conductors providing a choice of current ratings. The cables have a p.v.c. colour-coded insulation with an operating temperature range from −10 to +70°C. Belling & Lee Ltd, Great Cambridge Road, Enfield, Middlesex.
WW317 for further details

Resistors

A range of resistors from 1Ω to 100MΩ is available in a $\frac{1}{4}$W package measuring only 0.25×0.09in diameter. These miniature components have resistance variations of less than 2% in the temperature range −15 to +85°C with a failure rate of less than 0.001%/1000hrs. Jermyn Distribution, Sevenoaks, Kent.
WW319 for further details

Power supplies

Marconi Instruments has introduced a new range of general-purpose d.c. power supplies comprising the TF2153/154/155. These supplies provide a choice of voltages up to 60V and currents up to 4A, with a maximum power of 30W. Push-buttons alongside the panel-meter select monitoring of output voltage or current, with two sensitivities for each mode. Marconi Instruments Ltd, Longacres, St Albans, Herts.
WW311 for further details

200-way switch

A new switch from Sakae can be supplied for switching 30, 50, 100 or 200 ways; the switches can also be ganged. The contacts are arranged on a helical mounting strip, the wiping contact traversing the switch contacts in 3, 5, 10 or 20 complete rotations respectively. The indexing mechanism for the switch is contained in a multi-turn dial, giving an accuracy of switching to within ±2°. Techni Measure Dell House, Eastern Dene, Hazlemere, High Wycombe, Bucks HP15 7BT.
WW313 for further details

Coaxial attenuators

The Elcom Systems AT-50 series of calibrated 50Ω fixed attenuators can be used from 0 to 1500MHz. The devices are rated at 0.5W c.w. or 1000W peak power in the temperature range −25 to +85°C and are available as separate components or in sets with values of 1 to 10dB in 1dB steps and 10 to 20dB in 2dB steps. Aspen Electronics Ltd, 18a High Street, Northwood, Middlesex HA6 1BN.
WW312 for further details

Decade resistance box

The DB5R decade resistance box uses thumbwheel switching to select resistances from 10Ω to 1MΩ in five decades. The unit is housed in a plastic box with two sockets for the output. A chart for selecting resistor values is also available from the manufacturers. H & W Logitek Electronics Ltd, 13 Carron Place, Kelvin Industrial Estate, East Kilbride.
WW307 for further details

Capacitance meter

A direct-reading capacitance meter with dimensions of 150×85×40mm will measure capacitances up to 0.5μF in five switched ranges. The meter is powered from two 9V batteries and incorporates a battery-check facility. Chinaglia (UK) Ltd, 19 Mulberry Walk, London SW3.
WW304 for further details

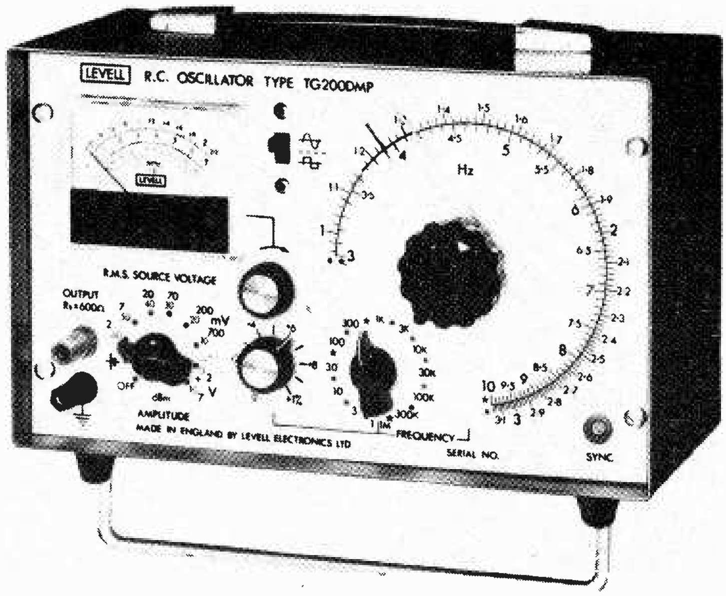
Multimeter

The model 2000 Danameter is one of the few instruments to use a liquid crystal display which, because of the very low power consumption, gives a claimed battery life of one year. The meter will measure direct and alternating voltages up to 1000V with a resolution of 1mV, direct current up to 2A with a resolution of 0.01μA, and ohms up to 200MΩ with a resolution of 0.1Ω. Dana Electronics Ltd, Collingdon Street, Luton, Beds.
WW303 for further details

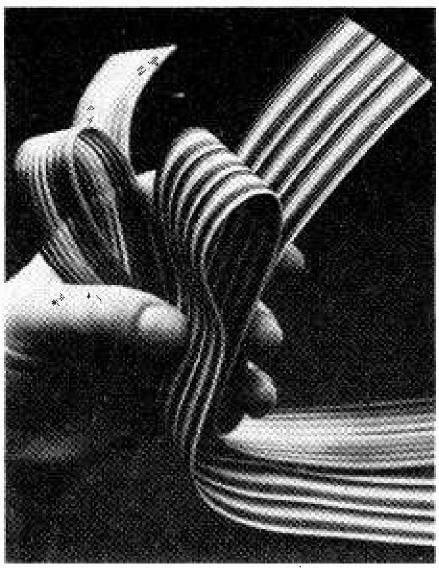
Digital to d.c. converter

The model 1501 converts a 14-bit digital input into two d.c. output voltages which are proportional to the sine and cosine of the input phase angle from 0° to 360°. Specifications of the instrument are an accuracy to within ±5% at 25°C, and individual outputs accurate to within ±0.1% f.s.d. at 25°C.

The input is buffered and includes a storage register that holds each data bit. A positive pulse, t.t.l. level, 2μs in width



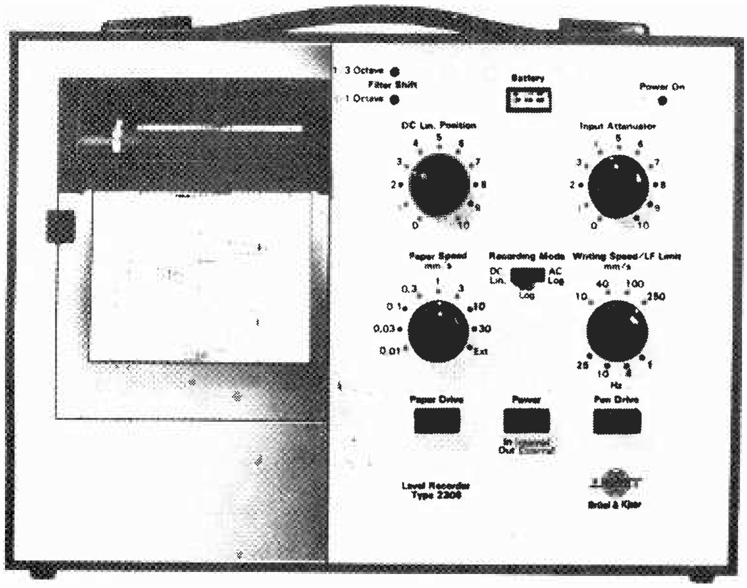
WW308


WW317

controls the transfer of data into the input register. The output voltages vary from 0 to ±10V d.c. with an output impedance of 1Ω for each source. REL Equipment and Components Ltd, Croft House, Bancroft, Hitchin, Herts SG5 1BU.
WW302 for further details

Level recorder

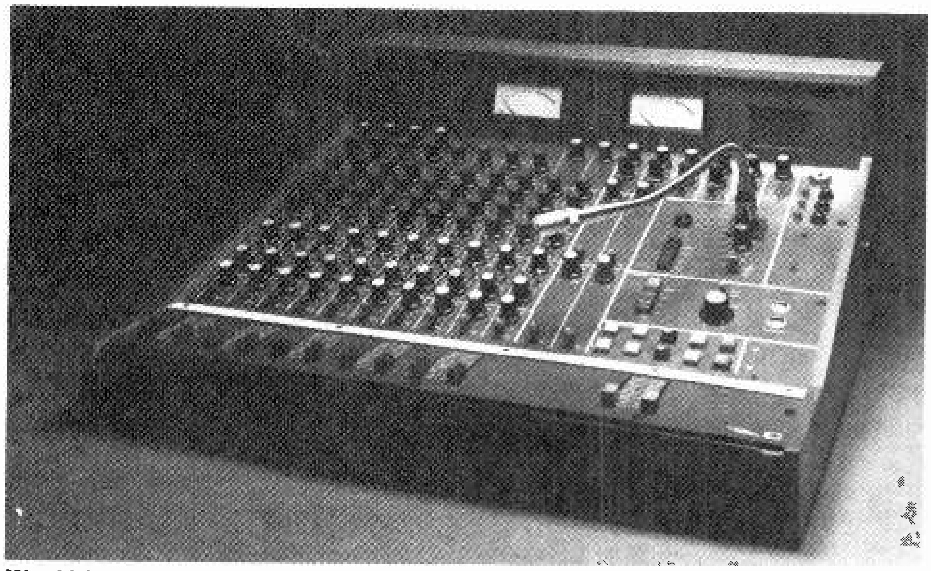
B & K Laboratories has announced a portable graphic level-recorder weighing only $7\frac{3}{4}$lb. The instrument, type 2306, provides three recording modes—logarithmic a.c. and d.c. in two dynamic ranges, and linear d.c. with variable zero calibration. In the a.c. mode, r.m.s. values of waveforms in the frequency range 1Hz to 20kHz are recorded with an accuracy to within ±0.5dB. In the d.c. modes, sinusoidal signals up to 1.6Hz may be recorded. B & K Laboratories, Cross Lances Road, Hounslow, Middx.
WW309 for further details



WW309

Mixing desks

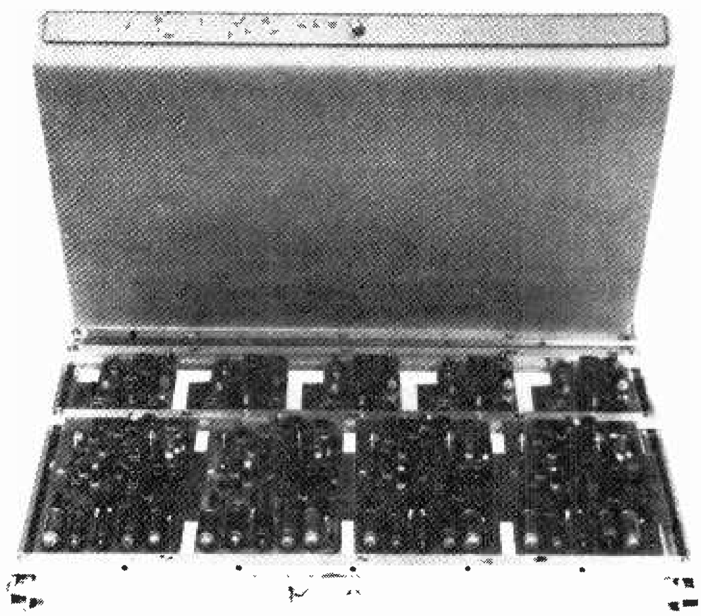
Cambridge Electronic Workshop has developed a new range of portable, stereophonic sound-mixing desks for theatre use. Features of the equipment are continuously variable presence-frequency and gain, separate mic. and line inputs and two auxiliary sends with pre/post switching on all ten channels. Other useful items on the desk are cue lights, intercom system, monitoring facilities and loudspeaker switching. The desks, which have 0.1% distortion and input noise better than −126.5dBm, measure 24in square × 11in high for the standard version with special requirements on request. Cambridge Electronic Workshop, 8 Perowne Street, Cambridge.
WW306 for further details



WW306

p.c.b. assembly frame

The DURO-04 p.c.b. assembly frame will accept boards from 1.5×1.5cm up to 30×42cm. The boards can be located in any position on the frame where they are held in position by special clips. After the components have been inserted they are held in place by closing the lid, which is lined with a foam material. The frame is then turned over to expose the underside of the p.c.bs for soldering. Circuitape Ltd, New Street, Aylesbury, Bucks.
WW305 for further details



WW305

Digital i.c. tester

Electro Scientific Industries has introduced an i.c. tester suitable for evaluating t.t.l., d.t.l. and c.m.o.s. logic in d.i.l. packages. The tester, model 1248, does not require a reference i.c. because each device is separately switch-programmed. Tranchant Electronics UK Ltd, Tranchant House, 100a High Street, Hampton, Middlesex TW12 2ST.
WW301 for further details

Microwave detector

A hand-held r.f. monitor has been designed to measure leakage fields emanating from microwave ovens. Operating frequency is 2450MHz ±25MHz and the indicated power range is from 0 to 10mW/cm². R. E. L. Equipment Ltd, Croft House, Bancroft, Hitchin, Herts.

WW327 for further details

Modular benching

Modular benching from Modulux is based on standard bench modules with a variety of ancillary equipment including drawers, databoards and trunking. Metal parts of the systems are stove-enamelled and the bench tops are covered in either a laminate or a non-slip material. Modulux, St. Michael's Road, Aldershot, Hants GU12 4JW.

WW326 for further details

Boxes

Boplast polycarbonate boxes are built to VDE standards, will withstand temperatures up to 140°C, and are water/oil/petrol resistant. The range contains 28 sizes from 35×52×5mm rising to 36×20×15cm with two sizes available with clear covers. Prices vary from 75p to £9 depending on size and quantity. West Hyde Developments Ltd, Ryefield Crescent, Northwood. Middx HA6 1NN.

WW325 for further details

Miniature coaxial cables

Miniature coaxial cables, suitable for applications up to 3GHz, feature a silver-plated copper conductor, p.t.f.e. dielectric, silver-plated copper screen and an outer sleeve, allowing operation in the −90 to +200°C temperature range. Type 50VMTX is a 50Ω cable with a diameter of 1.17mm and type 75VMTX is a 75Ω cable of 1.22mm in diameter, Waycom Ltd, Wokingham Road, Bracknell, Berks RG12 1ND.

WW328 for further details

Solid State Devices

The names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

Stripline mixer diodes

Models 5082-2207/10 are passivated silicon Schottky diodes in the beam-lead configuration, intended as mixers for microwave i.cs, microstrip or stripline application. Lowest noise figure (5082-2207) is 6dB at 9GHz, with a v.s.w.r. of 1.5:1. Matched pairs are available.

WW350 for further details **Hewlett-Packard**

Bipolar RAMS

256-bit bipolar random-access memories in low-power Schottky format. Access time is 45ns over the temperature range 0°C to 75°C and device dissipation is 275mW. Both models—Am27LS00/1—are organised as 256 words by 1 bit with either tri-state ('00) or open outputs.

WW351 for further details **Advanced Micro Devices**

Calculator chip

A m.o.s. calculator i.c., C596 intended for eight-digit "slide-rule" calculators, offers the four arithmetic functions, trigonometric (in degrees or radians) and log functions. There is also provision for $\sqrt{x}$ and $1/x$ and a key for π. The chip can be used either in dual-function key calculators or in 35-key single-function units. Floating point or scientific operation can be used, overflow causing the automatic change to scientific notation of mantissa and exponent. The new i.c. has the same pin connexions and voltage levels as the C594 and C595, which means that four-function calculators can be uprated very easily.

WW352 for further details **GIM**

Peripheral interface

MC6820 is a peripheral interface adaptor for use between input/output equipment and the Motorola microprocessor and contains six registers with a control and selection logic section. Control lines between the microprocessor and p.i.a. give the former control of the latter, although the p.i.a. can interrupt to allow a peripheral unit access.

WW353 for further details **Motorola**

Power transistors

A range of TO-3 metal power transistors from Thomson-CSF, using the n-p-n triple-diffusion technique. Types are BUX10 to BUX15, rated at 150W at between 125V V_{ceo} at 25A and 500V V_{ceo} at 8A. BUX20 to BUX25 are 250W devices for up to 500V V_{ceo} at 15A.

WW354 for further details **Lock**

Si rectifiers

Three families of power diodes. The BYX98 family possess a non-rep. surge rating of 60A and rep. p.r.v. from 300V to 1200V. BYX99 are rated similarly at 160A and up to 1200V, and BYX96 are 20A types at up to 1600V. All types are in DO-4 encapsulations and reverse polarity versions are available.

WW356 for further details **Mullard**

A/d converter

MN 5210 is a family of 12-bit analogue-to-digital converters with a maximum conversion time of 12μs. Power dissipation is 700mW from 15–0–15V and 5V rails, and input ranges are 0 to −10V, ±5V or ±10V with internal or higher-precision external references. Accuracy of $\pm\frac{1}{2}$ least significant bit is offered over commercial or military temperature ranges.

WW355 for further details **Tranchant**

Thyristor

The CS651 thyristor possess a built-in, auxiliary thyristor which is switched on by a small pulse. When the forward current of this device reaches a high value it is applied to the main thyristor gate. This feature is claimed to provide a 75A/μs di/dt rating. The unit is in disc form and withstands repetitive p.r.v. of 2.4kV, continuous limiting current of 650A and a surge current of 14000A.

WW357 for further details **Brown Boveri**

Timer

A product of the Ferranti collector diffusion isolation technique for the provision of digital and linear elements on one chip. A variable-frequency RC oscillator drives a divided-by-4096 counter, the frequency being externally adjustable, and the timed period is 4096 CR, where C and R are external components.

WW358 for further details **Ferranti**

Yellow l.e.ds

Siemens have added yellow-light devices to their range of light-emitting diodes. Types LD35 (3mm) and LD55 (5mm) are gallium phosphide units, and LD48 contains up to 10 characters per row.

WW359 for further details **Siemens**

Hewlett-Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.
Advanced Micro Devices Inc., 901 Thompson Place, Sunnyvale, California 94086, USA.
General Instrument Microelectronics Ltd, 57–61 Mortimer Street, London W1N 7TD.
Motorola Ltd, York House, Empire Way, Wembley, Middlesex.
Lock Distribution, Neville Street, Middleton Road, Oldham, Lancs OL9 6LF.
Tranchant Electronics (UK) Ltd, Tranchant House, 100a High Street, Hampton, Middx.
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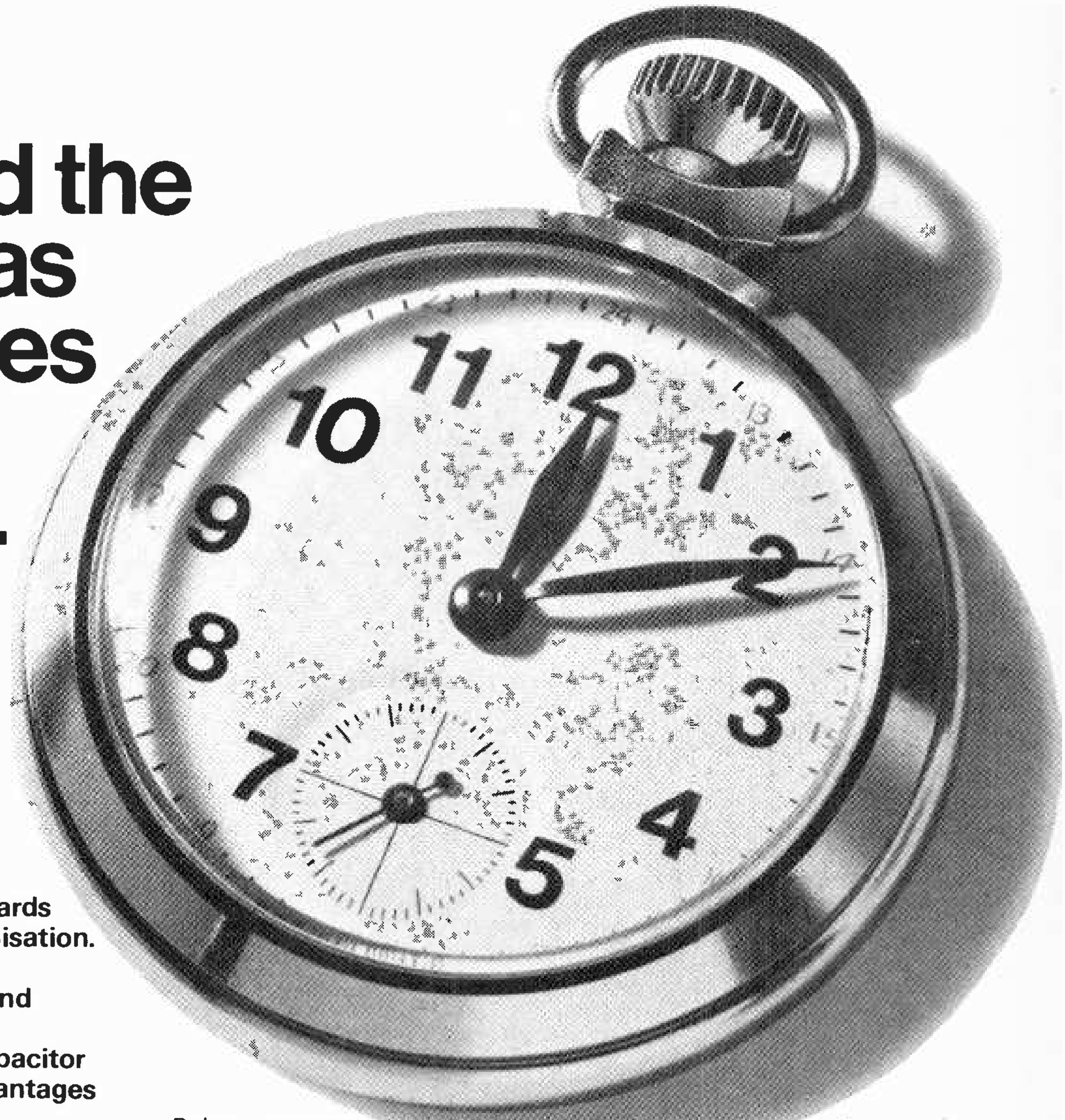

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*We incorporate the Quilter modification which is most important as it reduces distortion and increases the bass and treble control range.
As can be seen from the photograph the tone control unit is very slim (only 1½" from front to back) and may therefore be used in many other applications than our Bailey metalwork which it is designed to fit.
METALWORK AND WOODEN CASES These have been under review for some time: please send for latest information.
F.M. TUNER This latest addition to our range is designed to offer the best possible performance allied to the ease of operation given by push button varicap tuning. We have taken great care to look after the constructors' point of view and there are no coils to wind, no RF circuits to wire and no alignment is required, in fact the whole unit can be easily completed and working in an evening as there are only 3 transistors, one IC and two ready built and aligned modules comprising the active components. We have abandoned the concept of having a tuner as large as the amplifier and this new unit has a frontal size of only 1½ in. × 4 in. It can be mounted on the side of our Bailey amplifier metalwork thus turning it into a tuner/amplifier whilst only increasing its width by 1½ in.
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2	Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on pack 1	£4.80
3	Set of transistors, diodes, LED, integrated circuits for mounting on pack 1	£6.25
4	Pre-aligned front end module, coil assembly, three-section ceramic filter	£8.80
5	Fibreglass printed circuit board for stereo decoder	£1.10
6	Set of metal oxide resistors, capacitors, cermet preset for decoder	£2.60
7	Set of transistors LED, integrated circuit for decoder	£3.45
8	Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs preset adjusters, etc.	£8.30
9	Function switch, 10 turn tuning potentiometer, knobs	£5.30
10	Frequency meter, meter drive components, fibreglass printed circuit board	£8.60
11	Toroidal transformer with electrostatic screen, Primary: 0–117V–234V	£4.45
12	Set of capacitors, rectifiers, voltage regulator for power supply	£2.95
13	Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£1.50
14	Set of metal work parts including silk screen printed facia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc.	£6.50
16	Teak cabinet	£7.35
	One each of packs 1–16 inclusive are required for complete stereo FM tuner.	
	Total cost of individually purchased packs	£74.10

NOVEL STEREO FM TUNER

In the April and May 1974 issues of *Wireless World* there was published by J. Skingley and N. C. Thompson a novel design for an f.m. tuner which combines consistent high performance with the elimination of the critical setting-up procedure required by too many earlier tuners. The front end is a ready built pre-aligned module which then feeds an amplifier driven screened three section ceramic filter leading to an integrated circuit five-stage limiting amplifier providing excellent a.m. rejection. This is followed by a single coil integrated balanced demodulator from which the audio output may be taken. Temperature compensated varicap tuning allows stations to be selected either by a ten-turn tuning potentiometer or by a choice of six preset push-button controls. Each of the preset controls can be adjusted on the front panel with the settings being indicated by six LED lamps behind an acrylic silk screen printed facia panel insert. Additional circuitry includes temperature compensated AFC restricted to less than station spacing, inter-station muting, a single-lamp LED tuning indicator and a linear scale frequency meter. The stereo decoder, built on a separate board, is based on a well-proven integrated circuit phase-locked-loop to which has been added active filters to remove sub-carrier harmonics and 'birdies'. The power supply, to ensure station holding stability, uses an integrated circuit voltage regulator which is powered via a low-hum field specially designed TOROIDAL TRANSFORMER.

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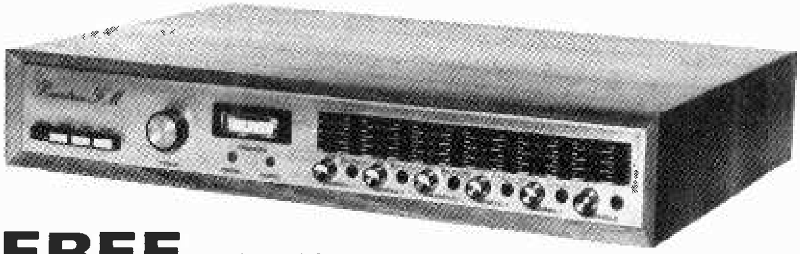

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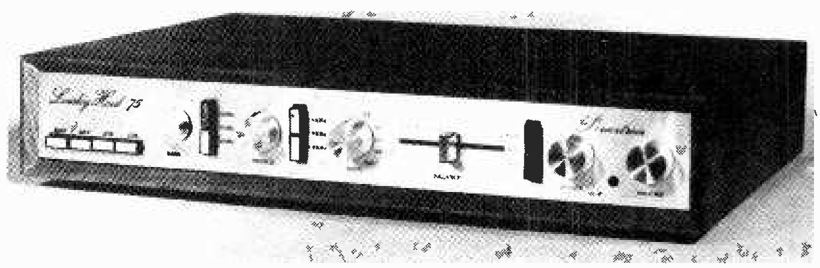
DESIGNER APPROVED KIT

In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November 1972–February 1973) and a subsequent follow-up article (April 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

Hi-Fi News Linsley-Hood 75W/Channel Amplifier Mk III Version (modifications as per Hi-Fi News April 1974)



Full circuit description in handbook (pack 15—price 30p)

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5	Fibreglass printed-circuit board for pre-amp.	£1.30
6	Set of low noise resistors, capacitors, pre-sets for pre-amp.	£2.70
7	Set of low noise, high gain semiconductors for pre-amp.	£2.40
8	Set of potentiometers (including mains switch)	£2.05
9	Set of 4 push-button switches, rotary mode switch	£3.70
10	Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V, secondaries: 33-0-33 V, 25-0-25 V.	£9.15
11	Fibreglass printed-circuit board for power supply	£0.65
12	Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£3.50
13	Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, interconnecting cable, control knobs	£4.25
14	Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£6.30
15	Handbook	£0.30
16	Teak cabinet	£7.35
	2 each of packs 1–7 inclusive are required for complete stereo system	
	Total cost of individually purchased packs	£69.75

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CY31	0.50	EF36	0.65
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DF96	0.55	EF40	0.75
DK96	0.55	EF41	0.65
DL92	0.40	EF80	0.30
DL96	0.60	EF83	1.25
DY86/87	0.40	EF85	0.35
DY802	0.45	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
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ECC81	0.40	EL84	0.30
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ECC83	0.35	EL86	0.45
ECC84	0.35	EL90	0.45
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ECC86	0.90	EM31	0.60
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ECF80	0.40	EM87	1.00
ECF82	0.40	EY51	0.45
ECF801	0.75	EY81	0.45
ECH42	0.80	EY86	0.40
ECH81	0.35	EY88	0.50
ECH83	0.45	EZ40	0.70
ECH84	0.45	EZ41	0.75

Many of these valves are imported and prices vary for each delivery, so we reserve the right to change prices for new stock when unavoidable.

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EZ81	0.30	PL802	0.95	U801	0.75
GY501	0.75	PY33	0.60	UABC80	0.40
GZ34	0.70	PY80	0.40	UAF42	0.65
GZ37	1.00	PY81	0.40	UBC41	0.60
KT66	2.50	PY82	0.40	UBF80	0.40
KT88	3.00	PY83	0.40	UBF89	0.40
MH4	0.75	PY88	0.45	UBL1	1.00
ML6	0.65	PY500	1.00	UBL21	0.70
OA2	0.45	PY800	0.45	UCC85	0.45
OB2	0.45	PY801	0.50	UCF80	0.75
PABC80	0.40	QQVO3-10	1.40	UCH42	0.75
PC97	0.50	QQVO6-40A	8.00	UCH81	0.45
PC900	0.50	QVO3-12	1.10	UCL82	0.45
PCC84	0.40	R19	0.60	UCL83	0.65
PCC85	0.40	SC1/400	3.00	UF41	0.70
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PCC89	0.50	SP61	0.75	UF85	0.45
PCC189	0.60	TT21	5.00	UF89	0.50
PCF80	0.40	U25	0.85	UL41	0.70
PCF82	0.40	U26	0.75	UL84	0.40
PCF84	0.90	U27	0.65	UY41	0.45
PCF86	0.60			UY85	0.40
PCF200	0.75			VR105/30	0.45
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				
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	£		£
VR150/30	0.45	3D6	0.40
X66	0.65	3S4	0.40
Z800U	2.70	3V4	0.85
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1A3	0.55	5R4GY	0.90
1L4	0.25	5U4G	0.50

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1R5	0.40	5Y3GT	0.55
1S4	0.30	5Z3	0.80
1T4	0.30	5Z4	0.80
1X2A	0.60	5Z4TG	0.55
1X2B	0.75	6AB7	0.60
2D21	0.50	6AC7	0.60
2K25	9.00	6AH6	0.70

	£		£
6AK5	0.40	6C6	0.50
6AK8	0.40	6CB6	0.50
6AL5	0.30	6CH6	1.45
6AL5 W	0.55	6CL6	0.75
6AM6	0.45	6D6	0.55
6AN8	0.45	6EA8	0.85
6AQ5	0.45	6F7	1.10
6AQ5W	0.70	6F8G	0.75
6AS6	0.80	6F23	0.90
6AT6	0.45	6F32	0.75
6AU6	0.40	6F33	3.50
6AV6	0.45	6H6	0.35
6AX4GT	0.75	6J4WA	1.25
6AX5GT	1.00	6J5	0.65
6B7	0.70	6J5GT	0.50
6BA6	0.35	6J6	0.30
6BE6	0.40	6J7	0.60
6BG6G	0.90	6J7G	0.40
6BJ6	0.65	6K6GT	0.80
6BQ7A	0.60	6K7	0.55
6BR7	1.20	6K7G	0.30
6BW6	1.00	6K8GT	0.50
6BW7	1.00	6K25	1.00
6C4	0.40	6L6	1.25

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

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6L7G	0.40	30FL1	1.00	1629	0.70
6SA7	0.50	30FL12	1.10	2051	1.00
6SA7GT	0.40	30FL14	0.90	5933	3.00
6SC7GT	0.40	3OL15	0.95	6057	0.75
6SG7	0.50	3OL17	0.95	6060	0.70
6SJ7	0.55	30P12	1.00	6064	0.60
6SJ7GT	0.35	30P19	1.00	6065	1.00
6SK7	0.55	30PL1	0.95	6080	2.30
6SL7GT	0.50	30PL13	1.10	6146	2.25
6SN7GT	0.50			6146B	3.25
6SQ7	0.55			8020	5.00
6V6G	0.15			9001	5.00
6V6GT	0.50			9002	0.50
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6X5G	0.40			9004	0.35
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12BH7	0.50	30PL14	1.10		
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12K5	1.10	35Z4GT	0.70		
12K7GT	0.50	50C5	0.60		
12K8GT	0.70	5DCD6G	1.10		
12Q7GT	0.70	75	1.00		
12SA7GT	0.70	75C1	0.75		
12SG7	0.55	76	0.75		
12SJ7	0.55	78	0.70		
12Y4	0.40	80	0.75		
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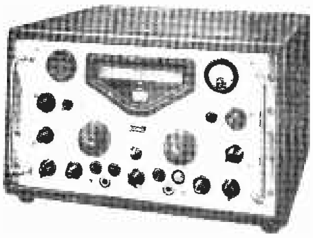

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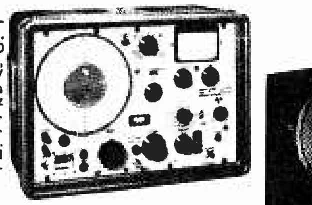

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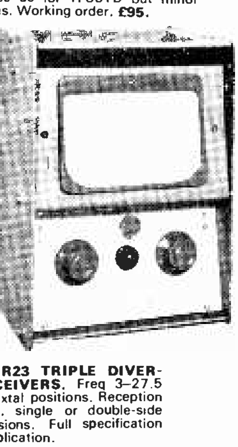

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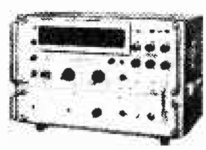

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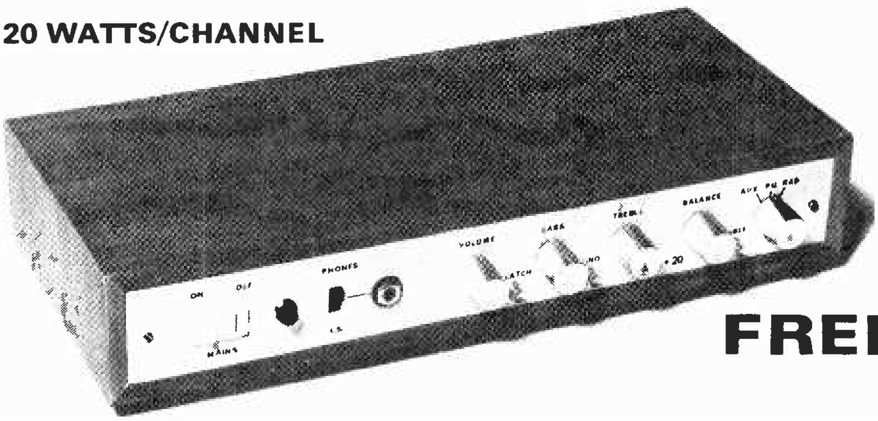
20 WATTS/CHANNEL



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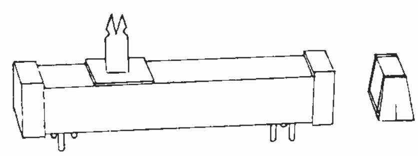

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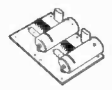
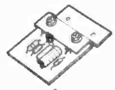
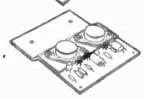

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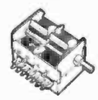

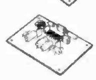
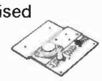

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40N2	40	40	NPN	30p	90N2	40	40	NPN	35p
40P1	15	15	PNP	20p	90P1	15	15	PNP	25p
40P2	40	40	PNP	30p	90P2	40	40	PNP	35p

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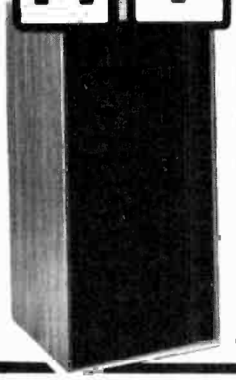


LE-4 SPEAKERS

Superb performance and beautifully finished in selected teak veneers. A professional standard four-way speaker system giving 25 watts RMS power handling. Bass unit is 14"×9" with 8"×5" unit for mid-range and twin 3" high frequency units to give monitor type quality and performance. **Specification** – Size 33"×14"×16" approx. Impedance 8 ohms. Power handling 25W RMS. (Peak 50 watts.) Frequency range 35 Hz–20 KHz.

Our Price £29.00 (normally £56.97) +£5 p & p.

EMI 350 KIT

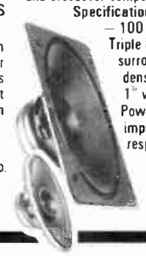
System consists of a 13"×8" approx. woofer with a 3" tweeter, crossover components and circuit diagram. Frequency response: 20 Hz to 20 KHz. Power handling 15 watts RMS into 8 ohms. (Peak 30 watts.)

Complete with crossover components and circuit diagram

£5.50 +£1 p & p.

*20 WATT SPEAKER SYSTEM

System consists of a 13"×8" (approx.) eliptical woofer unit with a 8"×5" (approx.) mid-range unit incorporating parasitic tweeter and crossover components. **Technical Specification:** Bass Unit: Flux density – 100 K, speech coil – 1½". Cone. Triple laminated paper with P.V.C. surround. Mid-Range Unit: Flux density – 33 K, speech coil – 1" with parasitic tweeter. Power handling: 20 watts RMS. impedance – 8 ohms. frequency response – 20 Hz to 18,000 Hz.



Our Price £7.50 Complete +£1.35 p & p.

EASY TO BUILD SPEAKER KITS

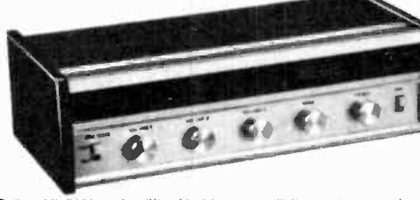
These superb simulated teak-finished speaker kits have been specially designed by RT-VC for the cost-conscious hi-fi enthusiast who wants top quality speakers but doesn't want to spend the earth. Built to EMI's exacting specification, these new RT-VC speaker kits (350 type kit) incorporate 13"×8" woofer, 3½" tweeter and matching crossover. Easily put together with just a few basic tools.

Specification (each speaker): Impedance 8 ohms. Power handling 15 watts RMS (30 watts peak). Response 20–20,000 Hz. Size 20"×11"×9½" approx. Comparable built units (EMI LE3) sold elsewhere for over £45 pair.

£18.95 pair complete +£4.50 p & p.

Complete with crossover components and circuit diagram

*DISCO AMPLIFIER



Reliant Mk IV Mono Amplifier, ideal for the small disco or house parties. Outputs 20 watts RMS into 8 ohms (suitable for 15 ohms).
Inputs *4 electrically mixed inputs. *3 individual mixing controls.
*Separate bass and treble controls common to all 4 inputs.
*Mixer employing F.E.T. (Field Effect Transistors). *Solid State circuitry.
*Attractive styling.
INPUT SENSITIVITIES – Input – 1). Crystal mic. guitar or moving coil mic. 2 and 10mV. (Selector switch for desired sensitivity.) – Inputs – 2), 3), 4). Medium output equipment – ceramic cartridge, tuner, tape recorder, organs, etc. – all 250mV sensitivity. AC Mains. 240V operation. Size approx: 12½"×6"×3½". **£17.00** +£1.15 p & p.

*PORTABLE DISCO CONSOLE

INCORPORATES: Pre-Amp with full mixing facilities, including switched input for mic with volume control, switched input for auxiliary with volume control, bass and treble controls, volume control and blend control for turntables.
Two B.S.R. MP60 type single play professional series decks, fitted with crystal cartridges.

TECHNICAL SPECIFICATION:
Pre-amp – Output – 200mV. Auxiliary inputs – 200mV and 750mV into 1 meg. Mic input – 6mV into 100K. 240 volt operation.
Turntables capacity – 7", 10" or 12" records.
Rumble, wow and flutter
Rumble Better than –35dB. Wow Better than 0.2%.
Flutter Better than 0.06% (Gaumont kalee meter).
Finish – Satin black mainplate with black turntable mat inlaid with brushed aluminium trim. Tonearm and controls in black and brushed aluminium.

Console size – Unit Closed – 17¾"×13¾"×8¾" (approx.)
Unit Open – 35¾"×13¾"×4¾" (approx.)

This disco console is ideally matched for the Reliant IV and Disco 50 or any other quality amplifier.
The unit is finished in black PVC with contrasting simulated teak edging, diamond spun control knobs with matching control panel.

Yours for only £49.00 +£5.60 p & p.

*PUSH BUTTON CAR RADIO KIT– THE TOURIST TT

NO SOLDERING REQUIRED!

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Fine tuning push button mechanism is fully built and tested to mate with printed circuit board.
TECHNICAL SPECIFICATION: (1) **Output** 4 watts RMS output. For 12 volt operation on negative or positive earth. (2) **Integrated** circuit output stage, pre-built three stage IF Module. **Controls volume** manual tuning and five push buttons for station selection, illuminated tuning scale covering full, medium and long wave bands.
Size chassis 7" wide, 2" high and 4¼" deep approx. **£8.00** +90p p & p.
Speaker including baffle and fixing strip £1.65+37p. p & p.
Car Aerial Recommended–fully retractable £1.37+32p. p & p.
The Tourist I Kit For the experienced constructor. If you can solder on a printed circuit board you can build this model. Same technical specification as Tourist TT **Price £7.00** +90p p & p.

Scotland P & P Surcharge
System 1a £1.75 System 2 £3.50

*COMPLETE STEREO SYSTEM

System 1a. £62.00 **40 Watt Amplifier. Viscount III – R102** now 20 watts per channel. (40 watts peak).

All systems include:
Viscount III amplifier – volume, bass, treble and balance controls, plus switches for mono/stereo, on/off function and bass and treble filters. Plus headphone socket.
Specification:
20 watts per channel into 8 ohms (40W peak). Total distortion@ 10W@ 1kHz 0.1% *P.U.1* (for ceramic cartridges) 150mV into 3 Meg. *P.U.2* (for magnetic cartridges) 4mV @ 1kHz into 47K. equalised within ∓1dB R.I.A.A. *Radio* 150mV into 220K. (Sensitivities given at full power). Tape out facilities: headphone socket, power out 250mV per channel. *Tone controls and filter characteristics. Bass* +12dB to –17dB@ 60Hz. Bass filter: 6dB per octave cut. Treble control: treble+12dB to –12dB@ 15kHz. Treble filter: 12dB per octave. *Signal to noise ratio: (all controls at max.)* –58dB. Crosstalk better than 35dB on all inputs. Overload characteristics better than 26dB on all inputs. Size approx. 13¾"×9"×3¾".
Garrard SP 25 deck with magnetic cartridge, de luxe plinth and hinged cover.
Two Duo Type IIa matched speakers – Enclosure size approx. 19¾" x 9½" x 7¾" in simulated teak. Drive unit 13" x 8" with 3" tweeter. 15 watts handling. 30 watts peak. Complete System with these speakers £62.00 +£5.50 p & p.

System 2. £82.00 **Viscount III amplifier** (As System 1a) **Garrard SP 25 deck** (As System 1a)
Two Duo Type III matched speakers – Enclosure size approx. 27"×13"×11½". Finished in teak simulate. Drive units 13"×8" bass driver, and two 3" (approx.) tweeters. 20 watts R.M.S., 8 ohms frequency range – 20 Hz to 18,000 Hz.
Complete System with these speakers £82.00 +£6.50 p & p.

PRICES: SYSTEM 1a

Viscount III R102 amplifier	£27.00+£1.60 p & p
2 Duo Type IIa speakers	£26.00+£5.50 p & p
Garrard SP 25 with Mag. cartridge de luxe plinth and cover	£21.00+£2.80 p & p
Total if purchased separately: total:	**£74.00**

Available complete for only: £62.00 +£5.50 p & p

PRICES: SYSTEM 2

Viscount III R102 amplifier	£27.00+£1.60 p & p
2 Duo Type III speakers	£39.00+£6.40 p & p
Garrard SP 25 with Mag. cartridge de luxe plinth and cover	£21.00+£2.80 p & p
Total if purchased separately: total:	**£87.00**

Available complete for only: £82.00 +£6.50 p & p

*8 TRACK HOME CARTRIDGE PLAYER

Elegant self selector push button player for use with your stereo system. Compatible with Viscount III system, Unisound module and the Stereo 21. Technical specification Mains input, 240V. Output sensitivity 125mV. Comparable unit sold elsewhere at £24.00 approx.
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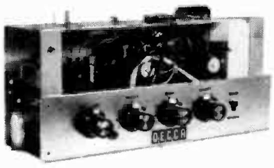
DECCA STEREO AMPLIFIER CHASSIS



Specification: 4+4 watts into 8 ohms. Input Sensitivity 4mV into 47K (for magnetic cartridges). AC Mains only 240V. Controls – volume, bass, treble, on/off, mono/stereo switch. Chassis size 11"×5½"×3¼" approx.
£5.95 +£1 p & p.

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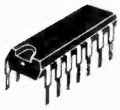

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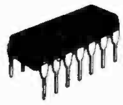

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7405	£0·18	£0·15	£0·12
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7407	£0·375	£0·312	£0·25
7408	£0·15	£0·125	£0·10
7409	£0·15	£0·125	£0·10
7410	£0·15	£0·125	£0·10
7412	£0·195	£0·162	£0·13
7413	£0·345	£0·287	£0·23
7416	£0·345	£0·287	£0·23
7417	£0·345	£0·287	£0·23
7420	£0·15	£0·125	£0·10
7423	£0·27	£0·225	£0·18
7425	£0·27	£0·225	£0·18
7426	£0·27	£0·225	£0·18
7427	£0·27	£0·225	£0·18
7430	£0·15	£0·125	£0·10
7432	£0·25	£0·225	£0·18
7437	£0·27	£0·225	£0·18
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7480	£0·435	£0·362	£0·29
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7483	£0·825	£0·687	£0·55
7485	£1·275	£1·062	£0·85
7486	£0·315	£0·262	£0·21
7490	£0·465	£0·387	£0·31
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7493	£0·465	£0·387	£0·31

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74122	£0·45	£0·375	£0·30
74123	£0·63	£0·525	£0·42
74141	£0·75	£0·625	£0·50
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Inverter transformers 13/15W (circuit included)		**70p**
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(Note: tube only supplied if case ordered, to prevent postal damage).
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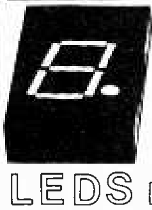

SLA7 RED LED 0.3" DIGIT 0-9DP 89p ea GREEN&YELLOW £1.40

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BC182/3/4A&L	10p	2N697	14p
BC212/3/4A&L	11p	2N706&8	11p
BCY70/1/2	17p	2N2646 UJT	32p
BD131 & 132	39p	2N2904 & 5	20p
BFR51		2N2926royg	9p
BFR50/51	23p	2N3053	17p
BFR50/51	23p	2N3055 115W	37p
BFR88 250V	29p	2N3563 & 64	16p
BFY50/1/2	15p	2N3614	49p
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CERAMIC 22pf to 0.1uf 50v 5p.
ELECTROLYTIC: 10/50/100 uf in 10v 5p, 25v 6p. 50v 8p. 2uf/10v 5p.
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TEXAS GOLD LOW PROFILE ea
8, 14, & 16 PIN 13p

SOLDERCON STRIPS
100 PINS 50p. 1K £3.

WW—213 FOR FURTHER DETAILS

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. **£8.50.** Carr. 75p.

SOLARTRON PULSE GENERATOR TYPE G1101-2: £75.00 each. Carr. £2.00.

TELEPRINTER TYPE 7B; Pageprinter 24V d.c. power supply, speed 50 bauds per min. second hand cond. (excellent order) no parts broken. **£15** each. Carriage £3.

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.

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. **£17.50.** Carr. £1.50.

TYPE 174/1 FREQUENCY SHIFT ADAPTOR (Northern Radio Co.): Convert. mark and space frequencies from the output of one or two Receivers into d.c. pulses. Suitable to operate Teleprinters or similar devices. 110/220V. Further details on request, s.a.e. **£55** each. Carr. £1.50.

TELEGRAPH TERMINAL UNIT (A.T.E.) TYPE TFS3: Converts signals from Receivers into d.c. pulses. Complete with monitor. **£75** each. Carr. £2.

FURZHILL SENSITIVE VALVE VOLTMETER V.200: Freq. 10Hz-6MHz (can be used beyond 6MHz). Probe in circuit—voltage range 1mV-1kV in 6 decade ranges; full scale deflection 10mV, 100mV-1kV. Without probe 100µV-100V in 6 decade ranges; full scale deflection 1mV, 10mV-100V. Accuracy ±5%. **£30** each. Carr. £1.

NOISE FIGURE METER TYPE 113A (Magnetic AB, Sweden): **£125** each. Carr. £1.

PRECISION PHASE DETECTOR TYPE 205: Freq. 0.1-15MHz in 5 ranges. Variable time delay microseconds 0-0.1c, 115V input. **£55** each. Carr. £1.

ROHDE & SCHWARZ HF MILLIVOLTMETER: 30Hz-30MHz Type UVH, 1mV-1V in 7 ranges, 220V. **£75** each. Carr. £2.

ROHDE & SCHWARZ VHF WATTMETER TYPE NAK: with matching indicator, 30 watts, 300-470MHz. **£25** each. Post 70p.

CT—38 ELECTRONIC MULTIMETER: A.C./D.C. volts 1-10,000 A.C./D.C. current 1µA—25 amps. **£30** each. Carr. £1.00

PHILLIPS VALVE VOLTMETER TYPE GM6014: 1-300mV in 6 ranges, 70-20dB, probe 1000Hz-30MHz, 300mV maximum. **£35** each. Carr. £1.

TF-1345/2 DIGITAL FREQUENCY COUNTER: Range 10KHz-100MHz with extension units. Details on request, s.a.e. **£100.** Carr. £2.

UHF MICROWAVE MILLIWATTMETER TYPE 14: Direct reading, can be used to measure power from 100MHz upwards. F.S.D. on 4in. scale meter 2.5mW. **£40** each. Carr. £1.

MARCONI HF SPECTRUM ANALYSER OA. 1094/3. Further details on request. **£250** each. Carr. £5.

Q METER: 30MHz-200MHz. **£55.** Carr. £1.

SIGNAL GENERATOR AIRMEC TYPE 701: 30KHz-30MHz, 7 ranges. **£65.** Carr. £1.50.

TF-1278/1 TRAVELLING TUBE WAVE AMPLIFIER: £125. Carr. £2.

BPL A.C. MILLIVOLTMETER TYPE VM.348-D Mk. 3: 2 millivolts-2 volts, 6 ranges. **£30.** Carr. £1.

WAYNE KERR WAVEFORM ANALYSER A.321: Low scale 0-1200 c/s. High scale 1-20 Kc/s, 600 ohms. Harmonic level is 0-55 dB in 12 steps. **£75.** Carr. £1.50.

SPECTRUM ANALYSER TYPE MW.69S (Decca): Further details on request. **£200.**

MARCONI DUAL TRACE UNIT TM-6456: £30. Post 60p.

SIGNAL GENERATOR TS-403B/U (or URM-61A): (Hewlett Packard). A portable, self-contained, general-purpose test equipment designed for use with radio and radar receivers and for other applications requiring small amounts of RF power such as measuring standing-wave ratios, antenna and transmission line characteristics, conversion gain, etc. Both the output freq. and power are indicated on direct-reading dials. 115V, AC, 50 c/s. Freq.—1800-4000 Mc/s. CW, FM, Modulated Pulse—40-4000 pulses per sec. Pulse Width—0.5-10 microsecs. Timing—Undelayed or delayed from 3-300 microsecs from external or internal pulse. Output—1 milliwatt max., 0 to —127 dB variable. Output Impedance—50 Ω. Price: **£120** each + £2 carr.

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SMOOTHING UNIT (for the above): **£10·00** each, carr. £2·00.

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.

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TEKTRONIX TIME MARK GENERATOR TYPE 180-S1: 5, 10, 50 MHz. **£65.** Carr. £2.

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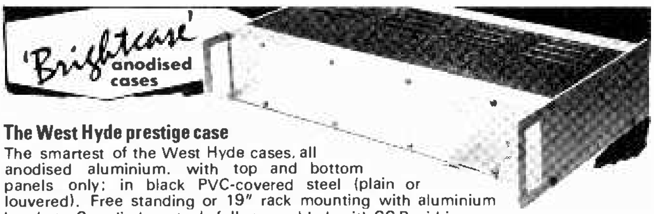


The West Hyde prestige case

The smartest of the West Hyde cases, all anodised aluminium, with top and bottom panels only; in black PVC-covered steel (plain or louvered). Free standing or 19" rack mounting with aluminium brackets. Supplied ex-stock, fully assembled, with SS Pozidriv screws.

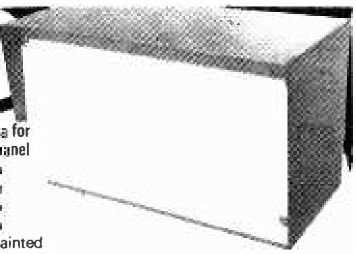
Brightcase	1 off	Pr. Brackets	Extra for Louvres
BC21 ($3\frac{1}{2}$" whole rack)	£14.96	86p	79p
BC22 ($3\frac{1}{2}$" half rack)	£12.16	86p	79p
BC31 ($5\frac{1}{4}$" whole rack)	£17.20	£1.22	79p
BC32 ($5\frac{1}{4}$" half rack)	£14.02	£1.22	79p

Prices include panels, feet, P. & P. and VAT. State whether $\frac{1}{4}$, $\frac{1}{2}$ or full panels required.

Prices correct April 1975.

CONTIL TEXTURED CASES

Available in a range of six sizes in 21-gauge Zintec with blue Acrylic texture. Front panels white Zintec steel or PVC/Aluminium.



Width	Depth	Height	No.	Case cost	Extra for ali panel
7"	5"	5"	755	£6.41	12p
8	6	7	867	£7.54	23p
9	7	5	975	£7.54	23p
12	7	7	1277	£8.61	15p
12	7	7	1277	£6.56	unpainted
16	12	7	16127	£12.06	35p
19	10	10	191010	£16.35	—

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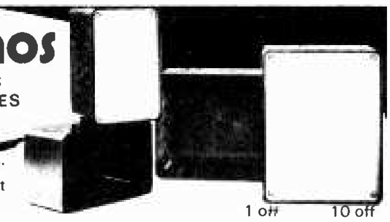
Less for quantities. Prices include steel panel with feet and screws, P. & P. and 8% VAT.

MINOS PLASTIC CASES

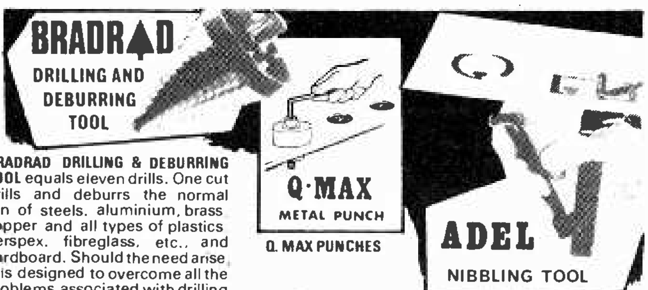
A smart miniature case in tough, rigid, high-gloss black ABS. Front panels in either aluminium or white PVC/Steel. Built-in slots for PC cards, dividers, or screens. Chassis or PC boards can be supported on "P" clips for internal pillars. Excellent as encapsulation boxes



		1 off	10 off
M2	65mm × 100mm × 50mm $2\frac{1}{4}$" × $3\frac{3}{4}$" × 2"	56p	48p
M3	100mm × 130mm × 50mm $3\frac{1}{4}$" × 5" × 2"	72p	62p

Prices include P. & P. and VAT. Less for quantities.

Also available without panel and screws. Prices correct April 1975.



BRADRAD DRILLING & DEBURRING TOOL equals eleven drills. One cut drills and deburrs the normal run of steels, aluminium, brass copper and all types of plastics perspex, fibreglass, etc., and hardboard. Should the need arise it is designed to overcome all the problems associated with drilling thin materials—it drills interlocking holes for instance.

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All prices include P. & P. and 8% VAT.

Q. MAX PUNCHES

$\frac{3}{8}$" **£1.39**
$\frac{1}{2}$" & $\frac{5}{8}$" **£1.60**
$\frac{3}{4}$" & $\frac{7}{8}$" **£1.70**
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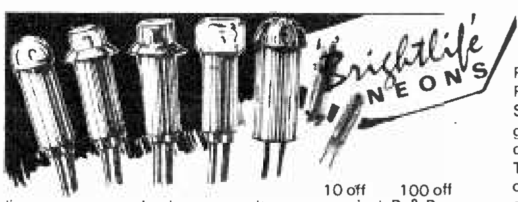
$1\frac{1}{2}$" **£2.47**

Prices correct April 1975.

ADEL

The Adel cuts holes of virtually any shape and size starting from a $\frac{7}{16}$" hole, cutting clean like a punch and die. Ideal for notching clearances on flanges of cabinets or chassis. **£6.75.**



Brightlife neons (illustrated are PC/A or C, PC/F, PC/E, PC/G or I, PP/A or B, Q and S) are brighter and give an average of 25,000 hrs. life. The 0.5" dia. are red or white, the 0.375" are red, amber or white: these have three cap shapes and all may be supplied for 115, 240V or the PP neons in 110, 240, and 440V with 6" or 30" leads.

dia.	leads	volts	10 off	100 off incl. P. & P.
$\frac{3}{8}$" PC/A to I	6"	110 or 160–260	$17\frac{1}{2}$p	$16\frac{1}{2}$p
$\frac{3}{8}$" PC/A to I	30"	110 or 160–260	$19\frac{1}{2}$p	$18\frac{1}{2}$p
$\frac{1}{2}$" PP/A	6"	110 or 160–260	$17\frac{1}{2}$p	$16\frac{1}{2}$p
$\frac{1}{2}$" PP/A	30"	110 or 160–260	$19\frac{1}{2}$p	$18\frac{1}{2}$p
Q type	none	110 or 160–260	29p	27p
S type	none	—	23p	21p

Add 8% VAT. Min. quantity each type 10 off. Prices correct April 1975.

WEST HYDE

WEST HYDE DEVELOPMENTS Ltd, Ryefield Cres., Northwood Hills, Northwood, Middx HA6 1NN
Tel: Northwood 24941/26732 *WRITE OR 'PHONE FOR NEW FREE CATALOGUE* Telex: 923231

WW—224 FOR FURTHER DETAILS

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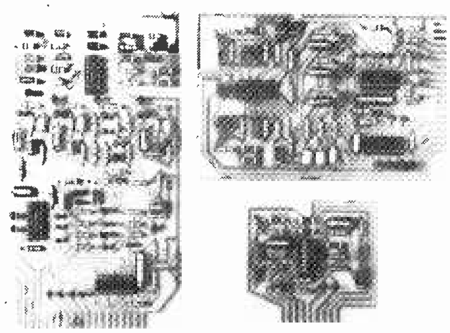


SQ QUADRAPHONIC DECODERS

SQ the leading quadraphonic system, designed by CBS engineers, offers not only 4 channel ambiophony from the fast expanding range of SQ encoded discs but also immensely increased depth and fullness of sound from standard stereo recordings too.

Feed 2 channels (200–1000mV as obtainable from most pre-amplifiers) into your choice of any of our 3 decoders and take 4 channels out with no overall signal level reduction. On the logic enhanced decoders Volume, Front-Back, LF-RF, LB-RB and Dimension controls can all be implemented by simple single gang potentiometers—no need for exotic 4-gang units!

These state-of-the-art circuits, used under licence from CBS, are offered in kit form comprising first grade components only—fibre glass circuit boards of professional quality designed for edge connector insertion, all resistors 2% metal oxide, all polystyrene and polycarbonate capacitors 5% or better and in decoder L2 ultra low noise (MPS A18–0.5dB typ.) transistors used in each amplifying stage.

M1 Basic matrix decoder with fixed '10–40' blend. 10 Resistors, 14 Capacitors, 1 Integrated Circuit. Printed Circuit Board. **£6·54.**

L1 Full logic controlled decoder with 'wave matching' and 'front-back logic' for enhanced channel separation using three specially designed Integrated Circuits. 24 Resistors, 42 Capacitors, 3 Integrated Circuits. Printed Circuit Board. **£19·80.**

L2 More advanced full logic decoder with 'variable blend', extended frequency response, increased front-back separation. 43 Resistors, 44 Capacitors, 3 Integrated Circuits, 9 Transistors, 6 Diodes, Printed Circuit Board. **£28·20.**

All kits include IC sockets and construction notes. Prices include CBS licence fee.

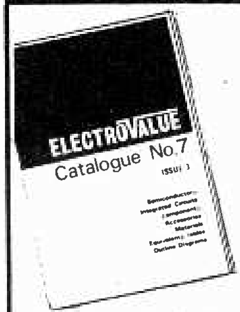
Please write for further details in FREE LIST.

United Kingdom: Post Free. Please add 8% VAT. Overseas: No VAT. Please add (per kit) £2·00 p & p AIR MAIL or £1·00 p & p SURFACE MAIL.

AMBIENTACCOUSTICS
PO BOX 3000
ANDOVER, HANTS SP10 3EQ

WW—215 FOR FURTHER DETAILS

ELECTROVALUE



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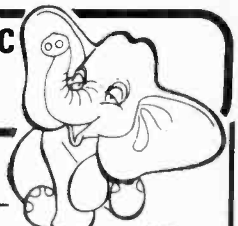
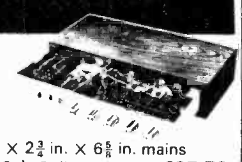


You can build the Texan and Stereo FM Tuner

TEXAN 20 + 20 WATT IC STEREO AMPLIFIER



Features fibre glass 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. **£31.00** (Carr. 50p). Built and tested **£37.50**

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Bandwidth 300KHz
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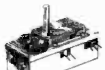
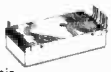


LP1171
AM Bandwidth 6.5KHz
Sensitivity 1mV
Built-in AGC
Supply 6V negative earth



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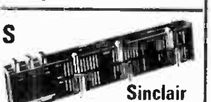

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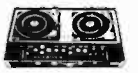

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pp 15p

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A Short-circuit proof power supply delivery up to 30v at 1A. Built-in volts and ammeters. **£34.00**

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Type	Pc	VCBO	FT MHz	
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BD107 (SNPN)	11·5w	64	100	65p
2N711B/2G106 (SPNP)	150mw	18	120/150 Tot. Sw. Time 275 nS	45p
2N985 (GPNP)	300mw	15	Tot. Sw. Time 115 nS	£1·00
2N1304 (GPNP)	150mw	30	6	17p
2N1309 (GPNP)	150mw	30	15	32p
2N1046 (GPNP)	50w	100	20	£2·60
2N1146A (GPNP)	90w	70	15	50p
2N1557 (G)	106w	40	0·35	55p
2N2080 (G)	170w	70	0·2	£1·20
2N2082 (G)	170w	40	0·2	£1·20
2N2405 (SNPN)	1w	120	120	57p
2N3054 (SNPN)	29w	90	1·2	45p
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ASZ16/OC26 **25p** OC35 **45p**. - OC42 **45p**. OC71 **12p**. CV7006/OC72 **20p**. OC75 **25p**. OC83 **28p**. GET110/NKT303 **25p**. OC702 **10p**. OA10 **25p**. RAS508AF **25p**. RAS310AF **25p**. STC Wire End 400PIV1A 4 for **50p**. IN3193 **13p**. IN3194 **14p**. IN3255 **20p**.

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4·0	—	Securex 5000
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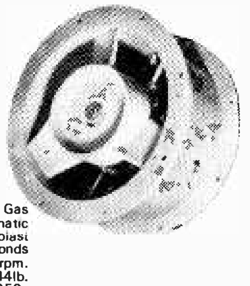

Airmax Type M1/Y3954 (3 blades) Cast Aluminium alloy impeller & casing (corresponds to current type 3965 7½") 230v. 1ph 50c 2900rpm Class "A" insulation 425cfm free air weight 9½lbs. inc. p.p **£23·00**.

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Cat. 2026391 Potter Instruments flange mounting capstan motor. 0·2HP cont. 110v DC 4 amp .... **£27·50** inc. carr.

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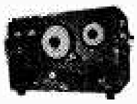
SIGNAL GENERATORS



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MARCONI TF801B/2S. 10-480 mHz **£225.**
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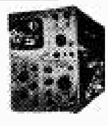
ROHDE & SCHWARZ SMLR 15-30mHz power generator. P.O.A.
RACAL/AIRMEC 201A. 30kHz-30mHz. As new. P.O.A.
ADVANCE SG21 VHF Square-wave generator 9kHz-100mHz. **£25.**

OSCILLOSCOPES



TEKTRONIX 661 Sampling scope with 4S1 & 5T1A plug-in units. 3GHz. **£200.**
TEKTRONIX 545A with CA unit. DC-30mHz. Price only **£295·00.**
TEKTRONIX 531 DC-15mHz with L type plug-in
TEKTRONIX 535 DC-15mHz with L type plug-in
TEKTRONIX 545B DC-30mHz with 'CA' plug-in.
NB: Due to the fragile nature of CRTs we regret that these oscilloscopes cannot be despatched 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 455E Wave Analyser **£120.**
MARCONI TF2600 Valve Voltmeter 1mV-300V. Excellent. **£75.**
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.**
RACAL SA520 Digital Frequency counter/timer. 300kHz. **£47.50.**
CAMBRIDGE A.C. Test Set. **£75.00.**
GAMBRELL Precision 4 Decade Resistance Box. 1-11, 110 ohms. **£24.50.**

BOXER 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 **£4.50.**

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.

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.

EDDYSTONE U.H.F. RECEIVER type 770S.
Continuous coverage from 500-1000mHz. AM/FM. Sensitivity approx. 10µV absolute. Completely self-contained with speaker. 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.

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.

MINI HELIPOTS
500Ω Beckman Linearity Tolerance 0.075% (10 Turn). 1KΩ Beckman Linearity Tolerance 0.25% (10 Turn). 20Ω Colvern CLR 26/6310/9S (3 Turn). 5KΩ Colvern (10 Turn).

MARCONI TF995A2/M AM/FM R.F. SIGNAL GENERATORS.
1.5-220mHz. 0-100kHz Deviation. 1µV—100mV output. Sold in excellent condition. P.O.A.

PLEASE ADD 8% V.A.T. TO THE TOTAL AMOUNT WHEN ORDERING. INCORRECT AMOUNTS WILL CAUSE DELAY IN DESPATCH. THANK YOU.

Ex-BEA CONTROL UNITS by UNIVAC

A free-standing, modern style diecast case consisting of:

2–50way gold-plated plug and sockets; sub-assembly with 3-multiway switch assemblies; 4-decade push button assembly with electrical reset; 2-decade push button assembly with electrical reset; single-bank 8-push button assembly; 1-decade lamp assembly; 1–2-decade lamp assembly; 1–12 × 3-lamp assembly; 4-decade thumb wheel assembly; 16-bit inline card code assembly; 6–15way plug and sockets.

Limited stocks at **£12.50** ea plus £2 carriage

ALSO MODERN STYLE TYPEWRITER KEYBOARD

with 21 separate function keys. Housed in slimline diecast case. Transistorised. No information but a "buy" at **£15** ea plus £2 carriage

MARCONI TF801A/1 Signal Generator 10 to 310 MHZ **£55** ea.
MARCONI TF801B Signal Generator **£120** ea.
MARCONI TF801C Signal Generator **£180.**
MARCONI TF791B Carrier Deviation Meter **£30** ea.
MARCONI TF934/2 FM Deviation Meter **£35.**
MARCONI TF1020A RF Power Meter 150 and 300 Watts. As New **£75** ea.
MARCONI TF1020A RF Power Meter 50 and 100 Watts. As New **£50** ea.
MARCONI TF1094A/S HF Spectrum Analyser. Late model. Must go. **£160.**
MARCONI TF1434/2 Counter Range extension unit 10–100MHz **£25** ea.
KELVIN & HUGHES Single Channel Recorders with spare paper **£18** ea.
HEWLETT PACKARD Power Meter 1mV to 300V dB scale **£20.**
DAWE Digital Printer type 3094A. As new **£27.50** ea.
WESTON THERMOPROBE −60 to +100 degrees Centigrade **£70.**
WANDEL & GOLTERMAN TFEK41 Level Meter **£60.**
PROSSER SCIENTIFIC INSTRUMENTS Model A100 Waveform Generator. Multi wave forms **£160.**
RHODE & SCHWARZ Admittance Meter VLUK-BN3511. As new **£140.**
TEKTRONIX Oscilloscope type 545B. Main frame only. As new condition **£370.**
HEWLETT PACKARD DB Oscilloscope type 175A. 3dB–50MHZ twice. Large 6 × 10cm screen **£185.**
AIRMEC 4 trace Oscilloscope. DC to 3MHz. Good condition **£50.**
PYE SCALAMP GALVANOMETER. Hammer grey. Tested **£5** ea.
SOLARTRON Multipurpose stab PU type 1094. 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 **£20** ea.
DUAL TRACE PLUG-IN units for CD1212 Scopes DC–24MHz **£35** ea.
TEKTRONIX Colour Monitor type 654 **£550.**
MARCONI TF2950 Mobile Radio Test Set **£650.**
TEKTRONIX RM527 Waveform Monitor **£250.**
TELONIC Sweep Generator SM2000/1. Main frame with 0–20kHz plug-in **£300.**
COLLINS RECEIVER IP-10ULR. 90MHz to 10GHz in 8 bands. Panoramic. Analyser or DF modes. With power unit **£350** ea.

HUNDREDS OF SQ. FT. packed with CLEARANCE ITEMS, TEST GEAR ETC. All individually priced. CALL or SEND for LISTS.

EX-MINISTRY CT436 Double Beam Oscilloscope DC-6 megs. Max Sensitivity 10mv/cm. Small compact. Size 10 × 10 × 16 in. Suitable for Colour TV servicing. Price **£85** each including copy of manual.

HARTLEY 13A Double Beam Oscilloscope TB 2c/s–750 kc/s. Bandwidth 5.5Mc/s. Sensitivity 33Mv/cm. Calibration markers 100kc/s and 1Mc/s. **£30** each.

TELEPHONES

MODERN STYLE 706 BLACK OR TWO-TONE GREY **£3.75** ea. P. & P. 45p. **STYLE 7006** TWO-TONE GREEN OR GREY **£3.75** ea. P. & P. 45p. **HANDSETS**—complete with 2 insets and lead **75p** ea. P. & P. 37p. **DIALS ONLY. 75p** ea. P. & P. 30p. **STILL AVAILABLE** MODERN STANDARD TELEPHONES IN GREY OR GREEN WITH A PLACE TO PUT YOUR FINGERS LIKE THE 746. **£3.00** ea. P. & P. 45p.

CAPACITOR PACK 50 Brand new components only **50p**. P. & P. 27p.

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. 15p.

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.

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. 25p.

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. 15p.

PHOTOCELL equivalent OCP71. **13p** ea.

MULLARD OCP70 10p ea.

GRATICULES. 12 cm. by 14 cm. in High Quality plastic. **15p** each. P. & P. 8p.

Vast quantity of good quality components —NO PASSING TRADE—so we offer **3 LB. of ELECTRONIC GOODIES for £1.50 post paid.**

HF Crystal Drive Unit. 19 in. rack mount. Standard 240V input with superb crystal oven by Labgear (no crystals) **£5** ea. Carr. £2.

ROTARY SWITCH PACK—6 Brand New switches (1 ceramic; 1–4 pole 2 way etc.). **50p.** P. & P. 25p.

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. 55p.

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. 3V 1 amp output. Brand New. **65p** ea. P. & P. 20p. Discount for quantity.

FIBREGLASS PRINTED CIRCUIT BOARD. Brand New. Single or Double sided. Any size **1½p** per sq. in. Postage 20p per order.

HIGH VALUE PRINTED BOARD PACK. no two boards the same—no short leaded computer boards. **£1.75** post paid.

METER PACKS—3 different meters for **£2.** P. & P. 55p.

RESETTABLE COUNTERS—4 digit by Stonebridge/Sodeco. 1.000 ohm coil. **£2** ea. P. & P. 35p.

E.H.T. CAPACITORS 1 mfd 7.5 KV working. 2 mfd 5 KV working. 8 mfd 2.5 KV working. 0.5 mfd 10 KV working **£2** each.

RAPID DISCHARGE 1 mfd 5.6 KV **£2.50** ea. 0.9 mfd 15 KV **£3.50** ea. 0.15 mfd 120 KV **£7** ea. Carriage extra.

DON'T FORGET YOUR MANUALS S.A.E. WITH REQUIREMENTS

LOW FREQUENCY WOBBULATOR

For alignment of Receivers, Filters, etc. 250KHz to 5MHz, effective to 30MHz on harmonics. Three controls—RF level. sweep width and frequency. Order LX63. Price **£8.50** P. & P. 35p.
As above but can have extended cover range down to 20KHz by addition of external capacitors. Order LX63E. Price **£11.50** P. & P. 35p.
Both models can be used with any general-purpose oscilloscope. Requires 6.3V AC input. Supplied connected for automatic 50Hz 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).

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.

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 **£6·75**. P. & P. 25p. (Not cased, not calibrated.)

TRANSISTOR INVERTORS

TYPE A	TYPE B	TYPE C	TYPE D
Input: 12V DC	Input: 12V DC	Input: 12V to 24V DC	Input: 12V to 24V DC
Output: 1.3kV AC 1.5MA	Output: 1.3kV DC 1.5MA	Output: 1.5kV to 4kV AC 0.5MA	Output: 14kV DC 100 micro amps at 24V. Progressively reducing for lower input voltages
Price **£3.45**	Price **£4.70**	Price **£6.35**	Price **£11**

Postage & Packing 36p

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.

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.)

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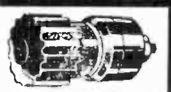
SERVICE TRADING CO



Available in black, red, white, yellow, blue and green. New **15p** each. Post Paid

RELAYS

SIEMENS PLESSEY, etc.
MINIATURE RELAYS

1	2	3	4	1	2	3	4
52	4–8	2c/o	**70p***	700	16–24	4 M2B	**60p***
58	5–9	6 c/o	**80p**	700	16–24	4 c/o	**80p***
185	8–12	6 M	**60p***	1250	18–36	2 c/o	**60p***
230	9–18	2 c/o	**70p***	2500	36–45	6 M	**60p***
430	15–24	4 c/o	**80p***	2500	31–43	2 c/oHO	**60p***
700	12–24	2 c/o	**60p***	9000	40–70	2 c/o	**60p***
				15k	85–110	6 M	**60p**

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*including Base)

OPEN TYPE RELAYS

6 VOLT D.C. 1 make con. **35p**. Post 15p.

9 VOLT D.C. RELAY
3 c/o 5 amp contacts. 70 ohm coil **75p**. Post 15p.

12 VOLT D.C. RELAY
3 c/o 5 amp contacts. 120 ohm coil **75p**. Post 15p.

24 VOLT D.C. 3 c/o 600 ohm coil **75p**. Post 15p.
2 HD c/o 700 ohm coil **75p**. Post 15p.
4 c/o 300 ohm coil **85p**. Post 15p.

ENCLOSED TYPE RELAYS

24 VOLT D.C. M.f.g. ITT 3 h.d. c/o contacts **55p**. Post 15p. Base 15p extra.

55 VOLT A.C.
3 heavy duty c/o contacts. Price **55p**. Post 15p. Base 15p.

100 VOLT A.C.
2 c/o sealed type, octal base **75p**. Post 15p. Base 15p.

240 VOLT A.C. RELAY
240V. A.C. heavy duty 3 c/o contacts.
Price **75p**. Post 15p. Octal base 15p extra.

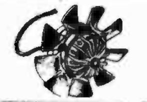
220/240 VOLT AC RELAY
3 c/o 5 amp cont. Sealed M.f.g. ISKRA. **£1.25**. Post 15p. Base 15p extra.

ARROW 230/240V AC 2 c/o 15 amp contacts. Amp connectors. **£1.00**. Post 15p.

110 VOLT A.C. 2 c/o. 20 amp. **£1.25**. Post 15p.

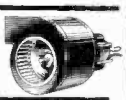
CLARE-ELLIOT Type RP 7641 G8
Miniature relay. 675 ohm coil. 24 volt D.C. 2 c/o. **70p**. P.P.

MANY OTHERS FROM STOCK, PHONE FOR DETAILS



BLOWER UNIT

200-240 Volt A.C. BLOWER UNIT Precision German built. Dynamically balanced, quiet, continuously rated, reversible motor. Consumption 60mA. Size 120mm. dia. x 60mm. deep. Price **£3.00**. Post 30p.

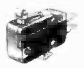


PRECISION CENTRIFUGAL BLOWER

Mfg. Airflow Developments Ltd., continuously rated, smooth running, 230/240v A.C. motor. 80 c.f.m. **£6.50**. Post 50p.

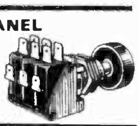
SUB-MINIATURE REED RELAY 3–9 VOLT D.C.

1 make, size 1¼" × ⅜" × ⅜". OUTSTANDING VALUE ONLY **£1.00** for six, **£1.50** for ten. Post 15p. (Min. order six).



VERY SPECIAL OFFER

Micro Switch. 5 amp. c/o contacts. NEW. 20 for **£2.00**. Post 10p. (Min. order 20.) Ditto. Press to break. 20 for **£1.50**. Post 10p.



'HONEYWELL' PUSH BUTTON, PANEL MOUNTING MICRO SWITCH

Each bank comprises of a change-over rated at 10 amps 240 volt A.C. Black knob 1 in. dia. Fixing hole ⅜ in. Prices: 1-bank **30p**. 3-bank **50p**. (Illustrated) inc. P. & P. Special quotes for quantities.

COIN MECHANISM (Ex-London Transport)

Unit containing, selector mechanism for 1p, 2p & 5p coins. Micro switches, relays, solenoid-operated hopper. 24 volt D.C. Precision built to high standard. Incredible VALUE at only **£2.50**. Post 70p.

230–250 VOLT A.C. SOLENOID

Similar in appearance to illustration. Approximately 1½ lb. pull. Size of feet 1⅝" × 1⅜". Price **£1.00** Post 15p.

24 VOLT DC SOLENOIDS

UNIT containing: 1 heavy duty solenoid approx. 25 lb. pull at 1 in. travel. 2 solenoids of approx. 1 lb. pull at ½ in. travel. 6 solenoids of approx. 4 oz. pull at ¼ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price: **£2.50**. Post 75p. **ABSOLUTE BARGAIN.**

600 WATT DIMMER SWITCH

Easily fitted. Fully guaranteed by makers. Will control up to 600 watts of all lighting except fluorescent at mains voltage. Complete with simple instructions. **£2.75**. Post 25p.

2000 WATT POWER CONTROL

For Power tools, Heating, Lighting etc. incorporating 13 amp. outlet and mains lead. **£8.00** Post 27p.

METERS NEW! 2¼in. FLUSH ROUND

available as D.C. Amps 1, 5, 10, 15 or A.C. Amps 1, 5, 10, 15, 20. Both types **£2.50**. Post 20p.
VOLTMETER 0–300V. A.C. **£2.50**. Post 20p.

VARIABLE VOLTAGE TRANSFORMERS

Carriage extra

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.
BRAND NEW. All types.

200W (1 Amp)	£10.00
0·5 KVA (Max. 2½ Amp)	£11.50
1 KVA (Max. 5 Amp)	£16.50
2 KVA (Max. 10 Amp)	£30.00
3 KVA (Max. 15 Amp)	£33.00
4 KVA (Max. 20 Amp)	£72.50
(Max. 37·5 Amp)	£102.50
1 Amp OPEN TYPE (Panel Mounting)	£10.00

300 VA ISOLATING TRANSFORMER

115/230–230/230 volts. Screened. Primary two separate 0–115 volts for 115 or 230 volts. Secondary two 115 volts at 150 VA each for 115 or 230 volts output. Can be used in series or parallel connections. Fully tropicalised. Length 13.5 cm. Width 11 cm. Height 13.5 cm. Weight 15 lb. SPECIAL OFFER PRICE Only **£5.00**. Carr. 80p.

LT TRANSFORMERS

0, 6, 12 volt @ 10 amp.	**£5.60** Post 70p.
0, 10, 17, 18 volt @ 10 amp.	**£7.90** Post 70p.
0, 6, 12 volt @ 20 amp.	**£9.00** Post 70p.
0, 12, 24 volt @ 10 amp.	**£9.20** Post 70p.
0, 4, 6, 24, 32 volt @ 12 amp.	**£9.90** Post 70p
0, 6, 12, 17, 18, 20 volt @ 20 amp.	**£10.40** Post 70p.

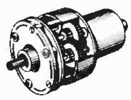
Other types to order at short notice—Phone your enquiries.

AUTO TRANSFORMERS

Step up step down 0–115/200/220/240 volts.
At 75 watt **£2.64** Post 40p. 150 watt **£3.50** Post 50p. 300 watt **£6.20** Post 60p. 500 watt **£9.20** Post 75p. 1000 watt **£12.00** Post 90p.

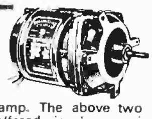
20 r.p.m. GEARED MOTOR

230/240 volt 20 r.p.m. motor. **£1.00** Post 15p.



9/12 VOLT DC GOVERNED REVERSIBLE MOTOR

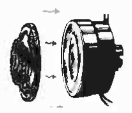
Machine-cut gear train, giving final speed of 2 r.p.m., with cam driving 3 sub-miniature micro-switches (removable). Spindle 12mm long. 6mm dia. Built to PO spec., in heavy metal hinged case. **£3.75** Post 40p.



BODINE TYPE N.C.I. GEARED MOTOR

(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle ·38 amp. **(Type 2) 28 r.p.m.** torque 20 lb. in. **Reversible** 1/80th h.p. 50 cycle ·28 amp. The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v **A.C.** Supplied complete with transformer for **230/240v A.C. input.**
Price, either type **£6.25** Post 65p. or less transformer **£3.75** Post 50p.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines, etc. etc.

BENDIX MAGNETIC CLUTCH



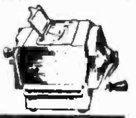
A superb example of Electro-mechanics! The main body is in two sections. The coil section is fixed and has a ⅝in. sleeve. The drive section rotating on the outer perimeters. The uniting plate has ⅝in. ID bearing concentric with main section and 18-tooth cog wheel. When energized transmission is extremely powerful. 24V d.c. at 240 MA. **OUR PRICE JUST £2.50**. Post 30p.

POWER RHEOSTATS

New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10, 25, 100, 150, 250, 500, 1k, 1·5k, 2·5k ohm, **£1.70** Post 15p. **50 WATT** 1, 5, 10, 25, 50, 100, 500, 1k ohm **£2.10**. Post 20p. **100 WATT** 1/10/25/50/100/250/500/1k/1·5k/2·5k/5k ohm **£3.30**. Post 25p.
Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia brass bush. Ideal for above Rheostats, 22p ea.

TRIAC

Raytheon Tag symmetrical Triac. Type TAG. 250/500V. 10 amp. 500 p.i.v. Glass passivated plastic triac. Swiss precision product for long-term reliability. **£1.00** Post 10p. Incl. data and application sheet. Suitable Diac. **18p**.



INSULATION TESTERS (NEW)

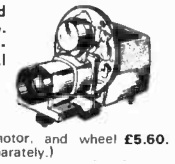
Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8 in., W. 4 in., H. 6 in., weight 6 lb.
500 VOLTS. 500 megohms **£30.00**. Post 80p.

VAT All prices are subject to **8% VAT.** (8p in the £)
To all orders add 8% VAT to total value of goods including carriage/packaging.

STROBE! STROBE! STROBE!

FOUR EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES, SOLID STATE TIMING + TRIGGERING CIRCUITS, PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.

RANGE OF 4 STROBE KITS FROM STOCK. PRICES FROM £6.30–£22.00. SAE FOR DETAILS.



COLOUR WHEEL PROJECTOR

Complete with oil filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. **£20.50**. Post 80p.

1 R.P.M. MOTOR and COLOUR WHEEL
200/240 volt A.C. 1 r.p.m. motor, and wheel **£5.60**. Post 40p. (Motor not available separately.)
Extra colour effect wheels from stock. SAE for details.

BIG BLACK LIGHT

400 Watt. Mercury vapour ultra violet lamp. Extremely compact and powerful source of u.v. Innumerable industrial applications also ideal for stage, display, discos etc. P.F. ballast is essential with these bulbs. Price of matched ballast and bulb **£18.00**. Post £1. Spare bulb **£8.00**. Post 40p.

BLACK LIGHT FLUORESCENT U.V. TUBES

2ft. 20 watt £4.25. Post 40p. (For use in stan bi-pin fittings.) MINI **12in. 8 watt £1.60**. Post 25p. **9in. 6 watt £1.30**. Post 25p. Complete ballast unit and holders for either 9" or 12" tube. **£1.70**. Post 25p. (9in. × 12in. measures approx.)

U.D.1. SINGLE CHANNEL. 750 watt MANUAL/AUTO DIMMER

750W Solid State Fader, with three functions. Manual fade; Auto fade-up; Auto fade-down. Automatic cycling up and down. Functions selected with 'three position' rocker switch. Two ranges of cycling for 'Flashing' or 'Slow blending'. Ready built module 6" × 3" glass fibre board incorporating 10 amp TRIAC. Two or more modules for top quality colour blending and flashing effects. PRICE **£15.00**. Post 45p.

50 in 1 ELECTRONIC PROJECT KIT

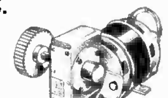
50 easy to build Projects. No soldering no special tools required. The Kit includes Speaker, meter, Relay, Transformer, plus a host of other components and a 56-page instruction leaflet. Some examples of the 50 possible Projects are: Sound level Meter, 2 Transistor Radio, Amplifier etc. etc. Price **£7.75** Post 50p. (price including VAT & Post **£8.91**.)

'GENTS' 6" ALARM BELL

200/250 volt AC/DC. **Brand New**. Price: **£5·00** Post 60p. (Illustrated)

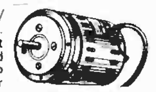
'STC' 6" RED ALARM BELL

Brand New. Price: **£4·00** Post 50p. **24/48V DC.**



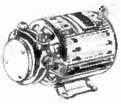
'FRACMO' 240 VOLT A.C. 50 cycle SINGLE PHASE GEARED MOTOR

33 r.p.m. 30 lb. ins. Reversible, fitted with mounting feet. Brand New. **£14.00**. Post £1.00. (Total price incl. VAT £16.20.)



REVERSIBLE MOTOR

A.E.I. 1/10th h.p. reversible motor. 100/120V A.C., 50/60 cycle. 1400/1680 r.p.m. Flange fixing. Dia. 4", length 6½", shaft 1" × 5/16". Price **£2.50** Post 50p. Brand new. Suitable 110/240V 150 watt Auto Transformer. **£3.50** Post 50p. (Post for both items together 75p.)

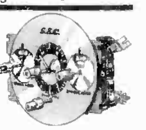


ROTARY VACUUM AIR COMPRESSOR AND PUMP

Carbon vane, oil-less, 100/115V A.C., 1/12 h.p. motor, 50/60 cycle, 2875/3450 r.p.m., 20" vacuum. 1.25 c.f.m., 10 p.s.i. (approx figures). New unused surplus stock, with elect. connection data. Fraction of maker's price. **£12.00** Post 50p. Suitable transformer as above.

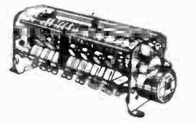
240 V A.C. SOLENOID OPERATED FLUID VALVE

Rated 1 p.s.i. will handle up to 7 p.s.i. Forged brass body, stainless steel core and spring. ½ in. b.s.p. inlet/outlet. Precison made. British mfg. PRICE: **£2·00**. Post 25p. NEW original packing.



A.C. MAINS TIMER UNIT

Based on an electric clock, with 25 amp. single-pole switch, which can be preset for any period up to 12 hrs. ahead to switch on for any length of time, from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets, etc. Attractive satin copper finish. Size 135 mm × 130 mm × 60 mm. Price **£2.00**. Post 40p. (Total inc. VAT & Post **£2.59**.)



PROGRAMME TIMERS

230/240 Volt A.C. 15 RPM Motors. Each cam operates a c/o micro switch. Ideal for lighting effects, animated displays etc. Ex equipment tested, similar to illustration.

2 cam model	**£2.00** post 35p
4 cam model	**£2.50** post 35p
8 cam model	**£4.75** post 40p

8 cam model, each cam fully adjustable. 6 r.p.m. M.f.g. by Magnetic Devices. **£7.50**. Post 35p.

ALL MAIL ORDERS, ALSO CALLERS AT:
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Tel.: 01-437 0576

MAINS TRANSFORMERS

All standard to 230–250 volt primaries

		£ p
1v	1 amp (special)	1.75
2.4v	5 amp	85
6.3v	2 amp	1.00
6.3v	3 amp	1.50
9v	1 amp	95
9v	3.5 amp	1.95
12v	2 amp	1.50
12v	1 amp	1.00
6.5v–0–6.5v	1 amp	1.35
18v	1 amp	1.25
20v	½ amp	1.00
24v	1 amp	1.50
24v	3 amp	3.50
12–0–12v	50mA	1.20
6–0–6v	50mA	1.20
8–0–8v	½ amp	1.25
18–0–18v	2 amp	3.50
25v	1½ amp	1.95
50v 2 amp & 6.3v	1 amp	5.50
60v 5 amp & 5v		7.50
27v	8 amp	4.50
30v	37 amp	22.00
80v tapped 75v & 70v	4 amp	5.50
230v—60mA & 6.3v	1.5 amp	1.75
275–0–275v at 90mA & 6.4v	3 amp	2.25
Charger Transformers		
6v and 12v	2 amp	1.25
6v and 12v	3 amp	2.25
6v and 12v	5 amp	3.50
EHT Transformer 5Kv at 23mA (intermittent)		5.50

NUMICATOR TUBES

For digital instruments, counters, timers, clocks, etc. Hi-vac XN.3. Price **99p** each, 10 for **£9.**

OIL PUMP

Driven by Redmond Motor of approx. 1/20th horse power, pump originally intended for oil-fired boilers etc. with normal inlet and outlet pipes and unions. **£2.15** plus 30p post and insurance.

LIGHT DIMMER KIT

For dimming up to 250w without heat sink or 750w with heat sink. This comprises quadrac variable control potentiometer, condenser, resistors, tag strip for mounting and data. Price **£1.50.**

RELAY BARGAIN

Type 600 relay, 2 changeover one open and one closed contact. Twin 500 ohm coils make this suitable for closing off DC 6v, DC 12v, DC 24v or AC mains using resistor and rectifier. **33p** each.

AM/FM TUNER

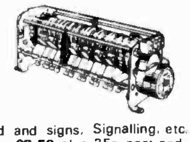
Unit made by the American GEC company, 8 transistor, all-wired ready to work. Complete with tuner condenser, needs only scale and pointer. Tunes AM range 540 to 1620 KHz. FM range 88 to 108 MHz. Switches for on-off and AFC. Output for MXP or direct. Special snip price **£5** plus 30p post. Three or more post free.

7 WATT STEREO AMPLIFIER

Again by the American GEC company. This has exceptionally good tone quality. Is complete with pre-amp and treble base, volume and balance controls. Also has mains smoothing circuit and rectifiers so requires only mains transformer. Output for 15 ohm speakers. Inputs for tuner, pick-up, mike, etc.

Special snip price **£6** plus 30p post. Three or more post free.

HONEYWELL PROGRAMMER

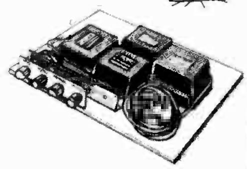


This is a drum type timing device, the drum being calibrated in equal divisions for switch setting purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 changeover micro switches each of 10 amp type operated by the trips, thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs. per min. Some of the many uses of this timer are Machinery control. Boiler firing. Dispensing and Vending machines. Display lighting animated and signs. Signalling, etc. Price from makers probably over £20 each. Special snip price **£8.50** plus 25p post and insurance. Don't miss this terrific bargain.

SWITCH TRIGGER MATS

So thin is undetectable under carpet but will switch on with slightest pressure. For burglar alarms, shop doors, etc.
24in × 18in £1.90
13in × 10in £1.50

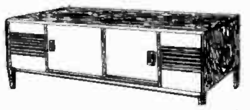
MULLARD UNILEX STEREO SYSTEM



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	**£1.75**
1 Unilex Amplifier	Ref. EP.9000	**£1.75**
1 Unilex Pre-Amp	Ref. EP.9001	**£2.00**
1 Unilex Power Unit	Ref. EP.9002	**£2.50**
1 Control panel kit with spun aluminium-faced knobs		**£3.80**

Or the complete outfit—£11.50 post paid.
Pair of 15 ohm speakers made by Goodmans are also available if required, price **£3.30** the pair. No extra postage if ordered with the above, otherwise add 25p.



STEREO RADIO CABINET

Long, Low and Modern. Teak veneered with sliding front and tapered legs. Speaker spaces each end. Size approx. 4ft 2in × 13in × 15in. Probably cost over £20.00 to make. Our Price **£8.10** each.
Plus £1 per 100 miles carriage.

HORSTMANN 24-HOUR TIME SWITCH

With 6 position programmer. When fitted to hot water systems this could programme as follows:

Programme	Hot Water	Central Heating
0	Off	Off
1	Twice Daily	Off
2	All Day	Off
3	Twice Daily	Twice Daily
4	All Day	All Day
5	Continuously	Continuously

Suitable, of course, to programme other than central heating and hot water, for instance, programme upstairs and downstairs electric heating or heating and cooling or taped music and radio. In fact, there is no limit to the versatility of this Programmer. Mains operated. Size 3in × 3in × 2in deep. Price **£4.35** as illustrated but less case.

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 in good order. Price **£1.95** plus £1 post and insurance.

TERMS. ADD 8% V.A.T. Send postage where quoted—other items, post free if order for these items is £6, otherwise add 30p.

NEW ITEMS THIS MONTH

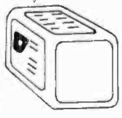
AC mains operated relay with single changeover 10 amp contacts, open type single screw fixing through the base. **50p** each.

Battery condition testers. This is another item which has been out of stock temporarily but we are pleasad to say, in stock again. Price now £3.50.

AM/FM tuning condenser as fitted to many Japanese and Hong Kong portables, this has two main tuning sections and four trimmers, approx. size 1" × 1" × 1". **60p** each.

Battery charger kit comprising 2 amp transformer, 2 amp full wave rectifier and 2 amp meter suitable for charging 6v or 12v. Special bargain price £1.50 the kit + 30p post.

MacDonald record auto-changer with cueing arm and ceramic stereo cartridge. This is a very superior auto-changer and one we can thoroughly recommend. Limited quantity, special price £7.35 + £1 post and insurance. Plinth and cover (the plinth has to be modified very slightly) available, price £4.95 + £1 post, or if you buy both together you can get a discount of £1.



Instrument case measures 18" × 12" × 12". This is a very well-made case built on an angled framework, has rounded corners and edges. Into this framework fit the 8 panels. All panels are louvred for ventilation, side panels are also fitted with handles, the bottom panel has 4 rubber feet. These instrument cases would probably cost around £15 each. We have approx. 100, not new but in very good condition and offer them at **£3** each.

Laboratory volt meter, BS1. This is the conventional square case, size 7" × 7" × 3½" with a leather carrying handle and rubber feet for horizontal and vertical standing. The meter is intended for horizontal use on the bench and has a mirrored scale. Hefty terminals along the top select the 3 ranges 0–150v, 0–300v and 0–600v DC. Price £6 + £1 post and insurance.

Laboratory amp meter, companion instrument to the above, but to read 0–20 amps 50 cycles. £5 + £1 post and insurance.

Soil heating transformer. 4v, 5v or 6v output, very heavy duty secondary rated at 250 amps, price **£20** + carriage £2 first 100 miles then £1 per 100 miles extra.

7 watt stereo/mono amplifier with usual switching and controls, in attractive teak style case. **£9.**

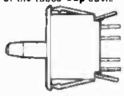
3 core lead, 7' 6" long, ribbed, virtually non-kinkable 23/36 conductors, so OK for 8 amps. Price **10p** each.

0–1 mA meter 2¼" square, flush mounting, English make ex equipment but perfect. **£1.75.**

0–100 microamp meter, as the above, but **£2.25.**

Solenoid 4–6v, size approx. 1" × 1" × 0.4" thick, twin coils give excellent pull. Mounted in frame but easily removable from this frame, fitted with lever giving approx. 0.4" push or pull. Price **30p** each.

Cold cathode tube Swiss made "Elasta" type No. ER 12A. We have no technical information on this tube and if any reader has this we will be obliged for any information. Price of the tubes **30p** each.



Push switch, double pole changeover contacts rated at 10 amps 250 volts made by the American Honeywell Co. A very reliable and robust switch with plenty of applications. Oblong plastic body, snap fitting into a hole size 1½" × ½". Offered at only a fraction of its proper price, namely **20p** each.

Ditto but single pole changeover, fits into a hole size 1" × ½". Price **15p** each.

(Note: the two switches above do not require a knob as they have a polished and tapered plunger.)

Ditto, but dished knob. 10p extra with knob.

J. BULL (ELECTRICAL) LTD.

(Dept. W.W.)

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Samson's

(ELECTRONICS) LTD.

9 & 10 CHAPEL ST., LONDON, N.W.1

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ADJACENT TO EDGWARE ROAD MET. LINE STATION

CURRENT RANGE OF NEW L.T. TRANSFORMERS FULLY SHROUDED TERMINAL BLOCK CONNECTIONS ALL PRIMARIES 220/240v

Type	Sec. Taps	Amps	Price	Postage
1A	25-33-40-50v	15	£14·00	75p
1B	25-33-40-50v	10	£12·00	75p
1C	25-33-40-50v	6	£8·50	60p
1D	25-33-40-50v	3	£7·50	60p
2A	4-16-24-32v	12	£10·00	75p
2B	4-16-24-32v	8	£8·00	60p
2C	4-16-24-32v	4	£4·95	45p
2D	4-16-24-32v	2	£3·50	40p
3A	24-30-36v	10	£9·00	60p
3B	24-30-36v	5	£7·50	50p
3C	24-30-36v	2	£3·50	40p
4A	12-20-24v	20	£12·00	75p
4B	12-20-24v	10	£7·50	60p
4C	12-20-24v	5	£4·95	40p
5A	3-12-18v	20	£10·00	60p
5B	3-12-18v	10	£6·95	60p
5C	3-12-18v	5	£4·50	40p
6A	48-56-60v	2	£4·50	40p
6B	48-56-60v	1	£3·50	40p
7A	6-12v	20	£7·90	60p
7B	6-12v	10	£4·50	40p
7C	6-12v	5	£3·50	40p
8A	17-32v	8	£8·00	60p
9A	12-24v	1	£2·50	30p
10A	9-15v	2	£2·50	30p
11A	8-0-8v	2	£2·50	30p

PLEASE ADD 8% V.A.T.

HEAVY DUTY UNSHROUDED TYPES 9 INCH FLYING LEADS ALL PRIMARIES 240v.

Type No.	Sec. Volt Tap.	Amps.	Price	Carr.
1	24-30-36	20	£15·75	£1·25
2	12-20-24	30	£15·75	£1·25
3	3-12-18	30	£15·75	£1·25
4	6-12	50	£15·75	£1·25

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. **£9·75**, carr. 50p.

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. Lists available.

PARMEKO OIL FILLED POTTED H.T. TRANSFORMERS

No. 1, Pri. 115-220-230v. Sec. 400-0-400v. 400 M/A. **£5·75.** Carr. £1. No. 2, Pri. 115-220-230v. Sec. 350-0-350v. 200 M/A. 6.3v. 6A., 5v. 3A. **£4·50.** Carr. 75p. No. 3, Pri. 115-220-230v. Sec. 330-0-330v. 200 M/A. 6·3v. 6A., 5v. 3A. **£4·00.** Carr. 75p. No. 4, Pri. 200-220-240v. Sec. 250-0-250v. 320 M/A. 6·3v. 10A. **£4·50.** Carr. £1·00. No. 5, Pri. 115-220-240v. Sec. 1875v. 60 M/A. and 500v. 31 M/A. **£4·95.** Carr. £1·00.

HT TRANSFORMERS BY FAMOUS MAKERS

No. 1, Pri. 110-210-230-250v. Sec. 230v. 200 M/A. and 6·3v. 7A. Potted type, **£3·00.** Carr. 50p. No. 2, Pri. 110-220-240v. Sec. 250v. 80 M/A. 15v./·2A., 6·3v. 4·5A. Open type table top connections. **£2·25.** Carr. 35p. No. 3, Pri. 220-240v, Sec. 250-0-250v. 75 M/A., 6·3v. 3A. **£1·75.** Carr. 35p. No. 4, Pri. 110-220-240v. Sec. 70v. 1A. and 30v. 1A. Separate windings, potted type. **£3·75.** Carr. 50p. No. 6, Pri. 220-240v. Sec. 140v. 195v. 6·3v. CT 1·25A. and 50v. 1A. **£3·50** Carr. 50p. No. 7, Pri. 220-230-240v. Sec. 1750v. 5 M/A. 400-100-0-100-400v. 120 M/A. 6·3v. 8A. 4v. 1A. 4v. 2A. Fully shrouded terminal block connections. **£6·50.** Carr. £1. No. 8, Pri, 230v. Sec. 125-0-125v. 100 M/A. "C" Core type. **£20·0.** P.P. 35p. No. 9, Pri, 220-240v. Sec. 250-0-250v. 50 M/A, 6·3v. 1A, 6/3v. 0·6A, 5.3v. 0/7A, "C" core type. **£2/25** P.P. 35p.

PARMEKO L.T. TRANSFORMERS

Open types. Pri. 110-220-240v. Sec. 30v 5·5 amps and 12v. 2·2 amps. Table top connections. **£4.95,** P.P. 75p. Pri. 240v. Sec. 26v. 10 amps and 12v. 0·1 amps. Table top connections. **£5·50,** P.P. 75p. Potted types. Pri. 115-230v. Sec. 24-30-32v 2 amps. **£2·75,** P.P. 35p. Pri. 220-240v. Sec. 50v. 0·4 amps. **£1·50,** P.P. 35p. Pri. 115-220-230v. Sec. 6·6v. 6A. twice, and 5v. 6A. The following outputs. can be obtained from this transformer: 6·6v. 6A., 6·6v. 6A., 5v. 6A., 13·6v. 6A., 5v. 6A., 6·6v. 12A., 5v. 6A., 11·6v. 6A., 18·2v. 6A. Potted type: **£4·95.** Carr. 75p. Pri. 220-240v. Sec. 24-0-24v. 470 M/A., 150v. 15 M/A., 4·5v. 1A. Potted type **£2·00.** P.P. 35p.

GARDNERS C CORE L.T. TRANSFORMERS

Table top connections. Primaries 200-220-240v. No. 1 Size 2·65-0-2·65v. 42 amps. **£4·50,** P.P. 70p. No. 2· 25v 10 amps and 2·5v amps twice. **£3·50,** P.P. 60p. No. 3 24v 3 amps. **£3·00,** P.P. 40p. No. 4 25-0-25v. 154 M/A and 7v. 1·35 amps. **£1·75,** P.P. 25p. No. 5 36v 350 M/A. **£1·00** P.P. 25p. No. 6 73v. tapped at 68v. 0·6 amp and 6v 1 amp. **£3·00,** P.P. 35p. No. 7 4·2v. 1 amp. **75p.** P.P. 25p.

GRESHAM MULTI TAPPED L.T. TRANSFORMERS

Pri. 110-220-240v. Sec. 21-22-23-27-28-30v 10a and 23-24-26v. 2·5a. Twice and 15-16-18v 15a Twice and 25-0-25v. m/a three times. C. core type. Table top connections **£10.00,** carr· **£1.00.**

GEC L.T. TRANSFORMERS

Pri. 220-240v. Sec. tapped. 51-61-65-67-69v. 10A. Unshrouded terminal block connections. **£8/75.** Carr. **£1/25.** Pri. 220-240v. Sec. tapped 58-63-69-74v. 3A. **£3/75.** Carr. 75p.

GARDNERS HEAVY DUTY TRANSFORMER

Pri. 240v. Sec. 50v. 20A. Very conservatively rated, unshrouded terminal block connections size 9x8x8 inches. **£17·50.** Carr. £2·00. Hoden, Pri. 110-220-230-240v. Sec. tapped 27-30-33v. 10A. **£7·50.** Carr. £1.

HOWELLS 'C' CORE TRANSFORMERS

Pri. 200-220-240v. Sec. 18-0-18v. 12·5A. Very conservatively rated, table top connections. **£10·00.** Carr. £2. Pri. 230v. Sec. 1·25-0-1·25v. 10A. **£2·00.** P.P. 35p. Siemens, Pri. 115-220-240v. Sec. 18v. 2A. twice. Unshrouded terminal block connections. **£3·00.** P.P. 35p.

GRESHAM E.H.T. TRANSFORMERS

Pri. 240v. Sec. 2300 M/A. 6·3v. 1·5A. Table top connections. Size. 5 × 3¼ × 3¼ ins. **£3·00.** Carr. 50p.

L.T. SMOOTHING CHOKES

By famous makers. 'C' Core types. 10 M/H. 25A. **£8·75.** Carr. £1·00. 140 M/H, 5A. **£3·00.** P.P. 75p. Potted types, 100 M/H. 2A. **£3·00.** Carr. 60p. 130 M/H. 1·15A. **£1·25.** P.P. 35p. Unshrouded types, terminal block connections. 150 M/H. 3A. **£3·00.** P.P. 60p. 4·8 M/H. 10A. **£3·00.** P.P. 60p. 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.

LEMARK L.T. TRANSFORMERS

Pri. 240v. 16-0-16v. 2·5a. 24v. 630 m/a twice. 24v. 65 m/a and 115v. 2a. auto tap on primary. Open frame table top connections **£3·50,** carr. 50p. Pri. 240v. Sec. 20-0-20 ½a. 5-0-5 2a. **£1·75,** carr. 35p. All above transformers have a screen winding. Pri. 220-240v. Sec. 56v. CT. 10a. Shrouded terminal block connections. **£8·50,** carr. 75p.

AIR CONTROL LTD

AIR BLOWERS 50-60v D.C. HP. 1/40th RPM 6000 cont rating. Size of motor 4x2¾x2¼ ins. Cowling 5 ins. dia. Outlet 1½x1¼ ins. **£2,50** carr. 45p.

PLEASE ADD 8% VAT TO ALL ORDERS INC. CARR.

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.

GENTS ALARM BELLS

6 volt DC 6 inch dia. Gong. Overall size 4½x6x6 inches. **£3·50,** P.P. 50p.

MOTOR START CAPACITORS TUBULAR TYPES

4 MFD 250v AC. 2·6 MFD 500v DC. 2·5 MFD 360v AC. 2·2 MFD 250v AC. All at 50p, P.P. 10p. Eire Miniature 2·2 MFD 400v Size 1¼ × 1 × ½ inches. **25p** post paid. TCC 8 MFD 800v DC WKG electrolytics **75p,** P.P. 15p.

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 × ½ in. Three for **50p,** post paid.

AEI AC 240V CONTACTORS

Type LS6-L11-02. 2 make, 2 break contacts, 20 amps. **£1·25,** P.P. 20p. Type LS6-L11-01, 3 make, 1 break contracts, **£1·25** P.P. 20p.

OIL-FILLED BLOCK CAPACITORS

MFD	DCV WKG	PRICE
8	2500	**£3·00**
8	600	**60p**
8	350	**40p**
6	750	**60p**
6	600	**50p**
4	1000	**60p**
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.

Fantastic DUAL BEAM DC–6MHz GENERAL PURPOSE PORTABLE OSCILLOSCOPE

As used by H.M. Forces

OSCILLOSCOPE CT436

Commercial Designation Solartron CD1014

General Purpose Dual Beam DC6MHz flat faced double gun cathode ray tube operating at 1.6kV. The time base velocity is continuously variable between 1cm/usec. and 1cm/sec. TIME BASE Free running or triggered from positive or negative pulses. Sweep speed 1cm/usec to 1cm/sec.

Synchronisation: positive or negative going internal from either channel or external continuous waves. Internal 3mm P/P. External 100mVP/P.

Sensitivity 100mV/cm; maximum on Y2 amplifier 1mV/cm. Size: 9½" × 11½" × 15". Wt. 25lb. PRICE: £79.50.

Solartron 1014 £85.

ADD 8% VAT TO ALL PRICES

MISCELLANEOUS TEST EQUIPMENT

SAMPLE OF OUR EXTENSIVE RANGES

UHF ATTENUATOR MARCONI INSTRUMENTS TF2163S
0–142dB in 1dB steps.
50Ω Impedance DC–1GHz. **£125**

ELECTROLYTIC CAPACITOR BRIDGE BY B.P.L.
Type CB 154-D. 0.2µf–22,000µf at 50Hz P.O.A.

DIGITAL VOLTMETER SOLARTRON LM1420.2
2.5µV–1KV in 6 ranges.
0.05% DC accuracy. **£235**

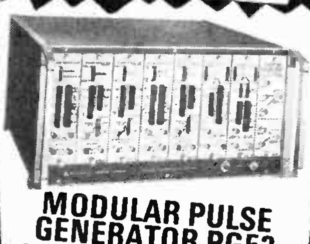
VHF ALIGNMENT SCOPE MARCONI TF1104
RF41–68MHz, 80–110MHz, 150–216MHz.
IF10–40MHz. VF5KHz–10MHz.
Output (Nom) 100µV–100mV.
Sweep Width 500KHz–10MHz Variable. **£150**

DOUBLE PULSE GENERATOR MARCONI TF1400/S
Ministry type CT434. C/W Secondary Pulse Generator plug in TM6600. 10Hz–100KHz. 100nsec–100µsec. Negative pulses up to 200V EMF. +VE pulses up to 60V EMF and simultaneous +VE and –VE pulses up to 20V EMF. **£100**

TRANSFER OSCILLATOR BECKMAN 7580H
DC–15GHz with counter. 7.5MHz–15GHz without coumer
Sensitivity 100mV (RMS). **£295**

DISTORTION FACTOR METER MARCONI TF142F
Fundamental frequency range 100Hz–8KHz.
Distortion measurement ranges 0–5% and 0–50% **£80**

SPECIAL PURCHASE OF ADVANCE EX-DEMONSTRATION TEST EQUIPMENT



MODULAR PULSE GENERATOR PG52

P1 Clock Gen. P2 Width or Delay, PL. P2, P3 P3 Outputs, P5 Variable Slope. Complete switched decade steps. Delay 25nS to 1S in switched decade steps. Output-up to 20V in 500 Ohms. Variable slope-rise and fall rates 1nS/V to 100m/V independently adjustable over 10:1 range. Double pulse output. Short circuit protection. **PRICE £275**

ADVANCE PG 56 DOUBLE PULSE GENERATOR

Independently variable 2Hz–3MHz pulse width. Delay 70nS–0.2 secs in 19 steps, rise time better than 10nS. External trigger and internal rate generator.

PRICE £120

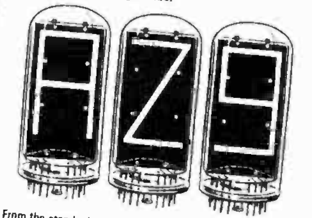
Advance T.V. Dot and Cross Hatch Generator SG73

Output in form of modulated signal at VHF and UHF at level suitable for aerial sockets of receiver. Two ranges, Band III on fundamental (MOD). Band IV & V On Harmonics (–MOD). Modulation 405 Lines or 625 Lines.
Ex-Demonstration, Brand New

SPECIAL OFFER THIS MONTH ONLY £29.50

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.



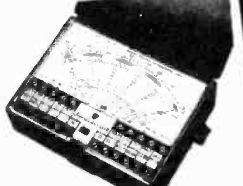
From the standpoint of both readability and electrical characteristics, the Alphanumeric NIXIE tube provides many unique benefits including
★ 170V–21mA ★ All DC operation
★ Uniform, continuous line characters of equal height
★ Memory with simple solid state drive circuits
★ Readability in high ambient light ... 200 footlamberts brightness ★ Long life with no loss of brightness
★ Character height 2¼ ins.

Price only 99p each plus 16p
Bases for above 60p each
DISCOUNT GIVEN FOR QUANTITY ORDER

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.

THE REVOLUTIONARY SUPERTESTER 680R

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.**

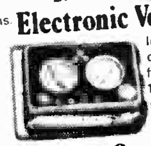
£18.50 with shockproof case

THESE ACCESSORIES CAN BE USED IN CONJUNCTION WITH THE SUPERTESTER 680R and MICROTESTER 80

Signal Injector Producing 1KHz and 500 KHz signals for circuit testing. **£5.95**

Gauss Meter For measuring magnetic field strengths. **£11.95**

Transistor Tester For transistors and diodes. **£11.95**



Electronic Voltmeter Input resistance of 11Mohms for d.c. and 1.6Mohms shunted by 10pF for a.c. **£24.00**

Amperclamp For measuring a.c. currents from 250mA to 500 amps. **£11.95**

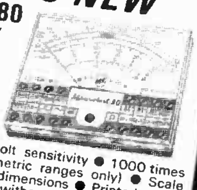
Temperature Probe Covering the range –50 to +200°C **£11.95**

Phase Sequence Indicator To indicate the phase sequence of a 3 phase supply. **£5.95.**

OTHER ACCESSORIES AVAILABLE: **LIGHT METER £11.95. RESISTOR MULTIPLIER £5.95. SHUNTS** D.C. 25, 50 and 100 amps. **£4.50 each. CURRENT TRANSFORMERS** A.C. 25 and 100 amps. **£7.00 each. E.H.T. PROBE** Extends D.C. voltage to 25,000v. **£5.95.**

FANTASTIC NEW MICROTEST 80

MEASURES ONLY 90×70×18 mm
AMAZING VALUE at £11.95



8 fields of measurement and 40 ranges
● 20,000 ohm per volt sensitivity ● 1000 times overload (on the ohmetric ranges only) ● Scale width and small case dimensions ● Printed circuit board is removable without soldering ● Fully screened against external magnetic fields ● Full ranges of accessories ● Accuracy and stability of indicated reading <2% in A.C.-D.C.> ● Simplicity and ease of use and readibility
Volts D.C. 6 ranges: 100mV–2V.–10V.–50V.–200V.–1000V. (20kΩ/V). **Volts A.C. 5 ranges:** 1.5V.–10V.–50V.–250V.–1000V. (4kΩ/V). **Amp. D.C. 6 ranges:** 50µA–500µA–5mA–50mA–500mA–5A. **Amp. A.C. 5 ranges:** 250µA–2.5mA–250mA–2.5A. **Ohms 4 ranges:** LowΩ–Ω×1–Ω×10–Ω×100 (da 1/10 di Ω fino a 5 Mega Ω). **V Output 5 ranges:** 1.5V.–10V.–50V.–250V.–1000V. **Decibels 5 ranges:** +6dB, +22dB, +36dB, +50dB, +62dB. **Capacity 4 ranges:** 25µF–250µF–2500µF–25,000µF.

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

AMPEX SP-300 FM/DIRECT RECORDER/REPRODUCER 4 Channels. Speed 1⅞, 3¾, 7½ 15 ips. Flutter 0.15% at 151 ips. Frequency Response: Instrumentation 50Hz to 40Hz at 15 ips. Audio 50Hz to 18Khz at 15 ips. **£1950**

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**

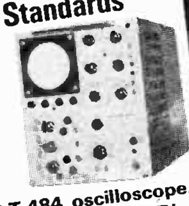
Cossor CDU 150 (CT531) DC 35MHz 5mV/cm Sensitivity fully transistorised P.O.A.

BONANZA

LIMITED QUANTITY

Made to meet the most stringent Government Service Standards

DC–40MHz DUAL TRACE



Solartron C.T.484 oscilloscope. 3% accuracy. Dual Trace Displays.

DUAL TRACE Y AMPLIFIER. Bandwidth: D.C.–24 Mc/s. Rise Time: 14 nanosecs. Sensitivity: 50 mV/cm. Input Impedance: 1 M.ohm 26pF. Measuring Accuracy: ±5% direct. ±3% with calibrator.
TIME BASE. 100 nanosecs/cm–5 secs/cm or continuously variable up to 12 secs/cm. Sweep expansion X 5. Accuracy: ±3%.
X AMPLIFIER. Bandwidth: D.C.–150 Kc/s. Input Sensitivity: 200 mV/cm and 1 V/cm. Input Impedance: 1 M.ohm 40 pF.
INTERNAL CALIBRATOR. Accuracy: ±3%.
WIDE BAND Y AMPLIFIER PLUG ALSO AVAILABLE: Bandwidth: D.C.–40 Mc/s. Rise Time: 8 nanosecs. Sensitivity: 50 mV/cm. Input Impedance: 1M.ohm 22pF Measuring Accuracy: ±5% direct. ±3% with calibrator.
P.O.A.

£149.50

HERE! NOW! FOR IMMEDIATE DELIVERY!

AVO's

Fully tested and checked, guaranteed 12 months with one free calibration. Inc batts.
Test Set No.1 panclimatic Avo similar to specification as model 9. **£42**

7X £28 8X £38
Leads extra

Ever-ready case enables the meter to be used while in its case £5.
*Please note: X stands for fully tropicalised, splash-proof and mu-metal shield.

FABULOUS RANGE OF SIGNAL GENERATORS

H.P. VHF Signal Gen. 608B 10MHz to 400MHz **£175**
H.P. UHF Signal Gen. 612A 450MHz to 1250MHz **£495**
H.P. UHF Signal Gen. 614A 800MHz to 2100MHz **£225**
H.P. Sweep Oscillator 693D 4GHz to 8GHz **£450**
801B.3 **£155**
TF801D Series **£275**
General Radio UHF Unit Oscillator + PSU 250MHz to 960MHz p.o.a.
Marconi PHM/AM Signal Generator TF2003 400KHz to 12.5MHz p.o.a.
Marconi 801A as is £25.00
CALLERS ONLY. NO GUARANTEE

NEW TOUCHLESS RETRO-REFLECTIVE TACHOMETER

FEATURES
- Reads RPM from as far as 24" away!
- Four ranges: 0–1,000, 3,000, 10,000, 30,000 RPM*
- Instant field calibration
- Reads low or high speed on any type of machinery
- Battery powered—built-in voltage checker
- "Touchless" (no torque loss) measurements
- Direct reading, mirror type scale
- Hand portable (only 32 oz.) (0.9 Kg)
- Accuracy: 1½% if full scale
- Aluminium case—baked enamel finish
- Reads on marked shafts as small as 1/16 dia.
- Marking tape provided
- Complete solid-state circuitry
- Push-button reading
- Hidden probe cable, extends to 24" (60cm)

ONLY £89.50

6V 25A Power Supplies

10% VARIABLE VOLTAGE HIGH CURRENT HIGH STABILITY HIGH RELIABILITY

These power supplies were designed for continuous operation in computer equipment. Manufactured to highest engineering standard for long-term reliability and stability. Independent voltage and current meters. C Core Transformer.
Manufacturer's price probably in excess of £200. **£25**

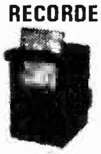
MULTI OUTPUT POWER SUPPLIES

Ex-Computer offered at mere fraction of original manufacturer's cost.

APT 13334 Mk III
Input 200/240V. + 10V – 5Amp. – 10V – 2Amp. + 24V – 2Amp. + 20V – 5Amp. – 20V – 2Amp. PRICE **£19.50**

Advances DC197
6V 7.5Amp. 6V 11Amp. 28V 9Amp. PRICE **£35**

BRAND NEW MINIATURISED STRIP CHART RECORDER BY RUSTRAK Model 88



This recorder indicates the magnitude of applied currents of voltages by a continuous distortion free line on pressure sensitive paper. Moving coil movement scale calibrated 1 milliamp D.C. internal resistance 100 ohms. Chart Drive motor 240V 50Hz.
Chart speeds 90" per hour **£39**
1" per hour **£45** or 6" or 12".

SINGLE PEN RECORDER by Record Electrical

3" chart sensitivity 1 milliamp chart speed 1 and 6" per hr. Size 8" X 11" X 6". Offered complete with pen assembly. Listed at over £120—this month's special price due to bulk purchase.

1mA version £50
500μA version £60

AC CLAMP VOLTAMMETER

Clamp-on Voltammeter is used for measurements of AC voltages and currents without breaking circuits.

Specification
Measurement ranges:—Current 10–25–100–250–500 Amps. Voltage 300. 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283X94X36mm. Weight 1.5 lbs.

£12.50

Potentiometers

TEN TURN 3600° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
50		Beckman	AR/S	£2.25
100	0.5	Beckman	A.S.	£2·00
200	0.5	Beckman	A.	£2·00
500	0.1	Beckman	S.	£2·50
500	1·0	Relcon	HEL107-10	£2·25
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07–10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·1	Beckman X	A.	£3·50
15K		Colvern	CLR2402	£3·00
25K	0·5	Helipot	SAJ337	£3·00
30K	0·1	Beckman	A.88	£3·50
30K	0·5	Beckman	SA1692	£3·00
50K		Reliance	07·10	£2·25
50K			07·5	£2·25
50K	0·5	Beckman	A.	£3·00
100K	0·1	Beckman	A.	£3·50
100K		Colvern	2501	£2·25

THREE TURN 780° ROTATION

100/100	Beckman	Type C	£3·00

FIFTEEN TURN 5400° ROTATION

25K/25K	Beckman B	10 watts	£6·50
46K/46K	Beckman B	10 watts	£6·50

NEW "Strobette" STROBOSCOPE–TACHOMETER

Combined Stroboscope-Tachometer. 200 to 6000 flashes per minute.
200 to 6000 r.p.m. Accuracy 3% or better. Beam angle 80°.
Flash Duration: 10 to 25 microseconds. Light colour Xenon white 500°.
Compact lightweight (27 oz.) easy to use one/off and on switch.

ONLY £49.50

FANTASTIC BUYS IN PEN RECORDERS

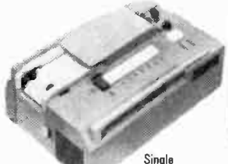
10 CHANNEL EVENT RECORDER

Response time 100 milliseconds. Chart width 110mm. Chart length 50ft. Inv. capacity 72 hours. Chart speeds 20-60-180-600-1800-5400 mm/hour. Size 160 X 160 X 255mm. Weight 9 lbs. Price complete with accessories.

£52.00

HIGH SPEED PEN RECORDER

Chart length 175 ft. Footage indicator. Width of recording channel 80mm. Chart speeds (selected by push buttons) 1.2 6-12-30-60-120-300-600-3000mm per minute. Full deflection current 8mA. Internal impedance 210 ohms. External impedance 800 ohms. Dimensions 320X340X175mm. Weight 35 lbs. Price complete with accessories.



Single Channel **£180**
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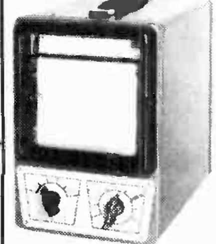

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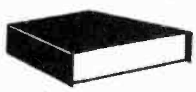

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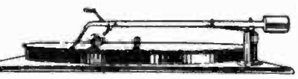

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UIC05=12×7405	0.54
UIC06=8×7406	0.54
UIC07=8×7407	0.54
UIC10=12×7410	0.54
UIC20=12×7420	0.54
UIC30=12×7430	0.54
UIC40=12×7440	0.54
UIC41=5×7441	0.54
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UIC54=12×7454	0.54
UIC60=12×7460	0.54
UIC70=8×7470	0.54
UIC72=8×7472	0.54
UI073=8×7473	0.54
UIC74=8×7474	0.54
UIC76=8×7476	0.54
UIC80=5×7480	0.54
UIC81=5×7481	0.54
UIC82=5×7482	0.54
UIC83=5×7483	0.54
UIC86=5×7486	0.54

Pak No. Contents	Price
UIC90=5×7490	0.54
UIC91=5×7491	0.54
UIC92=5×7492	0.54
UIC93=5×7493	0.54
UIC94=5×7494	0.54
UIC95=5×7495	0.54
UIC96=5×7496	0.54
UIC100=5×74100	0.54
UIC121=5×74121	0.54
UIC141=5×74141	0.54
UIC151=5×74151	0.54
UIO154=5×74154	0.54
UIC193=5×74193	0.54
UIC199=5×74199	0.54
UICXI=25 Assorted 74's	1.65

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

LINEAR I.C.'s—FULL SPEC.

Type No.	1	25	100+
72702	0.50	0.48	0.45
72709	0.25	0.23	0.20
72709P	0.20	0.19	0.18
72710	0.35	0.33	0.30
72741	0.30	0.29	0.28
72741C	0.28	0.27	0.26
72741P	0.30	0.29	0.28
72747	0.85	0.80	0.75
72748P	0.38	0.36	0.34
SL201C	0.59	0.45	0.40
SL701C	0.50	0.45	0.40
SL702C	0.50	0.45	0.40
TAA263	0.80	0.70	0.60
TAA293	£1.00	0.95	0.90
TAA350A	£1.85	£1.80	£1.70
μA703C	0.28	0.26	0.24
μA709C	0.20	0.19	0.18
μA711	0.35	0.33	0.30
μA712	0.35	0.33	0.30
TBA800	£1.50	£1.45	£1.40
76003	£1.50	£1.45	£1.40
76023	£1.50	£1.45	£1.40
76660	0.95	0.93	0.90
LM380	£1.00	0.97	0.95
NE555	0.65	0.63	0.60
NE556	0.95	0.93	0.90

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

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Send S.A.E. and 10p

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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
TSO 14 pin type	33p	30p	27p
TSO 16 „ „	38p	35p	32p
TSO 24 „ „	75p	70p	68p
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	£1.20
MAN 3M. L.E.D. 7-segment 0·127"	£1.90

All indicators 0.9 + Decimal point. All side viewing. Full data for all types available on request.

SHP80 STEREO HEADPHONES, 4-16 ohms impedance. Frequency response 20 to 20,000Hz. Stereo/mono switch and volume controls. £4.95

EDSR 3166 TRIPLE 66 BIT DYNAMIC SHIFT REGISTER TTL Compatible. Low Clock Capacitance, High Speed Diode Protected Inputs Wired 'OR' Capability SPECIFICATION SHEET AVAILABLE £1 each

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TC 20. £3.95 p&p 45p

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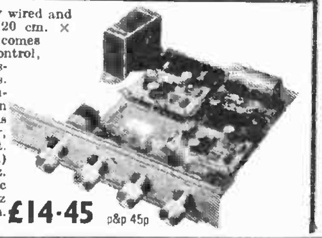
The STEREO 20



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 p&p 45p

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μA7818 18V	£1.35

TRANSFORMERS

T461 (Use with AL10) £1.60 P. & P. 22p.
T538 (Use with AL20 & AL30) £2.30 P. & P. 22p.
BMT80 (Use with AL60) £2.75 P. & P. 40p.

POWER SUPPLIES

PS 12. (Use with AL10, AL20 & AL30) 95p
SPM 80. (Use with AL60) £3.25

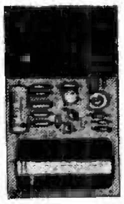
NOW WE GIVE YOU 50w PEAK (25w R.M.S.) *PLUS* THERMAL PROTECTION!
The NEW AL60 Hi-Fi Audio Amplifier FOR ONLY £4.25

- 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 £2.75 p. & p. 40p

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	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	3·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	75mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	3mV into 50KΩ	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 **£14.25**

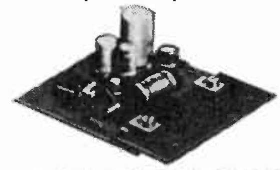
MK 60 AUDIO KIT

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: £29.75 plus 45p postage.

TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16¼"×11½"×3¾", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets etc. Kit price: £9.95 plus 45p 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

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

All prices inclusive of V.A.T. Giro No. 388 - 7006
Please send all orders direct to warehouse and despatch department

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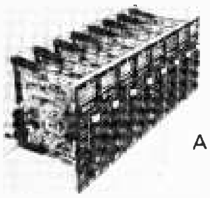
Postage and packing add 20p. Overseas add extra for airmail. Minimum order 55p. Cash with order please.

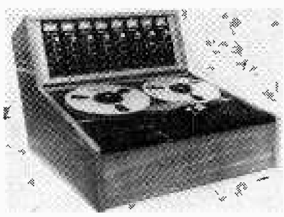
Guaranteed Satisfaction or Money Back

A revolution in the recording industry

Comprehensive facilities include sync on all channels, servo controlled capstan, modular electronics, variable speed (optional), relay solenoid operation.



Fully modular electronics using plug-in PCBs throughout. Separate sync and replay amps give identical levels. Switchable VUs with slow decay. Individual oscillator for each channel. Dolby A switching facility.



Compact console presentation for easy portability. £1,790 + VAT. Full console optional extra.

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Industrial Tape Applications, 5 Pratt Street, London NW1 0AE.
Tel: 01-485 6162/7833. Telex: 21879.

WW—190 FOR FURTHER DETAILS

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Broadcast pattern jackfields, jackcords, plugs and jacks
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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 source of reference for research workers and those in related fields.

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

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QUADROPHONIC TAPE PLAYERS

Tape Transports

Brenell Mark V Series III Tape Decks mounted on Imhof Case IMP503/1915 size 21 in. wide x 19 in. front to back and 10 in. high overall including deck. This rugged unit can be purchased separately or fitted with the amplifiers described below. Others are available giving up to eight tracks. Price from £118

Playback Pre-amplifiers

A self-powered unit size 19 in. x 5¼ in. x 4½ in. deep with four plug-in low noise preamplifiers giving 1V output into 100 ohm line. Price £32

Quad Power Amplifiers

A complete amplifier size 7 in. x 10½ in. x 4 in. high with four plug-in power amplifiers each giving 8W RMS into 8 ohms from TIP31/32 output stage. 30V supply. Price £37

Tax and carriage extra

Ask about tape controlled teaching equipment, with illuminated panel display, for typewriting and playing the piano or organ.

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Simmonds Road, Wincheap Industrial Estate,
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Tel: 0227 68597

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.

P.O. type 2201a MINIATURE UNISELECTORS including Jack 12 outlet 2 bridging 1 non-bridging wipers. This compact ratchet-driven 3-level selector is of unique design and occupies no more space than a standard 3000 type Relay. £8.50 each. P.O. Type 2 Uniselectors 25 outlet 8-level non-bridging wipers 300 ohms, £14 each. Eleven-level 1 bridging 10 non-bridging 65 ohms, £17 each. P.O. Type 3 Uniselectors 25 outlet 4 level including single homing arc 1 bridging 3 non-bridging wipers 100 ohms, £10.50 each.

We can supply from stock a complete range of G.E.C. miniature sealed and Ericsson cylindrical type Relays, also P.O. type High Speed open Relays 88 and 89 series, latest type 100 AM 2 × 53 ohms £3.50 each.

BRIDGE MEGGERS 1,000 volts range 0/100 meg—ohms/infinity with resistance box **£85**.

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.

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.

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L. WILKINSON (CROYDON) LTD., LONGLEY HOUSE, LONGLEY RD., CROYDON, CR0 3LH. Phone 01-684 0236. Grams: WILCO CROYDON

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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.

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For more information, write to: ETE Maritime Radio Services Division (L534), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London, EC1A 1AS.

Post Office Telecommunications

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(TV Systems)

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★ Methods Engineering/Aspects of work study
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We offer a competitive starting salary and full employee benefits, including assistance with relocation expenses in approved circumstances.

Please write, with details of qualifications and career, to: Mrs J. A. Macnab, Personnel Manager

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based in Camberley to assist in the final testing of personal and mobile radio equipment and sophisticated control systems.

Knowledge of RF, digital and thick film techniques desirable with academic levels to ONC or C. & G. Final, but for an applicant with exceptional experience and knowledge these qualifications may be waived.

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Apply: The Personnel Officer,
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LIMITED,
Frimley Road,
Camberley. Telephone: 0276 29131

Storno *SERVES THE NATION...*

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TEES 257

The Independent Local Radio Station based on Teesside is seeking technical staff. The staff will be responsible to the Chief Engineer for the full range of operational and maintenance requirements, including outside broadcasts.

The studios, based in Stockton, will be equipped with the most up-to-date stereo equipment, and transmissions are expected to start early this summer.

Salaries offered will reflect the experience of the candidate and there will be a contributory pension scheme.

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Cleveland

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BYFLEET 47117

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Tape Duplicating

The Tape Duplicating Co., the leading independent production company in this field, require an experienced electronics engineer to take charge of the calibration and maintenance of the extensive, modern electronic and electro-mechanical equipment at their plant in Waltham Abbey.

Applicants, aged 22-25, with at least ONC, should preferably have experience of tape recording techniques and be capable of working with the minimum of supervision.

A good salary, commensurate with age and experience, will be paid and there are opportunities for well-paid overtime.

Apply, Personnel Manager, (ref. RMW)
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Canada's Leader in cable Television requires personnel for research and production Departments.

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Opening for Director of Electronics Engineering—should have CATV or related experience.

Electronics person strong in leadership, Methods and Mechanical Acumen required for capacity of Production Manager.

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Research Fellow

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Applicants should hold appropriate degree qualification in Physics or Electronic Engineering, and have practical ability and experience relevant to this field.

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The post is available for one year in the first instance with the possibility of an extension for a further 2 years.

Applications, with full c.v., naming 2 referees to the Personnel Officer, RPMS, Hammersmith Hospital, DuCane Road, London W12 0HS, quoting ref. No. 8/220. [4601

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GRADE II

Electronic Technician is required to take charge of the Medical Engineering Maintenance Department dealing with the maintenance of a wide variety of electronic and electro medical apparatus. Applicants must possess HNC or HND in Electronics or equivalent qualifications.

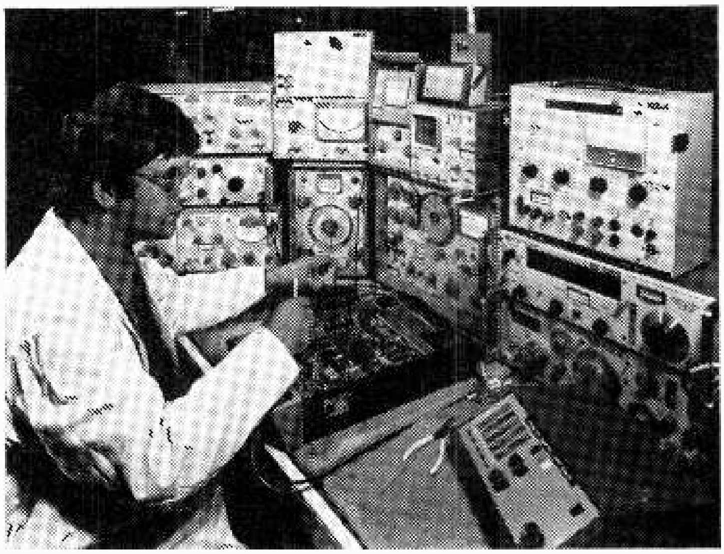
Several years experience in the field of Electronic Engineering in particular diagnostic maintenance is necessary. The ability to manage and supervise staff will play an important part of the job and training in the maintenance of specialised hospital equipment will be given.

Salary from £2,601-£3,390 p.a. plus Threshold. Additional payments are made if overtime is required.

There are many advantages of living and working in Coventry so find out more by writing, stating age, qualifications and experience together with the names of two referees to the Area Works Officer, Coventry Area Health Authority, The Birches, Tamworth Road, Keresley End, Coventry CV7 8NN.

[4615

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.

Find out more right now by phoning or writing to Mrs Audrey Darkin at:

Pye Telecommunications Ltd
Cambridge Works, Elizabeth Way, Cambridge CB4 1DW. Tel: Cambridge 58985

A member of the Pye of Cambridge Group

4496

Radiomobile

BRITAIN'S CAR RADIO SPECIALISTS

SENIOR ELECTRONICS ENGINEER

Reporting to the Production Engineering Manager, he will be responsible for providing a day-to-day service to manufacturing, ensuring maximum continuity of production.
He will liaise with design engineers to provide information concerning preferred production practice on the electronic aspect of radio assembly.
Experience in FM radio is highly desirable plus the ability to control a small section of electronic engineers.
A degree in electronic engineering is preferred, but candidates with HND or HNC will be considered.
It is considered that this position will be of interest to those in their late twenties or thereabouts. The starting salary will depend on the degree to which you can meet our requirements, and the conditions of service are those associated with a progressive organization.
Please write or telephone for an Application Form to:
Miss I. S. Thom, Personnel Manager,
RADIOMOBILE LIMITED,
North Circular Road, London, NW2, 452 3333, Ext. 4340 or 4518.

4587

THE UNIVERSITY OF HULL

Applications are invited for the post of

VIDEOTAPE/ TELECINE ENGINEER

in the Audio Visual Centre (a University Service unit). Duties include operating and maintaining the helical scan videotape system—including editing and telecine. The post is one of responsibility, working in an extensive and well equipped television unit. Candidates should have experience of broadcasting or educational television operations.

Preferred qualifications: H.N.C. or City & Guilds. Salary on scale £2,844–£3,450 (Grade 6). Applications quoting the names of two referees and ref. no. AV/1 to the Technical Staff Officer, University of Hull, by 13 May, 1975.

[4627

UNIVERSITY OF LIVERPOOL

Department of Physics

OPERATOR

Required to assist with running a 12 MeV Tandem Van de Graaff Accelerator. Candidates must possess an HNC or equivalent qualification, and practical experience of installation and maintenance of one of the following: electrical machinery, electric equipment, vacuum systems. Salary on the csale £2,439–£2,895 p.a. plus bonus for shift work (at present 30%).

Application forms may be obtained from the Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote ref. RV/427/WW.

[4618

VISION ENGINEER

required to join small team operating a

TV Unit for Horseracing

If you have an HNC or equivalent qualification and have experience in operating and maintaining mobile TV equipment and VTRs together with a willingness to travel and to work in a demanding field, then this Company offers you:

1 the opportunity to join an organisation that is forward looking and is planning to develop and expand in the field of television and electronics;
2 a job that is located in varied surroundings on British race courses;
3 a basic salary between £2,700—£3,375 plus expenses when on location.

Telephone: The Secretary, Racecourse Technical Services, 88 Bushey Road, London SW20. 01-947 3333. [4594

RADIO OFFICERS

Do you have PMG I, PMG II, MPT 2 years operating experience?

Possession of one of these qualifies you for consideration for a Radio Officer post with composite signals organisation.

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on a scale rising to £3,242 pa; commencing salary according to age—25 years and over £2,383 pa. During training salary also by age, 25 and over £1,724 pa with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Applications only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from:

Recruitment Officer,
Government Communications Headquarters,
Room A/1105, Priors Road, Oakley,
Cheltenham, Glos GL52 5AJ
Telephone Cheltenham 21491 Ext 2270

|92

Electrical and Electronic Engineering Instructor

Effective training is vital to keep Pye of Cambridge as one of Britain's leading electronic groups.
With this in mind, we seek an electrical and electronic engineering instructor to join the well-equipped Pye Technical Training Centre.
The work involves instruction, both theoretical and practical, of first-year craft and technician trainees in the electrical and electronic part of their course. This means lecturing, demonstrating and supervision, to develop basic skills and knowledge.
The man appointed will need as a minimum qualification ONC or C & G final or equivalent: HNC or equivalent and previous training experience would be desirable, but we are prepared to give necessary training in instructional techniques. He should also have factory experience of current assembly and wiring techniques, including printed circuits.
This vacancy could suit an electronic technician interested in training, as well as a more experienced person.
We offer a good starting salary and the benefits and job security of a major international group. Please send details of qualifications and experience to:
T. D. Humphreys, Personnel Manager

4591

Pye of Cambridge Ltd
St Andrews Road Cambridge
CB41DP Tel: Cambridge (0223) 58985

Southern Television Limited

requires an

ENGINEER

A vacancy has occurred for an Engineer at DOVER to undertake the operation and maintenance of broadcasting equipment.

Candidates should be aged 23-30 and qualified to minimum H.N.C. in Electronics, or preferably a Degree. Previous experience in the Broadcasting Industry would be an advantage.

Working conditions are excellent and include Pension, Life and Accident Insurance Schemes and four weeks annual holiday.

Please apply in writing to:-

The Personnel Administrator,
Southern Television Limited,
Northam,
Southampton SO9 4YQ

[4604

FOREIGN AND COMMONWEALTH OFFICE

We have 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 transmitters, and who hold a third year City and Guilds Certificate in Telecommunications or its equivalent.

SALARY:

£6,563 per annum plus a cost of living supplement of £229.68 per annum. In addition a tax free allowance of £480 per annum is payable 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

[4585

Join the EMI Service Team at Hayes

We urgently require

Electronic Repair & Calibration Engineers

for the repair and calibration of a wide range of electronic instrumentation, including oscilloscopes, DVMs, pulse generators, power supplies etc.

Applicants should be aged 18 years and should have had at least two years background in 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, there will be attractive starting salaries 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. 4621

ELECTRONIC CRAFTSMEN

Is your present job routine and uninteresting?

We are a research establishment and our craftsmen are engaged on a wide variety of work in the fields of prototype and small batch wiring and assembly, test and inspection, maintenance fault finding and repair. Why not join us and enjoy working in first class conditions in the country.

You can expect gross earnings including overtime of £45 per week, and we can offer good housing at low rental (for applicants who reside outside the radius of our Assisted Travel Area) together with 3 weeks paid holiday with holiday bonus, free pension and excellent sick benefit scheme.

Applicants who should have served a recognised apprenticeship or have had equivalent training together with experience in one of the fields detailed should 'phone Tadley 4111 (STD 073 56 4111) Ext. 5230, or write to:

INDUSTRIAL RECRUITMENT OFFICER
(PA/79/WW) PROCUREMENT EXECUTIVE
MINISTRY OF DEFENCE
AWRE ALDERMASTON
READING, BERKS.
RG7 4PR.

[4316

RADIO TECHNICIAN FOR CENTRAL AMERICA

Needed to work in Guatemala with the Radio Schools Movement, training a team of Guatemalans in the maintenance and repair of station equipment. A British Volunteer Programme post.

Information:

Paddy Coulter, Overseas Volunteers/CIIR, 41 Holland Park, London W.11. [4577

SITUATIONS VACANT

ELECTRO-MECHANICAL wire man/assembler required for work on professional recording equipment. Experience preferred but not essential. Good prospects for conscientious person capable of working to a high standard. Bias Electronics Limited, 572 Kingston Road, London SW20 8DR. 01-540 8808. [4608

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

TELEVISION ENGINEER required, for independent Company in West London. Must be fully experienced with Monochrome and Colour TV's. Able to drive. Top salary paid for the right applicant. Please contact Mrs Gostelow on 01-603 8488 for interview. [4619

UNIVERSITY OF LEEDS. A vacancy exists in the Department of Electrical and Electronic Engineering for an Electronic Technician in the Electronics Workshop. The duties will involve the development and construction of prototype electronic equipment together with the modification, testing and maintenance of a wide range of electronic equipment used in teaching and research. Minimum qualifications ONC, OND, or City & Guilds certificates in Electronic Engineering, together with at least 7 years relevant experience. Initial salary corresponding to the Grade 5 scale of £2,439 to £2,895 per annum. Applications in writing to Mr. C. S. Petch, Department of Electrical and Electronic Engineering, The University, Leeds LS2 9JT. [4605

ARTICLES FOR SALE

AARVAK, SOUNDLIGHT Converters, from £9; Strobes, from £21; loads more, free catalogue, 98A (W), West Green Road, London, N15 5NS; 01-800 8656. [23

CLEARING distributor stocks, transistors, diodes, components, etc. Sample pack 65p incl., postage or send stamp for list. Redhawk Sales Ltd. 10 Maple Lodge Close, Rickmansworth, Herts. Mail Order Only. [4499

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 CHIP, AY-5-1224, with data and circuit diagram, £3.66 plus VAT. 'Jumbo' LED digits (16mm high) type DL-747, only £2.04 each plus VAT, post free. Greenbank Electronics, 94 New Chester Road, Wirral, Merseyside L62 5AG. [83

EX GPO Miscellaneous parts and equipment for sale. Phone: 01-856 7923. [4599

HEATH 10-102 DC—5MHz Scope. Solid-State. Like new. Less than 25 operating hours. £60. 26 Oberon Close, Hartford, Huntingdon, Cambs. [4515

LADDERS unvarnished 14ft. 1in. closed, 25ft. 4in. extd. £21.40 delivered. Tel: Telford 586644. [13

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. Television construction cross hatch kit, £3.85, P/P 15p. Bush CTV 25. 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 £2.75, P/P 35p. CR1 Base panel, 75p. 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, 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. 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, 75p P/P 35p. PHILIPS 625 IF amplifier panel incl. cct., 75p. 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, £1.80 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. 200+200+100 Microfarad 350v Electrolytic, £1.00 P/P 20p. MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6. Shop premises, callers welcome. (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.

HIGH intensity electronic sirens for Police—ambulances—emergency cars. Representatives wanted World Wide. Polar Electronics. Box 710-3191 Horten, Norway. [4597

LOW COST IC MOUNTING. Use Soldercon IC socket pins for 8 to 40 pin DIL's. 70p (plus 5p VAT) for strip of 100 pins, £1.50 (plus 12p VAT) for 3 strips of 100, £4 (plus 32p VAT) for 1,000. Instructions supplied. Send for sample. SINTEL, 53c Aston Street, Oxford. Tel: 0865 43203. [67

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

VALVE TESTER AVO 160. Portable suitcase model with handbooks, £50 o.n.o. St Albans 69236. [4622

VALVES 1930 to 1975 types in stock, many obsolete. List 15p. Transistors. List 15p. We buy new and boxed valves, also transistors. Cox Radio (Sussex) Ltd., The Parade, East Wittering, Sussex, West Wittering 2023. [4598

VIDEO TAPE RECORDER. Ikegami TVR 301-3E. Records/plays T.V. programmes. 1 hour tape and handbook, £100 o.n.o. St Albans 69236. [4623

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

51 MM B. & H. 631 Sound Projector C/W Speaker & Transformer, £135. Hilton, 9 West Hill, Dartford 20009. [4574

16 MM B & H 631 Sound Projector, C/W Speaker and Transformer £135. Hilton, 9 West Hill, Dartford 20009. [4596

ARTICLES WANTED

SURPLUS Components, Equipment and Computer panels wanted for cash. Ring: Southampton 772501. [4616

TELEPHONES WANTED. Candle stick type or older (Foreign & English). 01-722 4151. [4624

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

WE BUY modern 16mm sound projectors. Burgess Lane & Co. Ltd., Thornton Works, Thornton Avenue, Chiswick W.4. 994 5752/5953. [4387

ELECTRONICS VACANCIES

Ministry of Defence Experimental Establishment in the Lake District requires experienced electronics mechanics to build, develop and diagnose a wide range of instrumentation.

Rate of pay for 40-hour, 5-day week £33.41 plus Productivity Bonus of £4 and Cost of Living Allowance of £4.40 per week.

The posts are pensionable, there is a sick pay scheme, three weeks' annual paid holiday and an assisted travel scheme. There is a prospect of housing accommodation within a reasonable period for a married man, hostel accommodation is immediately available for single men.

If you have served a recognised apprenticeship or have had equivalent service training and would like to work in a beautiful part of the country, send for an application form to:

Personnel Officer,
Ministry of Defence (Procurement Executive),
Eskmeals,
Bootle Station,
CUMBRIA LA19 5YR

Telephone: Ravenglass 214/5/6

4593

Department of Anaesthetics

Technician

required to be responsible for the deployment, servicing and maintenance of electro-mechanical equipment in the Intensive Care Units of Guy's Hospital. The post carries responsibility for the cleaning and sterilization of ventilators and humidifiers to the highest bacteriological control standards, the proper functioning of oxygen delivery equipment and the supervision of equipment for resuscitation. In addition there will be a need to monitor the accurate performance of such equipment using suitable measurement techniques and there will be an opportunity to become involved in other technical and research procedures. There is a well-equipped workshop available in which the successful applicant's electrical and mechanical skills can be fully utilized. The ability to liaise with all levels of hospital personnel is an important feature of the post.

The appointment will be on the Medical Physics Technician IV scale (salary £2,315–£3.005) depending on qualification and experience.

Applications should be made to the Personnel Department, Guy's Hospital, London SE1 9RT as soon as possible, quoting ref. no. L255417.
Tel. 01-407 3662, ext. 35.

4586

Guy's
HEALTH DISTRICT

APPOINTMENTS CONT.

TV Broadcasting

Project Engineers

Fully experienced broadcasting engineers are needed to help the growth of Pye TVT as a leading international designer and manufacturer of TV broadcasting systems and equipment.

The applicants appointed as Project Engineers (Commercial) will closely liaise with all relevant departments in defining and design of Studio, Outside Broadcast and sometimes radio schemes or transmitters to meet customers' specific requirements. They will be responsible for the preparation of tenders and will assist in their negotiation, which will involve some travel overseas. They should be qualified to at least H.N.C. level and fully experienced in either design, installation or operation of TV Studio and/or Outside Broadcast vehicles, or Transmitters.

The appointments are based in Cambridge, and relocation expenses will be paid where applicable. There is a good starting salary, with a pension and other company benefits.

Please apply, with brief details of experience, to:

Mrs. J. A. Macnab, Personnel Manager,

Pye of Cambridge Ltd
St Andrews Road Cambridge
CB41DP Tel: Cambridge (0223) 58985

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709C Op Amp + data 8 pin DIL		34	32	30
723C Reg. + data 14 pin DIL		65	63	59
741C Op Amp + data 8 pin DIL		30	28	26
748C Op Amp + data 8 pin DIL		39	37	35
NE555 Timer + data 8 pin DIL		65	62	59
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
HP Red LED 1/8"		18	16	15
HP Red LED 0.2"		19	17	16
DIL Sockets,	8 pin	11	10	9
low profile	14 pin	12	11	10
	16 pin	13	12	11

BC109C	11	BZX88C-		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		

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7400	17	16	15
7402	17	16	15
7403	17	16	15
7404	18	17	16
7405	18	17	16
7410	17	16	15
7413	36	34	32
7420	17	16	15
7442	70	66	63
7447	90	85	80
7473	38	36	34
7474	35	33	31
7476	38	36	34
7486	30	28	26
7490	55	52	49
7492	55	52	49
7493	55	52	49
74121	44	42	40

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4000	27	25
4001	27	25
4002	27	25
4007	27	25
4011	27	26
4012	27	25
4013	60	54
4015	150	140
4023	27	25
4025	27	26
4027	90	82
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By return service. Prices include VAT. P & P 10p (UK) overseas at cost. All items new TI, Motorola, Mullard, SGS etc. SAE lists, enquiries. Data sheets 4p. Colleges etc. supplied.

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[34

Scholarship Awarded by The Institution of Electrical Engineers

The Council of the Institution of Electrical Engineers will consider for award this year Undergraduate and Postgraduate Scholarships with a maximum value of £600 per annum.

The closing date for the receipt of applications is 1st May, 1975 and late applications cannot be considered.

Full particulars of the conditions governing the award of these Scholarships may be obtained from:

The Director, Qualifications Department, The Institution of Electrical Engineers, Savoy Place, London WC2R 0BL.

[4625

C AND G EXAMS

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Or Phone 01-622 9911 (all hours). [4391

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[4224

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[82

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ECC82	28.0
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EF183	34.5
EF184	34.5
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PCF801	42.0
PCF802	40.0
PCL82	39.0
PCL84	39.0
PCL85	44.5
PCL86	41.0
PFL200	59.5
PL36	55.5
PL84	25.0
PL504	64.5
PL508	67.0
PL519	£1.50
PY88	35.5
PY800	33.0
PY500A	85.0

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Type	Price Each (p)
AC127	17
AC128	13
AC141K	25
AC142K	25
AC151	20
AC154	18
AC155	18
AC156	20
AC176	22
AC187	19
AC187K	24
AC188	17
AC188K	26
AD142	45

Type	Price Each (p)	Type	Price Each (p)
AD149	40	BD134	75
AD161	38	BD131	45
AD162	38	BD132	39
AF114	24	BD160	£1.39
AF115	21	BD235	49
AF116	22	BD237	62
AF117	19	BDX32	£2.40
AF118	50	BF115	20
AF139	35	BF160	15
AF178	45	BF167	20
AF180	45	BF173	20
AF181	45	BF178	35
AF239	40	BF179	40
AF240	60	BF180	31
BC107	11	BF181	32
BC108	10	BF184	25
BC109	14	BF185	25
BC109C	14	BF194	9
BC113	13	BF195	8
BC116A	19	BF196	10
BC117	14	BF197	12
BC125B	15	BF198	23
BC132	25	BF200	25
BC135	15	BF218	30
BC137	19	BF224	23
BC138	26	BF258	34
BC142	23	BF336	28
BC143	25	BF337	35
BC147	11	BF355	54
BC147A	11	BFX86	28
BC148	10	BFY50	19
BC149	10	BFY52	20
BC153	16	BSY52	35
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BC178B	20	MJE340	45
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BC183L	12	OC72	16
BC187	26	R2008B	£2.00
BC214L	15	R2010B	£2.00
BC328	28	RCA16334	80
BC337	19	RCA16335	80

DIODES

Type	Each (p)
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BA145	14
BA148	19
BA154/201	11
BY126	11
BY127	12
BY199	27
BY206	21
BY238	25
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OA202	7.5
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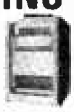

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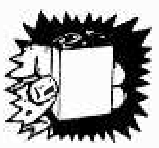

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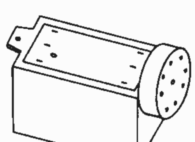

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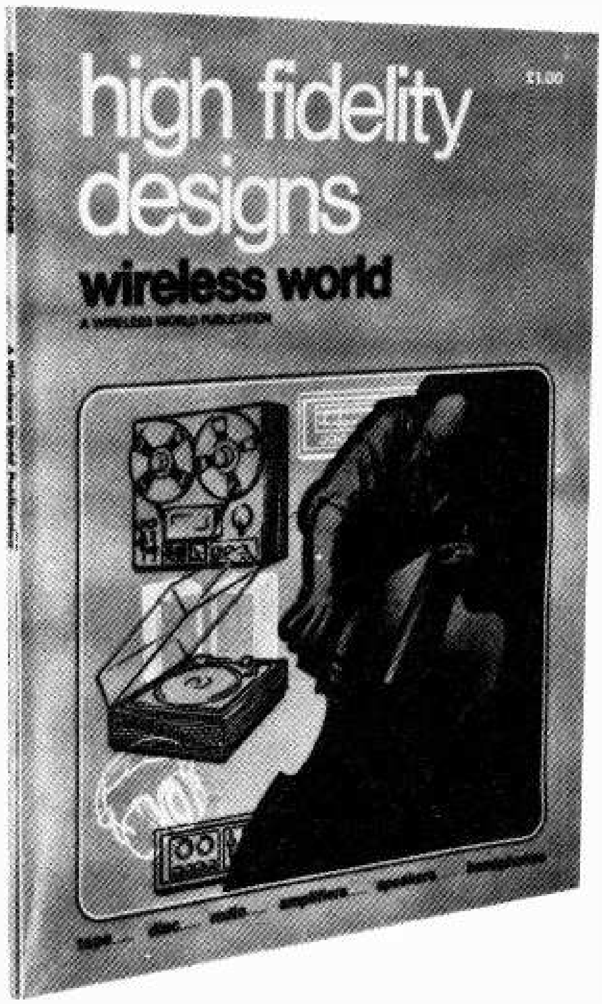

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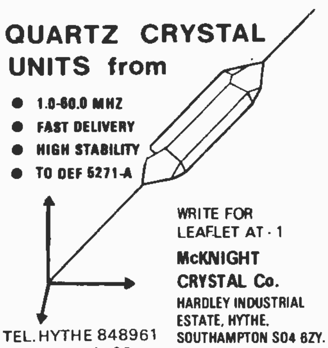

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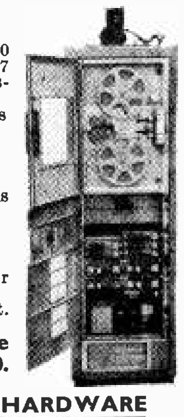

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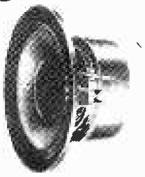

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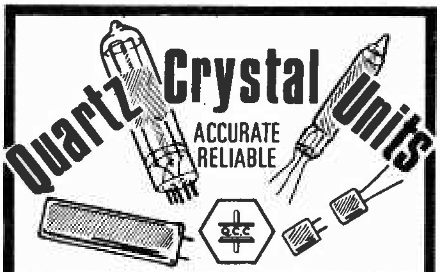

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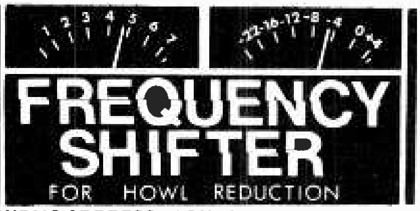

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AF SIG. GEN. CT420 case as above. Batt op 90/1.5v (check metered) 200 to 8.000Hz continuous switched range. Output 4v/5k ohm direct or 1v/75ohm and 10mv/0.1ohm attenuated. 100 and 500Hz callibrator **£65.00** (£2.00).

BC221T FREQUENCY METER in canvas carrying case P.O.A.

MINE DETECTOR No.4A KIT No.1 Ref: ZA27931/1. New in transit case. P.O.A.

RECT. SUPPLY UNIT No.25. All-weather type. 110–250vac 45/65Hz in. Conservative rating: 600vdc/80ma Super-smoothed +12vdc 0.9A Super-smoothed +20vac/2A screened + bias. **£32.50** (£2.00). plugs extra.

DITTO No.19 Bench type 12v + 12v (or 24v)dc 3/6amps **£25.00** (£1.50).

CREED REPERFORATORS 7TR/3. P.O.A.

TELEPRINTER TERM UNIT MARK 4 c/w 299 AN Relay. New Cond. **£40.00.** Used **£30.00** (£1.00).

TYPEWRITER TELEGRAPH (used but good) 9A/9B Imperial. Rollfeed. Cased **£16.00** (£3.00). uncased **£12.00** (callers).

GEC REGENERATOR UNIT (No. HE31105) **£3.50** (50p).

A.E.E. BITUMEN POTTED TRANSFORMERS. 110–250v Pri. Scr. 45/1amp sec **£3.00** (50p).

GRESHAM DITTO 240v Pri. Scr. 270–0–270/80ma + 45–0–45/40ma + 6.3–0–6.3/2.7amp secs **£4.50** (50p).

PYE WESTMINSTER R/T CONTROL UNITS, MICS and SPEAKERS as seen (callers). Racks—Cabinets—Panels. etc. P.O.A.

SPECIAL ITEM

SOUND RECORDING and REPRODUCING UNIT Type 2. Equip A8A Rack-Mounted. Ref: 10U/16873. Also substantial qty spares (Units-Gearboxes-Sapphires. etc.). Details and prices on application.

MANY OTHER ITEMS of Test equipment/Teleprinter — peripherals/Components/Meters/Connectors. etc.. in stock.

CALL ON US OR WRITE YOUR REQUIREMENTS. WHOLESALE ENQUIRIES WELCOMED. (U.K. CARRIAGE. ETC.) SHOWN. ADD 8% VAT to TOTAL. CASH WITH ORDER EXCEPT BY PRIOR ARRANGEMENT: **34 LISLE ST., LONDON WC2H 7BD**
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AC125	11p	BC142	35p	BF115	22p	MJ491	130p	ZTX109	13p	2N2369	14p	2N4059	10p
AC126	11p	BC143	35p	BF167	23p	MJE340	45p	ZTX300	14p	2N2484	30p	2N4060	13p
AC127	11p	BC147	7p	BF170	23p	MJE370	72p	ZTX301	14p	2N2904	20p	40360	35p
AC128	11p	BC148	7p	BF173	25p	MJE371	84p	ZTX302	18p	2N2905	18p	40361	36p
AC141	18p	BC149C	8p	BF177	26p	MJE520	68p	ZTX303	15p	2N2906	20p	40362	38p
AC142	18p	BC157	10p	BF178	28p	MJE521	80p	ZTX304	24p	2N2926RB		40409	50p
AC176	11p	BC158	8p	BF179	33p	MJE2955	99p	ZTX500	15p		7p	40410	50p
AC187	12p	BC159	9p	BF180	33p	MJE3055	65p	ZTX501	15p	2N29260	8p	40411	200p
AC188	11p	BC169C	12p	BF181	33p	MPSA12	50p	ZTX502	19p	2N2926YG		40594	65p
AD140	46p	BC171	12p	BF182	33p	MPSA06	30p	ZTX503	45p		9p	40595	75p
AD142	55p	BC177	18p	BF184	22p	MPSA56	32p	2N404	26p	2N3053	18p	40600	69p
AD143	50p	BC178	17p	BF185	22p	MPSU06	62p	2N696	15p	2N3054	45p		
AD149	45p	BC179	18p	BF194	10p	MPSU56	78p	2N697	13p	2N3055	49p	FETs	
AD161	36p	BC182	10p	BF195	10p	OC26	40p	2N698	30p	2N3441	80p	BF244	36p
AD162	36p	BC183	10p	BF196	14p	OC28	55p	2N706	12p	2N3442		MPF102	30p
AF114	13p	BC184	11p	BF197	15p	OC35	48p	2N708	18p		140p	MPF103	30p
AF115	13p	BC212	11p	BF200	32p	OC36	52p	2N914	18p	2N3702/3		MPF104	30p
AF116	13p	BC213	10p	BF257	32p	OC41	15p	2N918	40p		11p	MPF105	30p
AF117	13p	BC214	14p	BFR39	30p	OC42	15p	2N929	20p	2N3704/5		2N3819	20p
AF118	50p	BC237	12p	BFR40	30p	OC44	11p	2N930	18p		11p	2N3820	57p
AF121	33p	BC238	11p	BFR41	30p	OC45	11p	2N1131	18p	2N3705/6		2N3823	50p
AF124	30p	BC239	12p	BFR79	30p	OC70	11p	2N1132	18p		10p	2N5457	30p
AF125	30p	BC307	11p	BFR80	30p	OC71	11p	2N1302/3		2N3707	11p	2N5458	30p
AF126	30p	BC308	11p	BFR81	30p	OC72	11p		17p	2N3708/9		2N5459	30p
AF127	30p	BC309	12p	BFX29	30p	OC73	50p	2N1304/5			9p		
AF139	33p	BCY70	18p	BFX30	30p	OC74	30p		21p	2N3771		MOSFETs	
AF181	45p	BCY71	22p	BFX84	26p	OC81	12p	2N1306/7			170p	3N128	75p
AF186	48p	BD115	55p	BFX87	20p	OC82	12p		28p	2N3772		3N140	85p
AF239	38p	BD121	100p	BFX88	24p	OC83	20p	2N1308/9			180p	3N141	75p
BC107	9p	BD123	100p	BFY50	15p	OC84	18p		28p	2N3773		40603	58p
BC108	9p	BD124	65p	BFY51	15p	OC200	50p	2N1613	20p		220p	40673	58p
BC109	10p	BD131	40p	BFY52	15p	OC201	50p	2N1711	20p	2N3866	70p		
BC115	20p	BD132	45p	BSX19	16p	TIP41A	65p	2N2218	21p	2N3903/4		UJTs	
BC135	17p	BD153	65p	BSX20	16p	TIP42A	70p	2N2219	20p		15p	TIS43	26p
BC136	17p	BD156	60p	BSX21	22p	TIP2955	70p	2N2220	19p	2N3905/6		2N2160	80p
BC137	17p	BDY60	75p	BU105	220p	ZTX107	12p	2N2221	20p		15p	2N2646	35p
BC138	17p	BDY61	65p	MJ490	95p	ZTX108	10p	2N2222	20p	2N4058	15p	2N4871	31p

SIGNAL DIODES

BAX13	5p
BAX16	6p
OA47	7p
OA70	9p
OA79	10p
OA81	8p
OA85	10p
OA90	7p
OA91	7p
OA95	7p
OA200	8p
OA202	10p
IN914	4p
IN916	6p
IN4148	4p

RECTIFER DIODES

BY100	15p
BY126	12p
BY127	12p
BY133	15p
BYZ10	55p
BYZ11	55p
BYZ12	55p
BYZ13	55p
IN4001	5p
IN4004	6p
IN4007	7p
PL4004	10p
PL7004	20p

LED
TIL209 16p

ZENER DIODES
3.3V to 33V 400mW 9p
1.3W 18p
1.5W 30p
10W 55p
20W 70p

OTHER
BA145 15p
BA148 13p

TUNNEL
AEY11 50p

Varicap
BB105 25p

Low Noise
ZJ1 75p

BRIDGE RECTIFIERS

	50V	100V	400V	600V
250mA	16p	—	—	—
1 Amp	22p	24p	27p	30p
2 Amp	30p	35p	45p	48p
6 Amp	55p	60p	78p	

SCR—THYRISTORS

	50V	100V	400V	600V
1 Amp	40p	42p	52p	70p
3 Amp	43p	49p	75p	—
7 Amp	—	80p	84p	—
16 Amp	—	82p	98p	—

Other
C106D 45p. 2N3525 91p. 2N4444 185p.

TRIACS

	100V	400V	500V
3 Amp	85p	99p	120p
6 Amp	88p	120p	150p
10 Amp	109p	154p	165p
16 Amp	145p	180p	200p

Other
40430 90p. 40486 99p. 40669 95p.
DIAC. For use with above triacs 21p.

VARIABLE VOLTAGE REGULATORS
LM 300 DIL 90p
LM 304 TO5 ....120p
LM 305 TO5 ....95p
ML 723 DIL 14 pin 45p
TBA 625B TO39 ....130p

TTL 74 SERIES INTEGRATED CIRCUITS

7400	13p	7425	30p	7475	48p
7401	14p	7427	37p	7476	34p
7402	14p	7430	14p	7480	50p
7403	16p	7432	25p	7482	76p
7404	16p	7437	27p	7483	95p
7405	16p	7440	16p	7485	140p
7406	42p	7441	65p	7486	41p
7407	42p	7442	60p	7489	340p
7408	16p	7445	95p	7490	40p
7409	28p	7447	75p	7491	80p
7410	14p	7448	80p	7492	50p
7412	30p	7450	16p	7493	40p
7413	30p	7451	16p	74100	200p
7414	60p	7460	16p	74107	45p
7416	33p	7470	30p	74121	34p
7417	36p	7472	27p	74122	76p
7420	13p	7473	36p	74141	65p
7422	25p	7474	34p	74142	250p

CA3046	Transistor Array	50p
LM301	Op Amp with ext comp 8 PIN DIL	40p
LM307	Op Am with int. comp	50p
MC1310	Coilless Stereo Decoder	210p
MC1312	4 channel SQ Decoder	220p
MC3401	Quad Op Amp +ve rail only	75p
MFC6040	Electronic Attenuator	90p
MFC8070	Zero Voltage Switch	250p
NE536	FET Op Amp TO99	280p
NE555	Timer 8 PIN DIL	50p
NE556	Dual 555 14 PIN DIL	180p
NE560	Phase Lock Loop 16 PIN DIL	325p
NE561	PLL with Am Demod 16 PIN DIL	325p
NE562	PLL with VCO 16 PIN DIL	325p
NE563	PLL FM/IF Demod 16 PIN DIL	300p
NE566	PLL Function Generator 8 PIN DIL	200p
NE567	PLL Tone Decoder 8 PIN DIL	250p
709	Op Amp with ext comp 8/14 PIN DIL	26p
710	Diff. Voltage Comp 14 PIN DIL	35p
741	Op Amp with int comp 8 PIN DIL	23p
747	Dual 747 14 PIN DIL	70p
748	Op Amp with ext comp 8 PIN DIL	38p
ZN414	TRF Radio Receiver	110p
ICL8038	VCO Function Gen. 14 PIN DIL	290p

C-MOS LOGIC ICs— NEW LOW PRICES
CD4001AE 19p
CD4011AE 19p
CD4012AE 19p
CD4013AE 55p
CD4016AE 50p
CD4017AE 120p
CD4018AE 175p
CD4020AE 200p
CD4023AE 19p
CD4024AE 120p
CD4025AE 19p
CD4027AE 100p
CD4029AE 175p
CD4030AE 55p
CD4046AE 199p
CD4047AE 154p

ACCESSORIES
Low Profile DIL Sockets by Texas
8 pin..............12p
14 pin..............13p
16 pin..............14p

Mica — 2 Bushes (for TO-3 & TO-66)......5p

Data sheets on advertised I.C.s .... 10p each

Fixed VOLTAGE REGULATORS
Postive: 1 Amp Plastic 200 mA (TO5)

5V	MC7805	140p	—	
12V	MC7812	140p	7812	90p
15V	MC7815	140p	7815	90p
18V	MC7818	140p	—	
24V	MC7824	140p	—	

Negative: 1 Amp Plastic
5V MC7905 ....250p 18V MC7918 ....250p
12V MC7912 ....250p 24V MC7924 ....250p
15V MC7915 ....250p

OPTO-ELECTRONICS
OCP70 ....30p ORP12 .....50p Red LED......16p
OCP71 ....85p ORP60 .....55p Green/Yell ...35p
2N5777 ....40p ORP61 .....55p

Seven Segment Read Outs
3015F Filament DIL..............................120p
MAN-3M All LED .127 In. PCB..............................120p
MAN-4 All LED .19 In. DIL..............................180p
LIT704 Reflective Bar .3 In. DIL..............................135p
LIT707 Reflective Bar .3 in. DIL..............................135p
LIT747 Reflective Bar .6 in. DIL..............................225p

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High performance PLL fm/if demod 16 PIN DIL £3

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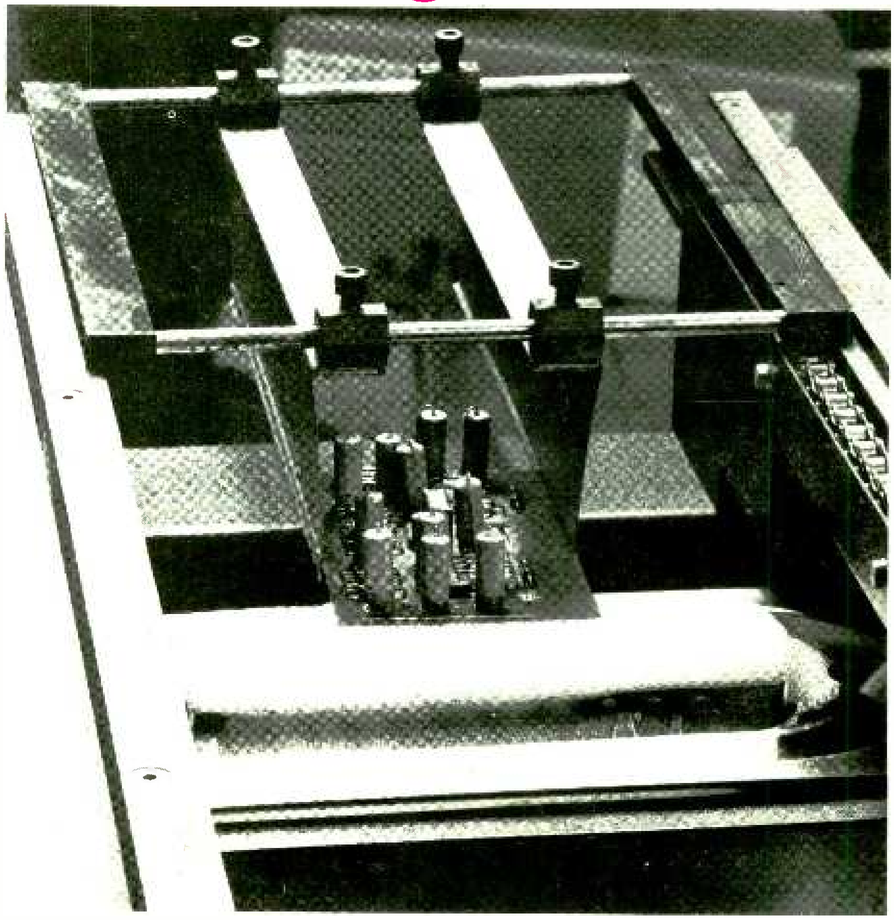
What's new in Soldering Chemicals?

Multicore's R & D Laboratories are still making news–three important new chemicals for electronics manufacturers.



MULTICORE PC 26 ROSIN FOAM FLUX

A completely new general purpose liquid soldering flux particularly suitable for the automated soldering of all types of printed circuits. PC 26 provides a unique combination of desirable properties.

- **Complies with U.K. Ministry Flux Specification D.T.D. 599A.**
- **Eliminates "icicles" and "bridging".**
- **0.5% max. halide content and yet gives better soldering than non-approved fluxes with high halide contents.**
- **Leaves negligible flux residues so p.c. boards are dry after soldering, can be handled and inspected easily and have better sales appeal.**

MULTICORE PC 81 SOLVENT CLEANER & FLUX REMOVER

A unique blend of polar and non-polar solvents formulated for degreasing electronic hardware prior to soldering as well as for removing rosin flux residues including ionizable activators after soldering. Its intermediate boiling range of 71 to 80°C and selective solvency make it ideal for vapour degreasing.

The boiling range of PC. 81 is higher than fluorinated solvents (approx 46°C) and lower than either trichloroethylene (87°C) or perchloroethylene (121°C). Also its solvency properties for rosin flux removal are superior to fluorinated solvents without in any way affecting most electronic hardware. As a result, PC. 81 solvent will perform its vapour cleaning function longer and more effectively than fluorinated solvents whose vapour condensation ceases at 46°C with a consequent end to flux removal.

Solvent evaporation rate is substantially lower than that of the fluorinated solvents, making it more economical to use in open tanks and vapour degreasers.

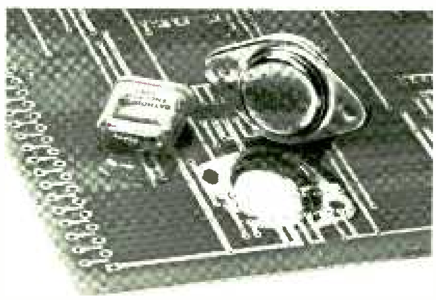
Multicore PC. 81 is a highly stabilized solvent blend, extremely resistant to thermal or chemical breakdown during prolonged heating or as a result of the introduction of activators from the solution of rosin during its working life. Its relatively narrow boiling range and high stability make it readily useable again without property changes after distillation.

PC. 81 can also be used for cold cleaning and to reinforce ultrasonic cleaning. Even though its toxicity is relatively low, well ventilated areas are required.

PC. 81 is expected to be particularly welcome as it is non-flammable and non-combustible under the new British "Highly Inflammable Liquid" Regulations.

Supplied in one gallon metal cans and 45 gallon steel drums.

Specific Gravity (20°C) — 1.256
Boiling Range ———— 71–80°C
Toxicity (TLV) ———— 340 ppm
Residue on Evaporation - less than 10 ppm



MULTICORE PC 54 CONFORMAL COATING

Fully meets the requirements of the new U.K. Defence Standard 59-47/issue 2 and U.S. Spec. MIL-I-46058C, which are becoming mandatory for the protection of many electronics assemblies against adverse environment, contamination and attack by chemicals.

PC. 54 is a two-part epoxy resin system which is conveniently mixed in equal parts by volume. It may be applied by dip, spray or brush to either one or both sides of p.c. boards and components where it forms a thin tough coating after curing. PC. 54 will dry in 1 hour under normal ambient conditions and develop its full properties after several days at room temperature or it may be cured in 2 to 4 hours at 65°C. A glass fibre brush can be used to remove the coating locally to enable rework and repair.

Other Multicore Soldering Chemicals include a complete range of liquid fluxes and the following special chemicals.

PC 2 Multicore Tarnish Remover
Cleans tarnish from metal surfaces prior to soldering.

PC 10A Activated Surface Preservative
Applied after pre-cleaning, preserves solderability and need not be removed.

PC 10D
A special version of PC 10A for application by roller coating machines.

PC 90 Peeloff Solder Resist and PC 91 Thinners
A temporary solder resist for edge-connector contact areas etc. Replaces masking tape.

PC 41 and PC 43
Solder Bath dross inhibitors.

PC 52 Protective Coating
One-part conformal coating. Can be soldered through.

PC 70 Thinners
Compatible Solvent blend for use with all rosin fluxes, PC 10A and PC 52.

Please write for Technical Bulletins on your Company's letterhead for products which interest you to:

ERSIN Multicore 5 CORE SOLDER

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