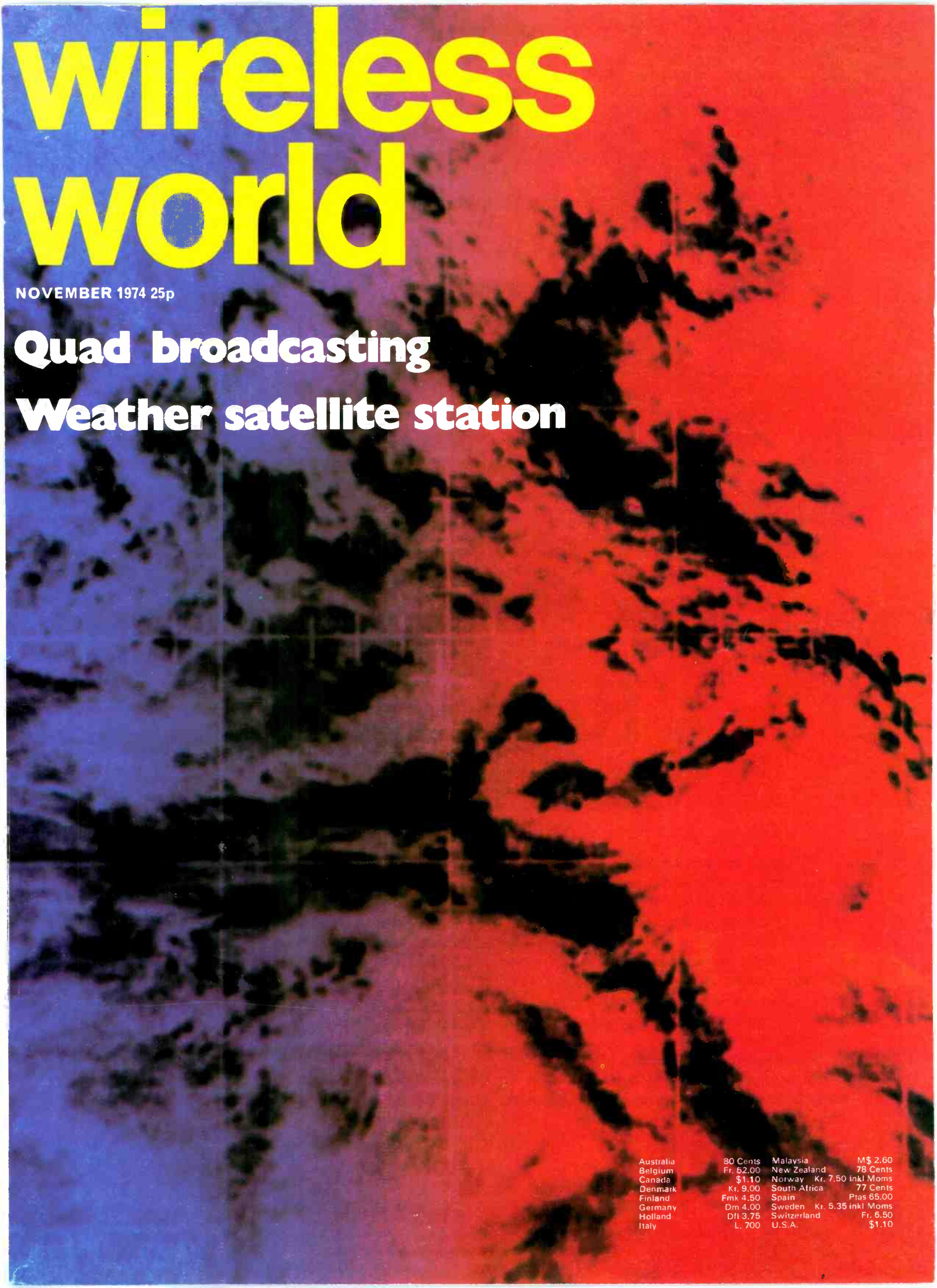

wireless world

NOVEMBER 1974 25p

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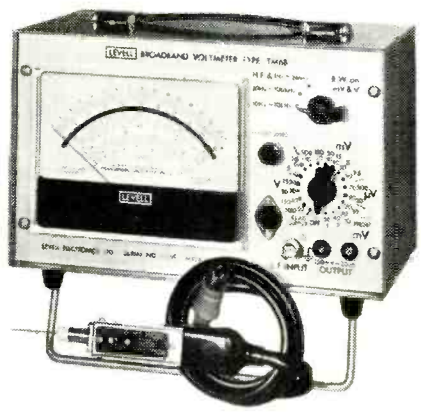
PORTABLE INSTRUMENTS

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. ± 1 μV 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.

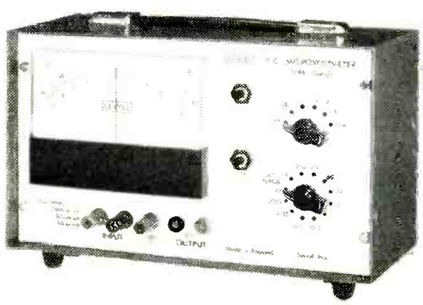
type TM3A **£62** type TM3B **£77**



BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1 mV, 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 1 mW/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 **£105** type TM6B **£120**



D.C. MICROVOLTMETERS

VOLTAGE RANGES: 30μV, 100μV, 300μV . . . 300V. Acc. ± 1%, ± 2% f.s.d., ± 1 μV. 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 **£65**

D.C. MULTIMETERS

VOLTAGE RANGES: 3μV, 10μV, 30μV . . . 1kV. Acc. ± 1% ± 1% f.s.d. ± 0·1 μV. 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 **£90** type TM9B **£105** type TM9BP **£110**

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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.

WW—039 FOR FURTHER DETAILS

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

SOUND SENSE = VORTEXION

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

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

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

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

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

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

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

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

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

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

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

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

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Name

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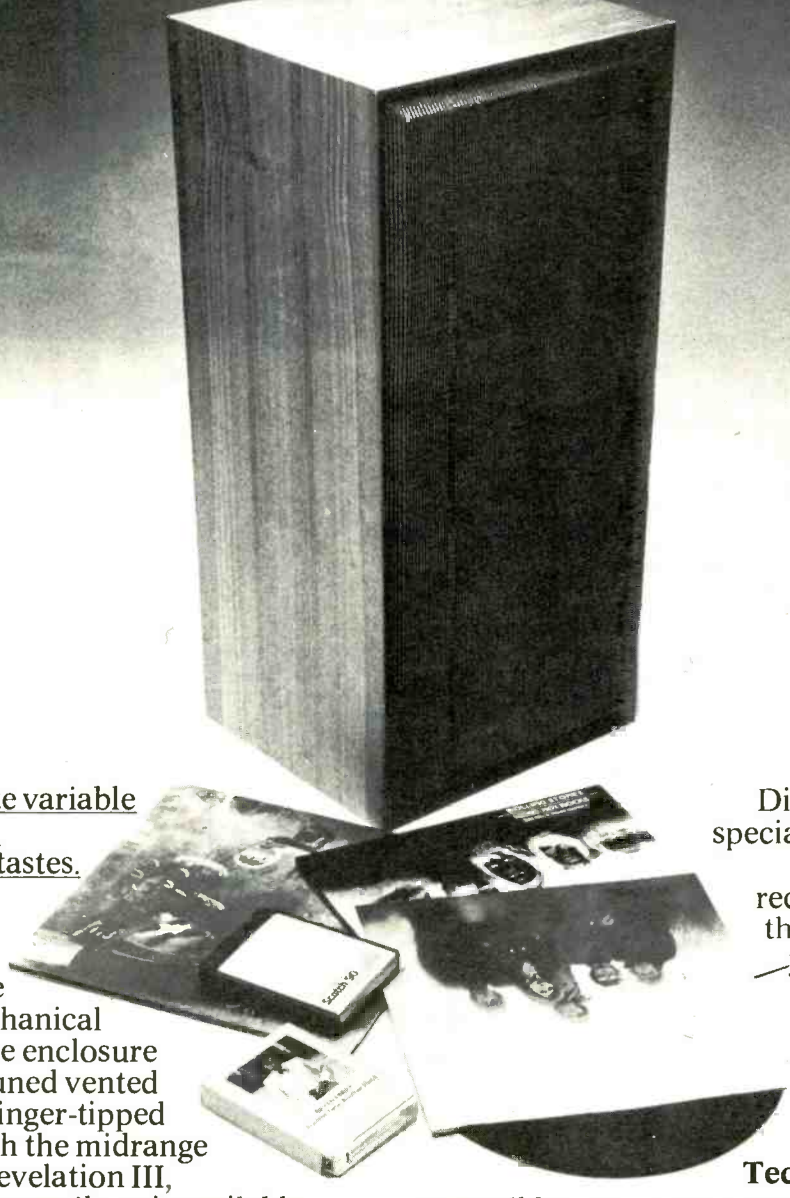

Who else can offer infinite variable control over all listening conditions and personal tastes.

Embodied in the LSL Revelation III is a bass response that can be modified by a simple mechanical adjustment converting the enclosure from infinite baffle to a tuned vented port. This, coupled with finger-tipped electronic controls of both the midrange and tweeter, makes the Revelation III, without doubt, the most versatile unit available today – at any price. The possibilities are infinite. Tailor your own sound to complement your own personal tastes and environment.

The three drive units are controlled by a sophisticated cross-over network, researched by the eminent Dr. A. R. Bailey of Bradford University and specially designed to create a flat frequency response whilst minimising transient distortion.

Panel resonance is minimised by a robust hand made enclosure. Constructed with the world's finest materials and choicest veneers.

Distribution is restricted to specialist dealers in order that the potential customer receives the demonstration the speaker merits. Should you experience difficulty locally, write to us for further information enclosing the name and address of your local specialist dealer.

Technical Specifications

Overall frequency response .... 35 HZ–22,000 HZ.
Power Handling Capacity .... 60 watts speech and music power. 35 watts R.M.S
Impedence ...... Nominal 8 ohms. Minimal 6 ohms.
Drive Units.
Tweeter ... . Soft domed high frequency unit.
Midrange ....5" unit. Bass ....13" x 8" unit.
Lack of colourisation and other forms of distortion enable the unit to be used at high sound levels without listener fatigue.

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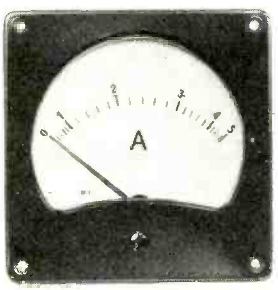
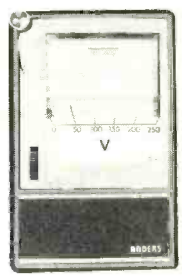
Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

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

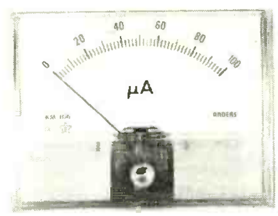


Vulcan Moving Iron. 4 models, 1·5″, 1·8″, 2·7″, 3·7″ scales. Voltmeters, ammeters and motor starting meters.

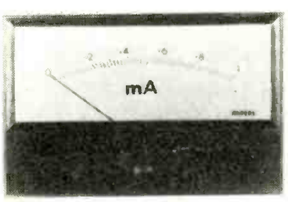
Profile 350 edgewise 4·3″ scale.
DC moving coil and AC moving coil rectified.
Horizontal or vertical mounting.



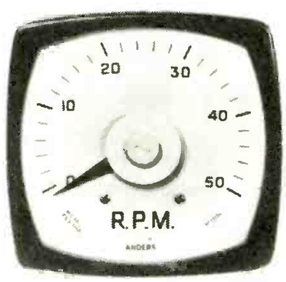
Recorders 60 or 120 mm. charts. Non-ink marking. DC moving coil and AC rectified.



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



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



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

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

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

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WW—Nov.

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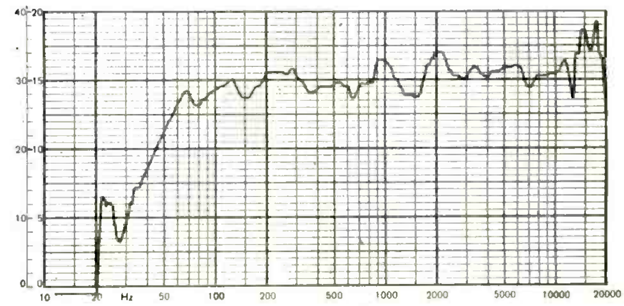
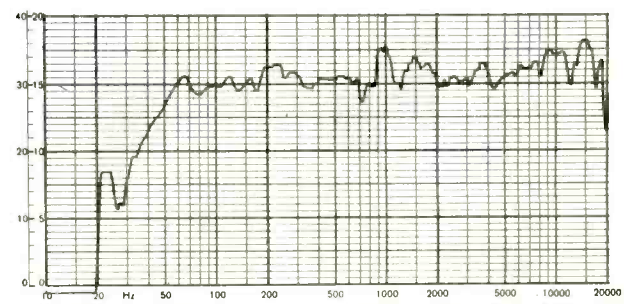
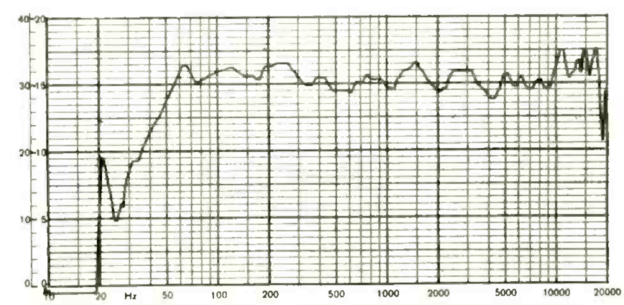


TYPICAL RESPONSE 260 mm HIGH PERFORMANCE DUAL (10″)



TYPICAL RESPONSE 310 mm HIGH PERFORMANCE DUAL (12″)



TYPICAL RESPONSE 410 mm HIGH PERFORMANCE DUAL (15″)

- ✱ INCREASED POWER HANDLING CAPACITY
- ✱ HIGH TEMPERATURE VOICE COILS
- ✱ **GIRDACOUSTIC** CONE FOR SMOOTHER RESPONSE (310 mm and 410 mm models only)
- ✱ **TANOPLAS** SURROUND FOR HIGH STABILITY AND LOW BASS RESONANCE
- ✱ IMPROVED AND UP-RATED CROSS-OVER NETWORK

	260 mm 10″	310 mm 12″	410 mm 15″
Power Handling Capacity*	50W	60W	85W
Frequency Response	27-20,000 HZ	25-20,000 HZ	23-20,000 HZ
Intermodulation Products	less than 2%	less than 2%	less than 2%
Impedance via Crossover network	8 ohms (5 ohms min.)	8 ohms (5 ohms min.)	8 ohms (5 ohms min.)

✱ INTEGRATED PROGRAMME MATERIAL

ALL SPECIFICATIONS SUBJECT TO ALTERATION WITHOUT NOTICE

TANNOY ® **NORWOOD RD. WEST NORWOOD. SE 27. 01-670 1131**

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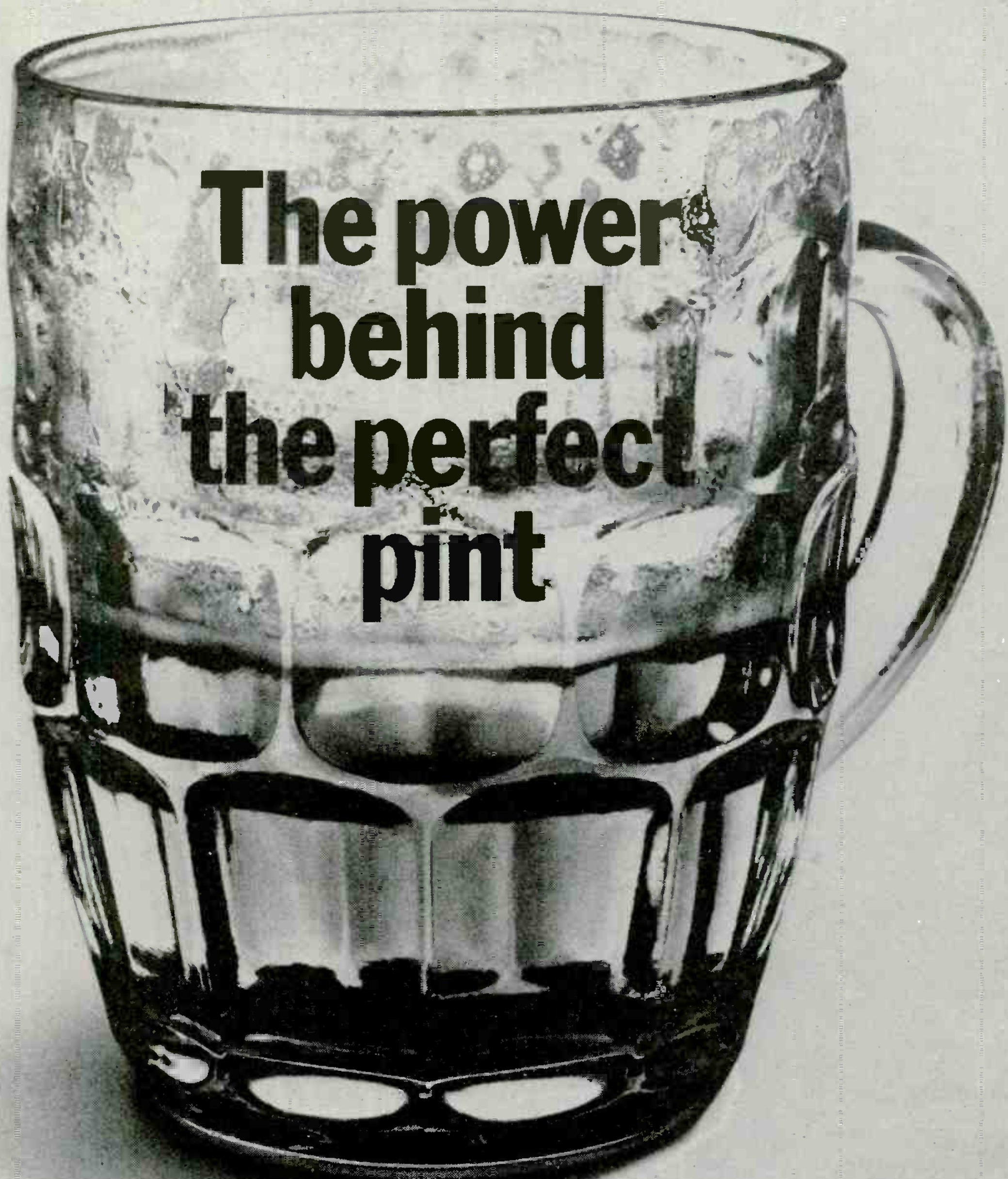

Absolute perfection? If so, then during its brewing, temperature control, especially at the fermentation stage, must have been equally perfect.

That's where the Thyristor comes in.

For in many of today's industrial processes, speed of switching and security of operation are as important as current and voltage ratings.

Motorola's Beam-Fired technology gives you a typical di/dt of 1000 A/µs—speed that comes from optimum cathode shunt placement, integrated gate cascade driver stages and simultaneous, large area, multi-gate turn-on.

Our unique glassivation process ensures parameter uniformity and stability for reliability and security.

There are standard ranges that operate up to 800V while the new MCR 80 series is ideal for medium power industrial and consumer applications where control of high current is needed. These 80Amp devices have hermetic metal packaging and are available in three case styles.

So Motorola's thyristors give you the range you need (from .5 to 800A and from 2.5V to 1500V, as well as SCR, and Triacs)—and speed and the security that industry demands today.

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WW—044 FOR FURTHER DETAILS

updating from

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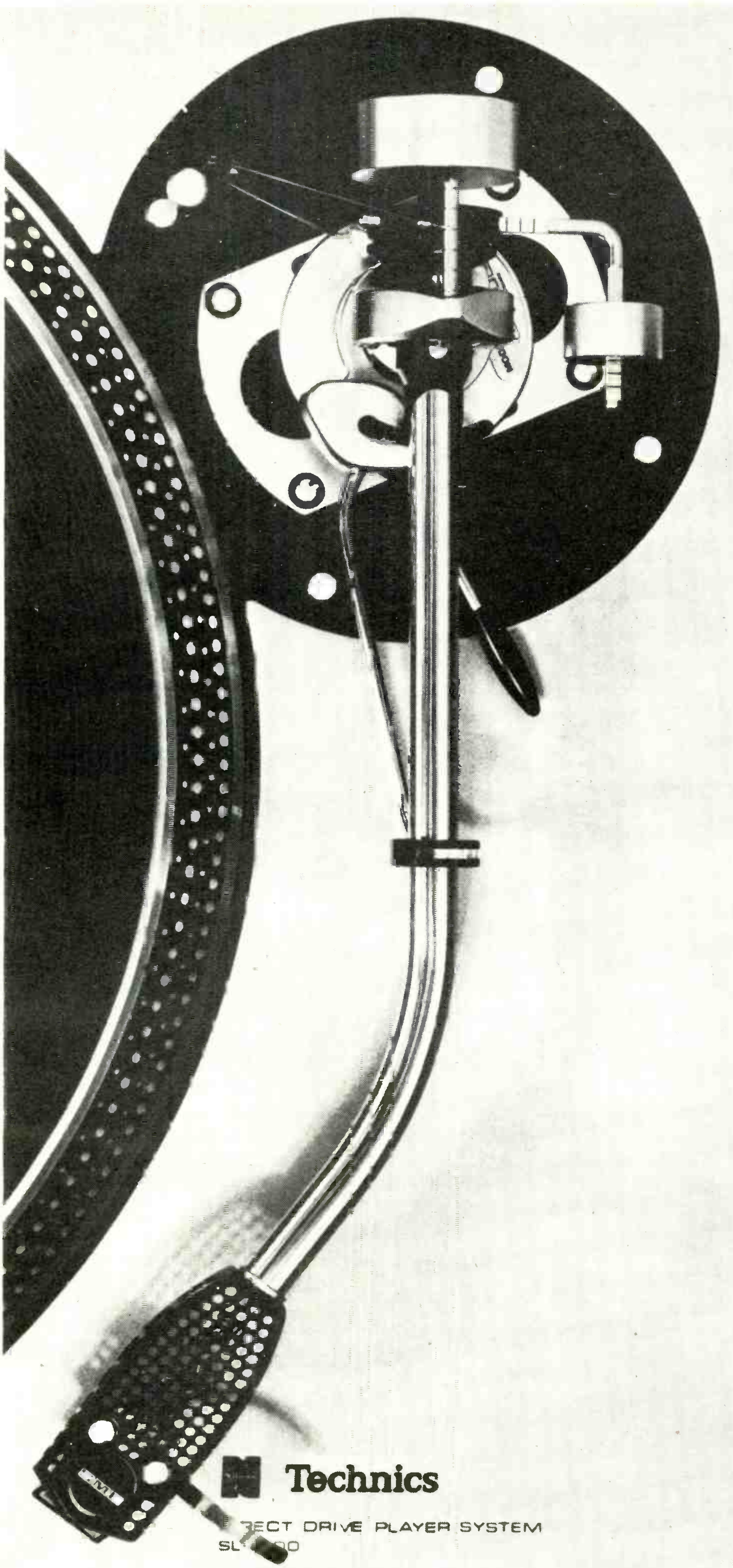
to make them crow at full power



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This new turntable offers the mechanical excellence of the SL110 in a more compact form.
Ideally suited to our precision pick-up arms, its use is detailed in information sheet No. 15, a copy of which will be sent to you on request.

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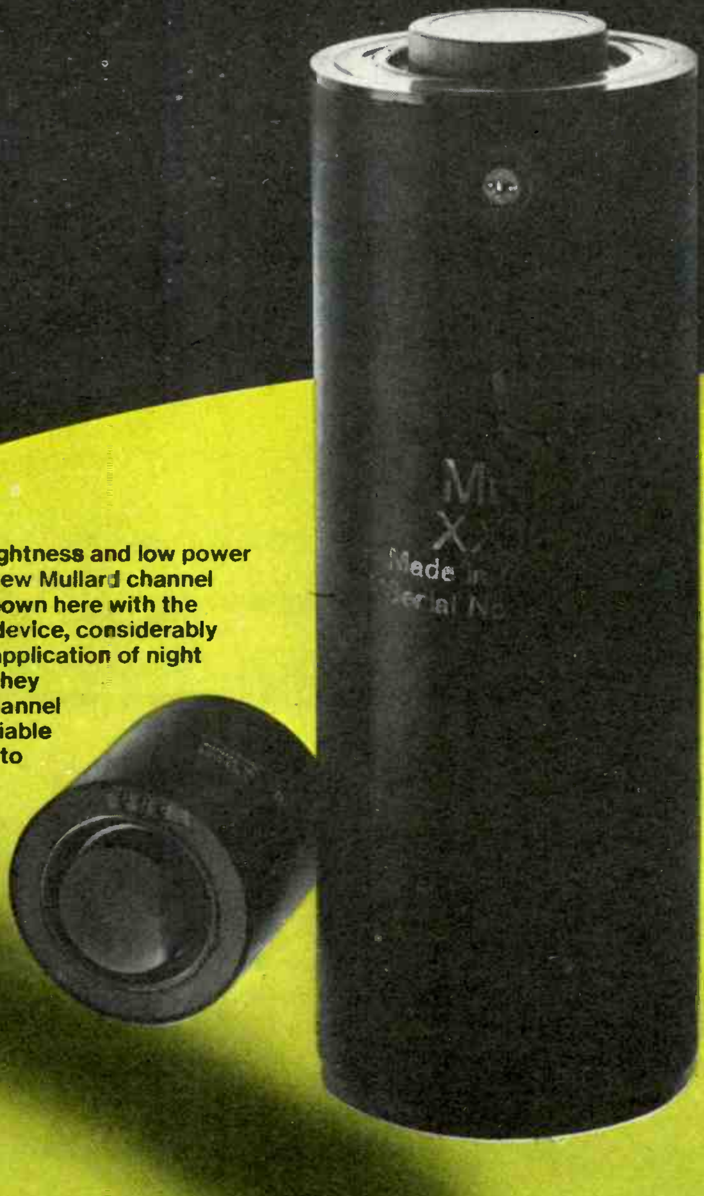
LTD/S30

WW—079 FOR FURTHER DETAILS

Smaller, lighter, image intensifiers for night vision



The small size, lightness and low power consumption of the new Mullard channel image intensifiers, shown here with the larger cascade tube device, considerably extend the range of application of night viewing equipment. They incorporate a multichannel plate to provide a variable luminance gain of up to 100,000 and operate from a 2.7V battery.

Under normal operating conditions, tube life is likely to be many thousands of hours.

Resistance to highlight overload and ease of gain control give them particular application in low light level television systems as well as direct view equipment.

These Channel devices join the well established range of extremely sensitive and reliable, high gain, – up to 100,000 – cascade tube image intensifiers from Mullard.

Behind Mullard's capability

Mullard's background in electron optics is based on a thorough understanding of vacuum and glass technologies. At Mitcham, part of Europe's biggest Electron-optics capability – complete with its own fibre optic drawing plant, we make night vision and low light level TV devices. Years of experience in the design and manufacture of image intensifiers and other electron optical devices has resulted in a capability well geared to today's and tomorrow's requirements.

Contact us for further information on Image Intensifiers.

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We know how easily sophisticated instruments can drift imperceptibly away from standard. So, after we've repaired, calibrated and returned your equipment to you, we make a note to remind you when a periodic check or recalibration should be carried out.

Jogging the memory is just one of the little, extra details that help to make up the Bradley Repair and Calibration Service; but, of course we need to hear from you in the first instance.

R & C is a separate division of Bradley Electronics with its own 20,000 sq. ft. factory next door to the main London works. We've been rejuvenating instruments for more than 20 years, during which time we've handled virtually every type and make in common use – from simple meters to complicated systems. We will tackle anything in the frequency range DC to 18 GHz and return it to you ready to plug in.

If you need authenticated performance in addition to our normal guarantee, our Standards Laboratory is approved by the British Calibration Service. It will supply calibration certificates for AC, DC and RF measurements. And our standards, of course, are directly traceable to the NPL and the National Bureau of Standards.

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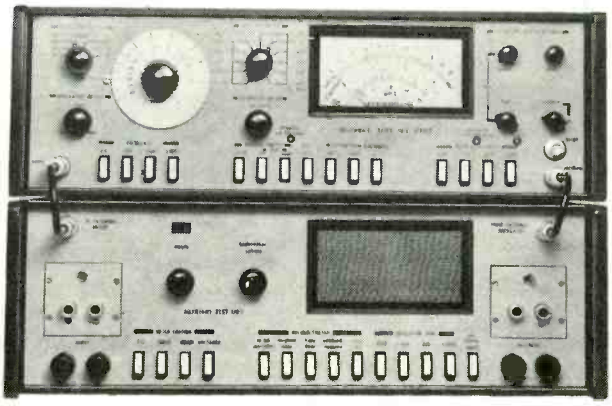
Audio Test Set



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signal/noise ratio
distortion
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. . . in one compact unit.

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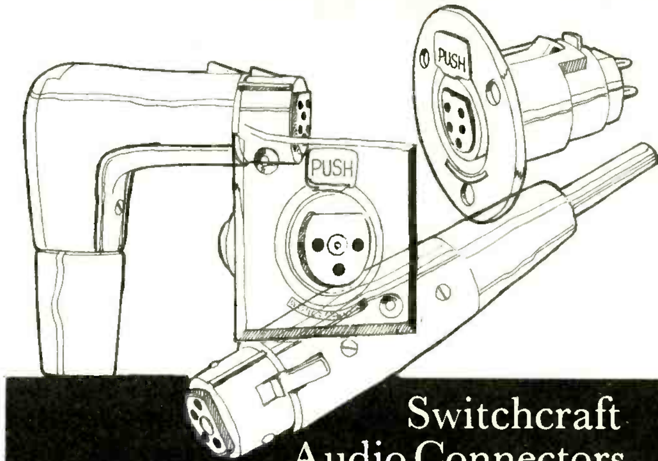

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Complete range of Switchcraft audio connectors for all studio and ancillary equipments.

Versatile—3, 4, 5 or-6 pole; wide variety of matching plugs receptacles; readily interchangeable with other leading makes.

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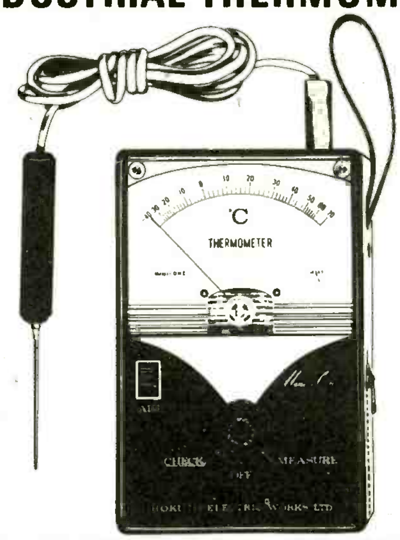
WW—052 FOR FURTHER DETAILS

ELECTRONIC INDUSTRIAL THERMOMETER



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Model "Mini-On 1" measures from — 40°C to + 70°C, price £17.50
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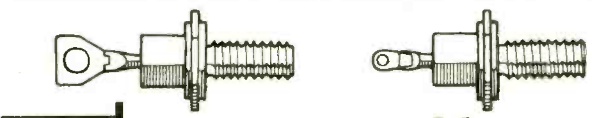
('Phone 01-837 7937)

WW—005 FOR FURTHER DETAILS

New from AEI Semiconductors

Four shapes for your diode requirement

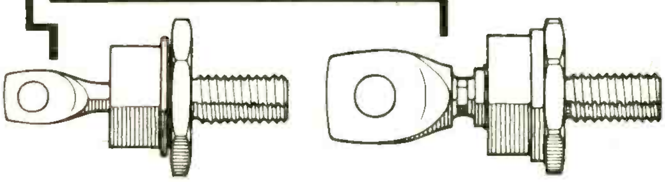
These four new diodes – comprising the "M" range – have been developed to meet demands for maximum availability at the lower price sector of the market. A 16 amps, 600v diode costs as little as 42p for quantities of 1000 or more. The range covers 6 to 70 amps, 50 to 800 volts.



Current/Voltage/Type No.

$I_{F(AV)}$ Amps	Type No. V_{RRM} 100	200	400	600	800
6	M6-100 M6-100R	M6-200 M6-200R	M6-400 M6-400R	M6-600 M6-600R	M6-800 M6-800R
16	M16-100 M16-100R	M16-200 M16-200R	M16-400 M16-400R	M16-600 M16-600R	M16-800 M16-800R
25	M25-100 M25-100R	M25-200 M25-200R	M25-400 M25-400R	M25-600 M25-600R	M25-800 M25-800R
40	M41-100 M41-100R	M41-200 M41-200R	M41-400 M41-400R	M41-600 M41-600R	M41-800 M41-800R
70	M71-100 M71-100R	M71-200 M71-200R	M71-400 M71-400R	71-600 M71-600R	M71-800 M71-800R

Suffix 'R' indicates reversed polarity (i.e. Stud Anode)



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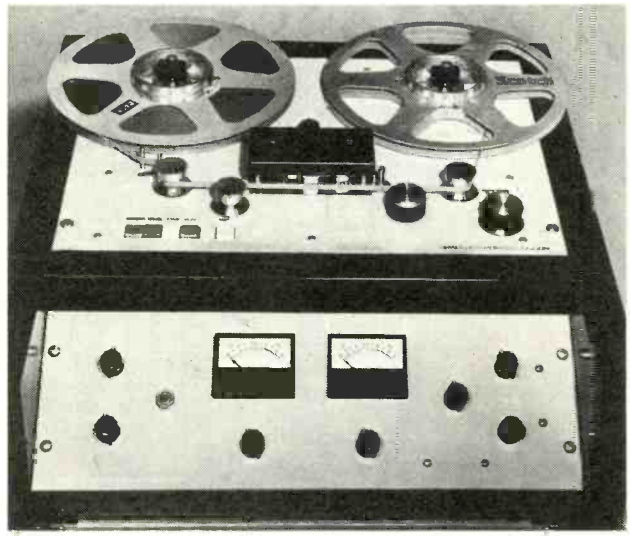
WW—056 FOR FURTHER DETAILS

TAKE A CLOSE LOOK



at a professional recorder that offers high performance, excellent reliability and is very easy to maintain. Ask yourself why so many commercial radio stations and recording studios are doing their best to wear them out, and not having much success. Decide if you need mono or stereo, console transportable or rack mounting versions and then inquire about prices.
We are sure you will be very pleasantly surprised.

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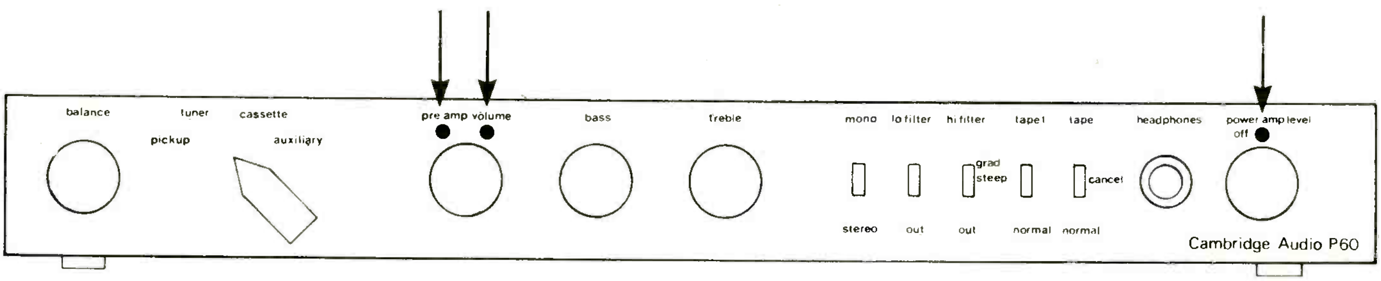
WW—023 FOR FURTHER DETAILS

NEW ARCHITECTURE IN STEREO AMPLIFIERS

The new Cambridge P60 brings radical changes to stereo amplifier design and operational concept

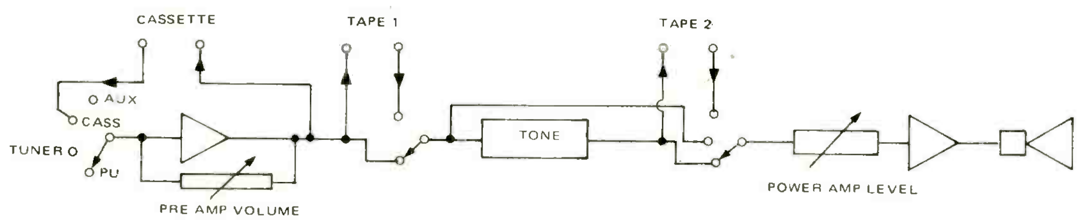
1. Split Section level control with normal and overload indication

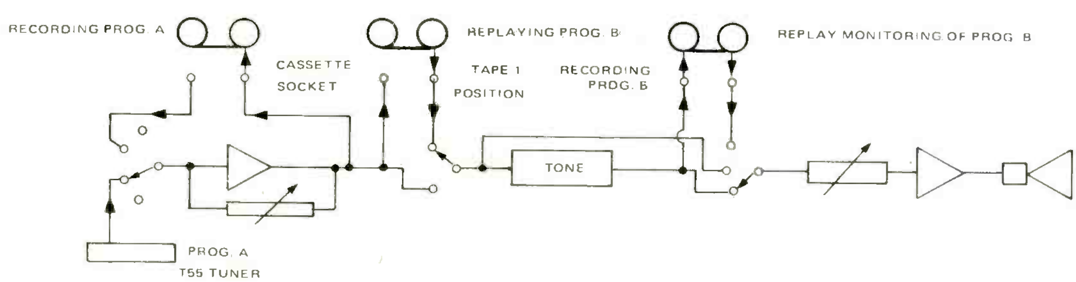
The new Cambridge Audio P60 Integrated Amplifier represents the outcome of radical rethinking of conventional audio amplifier architecture. For many years now the fundamental fixed gain pre-amplifier with its attendant inadequate headroom bringing limiting, clipping and unwanted distortion has been the order of the day. The volume control, placed after most of the pre-amplifier stages could not be turned down to correct a signal that was already in overload and therefore distorted. Cambridge Audio amplifiers are different. To begin with our compensation for disc equalisation to the R.I.A.A. standard is more accurate than that of virtually all our contemporaries. For instance, we employ a buffer stage to eliminate the differences in cartridge inductance that plagues other amplifiers (See Readers Letter W.W. December 1973). In the new P60 Stereo Amplifier separate main and pre-amplifier level controls each with L.E.D. indicators permit the user to optimise all signal levels precisely – thereby catering for every variable - without compromise. The result is audibly less distortion with the added bonus of monitoring just where distortion can be introduced first and at what level.



2. Record and Playback facilities for three tape recorders used individually or combined.

The following block diagram best explains the logic. At first sight the flexibility of the arrangement above is clearly apparent. In addition, interesting new possibilities arise – hitherto unavailable on other products such as the ability to record programme A on Tape Recorder 1 whilst at the same time replaying programme B on Tape Recorder 2 and recording it on Tape Recorder 3, with full monitoring facilities and the ability to modify the frequency response.





Cambridge Audio

for people who listen to music

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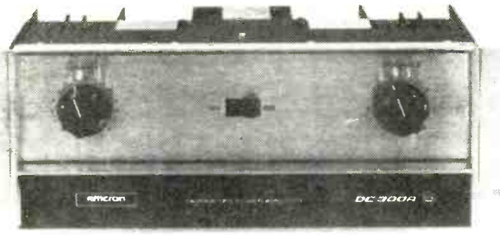
WW—104 FOR FURTHER DETAILS

HIGH POWER DC-COUPLED AMPLIFIER



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

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

Power Bandwidth	DC-20kHz @ 150 watts + 1db, − 0db.	Slewing Rate	8 volts per microsecond
Power at clip point (1 chan)	500 watts rms into 2.5 ohms	Load impedance	1 ohm to infinity
Phase Response	+0, −15° DC to 20kHz, 1 watt 8Ω	Input sensitivity	1.75 V for 150 watts into 8Ω
Harmonic Distortion	Below 0.05% DC to 20kHz	Input Impedance	10K ohms to 100K ohms
Intermod. Distortion	Below 0.05% 0.01 watt to 150 watts	Protection	Short, mismatch & open cct. protection
Damping Factor	Greater than 200 DC to 1kHz at 8Ω	Power supply	120-256V, 50-400Hz
Hum & Noise (20-20kHz)	At least 110db below 150 watts	Dimensions	19" Rackmount, 7" High, 9¾" Deep

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

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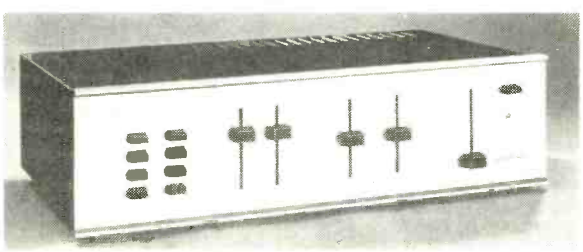
A NEW STANDARD FOR SOUND REPRODUCTION

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 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:	Zero. (Cannot be identified or measured as it is below inherent circuit noise.)
Power amplifier. at rated output:	Less than 0.02% (typically 0.01% at 1kHz).
at 25w output:	Typically 0.006%.

Overload margin.

Disc input	40 dB min.

Hum and noise output.

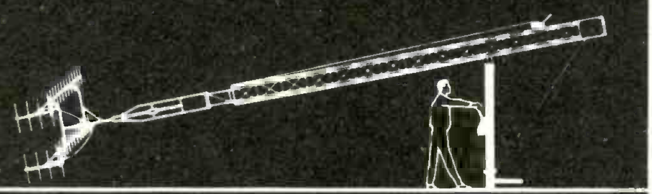
Disc:	—83dBV Measured flat with noise bandwidth of 23kHz.
	—88dBV Measured with 'A' weighted characteristic
Line:	—85dBV Measured flat.
	—88dBV 'A' weighted.
Size:	17 inches × 4¾ inches × 11 inches deep overall.
Weight:	21 lb.

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—019 FOR FURTHER DETAILS

INSIST ON VERSATOWER



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Models from 25' to 120'

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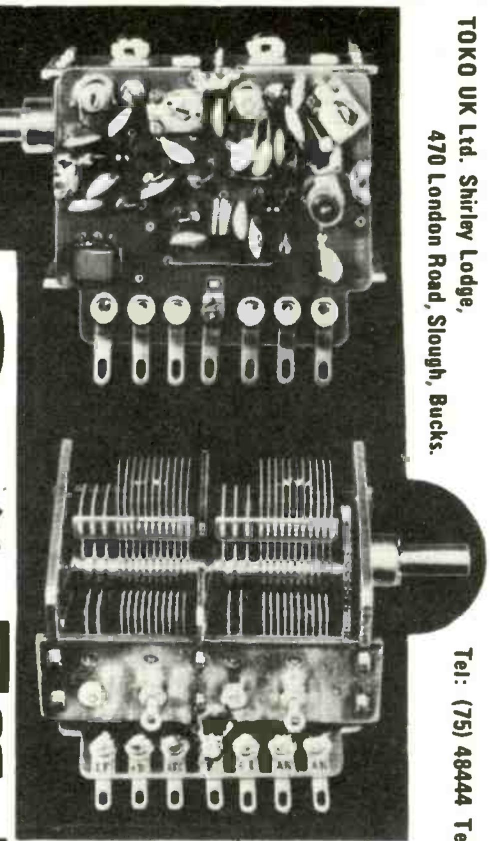
TOKO new low cost AM/FM TUNER



Type 703UA is an FM Tuner with an associated AM gang. 87-109 MHz supply voltage +6 IF Bandwidth 400 KHz noise 10dB max. AFC ± 150 KHz at 108 MHz. 3 : 1 reduction gear 360° rotation AM gang 2 x 323 pf plus 12 pf trimmer.

TOKO UK Ltd. Shirley Lodge, 470 London Road, Slough, Bucks.
Tel: (75) 48444 Telex: 847185

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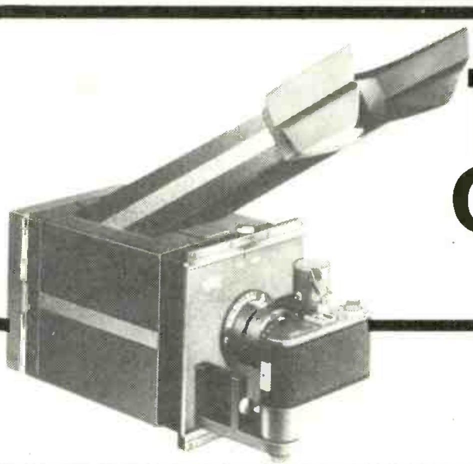

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- *Use economical 35mm film.
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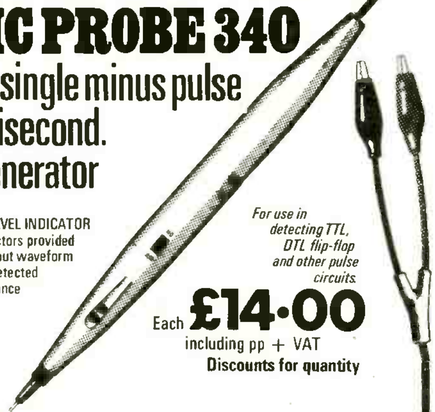

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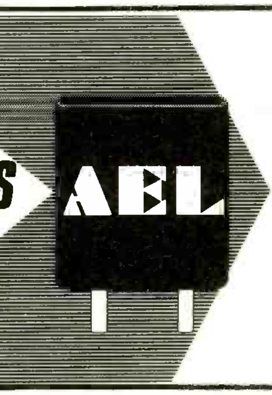

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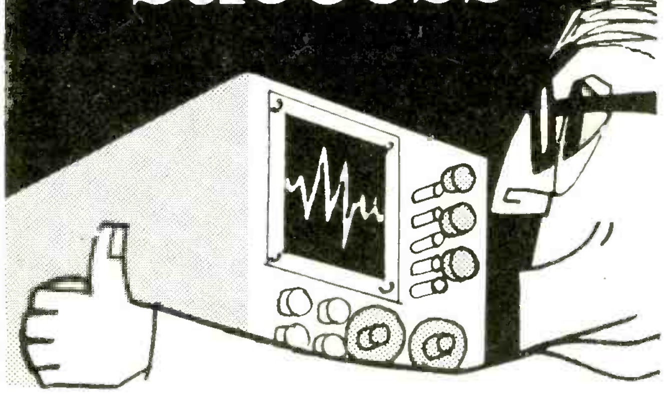
Our electronics are a signal success



Our manufacturing resources could contribute to *your* success, too! We've chalked up many years of service to ministries, government departments, armed forces, and a formidable list of significant names in industry. They all come to Whiteley for the specialist knowhow and resources we have developed. Can we help you? We can build to your drawings and specification, or put our design departments at your service, as needed. From a small component to a complete system, in audio work, relay switching circuits, control systems, and many other spheres—our facilities are ready. The Whiteley organisation is self-contained. The manufacturing resources are backed by our own toolroom, sheet metal working and press shops, plating and finishing lines, coil and transformer winding shop, plastics moulding shop and a modern new cabinet factory. Capitalise on all these Whiteley facilities—call us in for a look at your next electronics need. You'll be in good company!

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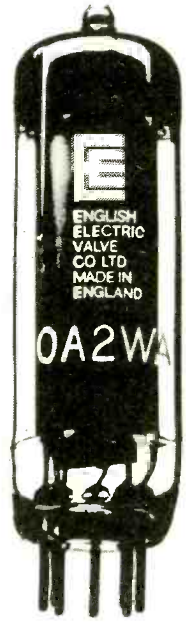
Write or 'phone for voltage stabiliser data sheets and prices.



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G&C

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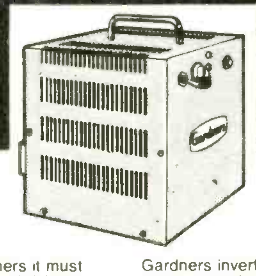
BIG BOOST FOR THE GARDNERS RANGE

50Hz 300VA Square Wave Inverters



If it's produced by Gardners it must be something special, and it is!
Now available, models 107A and B are precision built inverters providing 240 volts a.c. from 12 and 24 volt battery systems.

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Eight times copy speed.

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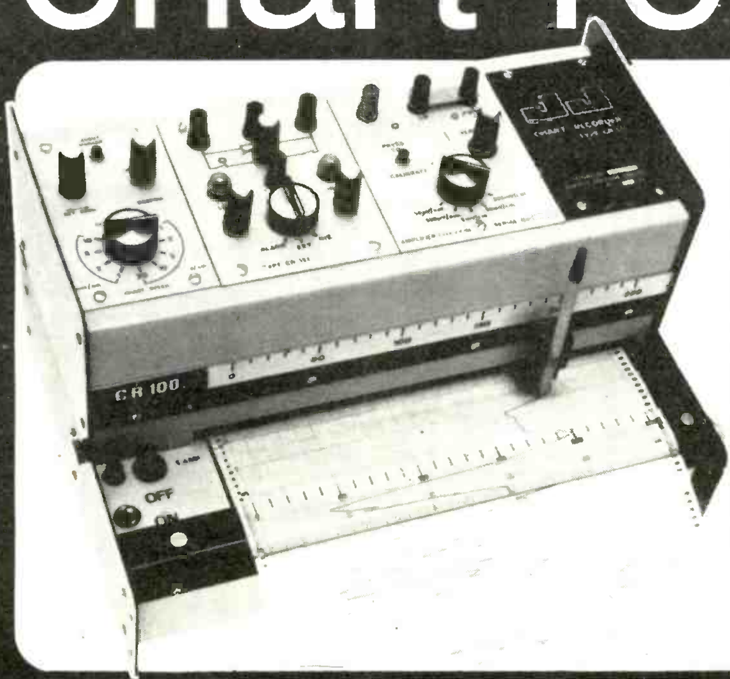
chart recorder



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Designed and built to professional standards this British product introduces a new price/performance concept in pen-recording. Modular design and optional facilities permit an advanced system to be built up at a modest cost.

Facilities include access to a transmitting potentiometer with or without "High-Low" alarm facilities; remote control of speed selection; extension of basic speed ranges by externally generated digital pulses; ability to 'slave' one recorder to another for chart speed correlation; event marker; range of existing and projected plug-in pre-amplifiers.

Slewing rate:	400 mm/sec
Sensitivity:	50μV/cm - 500 mV/cm (with pre-amplifier)
Speeds:	1, 2, 5, 10, 20 sec/cm, 1, 2, 5, 10 min/cm
Paper size:	270 mm wide (DIN 16230)
Paper drive:	Digitally controlled stepper motor
Pen type:	Ballpoint, fibre tip, capillary
Pen drive:	Infinite resolution d.c. potentiometric servo

Compact, robust design

Basic Recorder £218.90
Pre-amplifier from £39.60
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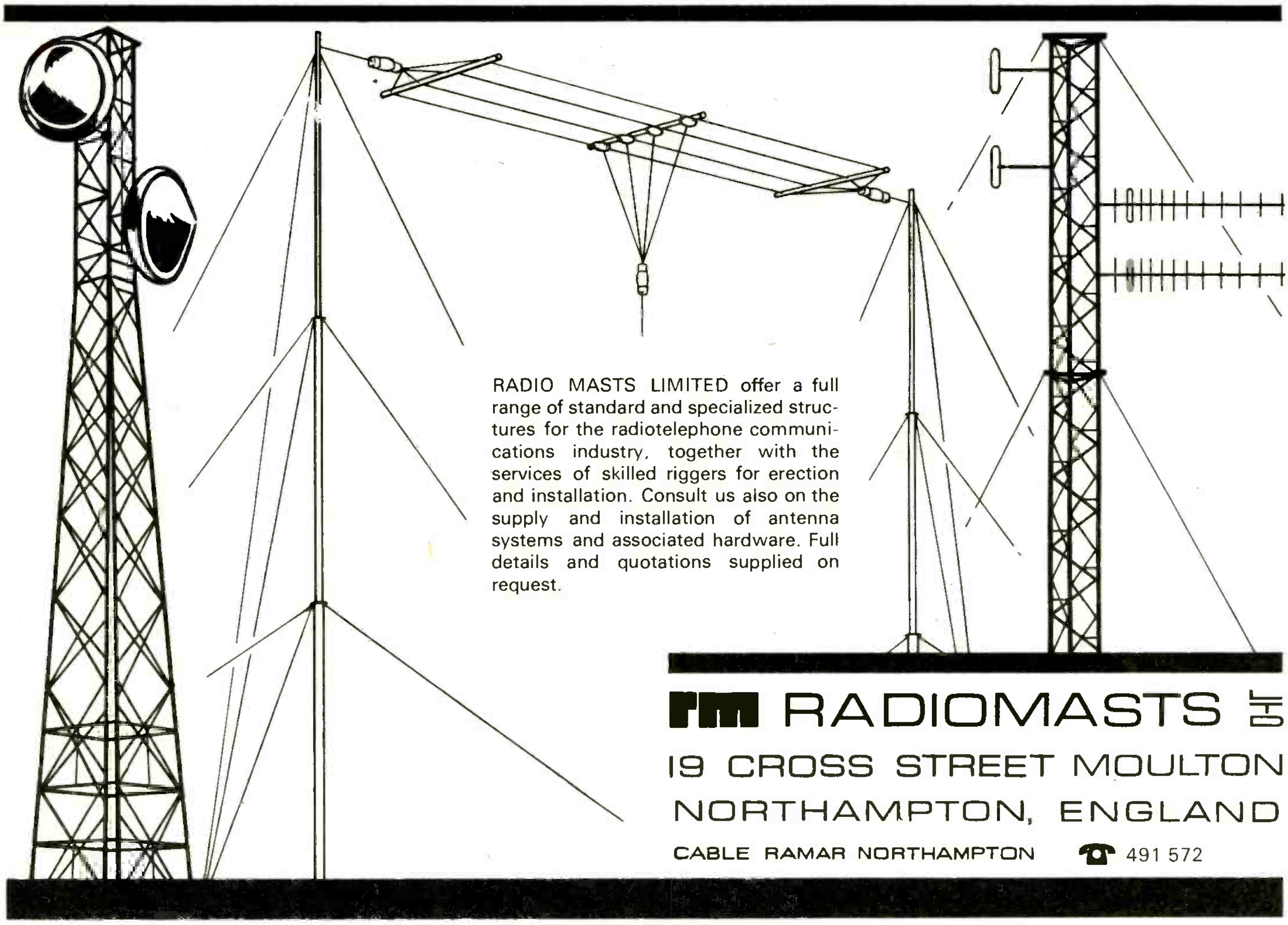

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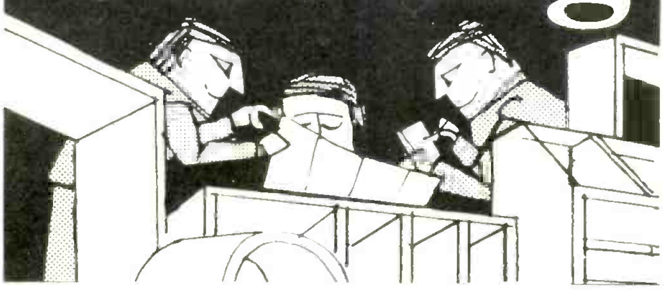

Next time you need instrument cases, cabinets or consoles, made in wood talk it over with Whiteley. It could be a very profitable discussion for you. Our new woodworking plant is ready with the most up-to-date machinery, to provide speed and quality in volume production. We can work from your drawings, or design to meet your needs. Tell us the problem. Our specialist experience spans acoustics, heat dispersal and many other problems met in instrument packaging—and it's all at your service.

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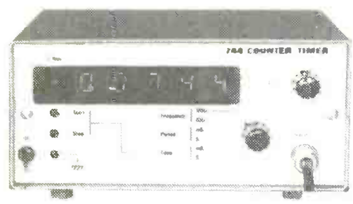

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RADFORD

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Specification:	
Frequency range:	10Hz–100kHz (4 bands)
Output voltage:	10 volts r.m.s. max.
Output source resistance:	150 ohms unbalanced (optional 150 ohms unbalanced, plus 150/600 ohms balanced/floating)
Output attenuation:	0–100dB (8–10dB steps + 0–20dB variable)
Output attenuation accuracy:	1%
Sine wage distortion:	Less than 0.002% 10Hz–10kHz (typically below noise of measuring instrument)
Square wave rise and fall time:	40/60 n.secs.
Monitor output meter:	Scaled 0.3, 0–10, and dBV.
Mains input:	110V/130V, 220V/240V
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Price: 150 ohms unbalanced output: £250
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A sensitive instrument with high input impedance for the measurement of total harmonic distortion. Designed for speedy and accurate use. Capable of measuring distortion products down to 0.001%. Direct reading from calibration meter scale.

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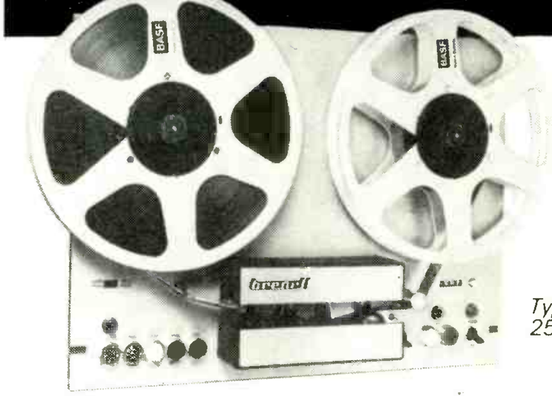

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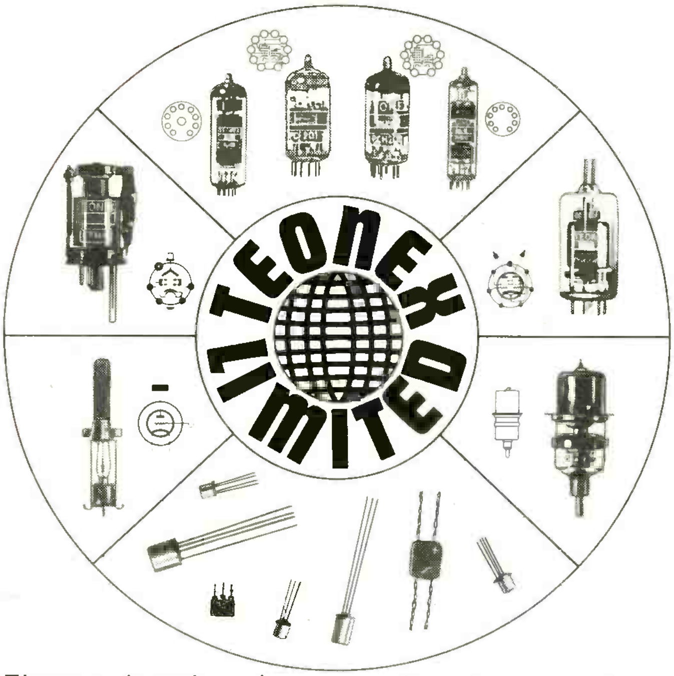

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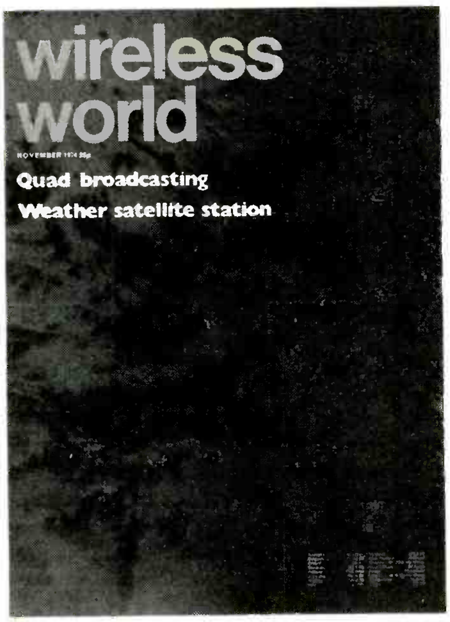
SIXTY-FOURTH YEAR OF PUBLICATION



This month's front cover carries a cloud cover picture obtained from a weather satellite and introduces G. R. Kennedy's article on a weather satellite ground station in this issue.

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(published November 20)

Capacitors survey. Review of the basic parameters of capacitors and types of construction with a comparison chart to aid selection.

Rhombic u.h.f. TV aerial. Design with good gain and directivity, with coaxial to wire transition, for mounting in the loft.

Psychoacoustics of surround sound. Discussion of how well surround-sound systems meet the ears' requirements for localization.

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Ambiguity in diagrams

An article in this issue draws attention to the need for meaningful layout, of both symbols and connections, in circuit diagrams. The layout should be meaningful in the sense that a group of symbols and connections should be immediately recognizable as having a particular function—an emitter follower, a multivibrator or whatever it is. This is essentially a matter of pattern. The eye quickly recognizes a familiar pattern without studying all the detail that goes to make up that pattern.

The absence of familiar patterns results in uncertainty of interpretation. There is, however, another source of uncertainty, in the possible ambiguity of the lines we draw in our diagrams. In electronics we have block schematics, theoretical circuit diagrams, logic diagrams, equivalent circuits (e.g. of semiconductor devices) and wiring diagrams, and in all of them the components, elements or units are connected by lines. Thus in a theoretical circuit diagram a line means an electrical connection but not necessarily an actual length of conductor; in a wiring diagram a line does literally mean a length of conductor; and in a block schematic or logic diagram a line usually means a path for information flow but possibly an electrical connection as well.

There is not much of a problem when the whole of a diagram is of a distinct category and is readily seen to be so. But such is the complexity of our modern electronic systems that many diagrams we see printed contain several categories of diagrams—they are hybrids. Thus a line might leave a transistor symbol as an electrical connecting path and arrive at a logic gate symbol as a binary information path. Analogue can mysteriously become digital, and vice versa. A very familiar situation nowadays is the presence of drawings of integrated circuit packages in the middle of theoretical circuit diagrams. The packages have numbered terminals and the lines attached to these terminals therefore seem to be part of a wiring (or printed circuit) diagram, helping one to construct the equipment concerned; but the other ends of these lines are no longer conductors in the physical sense but symbols for electrical connections in the theoretical sense.

Thus the meaning of a line in such diagrams can be ambiguous. It's difficult to see at present how any convention in drawing can avoid this ambiguity. Labelling the lines seems cumbersome and unnecessarily explicit. Does the ambiguity really matter? Perhaps the experience and mental agility of those who use the more complex diagrams are sufficient to cope with the metamorphoses of the lines. But students and beginners in electronics could well be worried by this oddity, especially when translating a "hybrid" diagram into terms of hardware. What is needed is a neat method of showing the status of a line in a particular position which can be readily understood by all, and we commend this problem to our readers.

Quadraphonic broadcasting—current proposals and the way ahead

by Michael J. Carey, B.Sc.(Eng.), A.C.G.I., and John C. Sager, B.Sc.

Several proposals for quadraphonic broadcasting have been put forward in the United States of America. This article reviews the merits of these and then discusses the performance of three- and four-channel systems. A three-channel system is advocated for quadraphony with the possibility of using the fourth channel for height information at some future date.

The problem of quadraphonic broadcasting is where to put third and fourth channels while maintaining the existing standards for monophonic and stereophonic listeners. The systems[1] now before the NQRC* in the USA are agreed on the method of transmitting the third channel. They all co-locate this with the existing stereo sub-carrier channel but in phase quadrature, so there is no interference between the three channels.

The need for a fourth channel and the method of encoding to be adopted for its optimum use is discussed later, but if it is necessary the provision of a suitable slot in the frequency spectrum of the f.m. signal is a much more difficult problem, and results in a number of separate solutions being proposed. The reason for this can be seen by considering the present use of the spectrum in the USA. The problem is the SCA (Subsidiary Communications Authorisation) transmissions, occupying the frequency range 61 to 73kHz (Fig. 1). This makes it difficult to fit in the fourth channel since this is the most suitable place for it.

Two four-channel systems, proposed by Quadracast Systems Inc and RCA, are not compatible with the SCA transmission. They each propose a second double-sideband suppressed-carrier channel using the second harmonic of the 38kHz stereo subcarrier as the carrier. Providing a full bandwidth channel, the channel spectrum extends from 61–91kHz (Fig. 2). In the same way that a stereo signal can be generated by switching between left and right channels at 38kHz a composite quadraphonic signal can be generated by switching between the four channels at 38kHz.

The system proposed by General Electric (USA) provides for the fourth channel as a vestigial-sideband suppressed-carrier signal with the second carrier again at 76kHz. The vestigial filtering enables a new SCA channel to be provided between 90 and 100kHz. Here, however, a switching-type modulator cannot be used and the encoder must incorporate a vestigial sideband filter.

The Zenith Corporation also proposes a vestigial sideband system as one of the two it puts forward. Both these systems leave the SCA broadcasts as they are now and allocate frequencies above 76kHz for the fourth channel. This is accomplished either by transmitting a single-sideband signal on a 76kHz carrier or a vestigial-sideband signal similar to the GE system but using a carrier at 90.25kHz.

The other proposal, by Duane Cooper and Nippon Columbia Co, has two options for the fourth channel. Where there is no SCA, a single-sideband signal of 15kHz bandwidth is transmitted from 57.72kHz; where SCA is to be used the bandwidth is restricted to 3kHz, so the SCA channel can occupy its present position.

The criteria we used to judge the systems are:

- minimum degradation of the signal-to-noise ratio of the received signal
- minimum extra bandwidth required
- simplicity of encoder and decoder.

The first and third requirements are self-evident; what may not be obvious is the need to restrict the bandwidth of the signal. The reasons for this are

—noise per unit bandwidth increases as bandwidth is increased
—bandwidth and phase response of many tuners now in use is restricted
—warbling noises that can occur due to adjacent channel interference would be worse with increased bandwidth
—gain-bandwidth product of the receiver can be kept to the minimum.

The two Zenith systems do not meet any of the above criteria. The Cooper/Nippon Columbia method does, but the use of an s.s.b. signal is best avoided as it can lead to peaks in the deviation of the complete signal. The remaining three systems are mutually compatible as far as receiver design is concerned. The use of v.s.b. and the SCA channel at 95kHz can add complications to the transmitters of stations but they do not inhibit the optimum use of the bandwidth by other stations. Each of these systems degrades the overall signal-to-noise ratio by 3dB (ref. stereo) when the 38kHz channel is in use, and 9dB (ref. stereo) when all four channels are in use.

Three- and four-channel systems

Are four channels necessary? It can be shown that a sound field, as it affects an observer, can be represented by an infinite

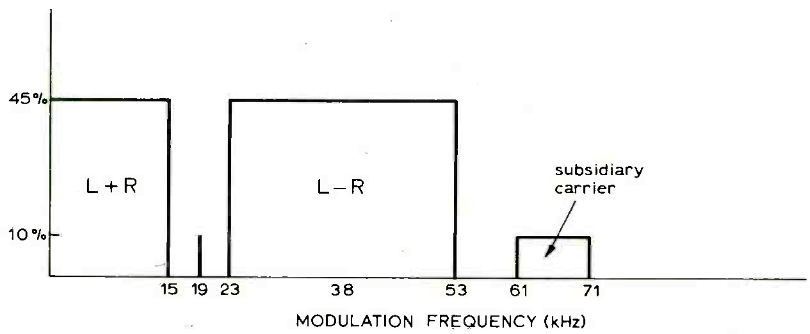


Fig. 1. Present allocation of the modulation spectrum showing the positions of the monophonic signal, difference signal and "storecast" channel.

*The Electronic Industries Association-sponsored National Quadraphonic Radio Committee is due to report to the FCC early next year, see p. 458—Ed.

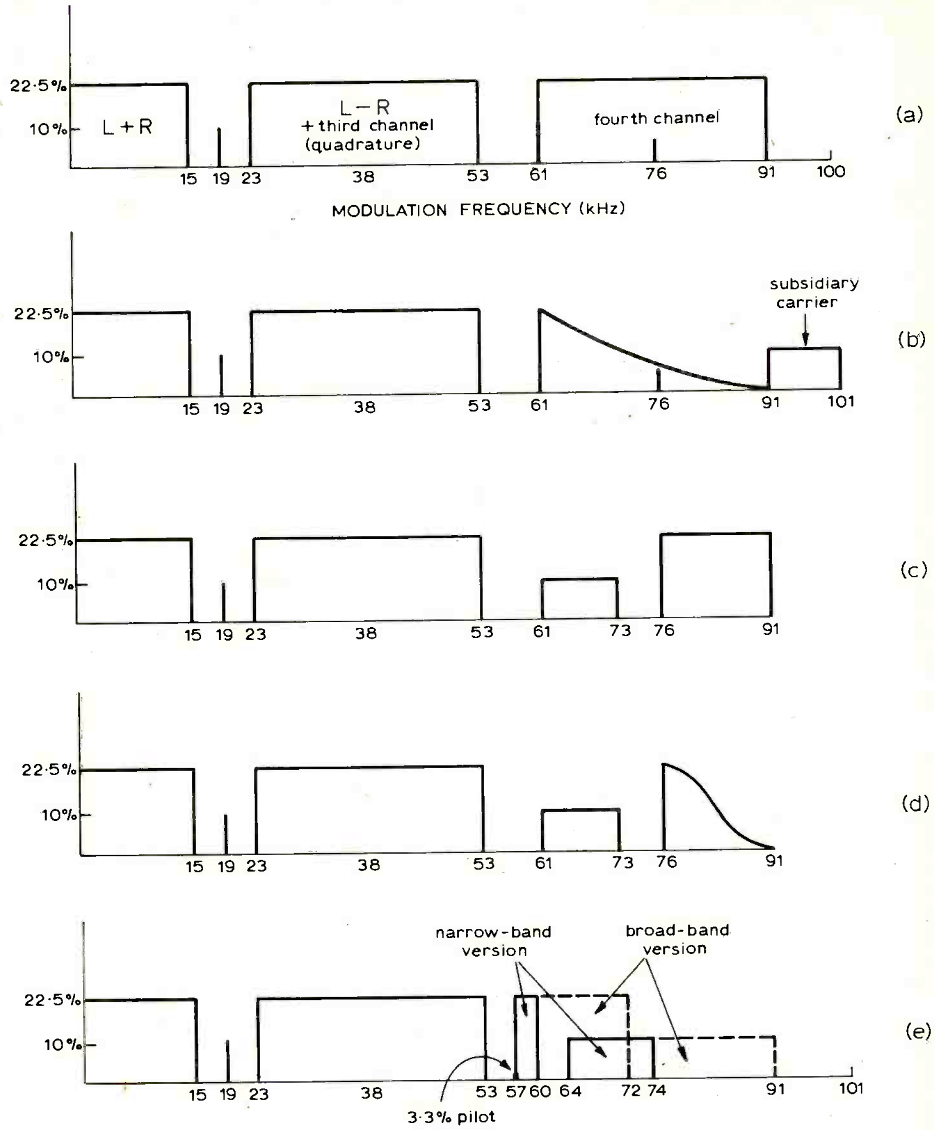


Fig. 2. Modulation spectra for proposals currently being assessed by the NQRC. Three systems require the SCA channel to be moved—QSI and RCA(a) and GE(b). Zenith systems, (c) and (d), place the fourth channel at a high frequency and are consequently susceptible to adjacent carrier interference. (Fourth channel in (b) and (d) should have lower sidebands shown flat-topped for the most part. In (d) limits should be 80 and 98kHz.) The Cooper/Nippon Columbia proposal (e) allows a narrow-band fourth channel and the existing "storecast" broadcast, but a full-band fourth channel would necessitate moving it. (Quadrature channels are encoded with reference to 45°.)

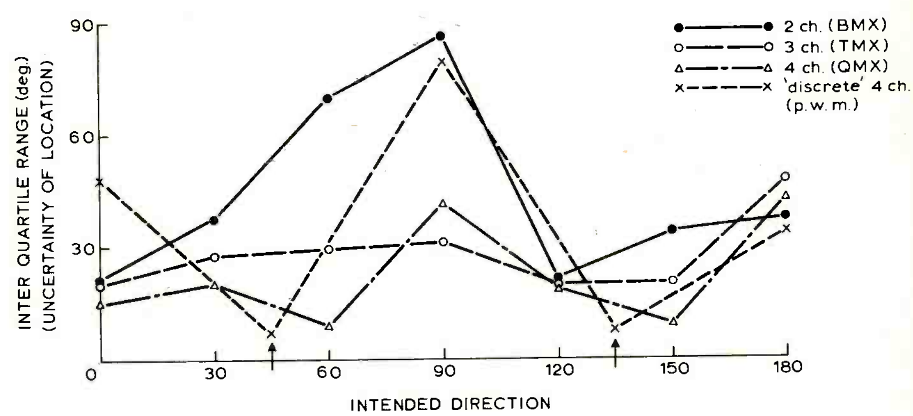


Fig. 3. Graph showing the subjective effect of two-, three- and four-channel transmission systems on the accuracy of sound image location.

number of spherical harmonics in an exactly similar way to the manner in which an electrical waveform can be represented by a Fourier series of harmonics. The nth spherical harmonic requires $2n+1$ independent coefficients to describe it, therefore N harmonics require

$$\sum_{n=0}^{N}(2n+1)=(N+1)^2$$

coefficients in total. Thus to reconstruct a sound field at a remote point there must be a means of transmitting the values of all these coefficients. Also, as the sound field is time varying, the coefficients will also be time varying. It is obviously impractical to transmit enough information to completely describe the sound field so the harmonic series must be truncated.

The simplest non-ideal representation of a sound field is an harmonic series of zero order ($n=0$). This requires one coefficient to describe it and consequently one transmission channel. This corresponds to monophonic sound transmission. A first-order series representation requires four independent transmission channels to transmit the coefficients, while a second series representation requires nine channels. Increasing the number of spherical harmonics used to re-create the original sound field improves the ability to represent fine detail in the sound field but at the cost of increasing the number of transmission channels required to convey the information.

The above analysis refers to the representation of a three-dimensional sound field. If the representation is limited to two dimensions, i.e. to sound coming only from directions around a horizontal plane, the number of coefficients required is reduced. In this case the *total* number of coefficients required is $2N+1$ for N circular harmonics. Again the zero-order representation is the monophonic case but now the first-order representation requires only three coefficients and the second-order only five. A more comprehensive and rigorous analysis of possible surround-sound systems is given in reference[2].

At this point, one might ask if it is impractical to use a large number of spherical or circular harmonics to re-create a sound field, how few can we get away with and still make the result indistinguishable, or at least not unacceptably different, from the original as far as the human ear is concerned. Experiments carried out in Japan suggest that, for the two-dimensional case, a first-order representation (three channels) gives good results and that the improvements to be gained by using a second-order representation (five channels) are marginal.

It would appear, then, that for the usual four-speaker layout, i.e. all speakers in the same horizontal plane, only three channels are required to adequately represent the original sound field, although at least four speakers are required in a practical system because of image location problems when speaker pairs subtend large angles at the head. In fact four channels produce a non-optimum system as there is too much information for a first-order representation and not enough for a second-order representation. The effect of this extra information is to increase the angular resolution of sound sources appearing to come from directions close to the location of the speakers. (This effect is much reduced using eight speakers.)

The effect is shown graphically in Fig. 3 which is reproduced from reference[3]. The horizontal scale shows the bearing angle of the intended location of the sound source from the straight-ahead position (0°) and the vertical scale gives a measure of the uncertainty about the intended direction of the sound source experienced by the subjects. In each case four speakers were used but the information was transmitted by the two-, three- and four-channel members of a family of transmission systems known collectively as UMX[4].

It shows clearly that the uncertainty in sound source location is much reduced near the speaker locations (45° and 135°) in the four-channel case (QMX) whereas the resolution is much more uniform in the three-channel case (TMX). The graph also shows just how unsatisfactory is the attempt to transmit surround-sound in two channels (BMX) with any degree of accuracy of location and also the shortcomings of the pairwise technique of mixing single sound sources into a surround-sound field. (The results for the discrete four-channel case were produced by this method.)

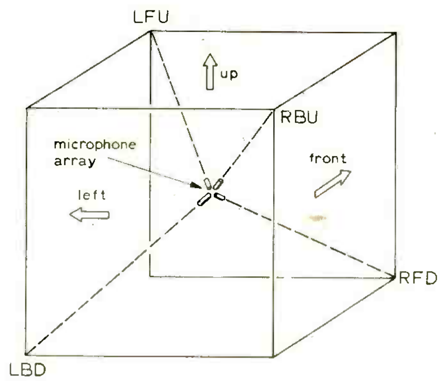


Fig. 4. Microphone aiming directions for four-channel, three-dimensional surround-sound pickup.

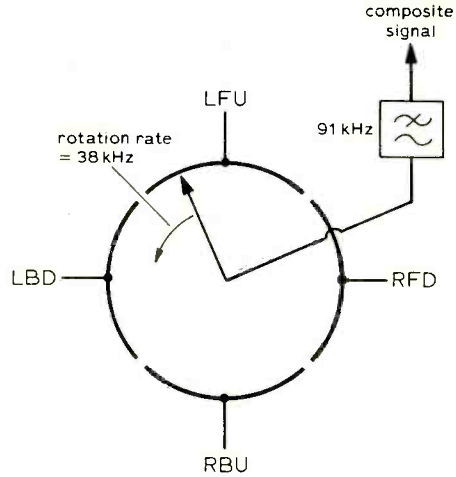
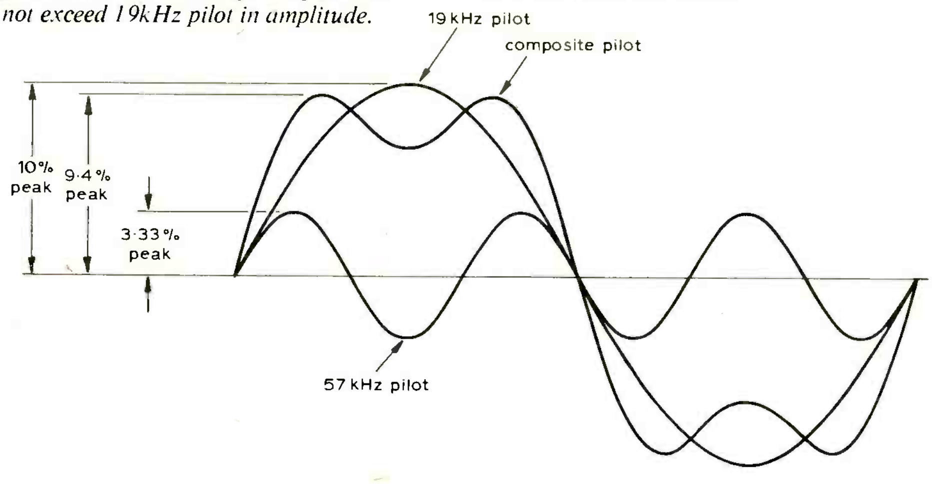


Fig. 5. Schematic showing principle of sampling four signals sequentially to produce a composite signal.

Fig. 6. Relationship of 19 and 57kHz pilots showing that composite pilot does not exceed 19kHz pilot in amplitude.



An alternative proposal

It seems then, that there is a spare channel available with a quadraphonic broadcasting system for alternative use. The obvious thing to do is to use this channel to convey height information. Experiments[5] suggest that the addition of height information makes a significant improvement in the realism of the reproduced sound.

If this is done the resulting system must be compatible with the present monophonic and stereo system and also with the three-channel horizontal surround-sound system. This can be ensured by using the baseband channel to carry an omnidirectional signal, the channel on the in-phase 38kHz sub-carrier to carry a left-right signal, the channel on the quadrature 38kHz subcarrier to carry a front-back signal and the channel on the in-phase 76kHz subcarrier to carry an up-down signal. This then enables monophonic receivers to use the omnidirectional signal and stereo receivers to use, as well, the left-right signals, as at present. A three-channel receiver would also make use of the front-back signal to create a two-dimensional surround sound system and a full four-channel receiver would use all these and the up-down signal to create a three-dimensional surround-sound system.

The method of encoding source material into this format is relatively simple, especially in the case of live material, e.g. concert broadcasts. If an array of four cardioid microphone capsules is placed in close proximity and with their directions of maximum pickup pointed at alternate vertices of an imaginary cube at the centre of which the array is located, then four signals produced contain all the information required by a three-dimensional surround-sound system. By convention, the directions in which the microphones point should be left-front-up (l.f.u.), left-back-down (l.b.d.), right-back-up (r.b.u.), and right-front-down (r.f.d.). The arrangement is shown in Fig. 4.

The system is very similar in concept to Blumlein's original coincident microphone technique for stereo sound pickup. The four signals produced may need to be processed by a 4×4 matrix with real coefficients to alter the balance between direction-dependent and direction-independent sound in the signals for a subjectively more pleasing effect. Sources picked up by single microphones can be mixed into a surround-sound field by feeding the signal to *all four* channels with the gains to each channel adjusted so that the source appears to be located in the desired direction. If the four signals are now sampled sequentially in the order l.f.u., l.b.d., r.b.u., r.f.d., with a repetition rate of 38kHz and all frequency components above 91kHz are removed by a low-pass filter it can be shown that the resulting signal is the one required.

Fig. 5 shows the encoding principle and Appendix 1 sets out the mathematics of the process. In practice an additional pilot would be required, perhaps at 57kHz, to indicate the transmission of three or four channels as opposed to only two channels. The four channels could be easily recovered using techniques similar to those already developed for decoding stereo broadcasts.

Conclusions

In this article we have reviewed several proposals for broadcasting surround-sound information and have shown that some of these have to resort to inelegant complications to accommodate SCA transmissions. We have also shown that three channels are sufficient for a horizontal surround-sound transmission system and have therefore suggested that the fourth channel should be used to convey height information in a manner compatible with existing mono and stereo systems and the three-channel horizontal system. It is unlikely that a three-dimensional surround-sound broadcast system based on this is feasible in the near future. However, it is important that the option of eventually broadcasting using such a system should be left open whilst catering in the immediate future for a two-dimensional system.

Present needs would be fulfilled by adding a third channel modulating a quadrature 38kHz subcarrier. This would entail a degradation of only 3dB or so in signal-to-noise ratio over and above that of the present stereo system. A second pilot tone would be needed to indicate whether all four speakers are required (for the three-channel system) or only the front pair (for stereo). This could conveniently be placed at 57kHz and if its level were kept sufficiently low the peak deviation caused by both pilots would be no greater than that of the 19kHz pilot alone (see Fig. 6).

Appendix

The sampling process can be regarded as multiplying each of the audio signals by one of the switching functions in Fig. 7 and adding to produce a composite signal

$$S=(LFU)A+(LBD)B+(RBU)C+(RFD)D. \qquad (1)$$

Each of the switching functions can be expanded as a Fourier series thus:

$$A=\tfrac{1}{4}+\frac{1}{\pi}(\sin\omega t+\cos\omega t+\sin 2\omega t+\ldots)$$

$$B=\tfrac{1}{4}+\frac{1}{\pi}(\sin\omega t-\cos\omega t-\sin 2\omega t+\ldots)$$

$$C=\tfrac{1}{4}+\frac{1}{\pi}(-\sin\omega t-\cos\omega t+\sin 2\omega t+\ldots)$$

$$D=\tfrac{1}{4}+\frac{1}{\pi}(-\sin\omega t+\cos\omega t-\sin 2\omega t+\ldots)$$

where $\omega=2\times 38$kHz. The series are truncated to include only terms in ωt and $2\omega t$, as $3\omega t$ and above terms are filtered out prior to modulation of the broadcast transmitter. Substituting into equation 1 and rearranging gives

$$S=\tfrac{1}{4}(LFU+LBD+RBU+RFD)+$$
$$+(LFU+LBD-RBU-RFD)\sin\omega t$$
$$+(LFU-LBD-RBU+RFD)\cos\omega t$$
$$+(LFU-LBD+RBU-RFD)\sin 2\omega t \qquad (2)$$

This, together with 19 and 57kHz pilot tones would be used to modulate the transmitter.

Consider now a spherical co-ordinate system (r,θ,ϕ) aligned in such a way that $\phi=0$ represents up, $\theta=0$, $\phi=\pi/2$ represents forward, and $\theta=\pi/2$ represents left. In this co-ordinate system the polar diagram of an upward-pointing cardioid microphone can be described by $r=0.5+0.5\cos\phi$.

By applying transformations to rotate this polar diagram to point in the four specified directions gives the following equations for the microphone polar diagrams:

$$r_{LFU}=0.5+\frac{0.5}{\sqrt{3}}(\cos\theta\sin\phi+\sin\theta\sin\phi+\cos\phi)$$

$$r_{LBD}=0.5+\frac{0.5}{\sqrt{3}}(-\cos\theta\sin\phi+\sin\theta\sin\phi-\cos\phi)$$

$$r_{RBU}=0.5+\frac{0.5}{\sqrt{3}}(-\cos\theta\sin\phi-\sin\theta\sin\phi+\cos\phi)$$

$$r_{RFD}=0.5+\frac{0.5}{\sqrt{3}}(\cos\theta\sin\phi-\sin\theta\sin\phi-\cos\theta) \qquad \ldots (3).$$

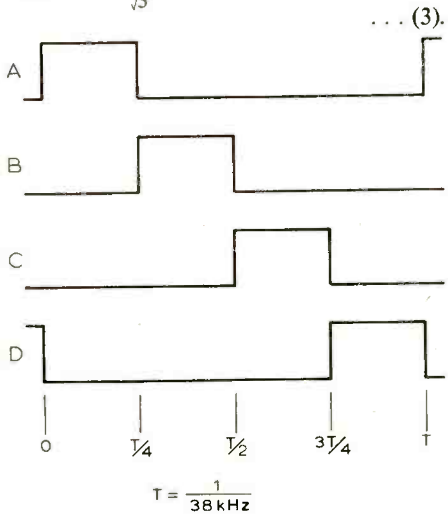


Fig. 7. Switching functions used to sample the four audio signals.

If the coefficients of the terms in equation 2 are represented in terms of equations 3 the following equations result:

$r(LFU+LBD+RBU+RFD)=2$,

the polar diagram of an omnidirectional microphone;

$r(LFU+LBD-RBU-RFD)=\frac{2}{\sqrt{3}}\sin\theta\sin\phi$,

the polar diagram of a horizontal figure-of-eight microphone aligned left-to-right;

$r(LFU-LBD-RBU+RFD)=\frac{2}{\sqrt{3}}\cos\theta\sin\phi$,

the polar diagram of a horizontal figure-of-eight microphone aligned front-to-back;

$r(LFU-LBD+RBU-RFD) = \frac{2}{\sqrt{3}}\cos\phi$,

the polar diagram of a vertical figure-of-eight microphone.

Therefore the coefficients of the modulating function equation 2 represent respectively, an omnidirectional signal, a left-right signal, a front-back signal and an up-down signal—just as required.

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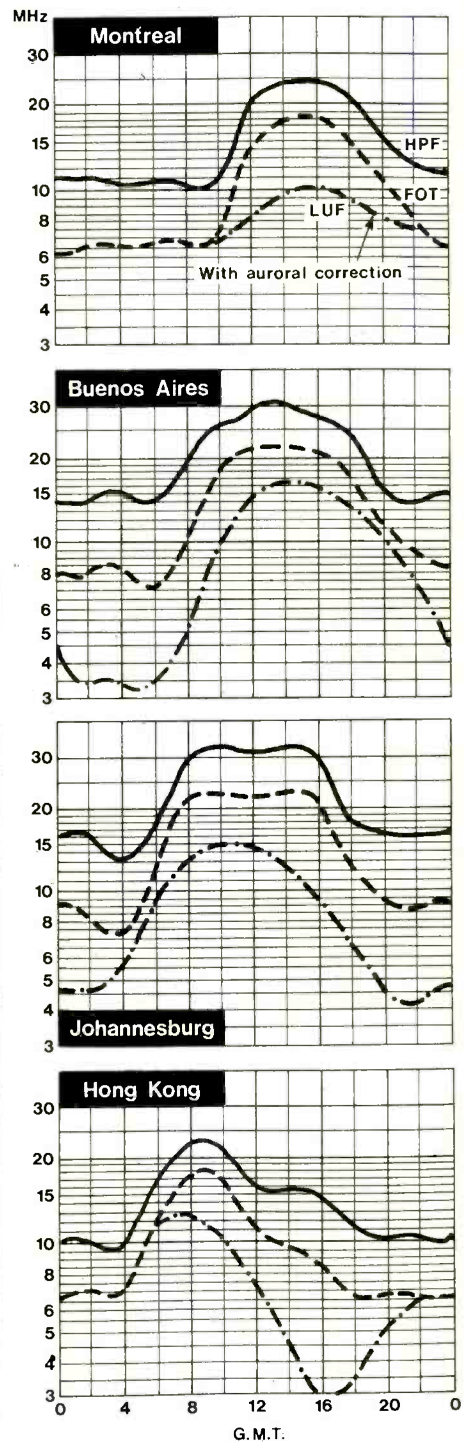
"Project"

Pt. 3 of the article "A digital clock and calendar" has been unavoidably postponed until the December issue.

HF predictions for November

Seasonal change brings F layer MUFs considerably higher by day and slightly lower by night with a small peak occuring before the pre-dawn dip. Layer virtual height, and thus elevation angles, are lower, less than the night value in fact. E layer MUFs, and thus screening frequencies, become lower, so the overall effect is a considerable increase in the available spectrum width by day. This is offset to some extent by larger day to day variation of signal and noise levels.



Letters to the Editor

ELECTRONIC IGNITION

Mr Watkinson has given us an interesting article on electronic ignition techniques (July issue). As we are convinced of the superior performance and development potential of the capacitor discharge (c.d.) system, we will confine our comments to the relative merits of contactless and contact derivation of the timing pulse for c.d. units, as laid out in the bottom two lines of Mr Watkinson's table of improvements. This table, incidentally, by means of dot rating, would seem to contain the only criticism of mechanical contact derivation in the article, emphasised of course by the weight of material written on alternative methods of deriving the timing pulse.

We disagree with some of the dot ratings given:

Acceleration or fuel consumption will be improved by the same factor, other things being equal, by a c.d. system using either contact or contactless derivation of timing pulse. Both systems suffer the same systematic and random errors since these are generated mainly in the crankshaft to distributor drive line and not by the actual pick-up system. We have found the c.d. system energy discharge parameters to be the controlling factor.

Increased r.p.m. The importance of points bounce has been greatly exaggerated in the literature. A good contact type c.d. system should feature a bounce suppressed firing circuit. This permits operation up to 12000–15000 r.p.m. on four-cylinder engines and further if contact-breaker points having a stronger spring are used. Since this will be beyond the range of even most competition engines the distinction between contact and contactless systems is academic. Some other engine factor, e.g. valve bounce, will limit the maximum r.p.m. first.

Servicing. We must include servicing of the c.d. unit itself, and contactless systems are inherently less reliable than contact systems simply because they must use a greater number of components to achieve the same end as a contact system. It can be argued that the contact system requires points maintenance but in practice, since the points are relieved of their load by the c.d. system, the erosion is negligible. It has been our experience that, provided the distributor cam is lubricated, contact-breaker sets will last 20,000 to 50,000 miles without adjustment. At this mileage interval one would wish to check ignition timing in any case to compensate for crankshaft to distributor drive line errors.

Once again the design of the c.d. unit proper can have a bearing on the servicing demands of the ignition system since some systems can overstress coil and distributor insulation with excessively short pulses of high amplitude. This leads to premature breakdown and occurs regardless of timing pulse derivation.

Breakdown of electronic components, being unpredictable, could leave one stranded miles from anywhere in the middle of the night, possibly on an urgent journey. Would one then rate a contactless system highly or would one prefer a contact system which can be converted to the Kettering system in a few seconds?

We find that claimed advantages of contactless derivation when examined closely are debatable, and that the design of the c.d. unit proper has far more bearing on engine performance and reliability. The high (120mJ) output of our own system, for example, is advantageous especially on commercial engines when low octane fuel is used. M.p.g. improvements of 10–15% have been observed under these conditions where lesser energy systems of contact or contactless timing gave no improvement.

D. Anderson,
C D Ignition Ltd,
Currie, Midlothian.

Mr Watkinson replies:

I thought it sufficient to dismiss the contact-breaker by weight of superior alternatives, as any condemnation outright of such an apologetic device would be like carrying coals to Newcastle.

No simplified table, in such a general form as I have drawn, can tell the whole truth, and to clarify the picture the text distinctly says "It (the table) shows the effect of using a particular technique with all other parameters remaining equal. The fact that many of the systems allow parameters to be changed should be borne in mind". If a conventional contact breaker is connected directly to a c.d. type circuit, the improvements I have claimed will be observed. I consider that adding an anti-bounce circuit constitutes a change of parameters, and in that spirit Note 3 is added to the table. It should be self-evident that adding anti-bounce circuitry increases the circuit complexity to accommodate the shortcomings of the contact breaker.

In any system which eliminates the contact breaker, no anti-bounce circuitry is needed, and thus extra circuit complexity is offset.

Mr Anderson states that with a c.d. system the breaker points are relieved of their load. They are only relieved of their electrical load; the mechanical wear is still present, particularly on the heel of the moving contact. I cannot accept that any lubrication of the distributor cam would remain effective for the claimed mileage, so if one has to lubricate regularly then one's service intervals have already deteriorated. It is, of course, not necessary to lubricate a contactless system, save for the advance mechanism. In the ultimate contactless system there is no advance mechanism.

I agree that there is little difference in performance between a brand new contact breaker c.d. and a contactless c.d. However, after 10,000 miles with no maintenance I know which will be closer to its original performance. In the first sentence of my article I stated that lengthened servicing intervals were one of the main features of electronic ignition. Having gained so much by the adoption of c.d. ignition, it seems a shame to spoil things by retaining the contacts.

In the conventional cam and breaker system, as the breaker rides up the cam to open, energy is removed from the distributor shaft. As the breaker rides down the cam to close, that energy, which was stored in the breaker spring, is returned to the shaft. As a result the distributor shaft receives alternating torsional excitation at a frequency proportional to the r.p.m. and the number of lobes on the cam. As the advance mechanism contains both mass (centrifugal weights) and compliance (advance springs) we have a potentially resonant situation, and the torsional vibration of the cam relative to the breaker shaft is a source of timing scatter, such that the actual point opening times fall in a statistical distribution around the theoretical time. No anti-bounce circuit can eliminate this. A stronger contact spring makes the problem worse.

In a contactless system, of course, no such problem exists, as the distribution of timings about the mean shows a much smaller deviation.

The technical advancement of the motor vehicle has been deliberately delayed for commercial and economic reasons, and for this reason the modern mass-produced motor car represents the triumph of economics over reliability. I hardly consider that incorporating electronics into the stone-age motor car in pursuit of reliability can be a retrograde step. I respectfully maintain that my article, read correctly, is accurate.

SUICIDE SOLDERING

In reply to Mr Clare's letter (July issue) regarding earthing oneself via a wrist band to metal plates, etc., it cannot be stressed too strongly that this practice is highly dangerous and potentially lethal. Surely it is preferable to blow a few f.e.ts than blow oneself into the next world!

The British Standards "Safety Code for Equipment" is all very well provided an unexpected fault doesn't occur.

Why not compromise and wear cotton clothing where possible, install an "earthing bar" (preferably connected to a separate earth from the "mains earth") and earth oneself and tools before and at frequent intervals during the soldering process?
David T. A. Jack,
Bolton,
Lancashire.

Mr Clare replies:
In reply to Mr Jack, I have two comments to make to my previous letter on soldering iron leakage (July issue).

Firstly, if Mr Jack will read my letter, he will observe that I did not mention "earthing" oneself nor the metal foil, only the joining of the two. This, if my understanding is correct, provides no additional path to ground which was not previously in existence, and thus cannot in itself increase the risk of a fault current flowing through the operator.

If the foil is earthed, however, it seems likely to me that any fault current which is going to flow will take a path from the operator's hand (wearing the wrist band and not manipulating the soldering iron) to the wrist band on that hand and hence to earth. This is a much less dangerous path than via the body of the operator, when the fault current could affect the heart directly.

Turning to Mr Jack's "cotton clothing", perhaps he can advise our readers where he obtains these items; all my shirts and trousers contain at least 65% polyester, a well known capacitor dielectric!

WHAT IS E.M.F.?

I would like to comment on a couple of points arising in the article with the above title published in the August issue. This article was, in fact, the unexpected but welcome outcome of a letter I wrote to Mr Scroggie some months ago saying I had been unable to make sense of the quoted paragraph from his book "Phasor Diagrams".

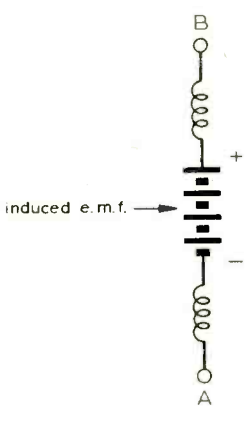
I am glad to say that as a result of thinking about the opposite-way-round explanation given in the article, I am now quite clear about the details of the original explanation—which, *in principle*, I prefer.

What puzzled me at the time was, indeed, the statement that "what was generated in L was positive at the A end whereas a voltmeter would show that L was positive at the B end". This, I must say, seemed like double-Dutch when I first read it! However, I do not think the difficulty would have arisen if the paragraph had been worded as follows:

"Looking at Fig. A.1.2. let us suppose that a magnetic field linked with the turns of coil L is steadily growing, producing an electric field along the wire turns, directed from end A to end B. The magnitude of the field, multiplied by the length of the wire, is 10 volts. Electrons in the wire therefore experience a force pushing them towards end A of the wire, causing a surplus of electrons there and a deficiency at end B. In other words, B becomes positively charged with respect to A. Etc."

It seems to me that an electric field produced by a varying magnetic field can be said to have magnitude and direction, but cannot properly be said to be "positive at one end". Surely it hasn't got an end? I now appreciate that Mr Scroggie's meaning when he said "positive at the A end" was "*as if* produced by a positive charge at the A end of the coil". But I think my suggested rewording, i.e. that the electric field along the wire is "directed from end A to end B", is unambiguous and clearer. Naturally any electrons in this field are pushed in the opposite direction to this conventional field direction, thus making the A end of the coil negative with respect to the B end.

One thing in the recent article I did not feel quite happy about, however, appears towards the end of p.292, where it is said "A first impulse might be to say that of course there is an induced e.m.f. in L, positive at B. But further thought should convince us that is nonsense". This did not seem nonsense to me, and is, indeed, what I would myself have said. At this stage I got quite worried, for Mr Scroggie seemed to have argued quite logically that it *was* nonsense! I think the answer, as Professor Joad would have said, is "it all depends what you mean by 'positive at B'". If it means "as if produced by a positive charge at B", which is evidently Mr Scroggie's meaning once again, then it *is* nonsense, but if it simply means that the direction of the induced e.m.f. is such as to make end B positive—which I would have thought was the more generally accepted meaning—then surely the whole sentence is perfectly sensible? I tend to visualize the induced e.m.f. as being equivalent to introducing a little battery in series with the coil, as sketched below.



Thus it seems to me that this "first impulse" explanation is not wrong but is simply a less detailed one than those given by Mr Scroggie.

In conclusion, I would like to say what a superb effort I think the "Phasor Diagrams" book is—a book which I feel ought to be studied most carefully, and acted upon, by everyone seriously interested in electrical and electronic engineering. As he says, "The current state of presentation of the basic theory of electrical engineering (in its widest sense) is deplorable".
Peter J. Baxandall,
Malvern,
Worcs.

Mr Scroggie replies:
I am most grateful to Mr Baxandall for (1) his outstanding contributions to audio design, (2) his kind assessment of "Phasor Diagrams", (3) the idea of writing "What is an e.m.f.?", and (4) his valuable and constructive criticisms thereof.

I accept without reservation his suggested rewording of my quotation from "Phasor Diagrams". He explains his point so clearly and precisely that there is nothing for me to add.

As regards his second point, I feel that here our roles are reversed. It is the statement that "there is an induced e.m.f. in L, positive at B", which he accepts, that I considered to be so loose and imprecise that (for shock treatment) I went so far as to call it nonsense. The main purpose of my article was to show that this statement was, by itself, inadequate and in fact the reverse of the truth. It might be acceptable as conventional shorthand that we know isn't literally true but which would take too long to express correctly every time (like "the sun is rising"). But such conventions can be misleading, if they are taken at face value and the full story is (as I suspected in this instance) commonly unknown or misunderstood.

To substitute, as Mr Baxandall does in his diagram, a battery for the varying magnetic field, is a good example of the logical fallacy of "begging the question", or assuming what you are setting out to establish. (It also contravenes the teaching principle that the obscure should not be explained in terms of the more obscure; what goes on in a battery is more complicated than an induced magnetic field and nothing is gained by substituting it.)

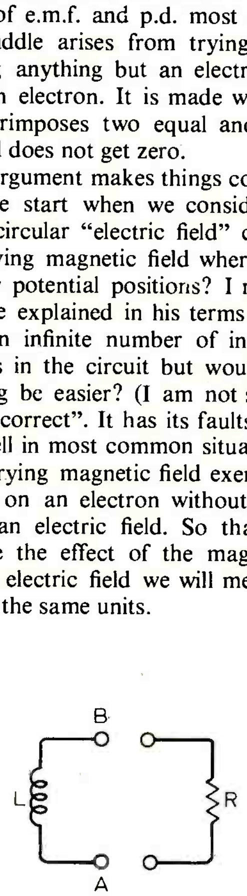
The electric field which we can deduce from a voltmeter reading is due to the electric charge, positive at B. The only way we can account for the absence of any electric field in the wire is by something we call an e.m.f., and if this is (as stated in the above quotation) also positive at B, then the potential at B must be doubly positive and the field in the wire doubly strong. I still believe I am justified in calling this nonsense. The induced (e.m.f.) field must be equal *and opposite* to the charge field observed by the voltmeter. "Less detailed" seems an understatement when applied to something that is upside down. I suggest that "an induced e.m.f. positive at B" is conventional shorthand for "an induced electric field × length causing a separation of charges (positive at B) which creates an electric field equal and opposite to its own". The important point is that however one regards an e.m.f. it is wrong to say (in this example) that it is positive at B. If the phrase is understood to mean that it leads to the accumulation of a charge that is positive at B, fair enough; but *does* everyone understand this?

Again, however, I must admit that describing an induced field as "positive at A" is rather a loose way of saying that its direction is the same as that of the field that would be produced by a positive charge at A, and I have already accepted Mr Baxandall's amendment on this.

Mr Scroggie's descriptions of basic electronics are usually most enlightening but in the August issue he seems to make the matter of e.m.f. and p.d. most confusing. The muddle arises from trying to avoid allowing anything but an electric field to move an electron. It is made worse when he superimposes two equal and opposite p.ds and does not get zero.

His argument makes things complicated from the start when we consider Fig. 3: in the circular "electric field" created by the varying magnetic field where are high and low potential positions? I realise this could be explained in his terms by postulating an infinite number of infinitesimal elements in the circuit but would not the following be easier? (I am not suggesting this is "correct". It has its faults but does quite well in most common situations.)

A varying magnetic field exerts a force directly on an electron without first producing an electric field. So that we can compare the effect of the magnetic field and the electric field we will measure this effect in the same units.



Suppose that in the circuit shown the magnetic field through L is varying so as to have the same effect on an electron as a p.d. of 10 volts positive at A relative to B. This does not itself produce any p.d. between A and B but because electrons will be forced towards A, A will become charged negative with respect to B. When the p.d. due to this charging is 10 volts then the resultant electric field will oppose the effect of the magnetic field and no more current will flow. Measurement of the potential across AB with an ideal voltmeter would show A 10 volts negative of B. If R is now connected across AB this p.d. will drive electrons through R from A to B and if they are not replaced the p.d. will drop. As the e.m.f. is not reduced there would then be a net force on the electrons and their rate of flow would increase until it is enough to maintain the p.d. of 10 volts across R. (No net force is needed on the electrons in L if L has no resistance.)

This argument can be extended easily to allow for resistance in L. Inductance and transformer action can be explained in these terms if the idea of varying currents producing magnetic fields opposing their change is introduced.

Incidentally, there are several otherwise good textbooks that start by pointing out the usual concept of an electric field as a single valued function of a single valued scalar called potential and then forget this when explaining the effect of a varying magnetic field on an electron.

F. C. Cole,
Sheffield,
Yorks.

Mr Scroggie replies:

Mr Cole's article is evidence of the truth of at least the first sentence in my article.

Having carefully studied his alternative explanation of my Fig. 1 (reproduced in his letter) I have come to the conclusion that it is the same as mine except for his inexplicable attempt to avoid what are generally accepted as physical facts by substituting for an induced electric field (which is known to exert a force on an electron) the hitherto unknown concept of something that has "the same effect on an electron as a p.d. of 10 volts". If this, and "the effect of the magnetic field" (in the next sentence) are replaced by "the magnetically induced electric field" then his explanation and mine (quoted from "Phasor Diagrams") are identical.

Does Mr Cole deny that a varying magnetic field creates an electric field? If so, how does he account for electromagnetic waves (to say nothing of the unanimous agreement against him on this point)? Does he deny that an electron in an electric field (whether due to charges or to a varying magnetic field) experiences a force proportional to the field strength? And if he does not deny these things, why does he substitute for them his own mysterious "effect"? If anything is muddling and confusing, surely that is. Why should he go out of his way to invent something other than an electric field to move an electron?

I wish he had referred me to where I superimposed two equal and opposite p.ds and did not get zero, as I cannot find it. I did say that in L (more precisely, the region subject to the varying magnetic field) there were two equal and opposite electric fields, one of them due to the equal and opposite electric charges at A and B, and the other magnetically induced. Outside L, where the latter is non-existent, there is only the charge field, and the p.d. due to this is the one read on Mr Cole's ideal voltmeter. But if his voltmeter had as part of it a coil wound close to L and making with it a 1:1 transformer, then it too would have equal and opposite fields and would read zero.

As to the accusation of making things complicated at the start with Fig. 3 (a uniform resistive ring around a varying magnetic field), nothing I said about this was contrary to either physical facts or generally accepted theory. Mr Cole, by apparently denying the creation of a circular electric field (which is the e.m.f.) in these circumstances would seem to be the one who is making things more complicated for himself and us. I hope he accepts that the total p.d. around any closed path is zero. If so, and the circuit is one in which the e.m.f. and the opposing *IR* drop both happen to be uniformly distributed around it, the absence of any net p.d. between any two points on the circuit is obvious, at least to anyone familiar with Kirchhoff's voltage law. Has Mr Cole a simpler explanation, preferably one that does not involve concepts peculiar to himself?

AMATEUR RADIO REPEATERS

I have just read the progress report by Mr Fitch on mobile amateur radio in the September issue. Mr Fitch suggests that there is only one British v.h.f. repeater station in operation on the 144MHz band, but he expects that there will be others in operation during the present decade. At present there are three UK repeaters operational and several others are expected to be in use within the next few months.

In addition to the GB3PI installation at Barkway (referred to by Mr Fitch), there is the London repeater GB3LO, now in operation from a site on Epsom Downs, and the Bristol Channel repeater GB3BC, located at an elevated site a few miles from Newport, South Wales.

The London repeater will shortly be moved to the Crystal Palace TV station, which will greatly increase the coverage provided, particularly towards the south and east of London, where there are a number of blind spots in the coverage from the Epsom Downs site.

The Home Office has recently licensed another repeater installation to be installed at an elevated site in Four Marks, Hampshire. It is expected that this repeater will provide good coverage into the south coast area from Worthing to Bournemouth and to the fringes of the coverage provided by the London and Bristol Channel installations.

Other repeaters are planned for East Anglia, Yorkshire, the Midlands and Scotland. A number of licence applications from local amateur groups for repeater stations in the 144 and 430MHz bands are known to be in preparation for submission to the Home Office, or are at present under consideration by the licence authority.

Mr Fitch is correct in stating that an access tone of 1750Hz has been standardized for European repeaters; however, the Barkway station GB3PI, which operates co-channel with Bristol, requires a tone burst of 1700Hz for access.

R. L. Glaisher (G6LX),
Croydon.

Signal-frequency meter

Digital indication of receiver input frequency

by G. Lomas

This instrument is a digital frequency meter arranged for a non-zero reset to enable the direct indication of the frequency to which a superhet receiver is tuned. The oscillator frequency is measured and i.f. offset is accommodated in the display.

After reading the article by C. Attenborough[1] the writer was inspired to construct a digital frequency meter to replace the dial on a poorly-calibrated receiver. This was a simplified version of the one described, and used the 50Hz mains as a frequency reference. This proved quite adequate for medium wave reception, for which this receiver is mainly used, and surprisingly useful at higher frequencies.

As this first unit was built integral with the receiver, a second version, to be described here, was made for more general use with other receivers. This uses the same basic design, but is self-contained, with its own power supplies, an optional crystal reference, and an amplifier to interface with the receiver. The unit as it stands gives a four-digit display of kHz, but can be readily extended to display from tens of Hz to 20MHz or more.

Operation

The functional diagram, Fig. 1, will be seen to be on fairly conventional lines. The input signal is taken from the receiver oscillator via the interface amplifier to the gate. The measurement cycle, repeated every 200ms, is controlled by a sequence of three pulses; reset, gate and store.

The reset pulse first sets the counter, not to zero, but to some value that will compensate for the i.f. offset of the oscillator. The pulse opens the gate and allows the oscillator signal to increment the counter for a period of 100ms. The store pulse transfers the value reached by the counter to the actual display, which then retains this value until the next store pulse.

The output from the gate is divided by 100 before reaching the counter, thus giving an effective gating period of 1ms, and a display in kHz. While this may at first sight seem a curious way of achieving a 1ms gating period, it does in fact offer considerable improvements in the short-term stability and clarity of the least significant digit—early experiments with an actual 1ms gate always gave a "fuzzy" display of this digit, and a marked ± 1 effect. While a longer gate time, with more division, would perhaps be even better, this value was chosen as the maximum possible without noticeable lag in response to the tuning control.

The value to which the reset pulse must force the counter is dependent upon the receiver i.f. value and oscillator arrangement. If the oscillator is below the signal frequency, the counter must obviously start at the i.f. value, in order to add this to the count. If the oscillator is above the signal, as is almost invariable, the i.f. value must be subtracted from the count. To do this the counter must start at the tens complement of the i.f. value, so that when the i.f. value has been counted, all the digits of the counter are zero.

The tens complement is 10^n – i.f. value, where n is the number of digits in the display, and the i.f. value is to the same scale as the display. For four digits, and an i.f. of 465kHz, this is 10000 – 465 = 9535. Similarly, for a five-digit display in kHz, the tens complement would be 99535, so that in all cases the resultant "1" after the addition of the i.f. value falls off the end of the display, as it were, and leaves it at zero.

Circuit design

It was found convenient to break the unit down into several sub-sections, which could be built and tested independently. These are the counter/display unit, the pulse generator unit, the interface amplifier, the crystal reference, and the power supplies.

Counter/display. This is a four-decade latched counter driving neon display tubes, and uses the usual 7490 counters, 7475 stores, and 74141 decoder/drivers. These

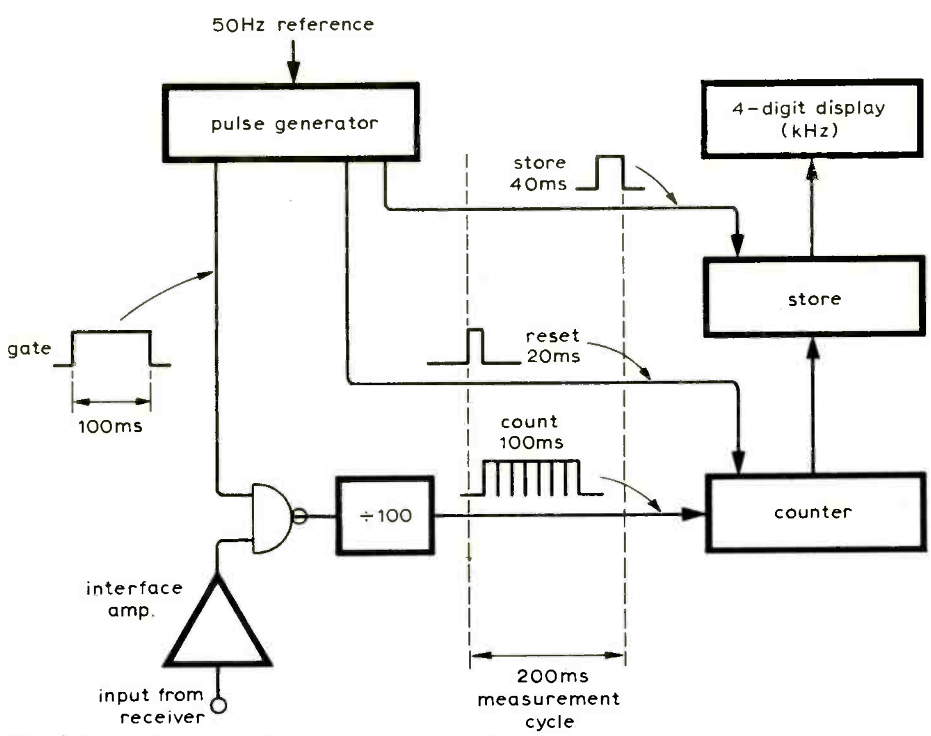


Fig. 1. Basic diagram of frequency meter operation.

are, however, used in a slightly unusual manner, in order to be able to reset the display to any required value. This involves only the addition of two of the cheapest i.cs; a 7410 gate package, and a 7404 hex inverter. The method of resetting is explained as follows.

A single-decade counter-display is shown in Fig. 2(a). This is connected as normal except that the wiring from the 74141 decoder to the tube is "rotated", as shown, five places. If the counter is reset to zero, the tube will indicate the digit "5". The counting action is not affected by this, only the number at which counting starts after the reset pulse. The outputs of the 7490 will not now be the b.c.d. equivalent of the displayed digit, but will be as in the table.

In order to "carry" to the next decade, a negative-going edge is required, coincident with the display changing from "9" to "0", which, with normal wiring, is provided by the D output of the 7490. In this case, it will be seen from the table that the carry pulse is required when the counter goes from 0100 to 0101. This pulse could be produced by the gating circuit of Fig. 2(b), which produces the carry by detecting the simultaneous presence of output C, and the absence or "not" of outputs A and B. In Boolean terms this is Carry = $\bar{A}.\bar{B}.C$, and because the 7490 has only true outputs, each "not" requires an inverter. A further inversion is required from the output of the gate, as this is a NAND gate, and not a true AND gate.

If the counter had been reset to 9, instead of 0, and the wiring rotated only four places, decoder 9 to display tube 5, and so on, the display at reset would be as before. The carry output would now be required as the counter moved from 0011 to 0100 (b.c.d. 3 to 4). The carry circuit then becomes as Fig. 2(c) which uses one less inversion than 2(b). The optimum reset, 9 or 0, for the display of a given digit by this method is given in Table 1. From this it will be seen that all but the two digits 7 and 8 can have the carry generated by the circuit of 2(c), covering virtually all practical values of i.f.

The full circuit of the counter/display unit is given in Fig. 3, and is shown arranged for an i.f. of 465kHz with the oscillator above the signal. The reset value of the display is therefore 9535, and the carries are generated as explained, using the 7410 and the 7404. The addition of the 7475 stores does not affect the reset system.

The unit is assembled on a printed-circuit board, which has the ABCD and input A connexions of each 7490 brought out to terminal points, together with the carry-circuit connexions marked ABC XYZ. These are joined with wire links in order to implement the gate connexion required for the reset value chosen. With this arrangement, any circuits not used for a particular carry are available to another. For example, if the i.f. value was the once common one of 110kHz, and the tens-complement required at reset, this would be 9890. Three of these digits could be the normal reset to 9 or 0, and the units and tens carry taken from output D. The hundreds decade, from Table 1, would be reset to 0. The carry to the thousands decade would be 1.$\bar{2}.\bar{4}.\bar{8}$, and could be achieved as in Fig. 3(b).

The board is arranged to take side-viewing wire-ended tubes directly, but the terminations can be wired to sockets for the larger tubes. The anode resistor for the tubes will depend on the types used, and a current of $1\frac{1}{2}$mA per tube is adequate for this kind of display.

Table 1

Display value at reset		*Reset counter to*	*Carry at counter*	*Carry logic*
0		0	9–0	D
1		9	7–8	A.B.C.
2		0	7–8	A.B.C
3		0	6–7	$\bar{A}$.B.C.
	or	9	5–4	A.$\bar{B}$.C (used)
4		0	5–4	A.$\bar{B}$.C
5		9	3–4	A.B.$\bar{C}$
6		0	3–4	A.B.$\bar{C}$
7		0	2–3	$\bar{A}$.B.$\bar{C}$
8		0	1–2	A.$\bar{B}$.$\bar{C}$.$\bar{D}$
9		0	9–0	D

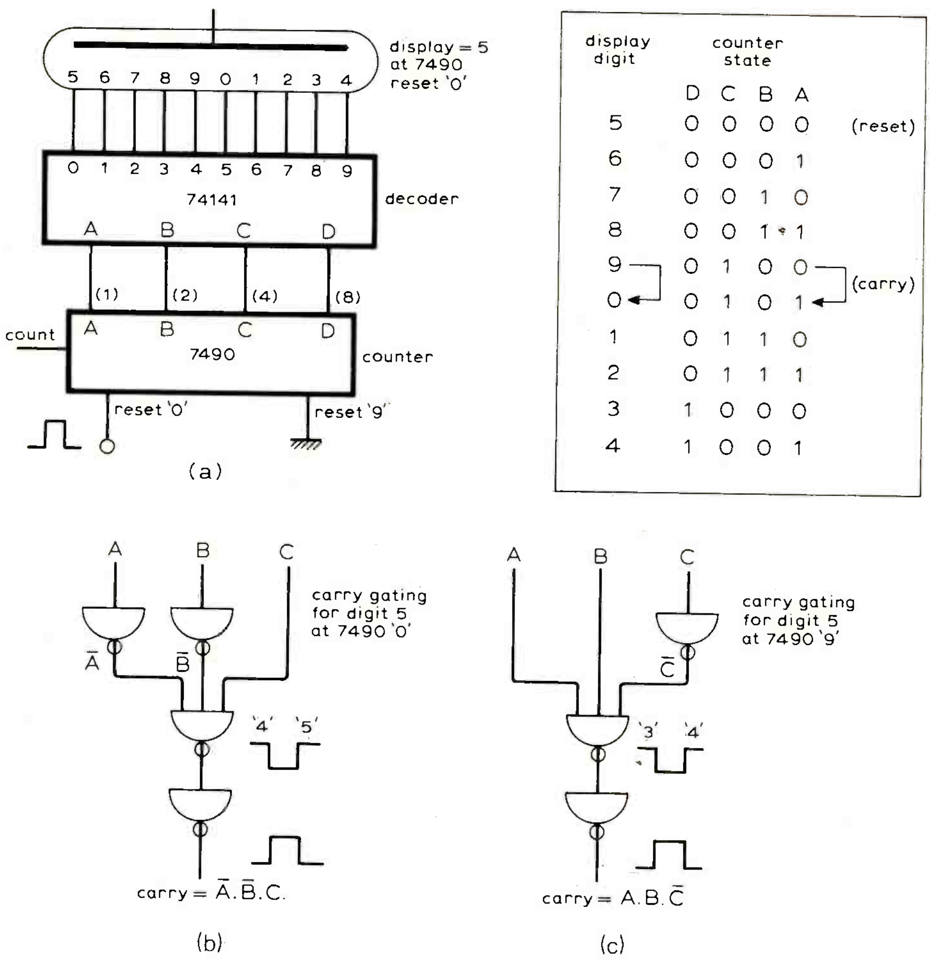


Fig. 2(a). A typical counter, decoder and display, showing the "crossed" connexions between decoder and display. "Carry" to the next decade is enabled by the circuits of (b) and (c) for resets to "0" or "9".

Pulse generator. This produces the sequence of the three timing pulses required by the counter/display unit, and also contains the signal gate and the divide-by-100. I.cs used are three 7490, one 7404, and one 7413 quad Schmitt gate, and the circuit arrangement is shown in Fig. 4. The 50-Hz input, limited then roughly squared by G_1, drives a 7490 connected in the square-wave output mode. The 200ms square wave at output A is used to open gate G_2 to the r.f. input for alternate 100ms periods. The C and D outputs are suitable for use as the store and reset pulses respectively, but are required only during the negative half of output A. These are extracted by gates G_3 and G_4 when these are opened by output A inverted by I_1. The store and reset pulses are now negative-going, and require a further inversion to get the correct polarity. A single inverter I_2 is sufficient for the reset, but the store output must be able to sink a worst case 50mA at logic zero with four 7475 stores. This is catered for by the three inverters $I_{3,4,5}$ in parallel. I_6 is spare, but may be used if more decades are added to the display.

The output from the gate G_2 is divided by the two remaining 7490s, which are also zeroed by the reset pulse to give a defined start to the count.

The 50Hz input is intended for a nominal 6.3V but will work at half this value. If the crystal reference is used, the gate G_1 is not really required, and the output can be taken direct to the 7490. In this case the 7414 could be replaced with the slightly cheaper 7410.

The prototype was constructed on a small piece of Veroboard, and the only layout point to note is that the signal input lead to gate G_2, and the G_2 output lead must both be kept short, and not inadvertently connected to a long length of copper track.

Interface amplifier. This uses a single 72710 comparator in a regenerative mode, as shown in Fig. 5. The input impedance is about 10kΩ at a sensitivity of 50mV. The worst case frequency response is some 12MHz, but all those tried have worked well at 20MHz. The amplifier is assembled

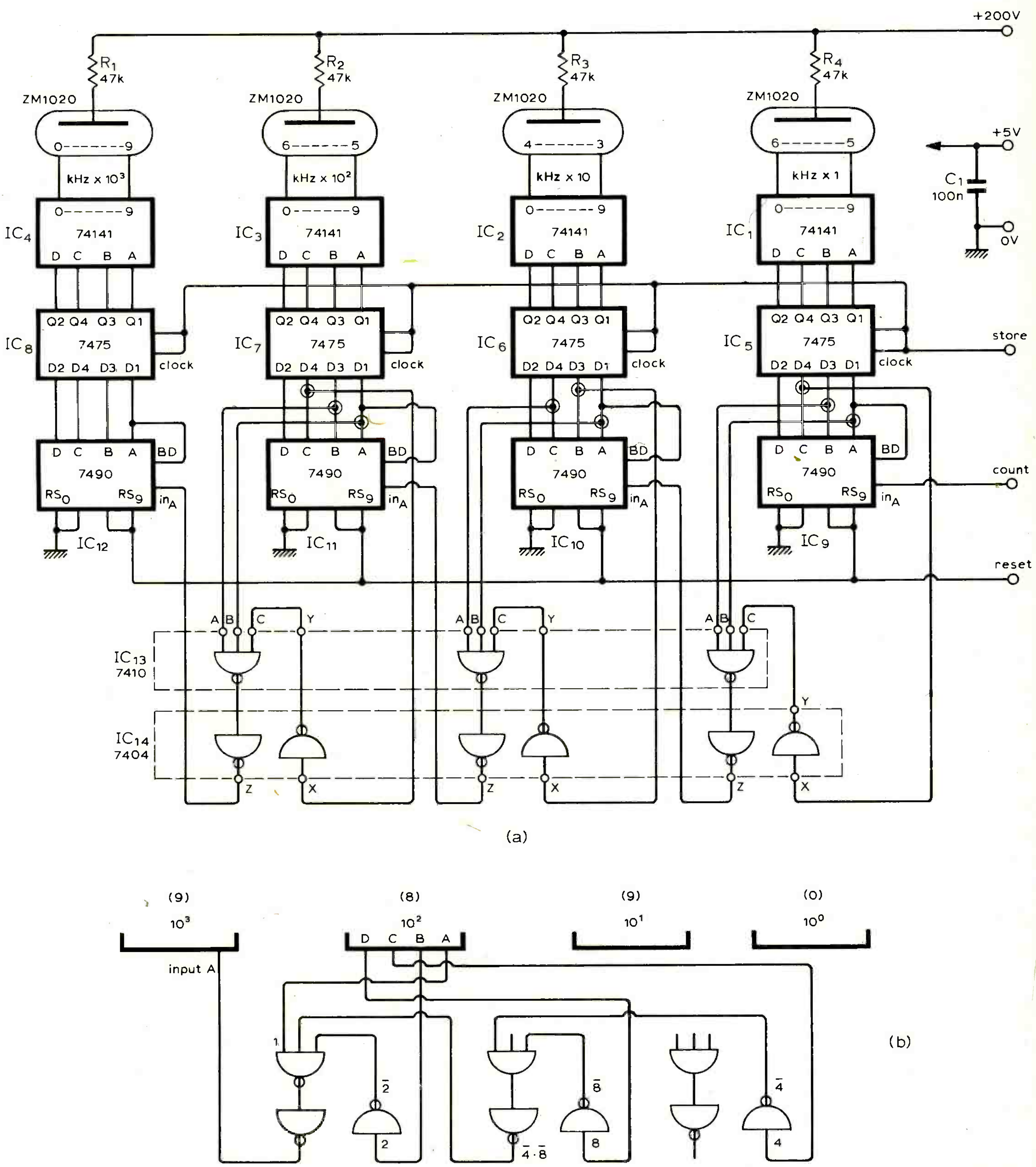


Fig. 3(a). Counter display arranged for reset to 9535. If carry circuits and counter connexions are taken to accessible pins at the edge of the circuit board, it is easy to arrange alternative i.f. offsets. A gating arrangement for an i.f. of 110kHz is shown in (b).

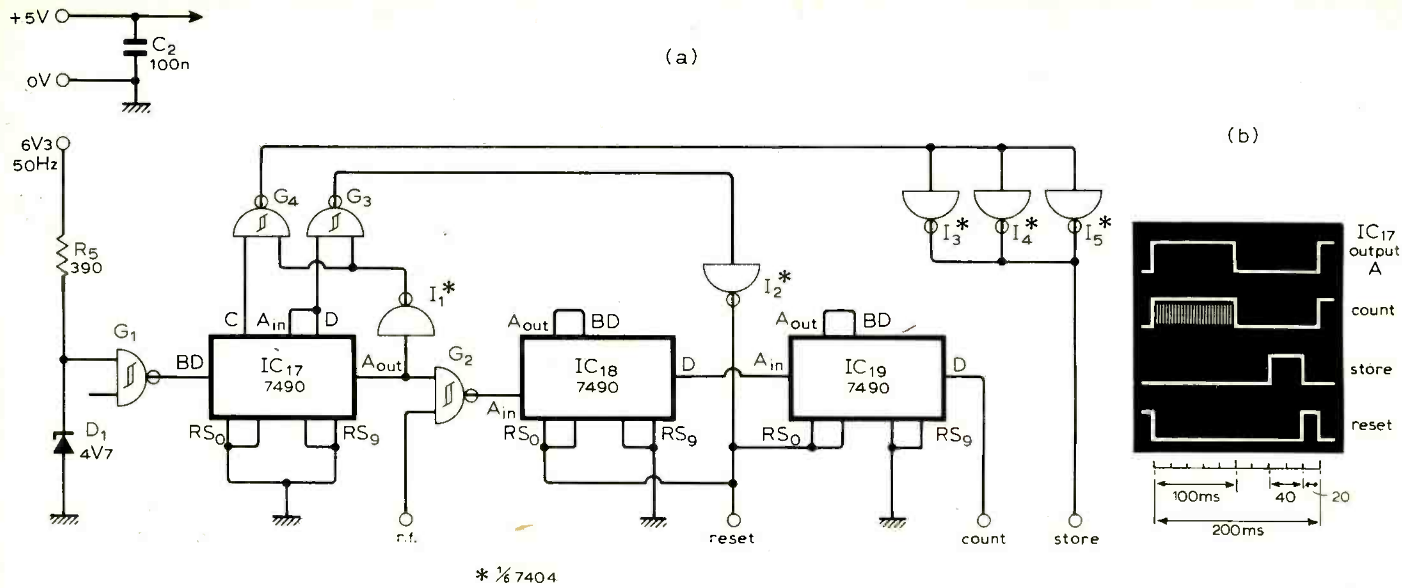


Fig. 4(a). Pulse generator circuit. The four Schmitt gates were 7414 in the prototype, but as they are rather difficult to obtain it is suggested that 7413 + 7440 be used in its place (7413 in G_1 and G_2 positions). A timing diagram for the unit is shown at (b).

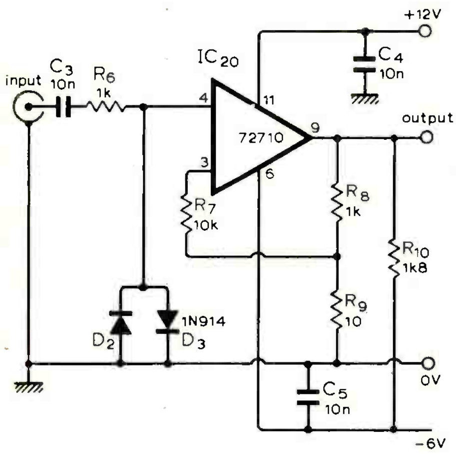


Fig. 5. Circuit diagram of the interface amplifier.

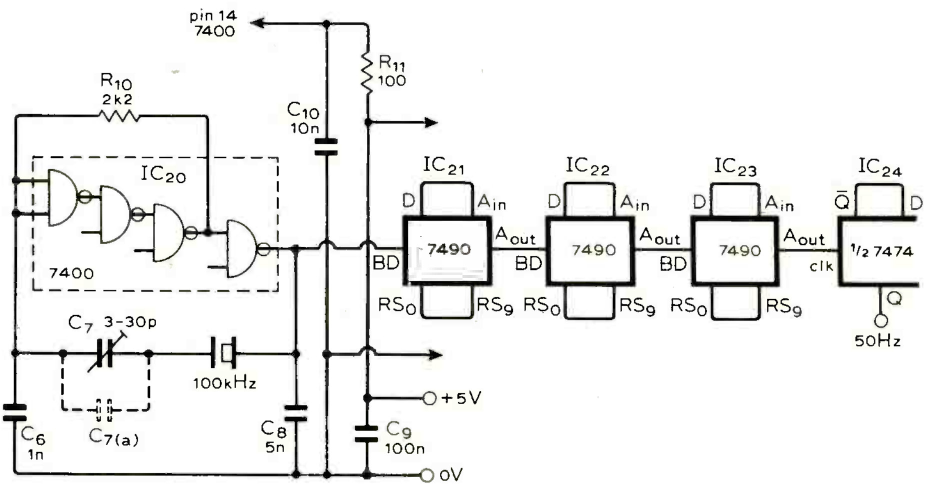


Fig. 6. Crystal reference oscillator circuit. The value of $C_{7(a)}$ will depend on the crystal used.

Table 2	
I.C.	*Typical supply current at 5V (mA) with all other connexions open.*
7400	12
7404	18
7410	9
7414	24
7474	17
7475	32
7490	32
74141	21

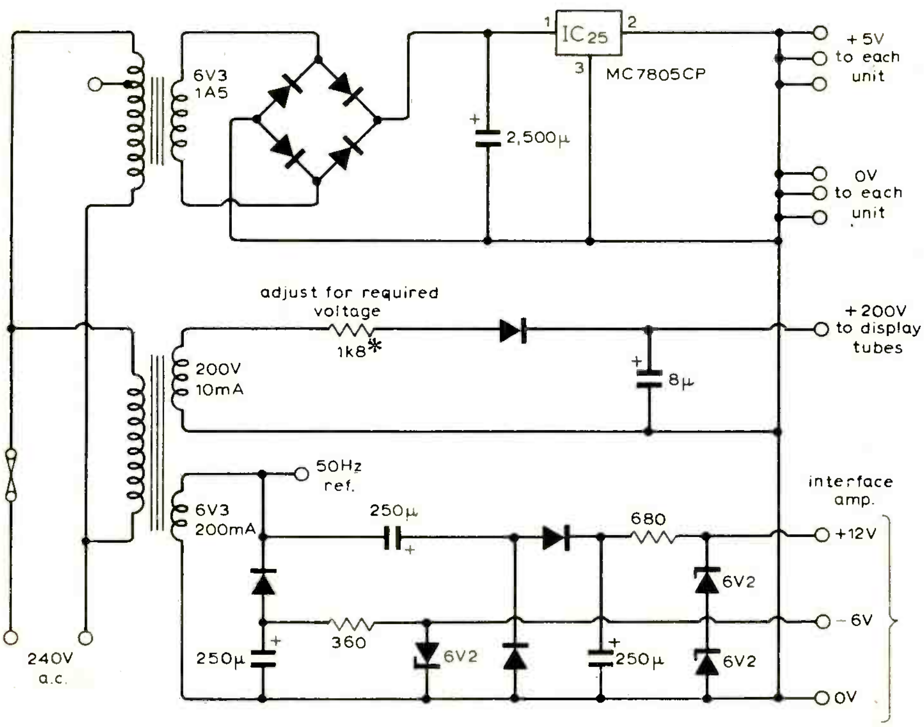


Fig. 7. Power supply.

on a small printed board, and should be reasonably well screened.

Crystal reference. The circuit used for the actual oscillator is rather unusual, but is compact, and works well with a high-Q bar. The output waveform has a sharp (<10ns) trailing edge, ideal for driving a 7490. As shown in Fig. 6, all four sections of a 7400 quad gate are connected in series, and held in a quasi-linear state by d.c. feedback around the first three sections. Positive feedback from the output via the crystal defines the frequency, and the capacitor at the output damps out any tendency to ring at the crystal overtones. The 100-ohm resistor in the 5V line ensures starting. The 100kHz output is divided by 1000 in the three 7490s, and then to 50Hz by a half section of a 7474 dual D-type flip-flop. This unit was also made up on Veroboard, and the 7490s are used in the "square-output" mode only because this makes the interconnexions on the board slightly easier. Calibration is by beating the 100kHz output with the BBC 200kHz, although for displays up to four digits this is hardly necessary.

Power supplies. The actual circuit used is shown in Fig. 7, but this can obviously be altered to suit individual circumstances. The 5V current for all the units as described is around 500mA, but could be more with some batches of i.cs. If this is derived from 6.3V the supply should be capable of at least twice this without much voltage drop, or the ripple will be excessive. If the current drain is increased by the addition of extra decades, the MC7805CP regulator will need a higher input voltage, up to say 7.5V to operate correctly.

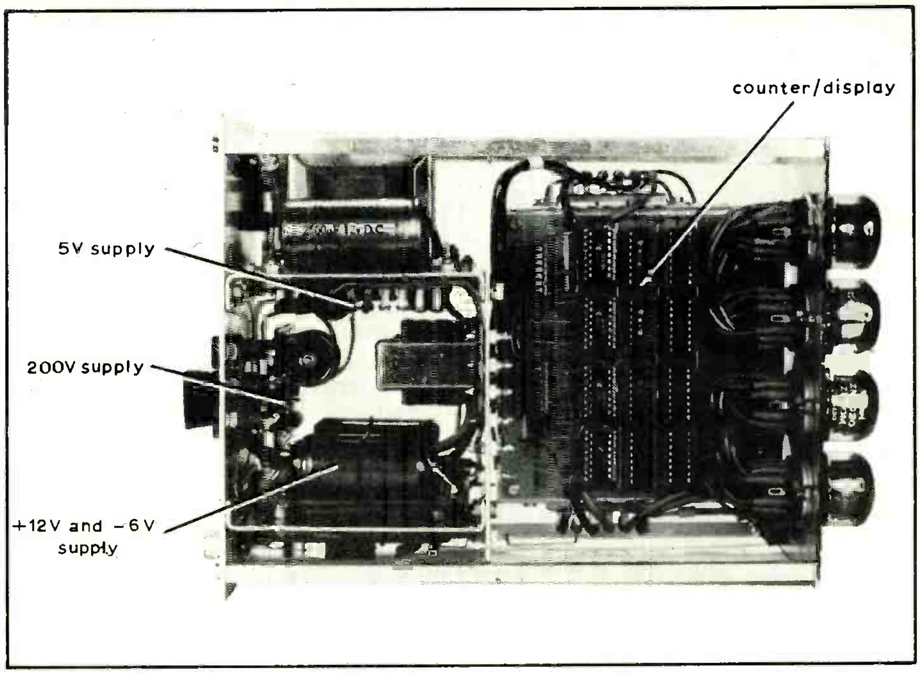
Each 5V supply should be taken separately to each unit, from as close as possible to the output capacitor. This is preferably a paper type, with a low r.f. impedance. The interface amplifier requires 6mA in each line, and the 200V supply must supply around $1\frac{1}{2}$mA per tube.

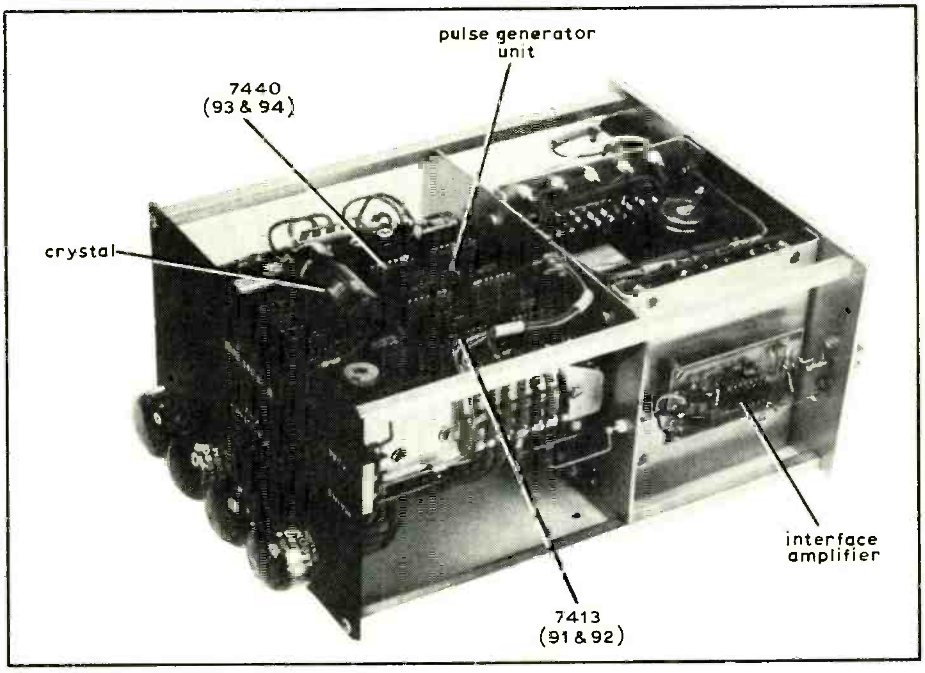
Construction

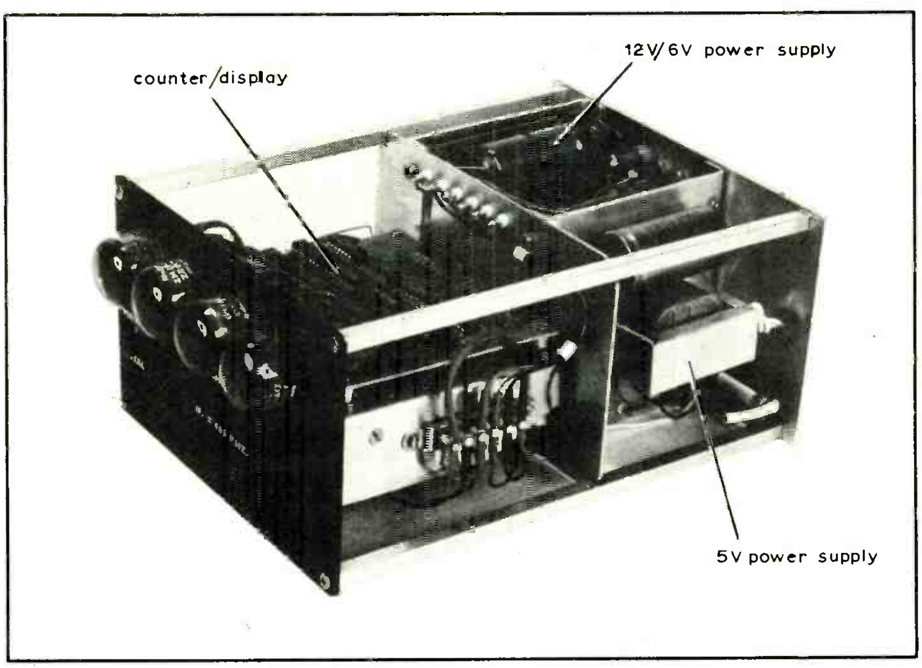
This is reasonably straightforward but should be tackled in an orderly manner. The power supplies should be completed first, so that these are available for testing the other units. Unless sockets are used, once the i.cs have been soldered in, they are extremely difficult to remove without special equipment. Whilst the probability of a faulty package is very low, it can happen, and a simple tester is well worth while. This need be little more than an i.c. socket on a small board, with the output pins brought out to some form of terminal.

A simple test of supply current should be first, with devices taking more than twice the typical value being suspect (see Table 2). Logic testing can be done on gates, inverters, and stores with a voltmeter on the outputs and the inputs taken to 0V, or 5V via a 3.3kΩ resistor. Counters can be driven from a 50Hz supply, similar to Fig. 4, and the 5Hz output checked with 'phones or a lamp and driver. Decoder drivers are not easily checked except by wiring up a single decade and tube.

When the i.cs or sockets are soldered in place, it is a good plan to test after each one







that the supply rails have not been shorted by a blob of solder.

Sub-assembly testing

Pulse generator. The first test should be supply current, which should be of the order of 90–130mA. For testing the pulse outputs, a double beam oscilloscope is ideal, but the 5Hz output is just discernible as a slight dither on a voltmeter around a mean value of 1V or less. Or it can of course be checked audibly with 'phones. These can also be used to test the count output if a signal of few hundred hertz is fed to the r.f. terminal. For all these tests, of course, the 50Hz reference must be present at the input of G_1. If all the outputs seem present, the unit is probably correct, and further tests can be made in conjunction with the counter/display unit.

Counter/display. Supply current should be typically 300–350mA from the 5V line and 5–7mA from the 200V supply. With the store input taken to 0V and the reset input left open, the display should be at the chosen reset value. With the reset input also at 0V and the count input taken to the pulse generator store or reset outputs, the display should count up at 5Hz when the store input is removed from 0V and freeze when this is replaced.

With the slow count, the first two decades should be checked to see that the count is in the correct decimal sequence, and that carry to the next decade is at the 9 to 0 transition. The third and fourth decades are treated the same, but with say 50–100Hz at the count input. This can be taken from the output of gate G_1 on the pulse generator if an oscillator is not available. If all seems well, the two units and the power supplies can be joined up and a working frequency meter is now available. It is, of course, quite useful as a straightforward frequency meter, and for occasional use in this role there is no great inconvenience in allowing for the non-zero start to the count.

Interface amplifier. Supply current should be close to 6mA for both positive and negative lines. The sensitivity at low frequencies can be checked at 50Hz via a pot-down network with C_3 temporarily shorted out, and the output taken to the r.f. input of gate G_2. The output of this gate can be checked with 'phones, and the minimum input determined. This should be around 50mV. The high frequency performance up to at least 10MHz will not differ greatly from this.

Crystal reference. The supply current should be 80–120mA and the 100kHz and 10kHz outputs can be tested on the counter, allowing for the i.f. offset. The subsequent outputs can be checked via 'phones, or even the receiver a.f. stage, and if present are fairly certain to be correct.

Connexions to the receiver

The ideal take-off point is one of low impedance where additional capacitance will not unduly affect the frequency. If it can be arranged, connexion to the high potential end of the oscillator padding capacitor is the simplest, and additional capacity may be adjusted out. If the receiver band switching makes this difficult, and the oscillator is a valve or an f.e.t. then the grid or gate resistor can be tapped some 10–20% from the earthy end. Failing this, a small pick-up coil may be wound over or placed inside the oscillator coil.

The interface amplifier is small enough ($2\frac{1}{2}$ in $\times$ $1\frac{1}{2}$ in) to be mounted in most receivers if desired, but should be well screened if this is done. Connexion to the frequency meter should be via coaxial cable and sockets.

Setting up the system

There are no adjustments to be made on the frequency meter itself, except to the crystal trimmer (if fitted) and this is more or less academic with a four digit display.

If the i.f. stages are not tuned to exactly the value used in the design of the meter, then the error will show up as a constant displacement of the same amount and sense as the error. If two known transmissions are received, the difference between the indicated frequencies will be the same as that between the correct values, but both will be low or high according to the error in the i.f. stages.

If, however, the two known transmissions have an indicated difference which is not the true value, then the percentage error is equal to the error in the 50Hz reference, but opposite in sense. This can be used as a cross check on the mains frequency. In all these measurements, due allowance must be made for the ± 1 "digital" error in each indication, which is inherent in any system where the signal is not phase locked to the reference.

Interference

With a completely self-contained unit, without a crystal reference, no particular problems were encountered. If the crystal is used, then this obviously produces strong signals throughout the r.f. spectrum, and must be well screened from both the receiver and the aerial.

If the power supplies are taken from the receiver, then rather more care must be taken, as all digital circuitry is a potential generator of interference. The worst offenders in this respect are the 74141 decoder drivers, and if the 200V supply is from the receiver, then inadequate filtering can be disastrous. In any case, the wiring of the frequency meter should be arranged so that no supply currents to any of the sub-units can flow through the metalwork.

Extension of the display

While frequencies greater than 10MHz can be measured with the four digit display, if one mentally puts a "1" in front, an additional stage may be easily added at the most significant end. This can be the same as the existing stage, and if the i.f. is less than 1MHz, can take its carry from the D output. There are only two i.cs in the system working at the full signal frequency, apart from the interface amplifier, G_2 and the following 7490 in the pulse generator unit. Most 7490s will operate at 20MHz, and most gates will do better. If even greater frequencies than this are required, then the replacement of this 7490 by a 74196 should take the limit to the region of 30MHz, but some selection may be needed for G_2.

For the display of less significant digits, signals at tens and hundreds of hertz can be taken from i.cs 18 and 19 respectively in the pulse generator unit. These stages will each require a 7475 and 74141 wired to a display tube in a normal manner. Note that the crystal reference is essential to display these lower digits satisfactorily.

For any extensions, the 7475 store line will need extra current sinking capacity; the spare inverter I6 may add sufficient, or an extra package may be necessary. If an extra 7404 is used, the required number of sections should drive a separate store line to the extra 7475s, and spare inputs taken to 0V. It may also be necessary to increase the input voltage to the 5V regulator to 7V or so.

Mains reference

As the use of this is often dismissed out of hand, the results of actual measurements may be of interest. These were made against an accurate 100kHz standard, phase locked to the BBC 200kHz, and taken at times from 8 a.m. to 12 p.m.

The general pattern was a slow cyclic variation over the range $\pm 0.1\%$, with a period of 10 to 15 minutes, and sometimes longer. Quite often the error did not exceed 0.05% for 10 minutes or more. No particular deviation was noted in the accepted "peak" periods. The greatest deviation measured was $+0.5\%$. and this occurred regularly each evening about 8.50 to 9.05. This is possibly designed to put clocks right before the BBC TV news, or possibly a result of a massive switch off by those who don't watch the news.

The practical results confirmed these measurements, and outside this short bad period, medium wave transmissions have never been indicated at more than ± 2kHz. from the true value, and still audible at the true indication. At the top end, the standard transmission on 10MHz has been within ± 3kHz for minutes on end, and never seen to be more than ± 15kHz in error.

It may be that the writer's area (North Cheshire) is specially favoured, but if the above results are all that is required, then the mains reference is certainly worth a try before going to the cost of the crystal unit.

Reference

"Displaying frequency digitally" by C. Attenborough. *Wireless World*, Dec. 1971, p.597.

Acknowledgment

The author gratefully acknowledges the assistance of J. L. White, of Northern Electronic Designs, during the design and manufacture of printed-circuit boards for the instrument. N.E.D., whose address is 174 Crossbank Street, Oldham, Lancs., is able to supply boards for this instrument.

Weather satellites ground station

Reception of cloud cover pictures transmitted in the 136MHz band

by G. R. Kennedy

This article describes a complete station for the reception of weather satellite cloud cover pictures. Its circuitry is straightforward, with the emphasis placed on economy and reliability. Assuming that a basic electronic workshop and a good quality oscilloscope are available the article is particularly aimed at meteorological, survey, school and university groups who might wish to build equipment in order to operate a compact weather satellite ground station in the field as well as in the laboratory.

The first of a series of weather satellites was launched by the Americans in December 1963. Since then over 20 satellites equipped with Automatic Picture Transmission (APT) have been launched by both the USA and USSR. At the time of writing six or seven weather satellites are transmitting weather pictures in the visible and infra-red portions of the spectrum. Of these, five transmit pictures in the 136MHz band. These v.h.f. transmissions are of one of two types: APT, which gives a TV type picture of a snap-shot picture taken by the satellite, and Scanning Radiometer (SR) pictures which are continuous scans received in real-time of a rotating camera mirror which sees the earth as the satellite progresses during a pass. APT pictures are usually only in the visible portion of the spectrum, whereas SR pictures may be infra-red (IR), visible, or both, sent in a side-by-side format.

The available weather satellites may be divided into polar orbiting vehicles which send either APT or SR pictures, and geostationary vehicles which send either APT or specially processed APT and SR. Currently, the polar orbiters sending v.h.f. APT are ESSA-8, NOAA-2 (ITOS-D) and NOAA-3, launched by the USA. Some Russian Meteor satellites transmit in the v.h.f. band and use a slightly different, though generally similar system of picture telemetry to the American satellites. The two geo-stationary satellites are ATS-3 over the Amazon, and ATS-1 over the Pacific Ocean. For more details of weather satellites, the reader is referred to refs. 1, 2 and 3.

Satellite APT telemetry

All American v.h.f. weather picture transmissions comprise amplitude modulated picture information on a 2.4kHz sub-carrier, which in turn frequency modulates the v.h.f. carrier. The received f.m. demodulated sub-carrier is essentially free from ignition and similar interference and from the effect of fading due to satellite tumbling and horizon refraction effects at low ground elevation. Some Russian APT satellites use a different and apparently variable sub-carrier frequency and may transmit in both v.h.f. and short-wave bands. The demodulated 2.4kHz is the video signal required for the replay electronics of the ground station. The pictures of the more recent APT satellites is of 800 lines. It is transmitted automatically for 200 seconds, preceded by an eight-second start and phasing signal. There is then a pause for two or three minutes whilst the satellite orientates itself for the next picture. During this time a steady peak-white signal is transmitted. The cycle then repeats, a three-second 300Hz burst of the 2.4kHz sub-carrier followed by five seconds of peak white lines at the 4Hz line scan rate, with 12.5ms black zero carrier phasing pulses. The picture follows, each line being made up of a 12.5ms white edge pulse followed by the picture modulation varying between black and white. The picture telemetry waveforms are shown in Fig. 1. There are various positioning marks called fiduciary marks, and the letters USA on the picture, and these appear as black pulses on the APT telemetry. APT pictures suffer from

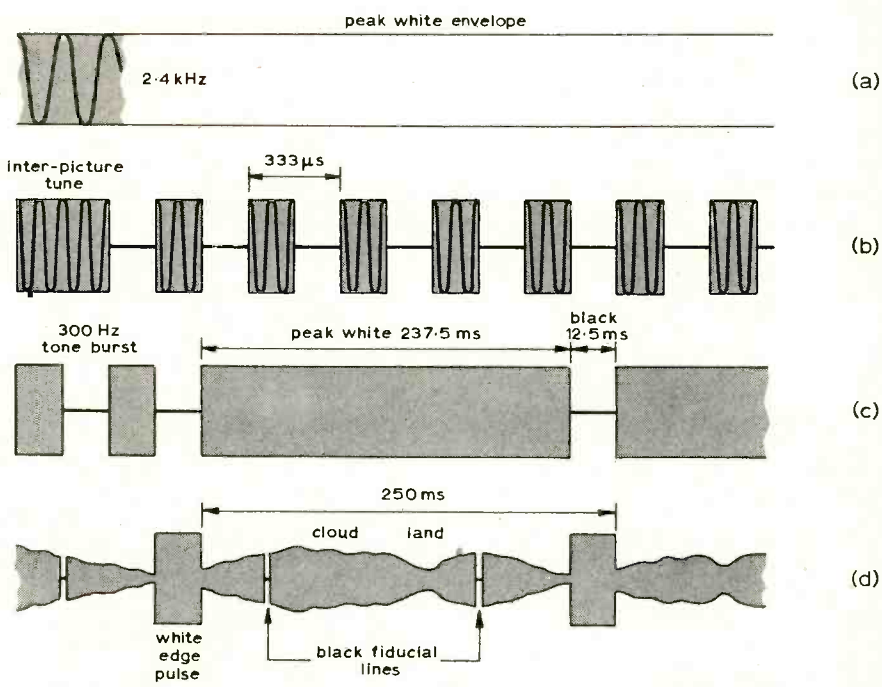


Fig. 1. ESSA-8 telemetry waveform sequence (APT), (a) peak white inter-picture tone, (b) three-second 300Hz tone burst, (c) five-second white/black phasing signal, (d) typical picture line.

"pin-cushion" distortion at the corners due to the camera viewing a spherical surface but presenting it as a flat surface. The aspect ratio of the picture is 1:1.

Satellite SR telemetry

The scanning radiometer telemetry runs continuously, so that as long as the satellite is in view, the SR signal can be received. Taking NOAA-2 (ITOS-D) as an example, the sub-carrier is 2.4kHz as for the APT satellites. The line-scan rate is 48 per minute, i.e., one scan per 1.25 seconds, one-fifth of the APT line scan rate. The pictures are sent side-by-side, infra-red first followed by the visible. The SR line scan is shown in Fig. 2. There are two windows in each telemetry line: one preceding the IR position which gives voltage calibration steps and one preceding the visible position which carries data depending on the line used. The repetition of similar lines occurs every 25 lines. The polarity of the IR transmission is such that a signal equivalent to a peak white signal in the visible portion is cold, and a dark signal is hot. In practice, the dynamic range of the IR picture is far less than that of the visible picture, and unless elaborate steps are taken, the two pictures cannot be read out in real time side by side: either one or the other is displayed. Due to the rotation of the camera view in SR satellites, the resultant pictures have "milk-bottle" distortion, that is, the pictures have the appearance of photographs of a flat surface curved round a cylinder ("bottle") and viewed close-to. Commercially some facsimile receiver manufacturers use circuitry to stretch the edges of the pictures to give an approximate Mercator Projection view. The "Index of Co-operation" = (width of scan in inches × lines per inch)/π is the facsimile equivalent of aspect ratio. The Index of Co-operation for the square ESSA-8 pictures is 255 (267 including start and phasing lines), and 135 for the picture portions of the NOAA-2 transmissions, not including phasing bars, etc.

Ground station

The block diagram of a weather satellite ground station is given in Fig. 3. The tape recorder stores the satellite demodulated sub-carrier signal for later use by the display system, or the picture may be printed in real time during a satellite pass.

The overall sensitivity of the system may be estimated as follows:

Satellite transmitter output	+ 37dBm
Loss B in TX antenna and feed	− 10dBm
Polarization loss	− 3dBm
Path loss at 5° elevation	− 147dBm
Signal level at ground	− 123dBm

Assume that a typical 50 ohm input f.m. receiver at 137MHz quietens fully at 1μV input. Input power is 2×10^{-11} mW $= -107$dBm. Hence 16dB of gain is required before the receiver. A typical eight-turn helix or 16-element crossed Yagi antenna would have a gain of about 12dB. A suitable low noise pre-amp should have a gain in excess of 10dB, which would allow for other losses not taken into account.

The antenna

Weather satellites vary in the type of transmitted signal polarization. ESSA-8 transmits a right-hand circular signal, and NOAA-2 a linear polarized signal, for example. Since a linearly polarized antenna will lose 3dB of a circularly polarized signal compared with a circularly polarized antenna, the best compromise is a satellite ground station antenna designed for right-

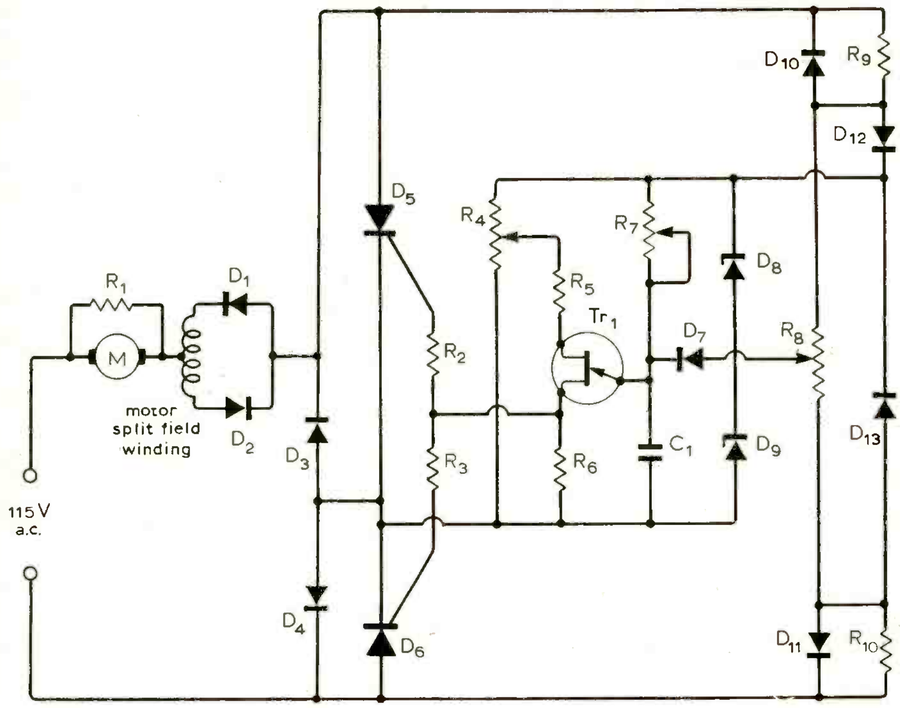


Fig. 6. Antenna motor drive.

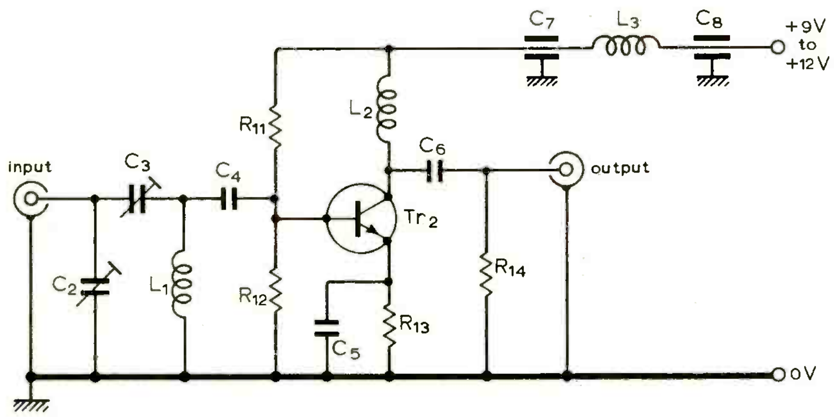


Fig. 7. Pre-amplifier circuit.

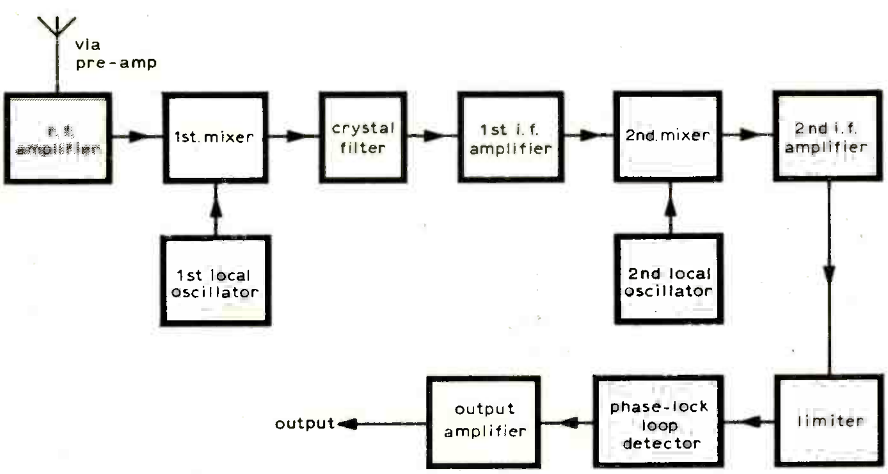


Fig. 8. Block diagram of the receiver.

hand circular polarization. There are two possibilities for a practical antenna, a helix or a crossed Yagi array.

Helical antenna. The design parameters for a helix antenna fed against a ground plane are, wavelength, λ, pitch, p, diameter, d and turn length, t. For a small copper conductor the relationship is $p=0.25\lambda$ $d=0.375\lambda$, $t=1.18\lambda$. For 137.5MHz this gives $p=21.5$ inches, $d=32.2$ inches and $t=101.4$ inches. For an eight turn helix, 67.6 feet of copper conductor are required. The gain would be 13dB, the beam width 30° or so between half power points, and the feed impedance 150Ω. Matching can be carried out using a quarter-wave coaxial transformer. For example, a reasonable match to 50Ω coax is given by a $\lambda/4$, $1\frac{1}{4}$in diameter aluminium tube surrounding a $\lambda/4$ section of $\frac{1}{4}$in helix conductor (Fig. 4). Suitable material for the helix are copper-sheathed mains cable ("Pyro"), old car hydraulic copper tube or the braid section of $\frac{1}{4}$in diameter coax cable. The winding sense is such that, if viewed from the satellite, a particle travelling down the wire of the helix appears to rotate clockwise, or in other words, as though one is screwing down the top of a conventional right-hand threaded jar.

Crossed Yagi array. There are three methods of arranging a crossed Yagi antenna for circular polarization: Fig. 5 (a) feeding two separated Yagis on a cross boom in phase, each Yagi at right-angles axially to the other; (b) feeding two co-axial crossed Yagis on the same axial boom $\lambda/2$ out of phase; (c) feeding two co-axial crossed Yagis on the same axial boom in phase, but setting one Yagi $\lambda/4$ up the boom from the other.

Method (a) is somewhat cumbersome, but has the advantage of being convenient for mounting so that the antenna can track from horizon to horizon through zenith for an overhead pass. Method (b) is mechanically more awkward than method (c), which is widely used in commercially available antennas, such as the J Beam 2/10XY. For a given feed, the antenna receives left-hand circular polarization in one direction along the axis, and right-hand circular along the other. Polarization can be changed by reversing the polarity of the feed to one dipole. Conventional design formulas apply to these three types of Yagi arrangements[4]. A double ten-element Yagi array of the above type will give a gain of about 15dB and a beam width of 33° for half power points.

Antenna drive

The simplest method of driving the antenna is to mount it on an azimuth-elevation mount and to move it by hand. For powered drive, the mount may be driven by two d.c. motors. Drive electronics are required to stop, start, reverse and speed control the motors. A suitable circuit is shown in Fig. 6.

The circuit is basically a bridge drive for a 1/10 h.p. series-wound split-field d.c. motor—in the example shown, for a 110V d.c. motor. Diodes D_5 to D_{12} are a series diode bridge which supply the positive and negative rails for the unijunction circuit. For whichever polarity of the 115V a.c. supply, the diodes supply the unijunction circuit rails with the same polarity. Zener diodes D_8 and D_9 in series stabilise these rails at 16.8V. The unijunction transistor Tr_1, circuit is a relaxation pulse generator, the p.r.f. being determined by C_1 and R_7 time constant, and by the current through R_5 or R_7 and R_8. Potentiometer R_4 sets the sensitivity and hence "dead band" of the control pot, R_8. Due to the forward bias shorting action of D_{12}, D_{11}, D_4 or D_{10}, D_{13}, D_4, pot R_8 is across the 16.8 volt unijunction rail. When the wiper of R_8 is in mid-position, the potential on the wiper rises with the 115V half cycle. If C_1 is discharged, D_7 is forward biased and the potential on Tr_1 emitter rises to approximately the maximum value of eight volts. Potentiometer R_4 is so adjusted that the peak point of Tr_1 is above this value. Current flows through R_7 to charge C_1

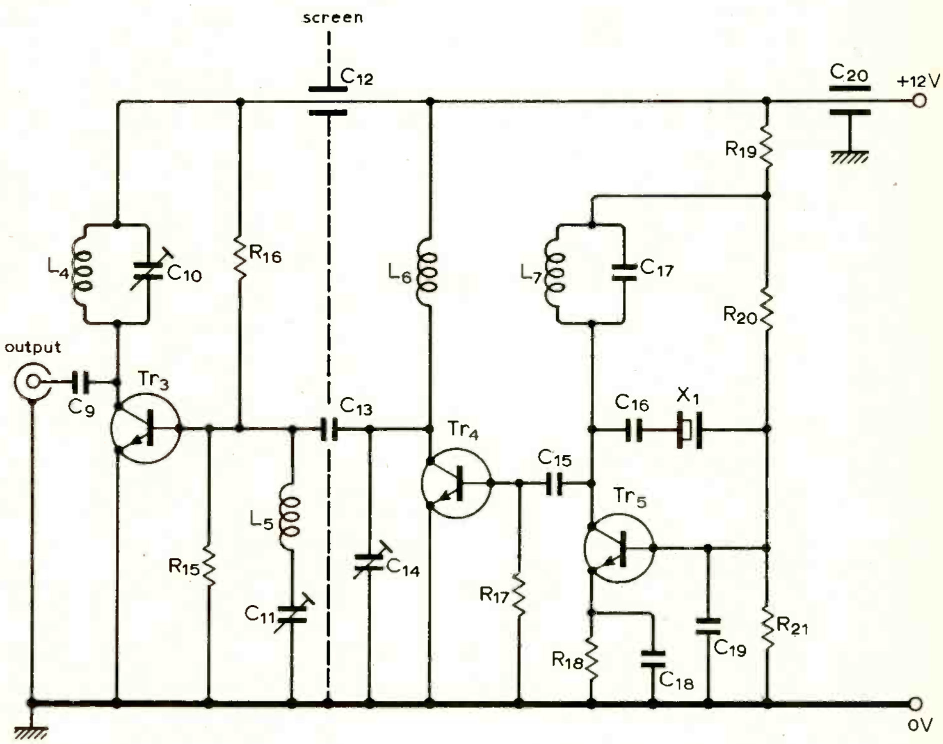
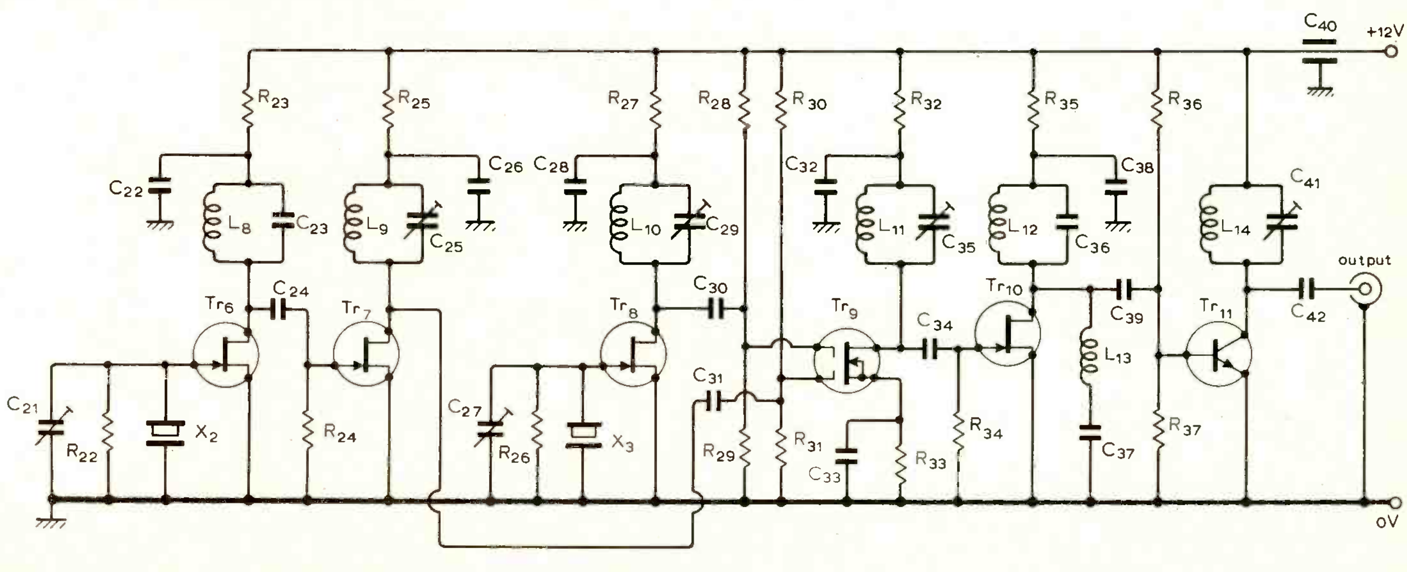


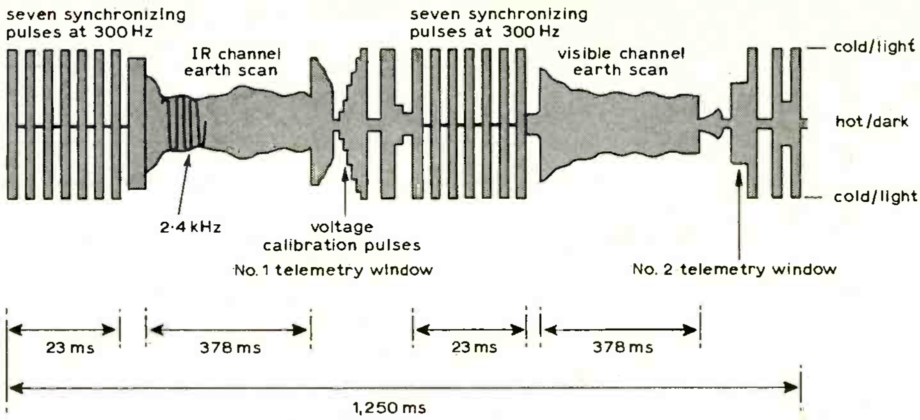
Fig. 9. Circuit of the first local oscillator.

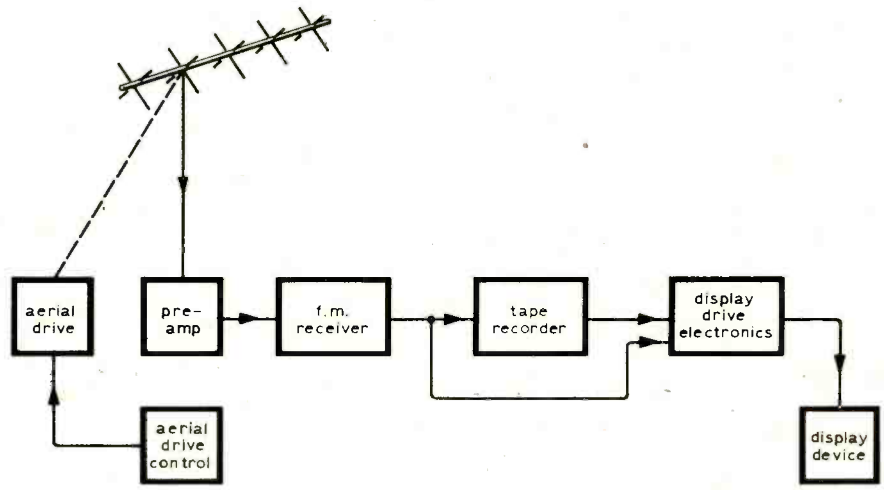
Fig. 10. Mixer local oscillator circuit.

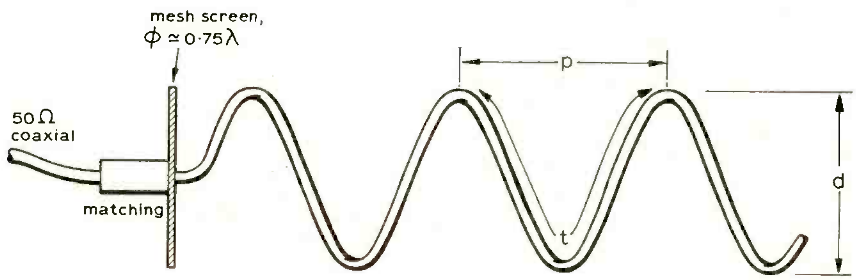


and when the potential at Tr_1 emitter rises above the wiper potential of R_8, D_4 becomes reverse biased. The voltage level due to the charging of C_1 through R_8 and D_7 forms a pedestal voltage, the pedestal level being determined by the cut off of D_7. A ramp voltage then rises on this pedestal due to the further charging of C_1 through R_7. This latter is adjusted so that, with R_8 wiper at the mid-point, the time constant of R_2, C_1 is too long for the ramp voltage on top of the pedestal voltage on C_1 to exceed the peak point of Tr_1. Since the 16.8 volt rail is un-smoothed it will return to zero volts instantaneously with the zero crossing of the 115 volt sinusoidal supply. As the zener stabilized rail falls in voltage below 16.8 volts, the potential on C_1 becomes equal to the peak point for the interbase voltage at that instant, and Tr_1 fires, discharging C_1. Since the a.c. supply at this moment is approaching zero, the s.c.rs are not triggered.

If the wiper of R_5 is moved from the centre position, the pedestal voltage on C_1 is raised and the ramp voltage due to C_1, R_7 reaches the unijunction peak point during that half a.c. cycle. Transistor Tr_1 fires, and the pulse developed across R_6 triggers whichever s.c.r. is forward biased during the half a.c. cycle. One of the motor series diodes then conducts, and the motor runs. As R_8 wiper traverses the potentiometer, the triggering of the motor current via the appropriate s.c.r. is earlier in the half a.c. cycle. Hence conventional phase control of the motor takes place.







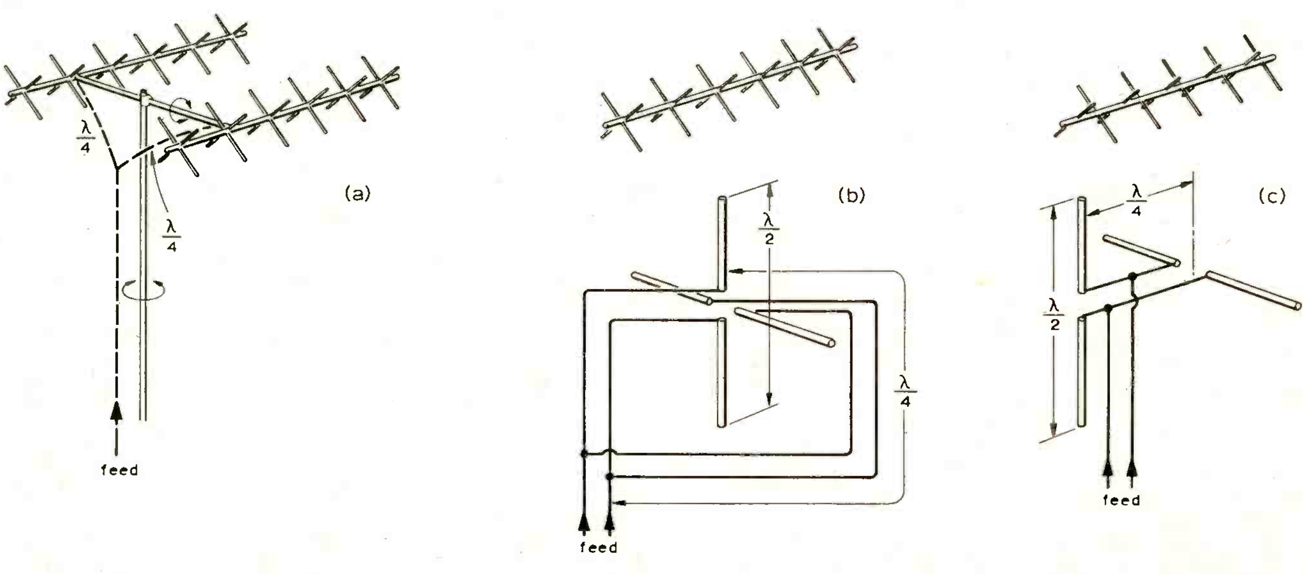
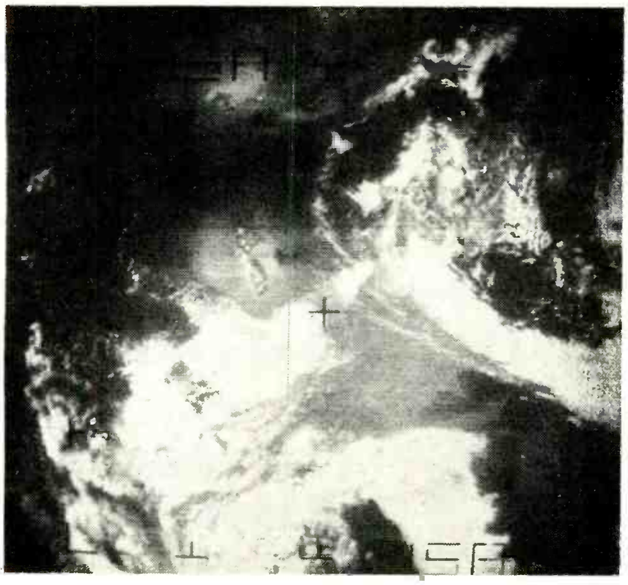


Fig. 2. NOAA-2 telemetry waveform sequence (SR).

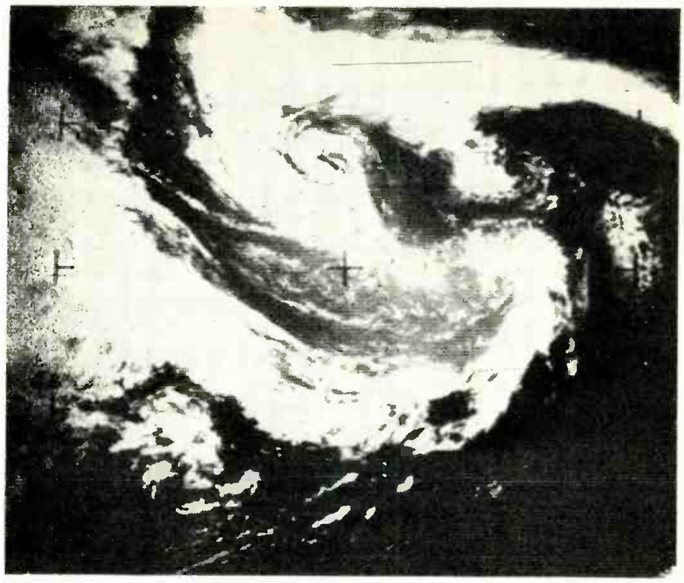
Fig. 3. Block diagram of a weather satellite ground station.

Fig. 4. Basic helix antenna.

Fig. 5. Three methods of arranging crossed Yagi antennas for circular polarization.



ESSA-8 (1968-114-A): orbit 25293 22 June 10.16Z, shows sun-glint in Sardinia, Corsica area. Note UK, Spain, Italy and North Africa. First run of prints from prototype facsimile machine by G. R. Kennedy on 25.6.74. Paper Kodak white, smooth, glossy bromide, single weight, No. 2 (normal). Crater tube white current 10mA, black current 30mA. Brightness pot = 7.00. Traverse jitter and drum vibration evident on print No. 13.



ESSA-8 (1968-114-A): Orbit 25294 22 June 12.08Z. Weather system to west of Spain: N.W. coast of Spain is on right-hand border. Portion of complete satellite picture, produced on first run of prototype facsimile machine by G. R. Kennedy on 25.6.74. Paper Kodak WSG bromide, single weight, no. 2 (normal). Crater tube white current 7mA, black current 30mA. Brightness pot 9.00. Traverse jitter and drum vibration evident on print No. 6.

Receiver preamplifier

As shown earlier, a pre-amp giving at least 10dB gain at 136MHz is required for satisfactory reception of weather satellite signals. Since an f.m. system is used, the pre-amp need not have an outstandingly good noise figure, providing a high quality receiver is in use. However, if the receiver to be used is itself somewhat noisy, the pre-amp should be of a reasonably low noise type. There are many circuits available using either bipolar or field-effect transistors. A circuit[5] is shown in Fig. 7.

Tr_1 is a low noise u.h.f. transistor designed for microstrip circuits. It is a flat device of capstan layout, and is best mounted on a triangle of p.t.f.e. standoff insulators above an earth plane of copper-coated fibreglass. The merit of the circuit is that it is broadband and is thus particularly suitable for the satellite v.h.f. band of 136–138MHz: it gives a gain of at least 15dB, has a true noise figure of 1.5dB and is simple to make. Components C_2, C_3 and L_1 form a broadband input matching circuit for the common emitter transistor. Bias is straightforward, L_2, C_6 and R_{14} form a broadband output matching network for approximately 50 ohms. The circuit consumption is less than 10mA, so a nine-volt dry battery supply is the most economic. For best overall results the pre-amp should be as near the antenna as possible.

Receiver

The main receiver requirements are as follows. The satellite transmission bandwidth is usually 30kHz with a maximum deviation of ±10kHz. A receiver i.f. bandwidth of at least 20kHz but not more than 50kHz is thus required. Within the satellite band other types of satellites are continuously transmitting on frequencies very close to those of the weather satellites. Good selectivity is essential to avoid interference from these. The narrow bandwidth dictates the order of stability required. Jitter in a local oscillator will be seen by the detector as signal f.m. The satellite band is within a band of frequencies used by aircraft. These signals are, in the UK, very strong and may cause cross-modulation. A high i.f. is essential to reject image frequencies which might well be on a local civil aircraft channel. High gain—to ensure adequate limiting of amplitude changes in the signal, high gain preceding the limiter is required. The amount of gain depends on how much limiting is required by the detector for linear operation.

All of these requirements, brought together, specify the type of receiver required within narrow bounds—a double superhet receiver with both local oscillators preferably crystal controlled, with a crystal or mechanical i.f. filter and phase-lock loop detector meets the requirements mentioned above. A receiver block diagram is shown in Fig. 8. The detailed design of such a receiver is a standard text-book exercise and need not be further dealt with here. However, some sections are worthy of closer examination, particularly the first local oscillator, the crystal filter, the limiter and phase-lock loop detector. The most economical approach is to obtain a surplus v.h.f. receiver, such as from a redundant public service mobile or base station transceiver which should furnish r.f. amp, 1st mixer, 1st i.f., 2nd mixer, 2nd local oscillator and 2nd i.f. amplifier, even if the original design was for a.m. reception. The remainder of the final receiver can then be built and tested as separate items and added en bloc to the basic chassis.

If the second local oscillator is fixed in frequency, such as by crystal control, then the first local oscillator is the frequency determining standard of the receiver. Due to the narrow bandwidth and selectivity requirements of the overall receiver system, the first local oscillator must be either synthesized or crystal controlled. Synthesis implies the digital counting down and heterodyning of a highly accurate source, which may be a high grade transmitter radio source such as WWV or MSF, or more usually, a temperature controlled crystal oscillator, so these two options basically are the same. A crystal oscillator and multiplier first local oscillator is shown in Fig. 9.

Transistor Tr_5 is an overtone oscillator, the frequency of oscillation being determined by the series resonant frequency of the quartz crystal. The combination L_7 and C_{17} is tuned to slightly higher in frequency than the crystal frequency. Capacitor C_{16} blocks d.c. from the crystal. The oscillator output is taken via C_{15} to the doubler transistor Tr_4. Inductor L_6 and C_{14} form a series resonant circuit at twice the oscillator frequency and the output is taken via C_{13} to the amplifier Tr_3. An acceptor circuit acting as a trap at the oscillator frequency is formed by L_{10} and C_{11} Inductor L_4 and C_{10} are resonant at the output frequency, and the output is taken via C_9. The output level may be conveniently altered in practice by tuning the L_7 core. With the circuit values shown, approximately 1mW of 126.80MHz sine wave is available at the output. This circuit relies on the accuracy of the crystal. Modern hermetically-sealed metal cased crystals of HC6/U, HC18/U and HC25/U outline are normally available with ±0.01% or ±0.005% tolerance. To take the worst case ±0.01% crystal at the extreme of its limit, and used in a frequency tripling circuit for the first local oscillator, the error for 137.000MHz will be 12.6kHz assuming a 10.7MHz first i.f. This is approximately half the receiver bandwidth and hence for a transmitted signal being deviated ±10kHz, one half of the deviation per f.m. cycle may be lost. For this reason, a more complex local oscillator may be required if the crystal error cannot be corrected by crystal "pulling" with a parallel capacity, for crystals too high in frequency. Such a circuit is shown in Fig. 10. Here, two crystal oscillators are used; one of these contains one of a number of close-frequency crystals covering the desired range. Such collections of crystals with frequency increments a few kHz apart are often available from redundant aircraft or public utility equipment where close channelling is used. If the family of frequencies is too low, frequency doubling may be used, as shown in Fig. 10. Here j.f.e.ts Tr_6 and Tr_8 are crystal oscillators. The output frequency of Tr_6 is doubled by j.f.e.t. Tr_7 and applied together with the output of Tr_8 to the dual-gate m.o.s.f.e.t. mixer Tr_9. The mixer output is *RC* coupled to j.f.e.t. amplifier Tr_{10} which has a mixer difference frequency trap L_{13}, C_{37} across its output. Bipolar transistor Tr_{11} is a 1mW output driver. Two crystal frequencies are shown by way of example, but the circuit, which is very flexible, is capable of operation over wide frequency limits, with suitable revision of the tuned circuit values. As before, the crystal tolerances and stability should be borne in mind. However, if a series of crystals of small incremental frequency values is available, correction of output frequency is readily obtained.

Intermediate frequency filter

The narrow but precise bandwidth required for the receiver is difficult to obtain by *LC* single or double resonant i.f. transformers. A convenient method for specifying the bandwidth is to use a crystal or mechanical filter. The type of filter will depend on the i.f. frequency chosen: mechanical for lower frequencies are available from manufacturers such as Collins or Kokusai, whereas crystal for higher frequencies, such as 10.7MHz tend to be more readily available from manufacturers such as ITT, Cathodean/Pye, and Salford Electrical Instruments/GEC. A typical 10.7MHz filter will measure 36 × 27mm × 19mm high, and will have the following electrical characteristics (ITT 015AD): 3dB bandwidth ±15kHz, minimum attenuation 4.5dB, minimum stop-band attenuation of 70dB at ±35kHz and 90dB at ±50kHz, terminating impedance 910Ω in parallel with 25pF and maximum terminated input of 10mW. It might be possible to approach the performance of a commercially available crystal filter by constructing a double half lattice crystal filter, but the economics of four or eight close tolerance discrete crystal units is not significantly better than the cost of a single monolithic unit, currently about £16. One cheaper source is to extract a 50kHz channel crystal filter from a redundant public utility v.h.f. f.m. transceiver. It should be borne in mind that even at centre frequency there is an insertion signal loss of 4.5dB typically, and also that for optimum performance the terminating impedances should be maintained.

The second part of this article will describe the i.f. filter circuit limiter, p.l.l. system and the display.

Components

Resistors—*R*

Fig. 6	1	680, 10W
	2, 3	47
	4	2.5k
	5	1k
	6	47, 1/4W
	7	111
	8	5k
	9, 10	3.3k, 2W
Fig. 7	11	4.7k
	12	1k
	13	100
	14	220
Fig. 9	15	6.8k
	16	47k
	17	1k
	18, 19	470
	20	15k
	21	6.8k
Fig. 10	22	100k
	23	100
	24	100k
	25	270
	26	100k
	27	100
	28	330k
	29	10k
	30	330k
	31	10k
	32, 33	270
	34	100k
	35	270, 1/4W
	36	47k
	37	6.8k

Capacitors—*C*

Fig. 6	1	0.1	24	4.7p
Fig. 7	2, 3	3–25	25	3–36p
	4	5n	26	1n
	5	1000	27	0–7p
	6	12	28	10n
	7, 8	10n	29	2–20p
Fig. 9	9	10	30, 31	6.8p
	10	3–20	32	10n
	11	3–30p	33	1n
	12	1	34	2.2
	13	2.2p	35	2–20p
	14	3–20p	36	33p
	15	2.2	37	22p
	16	100p	38	1n
	17	22	39	4.7p
	18	1000	40	10n
	19	6.8p	41	12–50p
	20	1000	42	6.8p
Fig. 10	21	0–7p		
	22	1n		
	23	47p		

Diodes—*D*

Fig. 6	1, 2	1N1616	8	6.8, zener
	3, 4	1N1616	9	10V, zener
	5, 6	2N4444	10, 11	1N1616
	7	1N1612	12, 13	1N1616

Inductors—*L* (t—turns)

Fig. 7	1	8t, 22 swg on 1k, 1/2W resistor
	2	6t, 22 swg on 10k, 1/2W resistor
	3	10t, 36 swg torroid wound on ¼in dia. ferrite ring
Fig. 9	4	3½t, 20 swg close wound on ¼in mandril then opened 1t thickness between each turn
	5	10½t, 20 swg close wound on ¼in mandril then opened 1t thickness between each turn
	6	6½t, 20 swg close wound on ¼in mandril then opened 1t thickness between each turn
	7	5½t, 20 swg close wound on ¼in mandril then opened 1t thickness between each turn
Fig. 10	8	0.2µ
	9	0.15µ
	10	7.0µ
	11	0.1µ
	12	0.5µ
	13	0.2µ

Transistors—*Tr*

Fig. 6	1	2N1671
Fig. 7	2	11S-1757B
Fig. 9	3, 4	TIS18
	5	2N708
Fig. 10	6, 7, 8	2N5245
	9	3N141
	10	2N5245
	11	TIS18

Crystals—*X*

Fig. 9	1	63.4MHz
Fig. 10	2	51MHz
	3	24MHz
Fig. 9	1	63.4MHz
Fig. 10	2	51MHz
	3	24MHz

Integrated Circuit—*IC*

Fig. 13 1CA3076

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News of the Month

Teletext to go ahead

The Government, through the Home Office, has approved the introduction of broadcasting of live textual and graphical information on television by the CEEFAX/ ORACLE technique for a two-year experimental period. (Test transmissions have been in progress for some months, but "live" information means information that is expected to be of real use to the recipients.) The purpose of the two-year experiment is to assess the demand for the service, to decide what form it should take and to estimate the scope for the manufacture of television sets equipped with decoders. The BBC has already started live broadcasts on BBC 1 (on September 23) and Independent Television will probably start through the London Weekend programme company in May 1975. A complete specification of the standards adopted (outlined in the May 1974 issue, p.115) has been published jointly by the BBC, the IBA and BREMA (the set makers' trade association), and can be obtained from them at a price of 50p.

Experimental receivers, which are essentially conventional colour television sets equipped with decoders, have been demonstrated by Decca, GEC and Mullard. At present the decoders cost about £400, and the system will not be viable for widespread use by the public until the decoder cost has been reduced to the region of £10–£30—probably by the use of large-scale integrated circuits.

At a recent demonstration of ORACLE, at the IBA's new engineering headquarters, Crawley Court near Winchester, engineers showed how "on air" editing can be carried out using a small Honeywell digital computer. A video display unit incorporating a typewriter was used to type the pages of information, which were automatically fed into the computer's magnetic disc memory. The output system transmitted the pages (each 24 rows of 40 characters per row) in sequence over a microwave link to the IBA's Croydon transmitting station, where they were injected into the field blanking period of the normal television signal (on lines 17, 18, 330, 331) for transmission from the Crystal Palace aerial.

Eventually tests of the system will be made on v.h.f. transmissions, to be ready for the time when the v.h.f. television bands are "re-engineered" for 625-line pictures. Italian and German broadcasting organizations are already studying the system.

The following is an abbreviated description of the adopted standard. Data lines: initially two per field, 17, 18, 330, 331. Page format: 40 characters per row, 24 rows per page including page header (page address, system name, and digital clock read-out). Magazines and content: up to 100 pages, up to eight magazines. Transmission sequence: page sequential; blank rows may or may not be transmitted; in this way magazine cycle time can be optimized. Character coding: eight bits including parity ISO-7 (BS 4730: 1971) i.e., ASCII with selected "national usage" characters, includes upper and lower case. Control characters: (a) for flashing characters. (b) seven colours plus white (by individual on/off control of RGB; (c) subtitle and newsflash "boxing"; (d) graphics. Data protection: all words include some form of error protection; the character codes by odd-parity bit and others (control characters) have the extra protection of inserted "Hamming code" error bits. The characters so coded are magazine identification, page address, row address and "clock time" for time-coded pages. Bit format: non-return to zero, pulse shape is roughly raised cosine. Bit rate: 6.9375 Mb/s (444 × line frequency). Access time: with 100 pages and one magazine only, maximum waiting time is approximately 24 seconds (blank rows transmitted).

London traffic control phase two

Work on the computer and data transmission contract for the latest phase of the Greater London Council computerized Area Traffic Control system is now following the completion of the phase one computer system which now controls 400 road junctions in Central London. The extension work to this, now in its final stages, allows the number of junctions under control to be increased to 500. The new contract will enable a further 500 junctions to be brought under computerized control, laying claim to be the most up-to-date traffic control system in Europe. The transmission system is being supplied by the Plessey Company while Siemens have delivered the third Siemens type 306 computer plus auxiliary equipment to New Scotland Yard.

Radio love call stirs Darwin

Residents of Darwin, Northern Territory capital of Australia have been standing by to hear something unusual on their radios —the mating call of a toad broadcast by radio in an effort to recapture 11 cane toads.

A school teacher took these toads to Darwin from Queensland where they have been a pest for his botany students. Their

Main control room of the closed circuit television studio at the Department of Health and Social Security headquarters training department, Hinchley Wood. Rediffusion Industrial services installed the equipment. Shown here are the monitors, control panel for remote control camera and a video tape recorder.

escape has sparked off an intensive hunt, with Darwin Conservation Society offering \$5 a head for the capture of each toad. The president of the Northern Farmers' Association, Mr David Veal, said the reward should be \$A1000 (\$US1500) a toad, paid by the Education Department. The Minister for Northern Territory, Dr Rex Patterson rejected this as dangerous and unworkable since thousands of toads might mysteriously arrive from Queensland if there was a big price on their heads in the Northern Territory. Dr Patterson suggested playing toad calls on the city's two radio stations to help people find the escapees. He also emphasized the threat of the toads to the Northern Territory which has no toad of any kind. Cane toads could become a menace if they were to breed in the northern coastal plains, an area of thousands of square miles, feeding on moths, insects and beetles, many of which performed vital tasks for the upkeep of their environment.

Dialling aid for Telex

A new dialling aid for Telex machine operators has been made available nationally during October. The callmaker aid is a small automatic dialler linked to the Telex machine so that instead of rotating the dial by hand, calls are made simply by slipping a small plastic card into the auto-dialler (see photograph). The device is a modified version of the card callmaker which is already being used in association with telephones.

Users of Britain's 50,000 Telex machines will be able to use the dialling aid developed by the Post Office, for making calls within the UK and to mainland Europe. Although it cannot yet be used for international Telex calls which involve dialling and keying, Post Office engineers are examining the possibility of developing a Telex dialling aid which will do this.

The advantages of this method of dialling are said to be that human error is eliminated, it does away with the need to consult directories or dialling instructions; also, while the callmaker dials the number, the caller is free to examine documents or continue a conversation. Numbers are stored on small plastic cards measuring $3\frac{1}{2}$in by $2\frac{1}{4}$in, with one card for each number represented by punching a pattern of holes according to a simple guide supplied with the callmaker. This then forms a permanent record for future use.

The callmaker's dialling unit uses a photo-electric principle to read the punched out code on the dialling card.

Card callmaker automatic dialling system for Telex machine operators. See accompanying news item.

Light-fingered touch

A new type of touch-sensitive display input device for use in data processing systems made its first public appearance as part of an air traffic control exhibit in the GEC-Marconi Electronics pavilion at this year's Farnborough International Air Show. The device known as Digilux, operates like a programmable keyboard and is used in a similar way to the "touchwire" system used in the Flight Data Processing System at the London Air Traffic Control Centre at West Drayton.

The advantage of the new technique is that it is "wireless" and does not rely on physical contact between the finger and a bare wire conductor; instead it uses narrow infra-red beams which form an invisible grid over the display screen. A finger placed on the face of the screen intercepts two beams at right angles and the location of the finger is rapidly determined and signalled to the computer.

As there are no touch contacts on the screen or wires to them, there is no obscuration of the screen itself. The system is unaffected by room lighting because the beams are infra-red. In addition, Digilux retains all the advantages which the touch-wire technique has over the conventional keyboard as a computer entry device; it is faster, less prone to error, needs very little time for learning and can offer a significant saving in space.

Dial-a-ride

The first major sponsored "dial-a-ride" system in the UK started operation in Harlow at the beginning of September and is known locally as the "Pick-me-up" service. The system uses three Ford Dormobile vehicles providing an urban transport service which allows passengers to telephone their particular travel requirements to a control centre, which in turn co-ordinates the available vehicles in order to meet these requirements. It offers a door-to-door service which combines the advantage of travelling by car and by bus. While retaining the flexibility and convenience of a car, dial-a-ride is cheaper for the passenger because the vehicle is shared. The Harlow version of the concept revolves around a control centre which is in constant two-way radiotelephone communication with the vehicles. Each of these is equipped with RC665 mobile radiotelephones supplied by GEC-Marconi Electronics Ltd and the project is being sponsored by the Transport and Road Research Laboratory of the Department of the Environment in order to evaluate the viability of this new form of public transport.

IEE establishes microprocessor group

"Microprocessor applications" is the title of a new group which has been formed under the aegis of the IEE to fulfil a need in this area of advancing technology. Because of the continuous flow of information in this field, meetings will be held every two months, mainly at Savoy Place, London.

The aim of the group is to provide a multidisciplinary forum for the discussion of techniques associated with the uses of microprocessors and the technical aspects of microprocessor applications, and to identify areas in which research and development are required. Areas of particular interest will be: instrumentation, aviation, telecommunication, signal processing, medical instrumentation, process control, pollution monitoring and data collection.

Further information and membership application forms can be obtained from the Secretary, IEE, Savoy Place, London WC2R 0BL, quoting the reference LS(CA).

Briefly

Inspec milestone. The Institution of Electrical Engineers' world information service reached a milestone in the dissemination of information when it published the 1,000th issue of Physics Abstracts on the 16th September.

Active crossover networks

Using a single bass speaker in a stereo system

by D. C. Read, B.Sc.

The author finds that active crossover networks, giving better speaker damping and improved transient response, sound better than passive ones as well as being easier to adjust. But the system first designed (December 1973 issue) needed six amplifiers. This article therefore describes three ways to reduce size and cost, by using a common bass unit with 1-cu.ft sealed enclosures, by using the bass unit with 0.33-cu.ft enclosures, and by omitting the bass unit. Alterations to active filter circuit values for these options are given together with a modification to the "full" six-unit system.

The first and most obvious economy in the previous active crossover design was to follow the well-tried example of Baxandall* using the fact that low-frequency sounds are non-directional and have a mixed mono and stereo system. Fortunately, for modern living rooms of average size, this non-directional effect extends well into the audio band. By combining a single bass speaker with a pair of relatively small mid-range/tweeter boxes working in stereo there is an immediate saving of one power amplifier, its driving filter circuit and one large enclosure.

Although one filter and amplifier assembly would be unchanged, the other would be smaller, with about one-third of the components removed from the filter (front board in photograph) and two power amplifier boards instead of three. An added practical advantage is that the bass speaker can be placed in any convenient position to suit the general room layout.

Choice of bass crossover

Having decided on a combined bass arrangement, the first requirement was to determine where in the audio band to make the change between mono and stereo operation. In doing this work, the ease of adjustment afforded by active filters was most helpful.

The single bass unit, KEF type B139, was installed in a box of about 5cu.ft and then subjected to listening tests in a normal-size living room. For experimental purposes, the middle and upper frequency sounds were produced by units in the transmission-line enclosures described in the previous article. Simple A-B switching allowed repeated comparison between this combined bass set-up and the complete 2 × 3-way system, i.e. between mixed mono and stereo, and full audio-band stereo.

Initially, the bass speaker was fed with combined signals from the two channels up to about 490Hz: this was the bass crossover frequency already in use for the transmission-line speakers.

But stereo separation was not then maintained over the whole band: the single source of low frequencies could be identified and located when moved. The cross-over point was then lowered by successive amounts until, with it set at 150Hz, the mono bass effect disappeared. Thus, when compared against the full 2 × 3-way stereo it was found that the l.f. speaker could be placed virtually anywhere in the room, facing in any direction, without noticeable change in the stereo image.

The 150-Hz crossover frequency determined as above provided for satisfactory (i.e. undetectable) mono bass for a stereo installation working in a room measuring about 15 feet square. In a listening room with dimensions considerably greater than this, however, the presence and location of the single source of l.f. may become apparent, and it will then be necessary to lower the stereo-to-mono changeover point.

To move the changeover point either way, the response curves of both the mid-range band-pass filter (high-pass) and the bass-unit low-pass filter must be modified by altering the roll-off frequencies of the 6dB and 12dB/octave circuits (the circuits surrounding IC_3/Tr_5 and IC_4/Tr_6 in Fig. 2). As the change of frequency in each instance is likely to be relatively small, the appropriate new component values can be deduced by simple linear scaling. For readers who wish to re-calculate circuit constants, perhaps to satisfy the requirements of different units or considerably changed listening conditions, the pro-

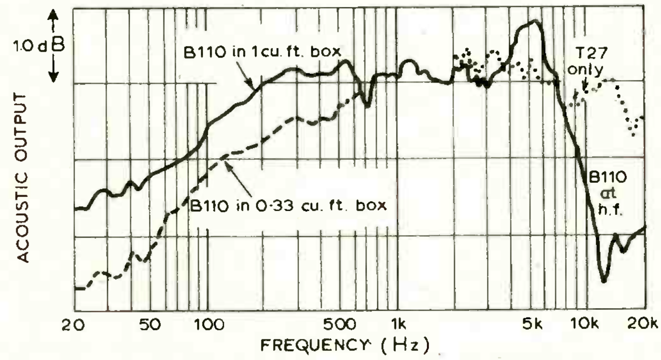


Fig. 1. For the common-bass system the mid and upper-ranges use B110 and T27 drive units, as in the original design. Graph shows axial response of B110 in a 1-cu.ft sealed box (upper solid line). T27 curve (broken line) shows an upper crossover of about 4kHz is suitable. Lower B110 curve shows axial response for a small, 0.33-cu.ft sealed box, for which slope correction is needed (see Fig. 5). Acoustic response curves taken with a writing speed of 80mm/s and a paper speed of 3mm/s.

*Low-cost high-quality loudspeaker, (part 2) by P. J. Baxandall, *Wireless World* vol. 74 1968, pp.316–9.

cedure is given in a section at the end of this article.

The component-scaling process is straightforward. In all instances, suppose the existing crossover frequency is f_1 and the wanted frequency is f_2. Suppose also, for example, that the required frequency shift is that necessary to lower the crossover point (to raise it each multiplying factor would, of course, be inverted). In the feedback circuit to input 3 of IC_3 (Fig. 2), either the two C values (33nF) or the R values ($2 \times 56k\Omega$ and $36k\Omega$) must be increased in the ratio f_1/f_2. For the Tr_5 input circuit increase either the series C (to $f_1/f_2 \times 0.033\mu F$) or the two shunt Rs (both to $f_1/f_2 \times 62k\Omega$).

Similarly, in the IC_4 circuit, new values are found for the input 3 components such that either the 100kΩ and 15kΩ resistors or the 33 and 68nF capacitors are increased by the factor of f_1/f_2. The Tr_6 input circuit is modified in the same way as for Tr_5.

As a further practical point relating to the use of a single, combined bass system as suggested here, note that the power amplifier described in the first article (Fig. 4 of the December article) is easily able to provide the necessary drive for a single unit taking l.f. signals from both channels, or even from four channels.

Smaller mid and upper range stereo units

With the optimum changeover point between stereo and mono working now established, it was necessary to construct a pair of small enclosures with speakers to produce the mid and upper audio frequencies. Identical units to those already used (KEF types B110 and T27) were used.

An obvious minimum requirement here was that the bass response of the mid-range unit must extend at least to 150Hz. Past experience suggested that for this an enclosure volume of about 1cu.ft would be suitable. Accordingly, a sealed box of this size was made, with dimensions $10 \times 20 \times 9$in. Damping was provided by a thick coat of car underseal on all internal surfaces and the box was filled with about ½lb of long-fibre wool: an inside layer of 2-in. foam plastics material would be a suitable alternative.

With the units installed, the assembly was tested in non-reverberant surroundings. As the B110 axial response given in Fig. 1 shows, the arbitrary estimation of enclosure volume was about right and obviates the need for slope equalization in the mid-range band-pass filters. The T27 response curve, drawn dotted in Fig. 1, shows that an upper crossover frequency of 3.5 to 4kHz was suitable here; the overall 6dB/octave slope is easily offset by making the high-pass filter l.f. roll-off more gradual.

Fig. 3 illustrates the three active filter responses as finally set for the mixed system. These curves are the voltage outputs from the full circuit given in Fig. 2, with $R_2 = 33k\Omega$, R_3 shorted and R_5, R_6, C_1 omitted. Note that two each of the band-pass and high-pass filters shown in Fig. 2 are needed but only one low-pass circuit

Overall response with combined bass

To check the overall acoustic output of the total system, the bass speaker together with a 1-cu.ft mid-range/tweeter assembly was tested in non-reverberant surrounding. Fig. 4 shows the complete response.

Note that only one of the stereo pair was used to obtain the curve of Fig. 4 because large differences in phase response

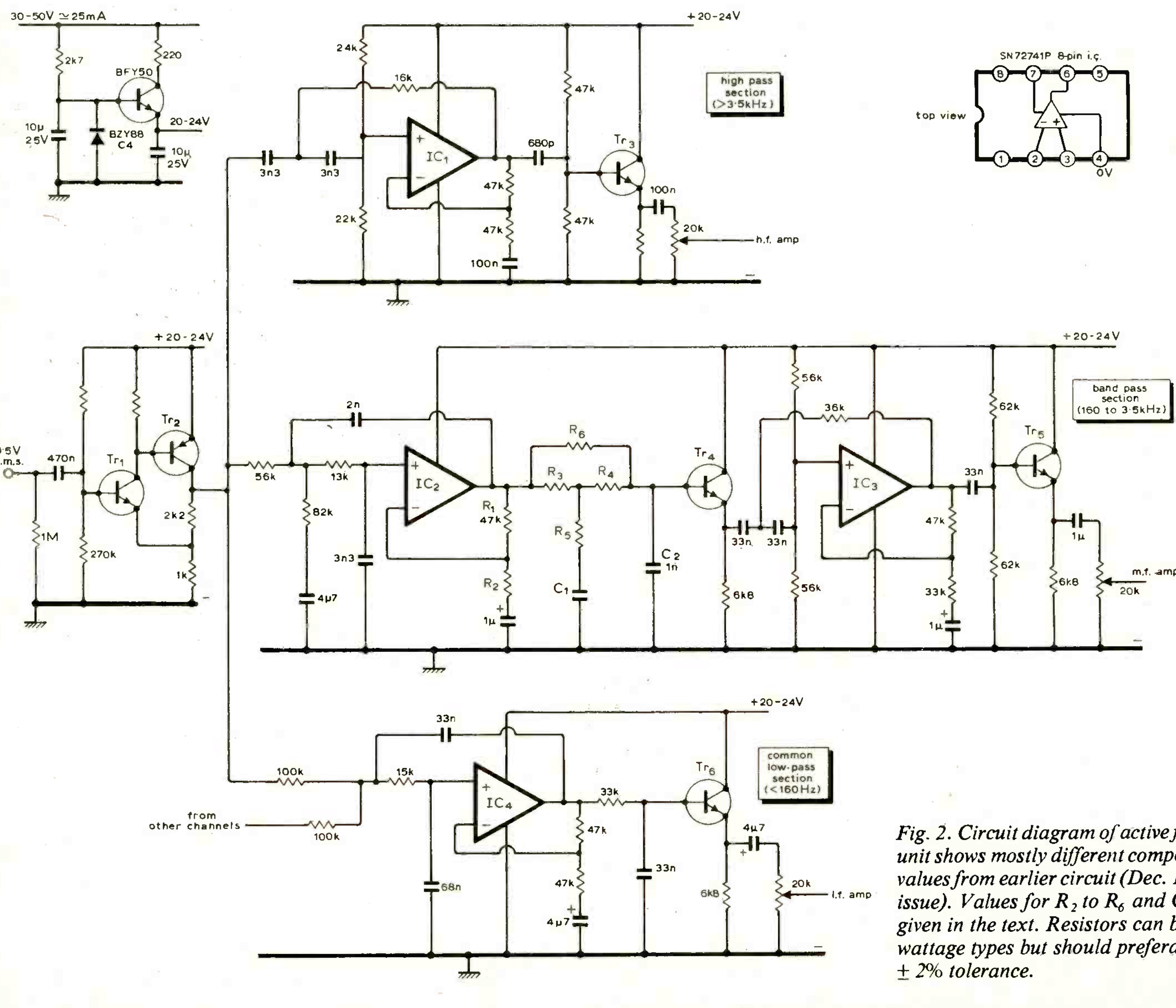
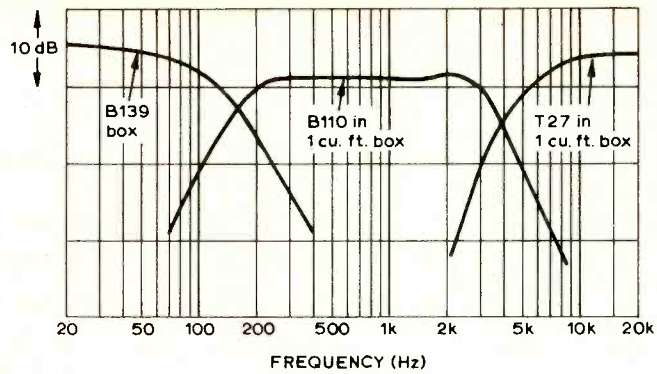
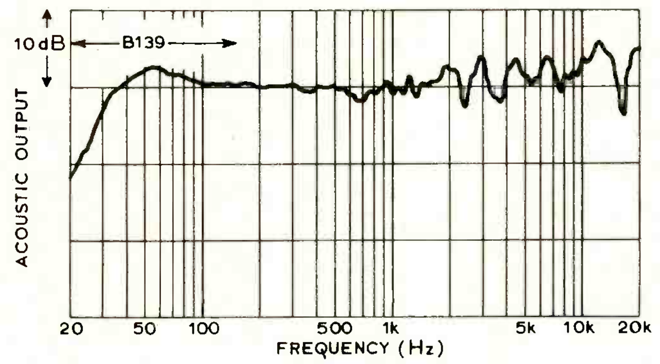


Fig. 2. Circuit diagram of active filter unit shows mostly different component values from earlier circuit (Dec. 1973 issue). Values for R_2 to R_6 and C_1 are given in the text. Resistors can be low-wattage types but should preferably be ± 2% tolerance.





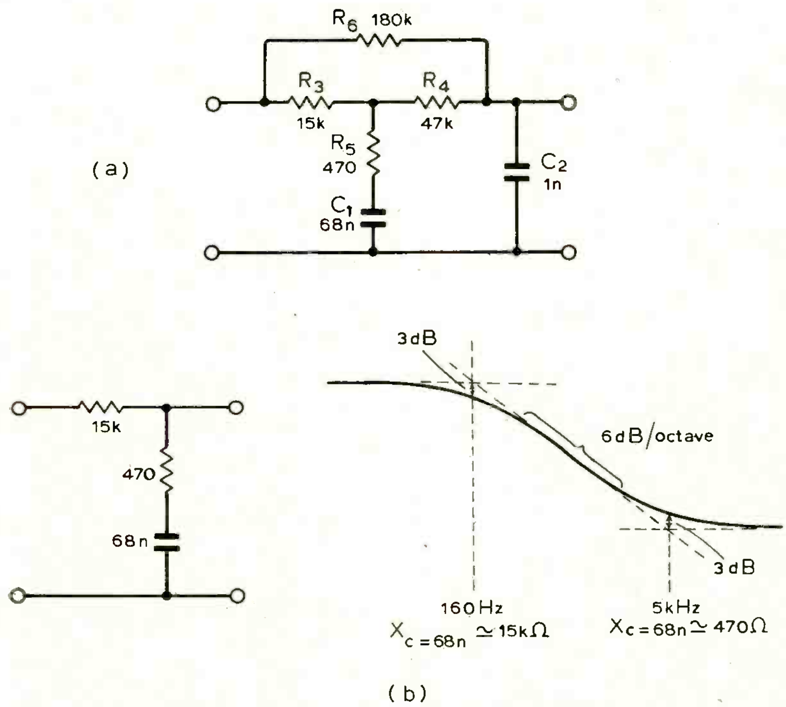


Fig. 3. Active filter responses for common-bass system. Curves are voltage outputs from Fig. 2 circuit, with $R_2 = 33k\Omega$, R_3 shorted and R_5, R_6, C_1 omitted.

Fig. 4. Axial acoustic output for B139 unit in separate l.f. enclosure and 1-cu.ft box using B110 and T27, in non-reverberant surroundings.

Fig. 5. Correction circuit used in bandpass filter to compensate for response of 0.33-cu.ft box in Fig. 1. Other components in (a) give part of the 18dB/octave roll-off at the top of the passband (C_2, R_4) and R_6 determines in-band slope (see text for value of R_2).

between individual units of the same type (e.g. as exhibited by different examples of the B110 unit) resulted in a spikey response with almost complete cancellation at some points. Such disparity in phase performance is, of course, a well-known failing of cone radiators; plane-driven electrostatic speakers are much more consistent in this respect. However, in normal domestic surroundings, multiple reflection tends to smooth out such variations in combined response and therefore largely overcomes the problem.

Active-filter phase response

While on the subject of phase performance, it should be mentioned that this was an aspect of active-filter operation which was carefully considered at an early stage. For the full stereo installation outlined in the December article, the various filter phase responses were calculated and their combined effect on acoustic performance tested. Specifically, this was compared to performance with the conventional passive-network equivalent. Detailed results of these tests have not been given because they showed only that even the largest differences in phase characteristic, particularly those occurring in the crossover regions, had little effect on sound output. The one observable change was a frequency redistribution, without increase in amplitude, of troughs and peaks in the overall response.

Even smaller stereo speakers

Although the combined-bass speaker enclosure used in the mixed system can be of any suitable shape and put in any convenient out-of-the-way corner, the mid- and upper-range assemblies must of necessity occupy particular positions, divided and directed so as to obtain the intended stereo effect. But, in rooms where space is at an absolute premium, even the 1-cu.ft enclosures used as above may be too large. To meet this objection and to exploit other properties of active filter, notably their possible use in correcting speaker response deficiencies, a pair of 0.33-cu.ft boxes was built (dimensions 8 × 6 × 12in) to form part of a modified stereo/mono system using the same units as before, i.e. one B139 and two each B110, T27.

Mid-range unit slope correction

The l.f. axial response of a B110 in a 0.33-cu.ft enclosure is given by the lower, dashed, curve up to 1kHz in Fig. 1. This shows that slope correction is needed in the band-pass filters which provide input signals for the mid-range units. An *R-C* network feeding Tr_4 can be used for such equalization. In Fig. 5a, the correction network is re-drawn with appropriate values. Here, R_3, R_5 and C_1 give a 6dB/octave bass lift over the required frequency range as shown in Fig. 5b.

Components R_4 and C_2 provide a similar slope as part of the overall 18dB/octave roll-off at the top end of the pass band. The value of R_6 determines the amount of in-band slope obtained for the whole circuit.

Using the values shown in Fig. 5a, the band-pass filter output response is as shown full line in Fig. 6. The other two filter responses remain as before but are included here to show how they relate to the modified band-pass curve.

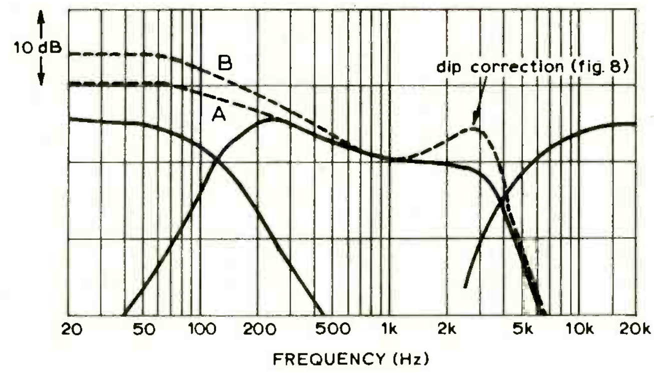


Fig. 6. Filter response for small enclosure, using values of Fig. 5 (a). Curves A and B are obtained with high-pass part of band-pass filter removed (by taking output from Tr_4 emitter) and apply for an inexpensive system using only the 0.33-cu.ft enclosures (see Fig. 7).

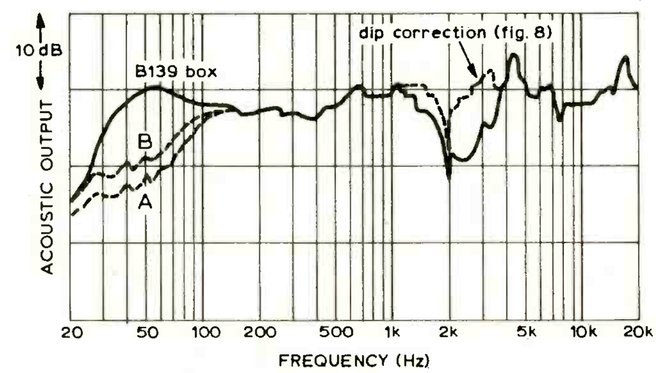
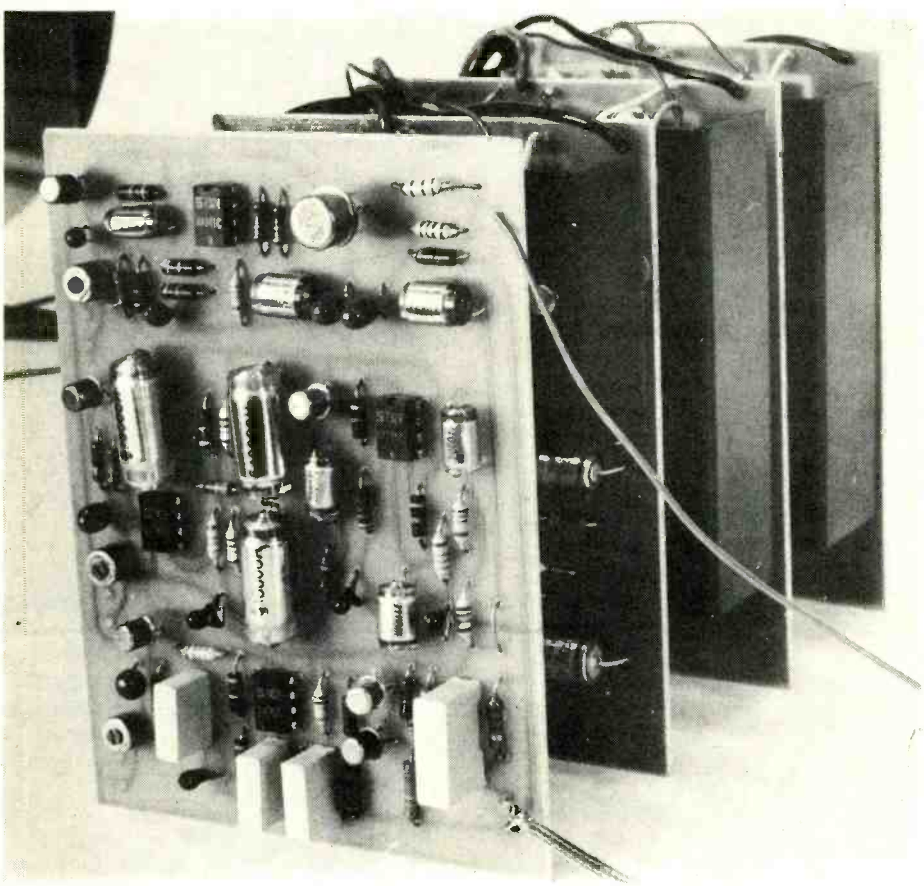


Fig. 7. Axial acoustic response for B139 unit in separate enclosure and 0.33-cu.ft box, in non-reverberant surroundings, showing dip at 2kHz before and after correction. Curve A applies when common-bass unit is not used, and high-pass filter of bandpass section is removed (to the right of Tr_4). Improvement at B is obtained by making C_1 100nF and R_6 270kΩ.



Complete amplifier for one channel. Front board is modified active filter, including l.f. section and voltage regulator, not needed for the other channel. Note reduced-size heat dissipator for h.f. power amplifier.

Mid-range dip correction

Fig. 7 gives the axial response in non-reverberant surroundings of the smaller mixed system, i.e. of the single B139 bass unit together with the B110/T27 combination in a 0.33-cu.ft enclosure. It shows that the bass response has been considerably improved, but there remains a large dip around 2kHz. Fortunately, since the response region requiring correction occupies a narrow range of frequencies mainly below the h.f. crossover point, the dip can largely be filled by creating a suitable peak in advance of the upper band-pass filter roll-off. This is done by adjustment of feedback over the first of the 741P amplifiers (IC_2 in the low-pass section of the band-pass filter). Fig. 8, which shows the roll-off characteristic for a 741P gain setting of 2.74, achieved with $R_1 = 47k\Omega$ and $R_2 = 27k\Omega$ (gain $= 1 + R_1/R_2$). (Peak height can be changed by altering gain slightly.)

With this modification to the band-pass filter circuit the overall response appears double-humped as illustrated in Fig. 6 by taking the upper dotted curve. The resulting acoustic response of the system is then as shown in Fig. 7 with the broken dip-corrected curve replacing the full-line one between 1.2kHz and 3.8kHz.

Miniature full stereo arrangement

A simpler stereo system was set up by using only the B110 and T27 units in the 0.33-cu.ft boxes, i.e. without the large combined bass enclosure. This economy also dispenses with about half of the filter circuitry; the parts now required are just the low-pass sections of the original band-pass filters and the two unmodified high-pass sections for the T27 tweeters. Further equalization must be added to give the B110 units extra l.f. response and thereby compensate for the absence of the B139 speaker.

In Fig. 6, the dotted line from 230Hz to 20Hz (curve A) shows the output from Tr_4 in Fig. 2. Because the IC_3/Tr_5 circuit is not included in this reduced-scale system, it is therefore the low-pass response applicable to signals feeding the B110 units. The high-pass filters and output characteristics remain as before.

The axial response of one B110/T27 assembly (0.33-cu.ft box) as used for this full stereo arrangement is given in Fig. 7 by taking the full-line curve plus dip correction above 200Hz and adding to it broken curve A below this frequency. Evidently, bass is still lacking below 100Hz. Curve B gives a possible 4dB maximum improvement here, and corresponds with the curve B filter response illustrated in Fig. 6. For such additional l.f. output, C_1 in the correction network (Fig. 2 or Fig. 5a) becomes 0.1μF and R_6 is increased to 390kΩ.

More bass boost than is shown by curve B in Fig. 7 could be obtained by other changes to the *R-C* network values, but, whenever extra l.f. response is sought from the B110 in this way, there is a danger that excursion of the cone driving-coil might become too great; limiting and consequent distortion is then inevitable. For this reason such increased bass output must be accompanied by a restriction in overall listening level, especially for music with a heavy bass component.

Note that both the A and B filter curves give steady l.f. increase down to about 80Hz after which the response gradually levels off and the B110 characteristic takes over. This is a deliberate compromise. It not only helps to overcome the problem of excessive cone movement but also gives some protection against spurious low-frequency signals such as those caused by rumble.

Use of combined bass for quadraphony

A mono-bass arrangement using active-filter circuits to the design described in this and the earlier article has been applied to a quadraphonic installation. When considering the extension of a split-band, multiple-speaker stereo system to quadraphony, the prospect of doubling-up yet again on most of the equipment is a daunting one, and any possible saving in outlay—especially if this can be done without reduction in performance—is an attractive proposition. The use of a single bass speaker offers just such an economy.

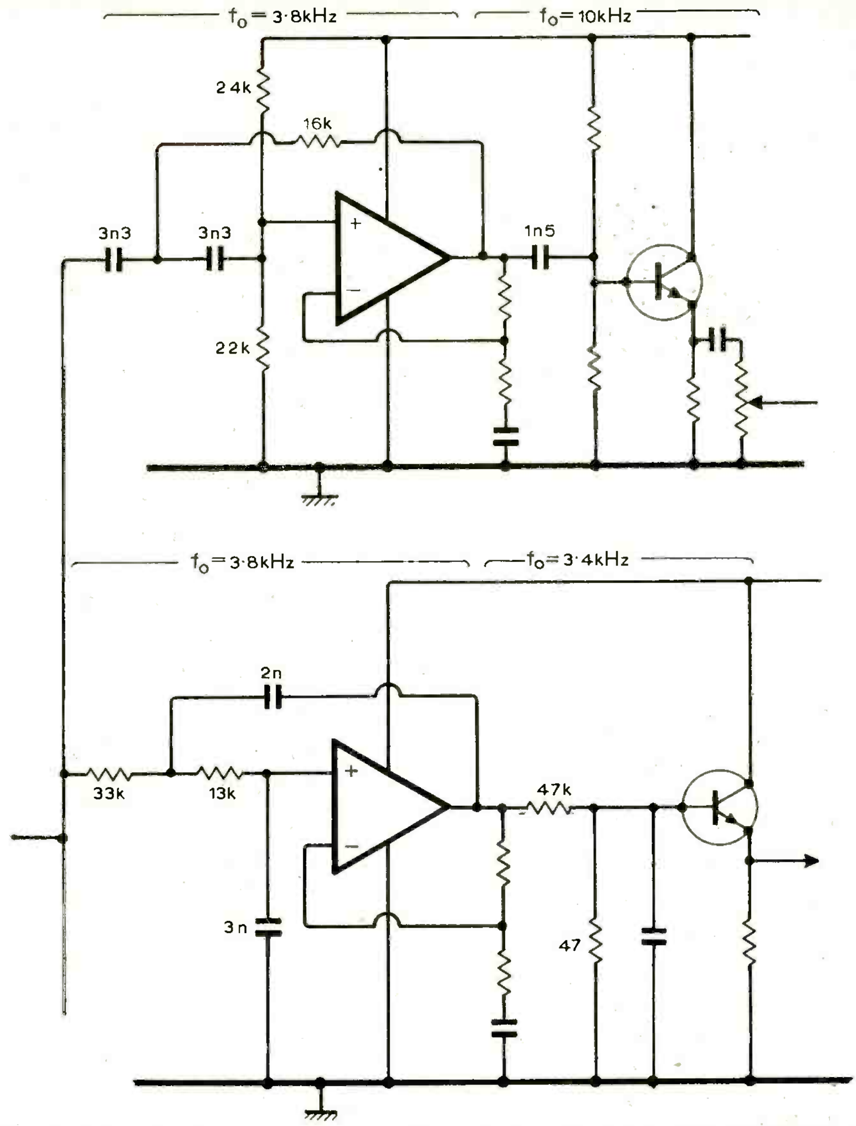


Fig. 9. Original active crossover design (December) can be improved by lowering upper crossover frequency to 4kHz. New component values shown above.

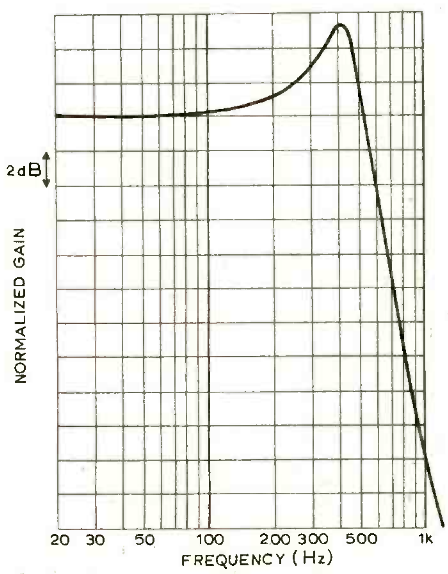


Fig. 8. Peak of appropriate height to compensate dip in Fig. 7 obtains for $R_2 = 27k\Omega$, with $R_1 = 47k\Omega$ in IC_2 circuit.

Obviously, twice the (stereo) complement of filters and amplifiers serving the mid and upper frequency ranges must be provided. For this quadraphonic application, however, the only change necessary in the basic circuit of Fig. 2 is that four mixing resistors, each of 200kΩ, are now needed to combine the l.f. signals at the input to IC_4. Although this input point is not a virtual earth, there is no danger of crosstalk between the four contributing channels because their outputs are fed from constant-voltage sources as represented in Fig. 2 by the circuit containing Tr_1 and Tr_2. Low output-impedance amplifiers in this position were, of course, already a necessity to prevent interaction between the stereo channels and, equally important, between the filters.

Although the foregoing outline suggests that bass combination is as easy to achieve for quadraphony as for stereo, there is a difficulty which may arise concerning the matrix system used and its effect on channel combination at low frequencies. In particular, the SQ coding system, and more especially the better QS system, which makes use of phase as well as amplitude relationships to improve separation, could create interaction problems at frequencies where the channels are combined. If this happened, it would be difficult to predict the subjective result; it would certainly depend on the programme content.*

Modification to original system

Readers who have either built or considered building the full 2 × 3-way system may be interested in a modification to the filter circuit given in Fig. 2 of the December 1973 article.

The change concerns the upper crossover frequency which has been lowered to 4kHz. In the original design, a 6kHz crossover was chosen so that a direct comparison of performance could be made with the Radford FN10 passive network. But as mentioned in passing (p.576 of that issue), the subjective effect was improved by shifting the crossover down by 2kHz; the reason for this improvement

*In mono reproduction of SQ and QS records, sounds intended for the centre back are heavily attenuated, and with QS records, left back and right back sounds would be 7.7dB down on the front sounds—Ed.

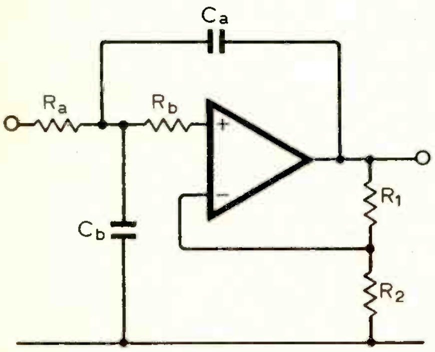
was not obvious at the time. However, subsequent discussion with the maker of the KEF B110 unit revealed that coupling between coil and cone becomes increasingly less stable at frequencies above about 3kHz (hence the response peak at 5kHz as shown in Fig. 1 of this article). By reducing the mid-range response in this region and making more use of the available lower-end output from the T27 tweeter, adverse effects from the B110 are avoided.

Fig. 10 shows the relevant parts of the circuit, taken from Fig. 3 of the December 1973 article, showing amended values.

Component layout. Photocopies of printed board positive transparencies, together with component layouts and a response curve for the modified crossover, are available from the *Wireless World* editorial office. Please send a stamped and addressed envelope for these.

Appendix

Circuit below applies to a low-pass filter where C_a, C_b and R_a, R_b are the component values to be determined.



First, choose a suitable value for C_a (in µF) and thus find a value for a number, k, where $k=2\pi C_a f_o$. In this expression, f_o is the 3dB-down frequency which can be related to a wanted cross-over frequency (normally at the 6dB-down point) by inspection of the appropriate curve.

Next, calculate

$$m=\frac{\alpha^2}{4}+(G-1),\ \text{where } \alpha=\sqrt{2}$$

maximally flat response, overall gain $G=1+R_1/R_2=2$ (nominal value).

Hence,

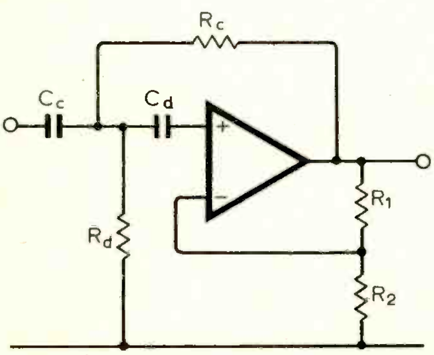
$$\left.\begin{aligned} C_b &= m.C_a \\ R_a &= \frac{2}{\alpha k} \\ R_b &= \frac{\alpha}{2mk} \end{aligned}\right\} \text{giving the remaining values.}$$

In the high-pass case C_c(µF) is chosen to find k from f_o as before. Assuming $\alpha=\sqrt{2}$ and $G=2$

$C_d=C_c$ (as chosen)

$$R_c=\frac{\alpha+\sqrt{\alpha^2+8(G-1)}}{4.k}$$

$$R_d=\frac{4}{\alpha+\sqrt{\alpha^2+8(G-1)}}\cdot\frac{1}{k}$$



Having thus established the basic curve shapes, further adjustments will have to be made to achieve the optimum performance. For example, Fig. 1 shows that the T27 tweeter output tends to fall at the higher frequencies and this tendency is counteracted by moving f_o for the 6dB/octave section of the high-pass filter to about 10kHz. This 'softens' the roll-off shape and also gives the wanted rising characteristic.

A similar technique was used to compensate for unit deficiencies at the l.f. end of the band. Other forms of response adjustment, such as roll-off "corner sharpening" and in-band dip correction are achieved as already described by altering the appropriate op-amp gains.

The above points are mentioned as a guide to the various ways in which active filters can be tailored to fit particular requirements. But, obviously, there are as many combinations and permutations of adjustment method as there are conditions to satisfy; it is largely a matter of trial and error which form is chosen to obtain the best result.

Literature Received

ACTIVE DEVICES

Beckman Instruments Ltd, Components International, have issued an eight-page technical bulletin providing complete information on their Model 881 Universal Active Filter. It includes performance specifications, mechanical characteristics, environmental specifications, and a number of response curves for particular applications and is available free from Mrs J. Shields, Product Administrator, Beckman Instruments Ltd, Queensgate, Glenrothes, Fife, Scotland. WW400

Jermyn have in stock the second edition of the General Electric *Semiconductor Data Handbook*. This is a selector guide, followed by full data and applications information on all the current GE semiconductor products including thyristors, transistors, diodes, triacs, unijunctions, opto-devices and many others. Price £2.75, post free, from Jermyn, Sevenoaks, Kent.

Fairchild's current issue of its house magazine, *Progress*, contains features on transmission-line signal quality, the input impedance of operational amplifiers, the compatibility of c.m.o.s. devices to e.c.l., the use of a multiplexer to adapt r.a.m. addressing to a c.r.t. display format and several other items. Extel PR, Pemberton House, East Harding Street, London EC4A 3JP. WW401

GENERAL CATALOGUES

Heathkit has issued a new catalogue containing several new products, including a remarkable new f.m. tuner with a digital display of frequency, numerical dialling of tuning or punched-card tuning. Heath (Gloucester) Ltd, Gloucester GL2 6EE. WW402

The latest 1974 catalogue from Radio Resistor shows a range of components from Piher, Greenpar, Spectrol, Dubilier and many others. The Radio Resistor Company Ltd, PO Box 193, 5 Platina Street, London EC2P 2JA. WW403

The RS Components Ltd August/September catalogue has been sent to us and is now available from RS Components Ltd, PO Box 427, 13–17 Epworth Street, London EC2P 2HA. WW404

JSH Electronics Inc. have announced the publication of their 25th Anniversary Price List. The product range includes valves, transistors, diodes and i.cs from most American manufacturers, but also has details of a comprehensive range of Japanese and European products. JSH Electronics Inc., 8549 Higuera Street, Culver City, California 90230, USA. WW405

The new Motorola McMOS Data Book contains detailed specifications of nearly 70 c.m.o.s. functions and also contains a comprehensive range of design information. Price £2.50, inclusive of postage and packing. GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Berks.

A wide range of instrument and electronics tools are listed in the Speciprod catalogue. Special Products Distributors Ltd, 81 Piccadilly, London W1. WW406

EQUIPMENT

A brochure describing and illustrating a kit PAL television receiver has been received from Forgestone Components, Ketteringham, Wymondham, Norfolk. WW407

Hellerman Electronic Components have issued a four-page leaflet, reference HEC 501F, on their new Fibrocon connector for multimode optic bundles. WW408

A handbook in three languages has been issued by Zeissler, which illustrates and describes in detail their range of mechanical component parts for electronic equipment. Zeissler D 521 Troisdorf, POB 1147, Koln, Germany. WW409

Varta have sent a technical leaflet on sealed nickel-cadmium cells. It contains data on various modes of charging, circuitry of suitable devices, mains fail circuits and the Varta TSL fast-charging system. Varta (Great Britain) Ltd, Hermitage Street, Crewkerne, Somerset. WW410

APPLICATION NOTES

A designer's handbook, entitled *Engineering the most out of and into digital panel instruments*, is now available from Analogic at £2. The manual is divided into three parts—installation, theory of operation and product design and maintenance. Analogic Ltd, Monument House, 25–27 Monument Hill, Weybridge KT13 8RT.

Hewlett Packard note AN948 describes the performance to be expected from the use of the HP5082-4350/51/60 isolators as line receivers in a t.t.l.-t.t.l. compatible NRZ data-transmission link. The note is available free from Hewlett-Packard Ltd, 224 Bath Road, Slough, Berks SL1 4DS. WW411

Audio '74 at Harrogate

by Basil Lane

Harrogate, one of the popular watering places of the North, is a charming town that has all the advantages of graceful architecture, beautiful surrounding country-side and one of the most enjoyable annual audio exhibitions in the calendar. What makes it so enjoyable is not only the friendly atmosphere generated by the warm-hearted Yorkshire folk, but the superb setting of the Majestic Hotel, venue for the exhibition, and having grounds that could grace many a stately home.

Suffice it to say that obviously Harrogate is one of the audio journalists' favourite annual events. This year, to use a cliché, it was bigger and better, with a total of 80 exhibitors, many of whom seem to have deserted the London shows for this and similar events. Another outstanding feature was the number of new products being previewed, where one normally would have expected them at the Audio Fair, Olympia.

In reporting on these new products, it is only possible to describe those that were seen (and heard!) and so some apology must be due to those exhibitors that I was unfortunate enough not to get round to.

An outstanding impression was of a polarization of extremes in demonstration. On the one hand there were those with a fairground policy of generating maximum noise to attract visitors like bees round a honeypot and those that chose a realistic discreet—and also very popular—presentation that gave a better chance of evaluation and after, conversation. Talking to the proponents of the two philosophies it was evident that although the big sounds would fill a demonstration room in no time at all, the real business seemed to be done by those who chose quieter demonstration material.

Products on show

On the ground floor I have distinct recollection of the AKG stand, since it had large photographs of Playboy Bunny Girls and when I was around—few visitors! A light-weight headphone called the K140 was being demonstrated for the first time together with some pickups for use with acoustic guitars. The well-known importer of Japanese products, JVC (UK) Ltd, occupied a stand on the ground floor and a demonstration room elsewhere and were showing several extensions to their range of products. The Model 1669U/F/S stereo cassette deck represents the top of their line of cassette recorders and features their own noise reduction system called A.N.R.S. (automatic noise reduction system). Sonab seemed a little sombre, perhaps because their electronics are all in black cases. A range of omni-directional loudspeakers went on show for the first time, the OA14 with a power-handling capacity of 40W and containing five drive units; the OA12, a little smaller, but still handling 40W, this time via three drive units and the OD11, smallest in the range, a 40W unit with two drivers. Also on show for the first time was the R3000 receiver, in a smart unobtrusive low-line case.

Rank Radio International, on show here but not, it seems, at the Audio Fair, were predictably crammed out with audiophiles anxious to see the new ranges launched earlier this year at the Spring Radio Show in London. Evidence of the enthusiasm of visitors was shown in the large attendances at the superb lecture (more of a homely chat) given by their technical staff at another hotel opposite. This was a welcome flashback to the days of Gilbert Briggs, containing something for everyone.

National Panasonic are usually a popular stand for the visitor and their room was well packed much of the time. They had chosen Audio '74 for the launch of many additions to both their own-name range and also to the Technics Hi-Fidelity brand. Notable among the latter was the RS676US cassette deck—a precursor to a new style which we will be seeing much more of in the future. This is the front-loading machine where all controls are on the front, enabling other equipment to be stacked on top. Claimed to have a high performance (and a high price), this machine excited considerable interest.

It seems almost inevitable that every audio exhibition will bring its collection of new loudspeakers, each said to be the finest things since sliced beans! Those I spotted included a remarkable venture by EMI-Keesonic into a hi-fi range of two. A high performance unit, the 353, which seemed capable of a phenomenal output and a smaller "bookshelf" unit, the 253. The former, which I heard (and felt!) at some length, sounded very crisp and I noted that a professional record cleaner was used extensively to avoid the obvious intrusion of surface noise due to dust.

EMI were using, and raving about, the Naim power and new pre-amplifier, of which more later. Monitor Audio presented two additions to their range of loudspeakers, the MA3 and the MA7, with a nicely balanced programme of music. Hayden Laboratories introduced the American Fisher range which not only

Fig. 1. One of the new Leak range of audio equipment, the 2100 amplifier.

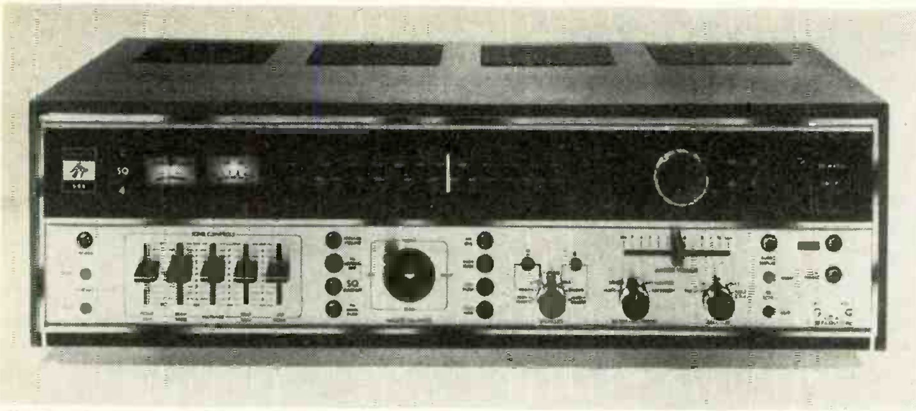


Fig 2. The Fisher 514 receiver forms part of a range of audio products including loudspeakers.

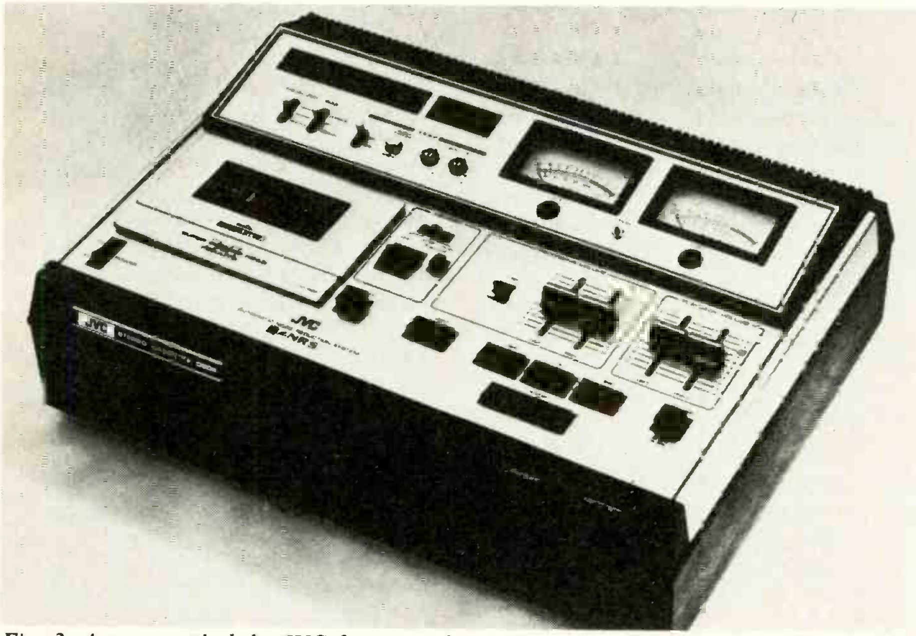


Fig. 3. A cassette deck by JVC featuring their own noise reduction system. The model is the 1669U/F/S.

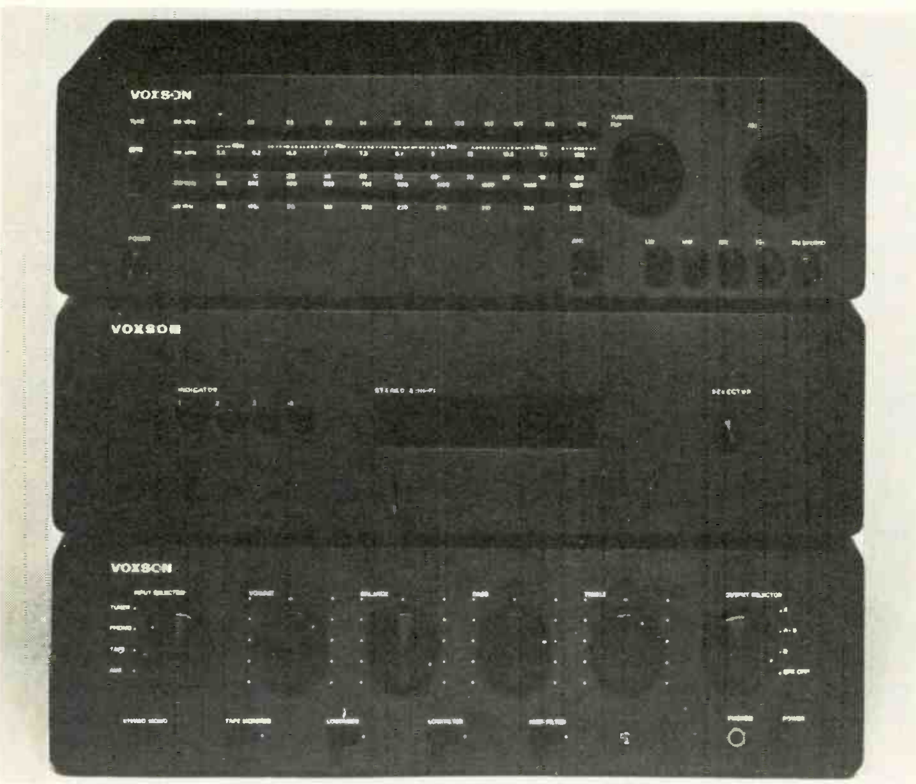


Fig. 4. Voxson equipment featured unusual styling and was coupled with a range of matching furniture.

included loudspeakers of unusual appearance but a very comprehensive range of quadraphonic receivers.

A new name to me, Voxson, manufactured in Italy by an EMI Group subsidiary, showed a stylish loudspeaker together with a comprehensive range of audio equipment and an interesting range of integrated furniture. Taking a very soft-sell line was Linn Products who had a large and very nice sounding loudspeaker, the Linn-Isobarik PMS, tucked away in the corners of their room. This was complemented by the Isobarik DMS which has a unique and patented bass "generator" concept.

Also in this room were the Naim Audio Products including their new pre-amplifier, the NAC12. A fascinating feature was the complete absence of tone controls and a specification which included an overload capability in the magnetic pickup input permitting a maximum of 2V at 20kHz. Maintaining this overload factor over the audio spectrum has been made possible by designing the initial pre-amplifier stage to be linear, with a small gain and then dividing the job of equalization into two separate parts. The NAP160 power amplifier was being used with the pre-amplifier and is, to quote the designer, "One of the few power amplifiers designed to drive loudspeakers." (!)

Not forgetting that tuners and receivers need aerials, Antiference made an interesting display of their latest product, the Rotenna aerial rotator for either f.m. or TV aerial arrays. Capable of providing a rotation through a full 360°, the Rotenna has a simple proportional control in a neat box with a single knob on the top surface.

One of the most amazing sights was to be found at the Marantz room—a large room with a wall completely shelved with different types of audio equipment. The demonstration was smoothly controlled from a central disc-jockey console and proved very popular with the public. New models included a loudspeaker said to have a revolving tweeter panel (!?) "so that properly mirrored sound images can be obtained".

Sanyo showed a new cassette recorder, the RD4600, which has a solenoid operated transport, ferrite head and variable angle VU meters. The DXK 2000 receiver was one of two new receivers also shown.

A new idea for FM tuners was exemplified by the Toshiba ST-910 digital synthesizer tuner which incorporated an l.e.d. frequency display and a computer-like memory capable of storing information for preset tuning of up to seven f.m. stations.

Finally to mention a publicity gimmick that proved very popular. Scandyna, now distributed by a new company, Scandinavian Audio Systems Ltd, were issuing circular stickers printed with a yellow sun-like face carrying a broad smile, this being over the company name. The "smile" was an allusion to their new product marketing manager, a jocular (and always smiling) Bill Smiley!

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

It's not only technicians who can see the finer points of Eagle multi-meters.
Every handyman notices them too.
They're easy to read.
They're tough.
Their construction comes up to laboratory standards.
Even our inexpensive pocket sized models have features you'd usually only find on professional equipment.
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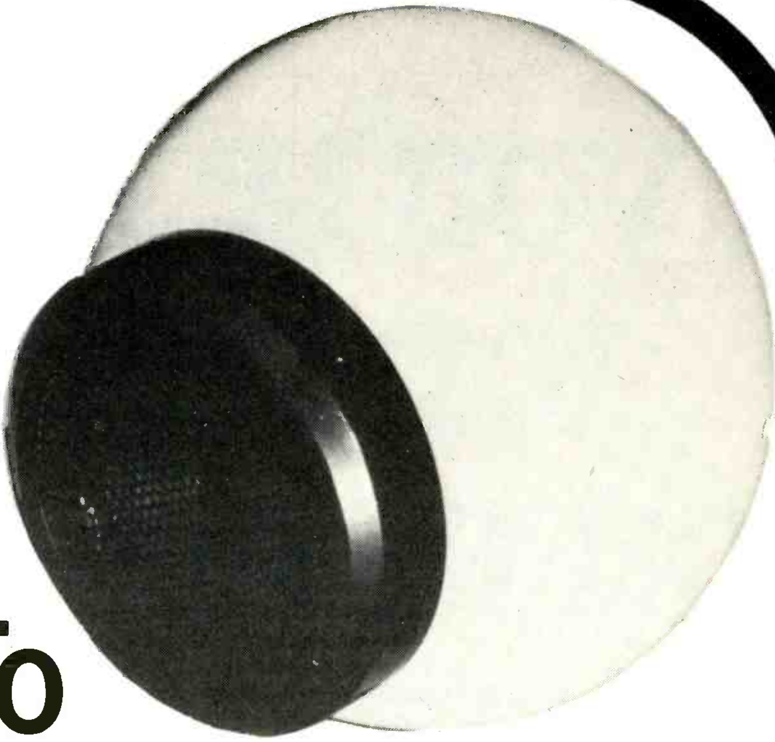

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Layout of circuit diagrams

The importance of standard patterns

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

The circuit diagram is the most useful of electronic diagrams. It shows how equipment works, is used for maintenance and as a source of information for preparing other diagrams such as wiring schedules and printed card layouts. Moreover, there is a movement in the technical literature on electronics, particularly that intended to assist maintenance, to reduce the amount of conventional text and to present more information on the circuit diagram: some of the techniques being used were described in an earlier article.* Because of this increased emphasis on the circuit diagram it is becoming more necessary to make the diagrams clear and easy to follow. Much time and frustration on the part of the reader can be saved by taking care in the layout of the diagram: on the other hand poor layout can easily make a familiar circuit unrecognizable. There is little doubt that the importance of good layout is insufficiently appreciated and it is hoped in this article to underline its importance by examining a number of published circuit diagrams of analogue equipment and showing how they can be improved.

Circuit diagrams are read in much the same way as a written or printed page of text. The direction of signal flow in well-laid-out diagrams is from left to right and from top to bottom, the order in which words are arranged on a page (and incidentally the order in which the picture elements are scanned in a television system). The process by which a group of component symbols is recognized as constituting a particular circuit arrangement is similar to that by which a group of letters is recognized as constituting a particular word. A word can thus be compared with a basic circuit arrangement such as that of the emitter follower. A group of words constitutes a sentence and a sentence can convey a thought or idea. Similarly a group of basic circuit arrangements can form an electronic equipment capable of carrying out a particular function, e.g., a number of basic circuits together constitute an a.f. amplifier. If the word order in a sentence is poor, the reader may be obliged to return to the beginning of the sentence more than once before the meaning becomes clear. Similarly if the individual circuits of an equipment are not well arranged so as to give a clear signal flow in a circuit diagram, the reader may have difficulty in understanding it. Groups of sentences form a paragraph and an electronic paragraph would presumably be the full circuit diagram of a complex item of equipment such as a television receiver. The analogy could be pressed further and it is possible to find electronic equivalents to chapters and complete books, but we can deduce a number of valuable points from the analogy between the smaller groups. For example, the reading of text is impeded if words are misspelt: this is equivalent, in circuit diagrams, to arranging the symbols for the components of a familiar circuit in an unfamiliar way so that the circuit is difficult to recognize. This occurs too frequently in circuit diagrams and some examples are given later.

Reading is also made difficult if the words in a sentence are arranged in a peculiar order so that several scans of the sentence are necessary to reveal its meaning. In circuit diagrams this means bad arrangement of the basic circuits of an equipment so that signal paths are difficult to follow, again a common fault.

*"Presenting maintenance information", *Wireless World*, October, 1973.

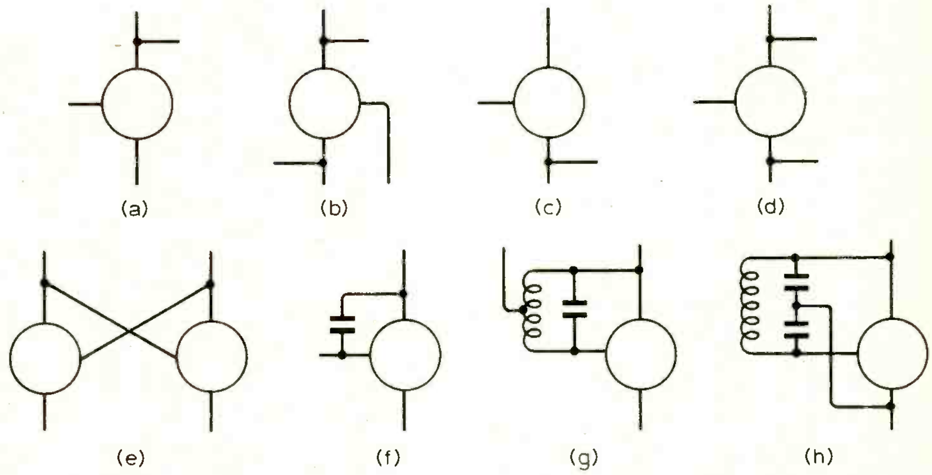


Fig. 1 The standard patterns formed by the essential connections in the circuit diagrams of a number of basic circuits are shown above: the circuits are identified in the text.

When words are printed or written in lower-case lettering, most acquire a characteristic shape or outline. This is conferred on them by the ascending strokes of letters such as b, d, h and the descending strokes of letters such as g, q and y. Experienced readers become so familiar with commonly occurring words that they recognize them at a glance from their outline and have no need to appreciate the individual letters of the words. The distinctive outline vanishes, of course, if the words are printed in upper-case lettering: all words then have a rectangular outline. This advantage of lower-case lettering is understood by the authority responsible for motorway signs which are always printed in lower case. There is a precisely analogous effect in circuit diagrams: the common basic circuit arrangements can be recognized from the shape conferred on the diagrams by the essential connections. Fig. 1 illustrates these characteristic shapes for a number of common electronic building bricks. In these the active element can be a valve or a transistor and is represented by a circle. Very few other component symbols are shown (there are no resistors at all!) yet few experienced electronic engineers will have any difficulty in recognizing: (a) common-emitter (or earthed-cathode) amplifier, (b) common-base (or earthed-

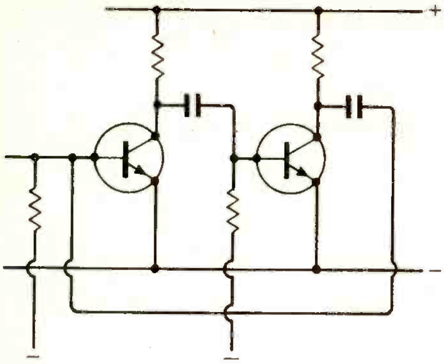


Fig. 2 An astable multivibrator drawn in an unconventional manner.

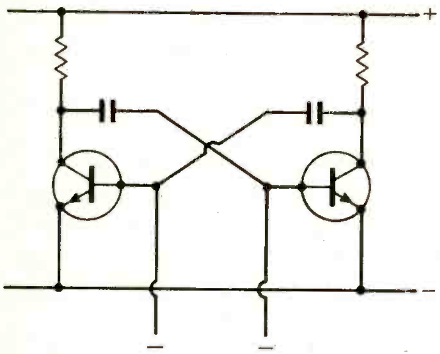


Fig. 3 A redraw of the circuit diagram of Fig. 2 in a more familiar layout.

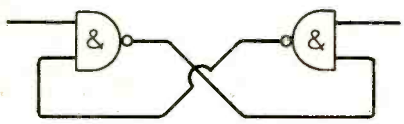


Fig. 4 Two NAND gates interconnected to form a bistable multivibrator.

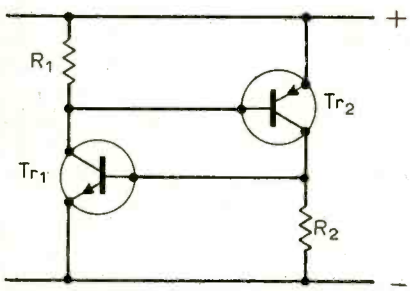


Fig. 5 A complementary multivibrator circuit—but it doesn't look like a multivibrator.

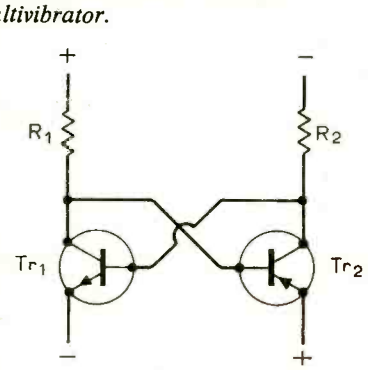


Fig. 6 A redraw of the circuit diagram of Fig. 5: in this form it is clearly a multivibrator.

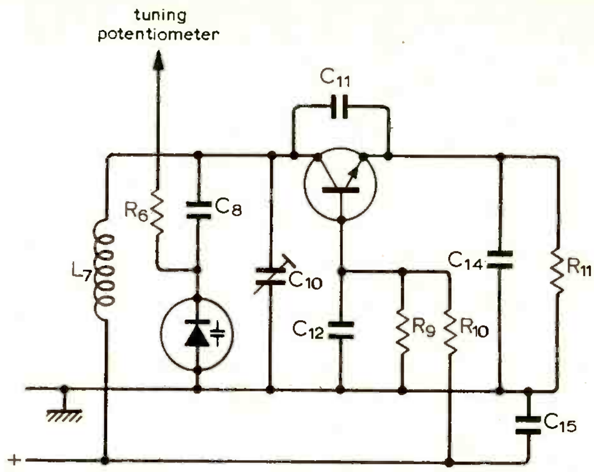


Fig. 7 Circuit diagram of a stage in an f.m. receiver.

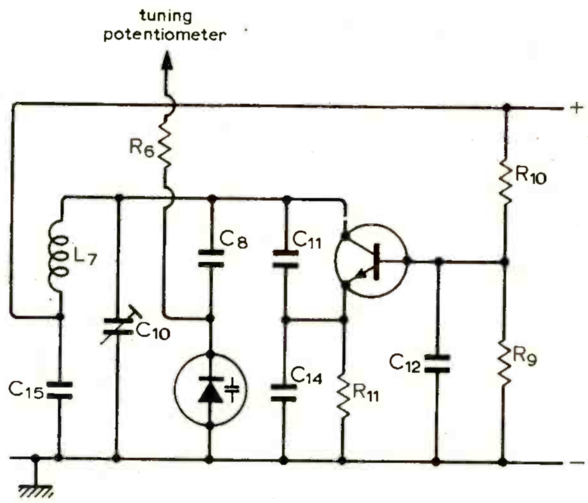


Fig. 8 From this redraw of Fig. 7 it is clear that the circuit is that of a Colpitts oscillator.

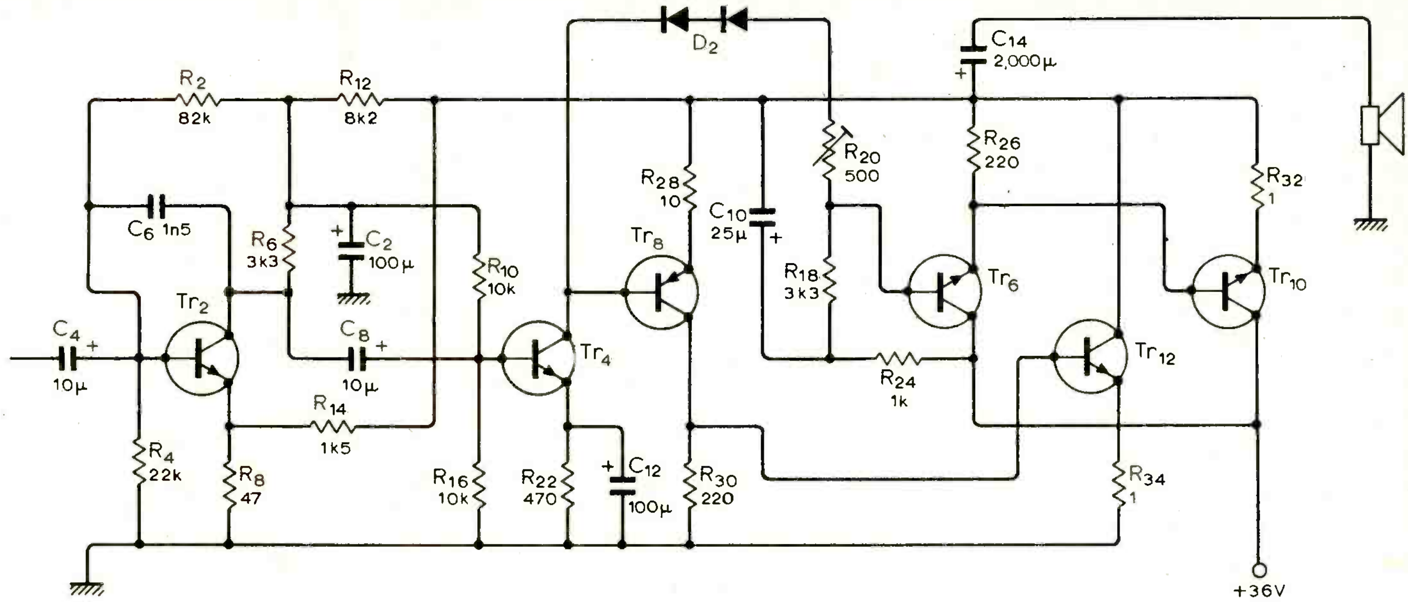
grid) amplifier, (c) emitter (or cathode) follower, (d) phase splitter, (e) multivibrator, (f) Miller integrator, (g) Hartley oscillator and finally (h) Colpitts oscillator. Clearly if common circuit arrangements are to be instantly recognized, the basic pattern of the diagram must be preserved despite elaboration of the diagram by signal-injection, signal-removal, d.c. or bias connections. Unfortunately the basic form of the diagrams for the common circuits is not always preserved: there is, to return to the analogy, some bad electronic spelling and a simple example is given in Fig. 2.

At first sight this appears to be a two-stage common-emitter amplifier with feedback but more detailed examination shows that the feedback is 100% and is positive. Enlightenment now dawns: it is a multivibrator circuit. How much more obvious this would have been if the circuit diagram had been drawn in the conventional way shown in Fig. 3. The crossing of the oblique lines is the trade mark of the multivibrator (see Fig. 1e) and should always appear. There is, of course, a legitimate use for the circuit arrangement of Fig. 2 and this is in teaching. There is virtue in introducing the multivibrator circuit to students as an amplifier with two stages and 100% positive feedback. It is perhaps more likely in future that the multivibrator will be introduced as a circuit composed of two inter-connected gates as shown in Fig. 4.

One of the ways of improving the clarity of circuit diagrams is to avoid unnecessary crossings of lines and thus there is a strong temptation to draw the circuit diagram of a complementary multivibrator as in Fig. 5 where the number of crossings has been reduced to the absolute minimum of zero. Unfortunately Fig. 5 does not look like the circuit diagram of a multivibrator and it is better to present the diagram in the form shown in Fig. 6 in which the single crossover instantly stamps the diagram as that of a multivibrator. Fig. 6 introduces the complication that the transistors must have individual supply terminals but this cost is worth paying to secure instant recognition of the circuit.

The confusion caused by bad electronic spelling is worse confounded when the circuits are more complex than those so far discussed. Consider, for example, Fig. 7 which is the circuit diagram of a stage in an f.m. receiver. It takes considerable time and it may be necessary to redraw the diagram several times before the following features of the circuit become clear:

(a) It is a Colpitts oscillator with C_{11} and C_{14} as the two fundamental capacitors (see Fig. 1h).

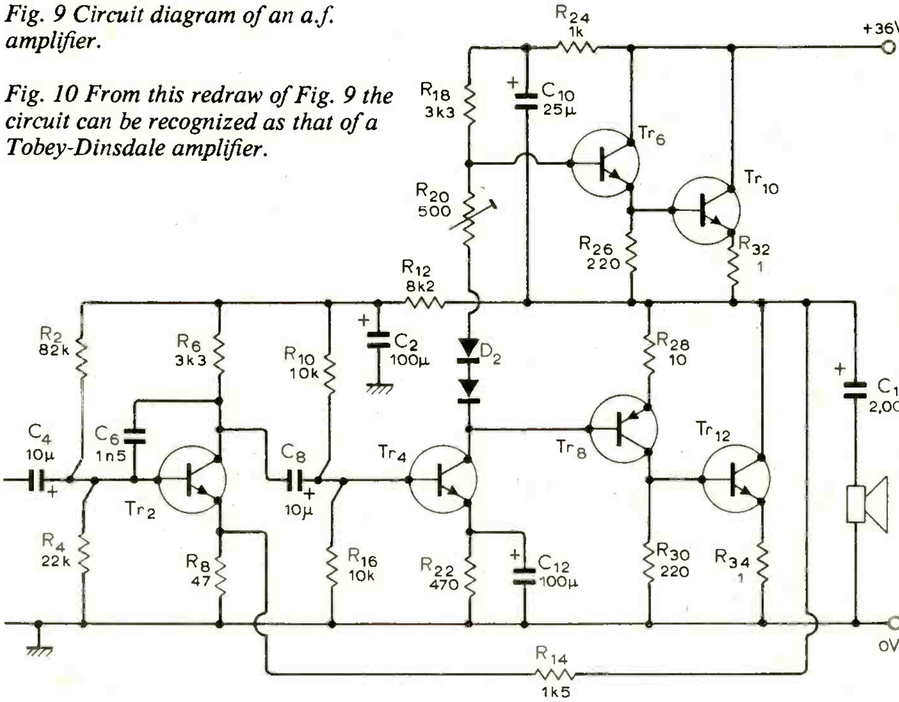


(b) The transistor is d.c. stabilized by the potential divider and emitter resistor method, R_9 and R_{10} forming the potential divider and R_{11} the emitter resistor.
(c) C_{15} completes the resonant circuit formed by L_7, C_{10}, C_{11}, C_{14} and the varicap diode.
These are all essential features of the circuit and should be emphasized in the circuit diagram. There are doubtless several possible layouts of the diagram which do this satisfactorily. One possibility is shown in Fig. 8. This shows C_{15} as an integral part of the resonant circuit with C_{11} and C_{14} clearly in series across L_7. The essential feature of the Colpitts oscillator is that the inductor is effectively connected between collector and base, the tapping point on the capacitive potential divider going to emitter. These connections are clear in Fig. 8, the capacitive tapping being returned to the emitter via C_{12}. Finally R_9 and R_{10} are arranged vertically in line, the standard arrangement for a potential divider.

Another example of bad electronic spelling is the circuit diagram of Fig. 9 taken from the service manual of a Continental hi-fi sound system. It is a puzzling diagram and in particular it is difficult to see how the loudspeaker can receive an input, being apparently connected between chassis and the supply line for the early stages. The difficulty in reading the diagram arises chiefly because a number of the recommendations which are normally observed in drawing circuit diagrams have been ignored. The principal points which need attention are the following:
(a) R_2 and R_4, the potential divider providing base bias for Tr_2 should be in line vertically.
(b) The decoupling components R_{12} and C_2 should be closely associated. R_{24} and C_{10} are also decoupling components and should be closely associated with each other and to the remainder of the circuit.
(c) R_{18}, R_{20} and D_2 constitute the collector circuit of Tr_4 and should be arranged vertically.

Fig. 9 Circuit diagram of an a.f. amplifier.

Fig. 10 From this redraw of Fig. 9 the circuit can be recognized as that of a Tobey-Dinsdale amplifier.



(d) Tr_6 and Tr_8 are a complementary push-pull pair and should be in line vertically.
(e) Tr_{10} and Tr_{12} form a single-ended push-pull output stage and should also be in line vertically.
(f) R_{14} applies negative feedback to Tr_2 emitter. Signal flow in this resistor is in the opposite direction to that in the rest of the circuit and it is usual to position such resistors below the chassis line.

Even when all these points have been attended to, there is still some freedom in the layout of the diagram. One possible version is given in Fig. 10, from which it can be seen that the amplifier is a fairly conventional Tobey-Dinsdale circuit.

Some words have alternative spellings, e.g., jail and gaol. The electronic analogy is a circuit which exists in two forms, i.e., with different names. An example is the bootstrap circuit and its alternative form can be deduced in the following way.

The circuit diagram of the bootstrap circuit is given in Fig. 11. It is used to

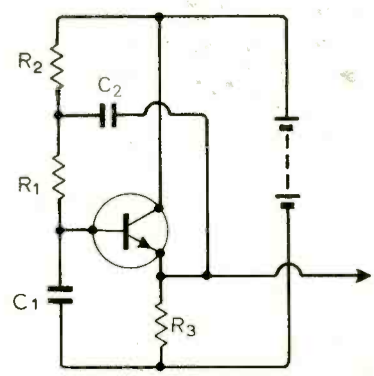


Fig. 11 A bootstrap circuit.

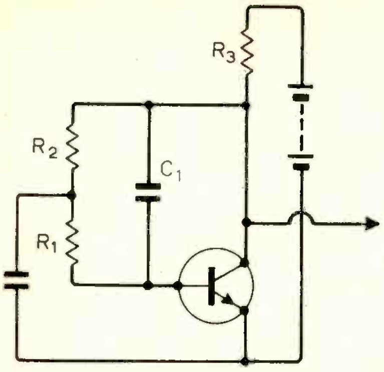


Fig. 12 A redraw of Fig. 10 with R_3 in the collector circuit.

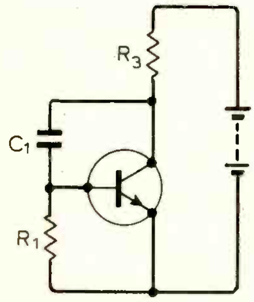


Fig. 13 The Miller integrator circuit.

generate a linearly-rising voltage across C_1. As C_1 charges through R_1 and R_2, the voltage across C_1 is transferred by emitter-follower action to R_3 and then via C_2 to R_2. Hence the voltage across R_1 scarcely changes during the charging process which means that C_1 receives a substantially-constant charging current: this is the condition required to generate a linear ramp voltage across C_1.

In essentials Fig. 11 represents a transistor connected in series with a resistor R_3 across a battery. R_3 is shown in the emitter lead but it could equally be in the collector lead and this change would make no difference to the operation of the circuit provided R_1, R_2, C_1 and C_2 are connected to the same points as in Fig. 11. When this is done the circuit diagram has the form shown in Fig. 12. Now R_2C_2 is a long-time-constant network used to transfer signals without change in waveform from the emitter to R_1 R_2 junction. In effect C_2 provides a signal-frequency shortcircuit between these two points. Such a network is necessary in Fig. 11 because of the difference in the zero-frequency voltage level at the two points. In Fig. 12 we can say, as before, that C_2 provides a signal-frequency shortcircuit between emitter and R_1R_2 junction but here C_2 can be omitted and R_1 can be directly connected to the emitter. R_2 now acts as an unnecessary drain on the battery and can be omitted. The circuit now has the form shown in Fig. 13. C_1 charges from the battery via R_1 and R_3 and the circuit operates in the same way as Fig. 11. Fig. 13 is, of course, the Miller integrator circuit and thus we can conclude that the bootstrap and Miller integrator are the same circuit.

The analogy between text and circuit diagrams has been used in this article to underline the need for careful layout of circuit diagrams to achieve ease of reading. Logical arrangement of basic circuits on the diagram is necessary to give clear signal-flow lines and the basic circuits must be consistently presented in their standard layouts to make them easily recognizable. Some standard layouts and some recommendations for the preparation of circuit diagrams are given in B.S.3939: Graphical Symbols for Electrical and Electronics Diagrams. The analogy has proved useful but is not perfect: what, for example, is the text equivalent of a negative feedback loop?

Portable television camera

The new Marconi Mk.VIIIP colour camera made its first appearance at the International Broadcasting Convention. The camera can be used with a standard Mk.VIII control unit and retains the Mk.VIII features of automatic registration and colour balance. Three 1-in lead oxide photoconductive tubes are used and the viewfinder c.r.t. is a 1-in type with magnifier.

The camera unit itself contains line-scan output stage, the three head amplifiers, a talkback facility and viewfinder electronics. An auxiliary pack, shoulder-frame mounted or carried on a trolley, contains field-scan and line generator, video stages and power unit, together with another talk-back station to enable communications between camera and auxiliary stations.

Industry finances report

The 1974 edition of "Company financial performance in the electronics industry" has been published. This covers the latest available results of over 300 of the industry's major companies and reveals how the consumer goods sector grew fastest of all up to 1972/73, while growth in the capital equipment sectors was very much slower.

The report provides an insight into the performance of companies in the industry with an annual turnover in excess of £½m. It also enables comparisons to be made between companies in the six sectors of the industry covered and for the industry's results as a whole to be compared with previous years.

The report shows that the decline in the industry's profitability from 1969 halted in 1971/72 when pre-interest profits as a percentage of net capital employed reached 13.5%. By 1972/73 this had recovered to 20.1%. Only the computer sector recovered less strongly, although the instruments sector did not experience good profitability throughout the whole period covered. The sector with the highest profitability—consumer goods—achieved the lowest export/sales ratio, while the reverse was true for the computers sector. The report for 1969/70, 1972/73 is available price £1 postage paid from Neddy Books, NEDO, Millbank Tower, London SW1P 4QX.

Sonex Europe 75

The annual Sonex audio exhibition will take place at the Centre Airport Hotel, Heathrow, during April 25–27 next year, with two trade and press review days on April 23 and 24. Organizers of the exhibition, British Audio Promotions Ltd, delayed arrangements in order to meet the Hi-Fidelity Group who have now made a unilateral decision to continue with their own private exhibition.

Corrections

Reducing amplifier distortion. A. M. Sandman, author of this article in the October issue, points out the omission of a 1-µF capacitor in series with the 100-kΩ resistor in Fig. 11. In Fig. 10 the emitter resistors for Tr_2 and Tr_3 should be taken to the −10-V supply. In the second line from the bottom on page 369 (column one) the equals sign should, evidently, be a minus sign. Mr Sandman wishes to acknowledge use of the facilities of the Research Department of Anaesthetics at the Royal College of Surgeons.

Novel stereo tuner. There are two small alterations to the circuit of Fig. 6 in the April issue, besides that mentioned on page 129 of the May issue. Components C_2 and R_{15} should be made 100nF and 470Ω. In the printed circuit board a connection from Tr_{12} (a BC179 and not a 109) emitter to the supply line was omitted. In Fig. 14, the BC109 collector and emitter annotations were transposed in error. If the integrated circuit type TBA750 is used in place of the SBA750, R_{23} should be made 8.2kΩ.

Optically coupled v.f.o.

A method for complete isolation of a high-frequency oscillator from its load, using a l.e.d./photodiode-transistor combination

by A. K. Langford, G4ARY

The method of transmitting information by amplitude modulation of a beam of light is not new (e.g. "Light-emitting diode—application to a short-path television link", *Wireless World*, Aug., 1964). Normally the light is pulsed or voice-modulated, but the transmission of high frequencies has been limited by the characteristics of the incandescent lamp. With the introduction of the light-emitting diode, the frequency range of the transmitting element was extended well above the audio spectrum. This was followed by the production of the optically coupled isolator (o.c.i.), which has the transmitting element (a l.e.d.) and the detector (a photodiode, or phototransistor) in close proximity within the same package. Primarily, the o.c.i. has been developed for d.c. isolation in digital and analogue circuits, in order to eliminate ground-loop currents. They may also be used as replacements for pulse transformers and mechanical relays. It is only recently, with the introduction of high-speed o.c.is, such as the 5082-4350 series and the 5082-4360 device by Hewlett Packard, that the useful frequency range can be extended to beyond 10MHz. This is quite sufficient for most v.f.o. applications in amateur equipment.

The prime consideration in the construction of a variable-frequency oscillator is the long-term frequency stability with respect to changes in ambient temperature. Attention to careful layout and choice of components can reduce this problem to acceptable levels. A problem not so easily dealt with is the frequency instability of the v.f.o. due to a varying load. For example, when the v.f.o. is directly coupled to a high-level mixer stage in a receiver, or a modulated/keyed stage in a transmitter. The usual procedure is to place one or more buffer stages between the oscillator and the fluctuating load. This can introduce instability and noise because of the loose coupling to the oscillator. The optically coupled isolator offers a simple solution.

The operation of the 5082-4350 series is as follows. A light-emitting input diode is optically coupled with a p-n photodiode which drives a high-speed transistor. The GaAsP input diode emits photons in proportion to its forward current. These photons are received by the p-n photodiode detector and amplified by the transistor. The current transfer ratio

$$\frac{I_{collector} \times 100}{I_{l.e.d.}}\ \%$$

is typically 11% for the 4350 device and 22% for the 4351. The 4360 package incorporates a linear amplifier driving a Schottky transistor in the output circuit, and exhibits a current transfer characteristic of typically 600%, with an improved frequency response (20MHz).

Although the 4360 is the best choice for simplicity of design, because of the high gain it offers, the 4350 device was chosen as the most practical for amateur use. Consequently, both the circuits described in this article use the low-cost 5082-4350 device.

Circuit description

An emitter-coupled Colpitts-type oscillator is used for the v.f.o. The bipolar transistor chosen for Tr_1 is the low-noise 2N3707, which in the experience of the author, produces an oscillator with excellent stability when used in this configuration. The v.f.o. can operate over the range 1.5 to 5.7MHz, without changing either of the feedback capacitors in the emitter-base circuit of Tr_1. As this transistor is used in the common collector mode, the l.e.d. section of the o.c.i. can be placed in the collector supply with little effect on the operation of the oscillator. The l.e.d. is forward biased by the 6mA current flowing through Tr_1, resulting in a d.c. collector current in the photodiode transistor of typically 0.7mA.

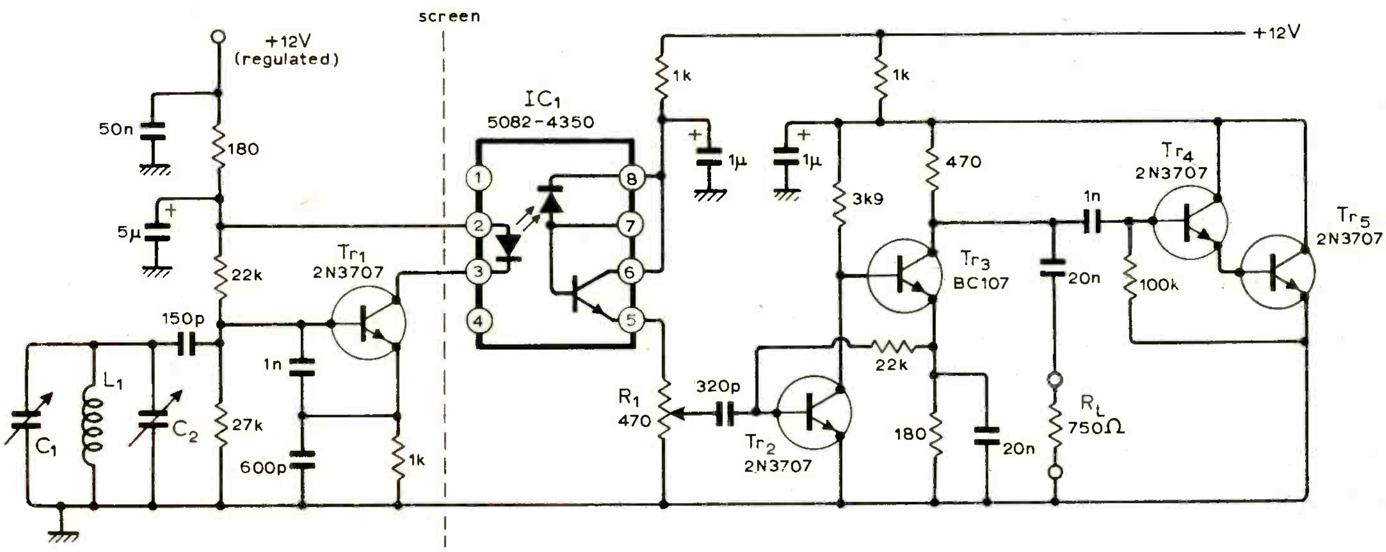


Fig. 1. Oscillator, optically coupled isolator and first stage of amplification.

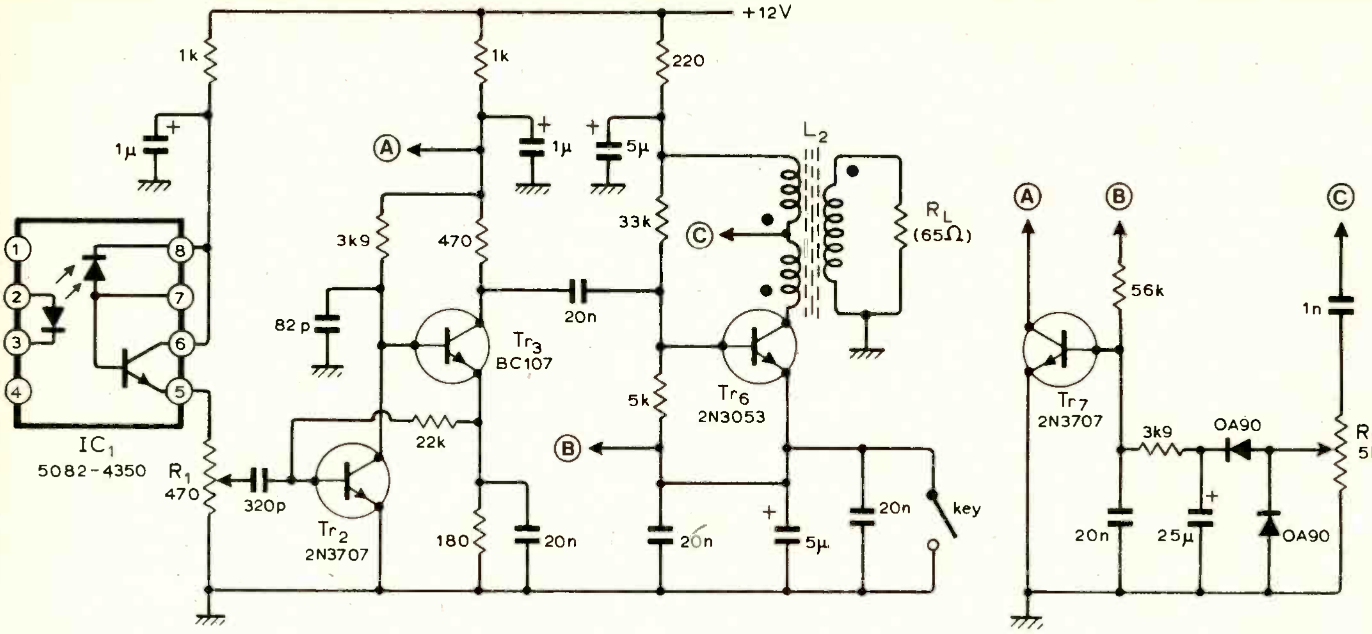


Fig. 2. Final circuit with preamplifier, output amplifier and automatic limiting control (oscillator omitted).

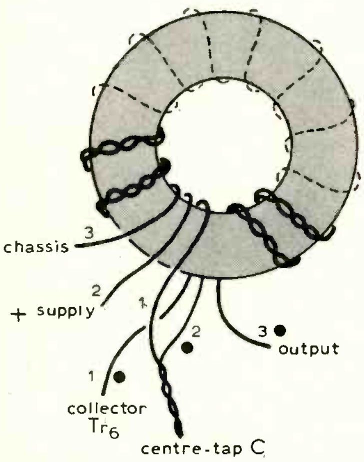


Fig. 3. Construction of the broadband output transformer for Tr_6.

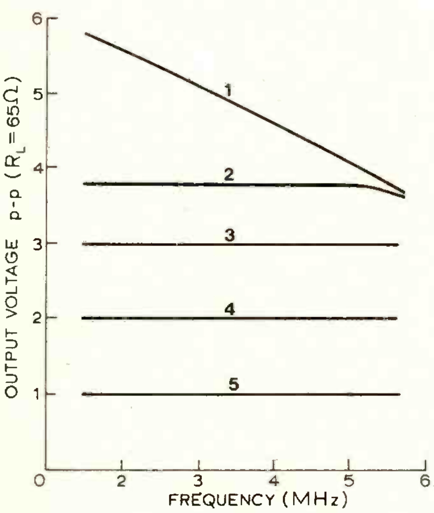


Fig. 4. Output curves of Fig. 2. Voltages are peak-to-peak across the secondary winding loaded with a 65Ω carbon resistor.

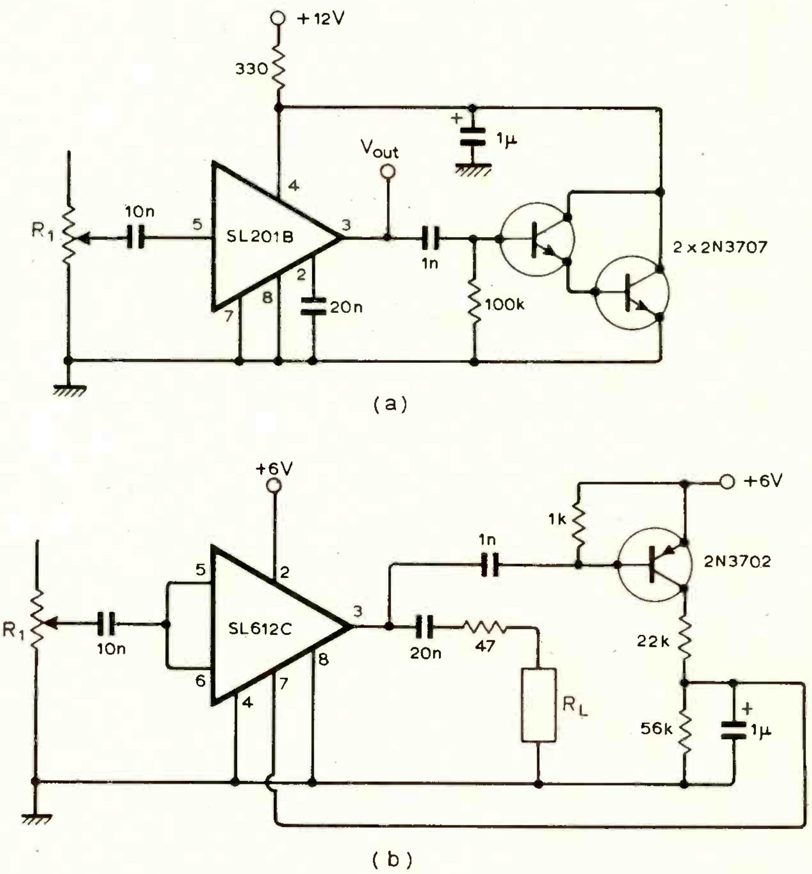


Fig. 5. Alternatives to Fig. 1 using integrated circuits.

The output stage of Fig. 1 is a broadband amplifier with d.c. coupling between Tr_2 and Tr_3. The output is maintained ($\pm 1\%$ over the frequency range of the v.f.o.) at about 2V peak-to-peak, by the automatic limiting control (a.l.c.) action of Tr_4 and Tr_5. Both the v.f.o. and the amplifier stage are fed from a common 12V regulated supply.

For greater output, a second broadband amplifier can be added, Fig. 2. This increases the output to 25mW into 65Ω from 1.5 to 5.7MHz. For simplicity, the output from Tr_3 is coupled via a capacitor to the base of Tr_6. The method of biasing Tr_6 is unusual for an output stage, but provides protection against overdrive or v.h.f. instability from a reactive load. The power output may be increased considerably by decreasing the value of the 220-ohm collector supply resistor for Tr_6, but care should be taken not to exceed the ratings for the transistor by operating into an incorrect load. The collector-to-output matching device is a broadband transformer, constructed as shown in Fig. 3. The output voltage may be kept constant by the action of the a.l.c. circuit, Tr_7 and associated diodes. The output voltage is adjustable by the setting of Tr_2.

The circuit of Fig. 2 also provides for keying of the output by "lifting" the negative rail to Tr_6, and simultaneously switching Tr_7 on, via the 56kΩ resistor to the base of Tr_7. The 5μF capacitor and the a.l.c. network produce a pleasant keying characteristic.

Modulation may also be applied to the base of Tr_7, with forward bias provided by adjustment of R_2. The setting of R_2 will be governed by the depth of modulation required.

Construction

The oscillator section should be built with particular attention to physical ruggedness and good-quality components. The oscillator should be screened from the amplifier. The prototype was built on a printed-circuit board 6cm wide by 11cm long, and this was mounted 1cm above an earth plane. Because of the relatively high r.f. currents present around Tr_6, the bypass capacitors should not be omitted from the Tr_6 emitter rail. In the circuit of Fig. 2 an 82pF capacitor may be necessary from the base of Tr_3 to ground to ensure complete stability. This should not be required in the circuit of Fig. 1.

L_1 is 42 turns of 36 s.w.g. enamelled copper wire, close wound on a 6mm former, with an adjustable iron-dust core, and metal screening can. C_1 and C_2 are chosen to give the required tuning range in conjunction with adjustment to the core of L_1.

L_2 is a broadband transformer comprising 14 turns of 28 s.w.g. enamelled copper wire, trifilar wound on a 12mm o.d., 6mm i.d., 3mm-thick ferrite ring, Fig. 3. The three strands of wire are twisted together, for tight coupling, before winding. The connections to the six free ends are shown in Fig. 3.

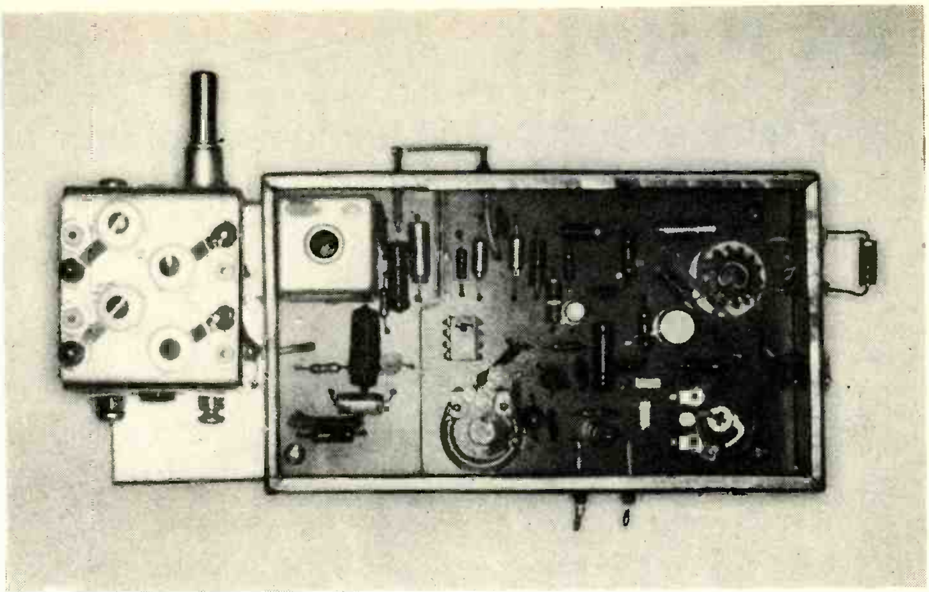


Fig. 6. Assembled v.f.o.

Conclusion

The 5082-4350 device can provide a useful output without further amplification. When used in the common emitter configuration, with a 470Ω resistor in the collector circuit of the photodiode transistor, an output of 200mV p.-p. was obtained at 5MHz. (The d.c. current transfer ratio of the o.c.i. used in the prototype was 13% at 6mA input.) Greater output was obtained at lower frequencies. However, if the frequency range of the v.f.o. is to be large, the output will need to be regulated and further amplification will be required.

The performance of the circuit in Fig. 2 is shown in Fig. 4. The uppermost trace is the output with no a.l.c. applied. The lower traces are with minimum effective a.l.c. (2) over the range 1.5 to 5.5MHz, and with maximum a.l.c. (5) applied. The output can be reduced further by taking the reference voltage (Fig. 2) from the collector of Tr_6. Although the output waveform of the prototype appeared "clean", a low-pass filter should be used if the output of the v.f.o. is to be fed directly to an antenna.

Keying of the final amplifier, and also intermittent disconnection of the 12V supply to the amplifier section, produced no detectable shift in oscillator frequency. A crystal oscillator was used as a reference because the large changes in input signal to the monitor receiver (a Lafayette HA800 A) were sufficient to "pull" the first oscillator of the receiver.

Although the final design is relatively complex, it must be realized that if a narrow band is to be covered (e.g. the c.w. band of 80 metres) then tuned inductors may be used to advantage. However, the present design can be used as a v.f.o. for all of the 160- and 80-metre bands by the switching of C_2 only.

For those constructors who prefer to use integrated circuits, the construction may be simplified by using an i.c. for the linear amplifier section. The circuit around Tr_2 and Tr_3 may be replaced by the Plessey SL201B d.c. coupled 10MHz amplifier (Fig. 5(a)). However, the current drain is increased by 4 to 5mA, and the supply resistor from the 12V line is reduced to 330Ω. A circuit was also built using the more expensive SL612C (current drain typically 3.5mA at 6V). This is a low-distortion broadband amplifier with 70dB a.g.c. capability, and the simple circuit shown (Fig. 5(b)) gave a very good performance.

The various circuits discussed in this article have been used to demonstrate the practicability of using an optically coupled isolator device such as the H.P. 5082-4350, as probably the ultimate solution to the isolation of a variable-frequency oscillator in all types of communications equipment.

Sixty Years Ago

Whoever it was had the idea of using "wireless" as a means of communication between Australian farmers and central stations, Mr W. King Witt, vice-president of the Wireless Institute of Victoria, is the first reported propounder of the notion in *Wireless World*. In an issue largely preoccupied with news of the war, there appears an unsigned report on a tour carried out by Mr Witt, after which he was moved to point out that the use of wireless would reduce "the terrors and disadvantages of loneliness".

"In illness or emergency of any description it would only be necessary for the farmer to seat himself at this instrument and tap out with the key before him his cry for help or his order for a new cultivator. From the transmitter the waves would flash like ripples in the ether, to be gathered in by the cobweb of wires at the central station; and in half the time that would ordinarily be taken, help would be at hand, or the new machine on the road. And, maybe, in the evenings the wireless would crackle busily with private gossip or invitations from one to another 'come round and see us'. Thus would loneliness be banished."

According to the Australian High Commission, there are now around 8,000 licensed operators, working with nine central stations.

IBC Notes

Digital television recording and quadraphonic broadcasting

Two engineers from the BBC Research Department, A. H. Jones and F. A. Bellis, demonstrated at the International Broadcasting Convention an experimental magnetic tape machine for the digital recording and playback of PAL colour television pictures (as illustrated in our June issue, p.185). Colour bars, a test pattern and a few minutes of a light entertainment programme were shown on monitors. The machine is basically a 42-channel data recorder using 1-inch tape (the tape transport supplied by S.E. Labs (EMI) Ltd) and the digital information representing the signal waveform is recorded directly on the tape without high frequency bias. Tape speed is 120 inches per second—about eight times that of a conventional transverse v.t.r.

The television signal is sampled at a sub-Nyquist rate of 8.867MHz (twice the PAL colour subcarrier frequency) and the samples are digitized to give 8 bits per sample. This flow of digital information is then divided among the 42 tracks to achieve a sufficiently low digit packing density on the tape to be suitable for the machine. In fact each track accepts and delivers information at a maximum rate of about 2.6Mbits/s, and with the tape speed of 120in/s this gives a packing density of 22,000 bits per inch. The binary code used for recording is called the "delay modulation" or "Miller" code and has been chosen partly because it allows a clock signal to be extracted from the data so that a separate clock channel is not required. (See "Digital stereo sound recorder" *Wireless World*, Sept. 1972, pp. 432–435 for details.)

Processing circuitry in the digital recorder consists of 42 identical p.c. boards, each carrying all that is needed to process the signal on one track for both recording and replay. Control of these boards is effected by "housekeeping" circuits, pulses from which are distributed via a bus-bar system. The division or "demultiplexing" of digital information into the 42 channels—and the subsequent multiplexing on playback—is done by distributing the signal along bus-bars, with multi-phase clocks to direct it into and out of the appropriate channels. To change the recording format, all that is needed is an alteration in the "housekeeping" circuits (a relatively small job), and the main processing circuits stay unchanged.

Going back to analogue television recording, RCA showed at the IBC a new v.t.r., the TR-70C, which operates with the proposed new "quad II" recording format. This format, for PAL 625-line pictures, is intended to improve machine performance and provide a second programme audio channel, but mainly to reduce tape consumption costs by operating with a tape speed of 7½ inches per second, half the normal quadruplex recorder speed.

Quad broadcasting

The aims of the National Quadraphonic Radio Committee are to determine the basic channel requirements from the surround-sound reproduction standpoint, to clarify the technical issues between proposed systems that meet these requirements, and to fix f.m. signal specifications based on the best available data. Formed in 1972, the committee is sponsored by the US Electronic Industries Association and will report to the FCC early next year, according to E. M. Tingley in a paper given at the IBC.

Subjective listening tests were conducted last year to assess the listening characteristics for systems having two, three or four transmission channels. Closed-circuit tests of f.m. broadcast systems proposed by five companies have just been completed and over-the-air tests are now being run.

The systems proposed basically differ in their handling of a fourth transmission channel, a third channel being accommodated with the existing stereo subchannel but in phase quadrature with it. The third and fourth channels would carry front-to-back and diagonal difference signals. The article starting on page 422 reviews the systems, but three of them stand out as significantly different from Dorren's widely-reported system.

One of the two RCA proposals is for a three-channel transmission system, presumably having the virtue of not consuming any more spectrum space. The Zenith proposal is interesting in that an option is the use of 57-kHz subcarriers to provide signal-to-noise ratio improvement with a companding technique having variable pre- and de-emphasis. The control information would be in double-sideband suppressed-carrier signals in quadrature and the controls would operate on the amplitudes of the four inputs at the transmitter and the four outputs at the receiver in a frequency-dependent way to ensure tracking.

The system of especial interest is the Cooper/Nippon Columbia proposal in which the 38-kHz sub-channels would be coded, while still having compatibility with stereo receivers, to allow a quadraphonic performance to be obtained with only a matrix decoder. Other things being equal, this would seem highly attractive from the consumers' viewpoint in that existing receivers would not need *conversion*—merely *addition* of simple 4-2-4 matrix decoder for quadraphony. The three and four-channel options would provide the consumer with the maximum amount of choice.

The results of the subjective listening tests, without the f.m. link, will be published soon, and they covered localization tests using bursts of a chirp signal with a pink noise background to all four speakers to simulate musical material. The results are said to suggest that the amount of crosstalk is a "major factor in influencing listener acceptance" of musical quadraphony.

On the closed-circuit tests, adjacent, alternate and co-channel interference was assessed, together with signal-to-noise ratios, intermodulation and multipath distortion, and the radiated spectrum under worst-case conditions. For over-the-air tests, being conducted over a 30-mile link in San Francisco, subjective quality will be assessed from recordings, and compatibility with mono and stereo receivers in cars will be checked from recordings made while the vehicle is driven over a certain course.

SCA interference into the mono stereo and quadraphonic services are being checked, as well as the converse case, where distortion and signal-to-noise ratio and amplitude response are also assessed. Amplitude, separation and single-tone distortion versus frequency using a swept sine wave are included.

Non-linearity of air in loudspeaker cabinets

Examination of distortion caused by different types of loading at low frequencies

by H. D. Harwood, B.Sc.

BBC Research Department

In most work involving sounds we assume that air behaves as a perfect medium and that effects due to non-linearity are absent. For the sound pressure levels at which most of us listen this is indeed the case but considerably higher levels exist inside sound-producing devices. Distortion due to the high sound pressures inside a horn[1] has been recognized for some time, but apart from some claims as to the advantages of using the air stiffness of a closed cabinet, to the author's knowledge nothing has been written as to nonlinearity in cabinets. This article deals with the various non-linear effects which are produced in different types of enclosure.

Let us start with the simplest case, that of the closed loudspeaker cabinet.

It is well known that mounting a loudspeaker unit in a closed cabinet raises the resonance frequency to an extent which depends on the volume of the cabinet and on the effective area of the cone. In some designs the engineer has deliberately made the stiffness of the enclosed air much greater than that of the suspension/spider stiffness as it has been claimed that the air stiffness is more linear and that this arrangement results in considerably less distortion at low frequencies. In fact some go further and claim that if the cabinet is also filled with absorbent then isothermal expansion and rarefaction take place and that the air stiffness is then perfectly linear. The argument is that if the usual gas equation $pv^{\gamma}=k$ is taken and γ is made equal to 1, then perfectly linear stiffness results. That this is fallacious is evident if we consider a rigid airtight piston with a volume V behind it in a cylinder. Suppose we displace the piston forwards by a volume also equal to V so slowly that we have isothermal conditions, then the pressure falls to one-half the original value. If, on the other hand, we slowly displace the piston inwards from the rest position again by a volume V, we have infinite pressure, and the stiffness is clearly non-linear.

Now we can calculate the non-linearity due to various percentage volume displacements of a cone in a cabinet and hence the effect on amplitude assuming the air stiffness to be the major component of the mechanical impedance and isothermal conditions. The sound pressure is the double differential of the amplitude and we can thus find the distortion due to various volume displacements. In practice this is largely second harmonic in nature. Now it matters not whether this volume displacement, and hence sound level in the room, is caused by a small piston operating at large amplitude or by a large piston operating at small amplitude, for a given volume displacement we get a given sound level at a given frequency. We can therefore draw up a graph relating the maximum sound level in a given room volume for a given size cabinet, cut-off frequency and say 3% of second harmonic distortion, independent of the size of loudspeaker unit employed, but assuming that the axial response/frequency characteristic is uniform down to the cut-off frequency and then falls off abruptly at 12dB/octave. This graph is shown in Fig. 1.

As we would expect, for a given cut-off frequency the volume required for the cabinet increases with an increase in sound level, and for a given sound level decreases with an increase in lower cut-off frequency. As an example for a cut-off of 40Hz and a sound level of 105dB, a volume of 65 litres ($2\frac{1}{4}$cu.ft.) would be required.

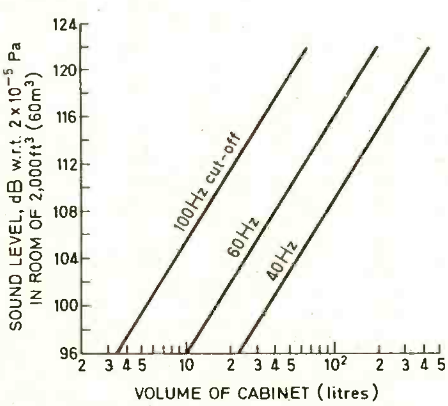


Fig. 1. Relation between Sound Pressure Level for 3% of second harmonic distortion in room of 2000ft³ (60m³) and volume of closed cabinet, assuming various lower cut off frequencies and isothermal conditions.

Several points should be noted here. Firstly that since below the lower cut-off frequency the moving system will be stiffness controlled, the amplitude will be constant as the frequency is reduced, so that the distortion due to the air stiffness is undiminished but as the frequency characteristic is falling at 12dB/octave the level of the second harmonic will be even greater. A second point is that under these conditions, for a given degree of distortion at cut-off, the number of occurrences of this distortion per unit of time will be increased as the cut-off frequency is increased, for the bandwidth over which the distortion takes place is correspondingly wider. Furthermore, since the distortion is largely second harmonic in nature, it follows that partial rectification is taking place with a corresponding displacement of the cone from its centre position, and still further increase in distortion due to non-linearity of the magnetic field, too.

Finally Avedon[2] has shown that it is not possible in practice to obtain true isothermal conditions by using normal acoustic fillings, a γ index of about 1.2 being the lowest he could achieve. From this aspect the air-spring distortion will be even higher than that calculated for Fig. 1.

In spite of its apparent simplicity the air-spring type of loudspeaker is therefore not as innocent as some of its protagonists would like us to think.

Vented cabinet loudspeakers

A common method of reducing the distortions associated with excessive cone velocity and amplitude is to use a vented cabinet, which also has the advantage of increasing the range of the low-frequency response. In this type of design, the acoustic compliance of the air in the cabinet resonates with the inertance of a vent at a specified low frequency as a Helmholtz resonator, and the device acts as an acoustic impedance transformer presenting a high impedance to the rear of the loudspeaker cone and a low impedance to the air. Now a vent may be divided into two extreme classes. It may consist of a simple orifice, that is, a hole whose length is small compared with its diameter, or it may consist of a pipe whose length is large compared with its diameter. The acoustic radiation resistance of the vent is independent of its area, and the vent area is therefore often made much smaller than that of the cone as this avoids, or reduces, the need for a pipe in series with the orifice to obtain a given inertance. It follows, however, that the sound particle velocity in the vent for a given overall sound pressure must be high. The vent is not streamlined and therefore turbulence will be generated; it is clear that this will be greatest when the vent is short, and therefore have a small area for a given inertance, so that the velocity is correspondingly high. Some guidance is therefore desirable as to how small the orifice may be before appreciable non-linearity distortion is generated. If, however, a pipe is connected in series with the vent in order to increase the area for a given inertance, then distortion due to the finite sound pressure or to turbulence may take place in the pipe, and these represent other design limits. These limits are examined here to see how present high quality loudspeaker designs lie with regard to them and to obtain generalized design data, applicable to any loudspeaker, for this form of distortion.

The two main recent investigations of acoustic non-linearity of orifices are by Bies and Wilson[3] and Ingard and Ising[4]. In both experiments Helmholtz resonators were employed in order to obtain high particle velocities, without the use of a source of excessively high sound pressures in the latter case, and in both cases to enable short orifices to be examined. In the former experiment the orifice was 28.5mm long and 90mm in diameter and is therefore representative of actual vents in loudspeakers; in the second case the orifice was made much shorter to emphasize the end effects and was only 0.1mm long and 6mm in diameter, thus representing an extreme case. Note, however, that in both cases the diameter is much larger than the length.

Bies and Wilson show in their Fig. 1 that the acoustic resistance of the orifice is constant for particle velocities up to about 600mm/s, gradually rising in value above this velocity as turbulence sets in. Ingard and Ising show in their Fig. 21 good agreement with this conclusion, although they indicate that the resistance may not be perfectly constant even for lower velocities. On the other hand, waveform traces are given in their Fig. 2, which show no visible harmonic distortion even for velocities* of 2.7m/s.

* Since the nonlinearity is in the orifice, which radiates into the air, it is the velocity waveform we are concerned with not that of the pressure in the cavity which is relatively sinusoidal.

As a compromise between these two values it is worth examining a round figure for maximum velocity of 1m/s. Note that the figure for the critical velocity is independent both of the size of the orifice and of frequency. However, the total percentage distortion obtained for a given sound pressure depends on the size of the orifice, and there is therefore from this point of view an advantage to be obtained in using a fairly large orifice in loudspeaker design.

Against this conclusion is the fact that a large orifice will need a pipe in series with it to enable a given value of inertance to be obtained, and when high sound pressures are propagated along a pipe distortion is generated, in the first place mainly of the second harmonic type.

Thuras et al[5] give the second-harmonic distortion in a planewave, e.g., in a pipe as

$$p_2=\frac{(\gamma+1)\omega p_1^2 x}{20\sqrt{2}\,p_0 c}$$

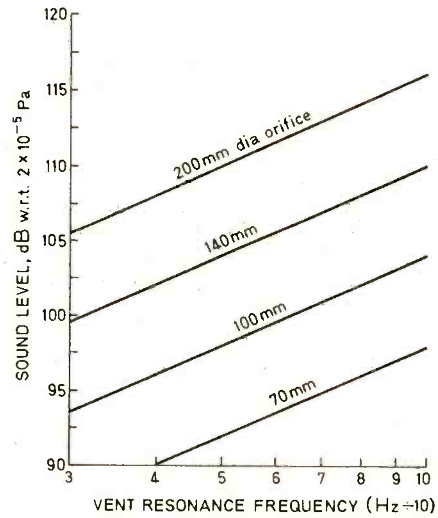


Fig. 2. Minimum pure-tone sound levels at vent resonance frequency in room of 2000ft³ (60m³) for various size orifices and vent resonance frequencies before nonlinearity is appreciable from orifice.

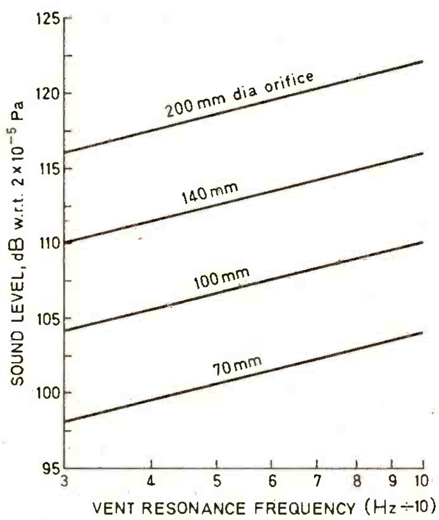


Fig. 3. Minimum programme sound level in room of 2000ft³ (60m³) for various size orifices and vent resonance frequencies before nonlinearity is appreciable from orifice.

where p_1 is the fundamental pressure in *Pa*, γ is the ratio of specific heats, $\omega=2\pi f$, f is the frequency in hertz, c is the velocity of sound in m/s, x is the distance in m, and p_0 is the static pressure in *Pa*.

The levels of the third and higher harmonics are appreciably lower than that of the second harmonic. It is seen that for a given sound pressure in the pipe the distortion is independent of the diameter of the pipe but proportional to its length and to frequency. Increasing the diameter of the pipe would for the same inertance, require a greater length; however, the sound pressure in the pipe would be less and the resulting distortion would be lower. Fortunately, in the present case, the distortion is least at the low frequencies at which a vent is used.

Finally, high sound pressures in the pipe also involve high velocities, and turbulence will occur in the pipe above a critical velocity, the value of which is a function of diameter. Reynolds showed for steady flow the ratio $v_c d/\eta$ is a constant, where v_c is the velocity in m/s, d is the diameter in m, and η is the SI kinematic viscosity, i.e., the dynamic viscosity divided by the density. In fact the constant, called Reynolds number, is not really fixed but for the present circumstances it is about 2300.

Note that in this case the critical velocity is inversely proportional to the diameter of the pipe with a corresponding effect on sound powers available.

Distortion due to an orifice

From the information provided in the previous section it is possible to calculate the sound levels produced by orifices of various diameters when the sound velocity is the maximum specified and for vent resonance frequencies in the range of 30–100Hz, values commonly used.

Olson[6] gives the peak amplitude of a 100-mm diameter piston mounted in an infinite baffle and radiating a sound power of 1 watt as 114mm at 40Hz, this being equivalent to an r.m.s. velocity of 10m/s. The far-field sound level in a listening room of 2000ft³ (60m³) for an omnidirectional source for this sound power[6] will be 102dB w.r.t. 2 × 10^{-5}Pa, or for a velocity of 1m/s a figure of 82dB will be obtained. Now it was shown elsewhere[7] that the programme spectrum is such that the power in an octave band at 40Hz is about 10dB below the peak signal level, and for a vent velocity of 1m/s this would permit a peak programme sound level of 92dB and *pro rata* for other vent resonance frequencies. To take a practical case, in which all the low-frequency sound may be regarded as coming from the vent, such as the BBC studio monitoring loudspeaker previously described[7] in *Wireless World*, the axial response-frequency curve is −5dB at 40Hz with respect to the midband figure. This means that for a vent velocity of 1m/s an overall peak programme sound level of 97dB could be achieved. In fact this loudspeaker is capable of delivering a sound level of 103dB and no complaints of bass distortion have so far been made. It appears therefore that the criterion has been too severe and that owing to the high Q of the orifice the change in total impedance caused by a small change in the resistive component is insignificant. In other words, the level of distortion generated for this value of vent velocity is too low to be audible.

It would appear to be more practical therefore to take the figure from Ingard and Ising just below the one which gives detectable waveform distortion, particularly as their experimental setup represents an extreme case and will therefore err on the safe side. The figure for vent velocity is then some 5m/s, i.e., 14dB higher than before, in which case there is some 8dB in hand in the case of the studio monitoring loudspeaker mentioned, before appreciable distortion is generated. As could be expected from the cause of the non-linearity, the distortion is symmetrical, i.e., consists essentially of odd-order harmonics, largely the third, provided the vent is also reasonably symmetrical.

It is possible to draw up a set of criteria for the maximum pure-tone sound levels at the vent resonance frequency which should not be exceeded for vents of various sizes, and the corresponding peak programme sound levels which can be generated, assuming the response-frequency characteristic of the loudspeaker to be uniform down to these frequencies and the spectrum distribution to be that previously determined. These two sets of criteria are shown in Figs. 2 and 3. For this purpose the curve of programme spectrum[7] has been regarded as a straight line over the frequency range concerned. The error is less than 1dB, and in view of the data this simplification is fully justified.

The importance of the orifice area on the distortion level may be illustrated by a practical example. Fig. 4(a) and (b) show the level of the fundamental from a miniature loudspeaker using a vented cabinet fitted with alternative pipes of differing diameters such that the ratio of the vent areas is about 2:1. To make the results more obvious, the vents used were of very small diameters but their lengths were so adjusted that the vent resonance was the same in each case, about 45Hz. (Owing to the parameters chosen the sound output at the vent resonance frequency was well below that in the mid-band.) The curves shown are the reverse of the customary ones in that they show the levels of fundamental for a constant level (-30dB) of distortion for the third harmonic. It will be seen that, as expected, a higher sound level can be radiated around the vent resonance frequency for the larger vent than for the smaller one.

Fig. 4(c) also shows clearly the effect of the size of the orifice itself on the distortion level. In this case the orifice was made the same size as that of the smaller vent, but the larger diameter pipe was placed in series with it to give the same resonance frequency as before. It will be observed that in spite of the use of the larger diameter pipe the distortion level was determined by the size of the orifice and at approximately the same level as that of the smaller vent.

Distortion in a pipe

Nonlinearity of medium at high sound pressures. As stated earlier, Thuras' formula for this form of distortion is

$$p_2 = \frac{(\gamma+1)\omega p_1^2 x}{20\sqrt{2}\, p_0 c}$$

and it is evident that unlike distortion from an orifice the distortion here is proportional to the frequency and to the length of pipe. The simplest arrangement seems to be to plot p_2 versus frequency for a 100-mm length of pipe.

As an example the sound levels permissible for a distortion level of -30dB, i.e., 3%, may be taken, a figure which corresponds to the degree of distortion just visible on the waveform trace on an oscilloscope and the same as that used earlier.

Rearranging the formula for distortion in a pipe we obtain

$$p_1{}^2 = \frac{20\sqrt{2}\gamma p_0 p_2 c}{(\gamma + 1)\,\omega x}$$

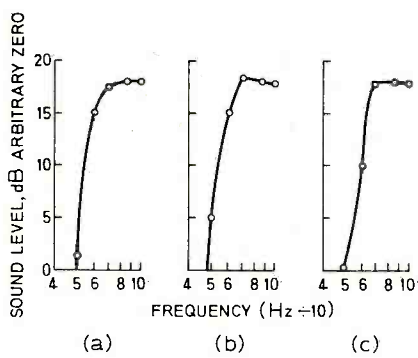


Fig. 4. Level of fundamental tone for 3% third harmonic distortion from miniature loudspeaker fitted with various vents.
(a) pipe diameter 18mm, (b) pipe diameter 25mm, (c) orifice 18mm, pipe diameter 25mm.

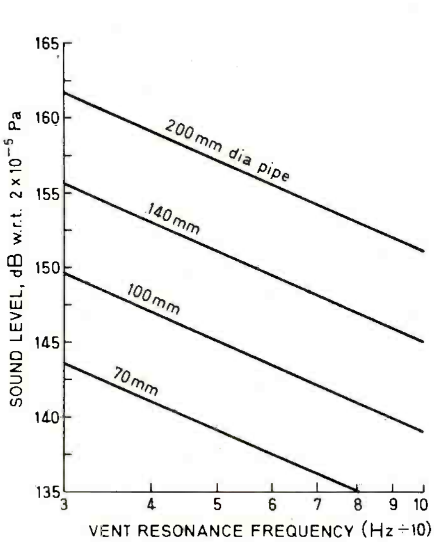


Fig. 5. Minimum pure-tone sound levels at vent resonance frequency in room of 2000ft³ (60m³) from vent pipes of 100mm length and various diameters for 3% second harmonic distortion.

or

$$p_1 = \frac{20\sqrt{2}\gamma p_0 c}{(\gamma+1)\omega x}\cdot\frac{p_2}{p_1}$$

For a value of $p_2/p_1 = 0.03$, $\omega = 50$Hz and $x = 100$mm, the value of p_1 is

$$p_1 = 3.3 \times 10^5 \text{ Pa}$$

with a corresponding particle velocity $p_1/\rho c = 7.5 \times 10^2$ m/s.

This will generate a sound level of 145dB w.r.t. 2×10^{-5}Pa. from a vent of 100mm diameter in a room of 2000ft³ (60m³), and as can be seen from the formula given above the sound level for a given percentage distortion will be inversely proportional to frequency. The values for pure tones and various diameter vents are plotted in Fig. 5. As with an orifice, even higher values will be permissible for the programme sound level.

In comparing these values with those of Fig. 2, it should be remembered that they are for a pipe of 100-mm length and that in practice a length of 200-mm is common for simple vented loudspeakers.

There are some cases, however, such as the labyrinth types of loudspeaker, where the length of the pipe may be as much as one quarter of a wavelength, at say, 40Hz. In such a case the length would be over 2000mm and the distortion would be correspondingly higher, not quite proportional to length as there would exist a standing wave in the pipe, but nevertheless very much higher than in a simple vented cabinet, or alternatively for the same degree of distortion the permissible sound levels might well have to be about 20dB lower.

In the case of the ordinary vented cabinet, for a given degree of distortion for this cause, much larger sound pressures may be developed by using a pipe than by a simple orifice. If, therefore, the sound pressures required are such as to lead to distortion from the latter cause, then the additional use of a pipe would appear at first sight to reduce distortion because for a given inertance a larger diameter orifice will be needed if a pipe is also employed in series with it; but this is not the whole story. It is now necessary to examine the effects of high particle velocity in the pipe.

Distortion due to turbulence in a pipe. As stated earlier, Reynolds gives the relationship for the critical velocity for laminar flow in a pipe as $V_c d/\eta = K$, where $K \approx 2300$. Now it is assumed in this formula that the pipe is long, which can be interpreted as meaning that the length is greater than, say, five times the diameter.

Under these conditions $V_c = 350$mm/s for a pipe of 100-mm diameter and *pro rata* for other diameters. However, just as the Q of an orifice is high and small changes in the resistive component of the impedance were found not to have a significant effect on nonlinearity, so also the Q of a pipe is high and a similar state holds. Unfortunately no known measurements exist of the effect of frequency on turbulence in pipes, so it will be necessary to assume that the same conditions apply as for orifices. It was shown earlier that for an orifice the lowest velocity which gave rise to detectable distortion of the waveform was approximately ten times that at which nonlinearity due to turbulence commenced. A similar ratio will be used here giving a value of 3.5m/s for a 100-mm diameter pipe. The critical velocity is seen to be inversely proportional to diameter while the sound pressure in a room for constant velocity in the pipe is proportional to $(\text{diameter})^2$; the minimum sound pressure in a listening room is therefore proportional to pipe diameter and of course proportional to frequency. This relationship is shown in Fig. 6 for pure tones. As with an orifice, the programme overall sound pressures can be higher and these are shown in Fig. 7; in common with Figs. 2 and 3, distortion is largely third harmonic.

On comparing Fig. 6 with Fig. 2 it will be seen that for large vents the use of a pipe reduces the sound pressure permissible, but that as the diameter is reduced this condition changes until at diameters smaller than those shown in the figure, higher sound pressures would be permissible. Unfortunately, it is in the former case that pipes are most often desirable to obtain a given inertance. In practice, except for labyrinth-type loudspeakers, the position is not quite as bad as this appears to make it, for the pipes employed with large vents are rarely the length postulated, i.e., five times the diameter. In these circumstances the maximum sound pressures capable of being produced will lie somewhere between the two conditions. It is clear, however, that adding a pipe to a large vent can only result in a reduction of the permissible sound pressure.

Finally, it should be remembered that the turbulence both from an orifice and in a pipe has the effect of reducing the Q of the inertance, this will result, as a secondary effect, in a reduction in the output of the loudspeaker at the vent resonance frequency.

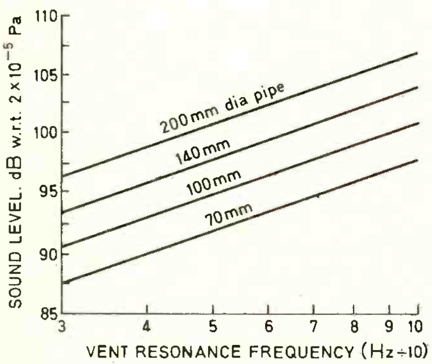


Fig. 6. Minimum pure-tone sound levels at vent resonance frequency in room of 2000ft³ (60m³) for various diameter long pipes and vent resonance frequencies before distortion is appreciable.

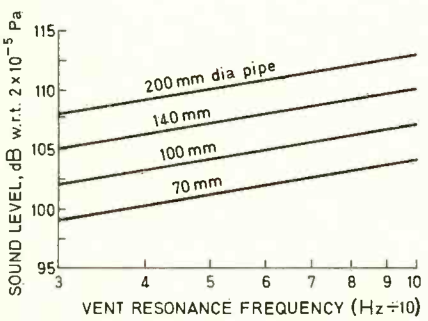


Fig. 7. Minimum programme sound levels in room of 2000ft³ (60m³) for various diameter long pipes and vent resonance frequencies before distortion is appreciable.

Conclusions

Nonlinearity distortion from high sound pressures or velocities is an inescapable property of all types of loudspeaker cabinet. It may be caused by high sound pressures in a closed cabinet, by turbulence at the orifice of a vented cabinet by turbulence in a pipe or even by high sound pressures in a pipe. Employing such data as is available calculations have been made of the minimum sound levels to be expected in a listening room of 2000ft³ (60m³) before distortion from these sources is audible, and for vented cabinets of the Helmholtz type that from high sound pressures in the pipe has been shown not to be a limiting factor in practice although it may well be so for a labyrinth-type of cabinet. For small vents distortion from the orifice predominates while for large vents pipes are to be avoided as far as possible. Design data for these conditions have been drawn up.

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Thanks are due to Director of Engineering for permission to publish this article.

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About People

James H. H. Merriman, C.B., O.B.E., M.Sc., A.Inst.P., F.I.E.E., F.K.C., Hon. D.Sc. (Strathclyde), took office as President of the Institution of Electrical Engineers, on October 1, 1974, having been a Deputy President and a Chairman of its Electronics Divisional Board. He is one of ten past presidents elected from the Post Office since 1873. He joined the Post Office at the Research Station, Dollis Hill, in 1936 after graduating in Honours Physics and following postgraduate research at the University of London. He went on to serve principally in engineering research and development and management of national and international telecommunications, becoming senior director of development in 1969.

In December 1969 he was appointed by the University of Strathclyde, Glasgow, as visiting professor in the Department of Electronic Science and Telecommunications and was awarded, in 1974, by that University, Honorary Directorate of Science. In 1972 he was awarded a Fellowship at King's College (F.K.C.), University of London, and in 1971 was appointed by the Council of the IEE to serve on the governing body of the Imperial College of Science and Technology for four years.

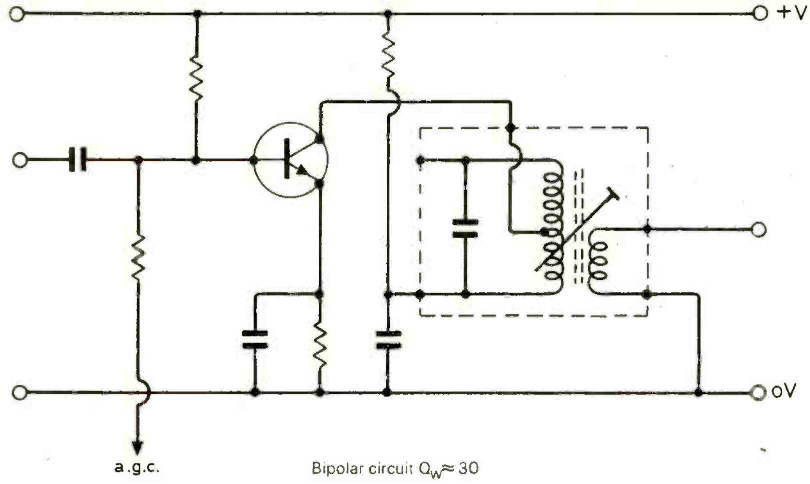
Dr Herbert A. Schulke, Jr, of Washington, DC, has been named general manager of the Institute of Electrical and Electronics Engineers (IEEE). Dr Schulke succeeds Donald G. Fink who has been general manager since IEEE was formed in 1963 and has held the additional position of executive director since 1972. Mr Fink will continue to serve the Institute in an executive role until his retirement in 1976. He plans to devote a substantial segment of his time to furthering co-operation by IEEE with other engineering organizations.

A Fellow of IEEE, Dr Schulke has had 28 years of experience in electronics and communications. He presently serves on the Administrative Committee for the IEEE Aerospace and Electronics Systems Society, and has had several technical papers published in the field of network theory, communications, research and development management and engineering management. He holds the B.S. degree from the US Military Academy at West Point and M.S. and Ph.D. degrees in electrical engineering from the University of Illinois.

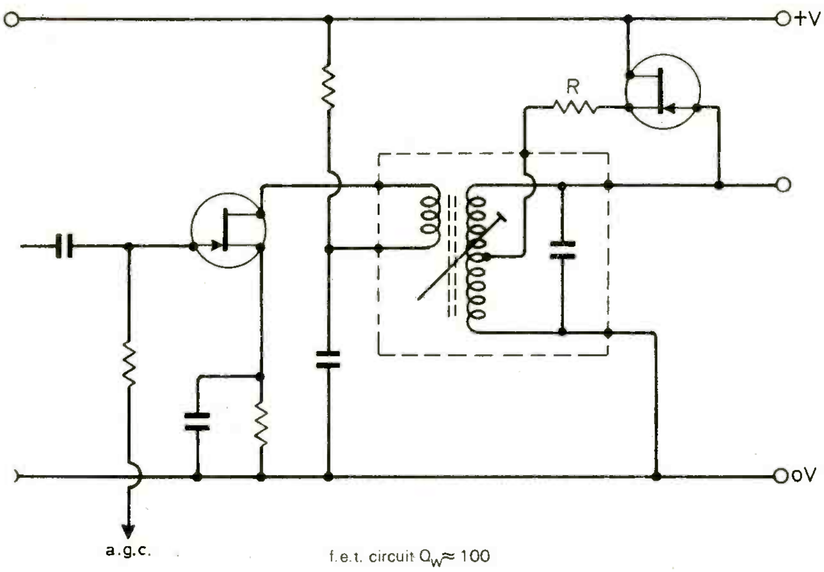
Circards

Sets 16, 17 and 18 of Circards are on the subject of current differencing amplifiers. Set 16, on signal processing, is now available (see October issue). Set 17, on signal generation, will be available at the end of November and Set 18, on measurement and detection, during December. Order a subscription to Circards by sending £13.50 for a series of ten sets to: Circards, IPC Electrical-Electronic Press Ltd, General Sales Department, Room 11, Dorset House, Stamford Street, London SE1 9LU. Make cheques payable to IPC Business Press Ltd.

Circuit Ideas



Bipolar circuit $Q_W \approx 30$



f.e.t. circuit $Q_W \approx 100$

Simple Q multiplier

Transistor i.f. amplifiers at 470kHz using bipolar devices commonly use transformers with an unloaded Q of about 50 and a working Q of around 30. If the bipolar device is replaced by an f.e.t., the transformer primary and secondary connections interchanged, and an f.e.t. added to the transformer to neutralize losses, much better performance can be obtained. Using the same transformer with its unloaded Q of about 50, a working Q of 100 is obtainable in the new circuit when followed by a similar stage. Resistor R controls the Q multiplication and if its value is too low oscillation will occur as $Q \rightarrow \infty$. Provided this situation is not approached, and reasonable decoupling precautions taken, there will be no problems with spurious oscillation. Automatic gain control may be applied in the usual way.

J. A. Short,
Ashford,
Middlesex.

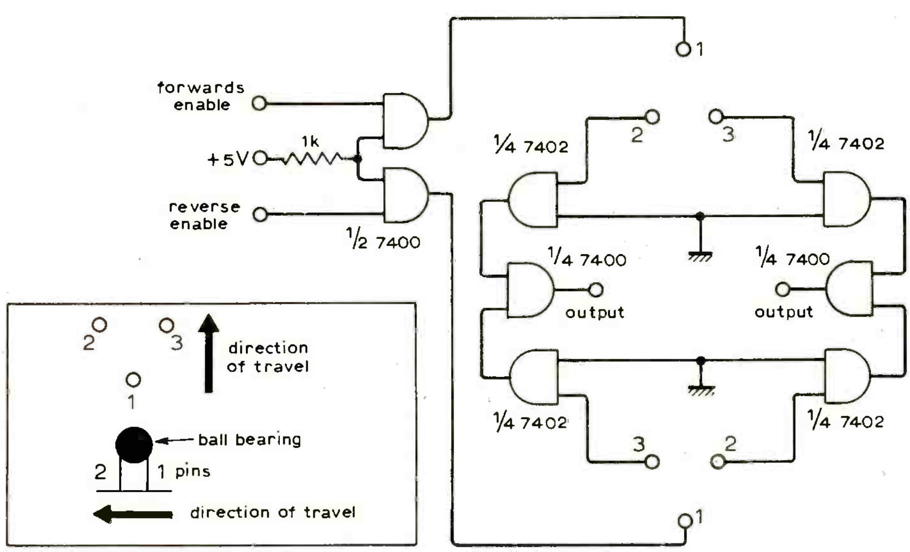
Collision sensor for electronic "animals"

Most published designs for electronic "animals" use either microswitch probes or load sensing for obstacle location, both of which have their limitations. The system to be described has only one fault and two moving parts.

The first two NAND gates serve to enable either the front or real collision sensor. The collision sensor consists of a half-inch ball-bearing mounted on three sewing pins arranged so that when the "animal" hits an obstacle the ball-bearing will rise, thereby breaking the circuit between points 1 and 2/3 which causes the output of one of the NAND gates to go low.

It should be a fairly simple task to incorporate this circuit into most of the published designs.

M. W. K. Cottrell,
London NW8.



November Meetings

LONDON

1st. IEE—Colloquium on "Broadcast camera tubes and the future", at 14.30 at Savoy Pl, WC2.

1st. R. Inst—"John Tyndall's demonstrations on sound 1854–1882," by Prof Charles A. Taylor at 20.45 at The Royal Institution of Great Britain, 21 Albemarle St, W1.

4th. IEE/I.Phys—Colloquium on "Integrated injection logic", at 14.30 at Savoy Pl, WC2.

4th. IEETE—"Television—the challenge and the choice," by T. B. McCrirrick at 18.00 at the IEE, Savoy Pl, WC2.

6th. IERE—Colloquium on "Batteries and power sources," at 10.00 at 9 Bedford Sq, WC1.

6th. I.Phys—Meeting on "How electron beams change surfaces", at 10.00 at Imperial College, SW7.

7th. IEE—"The use of lasers in scientific investigation," by M. J. Kear at 18.30 at Savoy Pl, WC2.

7th. RTS—"Full specification international colour television receiver," by S. C. Jones and R. E. Gray at 19.00 at London Weekend Television South Bank TV Centre, Upper Ground, SE1.

11th. AES—"Normal hearing and its susceptibility to damage," by Dr J. J. Knight at 19.15 at the IEE, Savoy Pl, WC2.

12th. IERE/IEE—Colloquium on "25th anniversary of stored programme computers", at 10.00 at the Royal Society, 6 Carlton House Terrace, SW1.

14th. IERE—"Recent progress in millimetric waveguide systems," by R. W. White at 18.00 at 9 Bedford Sq, WC1.

14th. RTS—"Beam indexing colour television tubes," by Prof. J. A. Turner at 19.00 at London Weekend Television South Bank TV Centre, Upper Ground, SE1.

19th. IEE—"The principles of colorimetry and its application to colour television," by E. W. Taylor and W. N. Sproson at 17.30 at Savoy Pl, WC2.

20th. IEE—Colloquium on "Advanced information processing in industrial inspection", at 14.30 at Savoy Pl, WC2.

20th. IEE—System X: a strategy for telecommunications," by L. R. F. Harris at 17.30 at Savoy Pl, WC2.

20th. IEE—"Stored programme control," by Dr K. Warren at 18.00 at Thames Polytechnic, Riverside House Annexe, Beresford Street, SE18.

21st. IEE/IEETE—Demonstration of "The use of closed circuit television facilities" at 14.30 at the BBC Staff Training Studio, Shepherds Bush, W12.

21st. IEE—Colloquium on "Measurement and control in highway engineering", at 14.30 at Savoy Pl, WC2.

21st. RTS—"A television camera for the cameraman," by P. Groves at 19.00 at London Weekend Television South Bank TV Centre, Upper Ground, SE1.

22nd. I.Phys—Conference on "Materials of electrical and magnetic interest", at 10.00 at the Geological Society, Burlington House, Piccadilly, W1.

22nd. IEE—Colloquium on "Analytical instrumentation", at 10.30 at Savoy Pl, WC2.

25th. IEE—Colloquium on "Weather radar for quantitative rainfall measurement and developments in data remoting", at 14.30 at Savoy Pl, WC2.

26th. IEE—"Adaptive quantization of speech and data signals," by Dr D. J. Goodman at 17.30 at Savoy Pl, WC2.

27th. IEE—Colloquium on "The design and application of microwave transistors", at 14.00 at Savoy Pl, WC2.

27th. IERE—"The US Navy navigation satellite system," by W. F. Blanchard at 18.00 at 9 Bedford Sq, WC1.

28th. IEE—"Photomultiplier tubes and related devices," by J. Sharpe at 17.30 at Savoy Pl, WC2.

28th. IERE—"CAD of type 2-phase lock loops," by P. Atkinson and A. Allen at 18.00 at 9 Bedford Sq, WC1.

28th. IEE—"Sound in broadcasting," by P. M. Weitzel at 18.30 at King's College, Strand, WC2.

ABERDEEN

14th. IEETE—"Standby generation," by H. A. Smedley at 19.30 at Earls Court Hotel, 96 Queens Road.

AYLESBURY

14th. IEE—"Lighting a television studio," by D. C. Lightbody at 19.30 at Aylesbury College, Oxford Road.

BIRMINGHAM

13th. IERE—"Using digital integrated circuits," by J. A. Scarlett at 19.15 at the City of Birmingham Polytechnic.

13th. RTS—"Ceefax/Oracle" at 19.00 at ATV Centre, Broad St.

29th. SERT—"The control aspects of the advanced passenger train," by R. W. Stokes at 19.00 at the Byng Kenrick Suite, University of Aston, Gosta Green.

BOURNEMOUTH

6th. IEETE—"Measurement of electromagnetic interference and transients in aircraft electrical systems," by G. A. Jackson at 19.30 at the Viscount Club, Sea Road, Boscombe.

CAMBRIDGE

21st. IEE/IERE—"Digital adaptive electronic circuits," by Dr I. Aleksander at 18.30 at the University Engineering Laboratories, Trumpington St.

CARDIFF

13th. IERE/IEE—"Mobile radio in the era of spectrum congestion," by Prof W. Gosling at 18.30 at the Dept of Applied Physics & Electronics, UWIST.

CHELTENHAM

12th. IERE/IEE—"Radar approach to weather forecasting," by Prof E. D. R. Shearman at 19.30 at the GC Club, GCHQ, Benhall.

12th. IEETE—"Protective multiple earthing," by J. B. Rudge at 19.30 at MEB Social Club, Hesters Way.

CHESTER

20th. IEETE—"Sounds interesting," by J. D. MacEwan at 19.30 at Chester College of Further Education, Eaton Road, Handbridge.

COVENTRY

7th. IERE/IEE—"The 25-metre steerable aerial at the radio and space field station," by J. A. McGiuney at 18.30 at Lanchester Polytechnic.

EDINBURGH

6th. IERE—"Calculator technology," by R. Bilton at 19.00 at Napier College.

GLASGOW

7th. IERE—"Calculator technology," by R. Bilton at 19.00 at Glasgow College of Technology.

GUILDFORD

6th. IERE—"Why 110° colour?" by A. W. Lee at 19.00 at Lecture Theatre F, University of Surrey.

HULL

13th. SERT—"In-car entertainment," by D. A. Faries at 19.30 at Hull College of Technology.

21st. IEETE—"The use of keyboards as input devices," by J. A. Purdie at 19.30 at Bullock Lecture Theatre, College of Technology, Queen's Gardens.

JORDANSTOWN

12th. IERE/IEE—"50th anniversary of broadcasting in Northern Ireland" (speaker from the BBC), at 19.00 at The Ulster College.

KINGSTON-UPON-THAMES

26th. SERT—Chairman of SERT to give address followed by "Quadraphonics", by Dr. K. Barker at 19.00 at Kingston College of Further Education.

LIVERPOOL

13th. IERE—"Satellite earth stations 1962–1974," by D. I. Dalgleish at 19.00 at the Dept of Electrical Engineering & Electronics, University of Liverpool.

LOUGHBOROUGH

12th. IERE/IEE—"Stereophonic and ambisonic reproduction of sound," by Prof P. B. Fellgett at 19.00 at Room J002, Edward Herbert Building, the University.

MANCHESTER

14th. IERE—"Medical electronics," by E. T. Powner at 18.15 at the Lecture Theatre R/H10, UMIST.

21st. SERT—"ITT CVC8 colour TV receiver," by A. E. Thomas at 19.30 at Room D7, Renold Building, UMIST, Sackville St.

NEWPORT (IoW)

15th. IERE—"Automatic weather stations," by H. R. S. Page at the Technical College.

PLYMOUTH

13th. IERE/IEE—"The life and work of a sound recording engineer," by R. Auger at 19.00 at The Main Lecture Theatre, Plymouth Polytechnic.

PRESTON

21st. IEETE—"Sounds interesting," by J. D. MacEwan at 19.15 at Preston Polytechnic, Corporation St.

READING

14th. IERE—"Hybrid computers and their applications," by Dr R. L. Davey at 19.30 at the J. J. Thomson Physical Laboratory, University of Reading, Whiteknights Park.

REDHILL

6th. IEE—"Medical electronics—in and out of the operating room," by Dr D. W. Hill at 19.30 at the Mullard Research Labs, Cross Oak Lane, Salfords.

20th. IEETE—"The CEEFAX system of information by television," by S. M. Edwardson at 19.30 at Redhill Technical College, Gatton Point.

SWINDON

12th. IERE/IEE—"Colour television," by D. Barnes at 18.15 at The College, Regent Circus.

26th. IEETE—"Stereo broadcasting" (speaker from BBC), at 19.30 at King's Head Hotel, Wood Street.

YORK

14th. IERE—"Development of digital transmission systems," by G. H. Bennett at 18.30 at York College of Further Education.

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

New exhibition for London

A new electronics exhibition is to be held in London from April 13 to 15 in 1976, the year the IEA exhibition, previously held at Olympia, London, moves to the new exhibition centre in Birmingham.

Grosvenor House has been booked for the new event, which is being organized by the Evan Steadman Group. They say "Grosvenor House was the venue some 15 years ago for the electronics shows. The industry will be pleased at the clock being put back to the days when a route march was not required in order to acquire information; when the venue was in central London; when union labour was not mandatory merely to lift a hammer; and when stand space did not represent the major item of the publicity budget".

World of Amateur Radio

"First-timer" 1.8MHz tests

From Stewart Perry, W1BB, comes news that this year's 1.8MHz Transatlantic and Transpacific tests are being specially directed towards the encouragement of "first time" 1.8MHz long-distance contacts by amateurs who have never previously worked across the oceans on this band.

Dates for the 42nd Transatlantic tests are on the Sunday mornings of November 17, December 22, January 12 and February 9 from 0500 to 0730 GMT. British and other European stations should use 1825 to 1830kHz and listen for North American stations between 1800 and 1807kHz, with American stations calling only during the first three minutes of each 15-minute period.

The emphasis on first-time contacts is to overcome any belief that with improved equipment, aerials and know-how, 1.8MHz DX has become commonplace. For many amateurs on both sides of the Atlantic the thrill of working across "The Pond" with low-power 1.8MHz equipment remains an eagerly sought-after experience.

Activity on 24GHz

A number of microwave distance records are held by L. W. G. Sharrock, G3BNL and A. Wakeman, G3EEZ. These include the world record for 21GHz with a 45-mile (72-km) contact between Cleeve Common, near Cheltenham and Clee Hill in Shropshire in 1972. Recently, after receiving permits for operation on the new band of 24GHz which replaces 21GHz, they repeated this performance to establish a 24GHz record of 45 miles using crystal-controlled equipment with 4mW output and 16-inch dish aerials. Contact was made with sufficiently high signal-to-noise ratio for them to feel confident that contact could be made over significantly longer distances and their target is 150km.

A few years ago, Fred Brown, W6HPH/G5AWI showed that on the lower u.h.f. and microwave bands effective use can be made of single and double conical reflectors to overcome the difficulty of constucting true parabolic dish reflectors, with relatively little loss of performance. Dr Dain Evans, G3RPE, has recently carried out some intriguing investigations into the shapes of dustbin lids and has discovered that many of the smoothly-rounded type of ordinary galvanized-iron lids make excellent microwave reflectors to at least 10GHz.

The v.h.f. scene

In World of Amateur Radio for October 1970 I reported the attempts by Geoff Mackenzie-Kennedy, VE2AIO, near Montreal, Canada to establish transatlantic contacts crossband on 50 and 70MHz by means of either auroral or multi-hop sporadic E propagation. But despite considerable effort on both sides of the Atlantic this was not achieved.

Now Geoff Kennedy, after being abroad for 34 years, is back and hoping to settle in Scotland where he hopes to obtain an amateur licence and pick up again his attempts to work crossband across the Atlantic. He remains convinced that it is mainly the problems of time difference, interest and proper equipment, particularly aerials, that have so far frustrated these attempts. While in Montreal on several occasions he has heard multi-hop sporadic E transmissions from the United Kingdom just below the 50MHz band. Similarly he still feels that long-haul auroral sporadic E transmission on 144MHz remains a possibility. At present the 70MHz distance-record for amateurs remains at 1430 miles for a contact between Scotland and Gibraltar in June 1967.

For many years a footnote to the British amateur licence has stopped amateurs from using a series of eleven spot aeronautical frequencies between 144.0 and 144.9MHz. A recent Home Office decision makes it clear that these restrictions have now been lifted for eight of the spot frequencies (144.09, 144.18, 144.27, 144.36, 144.45, 144.63, 144.7 and 144.81MHz), leaving only three forbidden frequencies: 144.0, 144.54 and 144.9MHz.

By the time these notes appear, Oscar 6 will have completed two years in orbit, by far the longest-lived and most successful of the Oscar series of amateur space satellites, although for some time the battery condition has limited operation of the frequency translator to three days a week. There is also a possibility that it may have been joined by Oscar 7, since the latest news is that this may be launched as a piggy-back package with an ITOS satellite on or after October 22. The Oscar 7 144 to 28MHz and 70cm to 144MHz translators will not be commanded "on" for the first three days after launch, and will then be in use on alternate days. Late news of Oscar operations can be gleaned from a weekly "Oscar net" on Sundays at 10.15am on 3780kHz or from the weekly RSGB news bulletins on GB2RS on the 3.5 and 144MHz bands. International "AMSAT" nets also operate on 14,280 and 21,280kHz. Several British amateurs are reported to be nearing a hundred countries worked through the Oscar 6 satellite.

As the number of v.h.f. repeaters, both operating and proposed, grows steadily, the Home Office has made it clear that they consider that only one such station is likely to be authorized to cover any given area and imply that this normally means a separation of about 100 to 150 miles between approved sites unless there are exceptional propagation problems. Among the places which have already been approved or which repeater stations have been proposed are: Bacton, Barnsley, Martlesham, Newquay, Buxton, Belfast, Birmingham, Four Marks (Hants), Myndd Machen, Barkway, Central Scotland, Crystal Palace, Aberdeen, Malvern Hills, Scottish Highlands and Torbay.

To mark the centenary of the birth of Marconi, the Italian amateur radio society ARI is organizing a special v.h.f./u.h.f. contest for Morse operation between 1600 GMT on November 2 and 1600 GMT on November 3 on 144, 432 and 1296MHz open to all amateurs in IARU Region 1 (Europe and Africa).

In brief

The International Amateur Radio Club in Geneva is discontinuing the issue of the special "Contribution to Propagation Research Awards" from the end of the year. More than 1000 diplomas, representing over a million reports, have been issued in ten years. . . . The American magazine *CQ* operates a "dial-a-prop" service providing latest information on propagation conditions and forecasts by means of recorded messages. . . . Apparently in the United States anyone can bring a lawsuit against anyone else for any sum of money and for any reason—nevertheless American amateurs are concerned at the attempt by the neighbours of one amateur to bring a one-million-dollar lawsuit against him over a question of TVI involving some $2000 legal costs. . . . The Canadian amateur, David Dudley, VE3BVD, operating the VE3HUM club station of the Humber Technology Amateur Radio Club was overall winner of this year's achievement as leading British contestant. . . . According to the newsletter of the Derby and District amateur radio society the following callsigns really do exist: W1NDY, K1NKY, SM0KE, W0MAN, 5Z4GT and SP1TS. . . . Fifty years ago the Radio Society of Great Britain chose an emblem—no, not the well-known aerial/capacitor/earth symbol but a design consisting of "the Union Jack surrounded by a frame aerial with the head of Mercury as a crest". . . . And in September 1924 Dr. W. H. Eccles, one of the prominent scientists associated with the RSGB in its early days, made a speech attacking the attempts by the Government to restrict amateur operation. He said: "One cannot reiterate too forcibly that it was the amateurs who discovered the valuable properties of short waves across long distances. Up to three years ago the commercial companies and the experts thought the short waves were no use for long ranges."

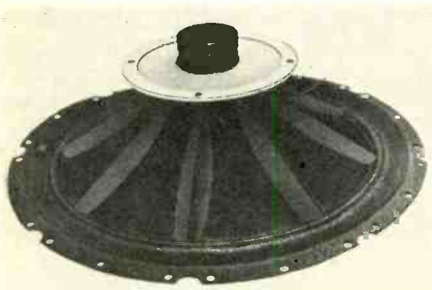
PAT HAWKER, G3VA

New Products

Loudspeaker units with ribbed cone

A new dual concentric drive unit by Tannoy is claimed to incorporate significant advances in performance and reliability compared with earlier models. The new Girdacoustic unit has a freely-suspended stiff-cone assembly possessing high damping. The plastics-lacquered fibrous cone is stiffened by attaching radial ribs on the cone rear (see illustration) allowing quick transmission along the ribs, a new sealed plastics foam surround (Tanoplas) acting as a resistive termination. Response to transients is claimed to be improved and typical amplitude response curves show a smoother response than its predecessor. Power handling capacity is improved (50, 60 and 85 watts for the 10, 12 and 15-in units) by a new four-layer voice-coil assembly. The nylon-based paper cylinder is epoxy-resin bonded with the coil, allowing operation up to 170°C. Crossover network has been redesigned for the high powers using solid-dielectric capacitors. A range of cabinet finishes is available. Tannoy Products Ltd, Norwood Road, London SE27.

WW323 for further details



WW323

Instrument gearbox

An instrument gearbox, the MG8, has been produced by PSB Instruments, and is designed for use with 42mm diameter d.c. motors, such as the Impex 9904 120 10801 low-inertia type. The gearbox is of the same diameter as the motor and can be specified to provide ratios of 5, 10, 20, 50, 100 and 200:1 as standard, with others to special order. The length of the box is 16mm and the 4mm spindle is offset by 10.4mm. PSB Instruments Ltd, Palmerston Road, Harrow, Middlesex HA3 7RL.

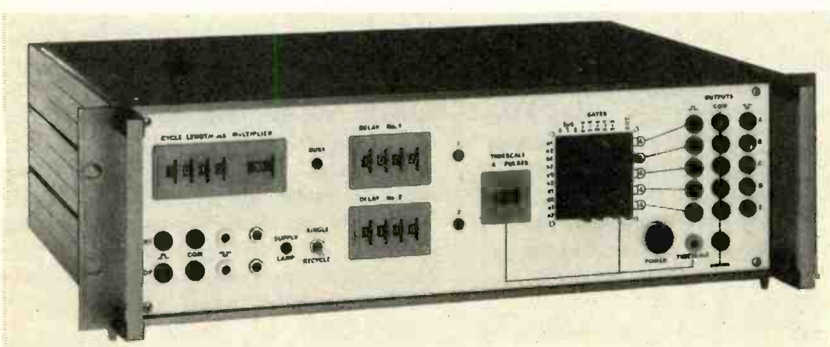
WW303 for further details

WW303

Digital programmer

The Digitimer type D100 has been designed to generate precisely timed pulses for use in electrophysiology. The timing standard used is a 2MHz crystal with digital counting techniques to provide the delays. The instrument will recycle to provide a regularly repeating programme of pulses or will carry out a single cycle and then wait for re-triggering. The length of the cycle is variable between 10µs and 1000s. A matrix board is provided on the front panel which allows signals, generated either internally or externally, to be combined in a variety of ways. The vertical columns carry input waveforms and the horizontal rows feed output stages. Signals on the same row may be 0Red together while adjacent rows implement the AND function. Pulse trains may be formed and signals can be gated by external logic signals. Digitimer Ltd, 37 Hydeway, Welwyn Garden City, Herts AL7 3BE.

WW314 for further details



WW314

Pocket frequency counter

The FM-1 is a hand-held frequency counter using l.s.i. circuitry. Five frequency ranges from 999.9Hz to 9.999MHz full scale are provided with a resolution from 0.1Hz to 1kHz for the decade steps. The input sensitivity is 100mV at 150kHz, decreasing to 300mV at 1MHz. The input is protected against overloads and is claimed to withstand 250V a.c. for 10ns. All readings are ± one count where a count is equal to the range resolution. The meter, which is powered by four pencells, measures 159 × 82 × 69mm and is manufactured by Shelton Instruments Ltd, 24 Copenhagen Street, London N1.

WW305 for further details

Charge neutralizer

The Zerostat is a pistol-shaped instrument for the neutralization of electrical charges (static) on the surface of records, among other objects. The manufacturer claims that it avoids the disadvantages of methods involving fluids, which they say are not completely effective and tend to leave a sticky residue. The device generates about 500 nanocoulombs of ionized air

WW305

at each squeeze of the trigger, which are attracted to oppositely-charged surfaces, thereby neutralizing them. No power is needed and each application will deal with around 100sq.in of surface. Cost is £6.69 inclusive of VAT and postal charges. Zerostat Instruments Ltd, 9 Station Road, St Ives, Huntingdon, Cambs PE17 4BH.
WW309 for further details

Decade voltage source

A six-digit, decade voltage generator with a maximum resolution of 1μV is announced by General Resistance. The DAS66-A will provide ±2p.p.m./°C outputs in three ranges up to 100V at 30mA, with a setting accuracy of ±0.005%, for use in instrument calibration, as a reference or in stability testing. Long-term output stability is ±10p.p.m. over 24 hours and the output is floating. Euro Electronic Instruments Ltd, Shirley House, 27 Camden Road, London NW1.
WW304 for further details

Transducer head amplifier

The D7M is a transducer supply and signal amplifier for use with linear variable differential transformers or other types of inductive transducer, with special relevance to the requirements of machine-tool position measurement. The unit provides 5V at 5kHz to energize the measuring element, the output of which is amplified and rectified to produce a 10V, 10mA maximum output. The whole is contained in a die-cast box with DIN connectors: two presets are provided for gain and zero adjustment. A low-pass filter rolls off at 250Hz. RDP Electronics Ltd, Upper Villiers Street, Wolverhampton.
WW310 for further details

Phase meter

Phase-angle measurements to an accuracy and resolution of 0.1% are performed by the Krohn-Hite 6400 digital meter. Sinusoidal, triangular, square or positively-pulsed waveforms can be accepted, between 100mV and 120V r.m.s., and the 4-digit, 7-segment display indicates phase angle directly in degrees. An analogue output of 10mV/degree is provided. Particular attention has been paid to the reduction of inaccuracies caused by crossover distortion and noise, and the two input signals can be of widely differing amplitudes. Keithley Instruments Ltd, 1 Boulton Road, Reading, Berkshire.
WW307 for further details

High-voltage divider

A high-voltage divider is now available from Wallis Electronics. This divider enables measurement of voltages up to 100kV d.c. with a load current of typically 130μA. The instrument uses calibrated metal-film resistors arranged in a guarded corona free assembly. Forced air cooling is employed and a 3in meter indicates the applied voltage. Two output sockets are provided for monitoring by a d.v.m. Stability is nominally 1 p.p.m. and the accuracy of the divider is ±1% with a temperature coefficient of 10 p.p.m./°C. Wallis Electronics Ltd, Meadow Road, Worthing, Sussex BN11 2RW.
WW319 for further details

520MHz counter

This eight-digit counter/timer from RCS is intended for work in the 470MHz communication band and exhibits a clock oscillator stability of ±2 parts in 10^9/°C. The full range of time and frequency measurements is possible. Input impedance is 1MΩ and 20pF, or 50Ω, and a low-pass filter can be selected for audio work. An additional input will accept t.t.l. logic signals. Radio Control Specialists Ltd, National Works, Bath Road, Hounslow, Middx TW4 7EE.
WW308 for further details

Impulse generator

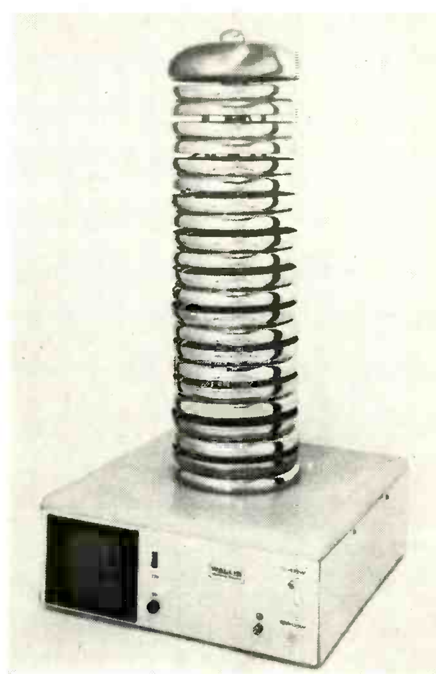
A calibrated impulse generator type CIG-25, recently announced, provides impulses at variable repetition rates between 1 and 100Hz. The repetition rate is accurate to within ±10% of the dial setting with a pushbutton for the generation of a single impulse. An internal fixed attenuator assures a v.s.w.r. of not more than 1.7 to 1. Polarity of impulses may be selected on the instrument which measures approximately 12 × 8 × 6in and weighs 6lb. Penril Corporation, 5520 Randolph Road, Rockville, Maryland 20852, USA.
WW311 for further details

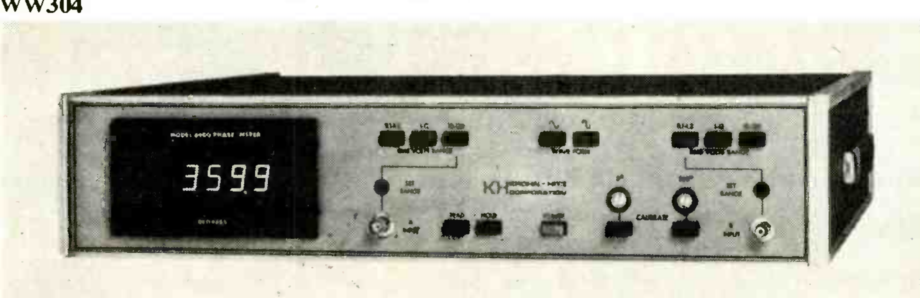
Low-profile socket

An 8-pin d.i.l. socket, type UL083, has been introduced for application where component height is restricted. The socket area for the i.c. has been recessed; therefore the socket height is the complete

WW304

WW310


WW319


WW307

height on the p.c. board. Double-sided spring contacts are used with a tin/nickel alloy finish. This alloy is claimed to give comparable qualities to gold such as good solderability. Jermyn Manufacturing, Sevenoaks, Kent.
WW312 for further details

Pin-insertion machine

The majority of Vero circuit-board terminal pins can be applied by means of their new pin-insertion machine at rates of over 30 per minute. A vibratory feeder orientates and presents the pins to the insertion head, which is controlled by a foot pedal. A sighting device enables easy alignment of the pre-drilled hole with the pin. The machine requires 240V a.c. and an 80 p.s.i. air supply. Packets of 10,000 pins especially selected for use with the inserter are available. Vero Electronics Ltd, Industrial Estate, Chandler's Ford, Eastleigh, Hants.
WW302 for further details

Zero force sockets

A zero force socket suitable for m.o.s./l.s.i. i.cs consists of a housing, two moving parts, tapered ramps and contacts. As the i.c. is inserted the tapered ramps force the pins against the terminals to ensure positive contact. The sockets are available in 24, 28, 38, or 40-pin configuration with automatic ejection of the i.c. if required. Molex Electronics Ltd, 14 Yeading Lane, Hayes, Middlesex.
WW318 for further details

Numeric display

A small l.e.d. display, which is only 0.11in high, is available in two- or three-digit packages, coded 508L-7432/7433 respectively. Both are common-cathode m.o.s.-compatible displays. Power consumption is less than 0.5mW per segment with a peak current of 2mA per segment. The price of the 508L-7432 is £3.31 each and for the 7433 £4.97 each both at the 100-off rate. Celdis Ltd, 37/39 Loverock Road, Reading, Berks RG3 1ED.
WW316 for further details

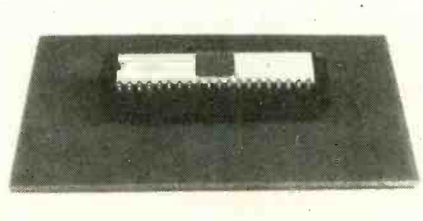
WW302

Digital multimeter

The model 21 multimeter measures capacitance, resistance and a.c./d.c. volts. Four voltage ranges from 2 to 2000V, and resistance ranges from 2kΩ to 2000kΩ are provided plus four capacitance ranges 2, 20, 200 and 2000nF with a corresponding resolution of 1, 10, 100 and 1000pF. The last three digits flash when in over-range. The meter is powered by four NiCad rechargeable batteries, the life of which is extended by a push-to-read button. The unit measures $7 \times 1\frac{3}{4} \times 3\frac{1}{4}$in and weighs 12oz. The meter is supplied complete with leads, batteries, charger and carrying case and priced at £130. Data Technology Corp., Sherwood House, High Street, Crowthorne, Berks.
WW315 for further details

A.m. receiver i.c.

The Signetics NE546A monolithic receiver i.c. is now available from Lock Distribution. The chip comprises a.r.f. amplifier, mixer oscillator, i.f. amplifier, a.g.c. detector, and voltage regulator. Specifications for the device are typically 2.5V sensitivity with a s.n. of 40dB in a temperature range from −40 to +85°C. Power requirements are 9–15V at 15–22mA and packaging is the 14-pin d.i.l. format. Lock Distribution, Neville Street, Middleton Road, Oldham, Lancashire OL9 6LF.
WW300 for further details



WW318

WW316

D.c.-to-d.c. converter

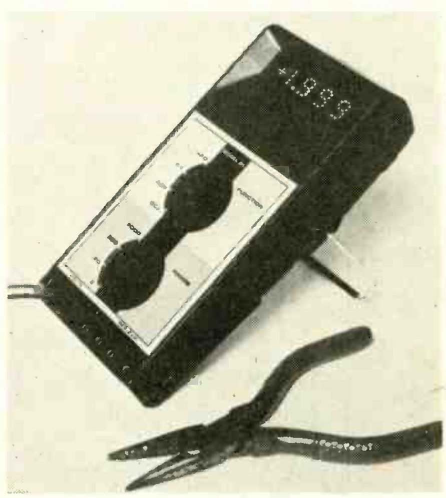
The PC15 range of converters consists of 21 models giving three input and seven output voltage ratings. Each unit has an output rating of 15W. Several models have two outputs which can be connected in series or parallel. All of the devices incorporate short-circuit and overload protection. Input voltages range from 10 to 120V d.c. with outputs from 1.1 to 3.5kV d.c. Operating temperature range is −20 to +55°C and all models measure 88 × 64 × 105mm. Distronic Ltd, 50–51 Burnt Mill, Elizabeth Way, Harlow, Essex.
WW317 for further details

Crystal oscillators

The range of ITT temperature-controlled oscillators is extended by the addition of types TCX04 and TCX08, working at specified frequencies between 4.8MHz and 12MHz. Stabilities are ±0.5p.p.m. between 15°C and 45°C for the 4 (±p.p.m. −55°C to 90°C) while the 8 stays within 1.5p.p.m. from −10°C to 60°C. The output is either a clipped sinusoid or is made available at an open collector. ITT Components Group Europe, Quartz Crystal Division, Edinburgh Way, Harlow, Essex CM20 2DE.
WW306 for further details

Power relay

A miniature power relay, primarily intended for use in car electrical systems, is introduced by B & R Relays. The V23033 is robustly constructed and will switch a current of 7.5A, breakdown occurring when 500V r.m.s. is across the contacts, which are rated at 120W. The relay is designed for printed board mounting, and the standard coil voltages are 6, 12 or 24V. Contacts can be either one make or one changeover. B & R Relays Ltd, Temple Fields, Harlow, Essex.
WW301 for further details



WW315

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.

Priority encoder

An eight-bit priority encoder i.c. in the c.m.o.s. family. Eight inputs are assigned priorities and the input with the highest priority is encoded to 3-bit pure binary.
WW350 for further details **Motorola**

H.f. power transistors

Three devices for use in h.f. transmitters, producing 10, 30 or 70W p.e.p. at 12V in the band 1.6–30MHz (single-ended). Maximum BV_{CES} is 36V and BV_{EBO} 4V. Gain/bandwidth is 100MHz minimum and large-signal current gain a minimum of 10. Type numbers are S10-12, S30-12 and S70-12. Made by Communications Transistor Corporation.
WW351 for further details **Walmore**

Plastic MOSFETS

MEM630 series of low-cost devices in plastic packages, otherwise equivalent to the MEM616 range. All are n-channel, depletion-mode transistors with input-protection diodes. MEM630 is for f.m. radio r.f. amplifiers, MEM631 for use in v.h.f. amplifiers (noise 3.5dB at 200MHz) and MEM632 for v.h.f. and h.f. mixers (conversion gain in 105 to 10.7MHz application is 20dB).
WW352 for further details **GI**

1-kbit RAM

1024-bit bipolar random-access memory, the 93L415, with a static power consumption of 200mW, or 250mW at 75°C. Access time is 80ns. Power dissipation compares with m.o.s. devices, but speed is much higher. Output is at t.t.l. levels.
WW353 for further details **Fairchild**

Linear i.cs

Harris Semiconductor HI-506A and HI-507A 16 and 8-channel analogue multiplexers possess overvoltage protection, break-before-make switching and ±15V input range. Both compatible with d.t.l., t.t.l. and c.m.o.s. and dissipate 7.5mW at standby. HA-2530 has a slew rate of 320V/μs with a power bandwidth of 5MHz. Offset current is 20nA.
WW354 for further details **GDS**

Counter-displays

Modular system of counters, decoders and 7-segment displays, with latches, mounted in anodized aluminium surrounds. Displays are assembled to requirements with edge connectors for the t.t.l. imputs. The units are available in m.o.s.-compatible form.
WW355 for further details **Spectra-Tek**

Trimmable chip capacitors

Two types of chip capacitor for use in hybrid microcircuits by Dionics, Inc. The capacitors consist of separate rectangles of aluminium on a silicon dioxide dielectric which is grown on a silicon substrate. Each area of aluminium is connected in circuit by wire, the adjustment being made by cutting wires. The back of the substrate is gold plated and is bonded to the microcircuit eutectically. Type C-700 exhibits a maximum capacitance of 94pF, while C1248 possesses separate areas in binary sequence (hence the name), enabling setting between 1 and 15pF in 1pF steps. Maximum working voltage is 50V and temperature coefficient is +35 ± 15p.p.m./°C.
WW356 for further details **Walmore**

Power divider

A series of miniature two-way divider/summers by Olektron in the 10kHz to 500MHz range. Power applied to the "sum" port is shared equally by ports A and B, both in phase, while two signals at ports A and B are summed vectorially at the "sum" port. The device is in the TO-5 package.
WW357 for further details **TCE**

10A regulator

A regulator from Motorola in the TO-3 configuration providing 10A at 100W. Output voltage is adjustable from 2 to 35 volts and the output is short-circuit protected.
WW358 for further details **Celdis**

Opto-isolator

A two-channel isolator using GaAs l.e.ds and silicon n-p-n transistors to provide 50% current transfer, 1nA leakage and 1500V insulation between input and output.
WW359 for further details **Guest**

M.o.s. driver

A device to convert t.t.l. signals to the 15V level needed by m.o.s. dynamic RAMs. Operating speed is 31ns for a 15V swing into 200pF. The 9607 device is a quad driver and is equivalent to the 3207A, but using less than half the static power.
WW360 for further details **Fairchild**

Varactor diodes

The VUE series from ITT is intended for high-order frequency multiplication at output frequencies from 4–14GHz.
WW361 for further details **ITT**

2-kbit PROM

Intersil IM5604 electrically programmable ROM organized as 512 4-bit words. The unit is t.t.l.-compatible, has a programming time of less than 1 second for all bits and output capability of 16mA at 0.45V. Access time is 50ns.
WW362 for further details **Celdis**

Programmable dividers

The Plessey SP8685A and B are programmable divide-by-10 or 11 counters, operating at up to 500MHz, for use in synthesizers. The clock input is biased internally and is capacitor-coupled. Division ratio is controlled by two e.c.l. 10k inputs and is 10:1 when either input is high or 11:1 when both are low. The package is 16-pin d.i.l.
WW363 for further details **Plessey**

V-f converter

The F4701 exhibits a maximum non-linearity of 0.01% full-scale from 0–10kHz output frequency. The output takes the form of 5V pulses or is made available at an open collector, protected by a shunt diode. The package is 1.5×1.5×0.4in and is pin-compatible with other units of this general type.
WW364 for further details **Ambleside**

Suppliers

Motorola Ltd, Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex.
Walmore Electronics Ltd, 11–15 Betterton Street, London WC2H 9BS.
General Instrument Europe S.p.a., 20149 Milano, P.zza Amendola 9, Italy.
Fairchild Semiconductor Ltd, Kingmaker House, Station Road, New Barnet, Herts.
GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Berks.
Spectra-Tek UK Ltd, Ings Lane, Kirkbymoorside, York YO6 6DW.
Tony Chapman Electronics Ltd, 3 Cecil Court, London Road, Enfield, Middx EN2 6DL.
Celdis Ltd, 37/39 Loverock Road, Reading, Berks RG3 1ED.
Guest Electronic Distribution Ltd, Redlands, Coulsdon, Surrey CR3 2HT.
ITT Components Group Europe, Standard Telephones and Cables Ltd, Edinburgh Way, Harlow, Essex.
Plessey Semiconductors, Cheney Manor, Swindon, Wilts SN2 2QW.
Ambleside Electronics Ltd, Sentry House, Frimley Road, Camberley, Surrey GU15 2QN.

Real and Imaginary

by "Vector"

"More things in Heaven and Earth . . ."

Maybe you remember the discussion we had a while ago about the mysterious "Raudive" voices which allegedly appeared on unused tapes? That provoked far more correspondence than any other single topic, which seems to indicate that interest in the unknown is still strong, even in our brash, material world. At any rate, that's my excuse for mentioning another spooky little incident, particularly as it's got an electronic content.

A friend of mine—let's call him Jim—dabbles in geology as a pastime and two years ago he took a holiday in Devon with a view to collecting specimens on the moors there. One day, as an aside, he visited a moorland village to locate an old woollen mill which, in the distant past, had been associated with his forebears. He found it to be a complete ruin, with the site overgrown with bushes and trees and the mill itself largely razed to the ground. The property was now owned by the Electricity Board who had utilized the leat to drive a small generator for emergency use.

On applying for permission to explore the ruins, Jim was surprised to find that the local manager was a chap he'd gone to school with, a coincidence that was the open sesame to a conducted tour beyond the locked gates. He was particularly interested in the mill cottage, about which he already knew something from old family records. He knew, for instance, that the mill leat ran right underneath it; that over a century ago a little girl had been drowned there under rather questionable circumstances and that the cottage was supposed to have been haunted, but whether the last two circumstances were connected, he had no idea.

Part of one wall was all that remained of the cottage; the leat had clearly flowed under it but large trees now flourished where the floors had been. As a memento of this eerie place Jim extracted a granite stone from the remains of the wall and in due course brought it home with him. Here it lay around for a while until Mrs Jim suggested that it would be interesting to have it psychometrized. As I'm sure you know, that's a process in which a medium handles a given object and writes his or her impressions.

Jim, who privately thought it would be a good way of exposing such nonsense, agreed, but stipulated that it should be done on an experimental basis. First, he chipped off a fragment of stone so that it was unrecognizable as part of a building; he then sent it to a far-away friend without giving any hint of its history; this friend passed it to another who knew someone who was an amateur practitioner of psychometry. There was thus no possibility that the ultimate recipient could have acquired any data.

Sometime later a "reading" was received and Jim's scepticism was shaken by the accuracy of its description, which mentioned *inter alia*, a strong smell of decay and decomposition, a place of "sinister happenings" and a death by drowning in the vicinity. The writer further strongly urged that the stone should be disposed of quickly—preferably in water. Mrs Jim soon saw to that.

The sequel came this summer when the old mill was again visited. This time Jim had with him a scintillation type of detector for the purpose of trying to locate significant radioactive deposits on the moors (he didn't find any, incidentally!). However, purely on impulse, he switched it on near the ruins and was startled to get readings which, although far from danger level, were much higher than any he'd obtained from the granite-strewn moors. With the instrument in its most sensitive condition the reading in the roadway was seven times the normal, while when the wall was contacted the needle went off-scale. This time Jim couldn't get into the site because the manager was away, so he couldn't determine whether the wall represented a peak or whether the maximum was further in. Moving away from the site did, however, cause a drop in readings.

Now Jim is wondering whether there might be some connection between the extraordinary accuracy of the psychometry reading and the relatively high incidence of gamma radiation. Incautiously he put forward this hypothesis to a senior colleague, a man not without honour in electronics research, who had no hesitation in damning it out of hand. Extra-sensory perception was a nonsense; all mediums were frauds—and so on.

All right; let's admit that Jim's hypothesis is just a long shot with not a shred of hard evidence to back it. But in the absence of an alternative rational explanation it strikes me as thoroughly unscientific to condemn it without investigation. One swallow doesn't of course make a summer, but this example, although extreme, is not isolated. Dogma is not an uncommon feature of research life.

Is such an attitude symptomatic, I wonder, of a defect in our modern mass-attack approach, particularly in industry? Today's graduate emerges from university with a head bursting in an effort to contain a mountain of semi-digested data; thereafter his research life will consist of assigned tasks and a struggle to keep abreast of developments in integrated circuits and black boxes. He won't have the time or the freedom to explore a research tributary if there's apparently no percentage in it. All the pressures conspire to keep him to the tramlines of conventional thought and to encourage the dogma that all the natural laws are enshrined in text-books.

As a money-making policy for industry this, in the short term, may be fair enough; but despite its monumental cost, most of what passes for research today is really development; a fining and refining of the cruder technologies of the past. It's perhaps salutory to reflect that the fundamental laws which we use and the devices which we proudly regard as twentieth-century products were in fact nearly all the results of nineteenth-century research presented to us by a handful of men working with pitiably simple instruments.

"A little learning is a dangerous thing." True. But perhaps not so dangerous to research as the inner conviction that all that there is to know is already known and that any project which doesn't fit readily into the existing framework of laws is impossible. If James Watt had been steeped to the ears in thermodynamics theory, would he still have possessed the naïvety to translate the message of the kettle lid? And would Marconi have got wireless telegraphy off the ground if he'd had prior knowledge of the complexities of ionospheric propagation?

So, back to Jim's hypothesis. Of course it's far-fetched, but no more so than the concept of electromagnetic wave propagation would have been at the start of the nineteenth century. After all, radiation from inanimate objects is known to be information-bearing in that it can give an accurate assessment of age. If it was subsequently shown that, by some means we presently know nothing about, the information content is far more complex, then the possibilities are enormous. And if the idea was shown to be a nonsense, surely it's better to know than not to be sure?

The WW Annual

Wireless World proudly introduce their Annual. Having the same format as *Wireless World*, the Annual contains over 80 pages of editorial, including three major construction features: an audio oscillator, a small-boat echo-sounder, and a double phase-locked loop f.m. tuner. Nomographs and formulae are presented for reference purposes and theoretical articles such as "Estimating signal strength from v.h.f. aerials" and "Loudspeaker design" provide valuable basic design information.

Available from leading bookstalls in November, the Annual is priced at £1 or £1.35 by post from Room 11, General Sales Dept., Dorset House, Stamford St., S.E.1. Cheques and postal orders should be made payable to IPC Business Press Ltd.

Project 80
The slim modules for building stereo hi-fi with FM

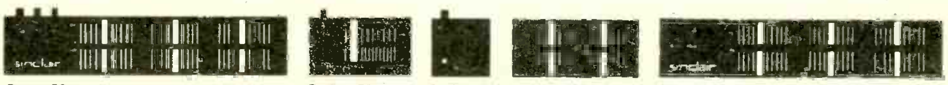
Project 805
Project 80 made even easier to build

Project 805SQ
The add-on assembly that gives you quadraphony

Q16 Loudspeakers
The square speakers for 4 channel listening

Four channel listening has arrived!

Thanks to Project 80 versatility and marvellous compactness, adding two more channels is easy, efficient and economical – you simply add on Project 805SQ, or select the necessary modules from the Project 80 range detailed on the fourth page of this advertisement. Another way is to start with the new Project 805 (which is Project 80 complete in one pack) and add 805SQ to it. Our technicians have adopted the CBS SQ matrix principle to carry the rear left and right channels since it is already clearly the most widely used method in quadraphonic recordings. The decoder, however, can be modified to discrete systems without difficultly. Sinclair suitability for quadraphonics by no means stops with Project 805SQ. The Q.16, always a superb loudspeaker in its own right becomes one of the best ways of creating effective ambience without taking up too much space or money. Project 80 quadraphonic modules are ready now for you to enjoy both stereo and true quadraphonics right away with better reproduction from mono records as well.



Stereo 80 pre-amp/control unit | Project 80 F.M. tuner | Project 80 stereo decoder | Project 80 active filter unit | Project 80SQ quadrophonic decoder

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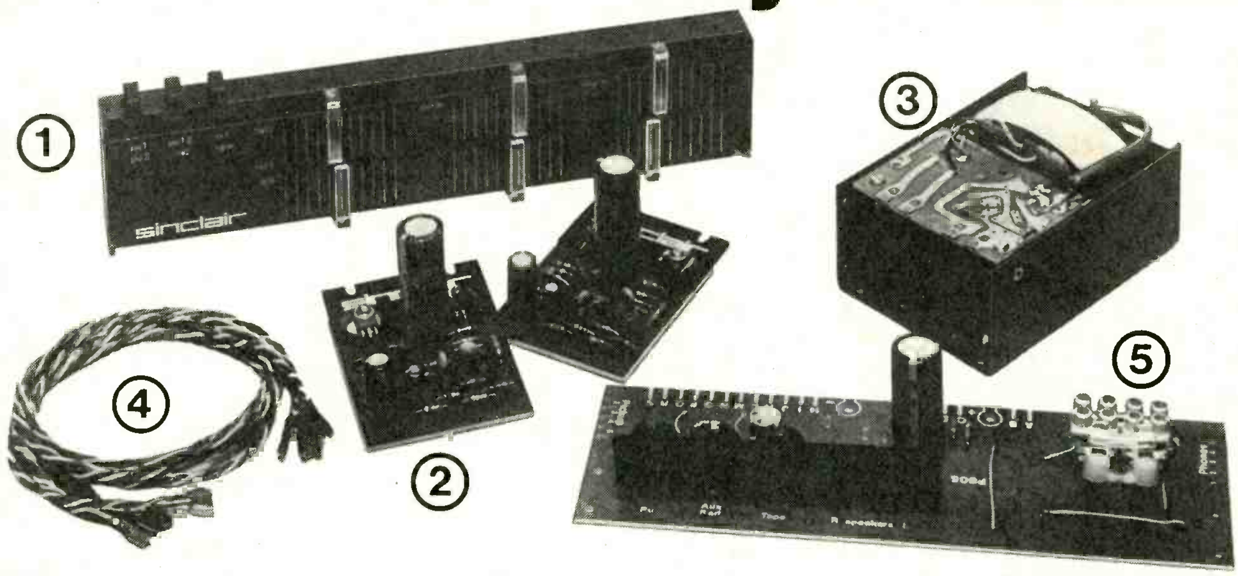
Forward with Project 80 into



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   Two Z.40s to give 8/8 watts R.M.S. output per channel.
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5. Project 805 Masterlink
   For input and output connections.
6. Mains switch block and instructions manual (not illustrated).

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You have seen how the marvellously compact Project 80 modules (only 2″ high × ¾″ deep) are so adaptable and easy to install. Now, with Project 805, this wonderful system is made easier still to put together. In this, you have not only all the Project 80 modules in one pack for building an 8/8 watt R.M.S. hi-fi amplifier – there is also a loom of colour coded wires cut to length and tagged for clipping on so that you don't even have to solder! Input and output connections go via the 805 Masterlink panel. With the explicit stage-by-stage large 32 page instructions manual included, it becomes easy for anyone, no matter how inexperienced to install an ultra-modern assembly so advanced in appearance and design that it sets brand new concepts in domestic hi-fi – and of course, you can convert to quadraphony just whenever you wish by adding 805SQ. Only Sinclair know-how and manufacturing facilities could hope to bring you such quality and versatility.

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Project 805

the complete ready·to·build hi·fi STEREO AMPLIFIER

Project 805 comprises a Stereo 80 Pre-amp/Control Unit with input for both magnetic and ceramic cartridges, radio, tape; separate bass and treble cut/lift, and volume controls 2 × Z.40 power amplifiers, PZ.5 power unit, 805 Masterlink, wire loom, instructions manual, etc. down to nuts, bolts and washers. For technical specifications, see fourth page of this advertisement.

£39.95
+£3.20 VAT (R.R.P.)

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WW—041 FOR FURTHER DETAILS

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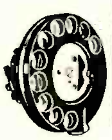

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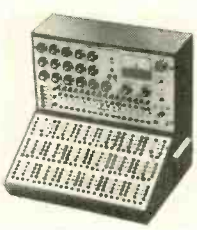

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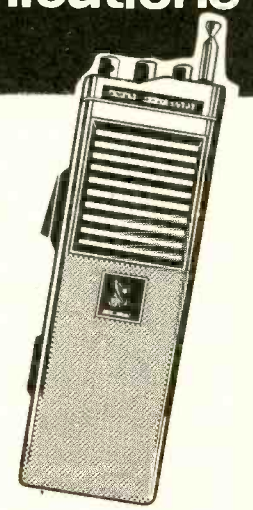

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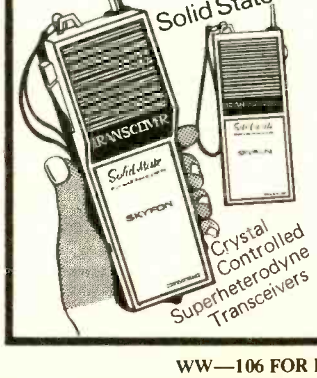

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Type	1+	100+	Type	1+	100+	Type	1+	100+	Type	1+	100+
·47/100v	6p	5½p	22μ/25v	6p	5p	220/40v	7p	6½p	4700/25v	33p	31p
1μ/40v	6p	5½p	22μ/40v	6p	5p	220/100v	16p	14p			
1μ/100v	5p	4½p	22μ/63v	6p	5p	470/16v	6p	5p			
2·2/25v	6p	5½p	22μ/100v	6p	5½p	470/25v	8p	7½p	**Can Type**		
2·2/63v	5p	4½p	47μ/16v	5½p	5p	470/40v	10½p	9¾p	1000/40v	23p	21p
4·7/16v	6p	5½p	47μ/25v	5p	4½p	1000/16v	11p	10p	1000/63v	25p	23p
4·7/40v	5p	4½p	47μ/63v	5½p	5p	1000/25v	12p	11p	2200/25v	34p	31p
4·7/63v	5½p	5p	100/63v	7½p	6¾p	1000/40v	13½p	12½p	2200/40v	39p	36p
10μ/40v	6p	5½p	100/100v	11½p	10½p	1000/63v	25p	23p	2200/63v	53p	49p
10μ/63v	6p	5½p	220/10v	5p	4p	2200/16v	15p	14p	4700/25v	46p	43p
10μ/100v	6p	5p	220/16v	6p	5½p	2200/25v	20p	22p	4700/63v	88p	82p
			220/25v	7p	6p	4700/16v	24p	22p	10,000/25v	70p	65p

DUCATI ELECTROLYTICS

Type	1+	100+	Type	1+	100+	Type	1+	100+	Type	1+	100+
1μ/16v	5p	4½p	22/100v	5p	4⅓p	470/25v	7p	6½p	1500/63v	23p	20p
1μ/350v	6p	5p	47/50v	5p	4½p	470/63v	8p	7p	1500/100v	30p	28p
2·2/25v	5½p	5p	50/50v	5p	4½p	470/100v	8p	7p	2200/6·3v	12v	10p
2·2/63v	5½p	5p	68μ/4v	3p	2¾p	680/6·3v	7p	6½p	2200/16v	12p	10p
2·2/350v	6p	5p	100/3v	4p	3½p	680/16v	7p	6½p	2200/25v	18p	16p
3·3/25v	5½p	5p	100/50v	6p	5p	680/25v	10p	8p	2200/40v	30p	25p
3·3/40v	5½p	5p	100/63v	6p	5p	680/40v	14p	10p	3300/6·3v	19p	15p
3·3/63v	5½p	5p	100/100v	7p	6p	680/63v	20p	15p	3300/16v	15p	14p
4·7/100v	6p	5p	150/6·3v	4p	3½p	1000/10v	6p	4p	3300/25v	20p	18½p
4·7/350v	6p	5p	150/40v	6p	4¾p	1000/16v	8p	7p	3300/63v	45p	40p
6·8/350v	6p	5p	150/63v	6p	5½p	1000/40v	10p	8¾p	4700/6·3v	18p	15p
10μ/100v	5p	4½p	220/40v	6p	5½p	1000/63v	18p	15p	6800/6·3v	18p	15p
10μ/350v	6p	5½p	330/6·3v	4p	3½p	1500/6·3v	9p	8p	6800/6·3v	18p	15p
22/6·3v	5p	4p	330/25v	6p	5p	1500/16v	10p	9p	6800/10v	19p	16p
22/40v	5p	4p	330/40v	7p	5¾p	1500/25v	15p	13p	6800/25v	38p	34p
22/50v	4p	3¾p	470/6·3v	4p	3½p	1500/40v	20p	17p	6800/40p	39p	35p
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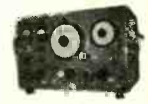

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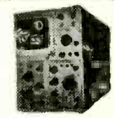

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BA156	15p
BC107	14p
BC108	14p
BC109	15p
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BC149	12p
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BFX85	30p
BFX86	30p
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BFY44	50p
BFY50	25p
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OA200	10p
OA202	10p
OA210	35p
OA211	38p
OC16	90p
OC19	85p
OC22	55p
OC26	65p
OC28	65p
OC35	60p
OC36	65p
OC42	40p
OC44	20p
OC45	20p
OC70	15p
OC71	17p
OC72	20p
OC75	25p
OC76	25p
OC77	40p
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2N1305	25p
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2N2905	0·24
2N2905A	0·26
2N2906	0·19

2N2906A	0·21
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2N2907A	0·24
2N2926	0·11
2N3053	0·32
2N3054	0·60
2N3055	0·75
2N3390	0·26
2N3391	0·23
2N3391A	0·29
2N3392	0·13
2N3393	0·13
2N3394	0·13
2N3402	0·18
2N3403	0·19
2N3440	0·59
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2N3415	0·10
2N3416	0·15
2N3417	0·21
2N3638	0·15
2N3638A	0·15
2N3639	0·27
2N3641	0·17
2N3702	0·11
2N3703	0·12
2N3704	0·14
2N3705	0·12
2N3706	0·09
2N3707	0·13
2N3708	0·70
2N3709	0·11
2N3710	0·12
2N3711	0·11
2N3712	0·96
2N3713	1·20
2N3714	1·33
2N3715	1·50
2N3716	1·80
2N3771	2·20
2N3722	1·80
2N3773	2·65
2N3779	3·15
2N3790	2·40
2N3791	2·35
2N3792	2·69
2N3794	0·24
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2N3901	0·32
2N3903	0·24
2N3904	0·27
2N3905	0·24
2N3906	0·27
2N4036	0·63
2N4037	0·42
2N4058	0·16
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2N5174	0·22
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2N5190	0·82
2N5191	0·95
2N5192	1·24
2N5195	1·46
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2N5457	0·49
2N5458	0·45
2N5459	0·49
40361	0·48
40362	0·50
40363	0·88
40389	0·46
40394	0·56
40395	0·65
40406	0·44
40407	0·33
40408	0·50
40409	0·52
40410	0·52
40411	2·25
40414	3·55
40430	0·85
40583	0·23
40601	0·67
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40603	0·53
40604	0·56
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AF139	0·39
AF170	0·25
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AF178	0·56
AF179	0·65
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BC115	0·17
BC116	0·17
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BC118	0·11
BC119	0·29
BC121	0·23
BC125	0·16
BC126	0·23
BC132	0·30
BC134	0·13
BC135	0·13
BC136	0·17
BC137	0·17
BC138	0·24
BC140	0·34
BC141	0·29
BC142	0·23
BC143	0·25
BC145	0·21
BC147	0·12
BC148	0·13
BC149	0·12
BC153	0·18
BC154	0·18
BC157	0·14
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BC186	0·25
BC187	0·27
BC207	0·12
BC208	0·11
BC212K	0·10
BC212L	0·16
BC214L	0·21
BC237	0·09
BC238	0·09
BC239	0·09
BC251	0·20
BC252	0·18
BC253	0·23
BC257	0·14
BC258	0·13
BC259	0·13
BC261	0·20
BC262	0·18
BC263	0·23
BC300	2·12
BC301	0·34
BC302	0·29
BC303	0·54
BC307	0·10
BC307A	0·10
BC308	0·09
BC308A	0·12
BC308B	0·09
BC309	0·10
BC309A	0·10
BC309B	0·10
BC327	0·21
BC328	0·19
BC337	0·19
BC338	0·19
BCY30	0·64
BCY31	0·64
BCY32	1·15
BCY33	0·45
BCY34	0·49
BCY38	0·55
BCY39	1·50
BCY40	0·87
BCY42	0·28
BCY58	0·21
BCY59	0·22
BCY70	0·17
BCY71	0·22
BCY72	0·13
BCY87	3·54
BCY88	2·42
BCY89	0·97
BD115	0·75
BD116	1·00
BD121	0·75
BD123	0·82
BD124	0·67
BD131	0·40
BD132	0·50
BD135	0·43
BD136	0·49
BD137	0·55
BD138	0·63

BD139	0·71
BD140	0·87
BDY20	1·05
BF115	0·25
BF116	0·23
BF117	0·43
BF119	0·58
BF121	0·25
BF123	0·27
BF125	0·25
BF152	0·20
BF153	0·21
BF154	0·20
BF158	0·23
BF159	0·27
BF160	0·23
BF161	0·42
BF163	0·32
BF166	0·21
BF167	0·21
BF173	0·24
BF177	0·29
BF178	0·35
BF179	0·43
BF180	0·35
BF181	0·34
BF182	0·40
BF183	0·40
BF184	0·30
BF185	0·30
BF194	0·12
BF195	0·12
BF196	0·13
BF197	0·15
BF198	0·18
BF199	0·18
BF200	0·40
BF225J	0·19
BF237	0·22
BF238	0·22
BF244	0·21
BF245	0·33
BF246	0·58
BF247	0·23
BF254	0·16
BF255	0·17
BF257	0·46
BF258	0·59
BF259	0·55
BFS21A	2·30
BFS28	0·92
BFS61	0·27
BFS98	0·25
BFX29	0·30
BFX30	0·27
BFX44	0·33
BFX63	2·48
BFX68	0·30
BFX84	0·24
BFX85	0·30
BFX87	0·28
BFX88	0·25
BFX89	0·90
BFY18	0·52
BFY19	0·62
BFY20	0·50
BFY29	0·40
BFY50	0·23

BFY51	0·23
BFY52	0·21
BFY53	0·18
BFY90	0·75
BRY39	0·48
BU104	2·00
BU105	2·25
C106A	0·46
C106B	0·55
C106D	0·65
C106E	0·43
CA3011	0·83
CA3020A	1·80
CA3029	0·52
CA3046	0·70
CA3036	0·52
CA3043	1·57
CA3045	1·35
CA3048	2·11
CA3049	1·96
CA3050	1·89
CA3051	1·31
CA3052	1·62
CA3053	0·52
CA3070	1·94
CO3086	0·40
CA3089E	1·96
CA30900	4·23
CD4000	0·51
CD4001	0·51
CD4002	0·51
CD4009	1·07
CD4010	1·07
CD4011	0·51
CD4015	2·66
CD4016	1·02
CD4017	2·66
CD4020	2·96
CD4023	0·51
CD4024	1·90
CD4027	1·56
CD4028	2·34
CD4029	3·79
CD4041	2·11
CD4044	2·11
CD4047	1·65
CD4049	0·90
CD4050	0·90
LM301A	0·48
LM304A	2·03
LM309K	1·88
LM702C	0·75
LM709T099	0·48
8DIL	0·38
14DIL	0·40
LM723C	0·90
LM741T099	0·40
8DIL	0·40
14DIL	0·38
LM747	1·00
LM748 8DIL	0·60
14DIL	0·73
LM7805	2·00
MC1303P	1·26
MC1310	2·92
MC1458CP1	0·79
MJ480	0·90

MJ481	1·14
MJ490	0·98
MJ491	1·38
MJE340	0·45
MJE2955	1·12
MJE3055	0·68
MP8111	0·32
MP8112	0·40
MP8113	0·47
MPF102	0·39
MPSA05	0·25
MPSA06	0·26
MPSA55	0·26
MPSA56	0·27
NE555V	0·70
NE560	4·48
NE561	4·48
NE565A	4·48
OC23	1·35
OC28	0·76
OC35	0·60
OC42	0·50
OC45	0·32
OC71	0·20
OC72	0·25
OC81	0·25
OC83	0·24
ORP12	0·55
R53	1·75
RL54	0·15
SC35D	1·68
SC36D	1·46
SC40D	1·89
SC41D	1·32
SC45D	1·89
SC46D	1·96
SC50D	2·60
SC51D	2·39
SL414A	1·80
SL623	4·59
TAA263	1·00
TAA350	2·10
TAA621	2·03
TAA661B	1·32
TAD100	1·50
Filter	0·70
TBA271	0·64
TBA641B	2·25
TBA800	1·50
TBA810	1·50
TIL209	0·30
TIP29A	0·49
TIP30A	0·58
TIP31A	0·62
TIP32A	0·74
TIP33A	1·01
TIP34A	1·51
TIP35A	2·90
TIP36A	3·70
TIP41A	0·79
TIP42A	0·90
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ZTX502	0·18
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W	Tol	Price	Value	
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¼	5%	1·5p	.22/35	14p
½	5%	2p	.47/35	14p
1	10%	2·5p	2.2/35	14p
2	10%	6p	4.7/35	18p
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5	5%	9p	47/6.3V	20p
10	5%	10p	100/3V	20p

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2.5 × 5	30p	30p	—	14p
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× 200	89p	92p		

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1	0·06	0·06½	0·07	0·07	0·09	0·10	—
1·5	0·08	0·09	0·10	0·11	0·12	0·15	0·20
3	0·15	0·17	0·20	0·22	0·25	0·27	0·20
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IN916	0·07	BA115	0·07	BY100	0·15	BYZ11	0·32	OA73	0·10	OA95	0·07
AA119	0·07	BA141	0·17	BY126	0·15	BYZ12	0·30	OA79	0·07	OA200	0·07
AA129	0·15	BA142	0·17	BY127	0·17½	OA9	0·10	OA81	0·08	OA202	0·10
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100	0·36	0·37	0·70	0·75
200	0·30	0·41	0·75	0·80
400	0·36	0·45	0·85	1·10
600	0·40	0·52	0·95	1·25

SCRs	100V	200V	400V	600V
½A	0·43	0·44	—	—
1A	0·45	0·50	0·60	—
1.2A	0·38	0·42	0·53	0·75
3A	0·47	0·53	0·60	0·90
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BA4	5¼"	×	4"	×	1½	50p
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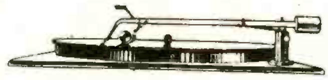

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PS 26 Jack 3.5mm Plastic	0.16
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PS 28 Jack ¼" Screened	0.35
PS 29 Jack Stereo Plastic	0.30
PS 30 Jack Stereo Screened	0.38
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PS 32 Car Aerial	0.22
PS 33 Co-Axial	0.22

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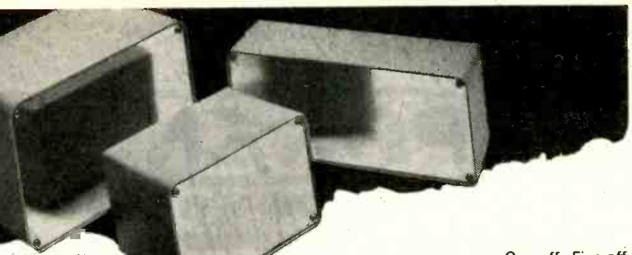

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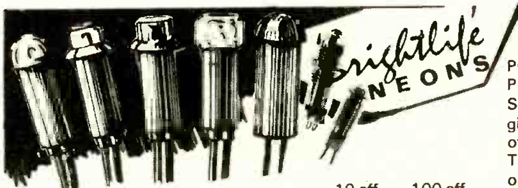
Prices include feet, P & P and 8% VAT.



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.
⅜" PC/A to I	6"	110 or 160–260	**17½p**	**16½p**
⅜" PC/A to I	30"	110 or 160–260	**19½p**	**18½p**
½" PP/A	6"	110 or 160–260	**17½p**	**16½p**
½" PP/A	30"	110 or 160–260	**19½p**	**18½p**
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 September 1974.

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Prices include VAT.

Less for quantity.

(1) No. 265.55. Anodised aluminium centre bar. Black plastic brackets with moulded-in core. 75mm @ **£1.01.** Five more sizes up to 254mm.
(2) No. 281.1. Nylon. 112mm. Load 50 Kg. @ **46p**
(3) No. 277. Ali., ground polished anodised 88mm. @ **98p.** 120mm. @ **£1.11.**
(4) No. 268. Satin ali. 57.5mm. **98p;** 102mm. @ **£1.05;** 146.5mm. @ **£1.22.**(5/6) No. 250. Black nylon, very comfortable. 75mm. @ **30p.** 110mm. @ **43p.** 155mm. @ **69p.**
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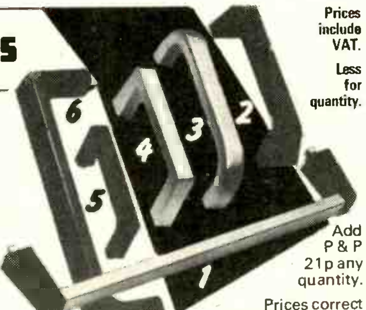

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10 off **£26.95**
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Bi-polar option: + **£5.00**
Sample and hold module: + **£3.**
Prices include P & P, but please add 8% VAT

The Contil DPM is a complete instrument built on a single board with the O.E.M. in mind. Believed to be the lowest cost 2½ digit DPM available, it requires only a 5V supply to operate.
Ranges available are 200mV, 2V, 20V, 200V, unipolar. Bi-polar models are available, also sample and hold. All models normally available ex stock.

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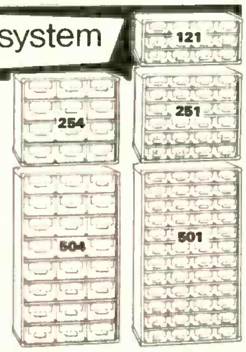

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Frequency range:
10kc/s–33Mc/s in nine directly calibrated ranges. Accuracy ±3% of the indicated centre frequency.
F.M. deviation: (nominal)
0–500kc/s above—4Mc/s
0–400kc/s at 1.5Mc/s—4Mc/s
0–165kc/s at 600kc/s—1.5Mc/s
falling to 3kc/s at 10kc/s.
Output impedance:
75 ohms resistive.
Power supplies:
Mains 100–120V and 180–250V. Frequency 50–500c/s. Consumption 340W (nominal).

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185A 800MHz Sampling oscilloscope.	
185B Sampling oscilloscope.	

TINSLEY TYPE 4363E AUTO VERNIER POTENTIOMETER.
PYE Precision vernier potentiometer 7568. 1µV to 1.90100V in two ranges. Accuracy 0.002%.
SULLIVAN T2100 PRECISION POTENTIAL DIVIDER.
Range:
Input: 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000V. Output: 1V, 200 ohms/V. Accuracy of Ratio: 0.001% or better.
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Main Dial: 17 steps of 0.1 or 0.01V according to the range selected: incorporating a double pole switch which has ⅜" dia. copper studs faced with a 10% gold silver alloy, the multileaf phosphor-bronze brushes are self cleaning. Accuracy ±0.001%.
L30047 CAMBRIDGE UNIVERSAL BRIDGE.
Voltmeter Valve CT54 (Micovac), with mains power supply (power supply not available separately). In strong metal case with full operating instructions. 2.4V–480V AC or DC in 6 ranges, 1 ohm to 10 Megohm in 5 ranges. Indicated on 4 in. scale meter. Complete with probe, £12.50 including p. and p. (Leads extra.)

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515A. DC–15MHz. **£150.**
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545. DC–30MHz. 545A. DC–30MHz.
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Type B. 0.005V/cm to 20V/cm. 0.05V/cm to 20V/cm.
Type CA. 0.05V/cm to 20V/cm.
Type D. 1mV/cm to 50V/cm. Type G. 0.05V/cm to 20V/cm.
Type L. 5mV/cm to 2V/cm. 0.05V/cm to 20V/cm.
Type M. 0.02V/cm to 10V/cm.
230 DIGITAL UNIT.
Digital readout parameters. Pulse amplitude, pulse risetime and falltime, pulse width, time interval.
R116. 10-NS PROGRAMMABLE PULSE GENERATOR
with Delay.
PASSIVE PROBE P6006 with 10X attenuation, designed for oscilloscopes having an input resistance of 1 megohm and input capacitance of up to 55pf. Price **£10.**
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Ranges X1, X10, X100 ±0.05% } After
Ranges X0, 1, V.L.F. ±0.1 } 3 hours.
T.F.801D/1/S A.M. SIGNAL GENERATOR.
Freq. range: 10 MHz to 485 MHz. Built-in crystal calibrator. Internal and external sine a.m. External pulse modulation. Calibration Accuracy: Using crystal calibrator, within ±0.2% over entire frequency range. R.F. output level 0.1µV to 1V source e.m.f. **£249.**
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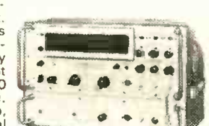

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BASES for above **20p**. P. & P. 15p.

GRATICULES. 12 cm. by 14 cm. in High Quality plastic. **15p** each. P. & P. 5p.

PANEL mounting lamp holders. Red or green. **9p** ea. Miniature. **PANEL** mounting lamp with holders—10V 15MA **5p** ea.

BECKMAN MULTITURN DIAL
Model RB. Brand new.
£1·90. P. & P. 10p.

FIBRE GLASS PRINTED CIRCUIT BOARD. Brand New. Single or Double sided. Any size **$1\frac{1}{2}$p** per sq. in. Postage **10p** per order.

LIGHT EMITTING DIODES (Red) from Hewlett-Packard. Brand New. **38p** ea. Information **5p.** Holders **1p.**

METERS. Ernest Turner Model 402. 100 micro amps. BRAND NEW. Lousy scale—hence **£2·25** ea. P. & P. 25p.

METERS by SIFAM type M 42. 25–0–25 micro amp. Scaled 25–0–25 green; 250–0–250 red; linear. As new. **£2·95** ea. P. & P. 37p.

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0·05mfd 2·5kv **50p** ea. 0·01mfd 5kv **40p** ea.
0·05mfd 8kv **50p** ea. 0·01mfd 10kv **50p** ea.

BLOCK PAPER CAPACITORS AVAILABLE. S.A.E. with requirements.

PHOTOCELL equivalent OCP 71, **13p** ea.

MULLARD OCP70 10p ea.

LOW FREQUENCY WOBBULATOR

Primarily intended for the alignment of AM Radios; Communication Receivers; Filters, etc., in the range of 250 KHZ to 5 MHZ, but can be effectively used to 30 MHZ. Can be used with any general purpose oscilloscope. Requires 12V AC input. Three controls—RF level; sweep width and frequency. Price **£8·50.** P. & P. 35p.
A second model is available as above but which allows the range to be extended down in frequency to 20 KHZ by the addition of external capacitors. Price **£11·50.** P. & P. 35p.
Both models are supplied connected for automatic 50 HZ sweeping. An external sweep voltage can be used instead. These units are encapsulated for additional reliability, with the exception of the controls (not cased, not calibrated).

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YOUR MANUALS
S.A.E. WITH
REQUIREMENTS

MAKE YOUR SINGLE BEAM SCOPE INTO A DOUBLE WITH OUR NEW LOW PRICED SOLID STATE SWITCH. 2 HZ to 8 MHZ. Hook up a 9 volt battery and connect to your scope and have two traces for ONLY **£6·25**. P. & P. 25p.
STILL AVAILABLE our 20 MHZ version at **£9·75**. P. & P. 25p.

20HZ to 200KHZ SINE AND SQUARE WAVE GENERATOR

In four ranges. Wien bridge oscillator thermistor stabilised. Separate independent sine and square wave amplitude controls. 3V max sine, 6V max square outputs. Completely assembled P.C. Board, ready to use. 9 to 12V supply required. **£8·85** each. P. & P. 25p. Sine Wave only **£6·85** each. P. & P. 25p.

MARCONI TF 1331 Double Beam Oscilloscope DC–15MHZ. Sensitivity 50mv/cm. 5 in. flat face tube. TB 0·1 micro sec/per cm. to 0·02 micro sec/per cm. with expansion. Complete with copy of manual **£95.**

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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.)

Unless stated—please add £1·50 carriage to all units.

VALUE ADDED TAX not included in prices—please add 8%

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ELECTRONIC

FABULOUS Marconi

MARCONI Type TF144H STANDARD SIGNAL GENERATOR

Frequency range: 10kHz–72MHz. Crystal Check: 400kHz and 2MHz crystals. Stability: 0.002% in 10 minute interval.

Full specification available on request

£245

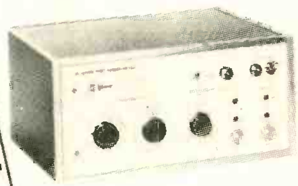
MARCONI TF867 STANDARD SIGNAL GENERATOR

Carrier Frequency. Range: 15Kc/s—30Mc/s in 11 bands. Calibration Accuracy: ± 1%. Output Voltage: 0.4µV–4V. Impedance: 75 ohms nominal for outputs from 2–4V. 75 ohms for outputs from 4µV–2V 13 ohms for outputs from 0.4µV–0.4V. Accuracy: below 3Mc/s ± 0.25dB to ± 0.1µV. 3–10Mc/s ± 0.5dB or 00.2µV. 10–30Mc/s ± 1.0dB or ± 0.5µV. Power Supply: 100–125V, 200–250V, 40–100c/s. Dimensions: 18 in. high x 21in. wide x 14½in. deep.

£139.50

ADVANCE SQUARE WAVE GENERATOR SG21

Frequency Range 9Kc/s to 100Mc/s, Rise time less than 1nS Ex-Demonstration. New condition in manufacturer's original carton.

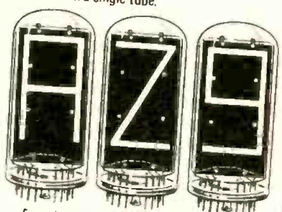


9Kc/s to 100Mc/s continuously variable.
Accuracy ± 4%, ± 1% F.S.
MAIN OUTPUT 20mV–1V into 50 ohm external termination continuously variable.
Accuracy ± 5%.
Maximum output on open circuit 2V.
RISE TIME less than 1nS up to 500mV.
TRIGGER OUTPUT
0.2, 0.4, 1.0, 2.0V into 50 ohm external termination maximum output on open circuit 4V.
Rise time nominally 1.5nS.
Fall time nominally 3.5nS.
Size: 11inW, 5½inH, 9inD.
Wt. 7.1 lb.
LAST LISTED PRICE £95

OUR PRICE £35 P/P £1.50
Also available SG21A 100Kc/s–30Mc/s.

ALPHANUMERIC NIXIE TUBES B7971

The Alphanumeric NIXIE tube has the ability to display all the letters of the alphabet, numerals 0 thru 9 and special characters in a single tube.



From the standpoint of both readability and electrical characteristics, the Alphanumeric NIXIE tube provides many unique benefits including
★ All DC operation ★ Uniform, continuous line characters of equal height
★ Memory with simple solid state drive circuits ★ Readability in high ambient light . . . 200 footlamberts brightness
★ Long life with no loss of brightness
★ Character height 2½ins.

Price only 99p each plus 16p

JUST ARRIVED NIXIE TUBES NUMERIC ONLY. PHONE FOR DETAILS LARGE QUANTITIES

HERE! NOW! FOR IMMEDIATE DELIVERY!

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Fully tested and checked, guaranteed 12 months with one free calibration.

Leads and batteries extra. Leather cases for above £3.50. Ever-ready case enables the meter to be used while in its case £5.

***Please note: X stands for fully tropicalised, splash-proof and mu-metal shield.**

ADD 8% VAT TO ALL PRICES

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MEMORY DRUMS—
SAVE OVER 50% ON ORIGINAL COST

Sperry Floating Head J101 Memory System
* 256 Data Tracks
* 1000 bits/inch
* 8 Megabits
* Speed 3000 rpm
* Access time 10 millisec.
* Data transfer rate 1.65 megabits/sec.
* Recording bit density 1050 bpi
* Complete with electronics for interfacing to DEC PDP8

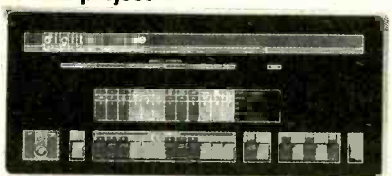
Vermont 1004 Memory Drum
* 128 Data Tracks
* 650 bits/inch
* 4.4 Megabits
* Speed 3000 rpm

RING NOW FOR LATEST ON BRAND NEW DRUMS OR EX-DEMONSTRATION MODELS

WIDE RANGE OF SPARES FOR THE FOLLOWING COMPUTERS ICI 1500, ICL 1900, SYSTEM 4, 4100, 803, AMPEX, etc.

COSSOR VISUAL DISPLAY DID400. Consisting of Keyboard & Display 402 stand alone capability for alphanumeric data entry. Available from **£500**. Please phone for details.

Little used DEC PDP8 systems available for immediate delivery at special prices as a result of cancelled project



PDP8E 12K Processor complete with
Facit 4001 High Speed Reader (500 cps)
Data Dynamics BRPE 114 Punch (110 cps)
ASR33 Teletype
Sperry J101 8 megabit Memory Drum
Line Printer
Rack-mounted in double cabinet

PDP8E 4K Processor complete with
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Data Dynamics BRPE 114 Punch (110 cps)
ASR33 Teletype
Complete in cabinet

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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.**

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BRPE High-speed punch. Self-contained, consists of punch unit, base, motor unit. For use in many data communication systems. Operating speeds up to 100 characters per second (1100 words per minute). Available for punching 5, 6, 7, or 8, level codes, into $\frac{11}{16}$", $\frac{7}{8}$" tape. Synchronous, parallel-wire input. **£145**

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Models S110 and R82C. 17 char. per sec. Rebuilt, available from stock. **£45.**

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In original packing—Numerical from **£4·50.**
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Magnetic Tape Transporters AMPEX TM4, TM2, TM7, FR300, IBM 7330, POTTER. From **£89.00.**

TAPE READERS

Photo-electric Readers for all colour paper tapes up to 1 in.
1CL Type 2640 (250 cps), Elliott T2/94 (250 cps). Elliott D4/42 (500–1,000 cps).
Available with full warranty.
Prices from **£220.**

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Data Entry, parallel to 11 columns. Print speed 5 lines per second. **PRICE £85·00.**

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TEKTRONIX 453A Listed at over £1300.
Special Offer this month £795.

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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**
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Price Per Pair **£950.00**

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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. 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

SPECIAL OFFER

Brand New Digital Volt Meter

NEW LOW, LOW PRICE £37.50

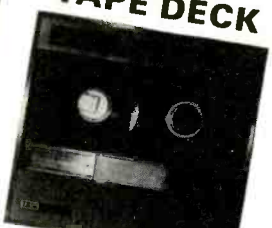
★ With 4 independent inputs ★ 3 digits plus polarity ★ range switching without breaking current measuring circuit ★ High input impedance on voltage ★ low input impedance on current.
Frequency Range 300Hz–500Hz on volts.
Measures 0.01mV–600VDC. 1nA–999mA current. 1mV–600VAC. 100nA–999mA.
NEW CONDITION IN MANUFACTURER'S ORIGINAL PACKING

PRECISION A.C. MILLIVOLTMETER VF 252 BY SOLARTRON

£75

- 1% Accuracy on all ranges
- 0.5% Long Term Stability
- 1.5mV–150V f.s.d. Sensitivity Range
- < 20μV Internal Noise
- 6in. Linear Scale calibrated in volts and dB
- > 30MΩ Input Resistance
- Isolated or Balanced Input

DIGITAL MAGNETIC TAPE DECK



These machines, originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay Heads encased in one common unit. Low resistance heads. Bit density 557 b.p.i. ½ in., 10½ in. spools. 230V to 380V. Capstan motor speed 1,500 r.p.m. 48V DC rewind motors. Finished in brush aluminium and matt black. Size 27 in. X 26 in. X 8 in. Weight 90 lbs.

NEW LOW PRICE £49.50
Vacuum Assembly £15 extra.
Tape £1.50 extra.

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**

THE VERY, VERY LATEST COSSOR

4000–50MHz DUAL TRACE OSCILLOSCOPE

5mV/cm Sensitivity. 10ns/cm to 2s/cm Timebase. Calibrated Sweep. Gated Trigger.
SPECIAL PRICE FOR THIS MONTH ONLY
£349.50

RCA 301 TAPE DECK MODEL 381

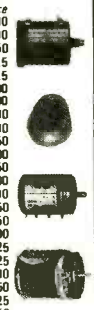
PRICE £29.50

Technical Data. ½" wide Magnetic Tape. Power supplies: Input 208-230V AC 60 c/s. Single phase Magnetic recording head. read/write and erase. Seven channels each head. Speed 30"/sec. forward or reverse. 90"/sec. during rewind. The recording density of 333 characters per inch is maintained, thus giving the nominal read and write rate of 10,000 characters per second. Maximum diameter of 8" tape reel. Accommodates 1200ft. of Magnetic Tape, which gives a minimum of 1,150ft. available for recording.

MINITRON

K.G.M. Type 3015F 7 Segment display showing figures 0–9 plus decimal point. Character pf 9mm height. In 16 DIL case.
NEW LOW PRICE £1·25
SN7447N BCD Decoder Driver **£1·00**.

Potentiometers



TEN TURN 3600° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
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
1K		Relcon	HEL0710	£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
29K	0·05	Beckman	SA1244	£4·50
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
298K	0·1	Beckman	8A3902	£3·50
300K	0·1	Beckman	A.	£3·50

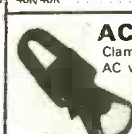
THREE TURN 780° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
25Ω		Beckman	Type C	£2·25
100/100		Beckman	Type C	£3·00
300		Beckman	9303	£2·25
1K		Fox	PX2/H3	£2·25
10K	0·5	Beckman	C.ss.	£2·25
20K/20K	0·1	Beckman	C.S.	£3·00
10K/10K	0·1	Beckman	C.	£3·00
50K	0·5	Beckman	C.S.	£1·75

FIFTEEN TURN 5400° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
25K/25K		Beckman B	10 watts	£6·50
46K/46K		Beckman B	10 watts	£6·50

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 283×94×36mm. Weight 1.5 lbs.
£11.75

SPECIAL PURCHASE OF ADVANCE EX-DEMONSTRATION TEST EQUIPMENT

Advance PG56 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. **£120**

Advance PG52 Pulse Generator
Repetition frequency up to 20MHz and output pulses up to 20V into 5 ohms with rise and fall times of 5nS. Also produces complex ramp wave forms not obtainable from conventional pulse generators. Fully protected against short circuit. **£275**

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
£49.50 EX-DEMONSTRATION BRAND NEW

Carriage and packing charge extra on all items unless otherwise stated.

Please note: all instruments offered are second-hand and tested and guaranteed 12 months unless otherwise stated.

ADD 8% VAT TO ALL PRICES

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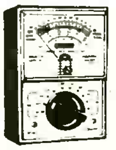
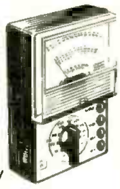
PROMPT DESPATCH MAIL ORDER. CALLERS WELCOME MON–FRI 9 A.M. to 5.30 P.M.

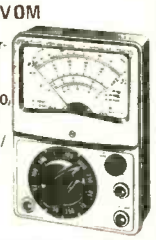
ASK LASKYS and make no mistake

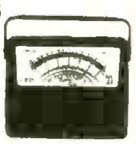
AUDIOTRONIC Model ATM1

Top value 1,000 opv pocket multimeter. Ranges:– 0/10/50/250/1,000 volt AC and DC. DC current 0-1mA/100mA. Resistence: 0/150k ohms. Decibels: –10 to +22dB. Size 90 x 60 x 28mm. Complete with test leads.
OUR PRICE £3.25 P&P 15p

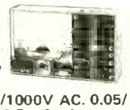
AUDIOTRONIC Model ATM5

Jewel movement, attractively moulded case with edgwise ohms adjustment. Ranges: 0-3/15/150/300/1200V AC, (2500 opv). 0-6/30/300/600V DC, (5000 opv). 0-300 uA/0-300mA DC. Resistance: x 10 & x 100. –10 to +16dB. Supplied with battery test leads and data booklet. Size: 121 x 73 x 29mm.
OUR PRICE £3.95 P & P 20p

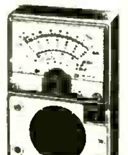
MODEL TH12

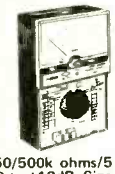
20,000 opv. Overload protection. Slide switch selector. 0/0.25/2.5/10/50/150/1000V DC. 0/10/50/250/1000V AC. 0/50uA/25/250mA DC. 0/3k/30k/300k/3 Megohms. –20 to +50dB.
OUR PRICE £5.95 P&P30p

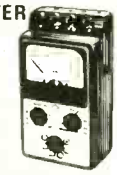
HIOKI 720X VOM

A versatile, accurate measuring instrument. 20,000 opv. 0/5/25/100/500/1000V DC. 0/10/50/250/1000V AC. 0–50uA/250mA. 0–20k/2 Megohms.
OUR PRICE £5.97 P&P 30p

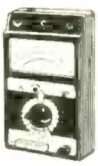
MODEL PL436

20,000 opv DC. 8000 opv AC. Mirror scale 6/3/12/30/120/600V DC. 3/30/120/600V DC. 50/600µA/60/600mA. 10/100K/1 Meg/10 Meg Ohm. –20 to +46 dB.
OUR PRICE £6.97 P&P 30p

U4323 MULTIMETER

20,000opv. Simple unit with audio/IF oscillator. Suitable for general receiver tuning. Ranges: 0.5/2.5/10/50/250/500/1000V DC. 2.5/10/15/250/500/1000V AC. 0.05/0.5/5/50/500mA DC. Resistance: x 10, x 100, x 1,000, x 10,000 (50Ω, 500Ω, 5kΩ, 50kΩ centre scale) Battery operated. Size: 160 x 97 x 40mm. Supplied in carrying case complete with test leads.
OUR PRICE £7.70 P&P30p

HIOKI 730X

30,000 opv. Overload protection. 6/30/60/300/600/1200V DC. 12/60/120/600/1200V AC. 60/µA/30mA/300mA. 2K/200K/2 Meg Ohm. –10 to +63 dB.
OUR PRICE £7.50 P&P 30p

U4324 MULTIMETER

High sensitivity, overload protected. 20,000opv. Ranges: 0.6/1.2/3/12/30/60/120/600/1200V DC. 3/6/15/60/150/300/600/900V AC. Current: 0.06/0.6/6/60/600mA/3A DC. 0.3/3/30/300mA/3A AC. Resistence: 25/500 ohms/0.5/5/50/500k ohms/5 Mohms. Decibels: –10 to +12dB. Size 167 x 98 x 63mm. Supplied complete with test leads, spare diode and instructions.
OUR PRICE £9.25 P&P 30p

U435 MULTIMETER

20,000opv. Ranges: 75mV/2.5/10/25/100/250/500/1000V DC. 2.5/10/25/100/250/500/1000V AC. Current: 50uA/1/5/25/100mA/0.5/2.5A DC. 5/25/100mA/0.5/2.5A AC. Resistance: 0.3/3/30/300k ohms. Size: 205 x 110 x 84mm. Supplied complete with leads, crocodile clips and steel carrying case.
OUR PRICE £8.75 P&P 30p

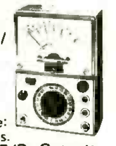
U4312 MULTIMETER

extremely sturdy instrument for general electrical use. 667opv. 0/0.3/1.5/7.5/30/60/150/300/600/900V DC & 75mV. 0/0.3/1.5/7.5/30/60/150/300/600/900V AC. 0/300uA/1.5/6/15/150/60/600mA/1/1.5/6A DC. 0/1.5/6/15/60/150/600mA/1.5/6A AC. 0/200/3k/30k ohms. DC accuracy 1%. AC 1.5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions.
OUR PRICE £10.25 P&P50p

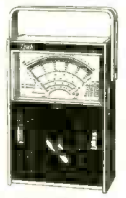
U91 Clamp VOLT AMMETER

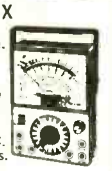
For measuring AC voltage and current without breaking circuit. Ranges: 300/600V AC. Current: 10/25/100/250/500A. Accuracy 4%. Size 283 x 94 x 36mm. Complete with carrying case, leads and fuses.
OUR PRICE £13.50 P&P 30p

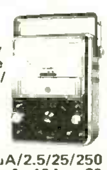
MODEL 500

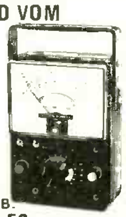
30,000 opv with overload protection. Mirror scale. 0/0.5/2.5/10/25/100/250/500/1000V DC. 0/2.5/10/25/100/250/500/1000V AC. 0/50uA/5/50/500mA. 12A DC. 0/60k/6 meg/60 megohms.
OUR PRICE £13.95 Carr. paid
Leather case for above £1.75

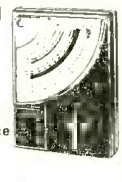
HIOKI 750X VOLT-OHM-MILLIAMETER

43 ranges: 0–0.3/0.6/1.5/3/6/12/30/60/150/300/600/1,200V DC. 0–3/6/15/30/60/120/300/600/1,200V AC. Current: 0–30/60uA/1.5/3/15/30/150/300mA/6/12A. Resistence: 0–3/300k/3/30Mohms. Decibels: –10 to +17dB. Output:– 0–3/6/15/30/60/120/300V. Accuracy ± 3% DC, ± 4% AC. Sensitivity: 50,000 opv DC, 5,000 opv AC. 4 inch meter. Built in protection. Size: 57 x 102 x 153mm.
OUR PRICE £11.95 P&P 40p

TMK MODEL TW50K

46 ranges, mirror scale. 50k/V DC 50k/V AC. DC Volts: 0.125/0.25/1.25/2.5/5/10/25/50/125/250/500/1000. AC Volts 1.5/3/5/10/25/50/125/250/500/1000. DC current 25/50uA/2.5/5/25/50/250/500mA/5/10A. Resistence: 10k/100k/1 Meg/10 Meg ohms. –20 to +81.5dB.
OUR PRICE £12.50 P&P 20p

HIOKI MODEL 700X

100,000opv. Overload protection. Mirror scale. 0.3/0.6/1.2/1.5/3/6/12/30/60/120/300/600/1200V DC. 1.5/3/6/12/30/60/150/300/600/1200V AC. 15/30uA/3/6/30/60/150/500mA/6/12A DC. 2k/200k/2M/20MOhms. –20 to +63dB.
OUR PRICE £14.95 P&P30p

Model HT100B4 MULTIMETER

Overload protected, shock proof circuits. 9.5uA Meter with mirror scale. Sensitivity 100kV. Polarity change switch. Ranges: 0.5/2.5/1-/50/250/500/1,000 Volts DC. 2.5/10/50/250/1,000 Volts AC. DC resistence' 0–20/200k/2/20 Meg. ohms. DC current:– 10/250uA/2.5/25/250mA/10A. AC current:–0–10A. –20 to +62dB. Operates from 2 x 1.5V batteries. Size: 180 x 134 x 79mm.
OUR PRICE £17.50 P&P 40p

MODEL AS.100D VOM

100,000 opv. Mirror scale. Built-in meter protection. 0/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600V AC. 0/10µA/6/60/300mA/12 Amp. 0/2K/200K/2M/200 Meg Ohm. – 20 to +17dB.
OUR PRICE £17.50 P&P 30p.

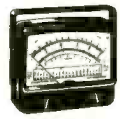
MODEL C7202EN

20,000 o.p.v. DC. 10,000 o.p.v. AC Mirror Scale. 5/25/50/250/500/1000/2500 V. DC. 10/50/100/500/1000 V. AC. DC Resistance x10, x1000 (30Ω centre scale) DC Current 50uA/2.5mA/250mA. –20 to +68 dB.
OUR PRICE £6.50 P & P 30p

KAMODEN 360 MULTIMETER

High sensitivity. DC 100kohm/V AC 10kohm/V 5" mirror scale, overload protected. Ranges: 0.5/2.5/10/50/250/1000V DC. 5/10/50/250/1000V AC. Current: 0.01mA/0.5/5/50/500mA/10A. Resistance: 0.1/1/10/100 ohms/1/10/100k ohms/10/100M ohms. Decibels –20 to +62dB. Battery operated. Size: 180 x 140 x 80mm. Supplied complete with, test leads etc.
OUR PRICE £17.50 P & P 40p

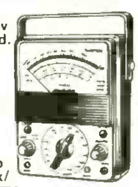
TMK MODEL 117 FET ELECTRONIC VOLTMETER

Battery operated. 11 Meg input, 26 ranges. Large 4¼" mirror scale. Size: 149 x 117 x 60mm. 0.3–12000V DC. 3–300V RMS AC. 8–800V P.P. DC current 0.12–12mA. Resistence up to 2000MOhms. Decibels: –20 to +51dB. Supplied complete with leads and instructions.
OUR PRICE £18.50 P&P 20p

TMK 100K LAB TESTER

100,000opv. 6½" scale. Buzzer short circuit check. Sensitivity 100,000 opv DC. 5k/V AC DC Volts: 0.5/2.5/10/50/250/1000V AC. 3/10/50/250/500/1000V DC. current 10/100uA/10/100/2.5/10A. Resistence: 1k/10k/100k/10 Meg/100 Meg ohms. Decibels: –10 to +49dB. Plastic case with carrying handle. Size: 190 x 172 x 99mm.
OUR PRICE £19.95 P&P 30p

370WTR MULTIMETER

Features AC current ranges. 20,000opv. 0/0.5/2.5/10/50/250/500/1000V DC. 0/2.5/10/50/250/500/1000V AC. 0/50uA/1/10/100mA/1/10A DC. 0/100mA/1/10A AC. 0/5k/50k/500k/5 Meg/50 Meg. Decibels: –20 to +62dB.
OUR PRICE £19.95 P&P 30p

KAMODEN 72.200 Multitester

High sensitivity tester. 200,000 opv Overload protected. Mirror scale. Ranges:–0/.06/.3/3/30/120/600/1200V DC. 0/3/12/60/300/11200V AC. 0/6uA/1.2mA/120mA/600mA/12A DC 0/12A AC. –20 to +63dB. 0/2k/200k/2 Meg/200 Megohms.
OUR PRICE £22.50 P&P 30p

U4317 MULTIMETER

High sensitivity instrument for field and laboratory work. Knife edge pointer, 86mm. mirror scale. Overload protection. Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000V DC. 0.5/2.5/10/25/50/100/250/500/1000V AC. Current: 50uA/0.5/1/5/10/50/250mA/1/5A DC. 0.25/0.5/1/5/10/50/250mA/1/5A AC. Resistance: 0.5/10/100/200 ohms/1/3/30/300k ohms. Decibels: –5 to +10dB Battery operated. Size: 210 x 115 x 90mm. Supplied in carrying case complete with leads.
OUR PRICE £16.50 P&P 40p

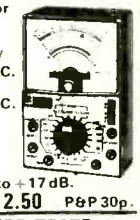
MODEL U4311 Sub-standard Multi-range Volt-Ammeter

Sensitivity 330 Ohms/Volt AC and DC. Accuracy 0.5% DC. 1% AC. Scale length: 165mm. 0/300/750uA/1.5/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A DC. 0/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A AC. 0/75/150/300/750mV/1.5/3/7.5/15/30/75/150/300/750V DC. 0/750mV/1.5/3/7.5/15/30/75/150/300/750V AC. Automatic cut out device. Supplied complete with test leads, manual and test certificates.
OUR PRICE £52.00 P&P 50p

ALL PRICES EXCLUDE VAT

MODEL C7208FM

30,000 opv DC. 15,000 opv AC. 6/3/15/60/300/600/1200 V. DC. 6/30/120/600/1200 V. AC. DC Resistance x 1, x 10, x 100, x 1000 (50Ω centre scale) DC Current 30uA/3/30/600mA. –20 to +63dB.
OUR PRICE £8.95 P & P 30p

MODEL AF.105 VOM

50,000 opv. Mirror scale. Meter protection. 0/3/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600/1200V DC. 0/30µA/6/60/300 mA/12 Amp. 0/10K/1m/10m/100 Meg Ohms. –20 to +17 dB.
OUR PRICE £12.50 P&P 30p.

LB3 TRANSISTOR TESTER

Tests ICO and B. PNP/NPN. Operates from 9V battery. Instructions supplied.
OUR PRICE £3.95 P&P 20p

LB4 TRANSISTOR TESTER

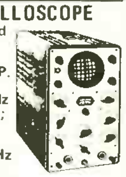
Tests PNP or NPN transistors. Audio indication. Operates on two 1.5V batteries. Complete with instructions etc.
OUR PRICE £4.50 P&P 20p

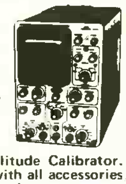
U4341 Multimeter & Transistor Tester

27 ranges. 16,700opv. Overload protected. Ranges: 0.3/1.5/6/30/60/150/300/900V DC. 1.5/7.5/30/150/300/750V AC. Current: 0.06/0.6/6/60/600mA DC. 0.3/3/30/300mA AC. Resistance: 0.06/0.6/2/6/20/60/200k ohms/2 Mohms. Battery operated. Supplied complete with probes, leads and steel carrying case. Size: 115 x 215 x 90mm.
OUR PRICE £10.50 P&P 30p

S100TR MULTIMETER TRANSISTOR TESTER

100,000opv. Mirror scale. Overload protection. 0/0.12/0.6/3/12/30/120/600V DC. 0/6/30/120/600V AC. 0/12/600uA/12/300mA/6/12A DC 0/10k/1 Meg/100 Meg. –20 to +50dB. 0.01–0.2 MFD
Transistor tester measures Alpha, Beta and ICO. Complete with instructions, batteries and leads.
OUR PRICE £19.95 P&P 25p

C15 PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1–25; HOR. AMP. Bandwidth: 500kHz. Sensitivity ay 100kHz VRMS/mm: 0.3–25 Preset triggered sweep 1–3000usec. Free running 20–200 kHz in nine ranges. Calibrator pips. 220 x 360 x 430mm. 115–230V AC.
OUR PRICE £43.00 Carr. paid

RUSSIAN CI16 Double Beam OSCILLOSCOPE

5 MHz pass band. Separate Y1 and Y2 amplifiers. Rectangular 5" x 4" CRT. Calibrated triggered sweep from 0.2usec. to 100 milli-sec/cm. Free running time base, 50Hz–1MHz. Built-in time base Calibrator and amplitude Calibrator. Supplied complete with all accessories and instruction manual.
OUR PRICE £87.00 Carr. paid

SWR METER Model SWR3

Handy SWR meter for transmitter antenna alignment, with built-in field strength meter. Accuracy 5%, Impedence 52' Indicator 100uA DC. Full scale 5 section collapsible antenna. Size 145 x 50 x 60mm.
OUR PRICE £4.25 P&P 30p

Also see following pages

Also see previous page

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This is our second list of high-quality equipment, surplus to our present requirements. It is all in good working order and has been regularly maintained to the manufacturers' own standards. Instruments may be viewed by arrangement only at the above address. Please telephone for an appointment.
Please check the availability of instruments and ask for a quotation by telephone or telex.
A Calibration service is available. Please ask for a quotation.

Sale Price Range

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High Power Loudspeaker Units (Altec) **£70–£80**
Stereo Recorders **£400–£500**

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Wayne Kerr
601Z. LCR Bridge. Wide Frequency range **£200**
SR268. Source and Detector **£300**
B221/Q221. LCR Bridge **£350**

COUNTERS AND TIMERS
Hewlett Packard
5216 12MHz. 7 Digits **£320**
5246 50MHz. 6 Digit Counters **£190–£290**
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5253B 512MHz. Converter plug-ins **£100–£190**
Marconi
TF2401, Main Frames On Application
TM7558, plug-ins On Application
TM8267, 110MHz, plug-ins On Application
TM8094/1, 0.3–2.5GHz. plug-ins On Application

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Dana
3800A. Digital Multimeter. 0.1%, 3 Digits **£140–£180**
Dynamco
DM2022. DV. 0.02% 10μV resolution—2KV **£130–£290**
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DM2140/A1/B3. RMS AC Converters **£64**
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3440 and Range of plug-ins (complete) **£600**
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LM1420. 2. DC. 0.05% 2.5μV resolution to 1KV **£110–£190**

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Cossor
CDU150. DC–35MHz. 5mV–50V/DIV dual trace **£400**

Dynamco
7100. DC–30MHz. Main Frames **£100–£150**
1Y2. DC–30MHz. Dual Trace Amplifier Plug-ins **£25–£40**
1Y4. 625 lines TV Monitor **£60**
1x1. Time Base plug-ins **£20–£40**
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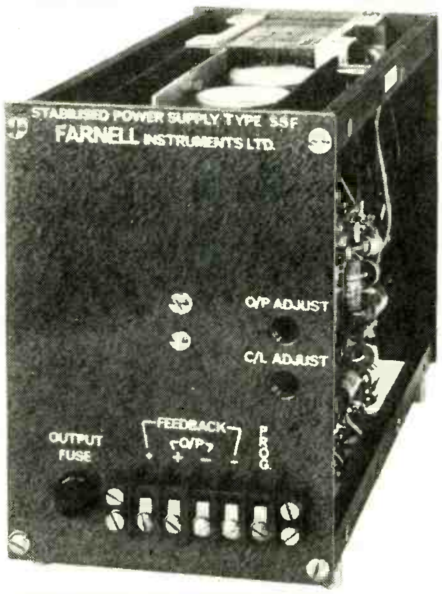
1200A. X–Y or standard Dual Trace. DC–500KHz. **£180**
Marconi
TF2203. DC–15MHz. Single Trace. Battery/Mains **£40–£80**
Telequipment
D. 43. DC–25MHz. Main Frames with Time Base **£60–£70**



A. DC–1.5MHz. Single Trace Amplifier plug-ins **£10–£20**
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D53S with 2 × 'A' amps. Storage. Dual Trace **£290**

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SSF. 0–15V. 15A. Pre-set **£25–£35**
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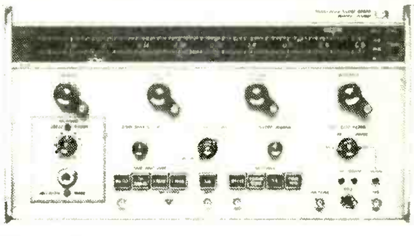

Wayne Kerr
0.22D. 10KHz–10MHz. Video Oscillator **£160**

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(Other plug-ins on application)

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(Filters also available at extra charges)
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SN7404N	0.26	SN7496N	0.95
SN7405N	0.22	SN7497N	3.87
SN7406N	0.42	SN74100N	1.89
SN7407N	0.42	SN74104N	0.58
SN7408N	0.28	SN74105N	0.53
SN7409N	0.28	SN74107N	0.45
SN7410N	0.22	SN74110N	0.58
SN7411N	0.25	SN74111N	0.86
SN7412N	0.30	SN74116N	1.89
SN7413N	0.36	SN74118N	0.90
SN7414N	0.72	SN74119N	1.68
SN7416N	0.36	SN74120N	0.95
SN7417N	0.36	SN74121N	0.50
SN7420N	0.22	SN74122N	0.70
SN7421N	0.33	SN74123N	1.00
SN7422N	0.25	SN74125N	0.65
SN7423N	0.37	SN74132N	0.72
SN7425N	0.37	SN74141N	0.90
SN7426N	0.32	SN74145N	1.26
SN7427N	0.37	SN74150N	1.75
SN7428N	0.40	SN74151N	1.00
SN7430N	0.22	SN74153N	0.95
SN7432N	0.37	SN74154N	2.00
SN7433N	0.37	SN74155N	1.00
SN7437N	0.37	SN74156N	1.00
SN7438N	0.37	SN74157N	0.95
SN7440N	0.22	SN74160N	1.38
SN7441AN	0.92	SN74161N	1.38
SN7442N	0.79	SN74162N	1.38
SN7443N	1.27	SN74163N	1.38
SN7444N	1.27	SN74164N	1.76
SN7445N	1.60	SN74165N	1.76
SN7446N	1.89	SN74166N	1.60
SN7447AN	1.60	SN74167N	3.00
SN7448N	1.27	SN74170N	2.52
SN7450N	0.22	SN74173N	1.66
SN7451N	0.22	SN74174N	1.57
SN7453N	0.22	SN74175N	1.10
SN7454N	0.22	SN74176N	1.26
SN7460N	0.22	SN74177N	1.26
SN7470N	0.36	SN74180N	1.26
SN7472N	0.38	SN74181N	3.95
SN7473N	0.41	SN74182N	1.26
SN7474N	0.42	SN74184N	1.80
SN7475N	0.59	SN74185N	1.80
SN7476N	0.45	SN74190N	2.00
SN7480N	0.60	SN74191N	2.00
SN7481N	1.10	SN74192N	2.00
SN7482N	0.87	SN74193N	2.00
SN7483N	1.10	SN74194N	1.30
SN7484N	1.00	SN74195N	1.10
SN7485N	1.63	SN74196N	1.20
SN7486N	0.47	SN74197N	1.20
SN7489N	3.87	SN74198N	2.77
SN7490N	0.70	SN74199N	2.52
SN7491AN	1.00		

TRIACS

STUD M7G WITH ACCESSORIES

See above for small quantity discounts. Large quantities and OEM phone 01-723 3646

Triacs	£ p
3 Amp	
SC35A	0.85
SC35B	0.91
SC35D	0.99
SC35E	1.30
6 Amp	
SC40A	0.88
SC40B	0.97
SC40D	1.20
SC40E	1.50
10 Amp	
SC45A	1.09
SC45B	1.12
SC45D	1.50
SC45E	1.65
15 Amp	
SC50A	1.46
SC50B	1.57
SC50D	1.80
SC50E	2.00
Also	
40430	0.85
40669	0.90
40486	0.85

SILICON CONTROLLED RECTIFIERS

See above for small quantity discounts. Large quantities and OEM phone 01-723 3646

	£ p
T05 1 Amp	
CRS1/05AF	0.42
CRS1/10AF	0.48
CRS1/20AF	0.52
CRS1/40AF	0.60
CRS1/60AF	0.78
T048 3 Amp	
CRS3/025AF	0.36
CRS3/10AF	0.48
CRS3/20AF	0.54
CRS3/40AF	0.65
CRS3/60AF	0.80
T048 7 Amp	
CRS7/400	0.84
CRS7/600	1.14
T048 16 Amp	
CRS16/100	0.78
CRS16/200	0.85
CRS16/400	0.96

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400 m/w **BZY88/BZX83**. From 3.3 volts–33 volts **10p** each.

1.3 watts 5% Miniature Tubulars **IN4700** series. From 3.3 volts–33 volts **18p** each.

SILICON RECTIFIERS

1 amp series IN4001 to IN4007. From **6p each.**

1.5 amp PL4001 to PL4007 from **7p each.**

3 amp PL7001/IN5400. From **32p each.**

Send for full list No. 36.

BRIDGE SILICON RECTIFIERS

FEATURING SMALL SIZE AND LOW COST

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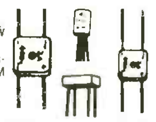

	£ p		£ p
½ Amp			
B025/025	0.14		
B025/05	0.16	B4/10	0.48
1 Amp		B4/20	0.54
B1/05	0.20	B4/40	0.60
B1/10	0.21	B4/60	0.70
B1/20	0.24	B4/80	0.90
B1/60	0.25	**6 Amp**	
B1/100	0.30	B6/05	0.50
2 Amp		B6/10	0.58
B2/05	0.30	B6/20	0.68
B2/10	0.35	B6/40	0.75
B2/20	0.40	B6/60	0.87
B2/40	0.44	**1 Amp Tubular**	
B2/60	0.45	W005	0.27
B2/100	0.55	W01	0.29
4 Amp		W02	0.30
B4/05	0.45	W06	0.33

CASH & CARRY PRICES

for callers or by post
G.B. Post/Packing 15p per item

Ref No.		Price
1.	D1203 telephone amplifier—SUCTION	£4.95
2.	D1201 telephone amplifier CRADLE	£7.50
3.	T1206 2 station intercom	£4.95
4.	T1306 3 station intercom	£9.95
5.	T1406 4 station intercom	£12.50
6.	TAIA 2 station telephones intercom	£13.50
7.	W1.2 2 station wireless intercom	£18.20
8.	DP303 door phone intercom	£7.00
9.	PK3 ETCH your own printed circuits	£2.25
10.	EA41 reverberation amplifier	£11.75
11.	U550 ultrasonic switch	£12.75
12.	XP4002 photoelectric alarm system	£13.50
13.	Solid state tachometer	£11.30
14.	Power dash transistor assisted ignition	£13.50
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16.	4 amp 6–12 volt battery charger	£4.85
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18.	Fully disappearing car aerial	£2.00
19.	Electric disappearing car aerial	£7.80
20.	ET (F1009) Morse code key/buzzer	£1.70
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25.	STC tuner delay module	£1.50
26.	Gravenire 931A photo electric unit (with data)	£3.50
27.	3 cw. 3×500 watt sound to light	£21.50
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30.	MM1 (BZ005) 4 channel 9 volt mixer	£4.20
31.	MX100 deluxe 4 channel mixer	£6.78
32.	H67(G1320) stereo headphone amplifier	£10.50
33.	MP12 6-CH. slider control mixer	£27.95
34.	RE208 stereo phone adaptor	£2.25
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37.	CIS250 stereo phones	£6.50
38.	G1301 and G1305 stereo phone controls	£2.95
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41.	F1052 car speakers front/rear fadar	£1.00
42.	Bib groove clean (ref. No. 42)	£1.76
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44.	Bib cassette recorder care kit (ref. No. 26A)	£1.96
45.	Bib cassettee tap splicing kit (ref. No. 24)	£1.64
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49.	Cassette recorder mic. (2½ and 3½mm plugs)	£1.85
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54.	BC808 % pocket calculator	£21.95
55.	BC817 memory pocket calculator	£28.95
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59.	Bib record care kit (ref. No. 59)	£1.17
60.	5pc chassis punch kits	£5.50
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62.	1 amp in line mains suppressors	£2.50
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67.	'4' dec ..	£7.50
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70.	40 watt soldering iron	£1.90

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MM 5314 single chip clock with CCT **£9.00**

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IC12 with data and PC board **£2.10**

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ZN414 Radio IC with circuit **£1.20**

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replacement for most recorders **£2.00**

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0.13" dia. 64 fibres **£1** per metre
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Matched pair for 465 kHz IF **£2.00** pr. for all superhet trans. RX's.

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"17" High Impedance **£2.50**
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"36" Med. Impedance **£5.00**
Erase Heads for "17", "18" and "36" **£1.00**
"63" 2 track mono. High Imp. **£1.75**
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AC107	0.51	BSX20	0.13	TIS43	0.26
AC128	0.15	BU105	2.20	V405A	0.22
AC187	0.21	8Y100	0.27	ZTX108	0.08
ACY17	0.40	BY127	0.12	ZTX300	0.13
ACY39	0.78	BYZ13	0.42	ZTX302	0.18
AD149	0.50	C106D	0.54	ZTX500	0.13
AD161	0.44	GET111	0.72	2N697	0.16
AD162	0.44	GET115	0.90	2N706	0.12
AF117	0.24	GET880	0.60	2N930	0.18
AF118	0.57	LM309K	2.00	2N987	0.42
AF139	0.41	MAT121	0.25	2N1132	0.24
AF186	0.48	MJE340	0.47	2N1304	0.28
AF239	0.44	MJE520	0.63	2N1613	0.21
ASY27	0.33	MJE3055	0.77	2N1671	1.20
BA115	0.10	MJE2955	1.27	2N2147	0.78
BAX13	0.05	MPF105	0.36	2N2160	0.78
BC107	0.14	NKT404	0.66	2N2926	0.12
BC108	0.13	OA5	0.72	2N3053	0.18
BC109	0.14	OA81	0.18	2N3054	0.48
BC109C	0.16	OA200	0.08	2N3055	0.45
BC113	0.15	OA202	0.06	2N3440	0.58
BC147	0.10	OC28	0.66	2N3442	1.39
BC148	0.08	OC35	0.55	2N3525	0.91
BC149	0.10	OC36	0.60	2N3614	0.65
BC169C	0.15	OC44	0.20	2N3702	0.11
BC182	0.12	OC45	0.20	2N3714	1.41
BCY32	0.85	OC71	0.18	2N3771	1.77
BCT39	1.50	OC72	0.28	2N3773	2.40
BCY55	2.64	OC77	0.54	2N3790	2.10
BCY70	0.18	OC81	0.29	2N3B19	0.38
BCY71	0.22	OC83	0.27	2N3886	0.72
BCY72	0.12	OC140	1.14	2N3903	0.15
BD124	0.65	OC170	0.30	2N4002	0.14
BD131	0.42	OC200	0.54	2N4126	0.15
BF115	0.20	OC202	0.90	2N4871	0.34
BF180	0.36	OCP71	1.20	2N5457	0.30
BF194	0.10	ORP12	0.60	2S303	0.60
BFX13	0.26	ORP60	0.55	40550	0.54
BFX34	0.70	P346A	0.18	40361	0.45
BFX88	0.24	TIL209	0.20	40362	0.40
BFY50	0.21	TIP29A	0.49	40408	0.50
BFY51	0.20	TIP30A	0.57	40486	0.85
BFY64	0.36	TIP31A	0.61	40636	1.00
BFY90	0.81	TIP41A	0.74	40430	0.85

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CA3020	Wide band power amp	£1.80
CA3022	Low power video amp	£1.93
CA3028A	Diff cas wide band	£1.03
CA3036	Dual Darlington pair	£1.08
CA3046	Transistor array	£1.03
CA3048	4× low noise pre-amps	£2.76
CA3075	FM IF limiter and detector	£1.75
CA3081	Hi-Amp 7 seg com emit driver	£1.80
CA3089E	Complete FM IF system	£2.94
CA3090Q	PLL stereo decoder	£5.40
Signetics		
NE555	Timer	£0.85
NE560B	Phase lock loop (PLL)	£5.00
NE561B	PLL analogue multiplier	£5.00
NE562B	PLL open loop for dividers	£5.00
NE567B	PLL tone detector	£3.50
Motorola		
MC1303L	2× low noise pre-amp	£1.42
MC1304P	Stereo MPX decoder	£1.79
MC1310P	PLL (coil-less) MPX decoder	£2.91
MC1458CPI	Twin op-amp	£0.77
MC1710CG	Level detecting op-amp	£0.60
MFC4000P	250mW amp	£0.45
MFC4010P	Wide band pre-amp	£0.55
MFC6040P	AF attenuator	£1.00
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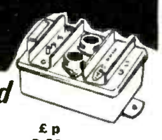
SN76003N	5W power amp (finned) (2 for £2.85)	£1.50
SN72741P	B pin d.i.l. op-amp	£0.60
SN72748P	8 pin d.i.l. Hi-Z op-amp	£0.61
702C	(TO5) op-amp	£0.75
709C	(TO5 or d.i.l.) op-amp	£0.39
723C	(TO99 or d.i.l.) reg	£0.90
728C	(TO99 or d.i.l.) reg	£0.45
741C	(TO5, 8 or 14 pin d.i.l.) gen pur op-amp	£0.50
747C	(TO5 or d.i.l.) gen pur dual op-amp	£1.00
748C	Hi-Z op-amp	£0.61
LM309K	5V 1.6A reg	£2.00
TAA960	3 st filter (ultra's ic transd)	£1.75

AMTRON KITS



Everything supplied

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157	Private TV loop trans	4.95	875	CAP. Discharge ignition for car engine (–Ve Earth)	13.19
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615	Power supply for 2×120	6.64	255	Level indicator	6.98
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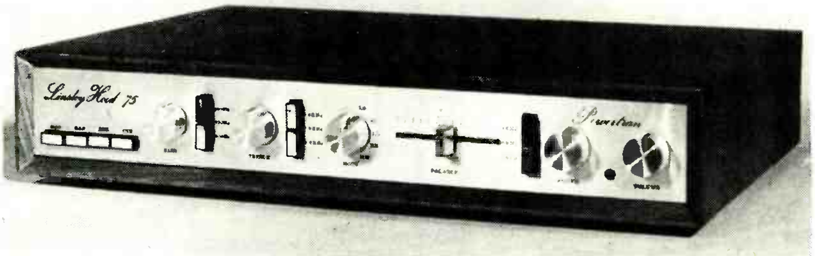
AMPLIFIER KITS OF *Distinction*

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 75 W 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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8	Set of potentiometers (including mains switch)	£2.05
9	Set of 4 push-button switches, rotary mode switch	£3.70
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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
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15	Handbook	£0.30
16	Teak cabinet	£7.35
	2 each of packs 1–7 inclusive are required for complete stereo system	
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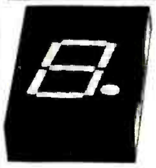

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709 DIL 14 29p
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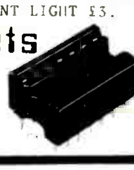

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2N1304 (GPNP)	150mw	30	6	15p
2N1309 (GPNP)	150mw	30	15	30p
2N1046 (GPNP)	50w	100	20	£2·50
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2N1542 (G)	106w	100	0·35	50p
2N1547 (G)	106w	100	0·35	75p
2N1557 (G)	106w	40	0·35	50p
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2N2082 (G)	170w	40	0·2	£1·10
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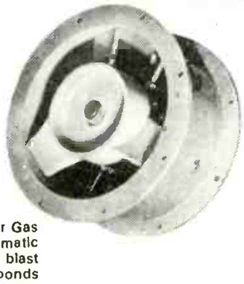

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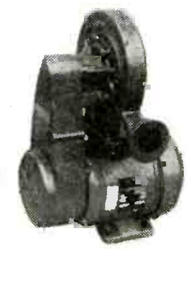

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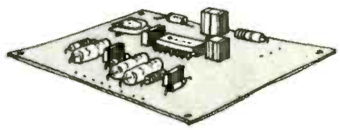

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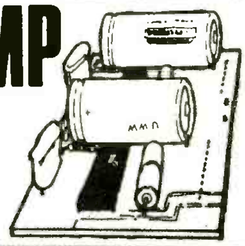

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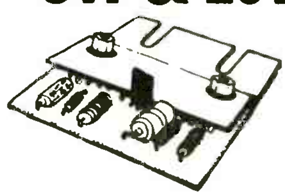

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RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high × 21 in. wide × 16 in. deep, with rear door. £12 each, Carr. £2·50.
CLASS "D" WAVEMETER NO. 1 MK. II: Crystal controlled heterodyne frequency meter covering 2-8MHz. Power supply 6V d.c. Good secondhand cond. £7·50 each. Post 60p.
ROTARY INVERTERS: TYPE PE.218E—input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1 Ph. P.F.9. £17·50 each. Carr. £2·00.
REDIFON TELEPRINTER RELAY UNIT NO. 12: ZA-41196 and power supply 200-250V a.c. Polarised relay type 3SEITR. 80-0-80V 25mA. Two stabilised valves CV 286. Centre Zero Meter 10-0-10. Size 8in. × 8in. × 8in. New condition £7·50, Carr. 75p.
TS 15C/AP FLUXMETER: Used to provide qualitative measurements of flux densities between pole faces of magnets. Range 1200-9600 gausses. ±2%. S/hand good cond. £25 + 60p post.
AUTO TRANSFORMER: 230V 50c/s, 1000 watts. Mounted in strong steel case 5in. × 6½in. × 7in. Bitumen impregnated. £10 each, Carr. £1.
UHF ASSEMBLY: (suitable for 1000MHz conversion) incl. UHF valves; 2C42, 2C46, 1B40. Complete with associated capacitors and screening; 3 manual counters 0-999. Valves 6AL5 and 8 × 6AK5. £10 each, 60p post.
TELEPRINTER TYPE 7B; Pageprinter 24V d.c. power supply, speed 50 bauds per min. 'as new' cond. in original packing case, £25 each; or second hand cond. (excellent order) no parts broken, £15 each. Carriage either type £3·00.
INSULATION TEST SET: 0-10 kV negative, earth with amplifier provision for checking ionisation. 110/230V a.c. input. S/hand good cond. £30 + £1 carr.
AUTOMATIC VIBRATION EXCITER CONTROL UNIT TYPE 1016: Manufactured by Bruel & Kjoer. 5-5000c/s per sec. S/hand V. good cond. £90, Carr. £2.
VRC 19X MOBILE TRANS/REC: 152-174 mc F.M. Power o/put 25 watts. Input voltage 24v. d.c. Weight 80lbs. £35·00 each, carr. £3·00.
BRIDGE MEGGER: 250V. (Evershed Vignoles) series 2. £30 each. Carr. £1.
BRIDGE MEGGER: 2,500V., series 1. £30 each. Carr. £1.
CRYSTAL TEST SET TYPE 193: used for checking crystals in freq. range 3000-10,000KHz. Mains 230V 50Hz. Measures crystal current under oscillatory conditions and the equivalent resistance. Crystal freq. can be tested in conjunction with a freq. meter. £15. Carr. £1·50.

RACAL OSCILLATOR: 1-100,000KHz in 1KHz steps with digital readout, BFO, CWN, FSK, CWW, LSB, USB, ISB, DSB. Line 1 and 2. £200 each. Carr. £5.

50-LINE TELEPHONE SWITCHBOARD: Complete with all plugs etc., excellent cond. £40 each. Carriage £5.
10-WAY TELEPHONE SOCKET STRIPS: 3 connections and 10 jack-plugs to suit. Similar to PL68. Complete with 6ft. cord. Ex-equipment, good cond. £4 each. Post 50p.
10-WAY TELEPHONE LAMP STRIP: Suitable for use with the above. £2 each. Post 30p.
10-WAY TELEPHONE MAGNETIC INDICATOR: 50V. For use with the above items. £2 each. Post 40p.
10-WAY TELEPHONE SOCKET STRIP: 3 connections. Takes standard P.O. Jackplugs; 201 or 316; and **10-WAY TELEPHONE LAMP STRIP.** £3 the pair. Post 50p.

DELPENA RF GENERATOR TYPE E.15: 15kW at 500Hz; input 440V 3 ph. 50Hz. £275. Carr. at cost.
H.V. TRANSFORMER: 8000/8000. Output 300mA. rms. Size: 12in. × 12in. × 36in. 230V input. £35, Carr. £4·00.
TELEPHONE CABLE: (Twin) 1,300ft. on metal reel. £5 per reel. Carr. £1.
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APN-1 ALTIMETER TX/RX: Freq. approx. 410MHz. Complete wit... 28V dynamotor, 3 relays, precision resistors, 11 valves. Useful breakdown for parts. £4 each, Carr. £1·50.
AVO VALVE TESTER CT.160: (Portable) similar to Avo Mk. 3 Characteristic Meter. Good cond. £35 each, Carr. £1·50.
MODULATOR UNIT: Complete with mod. transformer and 2 × 807 Valves. Mounted 19" chassis, 8" × 8". "As new" cond. £8 each; or secondhand £5 each. Carr. both types £1·50.
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TF.2000 A.F. SIGNAL SOURCE: £175·00, carr. £1·00.
WESTON INDUSTRIAL THERMOMETER MODEL 221: 0-100° 3 inch. dia. scale. Accuracy 1%. £3·00, post 30p.
POWER UNIT: 110/230 volts a.c. input. 28 volts d.c. at 40 amps output. £30·00 each, carr. £3·00.
SMOOTHING UNIT (for the above): £10·00 each, carr. £2·00.
SOLARTRON PLUG-IN UNIT TYPE C X-1251: Wideband 40MHz. £30 ea., 75p post.
SOLARTRON DUAL TRACE CX-1252: 24MHz. £35 ea., 75p post.
X-BAND MODULATOR CALIBRATOR TYPE MC-4420-X: Mnfr. James Scott. £125 ea., Carr. £1.
HP-766D DUAL DIRECTIONAL COUPLER: 940-1975MHz. £35 ea., 75p post.
BACKWARD WAVE OSCILLATOR TYPE SE-215: 6.3 heater, 105V Anode, 7.9mA. Mnfr. Watkins & Johnson. £85 ea., Carr. £1.
LISTS OF EQUIPMENT AVAILABLE: MOTORS; TELEPRINTERS; AR88 SPARES; TEST EQUIPMENT ETC. Send 10p for above lists.
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EF89 0·35
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EF183 0·40
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EL33 2·50
EL34 0·70
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EL42 0·90
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EM84 0·40
EY51 0·45
EY86 0·45
EZ40 0·75
EX41 0·75

EZ80 0·30
EZ81 0·35
EZ90 0·40
GY501 0·90
GZ30 0·65
GZ32 0·65
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KL66 2·50
KT81 (7C5) 1·30
KT88 2·90
KTW61 1·50
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N78 3·50
OA2 0·45
OB2 0·45

OZ4 0·55
PC86 0·65
PC88 0·65
PC900 0·55
PCC84 0·45
PCC89 0·55
PCC189 0·65
PCF80 0·40
PCF86 0·65
PCF801 0·60
PCF802 0·55
PCF805 0·80
PCF806 0·80
PCF808 0·90
POCL82 0·45
PCL83 0·70
PCL84 0·50
PCL85 0·60
PCL86 0·50
PD500 1·50

PEN45DD 0·85
PFL200 0·70
PL36 0·63
PL38 0·65
PL81 0·55
PL82 0·50
PL83 0·50
PL84 0·50
PL500 0·80
PL504 0·85
PL508 0·90
PL509 1·55
PL801 £1·00
PL802 1·00
PY32 0·63
PY33 0·63
PY81/800 0·50
PY82 0·45
PY83 0·50

PY500 1·10
PY801 0·55
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SP61 0·85
T41 1·00
U25 1·00
U26 0·85
U191 0·75
U404 0·75
U801 0·80
UABC80 0·50
UAF42 0·75
UBC41 0·75
UBF80 0·50
UBF89 0·50
UCC85 0·50
UCH42 0·80
UCH81 0·50
UCL82 0·40
UCL83 0·70

UF41 0·75
UF89 0·50
UL41 0·85
UL84 0·50
UY41 0·55
UY85 0·45
VP4B 1·25
VR75/30 0·48
UR105/30 0·40
UR150/30 0·40
Y63 1·50
1R5 0·50
1R5 0·40
1T4 0·40
3S4 0·50
3V4 0·85
5R4GY 1·00
5U4G 0·55

5U4G 0·60
5Y3GT 0·65
5Z4G 0·65
6/30L2 0·90
6AL5 0·30
6AQ5 0·50
6AS7 1·00
6AT6 0·60
6AU6 0·40
6AV6 0·50
6BA6 0·38
6BE6 0·45
6BN6 0·75
6BJ6 0·75
6BQ7A 0·65
6BR7 1·20
6BW6 1·00
6BW7 1·00
6C4 0·40
6CD69 1·60
6CH6 1·40

6E5 1·00
6F23 1·05
6J5G 0·45
6J5GT 0·55
6J7GT 0·55
6K6GT 0·80
6K7GT 0·35
6K8GT 0·50
6P25 1·75
6Q7GT 0·50
6SG7M 0·50
6SJ7GT 0·30
6SL7GT 0·55
6SN7GT 0·55
6U4GT 0·80
6U5G 0·75
6V6GT 0·60
6X4 0·45
6X5GT 0·55
7B6 0·80
7B7 0·80

7C5 1·30
7C6 1·00
7H7 0·80
7S7 2·25
7Y4 0·80
12AC6 0·80
12AD6 0·80
12AE6 0·75
12AT6 0·45
12AT7 0·45
12AU6 0·50
12AU7 0·38
12AX7 0·38
12BA6 0·50
12BE6 0·60
12BH7 0·60
30C15 1·05
30C17 1·10
30C18 0·90
30F5 1·10

30FL1 1·00
30FL14 0·90
30L15 1·05
30L17 0·95
30P12 1·05
30P19 1·00
30PL1 0·95
30PL13 1·20
30PL14 1·25
35L6GT 0·80
35W4 0·60
35Z3 0·80
35Z4GT 0·70
50C5 0·70
50CD6G 1·20
80 0·75
807 1·00
6080 2·50
6146 2·25

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1N21 0·17
1N23 0·35
IN4001 0·06
IN4002 0·07
IN4003 0·08
IN4004 0·08
IN4006 0·12
18111 0·25
18131 0·13
18132 0·13
2G220 0·63
2G301 0·40
2G302 0·40
2N696 0·15
2N697 0·15
2N706 0·10
2N706A 0·12

2N708 0·15
2N1302 0·18
2N1303 0·18
2N1304 0·22
2N1305 0·22
2N1306 0·28
2N1307 0·28
2N2147 0·75
2N2218 0·23
2N2444 1·99
2N2646 0·50
2N2926 0·10
2N3702 0·11
2N3703 0·12
2N3704 0·14
2N3705 0·15
2N3707 0·13

2N3709 0·10
2N3710 0·11
2N3711 0·11
2N3819 0·35
2N4286 0·15
2N4289 0·15
AC126 0·25
AC127 0·25
AC128 0·20
AC176 0·25
AC187 0·20
AC188 0·20
ACY17 0·35
AD140 0·50
AD149 0·50
AD161 0·39
AD162 0·39
AF114 0·25
AF115 0·25

AF116 0·25
AF117 0·20
AF139 0·33
AFZ12 1·50
BC107 0·12
BC108 0·12
BC109 0·12
BC115 0·20
BC116 0·20
BC117 0·21
BC169 0·14
BCY34 0·45
BD121 1·00
BD123 1·00
BF115 0·22
BF173 0·28
BF180 0·35
BF181 0·35
BF194 0·13

BF195 0·13
BF196 0·15
BF197 0·15
BF861 0·25
BF898 0·25
BFY50 0·20
BFY51 0·20
BFY52 0·20
BTY79/100R 0·75
BY100 0·15
BY126 0·14
BY127 0·15
BZY88 Series 0·10
CRS1/05 0·30
CRS1-40 0·45

CRS3-40 0·55
CS10B 3·50
CV102 0·25
CV103 0·18
CV253 1·00
CV2154 2·00
CV2155 2·00
CV7108 3·50
CV7109 3·50
DD000 0·15
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GET102 0·50
GET103 0·40
GET116 0·85
GET875 0·40
GEX66 1·25
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GJ7M 0·50
KS100A 0·20
MAT101 0·25
MAT120 0·20
MAT121 0·25
MJE370 0·68
MJE520 0·65
MJE2955 1·10
MJE3055 0·75
MPF102 0·40
MPF103 0·36
MPF104 0·35

NKT128 0·45
NKT211 0·25
NKT213 0·25
NKT214 0·24
NKT216 0·40
NKT217 0·45
NKT218 1·13
NKT301 0·85
NKT304 0·75
NKT401 0·75

NKT403 0·70
NKT404 0·60
NKT713 0·30
OA5 0·60
OA6 0·12
OA7 0·20
OA9 0·20
OA10 0·40
OA47 0·08
OA70 0·10
OA71 0·20
OA79 0·10
OA81 0·10
OA85 0·15
OA86 0·15
OA90 0·07
OA91 0·07

OA95 0·07
OA200 0·08
OA202 0·10
OA210 0·20
OA211 0·35
OAZ202 0·45
OAZ210 0·40
OAZ211 0·40
OAZ242 0·15
OAZ244 0·25
OAZ246 0·15
OC16 1·00
OC16T 1·00
OC19 0·50
OC20 2·00
OC22 1·00
OC23 1·25
OC24 1·10
OC25 0·40

OC26 0·40
OC28 0·70
OC29 0·65
OC30 0·40
OC35 0·55
OC36 0·65
OC41 0·35
OC42 0·40
OC43 0·70
OC44 0·18
OC44M 0·17
OC45 0·18
OC45M 0·18
OC46 0·27
OC57 0·60
OC58 0·60
OC59 0·60
OC66 0·50
OC70 0·18

OC71 0·15
OC72 0·25
OC73 0·50
OC74 0·30
OC75 0·30
OC76 0·30
OC77 0·55
OC78 0·25
OC78D 0·25
OC79 0·30
OC81 0·28
OC81D 0·28
OC81M 0·20
OC81DM 0·18
OC81Z 0·45
OC82 0·28
OC82D 0·25
OC83 0·25

OC84 0·30
OC123 1·10
OC139 0·40
OC140 0·65
OC141 0·80
OC169 0·20
OC170 0·25
OC171 0·30
OC200 0·55
OC201 0·80
OC202 0·90
OC203 0·55
OC204 0·65
OC205 1·00
OC206 1·10
OC207 1·00
OCP70 0·50
OCP71 1·00
ORP12 0·55

ORP60 0·45
ORP61 0·48
SX640 0·75
SX642 0·60
SX643 0·75
ZS21 0·30
ZS22 0·20
ZS170 0·10
ZS178 0·40
ZS271 0·18
ZT21 0·25
ZTX107 0·12
ZTX108 0·10
ZTX300 0·14
ZTX304 0·25
ZTX500 0·15
ZTX503 0·16
ZTX531 0·25

Industrial Valves

1B3GT
1B24
1B35A
1B63A
1N21
1N21B
1N23B
1N23CR
1X2A
1X2B
2A3
2AS15
2C26A
2C34
2C39A
2C43
2D21
2D21W
2E26
2J31
2J33
2J50
2J54
2J56A
2K25
2K26
2K28
2K45
2X2A
3A/107A
3A/108A
3A/108B
3A/109B
3A/110A
3A/110B
3A/146J
3A/167M
3A5
3B/240M
3B/241M
3B24

3B28
3B29
3C22
3C23
3C24/24G
3C45
3CX100A5
3E29
3J/121E
3J/160E
3J/170E
3Q/150E
3Q/195E
3S4
3V/340B
3V/390A
3V/390B
4-125A
4-250A
4-400A
4B32
4C35
4CX250B
4E27
4J50
4J52
4J52A
4J53
4X150A
4X150D
4X250B
5B/251M
5B/252M
5B/254M
5B/255M
5B/256M
5B/257M
5C22
5D21
5R4GY
5U4GB

5Z3
5Z4G
6AF4A
6AK5
6AM5
6AM6
6AN5
6AN8
6AR5
6AS6
6AU4GTA
6AU5GT
6AU6
6AV5GTA
6AW8A
6AX5GT
6B4G
6BA8A
6BK4
6BK7A
6BL7GTA
6BN6
6BR7
6BS7
6BX7GT
6BZ6
6CB6
6CH6
6CL6
6CW4
6DK6
6DQ6B
6EA8
6F33
6H6(metal)
6K7GT
6U8A
6V6GT
11E3
11E13
12AY7
12B4A
12BY7A

12E1
12E14
13D1
13E1
28D7
29C1
53KU
75B1
75C1
83A1
85A1
85A2
90AG
90AV
90C1
90CG
90CV
95A1
100TH
150B2
150B3
150C1
150C2
150C3
150C4
250TH
328
329
631-P1
705A
715A
715B
723A/B
725A
801
803
805
807
808
811
811A
812A
813

815
828
829B
830B
860
866
866A
866E
827A
881R
891R
954
955
956
957
1625
2050
2050W
2051
4003A
4212D or E
4242A
4313C
4328A
4687
5544
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5725/6AS6W

5726/6AL5W
5727/2D21W
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6005/6AQ5W
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6097C
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6807

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6939
7193
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7360
7586
8013
8025A
9001
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9003
9004
9005
9006
13201A
A1834
A2087
A2134
A2293
A2426
A2521
A2900
ACT6
ACT9
B1C 1E
BS90
BS156
BT5
BT35
BT45
BT79
BT83
C1C
C1K
CAA322
CV5
CV25
CV26

CV28
CV31
CV45
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CV73
CV74
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CV118
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CV220
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CV397

CV404
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CV428
CV434
CV447
CV449
CV466
CV469
CV488
CV491
CV492
CV493
CV717
CV808
CV1072
CV1076
CV1092
CV1219
CV1343
CV1475
CV1476
CV1477
CV1478
CV1794
CV1480
CV1481
CV1482
CV1787
CV1832
CV1833
CV1835
CV1994
CV2000
CV2131
CV2154
CV2155
CV2160
CV2179
CV2235
CV2237
CV2238
CV2253
CV2289

CV2325
CV2361
CV2466
CV2516
CV2519
CV2520
CV2522
CV2721
CV2901
CV3523
CV3929
CV3986
CV3988
CV3991
CV3998
CV4001
CV4002
CV4003
CV4004
CV4005
CV4006
CV4007
CV4008
CV4009
CV4010
CV4011
CV4012
CV4013
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CV4043
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CV4048
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CV4059
CV4060
CV4062
CV4063
CV4064
CV4079
CV4501
CV4502
CV4503
CV4504
CV4507
CV4508
CV5060
CV6004
CV6008
CV6045
DA30
DA41
DA42
DA100
DET22
E55L
E80CC
E80FC
E80F
E80L
E80T
E81CC
E81L
E82CC
E83CC
E83F
E88CC
E90CC
E90L
E91H
E92CC
E180CC

E180F
E181CC
E182CC
E186F
E188CC
EA50
EA52
EA76
ECC35
ECF804
EF50
EF54
EF55
EF804
EFP60
EL91
EN30
EN31
EN32
EN91
ESU74
ESU76
ESU77
F6057
F6060
F6061
F6063
FX219
FX225
FX227
G1/371K
G120/1B
G150/2B
G180/2M
G240/2D
G400/1K
GN4
GT1C
GTR120W
GTR150MS
GU18
GU20/21
GU50
GXU1

GXU2
GXU3
GXU4
GXU50
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QA2406
QA2407
QB3/300
QB3-5-750
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QQV02-6
QQV03-10
QQV03-20
QQV03-20A
QQV04-15
QQV06-40
QQV06-40A
QS70/20
QS75/20
QS75/40
QS75/60
QS83/3
QS92/10
QS95/10
QS105/45

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QS150/15
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QS150/80
QS1200
QS1202
QS1203
QS1205
QU37
QV03-12
QV04-7
QV05-25
QV06-20
QY3-120A
QY4-250A
QY4-400A
R10
R17
R18
S11E12
S130
S130P
STV280/40
STV280/80
SU41
SU42
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TZ40
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7402	0·20	7412	0·28	7440	0·20	7482	0·87	74111	0·86	74174	1·80
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7404	0·20	7416	0·30	7442	0·85	7484	1·00	74119	1·92	74176	1·44
7405	0·20	7417	0·30	7450	0·20	7486	1·50	74121	0·57	74190	2·30
7406	0·40	7420	0·20	7451	0·20	7490	0·75	74122	0·80	74191	2·30
7407	0·40	7422	0·28	7453	0·20	7491AN	1·10	74123	1·44	74192	2·30
7408	0·25	7423	0·40	7454	0·20	7492	0·75	74141	1·00	74193	2·30
7409	0·33	7425	0·37	7460	0·20	7493	0·75	74145	1·44	74194	1·72
		7427	0·37	7470	0·33	7494	0·85	74150	2·30	74195	1·44
		7428	0·43	7472	0·38	7495	0·85	74151	1·15	74196	1·58
		7430	0·20	7473	0·44	7496	1·00	74154	2·30	74197	1·58
		7432	0·37	7474	0·48	7497	4·32	74155	1·15	74198	3·16
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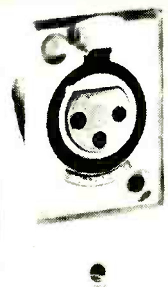


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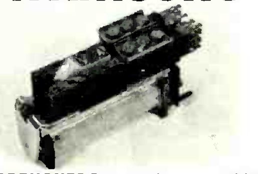

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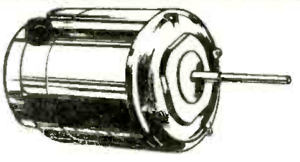
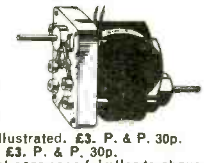


"SLO-SYN" 3-LEAD SYNCHRONOUS STEPPING MOTOR

Type SS15. These fine motors are easily reversed, starting and stopping in less than 5° without electrical or mechanical braking. Simple relay circuit can be applied to give DC., to winding for a maximum holding torque of 300oz/in with 35v at 0.35amps through winding. For AC. (synchronous) operation at 120v., 50Hz. Speed 60 rpm at 60Hz., 72 rpm. STEPPING. Holding torque at 60 steps per second—100 oz/in. Can be wired to give 100 or 200 steps per revolution with accuracy of 0·1° per step non-cumulative. Torque characteristics can be modified by simple R.C. circuits. Dimensions: dia. 4", body length 4¾", spindle length 2¼" × $\frac{5}{16}$" dia. Weight 6½ lbs. BRAND NEW in maker's packing. Offered at less than ½ maker's price. **£15**

OPEN FRAME shaded pole GEARED MOTORS



(Dural gear case) 240 AC., 28rpm. NEW HIGH TORQUE, approx. overall size: 3½" × 3½" × 2¾"+spindle ⅛" dia. as illustrated. **£3.** P. & P. 30p. Similar to above, 19rpm. **£3.** P. & P. 30p. 110rpm with pressed steel gear case (similar to above but slightly smaller). **£3.** P. & P. 30p.

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Similar to above with alloy gear case. 60 r.p.m. This item is ex-equipment but perfect. **£1.95.** P & P 30p.

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Reliable 15 minute times, spring wound (concurrent with time setting) 15×1min divisions, approximately ⅛" between divisions. Panel mounting with chrome bezel 3¾" dia. **£1·40.** 15p. P. & P.

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Fully stabilised "Labgear" Power Supply Unit. Input 90-240v, 50Hz. Outputs 6v, 6a D.C., and 6v+2v, 100MA. Hum and ripple at full load—less than 3MV peak to peak. Stability improvement ratio for 15% mains change—1/000 : 1. Output impedance 0·005 ohms. 9½" x 9½" x 12½". Weight 20¼lb. **£26.00.** Carr. & Pkg £1.50. **In manufacturer's carton.**

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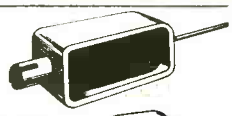
P.S.U. 200-250v. 40/60Hz. Alternative outputs fully variable (variac incorporated). Output 1. 12v at 5a D.C. fully smoothed. Output 2. 12v at 8a D.C., with ripple content. Output 3. 20v at 10a A.C. 2½" x 2½" flush 0-20v D.C. m/c meter. In attractive grey hammer finish case. **In maker's carton. £27.50.** Carr. & Pkg. £1.50.

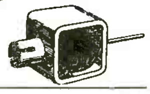
SHADED POLE MAINS MOTOR

A quality shaded pole motor. Open frame. 3" high × 2½" × 2". Spindle 1" × $\frac{3}{16}$". 1,4 20r.p.m. **£1.95** P & P 20p.

SOLENOIDS by WESTOOL

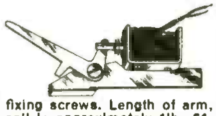


240AC type MM6. 3lb. pull, 2¾"×1"×1½". Travel 1". **90p** each. P.&P. 10p.



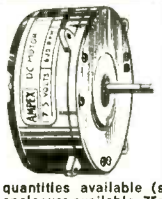
240AC type MM4. 2lb. pull, 1½"×1⅜"×1". Travel ⅝" **70p** each. P. & P. 10p. Quantity discounts; 10-50 10%. 50 upwards 25%

MAINS SOLENOID

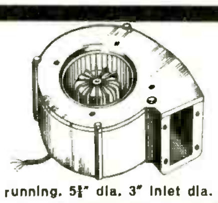


This little unit gives vertical lift of approximately 1" through hinged "elbow". Bracket incorporates 2 fixing screws. Length of arm, 2½". 240V AC. Pull at coil is approximately 1lb. **£1.** FREE P. & P. Special quotes for quantities.

AMPEX 7.5v. DC MOTOR



An ultra precision tape motor designed for use in the AG20 portable recorder. Torque 450GM/CM. Stall load at 500ma. Draws 60ma on run. 600rpm ± speed adjustment. Internal AF/RF suppression. ½" dia.×1" spindle, motor 3" dia.×1⅞". Original cost £16.50. **OUR PRICE £3.30.** P. & P. 25p. Large quantities available (special quotations). Mu-metal enclosure available. **75p** each. FREE P. & P.



ULTRA PRECISION CENTRIFUGAL BLOWER *by Air Control Ltd.*

30 segments individually balanced in heavy cast alloy case. 2,300 r.p.m. 240v A.C. Very powerful and silent running. 5½" dia. 3" inlet dia. Outlet flange 3" × 2½".

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Now complete with reference magnet!

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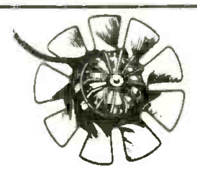
The famous American fibre-glass copper-clad laminate. Finest quality with woven glass base of Epoxy-resin. Excellent Mech. and Elec. conductive properties. Heat resistant, ideal for P.C.'s etc. THIS IS A SPECIAL PURCHASE AND ONLY AVAILABLE WHILE STOCKS LAST! Sizes: 12" × 12"; 24" × 12"; 24" × 24"; FULL SHEET 43" × 37" (11 sq. ft.). Single-sided Copper with thickness of 1/32", 3/64", 3/32 . Also double-sided 1/32", 1/16", 3/32". **£1** per sq. ft. Cut sizes (1-10 sq. ft.) 25p. P. & P. Full Sheet **£8** each. Carr. £1 for 1st sheet plus 25p each additional sheet.

FAN/ BLOWER



Precision-built in Germany. Dynamically balanced mains unit (200/240) continuous rated, reversible 60MA on run. Size: 5½" dia. × 2½" deep. Back plate is tapped for 4 fixing screws (supplied). Well under maker's price at **£3.** P. & P. 20p. Similar unit to above but 7½" dia. × 3" deep. **£4·50.** P. & P. 25p.

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HART ELECTRONICS

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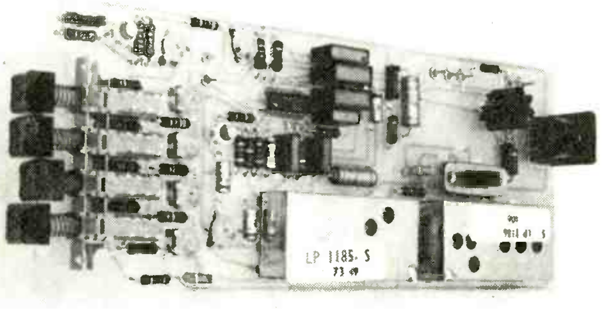

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BAILEY 30W Power Amplifier **18p.**
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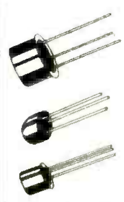

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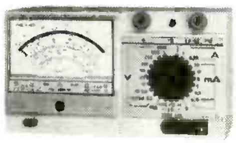
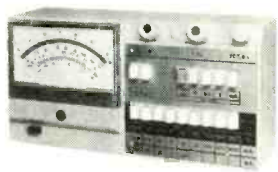


U4317 £16.50

U4323 £7.70



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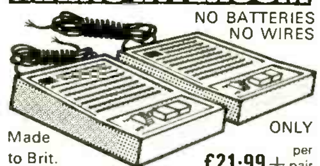
NO BATTERIES
NO WIRES



ONLY **£21·99** + VAT £1·76 per pair

Made to Brit. Safety & Telecom. Standards. Supplied with 3-core wire. Just plug into power socket. Ready for use. Crystal-clear communication from room to room. Operates over a ¾-mile range. On/Off switch, Vol. control. Useful as office intercom, baby alarm, invalids. No G.P.O. licence reqd. Full price ref. if returned in 10 days. 12 months' service guarantee. P. & P. 60p.

WEST LONDON DIRECT SUPPLIES (W/W)
169 Kensington High Street, London W.8

TWC

FOR EX STOCK DELIVERY OF:

B.P.O. COMPONENTS

Manufacturers', Trade and Export Enquiries welcomed, quoting BPO and/or Manufacturers' Reference numbers.

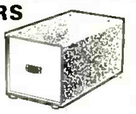
TELEPHONE & WIRELESS COMPONENTS LTD.
147 The Broadway, London, NW9 7EA

Tel: 01-203 2814 Cables: Telwirco London NW9

A.S.P for quick service!

TRANSFORMERS

CASED TRANSFORMERS



Housed in smart resin-coated steel cases, with 3-core power cable and outlet socket, fused primary winding. Isolation types are fitted with 3-pin outlet sockets, and are available with 110 volt or 240 volt output (Please state.) Auto types are fitted with 2-pin flat style sockets up to 500 VA. 3-pin sockets from 750 to 3000 VA. See Auto and Isolation sections for prices.

SAFETY ISOLATING

Prim. 120/240V. Sec. 120/240V. Centre Tap with screen

VA (WATTS)	REF. No.	PRICE Cased	Open £	£	Post £
60	149	7·35	0·80	4·00	0·38
100	150	8·22	0·80	4·60	0·52
200	151	10·20	0·80	7·40	0·52
250	152	11·68	0·80	8·88	0·65
350	153	14·10	0·80	10·80	0·80
500	154	15·68	0·80	12·38	1·00
750	155	24·63	1·00	18·72	1·20
1000	156	32·19	1·00	26·50	1·20
1500	157	38·18	1·00	30·34	O.A.
2000	158	45·20	2·40	34·68	O.A.
3000	159	66·50	2·40	53·35	O.A.

MINIATURE & EQUIPMENT

Primary 240V with Screen

VOLTS Sec. 1	VOLTS Sec. 2	MILLIAMPS Sec. 1	MILLIAMPS Sec. 2	TYPE No.	PRICE £	Post £
3-0-3	—	200	—	238	1·23	0·10
0-6	0-6	500	500	234	1·30	0·10
0-6	0-6	1000	1000	212	1·95	0·22
9-0-9	—	100	—	13	1·23	0·10
0-9	0-9	330	330	235	1·43	0·10
0-8-9	0-8-9	500	500	207	1·75	0·22
0-8-9	0-8-9	1000	1000	208	2·30	0·30
15-0-15	—	40	—	240	1·23	0·10
0-15	0-15	200	200	236	1·30	0·10
20-0-20	—	30	—	241	1·23	0·10
0-20	0-20	150	150	237	1·30	0·10
0-15-20	0-15-20	500	500	205	2·47	0·38
0-20	0-20	300	300	214	1·72	0·22
0-20	—	3500	No Screen	1116	3·00	0·40
20-12-0-12-20	—	700 (D.C.)	—	221	2·31	0·30
0-15-20	0-15-20	1000	1000	206	3·22	0·38
0-15-27	0-15-27	500	500	203	2·73	0·38
0-15-27	0-15-27	1000	1000	204	3·52	0·38

12 and 24 VOLTS PRIMARY 200-240 Volts.

AMPS 12V	AMPS 24V	TYPE No.	PRICE £	Post £
0·3	0·15	242	1·34	0·22
0·5	0·25	111	1·38	0·22
1	0·5	213	1·58	0·22
2	1	71		0·22
4	2	18	2·58	0·38
6	3	70	3·80	0·42
8	4	108	4·20	0·52
10	5	72	4·80	0·52
12	6	116	5·01	0·52
16	8	17	6·22	0·52
20	10	115	9·47	0·69
30	15	187	11·95	0·97
40	20	232	13·26	1·00
60	30	226	15·30	1·10

30 VOLTS

PRIMARY 200/240V.
SECONDARY 12, 15, 20, 24, 30V.

AMPS	Ref. No.	Price £	Post £
0·5	112	1·72	0·22
1	79	2·21	0·38
2	3	3·26	0·38
3	20	4·10	0·42
4	21	4·68	0·52
5	51	5·80	0·52
6	117	6·50	0·52
8	88	8·50	0·67
0	89	8·47	0·67

50 VOLTS

PRIMARY 200/240V.
SECONDARY 24, 30, 48, 60V.

AMPS	Ref.	Price	Post
0·5	124	2·08	0·38
1	126	2·96	0·38
2	127	4·63	0·42
3	125	6·84	0·52
4	123	7·94	0·67
5	40	8·86	0·67
6	120	10·15	0·82
8	121	13·58	1·00
10	122	18·15	1·00
12	189	16·00	1·10

60 VOLTS

PRIMARY 200/240V.
SECONDARY 19, 25, 33, 40, 50V.

AMPS	Ref.	Price	Post
0·5	102	2·33	0·30
1	103	3·00	0·38
2	104	4·57	0·42
3	105	5·20	0·52
4	106	6·89	0·52
6	107	11·17	0·67
8	118	14·19	0·97
10	119	15·47	0·97

BATTERY CHARGER TRANSFORMERS

	Price £	Post £
2 Amp 2–6–12 Volts	2·45	·35
4 Amp 2–6–12 Volts	3·29	·35
6 Amp 6–12 Volts	4·95	·50
12·5 Amp 2–6–12 Volts	7·80	·68

RECTIFIERS NOT INCLUDED

NEW PRODUCTS! Available shortly

Don't chance it!
isolate it!

"SPLASH PROOF" SAFETY TRANSFORMER

750 VA Isolation Unit (Interwinding Screen)

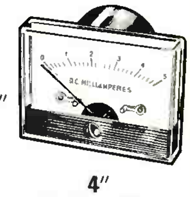
Housed in a tough Fibreglass case, with carrying handle. Complete with heavy duty 3-core power cable, splash proof outlet plug and socket, internal fuse. 110 Volt and 240 Volt versions available.

PRICE £26·20
CARRIAGE £1·30

AUTO TRANSFORMERS

VA (Watts)	Ref. No.	PRICE Cased £	PRICE Plugs 2 & 3 pin £	PRICE Open £	Post £
Tapped at 115, 220, 240 Volts					
20	113	3·00	0·15	1·55	0·30
Tapped at 115, 220, 240 Volts					
150	4	5·80	0·15	3·98	0·39
200	65	6·40	0·15	4·50	0·40
300	66	7·27	0·15	5·28	0·52
500	67	9·99	0·15	8·29	0·67
750	83	12·56	0·75	9·76	0·82
1000	84	15·70	0·75	12·40	0·82
1500	93	19·88	0·75	16·58	1·50
2000	95	30·10	1·44	22·05	1·50
3000	73	43·58	1·90	32·00	1·90

NEW! 2" AND 4" PANEL METERS



2"
SIZE: 60mm Wide × 45mm High × 40mm Deep.

4"
SIZE: 110mm Wide × 82mm High × 43mm Deep.

2" Movement	I.R. Ohms	4" Movement	I.R. Ohms
0–50 micro A	1250	0–50 micro A.	1400
0–100 micro A	580	0–100 micro A.	730
0–500 micro A.	170	0–500 micro A.	200
0–1 mA	170	0–1 mA	200
0–5 mA	170	0–5 mA	200
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
0–2 AMP	0·5	0–2 AMP	0·5
0–25 Volt	15K	0–25 Volt	15K
0–50 Volt	50K	0–50 Volt	50K
0–300 Volt	300K	0–300 Volt	300K
"g" Meter	170	"g" Meter	200
VU Meter	5250	VU Meter	5250

VU Meters are complete with detectors. Modern wide view.
Price 2" £2·95 Post 10p. Price 4" £3·95 Post 10p.
Lamps 55p per set.

C1000 MULTI-METER

Special Offer NOV. AND DEC. ONLY

Compact General Purpose Mini Multimeter
Input Resistance 1000 ohms per volt.
Ranges: AC Volts 0–15 50 250 1000 Volts
DC Volts 0–10 50 250 1000 Volts
DC Current 0–1 mA 0–100 mA
Resistance 0–150K ohms
Size 60 × 24 × 90 mm
Complete with: Batteries, Test Prods, Instructions.
Special price **£3.20** Post 20p.

MINIATURE NEONS

6 mm dia., 12 mm length, leads length approx. 20 mm. Recommended ballast resistor 150K ohms for 240 Volt operation. Price: Packet of 10 for 50p Postage 10p.

ELECTRONIC MAINS TIMER

A reliable unit ideal for timing Bathroom/Toilet Ventilators, Stairway/Cloakroom Lighting etc. Gives up to 30 mins. delay before switching off. Delay: 1–30 mins. adjustable. Max Load: 400 VA or 1000 Watts resistive. Ivory Case: 3⅜in. × 3⅜in. × 2in. Fitting Instructions included. Trade Price: £5·80. Post 20p.

MAINS KEYNECTOR

The safe, quick, connector for electrical appliances. 13 Amp rating, fused will connect a number of appliances quickly and safely to the mains, ideal for testing, demonstrating, window displays, etc., Warning Light, interlocked to prevent connecting when live.
Trade Price: £2·95. Post 25p.

BRIDGE RECTIFIERS

ONE AMP	Price	TWO AMP	Price
50 P.I.V.	0·25	50 P.I.V.	0·35
100 P.I.V.	0·25	100 P.I.V.	0·40
200 P.I.V.	0·28	200 P.I.V.	0·45
600 P.I.V.	0·30	400 P.I.V.	0·50
FOUR AMP		**SIX AMP**	
100 P.I.V.	0·55	50 P.I.V.	0·65
200 P.I.V.	0·59	100 P.I.V.	0·70
400 P.I.V.	0·65	200 P.I.V.	0·80
600 P.I.V.	0·75	400 P.I.V.	0·90

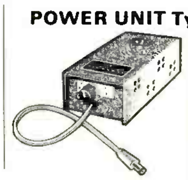
¼ WATT CARBON FILM RESISTORS

¼ watt at 70°C E 12 range 10Ω-1MΩ. 5% tol. above 470 KΩ 10% tol. at **95p** per 100.

POWER UNIT TYPE A125

Supplying 6 or 9 Volt DC at 200 mA.
In moulded case forming a 2 pin 5 A mains plug.
2 metre output lead with 4-way multiplug giving 2·1 and 2·5 mm sockets and 3·5 mm plugs.
Price £2·25. Post 10p.

POWER UNIT Type CC12–05



Output switched 3, 4·5, 6, 7·5, 9 and 12 Volts at 500 mA D.C. Operates from 240 V mains, suitable for Radios, Tape Recorders, Record Players etc. Size 7·5 × 5·0 × 14·0 cm. Price **£3·95**. Post 25p.

C1001 MULTIMETER

Input Resistance 20,000 ohms per volt
Overload protection
250 ua movement, clear scale
Ranges—AC Volts 0–10, 50, 250, 1000V
DC Volts 0–5, 25, 125, 500, 2500V
DC Current 0–50 mA
Resistance 0–60 Kohms 0–6 Mohms
Decibels −20 to +22 db.
Carrying Case, Test Prods and Batteries included.
Size: 11·5×8·3×2·7 cm.
Price **£9·85**. Post 20p.

A.S.P. (Dept. WW11), SIMMONDS RD., WINCHEAP, CANTERBURY, KENT CT1 3RW. Tel: Canterbury (0227) 52436

PLEASE ADD 8% FOR VAT

WW—043 FOR FURTHER DETAILS

ELECTRONIC ORGAN KITS

There are 5 superb models in kit-form specially designed for the D-I-Y enthusiast. With our free and generous after sales service you can build in sections, and the whole project can be extended over several months. All specialised components can be purchased separately.
We also stock keyboards, volume pedals, MOS master oscillators, ICs., transistors, ETC, for W/W synthesiser and W/W electronic piano. Send 50p for catalogue and vouchers worth 50p or send your own parts list, enclosing SAE for quotation.

ELVINS ELECTRONIC MUSICAL INSTRUMENTS
Components suppliers to the music industry
12 Brett Rd., Hackney, London E8 1JP. Tel: 01-986 8455

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.

LIGHT EMITTING DIODE
Suitable as stereo 'on' indicator for above
RED 29p
GREEN 59p

MC1310P only £3·15 plus p.p. 6p

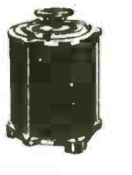
NOTE
As the supplier of the first MC1310P decoder kit, of which we have sold literally thousands, our customers can benefit from our wide experience.

V.A.T.
Please add V.A.T. at 8% to all prices

FI-COMP ELECTRONICS
BURTON ROAD, EGGINTON, DERBY, DE6 6GY

SERVICE TRADING CO

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) .... £9·00
0·5 KVA (Max. 2½ Amp) ... £10·00
1 KVA (Max. 5 Amp) .... £14·70
2 KVA (Max. 10 Amp) ... £28·10
3 KVA (Max. 15 Amp) .... £31·25
4 KVA (Max. 20 Amp) ... £72·50
(Max. 37.5 Amp) . £102·50
1 Amp OPEN TYPE (Panel Mounting) .... £9·00

L.T. TRANSFORMERS

All primaries 220-240 volts.

Type No.	Sec. Taps	Price	Post
1	30, 32, 34, 36 v. at 5 amps.	£7·25	60p
2	30, 40, 50 v. at 5 amps.	£9·60	65p
3	10, 17, 18 v. at 10 amps.	£7·55	60p
4	6, 12 v. at 20 amps.	£9·00	65p
5	17, 18, 20 v. at 20 amps.	£9·60	65p
6	6, 12, 20 v. at 20 amps.	£9·00	65p
7	12, 20, 24 v. at 10 amps.	£7·00	60p
8	4, 6, 24, 32 v. at 12 amps.	£9·00	65p
9	6 and 12 v. at 10 amps.	£4·50	55p

Large selection of other types in stock, phone for details.

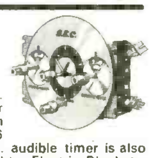
300 VA ISOLATING TRANSFORMER

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.

VENNER TIME SWITCH TYPE MSQP

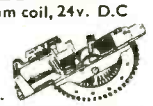
200/250 Volt 2-ON/2-OFF every 24 hours at any manually pre-set time. 20 amp contacts. Fitted die-cast case. Tested and in good condition **£4·75** Post 25p.

A.C. MAINS TIMER UNIT



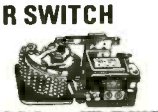
Based on an electric clock, with 25 amp. single-pole switch, which can be preset for any period up to 12 hrs. ahead to switch on for any length of time, from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets, etc. Attractive satin copper finish. Size 135 mm × 130 mm × 60 mm. Price **£2·00**. Post 20p. (Total inc. VAT & Post **£2·38**).

UNISELECTOR SWITCHES—NEW



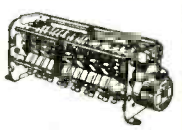
4 BANK 25 WAY FULL WIPER 25 ohm coil, 24v. D.C operation **£6·90**. Post 30p.
8 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. **£7.90**. Post 30p.
8 BANK 25 WAY FULL WIPER 24 v. D.C. operation **£9·50**. Post 40p.

MINIATURE UNISELECTOR SWITCH



2 Bank, 12 position, 24 volt D.C. operation, full wiper with ancillary contacts. NEW Price **£2·50** Post 20p.
As above but with 5 Bank, 12 position. Price **£3·50** Post 20p.

PROGRAMME TIMERS

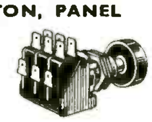


230/240 Volt A.C. 15 RPM Motors. Each cam operates a c/o micro switch. Ideal for lighting effects, animated displays etc. Ex equipment tested, similar to illustration.
2 cam model ..... **£2·00** post 30p
4 cam model ..... **£2·50** post 30p
6 cam model ..... **£3·25** post 30p
6 cam model 3 RPM .... **£3·25** post 30p.

VERY SPECIAL OFFER

Miniature Roller Micro Switch. 5 amp. c/o contacts. Mfg. BONNELLA. NEW. Price 10 for **£1·50**. Post 10p. (Min order 10.)
As above without roller. 20 for **£2.00**. Post 10p. (Min. order 20.)

'HONEYWELL' PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY



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, 2-bank 40p, 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 60p.

230–250 VOLT A.C. SOLENOID

Similar in appearance to illustration. Approximately 1½ lb. pull. Size of feet 1⅝" × 1⅛". 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 ⅛ in. travel. 6 solenoids of approx. 4 oz. pull at ⅛ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price: **£2·50**. Post 60p. **ABSOLUTE BARGAIN.**

POWER RHEOSTATS

New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10, 25, 100, 150, 500, 1k ohm. **£1·15** Post 10p.
50 WATT 1, 5, 10, 25, 50, 100, 500 ohm **£1·60**. Post 10p.
100 WATT 1/10/25/50/100/250/500/1k/1·5k/2·5k/5k ohm **£2·35**. Post 15p.
Black Silver Skirted knob calibrated in Nos. 1-9. 1¼ in. dia brass bush. Ideal for above Rheostats, 22p ea.

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.

EXPERIMENTERS "ECONOMY" KIT
Adjustable 1 to 30 Flash per sec. All electronic components including Xenon Tube + instructions **£6·30**, Post 30p.

INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. Adjustable 1-80 f.p.s., approx. ½ output of Hy-Lyght. Price **£14·00**. Post 50p.

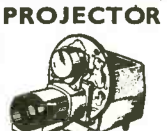
HY-LITE STROBE Mk IV
Designed for use in large rooms, halls and utilizes a silica tube, printed circuit. Speed adjustable 1-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. Price **£14·00**. Post 50p.

'SUPER' HY-LIGHT KIT
Approx. 4 times the light output of our well proven Hy-Lyght strobe.
Variable speed from 1-13 flash per sec.
Reactor control circuit producing an intense white light. **ONLY £22·00**. Post 75p.

ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE for the Super Hy-Lyght Kit including reflector. **£8·00**. Post 60p.

FOR HY-LYGHT STROBE incl. reflector, **£5·75**. Post 25p.

COLOUR WHEEL PROJECTOR



Complete with oil filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. **£18·50**. Post 50p.

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.)
6 INCH COLOUR WHEEL ONLY. Price **£4.50**. Post 30p.

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 **£16·00**. Post £1. Spare bulb **£7·00**. Post 40p.

BLACK LIGHT FLUORESCENT U.V. TUBES
4ft. 40 watt. Price **£5·50**. (Callers only). **2ft. 20 watt £4·25**. Post 25p. (For use in stan bi-pin fittings.) **MINI 12in. 8 watt £1·60**. Post 15p. **9in. 6 watt £1·30**. Post 15p. Complete ballast unit and holders for either 9" or 12" tube. **£1·70**. Post 25p. (9in. x 12in. measures approx.).

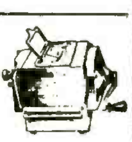
U.D.1. SINGLE CHANNEL. 750 watt MANUAL/AUTO DIMMER

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 30p.

GENERAL ELECTRIC POWERGLAS TRIACS

10 amp. Glass passivated plastic Triac. Latest device from U.S.A. Long term reliability. Type SC 146E 10 amp. 500PIV. **£1·00**. Post 5p. (Inclusive of 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 **£28·00**. Post 60p. **1,000 VOLTS**, 1,000 megohms **£34·00**. Post 60p.

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Available in black, red, white, yellow, blue and green. New **12p** each incl. P & P. Minimum order 6.

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SIEMENS PLESSEY, etc. MINIATURE RELAYS

1	2	3	4	1	2	3	4
58	5-9	6 c/o	80p	700	16-24	4 c/o	80p*
150	4-9	2 c/o	70p*	2500	36-45	6 M	60p*
185	8-12	6 M	60p*	2500	31-43	2 c/o HD	60p*
308	9-14	4 c/o	75p*	9000	40-70	2 c/o	60p*
410	12-20	4 c/o	80p*	15k	85-110	6 M	60p
700	16-24	4M2B	60p*				

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*Including Base)

6 VOLT D.C. 1 make con. **35p**. Post 10p.

9 VOLT D.C. RELAY
3 c/o 5 amp contacts. 70 ohm coil **75p**. Post 10p.

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100 VOLT A.C.
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DIAMOND H, Heavy Duty Relay
230/240V A.C. 2 c/o contacts 25 amp RES at 250v A.C. Price **£2·00**. Post 10p.

HEAVY DUTY SEALED RELAY
110 Volt 2 c/o 20 amp contacts. **£1·25**. Post 10p.

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3 c/o 5 amp cont. Sealed, incl 11-pin base. **£1.25**. Post 10p.

CLARE-ELLIOT Type RP 7641 G8
Miniature relay. 675 ohm coil. 24 volt D.C. 2 c/o. **70p**. Post Paid.

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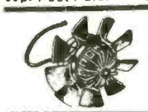
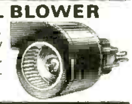
M.f.g. by ERG 12 volt D.C. encapsulated. Single c/o 65p. Post Paid. Two c/o 85p. Post Paid.
STC 280 ohm coil 6/12 V D.C. 3 make contacts metal shrouded 60p. Post Paid. Large range of other types available.

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., Heavy Duty, continuously rated, smooth running, 230/240v A.C. motor. Size: 16 × 14 cm. (case only). OAL 15 cm. Aperture 6 × 6 cm. **£6.50**. Post 50p.

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Comprising of impeller, continuously rated motor, motor housing and fixings as illustrated. Price **£1·75**. Post 25p. (Total inc. VAT & Post **£2·16**.)

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Continuously rated, removable aluminium blades. Price **£1·00**. Post 20p.

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2,750 r.p.m. Length 2¾ inch, dia 1⅜ inch, shaft ⅛ inch. No load 40mA. Ideal for portable recorders etc. **£1.50**. Post 15p.

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Speed 9,000 r.p.m. approx. or 3,200 r.p.m. if used with built-in governor, or variable speed over a wide range if used in conjunction with our Dimmer Switch, illustrated below. PRICE: **£2·00**. Post 35p.

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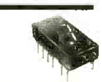

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1LD5	0·60
1LN5	0·60
1N5GT	0·65
1R5	0·45
1S4	0·33
1S5	0·30
1U4	0·60
1U5	0·75
2D21	0·45
2GK5	0·55
2X2	0·60
3A4	0·50
3B7	0·45
3D6	0·40
3Q4	0·60
3Q5GT	0·55
3S4	0·40
4CB6	0·55
5CG8	0·55
5R4GY	0·80
5T4	0·40
5U4G	0·40
5V4G	0·54
5Y3GT	0·45
5Z3	0·75
5Z4G	0·45
5Z4GT	0·45
6/30L2	0·80
6A8G	1·25
6AC7	0·49
6AG5	0·27
6AH6	0·60
6AJ5	0·65
6AJ8	0·33
6AK5	0·40
6AK6	0·60
6AK8	0·38
6AL5	0·20
6AM8A	0·55
6AN8	0·70
6AQ5	0·45
6AQ8	0·40
6AR5	0·60
6AR6	1·00
6AS7	1·00
6AT6	0·45
6AU6	0·30
6AV6	0·45
6AW8A	0·95
6AX4	0·75
6B8G	0·30
6BA6	0·28
6BC8	0·60
6BE6	0·35
6BG6G	1·05
6BH6	0·75
6BJ6	0·55
6BK7A	0·60
6BQ5	0·31
6BQ7A	0·55
6BR7	1·00
6BR8	1·50
6BS7	1·40
6BW6	0·90
6BW7	0·74
6BX6	0·26
6BY7	0·34
6BZ6	0·49
6C4	0·35
6C5G	0·50
6C6	0·40
6C9	1·00
6CB6A	0·40
6C12	0·33
6C17	2·00
6CD6G	1·25
6CG8A	0·75
6CH6	1·13
6CL6	0·65
6CL8A	0·80
6CM7	0·75
6CU5	0·75
6CW4	1·00
6D3	0·60
6DE7	0·75
6DT6A	0·75
6EW6	0·75
6E5	1·00
6F1	0·75
6F6G	0·50
6F12	0·37
6F13	0·70
6F14	0·75
6F15	0·65
6F18	0·55
6F23	0·80
6F24	0·85
6F25	1·00
6F26	0·34
6F28	0·67
6F32	0·50
6G6G	0·50
6GH8A	0·75
6GK5	0·65
6GU7	0·75
6H6GT	0·25
6J5GT	0·45
6J6	0·30
6J7G	0·30
6J7(M)	0·45
6JU8A	0·75
6K7G	0·30
6K8G	0·45
6L1	2·00
6L6GT	0·58
6L7(M)	0·50
6L18	0·55
6L19	2·00
6LD12	0·38
6LD20	0·75
6N7GT	0·60
6PL12	0·34
6Q7G	0·50
6Q7GT	0·50
6Q7(M)	0·55
6R7G	0·60
6R7(M)	0·75
6SA7(M)	0·44
6SC7GT	·33
6SG7(M)	0·44
6SH7	0·44
6SJ7(M)	0·55
6SK7GT	·44
6SQ7GT	·45
6U4GT	0·70
6U7G	0·45
6V6G	0·17
6V6GT	0·45
6X4	0·40
6X5GT	0·40
6Y6G	0·80
6Y7G	1·00
7A7	1·00
7B6	0·75
7B7	0·70
7F8	1·50
7H7	0·75
7R7	0·80
7V7	1·50
7Y4	0·75
7Z4	0·80
9BW6	0·75
9D7	0·65
10C2	0·65
10D1	0·70
10DE7	0·75
10F1	0·75
10F9	0·65
10F18	0·55
10L14	0·45
10LD11	0·70
10LD12	0·40
10PL12	0·38
10P13	0·75
10P14	2·00
10P18	0·42
12A6	1·00
12AC6	0·70
12AD6	0·65
12AE6	0·65
12AT6	0·40
12AT7	0·34
12AU6	0·45
12AU7	0·33
12AV6	0·50
12AX7	0·33
12AY7	0·80
12BA6	0·45
12BE6	0·50
12BH7	0·50
12E1	3·00
12J5GT	0·33
12J7GT	0·60
12K5	1·00
12K7GT	0·50
12Q7GT	0·45
12SA7GT	·55
12SC7	0·50
12SG7	0·40
12SH7	0·35
12SJ7	0·44
12SK7	0·55
12SN7GT	0·65
12SQ7GT	0·65
12SR7	0·75
14H7	0·55
14S7	0·80
18	1·00
19AQ5	0·50
19BG6G	1·00
19G6	6·00
19H1	2·00
20D1	0·60
20D4	2·00
20F2	0·75
20L1	1·10
20P1	0·55
20P3	0·80
20P4	1·00
20P5	1·30
25A6G	0·60
25L6G	0·60
25Y5	0·80
25Y5G	0·70
25Z4G	0·40
25Z5	0·80
25Z6G	0·70
28D7	1·00
30A5	0·65
30C1	0·40
30C15	0·80
30C17	0·90
30C18	0·80
30F5	0·80
30FL1	0·75
30FL2	0·75
30FL12	0·90
30FL13	0·55
30FL14	0·78
30L1	0·40
30L15	0·75
30L17	0·70
30P4MR	1·00
30P12	0·80
30P19/30P4	0·75
30PL1	0·85
30PL13	0·95
30PL14	1·10
30PL15	0·90
35A3	0·65
35A5	0·80
35D5	0·75
35L6GT	0·75
35W4	0·50
35Z3	0·75
35Z4GT	0·70
35Z5GT	0·75
42	0·50
50B5	0·85
50C5	0·60
50CD6G	1·25
50EH5	0·75
50L6GT	0·65
72	0·60
77	0·53
85A2	0·60
85A3	0·60
90AG	2·50
90CG	2·40
90CV	2·40
90C1	0·75
150B2	0·75
2158G	0·50
301	1·00
302	1·00
303	1·00
305	1·00
807	0·59
956	0·30
1821	1·00
5702	1·00
6057	1·00
6060	1·00
6067	1.00
7193	0·53
7475	1·00
9002	0·50
9006	0·30
A1834	1·00
A2134	1·00
A3042	1·00
AC2PEN	1·00
AC2PENDD	1·00
AC6/PEN	0·60
AC/PEN(7)	1·00
AC/TH1	1·00
AC/TP	2·00
AL60	1·00
ARP3	0·60
ATP4	0·50
AZ1	0·25
AZ31	0·60
AZ41	0·25
BL63	2·00
CL33	1·60
CV6	0·53
CV63	0·75
CV988	0·25
CY1C	1·00
CY31	0·50
D63	0·25
DAC32	0·60
DAF96	0·50
DC90	0·60
DD4	1·00
DF91	0·30
DF96	0·50
DH63	0·50
DH76	0·45
DH77	0·45
DH81	0·75
DK32	0·65
DK40	0·70
DK92	0·70
DK96	0·60
DL92	0·40
DL96	0·55
DM70	0·60
DM71	1·50
DW4/350	1·00
DY87/6	0·35
DY802	0·33
E80CC	2·20
E80F	1·40
E83F	1·30
E88CC	0·75
E92CC	0·60
E180CC	0·70
E180F	1·00
E182CC	1·25
E1148	0·53
EA50	0·27
EA76	1·00
EABC80	0·38
EAC91	0·75
EAF42	0·75
EAF801	0·75
EB34	0·25
EB91	0·20
EBC41	0·75
EBC81	0·35
EBC90	0·45
EBC91	0·45
EBF80	0·39
EBF83	0·43
EBF89	0·30
EBL21	2·00
EC52	1·00
EC53	1·00
EC54	1·00
EC86	0·70
EC88	0·70
EC92	0·45
ECC32	1·50
ECC33	1·50
ECC35	0·95
ECC40	1·00
ECC81	0·34
ECC82	0·33
ECC83	0·33
ECC84	0·30
ECC85	0·40
ECC86	0·85
ECC88	0·44
ECC189	0·65
ECC804	0·80
ECC807	1·20
ECF80	0·34
ECF82	0·38
ECF86	0·75
ECF804	2·10
ECH21	2·00
ECH35	1·25
ECH42	0·70
ECH81	0·33
ECH83	0·44
ECH84	0·44
ECL80	0·55
ECL82	0·34
ECL83	0·70
ECL84	0·60
ECL85	0·60
ECL86	0·40
EF22	1·50
EF40	0·75
EF41	0·70
EF42	0·70
EF73	1·50
EF80	0·26
EF83	1·00
EF85	0·34
EF86	0·30
EF89	0·27
EF91	0·37
EF92	0·50
EF94	0·30
EF97	0·80
EF98	0·80
EF183	0·30
EF184	0·35
EF804	1·25
EH90	0·55
EK90	0·35
EL32	0·50
EL33	2·00
EL34	0·66
EL35	2·50
EL37	2·50
EL41	0·90
EL81	0·60
EL83	0·55
EL84	0·31
EL85	0·44
EL86	0·38
EL91	0·50
EL360	1·20
EL506	0·85
ELL80	1·25
EM80	0·45
EM81	0·65
EM83	0·55
EM84	0·40
EM85	1·00
EM87	0·70
EMM803	2·00
EY51	0·40
EY81	0·40
EY83	0·54
EY84	0·70
EY87/6	0·35
EY88	0·40
EY91	0·58
EZ35	0·40
EZ40	0·50
EZ41	0·55
EZ80	0·28
EZ81	0·29
EZ90	0·40
FC4	1·00
FW4/500	1·00
FW4/800	1·00
GY501	0·75
GZ30	0·45
GZ32	0·54
GZ33	1·25
GZ34	0·65
GZ37	1·00
HABC80	0·60
HL13C	0·50
HL23DD	0·75
HL41DD	2·00
HL42DD	2·00
HN309	1·50
HVR2	1·00
HVR2A	1·00
IW3	1·00
KT2	0·75
KT8	2·50
KT41	1·00
KT44	1·00
KT63	0·50
KT66	2·50
KT81	2·00
KTW61	1·50
KTW62	1·50
KTW63	1·00
M8162	1·00
MHL4	0·75
MHLD6	1·00
MKT4	1·00
MU12/14	1·00
N308	1·00
N339	1·10
P61	0·50
PABC80	0·38
PC86	0·60
PC88	0·60
PC95	0·60
PC97	0·38
PC900	0·48
PCC84	0·40
PCC85	0·44
PCC88	0·60
PCC89	0·50
PCC189	0·60
PCF80	0·40
PCF82	0·35
PCF84	0·59
PCF86	0·60
PCF87	0·90
PCF200	0·75
PCF800	0·80
PCF801	0·50
PCF802	0·50
PCF805	0·80
PCF806	0·55
PCF808	0·78
PCH200	0·80
PCL82	0·35
PCL83	0·66
PCL84	0·49
PCL86	0·47
PCL88	1·10
PCL800	0·95
PCL801	0·85
PCL805/PCL85	0·60
PEN4DD	2·00
PEN45	0·80
PEN45DD	0·80
PEN46	0·50
PEN453DD	2·00
PENA4	1·00
PENDD/4020	2·00
PFL200	0·80
PL33	0·50
PL36	0·60
PL81	0·50
PL81A	0·55
PL82	0·45
PL83	0·45
PL84	0·40
PL302	0·75
PL504/500	0·75
PL505	1·45
PL508	0·90
PL509	1·45
PL801	0·80
PL802	0·95
PM84	0·65
PY33/2	0·50
PY80	0·40
PY81	0·35
PY82	0·35
PY83	0·38
PY88	0·40
PY301	0·75
PY500	0·95
PY500A	0·95
PY800	0·40
PY801	0·40
PZ30	0·48
QP21	0·50
QQV03/10	1·75
QS75/20	1·00
QS95/10	1·00
QS150/15	1·50
QV04/7	1·00
R11	1·00
R16	1·75
R17	0·88
R18	0·70
R19	0·55
R20	0·75
R52	0·45
RK34	1·00
SP13C	0·63
TH4B	1·00
TH233	1·00
TP2620	1·00
TP22	1·00
TP25	1·00
UABC80	·40
UAF42	0·60
UBC41	0·60
UBC81	0·45
UBF80	0·40
UBF89	0·40
UBL21	0·77
UC92	0·45
UCC84	0·75
UCC85	0·45
UCF80	0·70
UCH21	2·00
UCH42	0·75
UCH81	0·40
UCL82	0·38
UCL83	0·65
UF41	0·70
UF42	0·70
UF80	0·35
UF85	0·44
UF86	1·00
UF89	0·40
UL41	0·75
UL84	0·42
UM80	0·44
UR1C	1·00
UU5	1·00
UU9	0·70
UU12	0·29
UY41	0·45
UY85	0·40
U10	1·00
U12/14	1·00
U16	1·00
U17	0·75
U18/20	1·00
U19	2·50
U22	0·75
U25	0·85
U26	0·75
U31	0·40
U33	1·50
U35	1·50
U37	1·75
U45	1·00
U47	0·85
U49	0·75
U50	0·45
U76	0·70
U78	0·40
U81	0·80
U153	0·35
U191	0·75
U192	0·35
U193	0·40
U251	0·80
U281	0·90
U282	0·55
U291	0·50
U301	0·65
U329	0·80
U381	0·40
U403	0·75
U404	0·55
U801	0·85
U4020	0·60
VP13C	0·60
VP23	0·75
VP41	0·75
VT61A	0·65
VT501	0·50
VU111	0·80
VU120	1·00
VU120A	1·00
VU133	0·80
W76	0·45
W81M	1·00
W107	1·00
W729	1·00
XE3	5·00
XFY12	0·48
XH1.5	0·48
X41	1·00
X61	1·25
X65	1·25
X66	1·25
Z329	0·80
Z729	0·30
Z749	0·80
Z759	5·00
Transistors and Diodes	
1N1124A	·58
1N4952	0·55
2N404	0·20
2N966	0·58
2N1756	0·55
2N2147	0·94
2N2297	0·25
2N2369A	·15
2N2613	0·43
2N3053	0·36
2N3121	2·75
2N3703	0·21
2N3709	0·22
2N3866	1·10
2N3988	0·55
28323	0·55
AA119	0·17
AA120	0·17
AA129	0·17
AAZ13	0·20
AC107	0·17
AC113	0·28
AC114	0·44
AC126	0·14
AC127	0·19
AC128	0·22
AC132	0·22
AC154	0·28
AC156	0·22
AC157	0·28
AC165	0·28
AC166	0·28
AC167	0·66
AC168	0·42
AC169	0·36
AC176	0·61
AC177	0·31
ACY17	0·28
ACY18	0·22
ACY19	0·21
ACY20	0·20
ACY21	0·21
ACY22	0·17
ACY28	0·20
AD140	0·40
AD149	0·55
AD161	0·50
AD162	0·50
AF102	0·99
AF106	0·55
AF114	0·28
AF115	0·17
AF117	0·21
AF121	0·33
AF124	0·28
AF125	0·19
AF126	0·20
AF139	0·72
AF178	0·75
AF180	0·53
AF186	0·61
AF239	0·42
ASY27	0·47
ASY28	0·36
ASY29	0·55
BA102	0·50
BA115	0·15
BA116	0·20
BA129	0·14
BA130	0·11
BA153	0·17
BCY10	0·50
BCY12	0·55
BCY33	0·22
BCY34	0·25
BCY38	0·25
BCY39	0·28
BC107	0·14
BC108	0·14
BC109	0·11
BC113	0·28
BC115	0·17
BC116	0·28
BC118	0·25
BCZ11	0·42
BF154	0·28
BF158	0·20
BF159	0·28
BF163	0·22
BF173	0·42
BF180	0·33
BF181	0·44
BF185	0·44
BF194	0·17
BFY50	0·25
BFY51	0·21
BFY52	0·22
BTX34/400	2·20
BY100	0·20
BY101	0·17
BY105	0·20
BY114	0·20
BY126	0·17
BY127	0·20
BYY23	1·10
BYZ10	0·28
BYZ11	0·28
BYZ12	0·28
BYZ13	0·28
BYZ15	1·93
CG12E	0·22
CG64H	0·22
FSY11A	·25
FSY41A	·25
GD4	0·36
GD5	0·31
GD6	0·31
GD8	0·22
GD9	0·22
GD11	0·22
GD12	0·22
GD14	0·55
GD15	0·44
GD16	0·22
GET113	·22
GET118	·22
GET119	·27
GET573	·42
GET587	·47
GET872	1·05
GET873	·17
GET882	·55
GET887	·25
GET889	·25
GET890	·25
GET896	·25
GET897	·25
GET898	·25
GEX13	0·20
GEX35	0·25
GEX36	0·55
GEX45	0·36
GEX55	0·83
GT3	0·28
M1	0·17
MAT100	·43
MAT101	·47
MAT120	·43
OA9	0·14
OA10	0·47
OA47	0·11
OA70	0·17
OA73	0·17
OA79	0·10
OA81	0·10
OA85	0·09
OA86	0·22
OA90	0·14
OA91	0·10
OA95	0·10
OA200	0·10
OA202	0·11
OA210	0·53
OA211	0·75
OC19	1·38
OC22	0·42
OC23	0·42
OC24	0·42
OC25	0·42
OC28	0·66
OC29	0·69
OC36	0·47
OC38	0·47
OC41	0·55
OC42	0·69
OC43	1·30
OC44	0·11
OC45	0·12
OC46	0·17
OC65	1·24
OC70	0·14
OC71	0·12
OC72	0·12
OC74	0·25
OC75	0·12
OC76	0·17
OC77	0·30
OC78	0·17
OC78D	0·17
OC79	0·44
OC81	0·12
OC81D	0·12
OC82	0·12
OC82D	0·12
OC83	0·22
OC84	0·26
OC123	0·25
OC139	0·25
OC140	1·05
OC169	0·25
OC172	0·39
OC200	0·24
OC201	0·42
OC203	0·33
OC204	0·33
OC205	0·47
OC812	0·44
ORP12	0·58
S6M1	0·28
SM1036	0·55
ST1276	0·55
SX1/6	0·20
U14706	0·28
XZ30	0·28
Y543	0·20
Y728	0·20
ZE12V7	0·10

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LP15 (AC113, AC154, AC157, AA120). 58p per pack.
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1 watt Zeners. 2·4v., 2·7v., 3v., 3·6v., 4·3v., 4·7v., 5·1v., 13v., 15v., 16v., 18v., 20v., 24v., 30v., 20p each.

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WE ARE ANXIOUS TO BUY Synchro Test Equipment manufactured by Muirhead, Singer-Gertsch etc. Test Dials, Dividing Heads, Bridges, Standards etc. to expand our testing facilities.

SOLAR CELLS. Ferranti silicon MS11BE, active area 390 sq. mm. Open Cct voltage 550mV at 3000 lumens/sq. ft. Sht. Cct. Current 60mA. Optimum load 90hms. Dia. 34mm. Thickness. 6mm. mtg thrd 1/4-28 unf 2A. Ex Made up panel **£1.35** (inc. P. & P. and VAT).

PANEL DISPLAY RECORDING CAMERA. Manufactured A.G.I. Specifically for the recording of complex instrument displays on 2.1/4in. x 2.1/4in. shots. Fitted 80mm F3.5 lens. Shutter speeds 1/100, 1/50, 1/25 sec. and time exp. Focussing at 1.75 to 50 ft. in 18 steps. Aperture sttgs F3.5 to F22. Prismatic viewfinder and facility for viewing direct on ground glass screen. Rotating filter attachment. Cord film advance and shutter cock with septe. Button control and electrical release facility (24V DC) Spool holds 40 exposures. Camera may be wall mounted on bracket supplied. Tripod mounting socket provided. In wooden case. Two grades available 'as new' Grade A **£35.10** (inc. P. and P. and VAT). Somewhat used but serviceable Grade B **£28.08** (inc. P. & P. and VAT).

X-Y PLOTTER OUTPUT UNIT. End of production run. chart area 32in. x 11in., with drives etc. Lydd callers only **£27** each inc. VAT.

WEE MEGGERS, 250V **£12.53. RECORD MEGGERS,** 500V **£15.12** (inc. P. & P. and VAT).

200-250V AC MAINS TO 27V 500mA D.C. STABILISED P.S.U.

With circuit. These interesting 27v 0·5A units (will happily provide 700mA indefinitely) are built into an attractive grey-finished instrument case, provision being made for base or side mounting. Cable entry grommets are mounted in the base of the unit. The choke capacity smoothed output is solid state stabilised against variation in input voltage and output current, and input and output fuses with spares are fitted. The output operates a built-in S.P.C.O. relay to switch for instance an alarm circuit. There is adequate room for other equipment within the ventilated case, which is 12" × 10" × 6" deep.

£4.43 EACH (P.Pd U.K.)

Metal Oxide Resistors
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ETHER-TRANSITROL TEMPERATURE CONTROLLERS. 0-1,000°C for Chromel-Alumel Thermocouples. **£27.50** including carriage and V.A.T.

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RADAR CABLEFORM INSULATION TESTER for checking insulation between individual conductors and each other and ground at preselected voltages up to 10Kv. Full details on application.

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Tickets available to professional readers
S.A.E. Please

STAINLESS STEEL VACUUM CONTAINERS FOR LIQUIDS. Capacity 2 U.S. galls. fitted with delivery taps. Brand new in cartons—**£25** (C. Pd. U.K.).

N.E.P. Mod. 1050 6 Channel U/V Recorder. Fitted 5 galvos. With P.S.U. for 230v. A.C. 14 x 10 x 12 in. (recorder) and 14 x 10 x 8 in. (P.S.U.). **£220.00** (inc. carr. & V.A.T.).

FI-CORD MODEL 202 PORTABLE RECORDER with case 7½ or 3¾ in./sec. Within 3dB 50Hz to 12kHz at 7½ in./sec. 50Hz to 8kHz at 3¾in. sec. 4 in. spools ¼ in. tape ¼ track. Intnl. speaker and 2K phone output. Remote control socket. Twin cassettes take 8 miniature lead acid batteries. 9 x 6½ x 4½ in. Wt. 6½ lbs. Full data s.a.e. **£30·50** inc. P.P. & V.A.T.

DRY REED INSERTS

Overall length 1·85in. (Body length 1·1in.) Diameter 0·14in. to switch up to 500mA at up to 250v. D.C. Gold clad contacts 70p per doz.; **£4·10** per 100; **£29·80** per 1,000; **£270** per 10,000. All carriage paid U.K.
Heavy duty type (body length 2in.) diameter 0·22in. to switch up to 1A. at up to 250V. A.C. Gold clad contacts, **£1·38** per doz.; **£6·78** per 100; **£51·40** per 1,000; **Changeover Heavy Duty type £2·70** per doz. All carriage paid U.K.
Operating Magnets 65p per doz.; **£4·45** per 100; **£38·00** per 1000. All carriage paid U.K.
Operating Coils for 12v supply to accept up to four standard reeds **£2·20** per doz.; **£12.30** per 100. All carriage paid U.K.

ALL PRICES INCLUDE 8% V.A.T.

LEMANIA AIRCREW CHRONOGRAPHS

Stainless Steel case with screw back; luminous hands and markings. One fifth sec. sweep hand controlled independently of main movement by press to start, stop and return to zero button. 15 jewel movement. Many of these watches are as new but all have been completely overhauled and checked for accuracy. Fitted strap. White face **£18.25,** Black face **£19.20** inc. P.&P. **Inspection against remittance**

GS WATCHES all with brushed stainless steel case with screw back and black faces. Manufactured by CYMA, VERTEX, RECORD, etc., to a standard specification. We will try to meet your requirements for specific manufacturer and quantity orders will be of one manufacturer's production. Completely overhauled. Fitted strap. **£8·80** inc. P. & P.
We also have limited quantities of these watches by OMEGA, LONGINES, BUREN, JAEGER LE COULTRE at **£15·25** inc. P. & P.

TELEPRINTER PAPER. Standard rolls. 2 ply 3 ply **£4.10** per doz. 4 ply **£4.40** per doz. All P.Pd. U.K. Telex your order now!

A.C. SUPPLY PANEL for 19in. rack mounting carrying two 2kVA Variacs with double brush assemblies providing four individually fused and metered outputs of up to 4kVa and 270v in excellent condition at **£48.50** including carriage and V.A.T. (U.K. mainland).

TAPE STORAGE CANS. Brand new finished steel cans originally intended for 16mm film but ideal for storing 7 in. reels of tape. Our last supply of these items was quickly exhausted at **30p each** but as a result of a massive new purchase we can now offer a case of 55 at **£5.25** inc. P. & P. and V.A.T. Sample order 10 for **£1.10** inc. P. & P. and V.A.T.

OVER 300,000 IN STOCK!
Multiway and R.F. **Connectors** by twenty different companies! Send us your detailed requirements quoting Nato numbers if known. TELEX 965265.

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BOX NUMBERS: 30p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.)
PHONE: Allan Petters on 01-261 8508 or 01-261 8423.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Advertisements accepted up to 12 noon Tuesday, November 5th for the December issue subject to space being available.

Planning and Installation Engineer

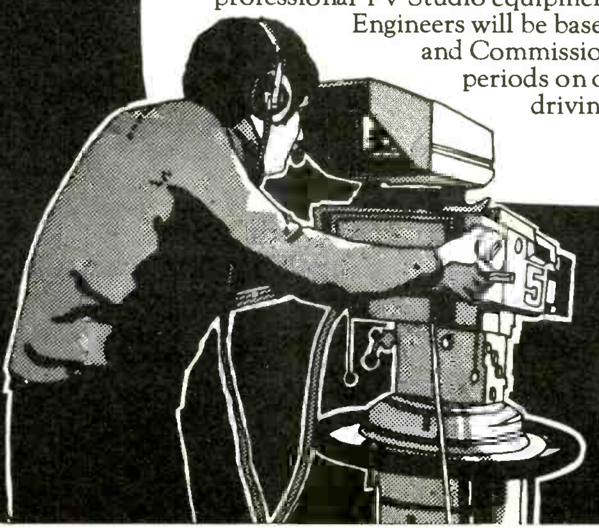
Pye TVT has recently won a £7.7m contract to supply a complete colour television broadcasting system to the Middle East Sultanate of Oman. This is just one example of our rapid expansion in the field of broadcasting systems, which has created a need for high calibre

Planning Engineers/Installation and Commissioning Engineers

for colour television Transmitter and Studio projects, in the U.K. and overseas.

Applicants should be well experienced in current UHF and VHF Colour TV Transmitters and peripheral equipment *or* professional TV Studio equipment and techniques.

Engineers will be based in Cambridge but Installation and Commissioning Engineers can expect to spend periods on overseas projects. A current driving licence is essential.



Please write, with a brief outline of your qualifications and career so far, to: Mrs. J. A. Macnab, Personnel Manager.

Pye TVT Limited
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Opportunities in the
ELECTRONICS FIELD

Men with analogue or digital qualifications/experience seeking higher paid posts in: TEST – SERVICE – DESIGN – SALES. Phone Mike Gernat. Ref. WW.

NEWMAN APPOINTMENTS
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HI-FI and AUDIO ENGINEERS

This could be the opportunity you've been looking for

Due to continued expansion Hardman Radio, the North-West's largest Hi-Fi Group, are looking for enthusiastic Hi-Fi and Audio Engineers with bench experience to join our teams in Liverpool, Manchester and Preston.
Excellent salary together with good working conditions and future prospects.

Phone or write to:
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33 Dale Street, Liverpool L2. Tel: 051-236 2828

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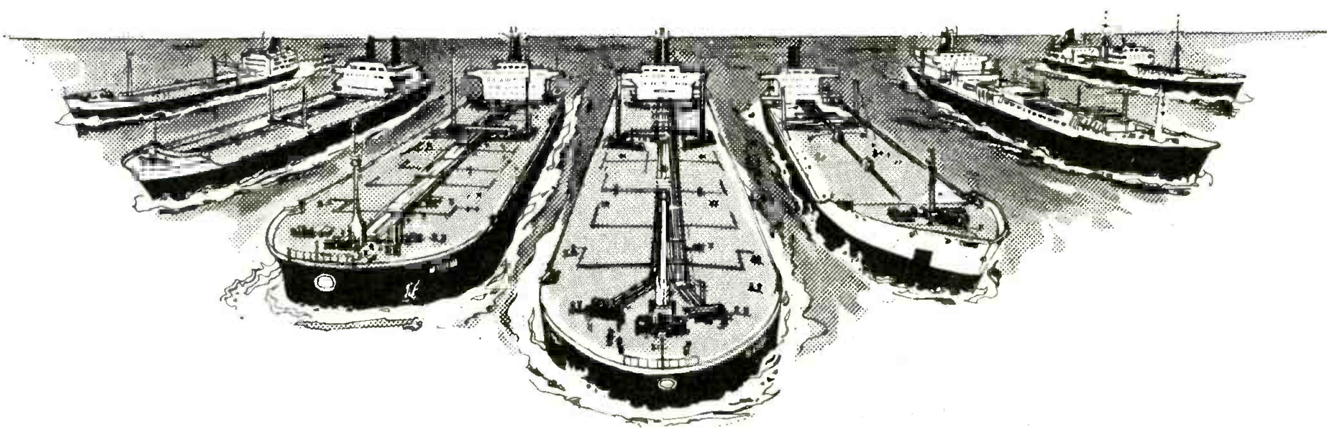
Radio/Electronics Officers

Does it make sense to settle for second best?



When you're thinking about your career and your family's future, it would be wise to think of Shell. Whether you're in the service now or ashore for the time being, you will already know a lot about us. Our British flag fleet of about 80 ships (with more on the way) is widely diversified, carrying many different cargoes—bitumen, luboils, crude, LNG, chemicals and black and white products. That means that you don't have to be stuck in one particular kind of tanker for long periods. You can move up and move around with equal familiarity. Our large and increasing investment in training underwrites our determination to ensure that we will achieve our intended service periods of 4½ months, and underlines our confidence in the future of the Fleet. When it comes to pay, you'll find our salaries are highly competitive. You can earn between £2,972 (with general certificate and DTI radar certificate) and £6,156 (including MNTB electronics certificate). Your experience and qualifications will determine the point at which you can enter this scale. Leave too is generous—at the rate of 183 days per year served. All officers are members of the company pension scheme and certificated officers can take their wives to sea whenever they wish, which includes two free air fares a year. If you are returning to the service after a spell ashore or already in service, we'll be pleased to tell you all about the extra benefits that Shell can offer you as a Radio/Electronics Officer in our fleet. Write or phone, reversing the charges:

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STP/13, (WW/11/74)
Shell Centre,
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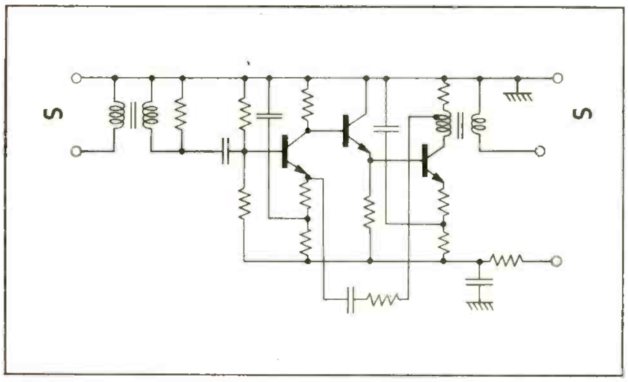

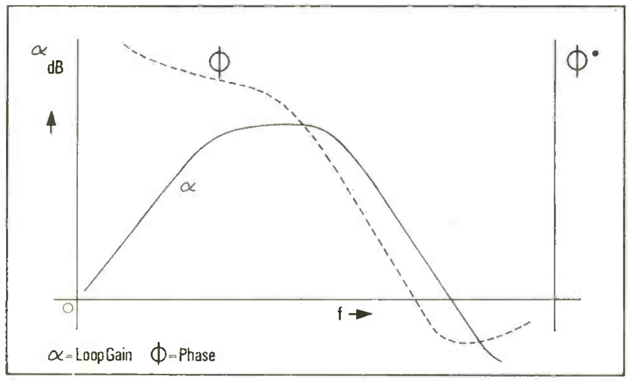

Could you stabilise this – by design?

This is only one example of the sort of work that our engineers do in the design and development laboratories of the Submarine Systems Division of S.T.C.

We are looking for graduate or similarly qualified engineers with experience of a year or more in electronic design and development. An analogue background will be preferred.

This is what we have to offer:—

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We are the world's largest supplier of repeatered submarine telephone cable systems. Most of our product is exported and our order books are healthy — £43m of orders so far this year. We are also the technological leaders in our field and through our design and development teams we are continuously improving on our fine record of innovation and reliability.

Money:

Starting salary will be up to £3,000 depending on experience. Your salary progression will be determined by your own performance, responsibilities and potential. Generous relocation expenses will be paid where appropriate.

A Satisfying Job:

You will design and develop wideband analogue amplifiers, filter networks (using C.A.D.), repeater supervisory circuits, terminal transmission equipment or advanced test gear. You will be designing a product of supreme quality, for once laid a system must operate for 25 years without fault or maintenance.

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We shall offer training to those whose experience of analogue circuitry is limited. Encouragement is given to engineers who wish to obtain corporate membership of the I.E.E.

Career Development:

You will be given every opportunity to develop and take responsibility. There is much scope for advancement in the Engineering Department and other functions of the company. Promotion is given on the basis of merit.

Travel:

Opportunities may exist for you to spend periods abroad on cable laying and commissioning operations. In 1975 this might take you to Spain, Italy, Israel, the Greek Islands, Australia, New Zealand or New Guinea.

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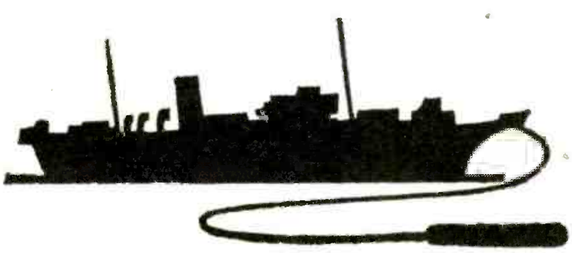
If you would like our special information pack 'phone David Stenhouse on 01-476 1401, or write to him at:—
Standard Telephones and Cables Limited, Submarine Systems Division, Henley Road, North Woolwich, E.16.



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Here's an electronics job worth looking into
A job as an Electronics Technician with Marconi-Elliott Avionics. A job working on project testing of prototype equipment and testing sub-units through to full systems from production.
Here at Basildon, we design and manufacture highly advanced communication systems and closed circuit T.V. equipment so you'll have every opportunity to put your ability to the test. We're looking for men with sound practical knowledge and experience of television pulse techniques or VHF and UHF communications. This experience could well have been gained in the electronics industry or in the Forces.
If you'd like to join our test team, we can offer you really good money and a generous range of benefits. Write with details of your experience to R. A. Bezant, Senior Personnel Officer, Marconi-Elliott Avionic Systems Limited, Christopher Martin Road, Basildon, Essex. Tel: Basildon 22822.
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DIVISION OF MARITIME SCIENCE

vacancies at

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A number of interesting posts with a wide range of duties are available at the above locations.

We use analogue and digital circuits, audio and radio frequencies, land and sea based equipment, together with computers to handle our results.

Assistant Scientific Officers, with an interest in electronics, are required to join small teams at both sites to help us maintain and develop our systems, and to assist in trials on ships and offshore structures.

Excellent opportunities exist to obtain broad practical experience and to study for higher qualifications leading to a worthwhile career.

The minimum qualifications are 4 GCE or CSE Grade 1 subjects, to include Maths, Science and English Language. Salary ranges from £887 (at age 16) to £1,547 (at age 25) rising to £1,899.

If you would like further details you may telephone Mr. R. F. Johnson or Mr. R. W. Cuffe at the numbers shown.

Mr. R. F. JOHNSON: 01-977 3222 Ext. 4165 during working hours or Woking 65942 evenings and weekends.

MR. R. W. CUFFE: Hythe, (Hants) 3065 (STD 042-14) in working hours, or Hythe 6804 evenings and weekends.

Alternatively, write to Mr. H. B. Boyle, Officer-in-Charge, Department of Industry, National Physical Laboratory, Division of Maritime Science, St John's Street, Hythe, Southampton, Hampshire, SO4 6YS, quoting Reference MS/INST.

[4072

MINISTRY OF DEFENCE

Require

TELECOMMUNICATIONS PERSONNEL

for employment with the British Forces in Germany. Duties include responsibility for the provision and maintenance of the permanent telecommunications networks and equipment serving the British Army of the Rhine and liaison between Forces on field exercises and the German Post Office. Posts may be in Berlin or the British area of responsibility in the Federal Republic of Germany.

Candidtates, who should be British subjects, must hold ONC in Engineering, including a pass in Electrical Engineering A, *or* an equivalent or higher qualification *or* have at least 5 years' relevant experience. They should also have practical experience of at least one of the following; lines and transmission systems; auto and manual exchanges; subscriber apparatus and PBXs; radio station practice involving microwave relay equipment. Knowledge of German would be an advantage. Starting salary, at present under review, will be £1722 plus Foreign Service Allowance of up to £1120 per annum with an additional allowance equal to London Weighting (£228 p.a. at present).

For fuller details and application form write to, Ministry of Defence, SPM4h(PE), Lacon House, Theobalds Road, London WC1 8RY or telephone 01 242 0222 extn. 6650. (4165)

CAMBRIDGESHIRE AREA
HEALTH AUTHORITY (TEACHING)
Peterborough Health District

Appointment of

X-RAY ENGINEER

to be based at Peterborough District Hospital and become a member of a small team engaged upon the commissioning, maintenance and repair of a wide range of diagnostic X-ray apparatus. Candidates should possess HNC (Electronics) or equivalent, but consideration will be given to suitable candidates with ONC who are proceeding to a higher qualification.

Salary scale offered is £2,601 to £3,390.

Possession of a car is desirable, travelling expenses being payable in accordance with agreed scales for Health Services staff.
Application forms and job description obtainable from the Group Engineer, Peterborough District Hospital, Thorpe Road, Peterborough, to be returned completed within 14 days of the appearance of this advertisement.

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Telecommunications is a field which West Midlands Gas is continually developing and expanding. The scope of its applications justifies the maintenance of a separate department forming part of the Directorate of Management Services.

Arising from promotion and expansion within the Department, vacancies now exist for the following positions:-

ASSISTANT ENGINEER (Telephone Systems) A795

(£2637 to £3111 plus Threshold Allowance)

Working in the Communications Planning Section of the Department, an engineer is required to assist in the planning and implementation of telephone switching systems. Candidates should be qualified at least to H.N.C. or C. & G. full Technological Certificate level and have several years of experience with the Post Office or a Telecommunications Manufacturer on duties encompassing telephone systems design and work on telephone traffic calculations. A knowledge of both common control and Strowger types of switching is required. The Region's systems include large PABX and tandem switching installations. Familiarity with multi-channel microwave network, loud-speaking and public address systems would be an advantage.

TELECOMMUNICATIONS TECHNICIANS (5 Posts) A683

(Salaries initially up to £2808 plus Threshold Allowance)

Technicians are required to install and maintain microwave radio networks, U.H.F. radio systems for telemetry and V.D.U.s, digital supervisory systems and extensively used V.H.F./U.H.F. mobile R/T systems.

More than 70 of our V.D.U.s in operation throughout West Midlands Gas rely on telecommunications networks, and one technician will be required to assist in the installation and maintenance of these units.

Candidates of O.N.C. level or equivalent having some experience of the above range of electronic equipment and wishing to further their careers in a sophisticated telecommunications environment are invited to apply.

Whilst normally based at Solihull, the work will involve travel throughout the Region.

Salaries on first appointment are normally in a scale rising to £2475 with progression on demonstrated ability to £2808. Further progression to £3000+ is possible for suitably qualified and experienced technicians.

In appropriate cases, generous relocation allowances are available for persons appointed to any of the above posts.

Applications quoting the appropriate reference number should be made in writing, to include full personal particulars and be addressed to:- The Senior Personnel Officer, (Headquarters and Marketing), West Midlands Gas, Wharf Lane, Solihull, West Midlands, B91 2JP.

WEST MIDLANDS GAS [4147

BBC EQUIPMENT

Power Road, Chiswick
(Near Gunnersbury, Acton Town, and Chiswick Park Tube Station)

LABORATORY TECHNICIANS

(Salary £1,872 to £2,364)

C. & G. Part 1 Telecommunications or Electronics Course 270 or 280 O.N.C. or equivalent.

For details of work, Pension Scheme, rates of pay and other conditions of employment please telephone: Mr. P. W. Green 01-994 8541 or write to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA quoting reference 74.E.4081 W.W. and enclosing a self-addressed foolscap envelope.

[4149

CHELSEA COLLEGE UNIVERSITY OF LONDON

TELEVISION TECHNICIAN

A Television Technician (Grade 5) is required to operate and maintain a wide range of audio and video equipment. The successful candidate will be expected to work closely with academic staff and students, and assist in the interpretation of their requirements in television terms. The television service at the College is expanding and the installation and commissioning of new equipment will present additional responsibilities Salary Scale: £2235-£2610 per annum (including London Allowance). Application forms from Personnel Officer, Chelsea College, (WW) Manresa Road, London, SW3 6LX. [4141

CUSTOMER ENGINEERS

BURNDEPT is anxious to recruit a number of Engineers for the Customer Engineering Department, to design control equipment for mobile radiotelephone systems and to meet customer requirements.

This work offers a great deal of variety and opportunity for personal initiative.

We would prefer engineers with mobile radiotelephone experience, but we would be interested to discuss career opportunities with engineers having a practical background in audio or telephone switching techniques.

A pleasant, friendly environment and a good salary is available to the right people.

Assistance with moving expenses will be provided if necessary.

Apply: D. W. TAYLOR (Personnel Manager), Burndept Electronics (ER) Ltd., St. Fidelis Road, Erith, Kent. Tel: Erith 39121.

[4193

CHIEF TECHNICIAN

For Guildford County College of Technology—Educational Television Unit. To take charge of a team of technicians responsible for technical and routine operations of a well established College Television Service and be responsible to the Senior Lecturer-in-Charge.

Applicants should hold relevant technicians' qualifications and have a sound knowledge of colour television systems. Experience with Helical-Scan, V.T.R.'s and Vidicon cameras essential, together with an interest in the uses of television and other audio-visual equipment as teaching aids. Some knowledge of, or experience in, television studio and mobile production techniques an advantage.

Salary up to £2,360, according to qualifications, age and experience.

Application Form from Vice-Principal, Guildford County College of Technology, Stoke Park, Guildford. Tel.: Guildford 73201.

SURREY COUNTY COUNCIL 4174

University of Surrey
Audio Visual Aids Unit

Technicians

Grade 2B
(£1524 - £1794)

The AVA Unit is responsible for projection and allied services in 26 Central Lecture Theatres, and also provides services of photography, film and television for teaching and research throughout the University. These new posts are for skilled technicians who will be responsible for installation, maintenance and repair of a wide range of Audio Visual equipment ranging from slide projectors to televisions. The Unit is well equipped for electronic and mechanical servicing, and instrument making and repair work. Experience in one or more of these fields is essential, although training in specific techniques will be given where necessary.

Applications immediately on forms available from

Assistant Secretary (Personnel), University of Surrey, Guildford. or Tel: Guildford 71281, ext. 452.

[4178

University of Edinburgh

Electronics Technician

Required fo the

DEPARTMENT OF RESTORATIVE DENTISTRY

The work is mainly concerned with medical electronics and electromyography. The successful candidate will be concerned with maintenance and modification of a wide range of medical electronic and allied equipment, and with research and development in electronics as related to dentistry. The post offers challenging and rewarding work in a new and expanding field.

Applicants should hold H.N.C. or equivalent in appropriate subjects. Salary will be on scale £2007-£2382 p.a. (under review), plus threshold payment. Assistance with relocation expenses is available if necessary.

Applications, quoting the post reference no. A064, and giving full details of age and qualifications, together with the names and addresses of two referees, should be addressed to the Personnel Officer, University of Edinburgh, 63 South Bridge, Edinburgh EH1 1LS. Telephone 031-667 1011, ext. 4446.

The closing date for applications is 30th October, 1974

GUY'S HOSPITAL
Department of Clinical Physics and Bioengineering

ELECTRONICS TECHNICIAN/ENGINEER

MEDICAL PHYSICS GRADE III

Applications are invited for the post of Electronics Technician/Engineer to join a small team engaged upon the maintenance, repair, and calibration of a wide range of electromedical equipment.

Candidates should have an ONC, HNC or equivalent in electronics with at least three years experience in maintenance and servicing of electronic instruments. Salary Scale £1,719 to £2,211 plus London Weighting plus Threshold Allowance.

Application forms available from the **Personnel Officer, Guy's Hospital, St. Thomas Street, London SE1 9RT. Tel: 01-407 3662 Ext 68.**

[4177

Papua New Guinea

Radio Technical Officers

Applications are invited from suitably qualified and experienced personnel for the posts of Technical Officer (Radio) and Senior Technical Officer (Radio) with the Civil Aviation Agency of the Department of Transport. There are twelve positions available working on the installation and maintenance of a variety of electronic communications equipment and appointments will be made at three levels of seniority based on experience and qualifications.

Candidates should have successfully completed City and Guilds Technician Courses, Part III Full Technological Certificate or HNC. A minimum of 6 years' relevant experience is required, with at least 3 years' involvement in a field of radio work closely related to civil aviation communications.

Conditions of service

Period of engagement is for two years (renewable in most instances). General entitlements are very attractive and include a generous gratuity (approx. 25% of salary combined with attraction allowance), education allowance for dependent children attending school overseas, return air passages with personal effects and luggage allowance, low cost married and single accommodation, and generous leave conditions.

Pay per annum

Expressed in $A. Current rate of exchange $A1 = 62p.

Level	*Salary*	*Attraction Allowance*	*Gratuity*
TO1	2035	3500	1500
TO2	2275	4200	1800
STO1	2755	4200	1800

Please write or telephone immediately for an application form and full details of the posts. The Papua New Guinea Public Service Board Representative, 22 Garrick Street, London W.C.2. Telephone: 01-240 1780.

Papua New Guinea

Papua New Guinea

[4133

Radio and TV Engineers for Green Shield

In order to provide our customers with a complete after sales service, we are setting up a new department at one of our warehouses in High Wycombe.

This is a great opportunity for first rate engineers who really know their way around radios, TV's (colour and mono) and other allied products.

We will be forming a completely new team and everyone will enjoy a good starting salary together with a company estate car, an annual bonus, special purchasing privileges, use of our private Country Club, good holidays plus other benefits.

There are excellent prospects for promotion too.

You will be based at High Wycombe and, if that entails moving house, we will make a generous re-location allowance.

So for full details, please phone or write to: Eddie Farrell, Personnel Officer, Green Shield Trading Stamp Company Limited, Green Shield House, Station Road, Edgware, Middlesex HA8 7AQ.

GREEN SHIELD stamps

4179

Outside Broadcast

Systems Engineer

Pye TVT Limited specialises in outside broadcasting equipment and broadcasting systems, serving single organisations or whole countries.

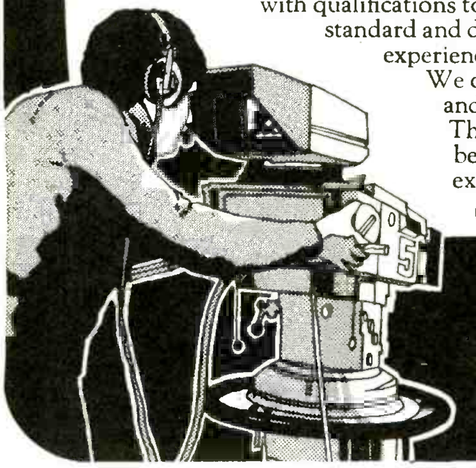
We have a good career opportunity for a Systems Engineer to undertake system planning and design of outside broadcast vehicles.

Duties will include planning and design of vehicles, their wiring, air conditioning and ventillation equipment, plus preparing various schedules, data and test procedures relating to Video, Audio and Central system functions.

Applicants should be aged between 25 and 40, with qualifications to HNC/HND electrical standard and directly relevant practical experience.

We offer an excellent salary and good promotion prospects. There are also many fringe benefits, including relocation expenses in approved cases.

[4132



Please apply to:
Mrs. J. A. Macnab, Personnel Officer

Pye TVT Limited
P O Box 41 Coldhams Lane
Cambridge CB1 3JU

PRODUCT INVESTIGATION ENGINEER

The Quality Control Department of the Vehicle Instrumentation Division of Smiths Industries Limited require a Product Investigation Engineer to assist in developing fault diagnostic procedures on a range of electronic instruments supplied to the motor industry. The position will involve the technical analysis of rejects and the development of rectification procedures for production operatives and will involve liaison with production and engineering staff.

The successful applicant will be between 25 and 40 years of age and will have a HNC Electronics or equivalent experience preferably in a similar position. An attractive salary will be offered, together with the usual fringe benefits associated with a large progressive Company.

Please write or telephone:

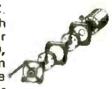
C. J. Sharkey,
Personnel Manager,
Smiths Industries Limited,
Vehicle Instrumentation Division,
Cricklewood Works,
London, NW2 6JN.
01-452 3333 Ext. 2433

SMITHS INDUSTRIES LIMITED

VEHICLE INSTRUMENTATION DIVISION

[4134

MARX-LUDER STACKABLE EPICYCLIC GEARED ELECTRIC MOTORS



A range of high efficiency reversible D.C. motors are now offered complete with stackable epicyclic gears giving all the gear ratios: **3, 4, 5, 6, 12, 15, 18, 20, 24, 30, 60, 72, 90, 120, 360** by combining them as shown. Extra gear sets extend the range to fit most requirements. Four sizes of motor each with pile gears and **6v** windings are available as under

	£
EM136P 1½ watts; 5000rpm; size 24×24×74mm Max. gearbox torque **2kg.cm**	**5.65**
EM136P/1 Spare gear set with 3,4,5,6 ratios	**1.70**
EM141P 8 watts; 5000rpm; size 35×35×109mm Max. gearbox torque **5kg.cm**	**6.45**
EM141P/1 Spare gear set with 3,4,5,6 ratios	**1.80**
EM145P 20 watts; 7000rpm; size 52×52×180mm Max. gearbox torque **10kg.cm**	**8.25**
EM146P 30 watts; 4000rpm; size 52×52×200mm Max. gearbox torque **10kg.cm**	**10.20**
SPECIAL OFFER 'Gearbox pack'. All items above	**30.00**

MOTORS without gearboxes:

EM131 0.8 watts; 20g.cm; 8000rpm; Ø17mm	**3.95**
EM136 1.2 watts; 40g.cm; 5000rpm; Ø21mm	**3.80**
EM139 4.2 watts; 160g.cm; 5000rpm; Ø30mm	**3.60**
EM141 8 watts; 320g.cm; 4500rpm; Ø30mm	**4.20**
SPECIAL OFFER "Motor pack". All motors above	**14.00**

Suggested applications. Laboratory equipment, stirrers, pump drives, servo systems, positioning of aerials, dampers, doors, power for models trains, boats, drills, cutting wheels etc.

S.A.E. for DATA SHEETS

"Motivator" Curtain Cord Controllers

A few of these new units have just become available. Ultra slim design. e.g. size 40×185×185mm. Screws flat on wall behind curtains without showing. Can be connected directly to existing corded curtains. Incorporates internal auto limit switches and power supply. May be operated remotely by 3-way switch (supplied).

Motivator Model B with 2 year battery pack. Kit	**18.00**
Fully assembled and tested as above	**24.00**
Motivator Model M with mains power supply. Kit	**22.00**
Fully assembled and tested as above	**30.00**

Additional information gladly supplied on request. All prices are inclusive in U.K. only.

MAIL ORDER ONLY FROM

AID-US PRODUCTS
Dept. WW2, 8 Hillview Rd., Pinner
HA5 4PA, Middlesex

4101

TECHNICIAN

with electronics experience, for interesting and varied work connected with children's heart disease.

Grading according to experience and qualifications.

Write with details to:

Consultant-in-Charge,
Department of Clinical Physiology,
The Hospital for Sick Children,
Great Ormond Street, London WC1

[4188

BBC EQUIPMENT

Power Road, Chiswick
(Near Gunnersbury, Acton Town, and Chiswick Park Tube Station)

SENIOR LABORATORY TECHNICIANS

(Starting Salary £2,424 to £2,676)

C. & G. Full Technological Certificate in Telecommunications or Electrical Technicians with Industrial Electronics or Communications (Courses 271 or 281) H.N.C. or equivalent.

For details of work, Pension Schemes, and other conditions of employment please telephone Mr. P. W. Green 01-994 8541 or write to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA quoting reference 74.E.4079 W.W. and enclosing a self-addressed foolscap envelope.

[4150

THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

PRINCIPAL TECHNICAL INSTRUCTOR
TECHNICAL INSTRUCTOR
(COMMUNICATIONS)

Applications are invited for the above positions to staff a course leading to the Diploma in Communications of this University. Equivalent to 3 years of full-time study, this is a sandwich course extending over 4½ years, and will train the high level sub-professional personnel required by the communications industry in Papua New Guinea.

Principal Technical Instructor

Under the general control of the Head of the Department of Electrical Engineering, the appointee will be responsible for detailed syllabus development, forward planning and administration, selection and ordering of equipment, and supervision of staff. He will also assist in the teaching programme.

Applicants should have extensive practical experience in communications, experience in training, in technical teaching and have administrative ability. Possession of tertiary qualifications would be an advantage. The successful applicant will be required to take up his duties at the earliest possible date.

Technical Instructor

The appointee will be required to teach technical subjects within the Diploma in Communications course and to assist the Principal Technical Instructor with planning and syllabus development. Applicants should have good practical experience in communications, suitable technical qualifications, and desirably experience in the field of technical teaching.

Salary:

Principal Technical Instructor: $A11,970 range $A12,921 per annum
Technical Instructor : $A7,756 range $A8,694 per annum
or: $A8,929 range $A9,443 per annum

according to qualifications and experience. Allowances additional to salary totalling $A1,260 are payable in certain circumstances. Other benefits include fully furnished housing supplied at a nominal rental, 6 weeks leave per annum, with fares paid to Australia; lower taxation than Australia.

Applications in duplicate should include full particulars of age, nationality, marital status and family, if any, qualifications, experience, present post, date of availability and the names and addresses of three referees from whom confidential enquiries may be made.

Lae, the gateway to the Papua New Guinea Highlands, is a pleasant tropical town situated on the Huon Gulf. The town's population totals approximately 5,000 Europeans and 25,000 Papua New Guineans. Sporting facilities are particularly well catered for and the 18-hole golf course is considered the best in the country.

Applications close on 15th November, 1974, and further particulars on Lae and the position may be obtained from

The Registrar,
The Papua New Guinea
University of Technology,
P.O. Box 793,
LAE: PNG.

4197

TRAIN TO BE AN

ELECTRONICS TECHNICIAN

GELLER
BUSINESS EQUIPMENT LTD.,

distributors of electronic calculating and dictating equipment, require a young man 17 plus as a trainee electronics technician. A well paid interesting career for an intelligent person prepared to work and study.

Write or phone to:

GELLER BUSINESS EQUIPMENT LTD.
15 PERCY STREET, LONDON, W1
Tel: 01-580 1614

DEVELOPMENT ENGINEERS
AND
PROJECT ENGINEERS

Required by a rapidly expanding Electronic Engineering Company producing R.F. Dielectric Heating Equipment.

Applicants should have some theoretical and practical experience of high power R.F. Techniques, though this need not necessarily be in the field of dielectric heating.

Salary is negotiable in the range of £2,500–£3,500.

Applications, giving age, details of experience and qualifications should be addressed to :—

STRAYFIELD LIMITED,
1 Tessa Road,
Reading, Berks. RG1 8NT.

[4186

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 £3,096 pa; commencing salary according to age—25 years and over £2,276 pa. During training salary also by age, 25 years 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

FIELD SERVICE ENGINEERS

COMPUTERS

Mini to main frame
£2,500–£3,500 p.a.
+ company car/allowance

BUSINESS MACHINES

Electro/Mech/Electronic
£1,800–£2,400 p.a.
+ company vehicle/allowance

Eric Stack

M.S.R. SERVICE
01-388 1607
362 Euston Rd.
London, N.W.1

[4191

SITUATIONS VACANT

F.W.O. BAUCH LIMITED have a vacancy for a SERVICE ENGINEER seeking interesting and varied work in the professional broadcasting and recording industry. Applicant would be responsible for servicing high quality condenser microphones and should have a good basic knowledge of electronics and some mechanical aptitude. Experience in broadcasting or recording engineering would be an advantage, but is not essential, as training would be given. Excellent working conditions and above average salary. Apply to: F.W.O. Bauch Limited, 49 Theobald Street, Boreham Wood, or call 01-953 0091. [4138

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

TEST ENGINEER required, varied work in audio field plus some digital. Future managerial prospects with small growing company. Salary commensurate with ability. Write full details Box WW4171. Harrow area. [4171

WANTED—Radio and Electronic Technicians for workshops in London NW1. Working on advanced communication equipment. Salary range £1,500 to £2,500. Luncheon vouchers. Flexible hours, overtime opportunities. City and Guilds intermediate or equivalent experience an advantage. Why not ring for more information Mick Ryall 01-485 4100 ext. 13 during the day or Peter Fischer 01-886 9307 evenings. [4176

YOUNG working foreman/manager for small expanding Audio manufacturing company. Excellent future prospects. Good salary for hard worker. Tel: 01-868 0443. [WW4172

ARTICLES FOR SALE

AARVAK ELECTRONICS, 3-channel sound-light converters, from £18. Strobes, £25. Rainbow Strobes, £132.—98A West Green Road (Side Door), London N15 5NS. 01-800 8656. [23

ALL types of Electronic Components supplied on 7 days free approval with priced invoice—simply return if unsuitable—competitive prices. Quotations on request. Box WW 4180.

COLOUR T.V.'s—Bush CTV25 displayed working £90+VAT. Large discounts for 3-up. Non-workers available. Rediffusion wired Mono T.V.'s all screen sizes, new condition. Sumiks, 1532 Pershore Road, Birmingham, 30. Tel. 021-458 2208. [12

COLOUR, UHF and TV SPARES. Colour and UHF lists available on request. 625 TV. If unit, suitable for Hi-Fi amp or tape recording, £6.75, P/P 35p. Bush CTV25 colour, new power units complete, incl. mains TX, Electrolytics, rectifiers, etc., £2.50, carr. 80p. New convergence panels plus yoke and blue lat., £3.85, P/P 40p. New Philips single standard convergence panels complete, incl. 16 controls, coils, P.B. switches, leads and yoke £5.00, P/P 40p. New Colour Scan Coils, Mullard or Plessey plus convergence yoke and blue lateral, £10.00, P/P 40. Mullard AT1025/05 Convergence Yoke, £2.50, P/P 35p. Mullard or Plessey Blue Laterals, 75p P/P 20p. BRC 3000 type Scan Coils, £2.00, P/P 40p. Delay Lines DL20, £3.50, DL1E, DL1, £1.50, P/P 25p. Lum. Delay Lines, 50p, P/P 15p. EHT Colour Quadrupler for Bush Murphy CTV 25 111/174 series, £8.25, P/P 35p. EHT Colour Tripler ITT TH25/1TH suitable most sets, £2.00, P/P 25p. KB CVC1 Dual Stand. convergence panels complete incl. 22 controls, £3.75, P/P 35p. CRT Base Panel, £1.75, P/P 15p. Makers Colour surplus/salvaged Philips G8 panels part complete; Decoder, £2.50, IF incl. 5 modules, £2.25. T. Base, £1.00, P/P 25p. CRT base, 75p, P/P 15p. GEC 2040 panels, Decoder, £3.50, T. Base, £1.00. RGB and Sound, £1.00, P/P 35p. CRT Base 75p, P/P 20p. B9D valve bases 10p, P/P 6p. VARICAP TUNERS. UHF ELC 1043 NEW, £4.50, Philips VHF for Band 1 and 3, £2.85 incl. data. Salvaged VHF and UHF Varicap tuners, £1.50, P/P 25p. UHF TUNERS NEW, Transistorised, £2.85 or incl. slow motion drive, £3.85. 4 position and 6 pos. push-button transistorised, £4.95. All tuners P/P 35p. MURPHY 600/700 series complete UHF Conversion Kits incl. tuner, drive assy., 625 IF amplifier, 7 valves, accessories housed in cabinet plinth assembly, £7.50 P/P 50p. SOBELL/GEC 405/625 Dual standard switchable IF amplifier and output chassis incl. cct., £1.50 P/P 35p. THORN 850 Dual standard time base panel, £1.00 P/P 35p. PHILIPS 625 IF amplifier panel incl. cct., £1.00 P/P 30p. VHF turret tuners AT7650 incl. valves for K.B. Featherlight, Philips 19TG170, GEC 2010, etc., £2.50. PYE miniature incremental for 110 to 830, Pam and Invicta, £1.00. A.B miniature with UHF injection suitable K.B. Baird, Ferguson, 75p. New fireball tuners Ferguson, HMV, Marconi, £1.90 P/P all tuners 30p. Mullard 110° mono scan coils, new, suitable all standard Philips, Stella, Pye, Ekco, Ferranti, Invicta, £2.00, P/P 35p. Large selection LOPTs. FOPTs available for most popular makes. PYE/LABGEAR transistd. Masthead UHF Booster, £5.75, Power Unit, £4.65 P/P 30p or Setback battery operated UHF Booster, £4.65 P/P 30p. 200+200+100 Mierofarad 350v Electrolytic, £1.00 P/P 20p. MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No. 28, 59, 159 Buses or W. Hampstead Bakerloo and Brit. Rail). MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON, N. W. 11. Tel. 01-794 8751. [60

Classifieds continued on page A114

BRENT AND HARROW

Area Health Authority

(HARROW DISTRICT)

NORTHWICK PARK HOSPITAL AND CLINICAL RESEARCH CENTRE

Watford Road, Harrow, Middlesex, HA1 3UJ. Tel: 01-864 5311

ELECTRONICS TECHNICIAN

required to service and calibrate a wide range of equipment used for medical, surgical and engineering purposes. The successful applicant will work closely with medical and other professional staff.

Salary: Grade III–£2,316–£2,943 including London Weighting, plus threshold payments.

The hospital will have over 800 beds by 1975 and is closely allied with the Clinical Research Centre. Good staff facilities and a pleasant working atmosphere. Active social club. Temporary single accommodation may be available.

Further particulars and application form from Miss P. Knight, Staffing Officer, Personnel Department, Ext. 2001.

[4140

Engineering Instructor

The Independent Broadcasting Authority requires an Electronics/Electrical Engineer with previous training experience to join a small training unit based at its Stockland Hill Transmitting Station near Honiton in Devon; appropriate relocation expenses will be paid where necessary.

With line responsibility to the Senior Engineer – Training, the Engineer will assist with syllabus preparation; advise instructional methods and visual aids and lecture and demonstrate to staff. Current instruction is largely concerned with training station staff in the maintenance of new and existing television transmission equipment; other courses, current and planned, include workshop practice and R.F. and video measurement techniques.

Candidates should be experienced instructors and should hold HNC in Electrical or Electronic Engineering or an equivalent qualification. They should have at least 3 years experience in television transmission engineering, preferably including operation and maintenance of UHF colour transmitters; a good knowledge of solid state devices, logic systems and circuitry, and associated techniques is essential.

Starting salary will be in the range of £3,238-£3,928 per annum.

IBA INDEPENDENT BROADCASTING AUTHORITY

Those interested should write or telephone for an application form quoting Ref. No. WW/2556 to:- The Assistant Personnel Officer – Recruitment & Training, Independent Broadcasting Authority, Crawley Court, Winchester, Hants. SO21 2QA. Tel: Winchester 822599.

4183

ESSENTIAL BOOKS

Radio Book Catalogue

MOBILE RADIOTELEPHONE EQUIPMENT HANDBOOK
Gives circuits, data and illustrations plus some valuable modifications for amateur use for commercial radiotelephone equipment including PYE and other popular makes. Available mid-November. £4.75, p.p. 35p.

HOW TO MAKE 2M & 4M CONVERTORS FOR AMATEUR USE
Fully comprehensive. Contains circuits, lay-outs, components lists, diagrams and full instructional notes. 60p, p.p. 15p.

HOW TO MAKE WALKIE-TALKIES FOR LICENSED OPERATION
40p, p.p. 15p.

THE THEORY OF GUIDED ELECTROMAGNETIC WAVES
The most comprehensive book yet written about waveguides, transmission lines, cavity resonators. Over 500 pages. Ideal for anyone interested in RADAR and UHF. Published at £11.50. Special offer £4.50, p.p. 50p.

RADIO BOOK CATALOGUE
Send for this fully comprehensive catalogue of radio books. Free.

THE BARGAIN BOOK GAZETTE
Contains thousands of interesting new and out of print books at bargain prices. Subjects include all types of hobbies, collecting, 1001 interests. Published regularly and sent free on request.

GERALD MYERS (Publisher & Bookseller), 138 Cardigan Rd., Headingly, Leeds 6. (Callers welcome.)

4201

Classifieds continued from page A113
Articles for Sale—continued

COMPLETE Akai portable VTR system, comprising camera, pistol grip, tv tuner, rf converter, portable tape recorder in carrying case with shoulder strap, charger, VOA-7 microphone, tapes and all cables. All very little used and in excellent condition. £600 o.n.o. Phone 01-568 0151 for demonstration. [4137

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

EX-GOVERNMENT MULTITRACK, studio and professional tape recorders, from £50. S.A.E. details. A. E. Wright and Son, 10 Church Street, Dowlais, Glamorgan. [4173

FLEXOWRITER (paper tape typewriter) £38. Ekco ttl counter-timer, £18. Electronic Associates VARIPLOTTER (X-Y plotter) £145. Ferranti Magnetic Memory DRUM, £49. Solartron ac voltmeter, £6. Singer 7102 Data Terminal, ASCII coded with serial pulse input/output available. Hardly used, £185. Singer 7151 Telegraph Adapter Unit, £15. H-P 6 speed mag. tape (new) £38. 400Hz Inverter, £9. EMI Studio Echo, £75. EMI L4 portable tape recorder, £66. HIGHEST QUALITY NEW AND SECONDHAND WORD PROCESSING MACHINES ALWAYS AVAILABLE FROM £300 TO £800. Computer Appreciation. Phone Raymond ffoulkes, Godstone 3106, or Richard Totman, Otford 3256. [4189

FOR SALE new and surplus components, test gear etc., 3½p stamp for catalogue. [4157

J ACOUSTICAL Society America 1962-68. Offers to Box No. W.W. 4155.

FALISMILE equipment for sale suitable for weather satellite pictures. Mufax transmitter, receiver and power unit. Mr. Shann, 112 Great Titchfield Street, London, W.1. 01-636 8280. [4194

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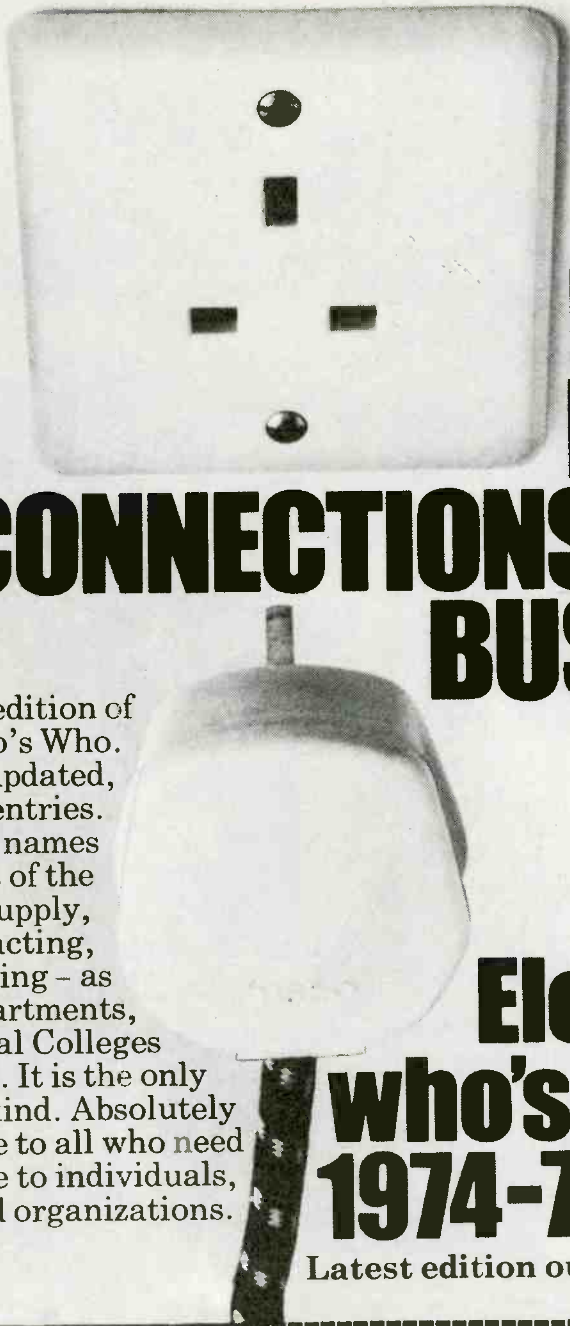

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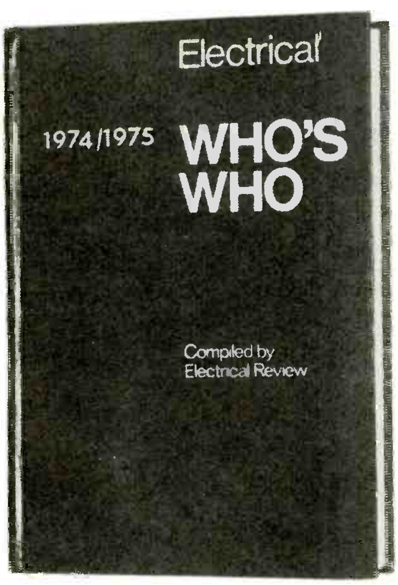

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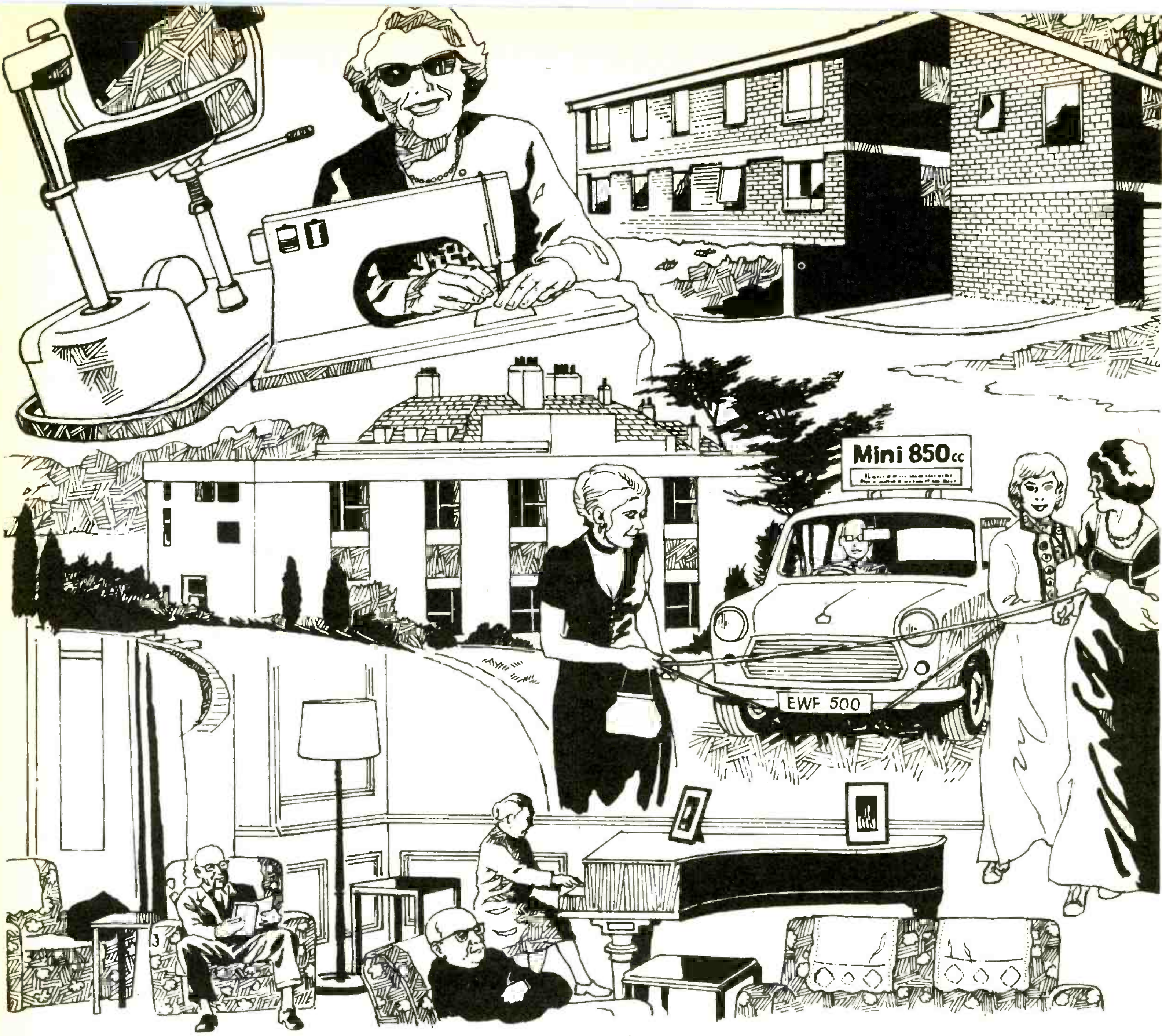
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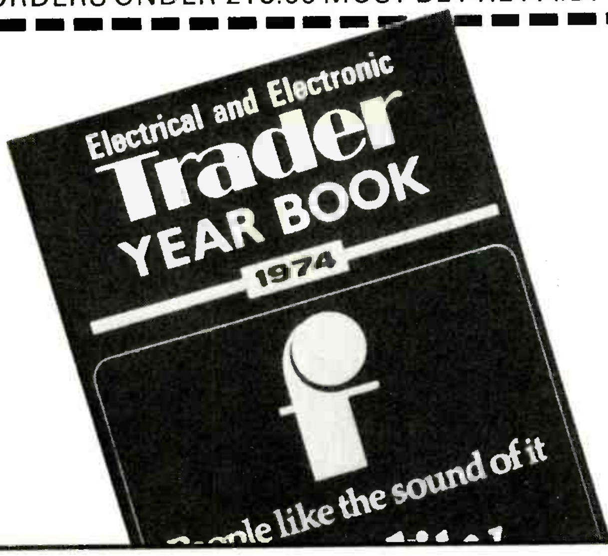

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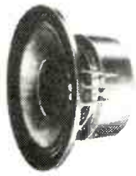

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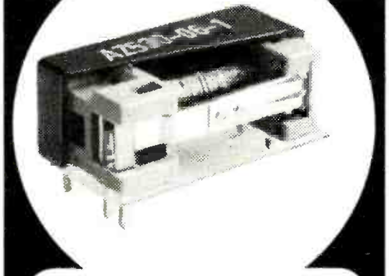

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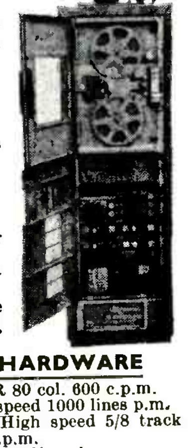

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