Wireless World

July 1973 20p

Howl suppressor

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WW—001 FOR FURTHER DETAILS

The new Bradley 200 is a quality 100 MHz general purpose oscilloscope it costs just £595*

That's remarkable value for money.
Considerably less than you could pay for the same performance, accuracy, sensitivity and versatility.
Not that we set out to undercut the competition.
All we wanted to do was to produce the best 100MHz general purpose oscilloscope on the market. But because we started from scratch, we were able to use the latest engineering techniques and advanced circuitry (including many i.c.'s). And this meant we could price the 200 very competitively.
The 200 incorporates all the features you would expect in a first-class modular instrument, plus several new ideas.
To find out about these, please telephone Ashley Stokes on 01-450 7811, Extension 113. Or write to him at the address below.

** UK Price quoted does not include VAT*

BRADLEY electronics

G & E BRADLEY LIMITED, Electral House, Neasden Lane, London, NW10 1RR Telex: 25583 A Lucas Company

WW—004 FOR FURTHER DETAILS

ANDERS MEANS METERS...

REGAL RANGE

- **New 100° arc high quality meters at low prices.**
- Rugged taut band construction
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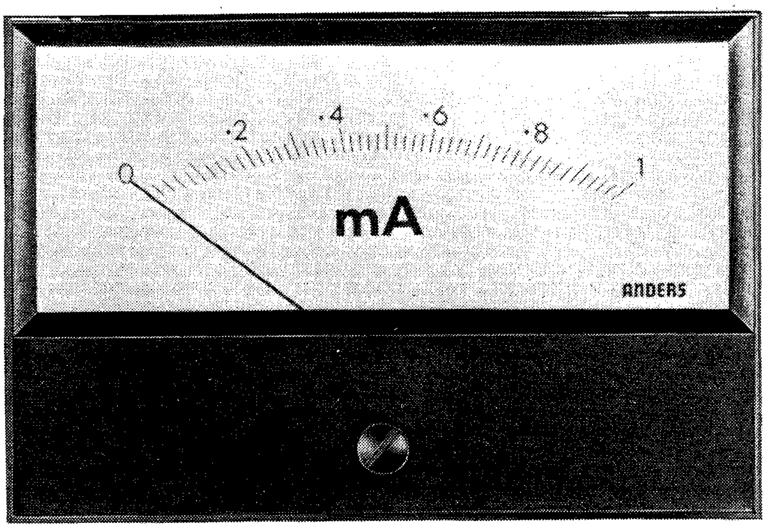
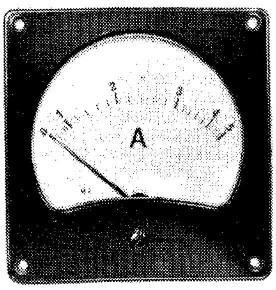
- Sensitivities to 10 μA
- Very competitively priced for OEM quantities
- Modern styled meters in matt black plastic cases with flattened arc giving long scale.

TWO MODELS
R55 2.5in (63.5mm) Scale length
R65 3.2in (81.3mm) Scale length

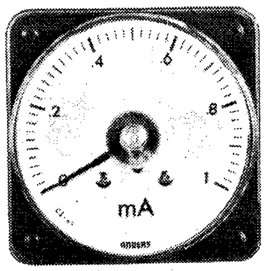


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

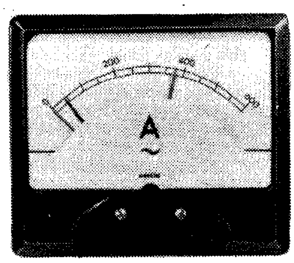
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



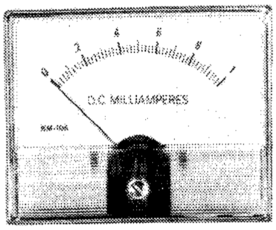
Vulcan Moving Iron. 4 models, 1·5″, 1·8″, 2·7″, 3·7″ scales. Voltmeters, ammeters and motor starting meters.



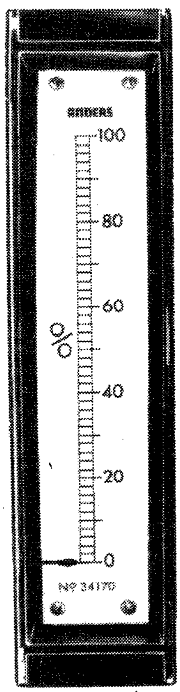
Oxford Long Scale 240°. 2 models, 5·5″, 8″ scales. DC moving coil and AC moving coil rectified.



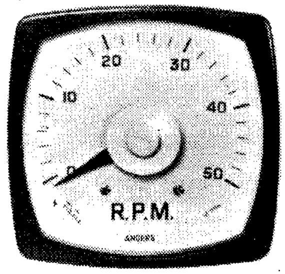
Solicontroller Moving Coil Relay. DC moving coil and AC moving coil rectified. 1 or 2 adjustable alarm controls.



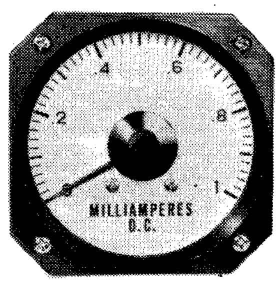
Kestrel Clear Front. 7 models, 1·3″—5·25″ scales. DC moving coil, AC moving coil rectified, AC moving iron.



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



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



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

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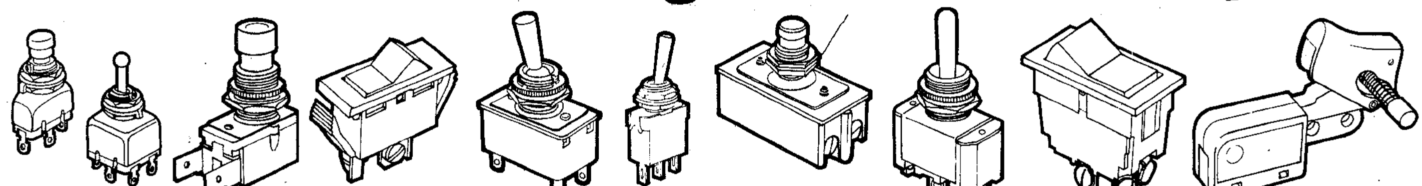
Arrow switches *right* across the panel



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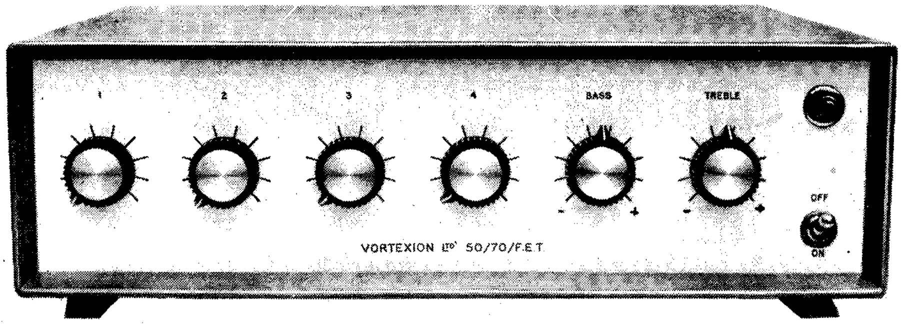
WW—006 FOR FURTHER DETAILS

Vortexion

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.



This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% 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 completely free from 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.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 5-WAY MIXER USING F.E.T.s. This is similar to the 4-way version but with 5 inputs and bass cut controls on each of the three low impedance balanced line microphone stages, and a high impedance (10 meg) 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 other 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 100V balanced line or 8/16 Ω 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 .3V out on 600 ohms upwards.

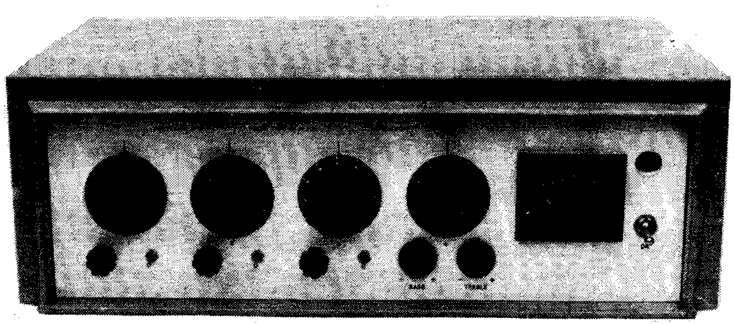
100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms–15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100K ohms.

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.

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 ± 1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt 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 PPMs.



Since we have been supplying professional mixers for 25 years we have delayed the introduction of solid state units until they were at least as good as their valve counterparts. (Which will continue where required.)

The various sections of the FET mixers and BBC type PPM's have been performing successfully for several years in other equipments with complete reliability. The PPM also uses an FET in its time constant circuit so that polyester capacitors can be used. The response from the 600 Ω output (25 Ω source impedance) is level 20 Hz to over 30 kHz with very low intermodulation distortion to zero level + 12dB. The input signal voltage range is over twice that of the valve unit and the noise at least halved.

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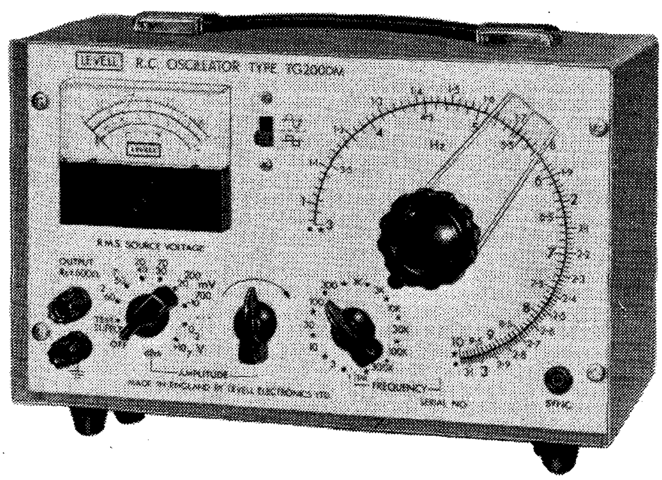

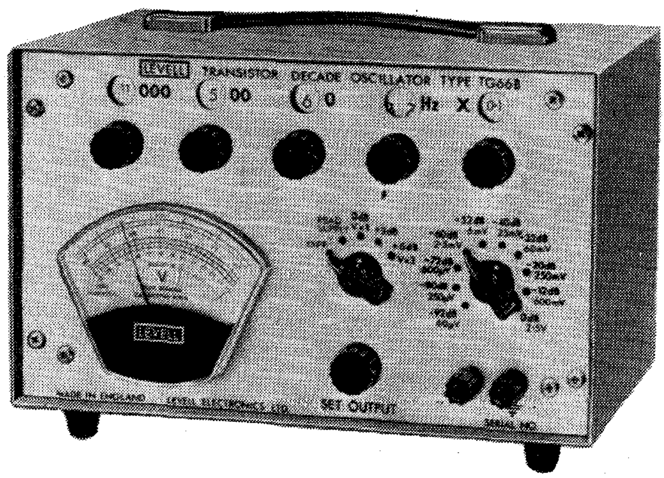

ANALOGUE

FREQUENCY	1 Hz to 1 MHz in 12 ranges. Acc. ± 2% ±0.03Hz.
SINE OUTPUT	7V r.m.s. down to <200μV with Rs = 600 Ω
DISTORTION	<0.1% to 5V, <0.2% at 7V from 10Hz to 100kHz.
SQUARE OUTPUT	7V peak down to <200μV. Rise time <150nS.
SYNC. OUTPUT	> 1V r.m.s. sine in phase with output.
SYNC. INPUT	±1% freq. lock range per volt r.m.s. input.
METER SCALES	0/2V, 0/7V & —14/+6dBm. on TG200M & DM only.
SIZE & WEIGHT	7″ high x 10¼″ x 5½″ deep. 10 lbs.

TG200	TG200D	TG200M	TG200DM
£42	**£45**	**£52**	**£55**
Sine O/P	Sine & Sq. O/P.	Sine O/P +meter.	Sine & Sq.O/P + meter.

DIGITAL

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

TG66B	TG66A
£120	**£150**
Batteries only.	Mains unit & batteries incl.

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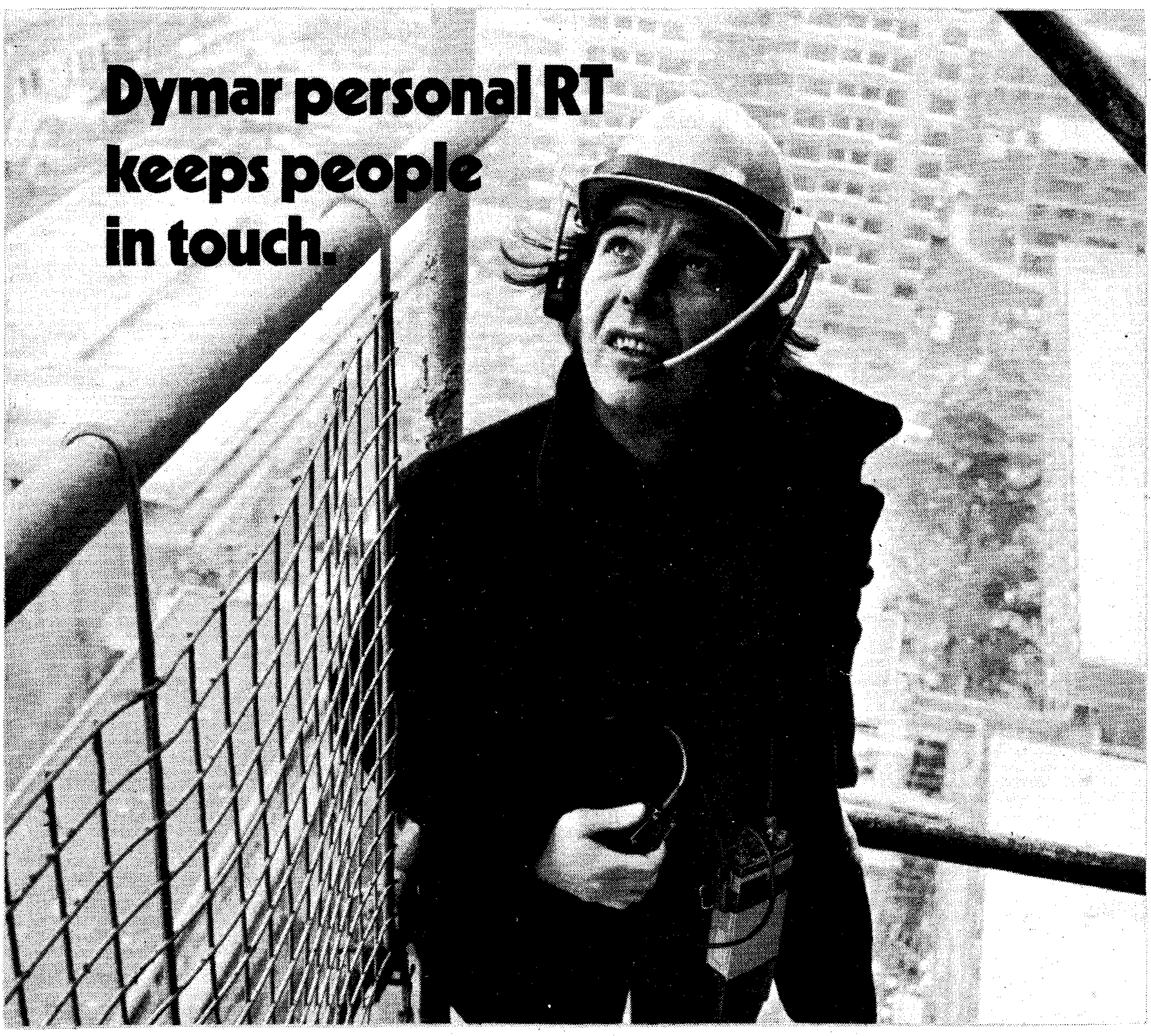

Wherever they are.

Two hundred feet up on a building site. At the far point of a security patrol. In the middle of a cliff rescue. In situations like these, Dymar personal radiotelephones provide a vital link.
Essential personnel are in touch at all times. Help is always at hand. Important messages are not missed.
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DYMAR **the name in radiotelephones**

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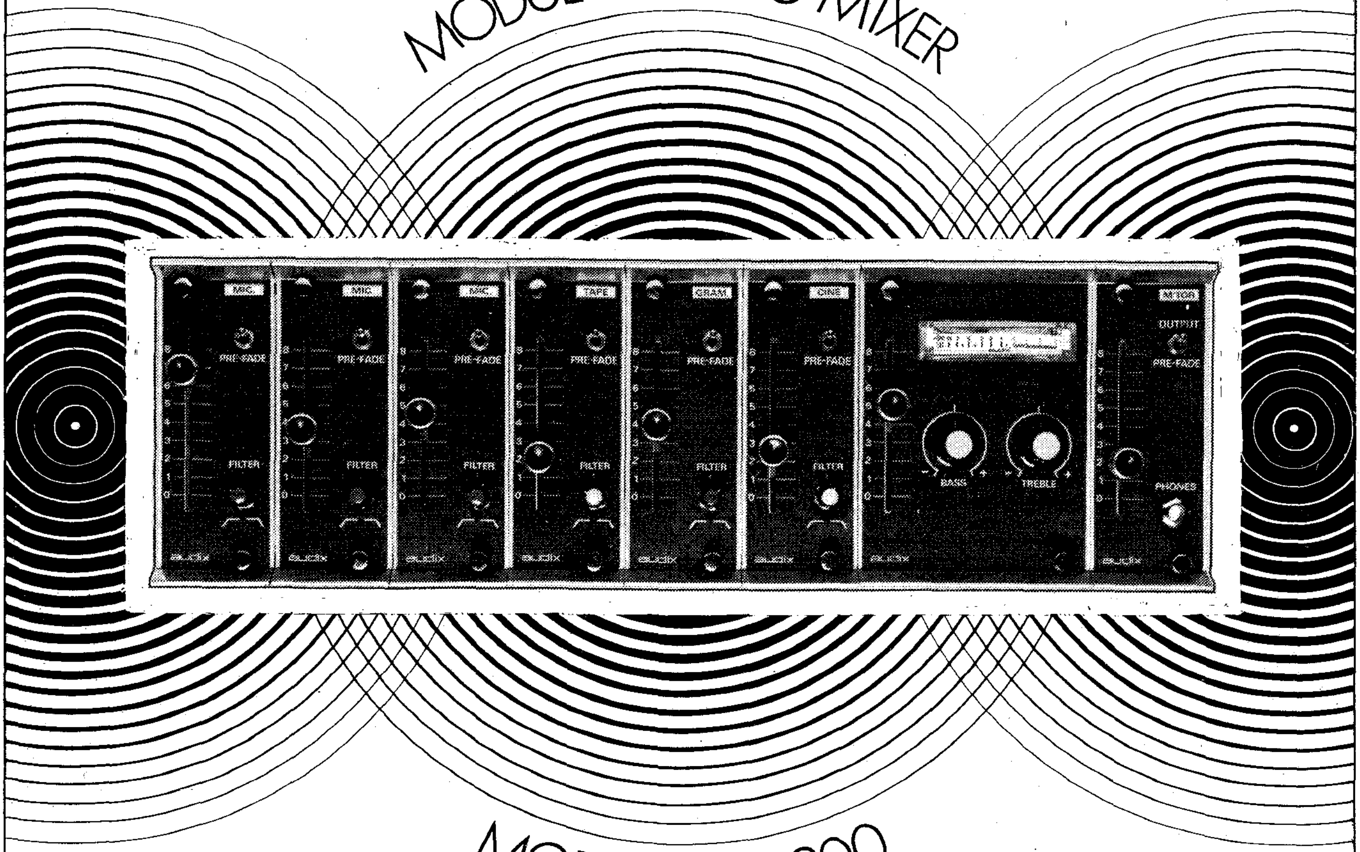
WW—009 FOR FURTHER DETAILS

audix
SOUND SYSTEMS AND ELECTRONICS

MODULAR AUDIO MIXER



MODEL MXT-200

The MXT-200 is the latest addition to the range of modular audio mixing units available from Audix for public address, theatre, broadcast and recording studio applications. Designed for either mono or stereo working the MXT-200 incorporates high and low frequency filtering per channel as well as overall treble and bass tone controls. A pre-fade listen miniature toggle switch is fitted to all plug-in channels; the maximum number of inputs being 16. The wide choice of modules including output routing, monitoring facilities, P.P.M. or V.U. metering units can be fitted within rack mounting or free standing cabinets.

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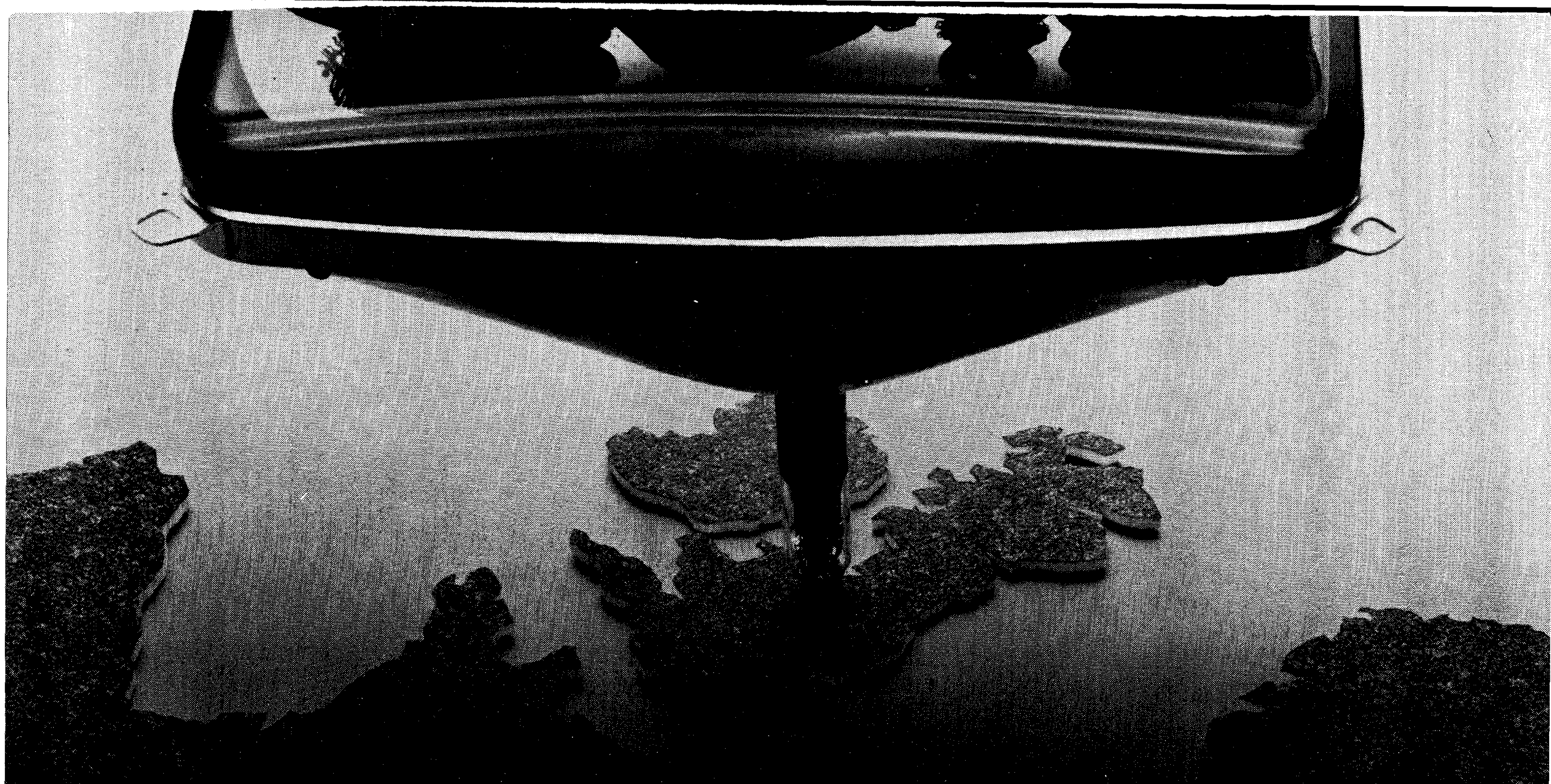
Now there'll be more colour tubes from Thorn to go round... ...around the world.



They want them in Sweden and Switzerland, in Finland and Yugoslavia and New Zealand, in Belgium and Austria and Australia . . . and you want them too!

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By early next year we'll be operating Europe's largest colour tube factory – ½ M. sq. ft. in all, representing a capital investment of £16 millions – capable of producing 1,200,000 tubes a year – offering the largest range of British made colour tubes.

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MAZDA

Tubes & Valves you know you can rely on

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THORN

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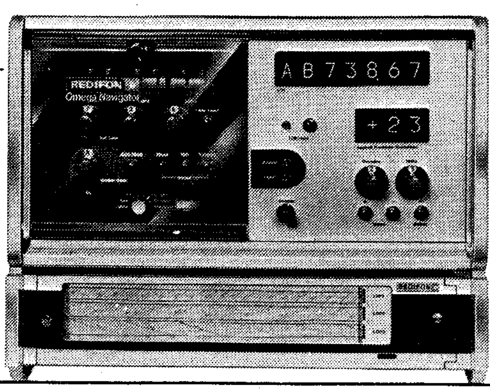

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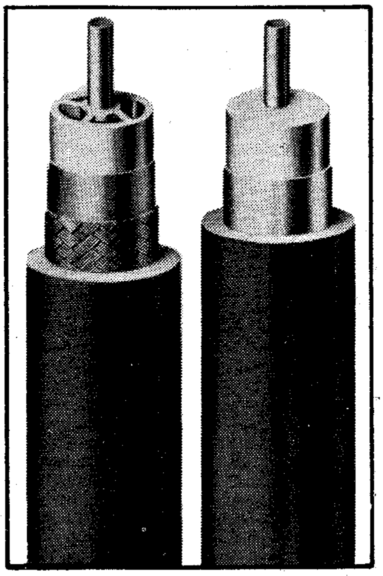

Aerialite will specially manufacture TV distribution cables for any special TV application—also, you can make use of the Aerialite free technical advisory service to help you in the selection and application of distribution cables.

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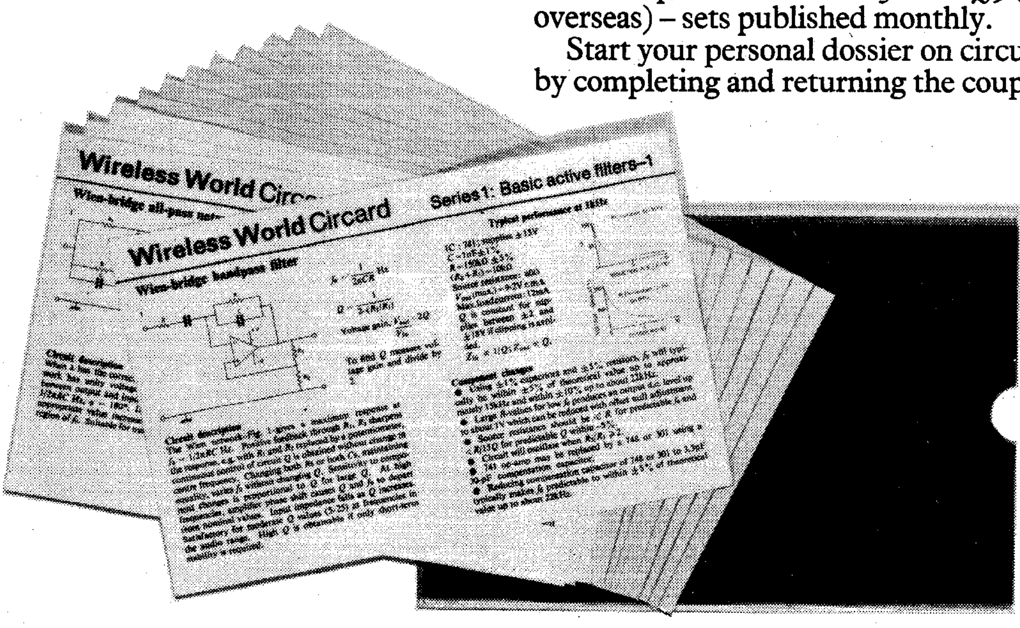

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These improved Westinghouse tubes are made available in two configurations – the standard 90° and the 10 cm shorter profile wide-neck 110° version... permitting their compatibility to the needs of the larger portion of European TV set manufacturers.

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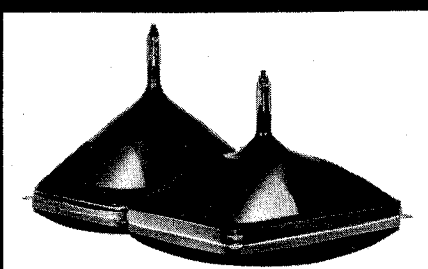
In these ways–compatible product availability–outstanding development facilities–local technical assistance...Westinghouse Electric respond to dynamic customer requirements – here in Europe and throughout the world.



The 110° Ⓦ A67-140X TV colour tube is 10 cm shorter in profile than the 90° Ⓦ A67-120X ...both offer superb colour definition as well as white field purity for black & white.

Westinghouse Electric S.A.
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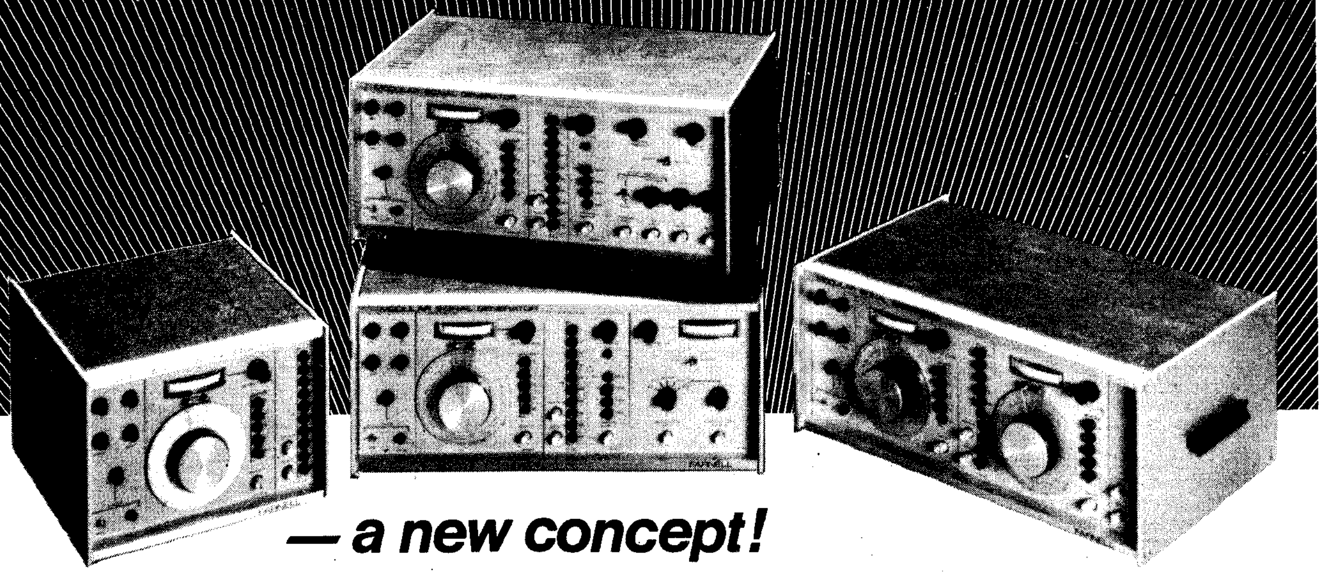
WW—015 FOR FURTHER DETAILS

SIGNAL GENERATORS



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You need no longer buy facilities you don't require. And yet, should your needs change later, you can adapt the system and avoid the cost of a complete replacement instrument. Your costs are kept down and your requirements are met . . . precisely.

Features include:

- Choice of oscillator modules

  100 kHz to 10 MHz
  10 MHz to 100 MHz
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For details of all Farnell r.f. test equipment please contact:

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Minimod

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Minimod provides a choice of a standard 5 volt output (available up to 1 Amp) for digital circuits or 12-0-12 or 15-0-15 volts for linear circuits, using a 230 volt input. Each unit is fully stabilised with fold back current limiting, and in the case of 5 volt units, over voltage crowbar is provided . . .

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3009 v 3009/S.2

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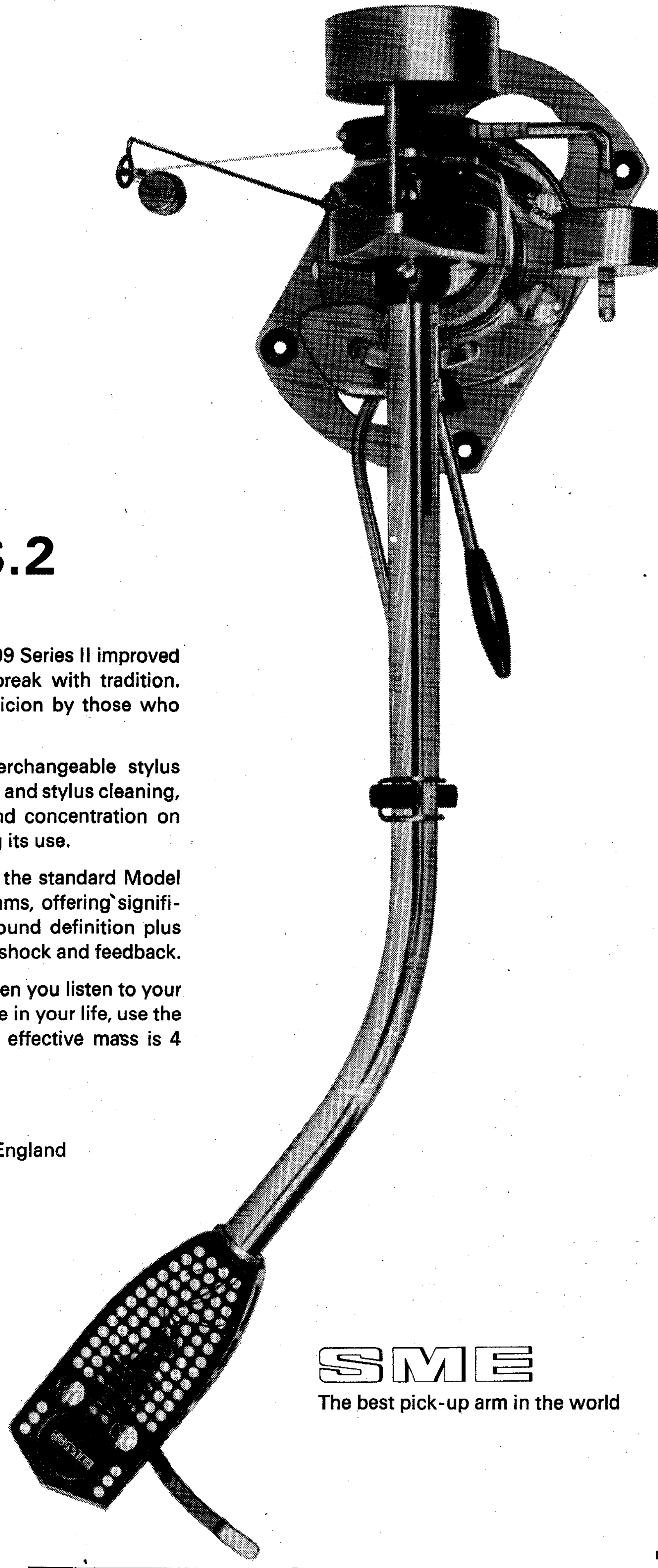

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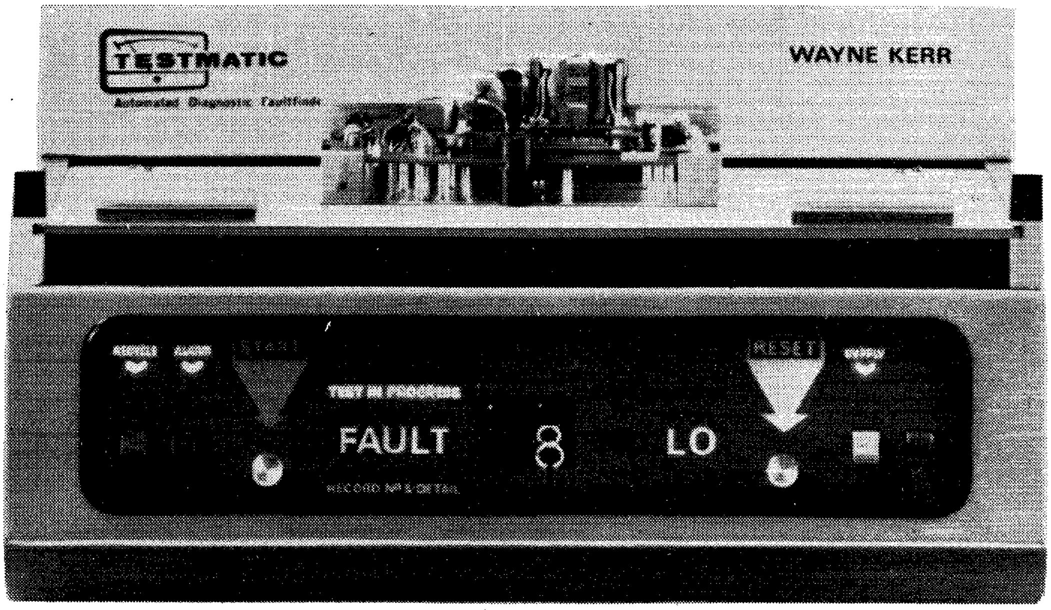

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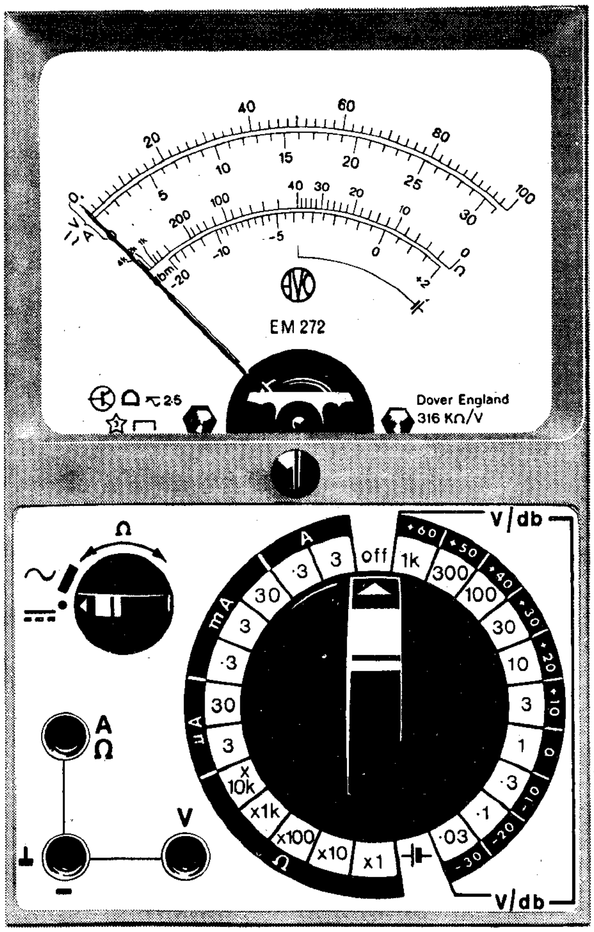

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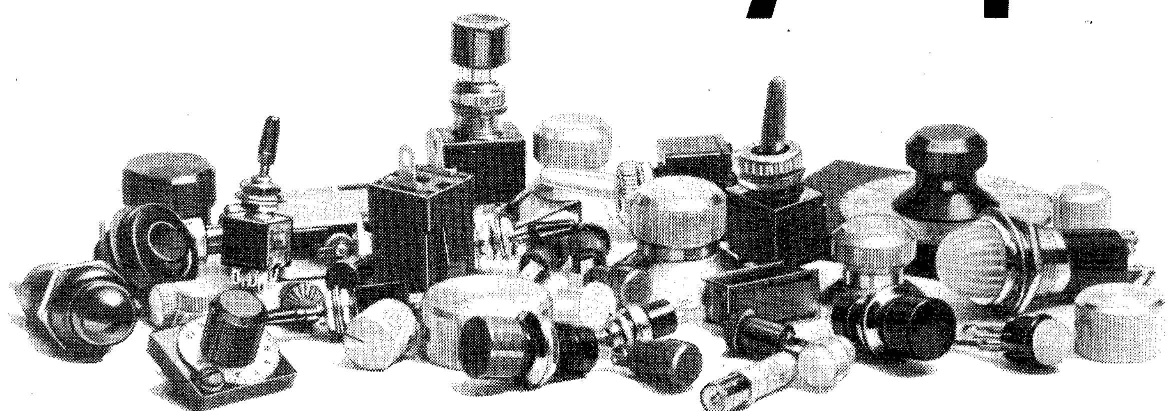

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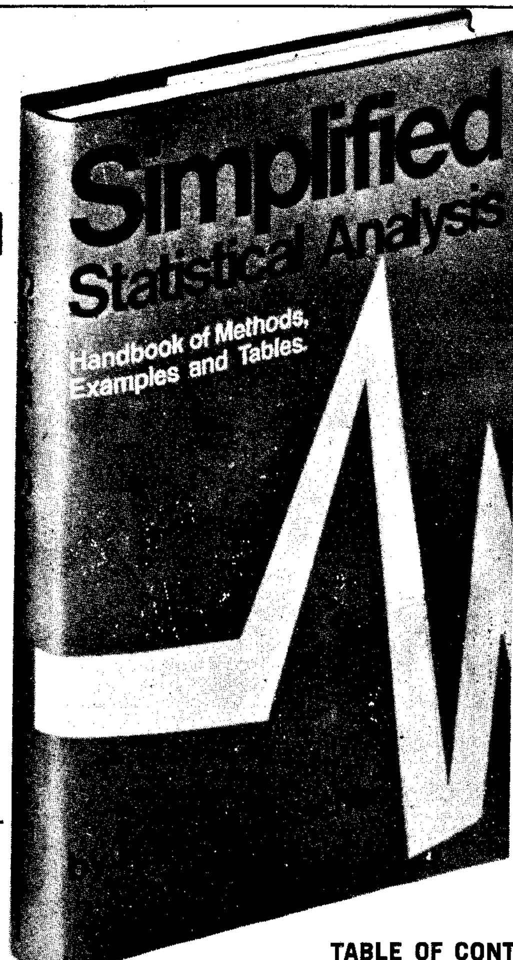

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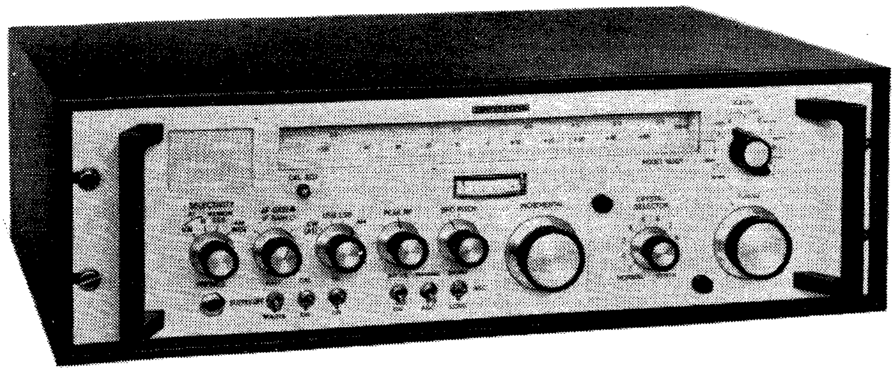

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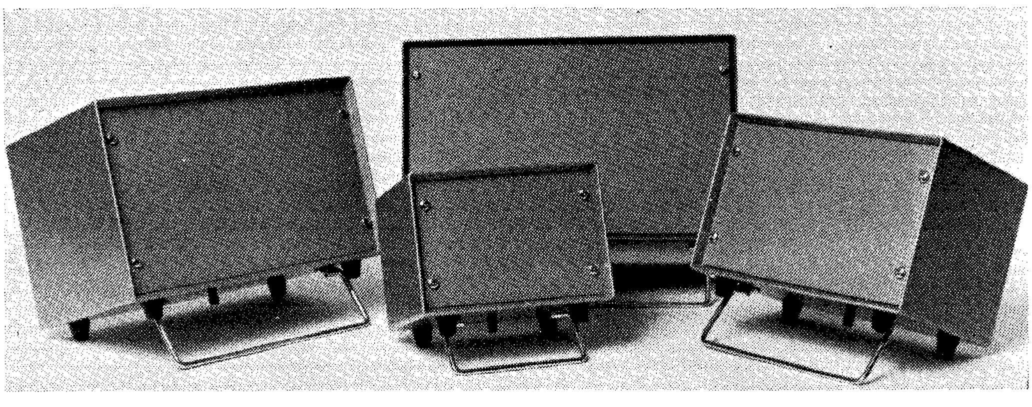

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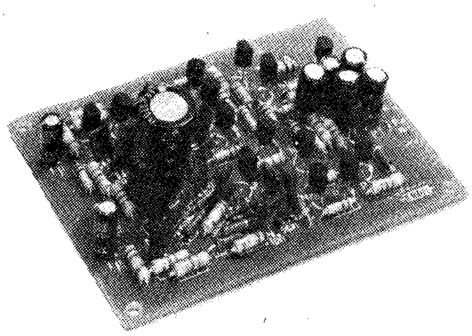

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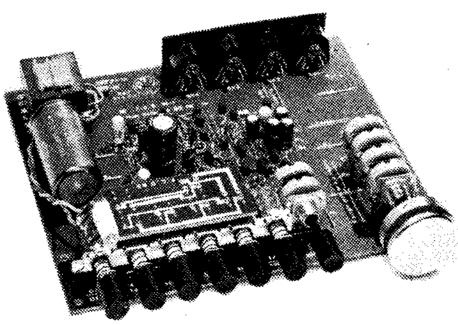

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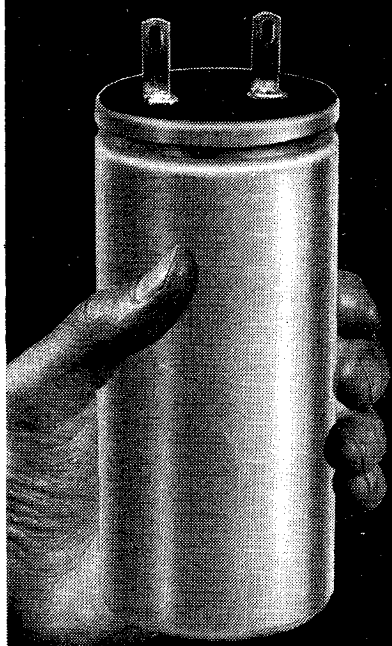

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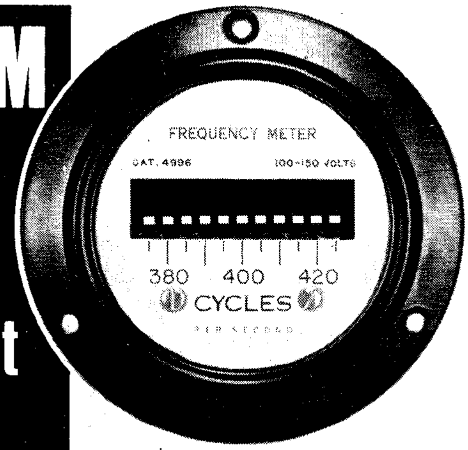

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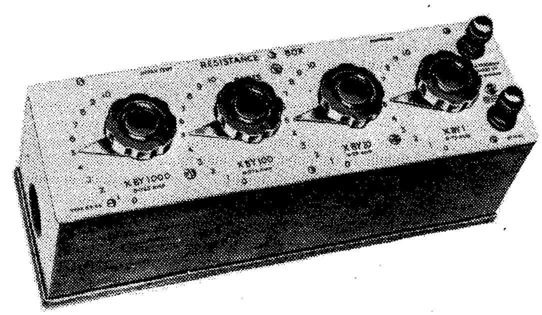

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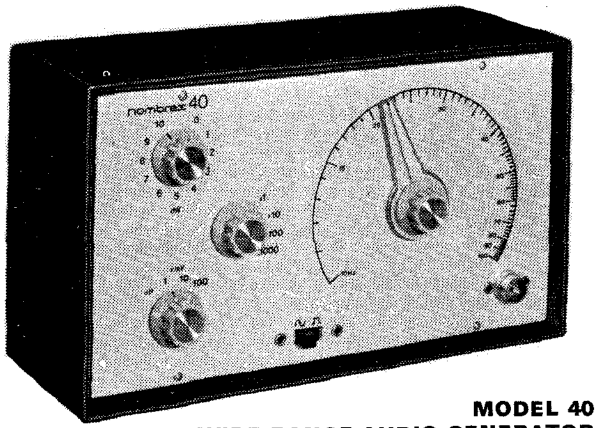

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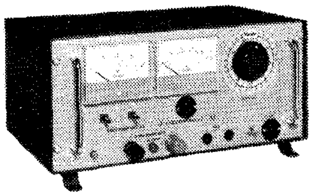

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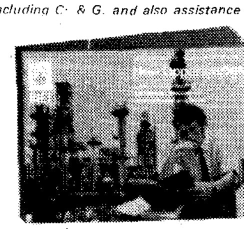

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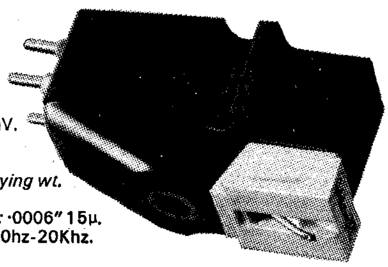

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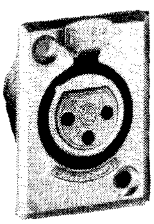

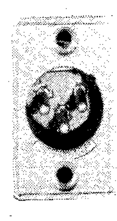

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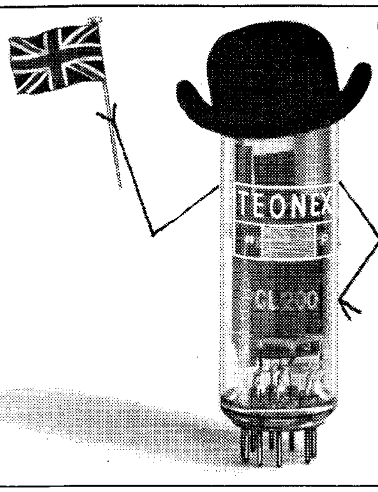

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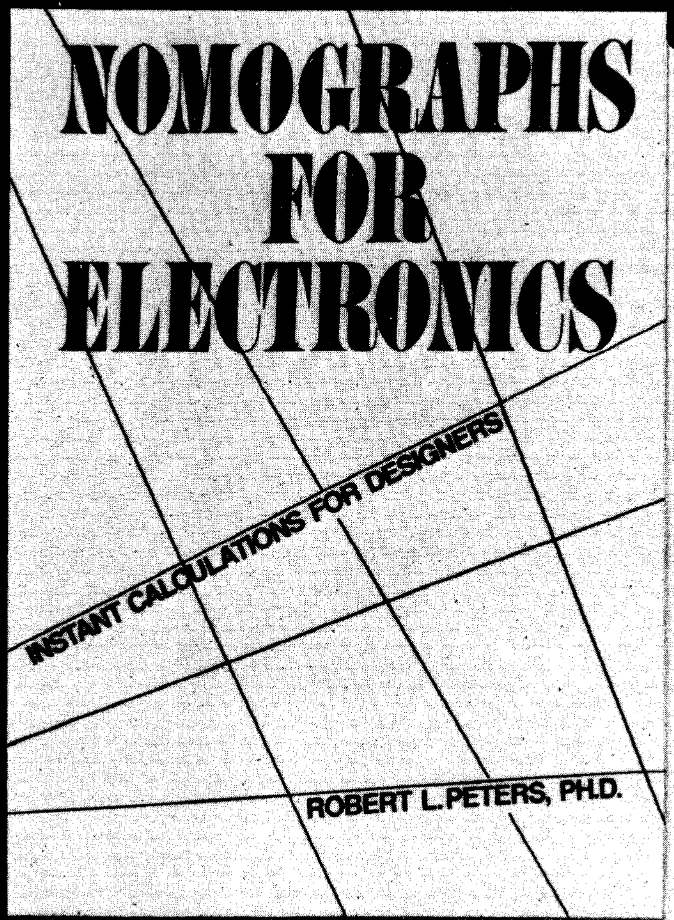

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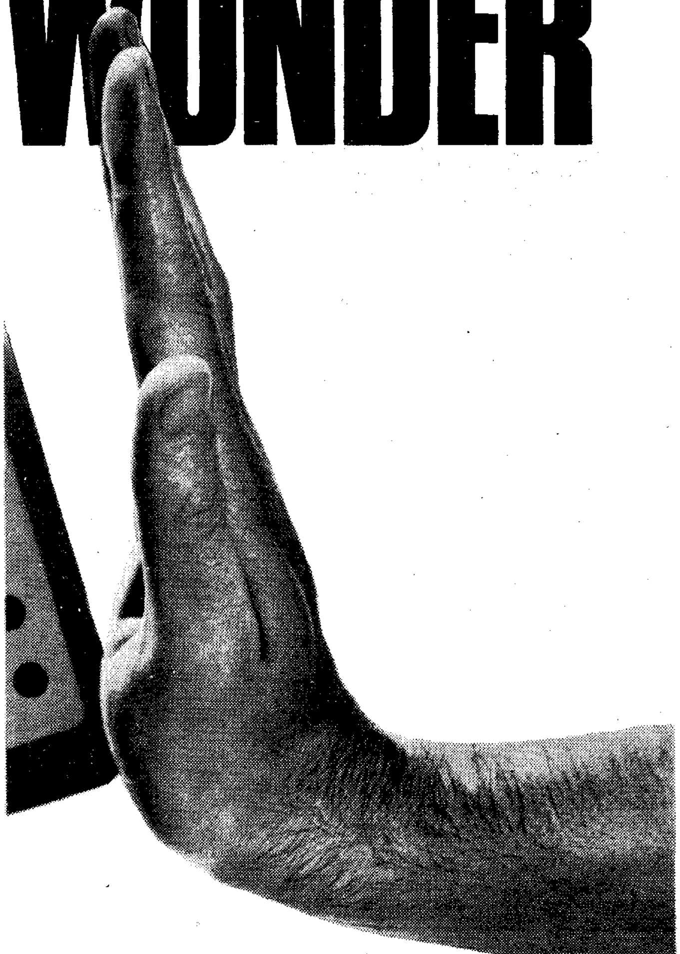

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The SEI MINITEST has made a remarkable impact in the pocket-sized multi-range meter market, by making itself a firm favourite with discerning people in the industry.
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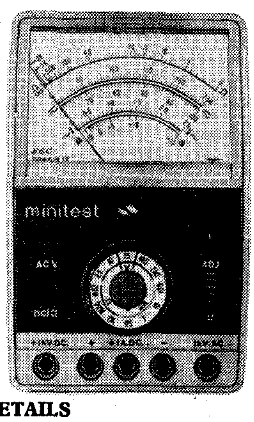

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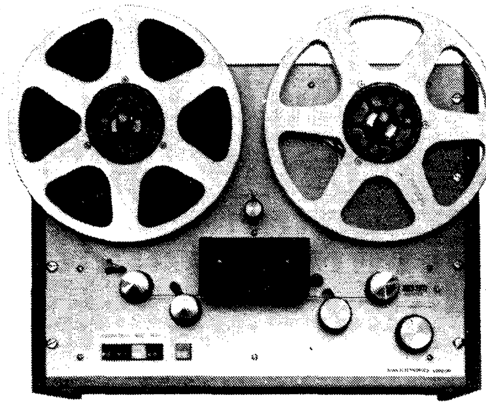

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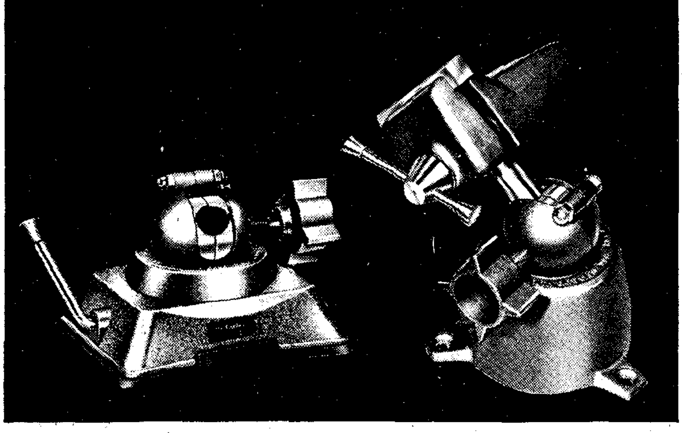

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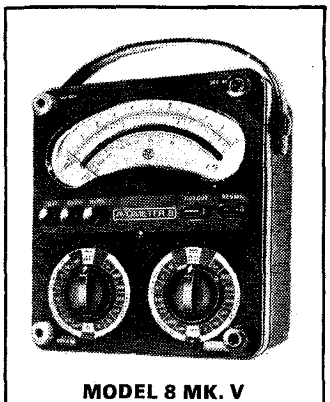

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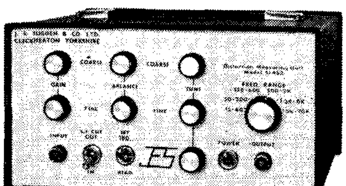

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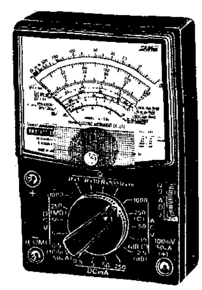

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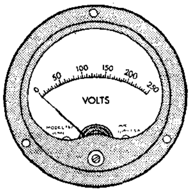
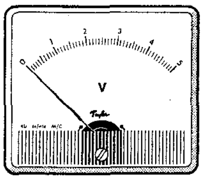
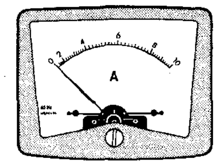


Models 250 and 350
10 mV to 1000 V dc (1000 Ω/V)
10μA to 30 A dc
10 V to 1000 V ac (1000 Ω/V)
50μA to 50 mA ac (to 50 A with external transformer)



Clarity range
10 mV to 100 V dc (1000 Ω/V)
10μA to 30 A dc
10 V to 1000 V ac (1000 Ω/V)
50μA to 50 mA ac (to 50 A with external transformer)



Vista range
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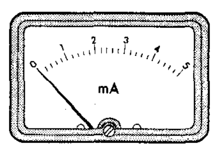
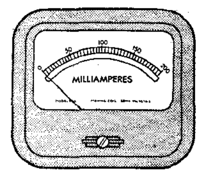
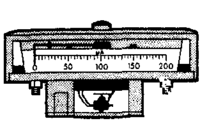
10μA to 30 A dc
10 V to 1000 V ac (1000 Ω/V)
50μA to 50 mA ac (to 50 A with external transformer)



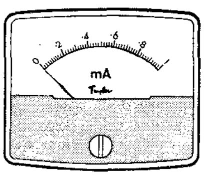
Model 55
10 mV to 1000 V dc (1000 Ω/V)
10μA to 30 A dc
10 V to 1000 V ac (1000 Ω/V)
50μA to 50 mA ac (to 50 A with external transformer)



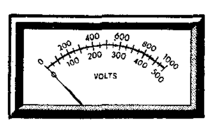
Models 400 and 500
10 mV to 1000 V dc (1000 Ω/V)
10μA to 30 A dc
10 V to 1000 V ac (1000 Ω/V)
50μA to 50 mA ac (to 50 A with external transformer)



Edgewise range (typical)
50 mV to 400 V dc (1000 Ω/V)
50μA to 500 mA dc
10 V to 400 V ac (1000 Ω/V)
50μA to 5 mA ac



Fyneline standard range
10 mV to 1000 V dc (1000 Ω/V)
10μA to 30A dc
10 V to 1000 V ac (1000 Ω/V)
50μA to 50 mA ac (to 50 A with external transformer)



Fyneline Pictureframe Window range
10 mV to 1000 V dc (1000 Ω/V)
10μA to 30 A dc
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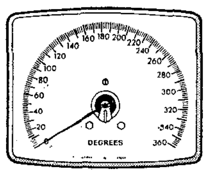

Fyneline Wide angle range
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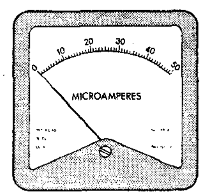

Model 45
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10 V to 1000 V ac (1000 Ω/V)
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Sensitivities above 1000 Ω/V available on application.

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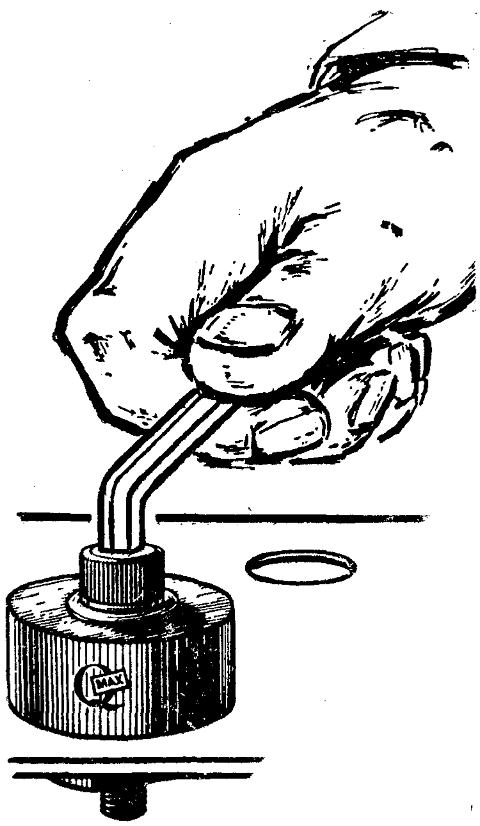

●The "IMPERIAL" Range will be continued

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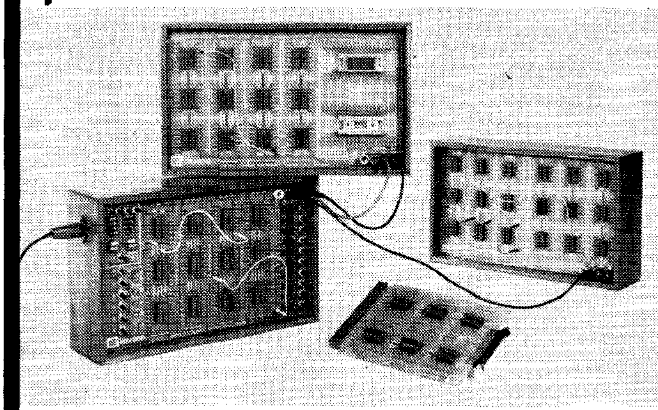
I C PATCHBOARDS and plug-in cards

low cost, high performance units



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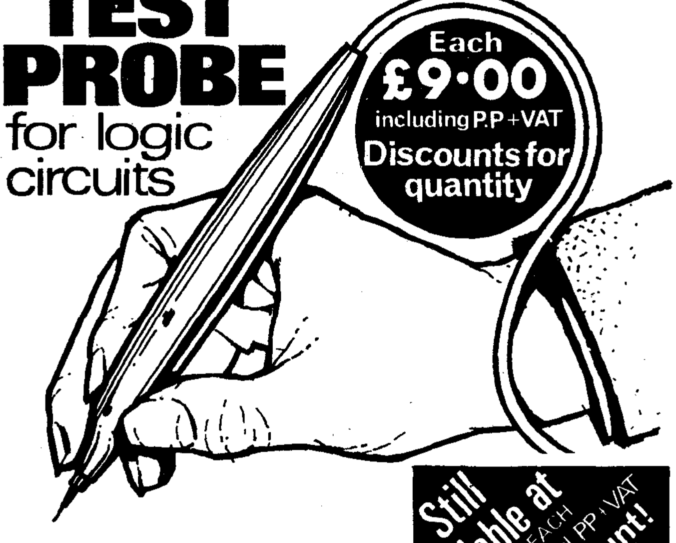
TEST PROBE

for logic circuits



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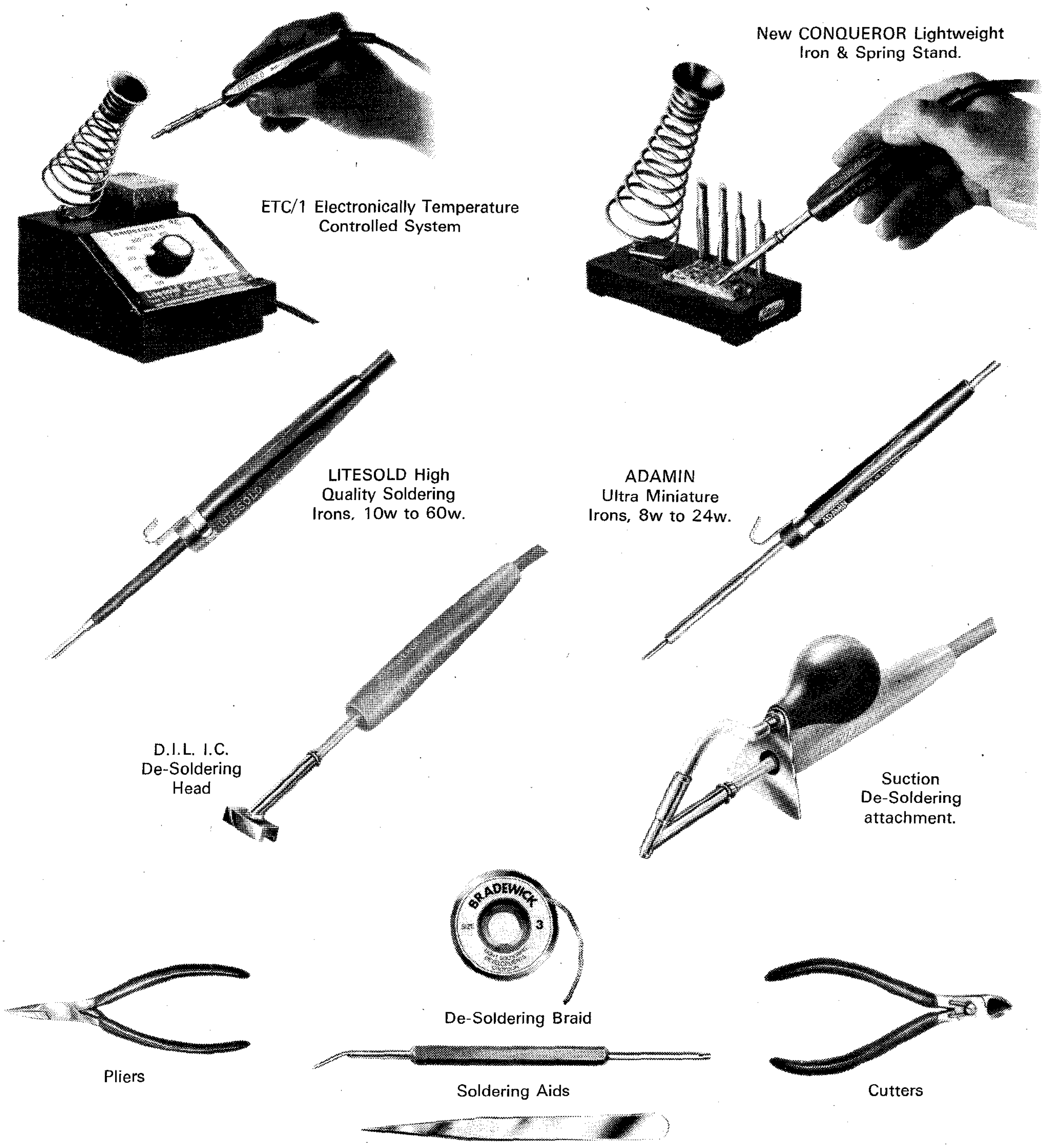

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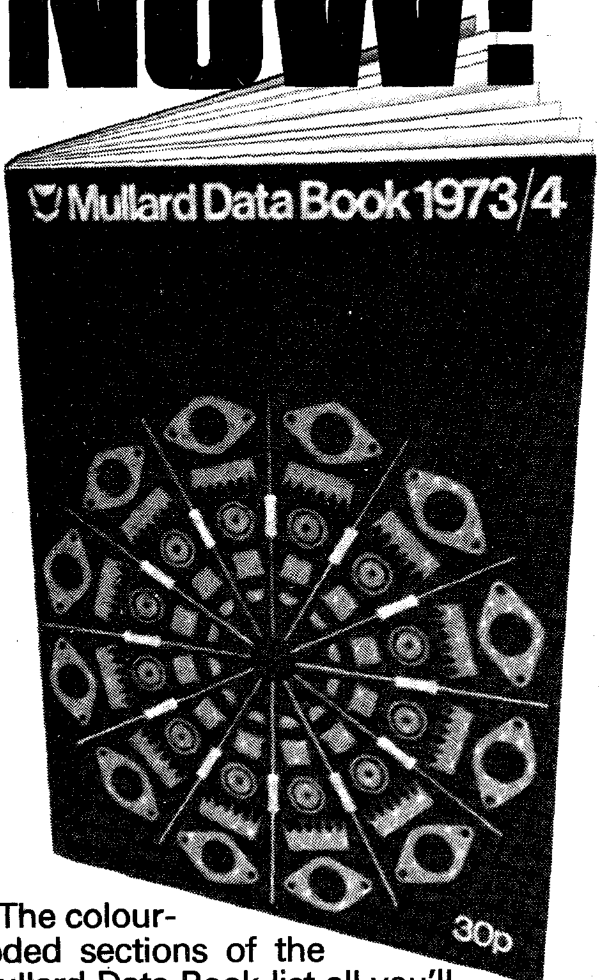

The colour-coded sections of the Mullard Data Book list all you'll want to know about valves, integrated circuits, semiconductors, picture tubes and other components. It also contains equivalents and comparables lists.

The Mullard Data Book 1973/74 is now available from your bookseller, or direct, cash with order, from the Selray Book Co Ltd, 60 Hayes Hill, Hayes, Bromley, Kent BR2 7HP.

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M54

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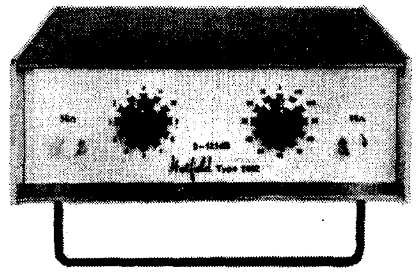
for your Attenuation



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SOUND MIXERS
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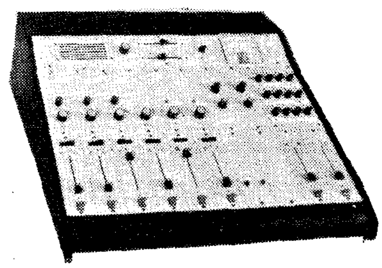
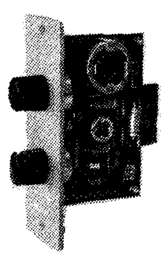
ALL TYPES OF INSTALLATIONS





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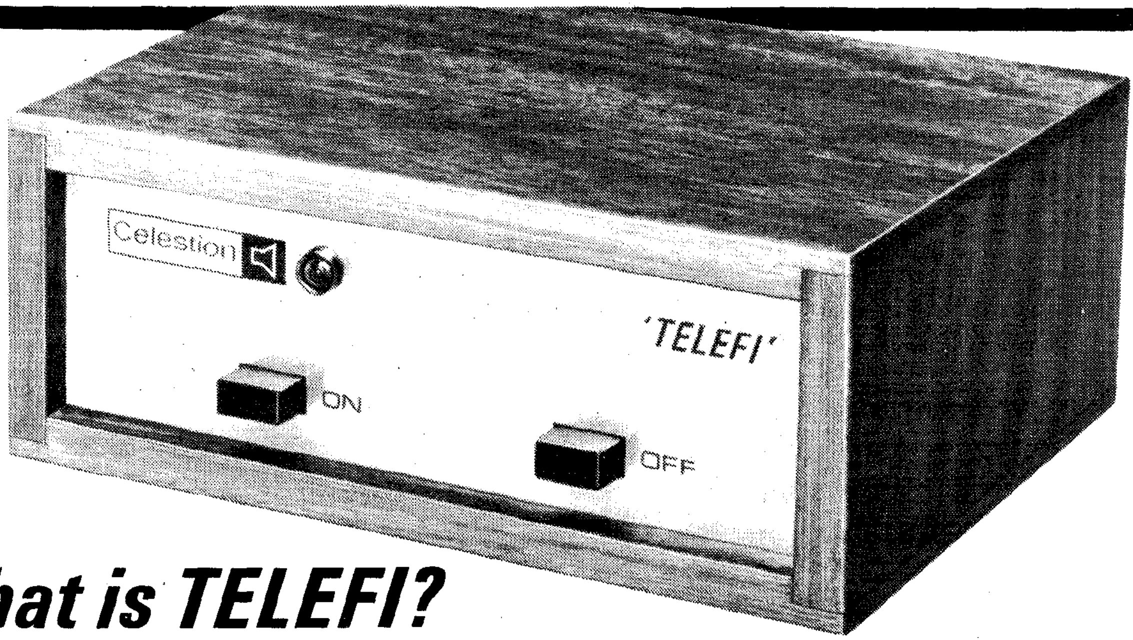

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I/P level: 560mV rms O/P level: 485mV rms per channel.
Input impedance: 50kΩ. Power requirements: 8-12V at 16mA
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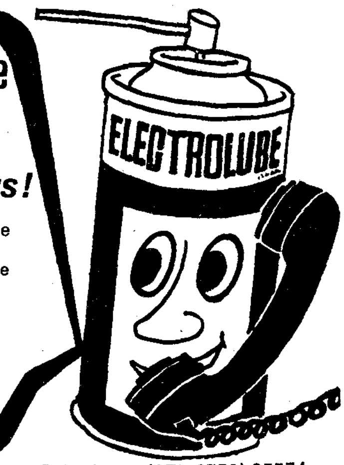

Electrolube Ltd. Slough, Bucks, England. Tel: Slough (STD 0753) 25574

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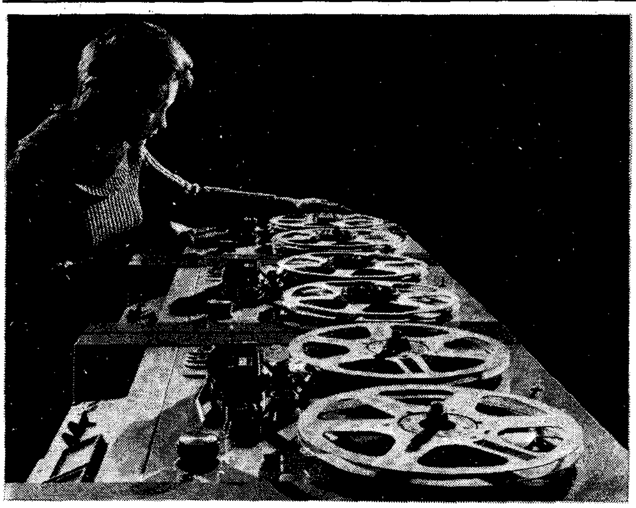

for the professional

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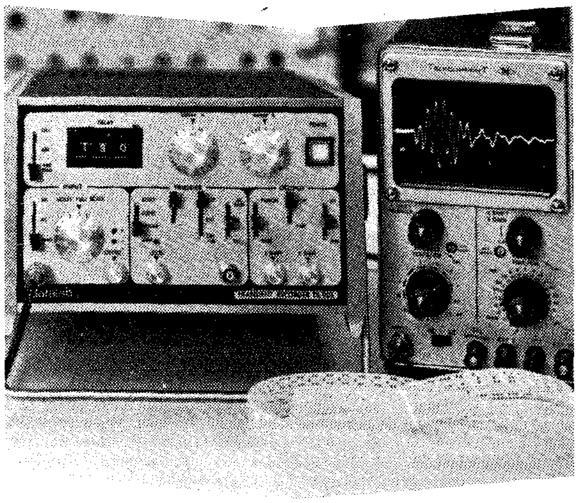

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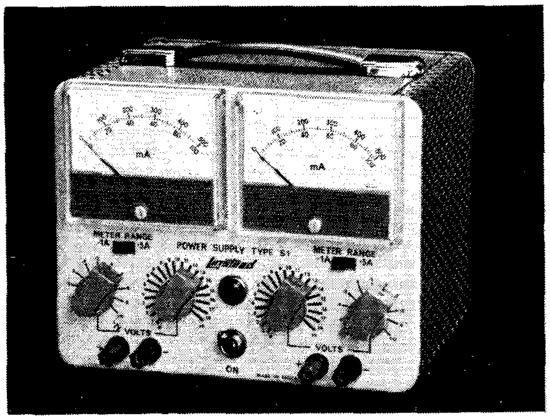
In one compact robust case.



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

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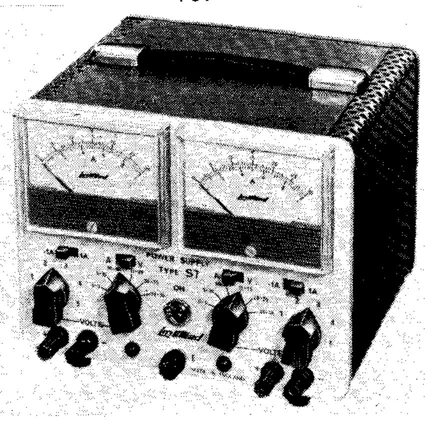

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Meters switchable for volts, 0 to 100mA and 0 to 1A.
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Wireless World, July 1973

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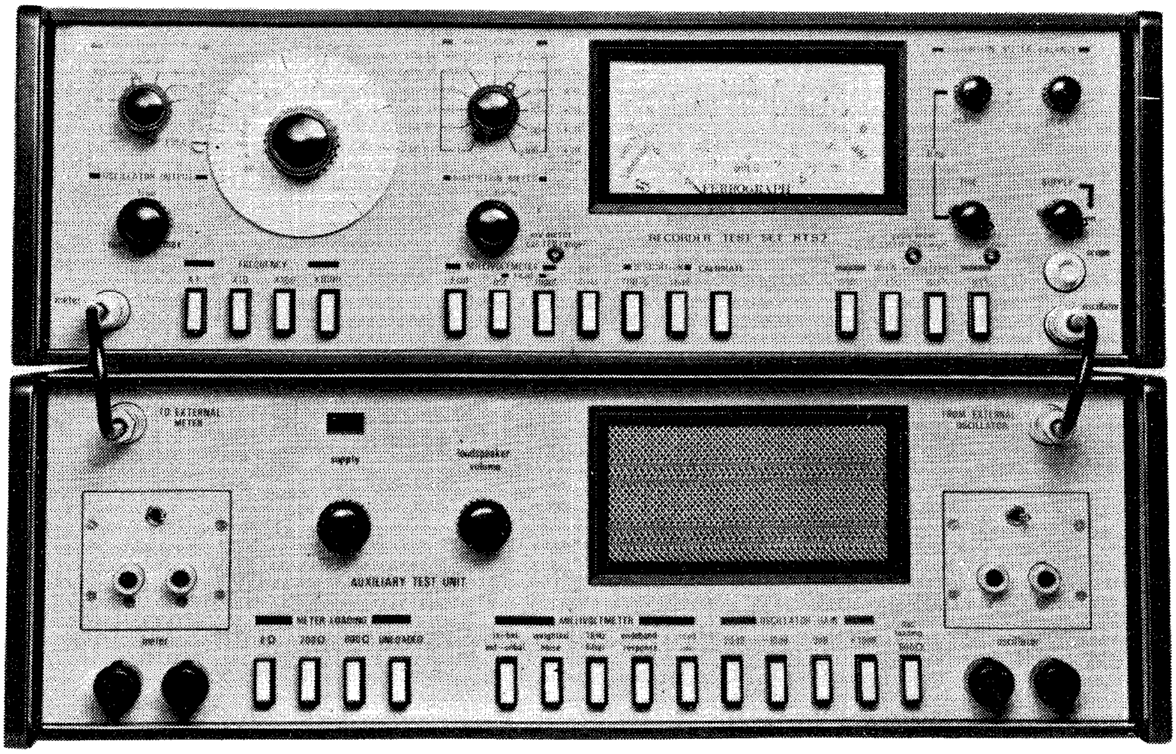

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RTS2 Checks Amplifiers, mixers, tape-recorders

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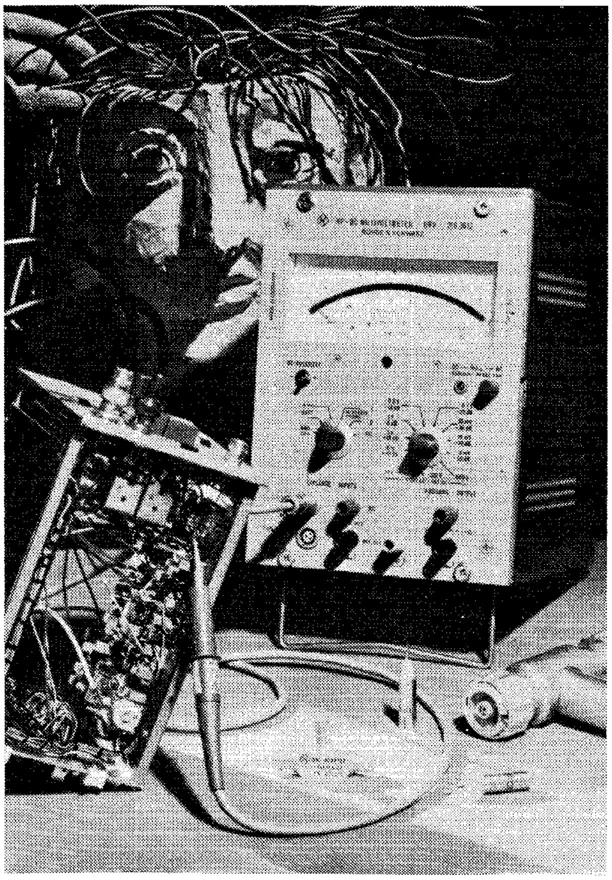
and NEW ACCESSORIES,



HF-DC Millivoltmeter model URV with RF probe and 20- or 40-dB attenuator.

The model HF-DC Millivoltmeter URV measures DC and AC voltages from 0.5 mV (50 μV for DC) to 1000 V and with a small RF probe, and proved coaxial insertion units (50, 60, 75Ω) the URV can be used for a wide variety of RF-Voltage measurements in the range from 1 kHz to 1.6 GHz.

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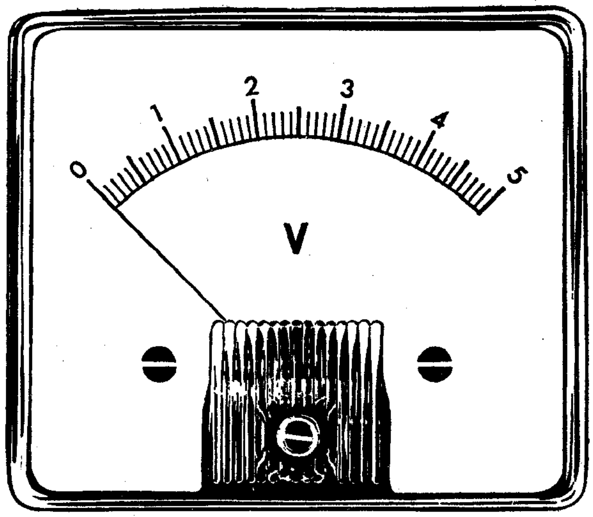
METER PROBLEMS?



A very wide range of modern design instruments is available for 10/14 days' delivery.

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HARRIS ELECTRONICS (London)

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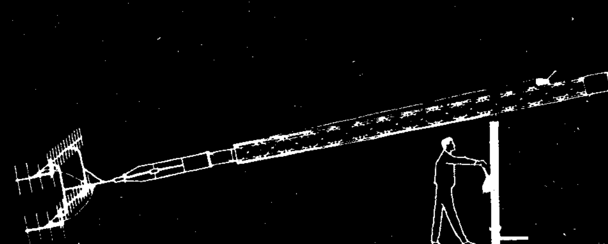

Acclaimed as the World's leading telescopic tiltover tower in the field of radio communication. Models from 25' to 120'

Look for the name

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Cool lighting **for hot parties.**

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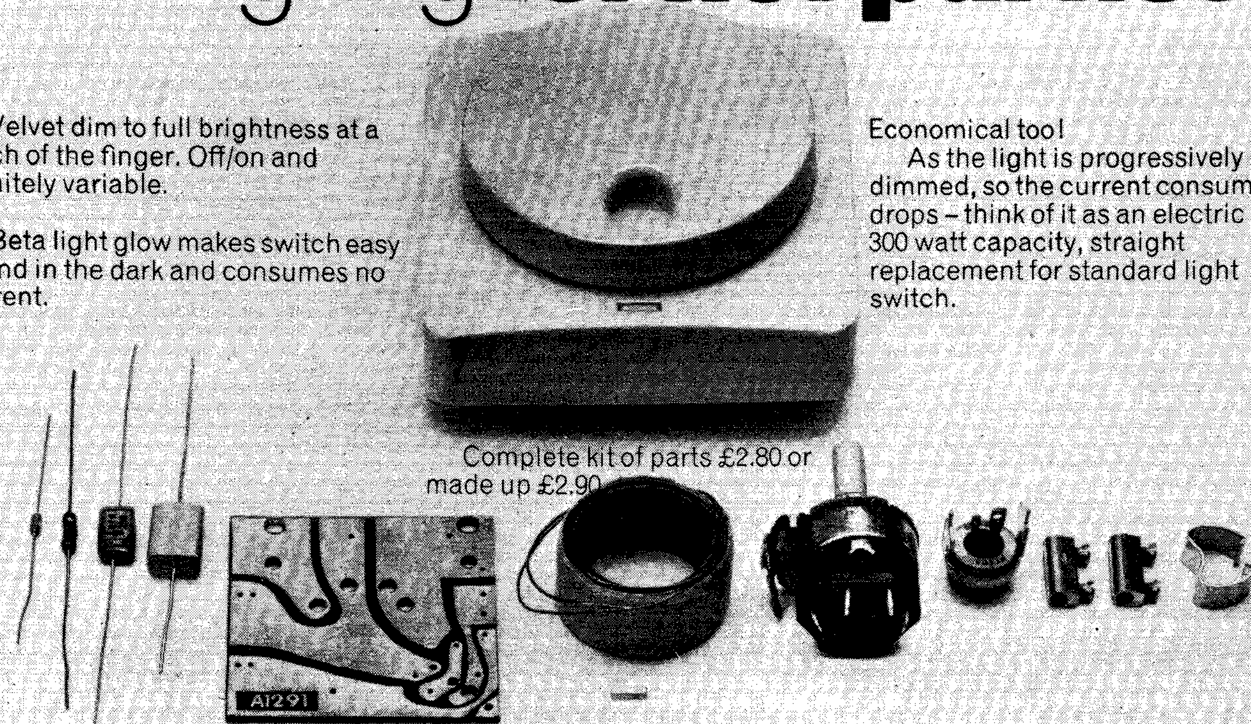
Beta light glow makes switch easy to find in the dark and consumes no current.

Economical too!

As the light is progressively dimmed, so the current consumption drops – think of it as an electric tap. 300 watt capacity, straight replacement for standard light switch.



Complete kit of parts £2.80 or made up £2.90

Hot Ignition for cold mornings.

The Jermyn capacitor discharge ignition system.

Instant starting in all weathers. Even with a near flat battery, the unit will produce a full sized spark.

Just one of the many advantages of an electronic ignition system, the others are:

High energy spark even at maximum revs.

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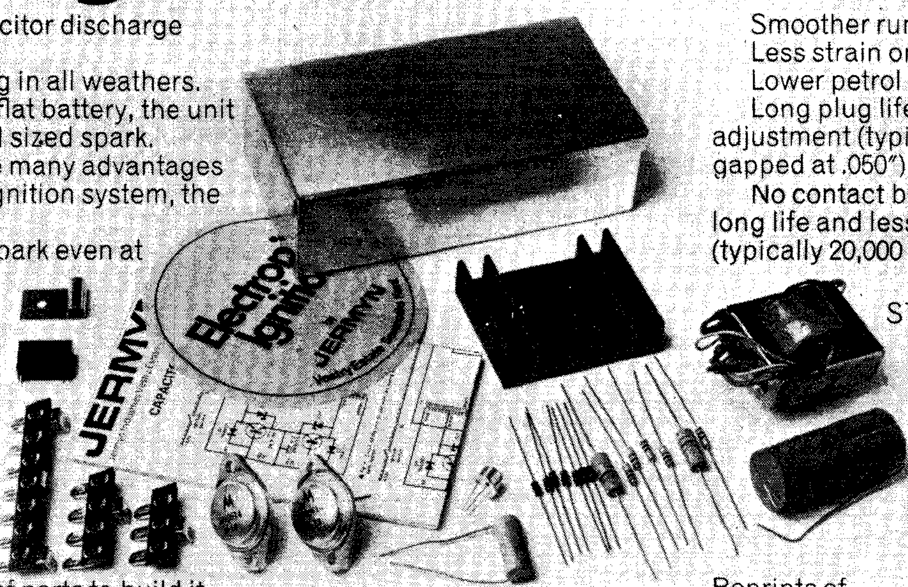
Long plug life with infrequent adjustment (typically 20,000 miles, gapped at .050").

No contact breaker arcing giving long life and less adjustment (typically 20,000 – 25,000 miles)

STATE + or – earth when ordering.



Complete set of parts to build it yourself for only £7.75, as described in Practical Wireless and fully approved by the author.

Save 55p
Buy both for £10.00

Reprints of the two part feature are available at 25p.

To Jermyn Industries, 94 Vestry Estate, Sevenoaks, Kent.

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Please despatch return of post .... light dimmer kit .... light dimmer ....
Ignition Kits .... + or – earth .... £10 pair. Enclose cheque or postal order.

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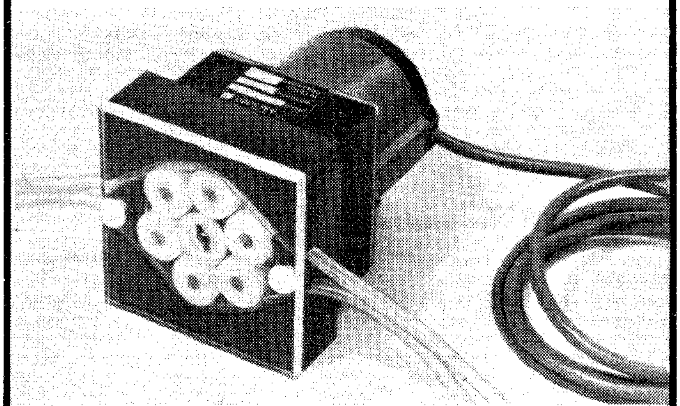

The equipment illustrated is available as a basic pump and a low cost precision-controlled unit offering an extremely wide range of delivery rates.

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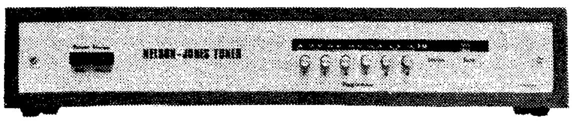
THE NEW NELSON-JONES FM TUNER



PUSH-BUTTON VARICAP DIODE TUNING (6 Position)

Exclusive Designer Approved Kits

For the first time the Nelson-Jones Tuner is available as a **complete kit** with all Metalwork, Printed and anodised Front Panel and Teak veneered cabinet. A Six Position push-button unit is used with each pre-selector button fully tuneable with its own scale and pointer and incorporating AFC disable for fine tuning.

Provision is also made for a Stereo LED, Stereo Decoder, Internal PSU and Fine Tuning indication (Meter or LED type). Push-button switches are also used for Stereo Mute and Mains On/Off. All sockets, board standoffs and panel mounting fuse are supplied.

Our attention to detail is such that even our cabinets are veneered inside and out for minimum warp and attractive appearance.

The tuner is available in two gain versions, and our **alignment service** is available to customers without access to a signal generator.

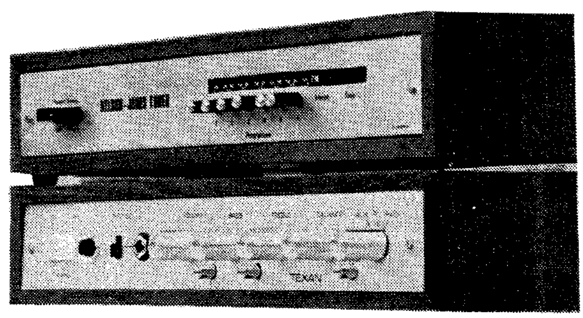
Prices for complete kits start at **£23·75** (mono) plus p.p. 45p., and of course all components are available separately.

Please send large SAE for our latest price lists which detail all of the many options and special low prices for complete kits. All our other products remain available e.g. **The Portus and Haywood Phase Locked Stereo Decoder Kit.**

PLEASE NOTE. Existing tuners are readily convertible and kits/parts are available for this purpose.

TEXAN AMPLIFIER. We have designed the tuner case and metalwork to match the Texan amplifier (see photograph). Complete designer approved Texan kits are available at **£28.50** plus p.p. 45p including a Teak Sleeve.

V.A.T. Please add V.A.T. at 10% to all prices for U.K. orders.



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Full theoretical and practical instruction on all types of modern receivers – including the latest colour sets.

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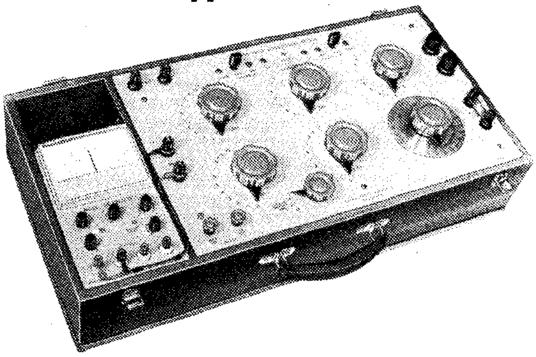
Type WS3/E



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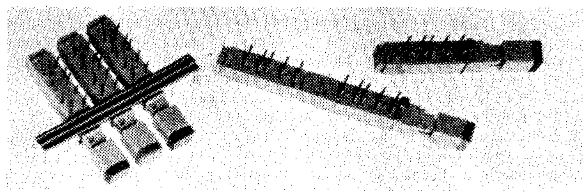
MINIATURE ILLUMINATED PUSH-SWITCHES



8mm x 8.7mm x 55mm (or 88mm ganged)
2 n/o + 2 n/c BBM or MBB (or 4 n/o + 4 n/c)
Momentary or Latching (optional interlocks)
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READY BUILT UNIT
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★ ALL HIGH QUALITY COMPONENTS ★

Capacitive discharge ignition is recognised as being the most efficient system and will give you

- **Continual Peak Performance**
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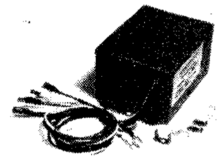

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12 volt only — state pos. or neg. earth. Supplied with illustrated assembly and fitting instructions, with details for fitting all types of tachometers. Can be built in an evening and fitted in 15 minutes. Spare snap-on connectors for coil, etc. Call in for a demonstration. S.A.E. all enquiries please. Or Phone Walsall 33652 for details. (Many letters from satisfied customers.

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Dixons Technical Ltd OF SOHO SQUARE

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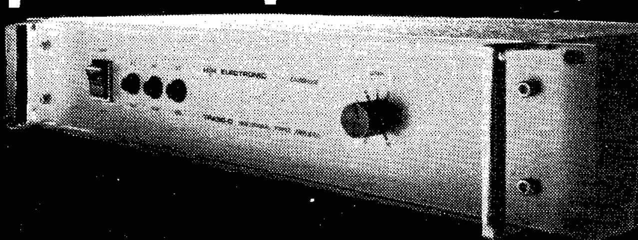
TPA SERIES-D

integrated circuit power amplifier



TPA 50 - D Specification

Power Output	100 watts rms into 4 ohms 65 watts rms into 15 ohms
Freq Response	±0·1dB 20Hz to 20KHz into 15 ohms. -1dB at 150KHz
Total harmonic distortion	Less than 0·04% at all levels up to 50 watts rms into 15 ohms
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100V Line (C.T.) and balanced inputs available.

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H||H ELECTRONIC

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Big Potential

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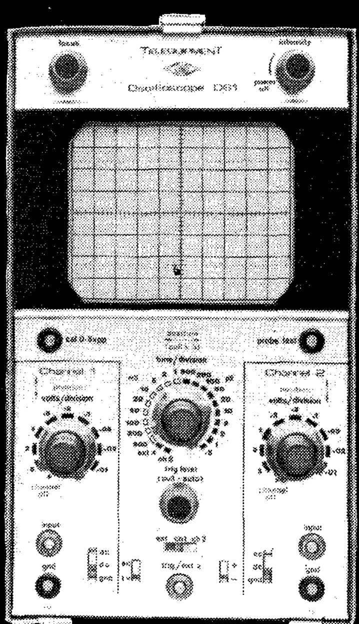

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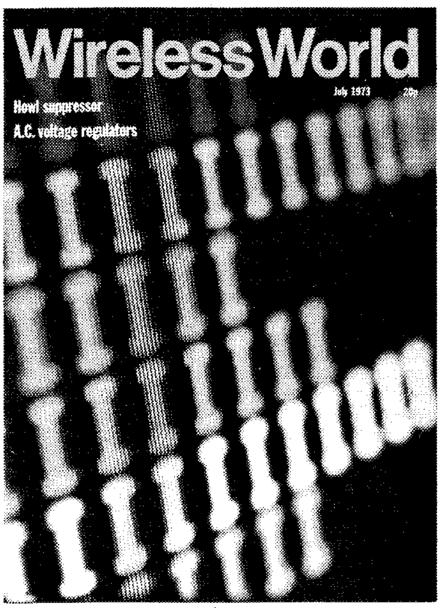
Wireless World

Electronics, Television, Radio, Audio

Sixty-third year of publication **July 1973** **volume 79 Number 1453**



This month's cover picture is a display on a Trimitron colour c.r.t. produced by Anchor, an electronic character generator developed by the B.B.C. and manufactured by Stabletron Ltd.

(Photographer Paul Brierley)

Contents

In our next issue
(publication date July 16)

Electronic sound synthesizer. First part of a series describing the circuitry and modular construction of a synthesizer capable of generating a large range of musical and special effects.

Audio amplifiers reappraised. Modern design techniques analysed against the background of existing research and present theories of psycho-acoustics.

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Brief extracts or comments are allowed provided acknowledgement to the journal is given.

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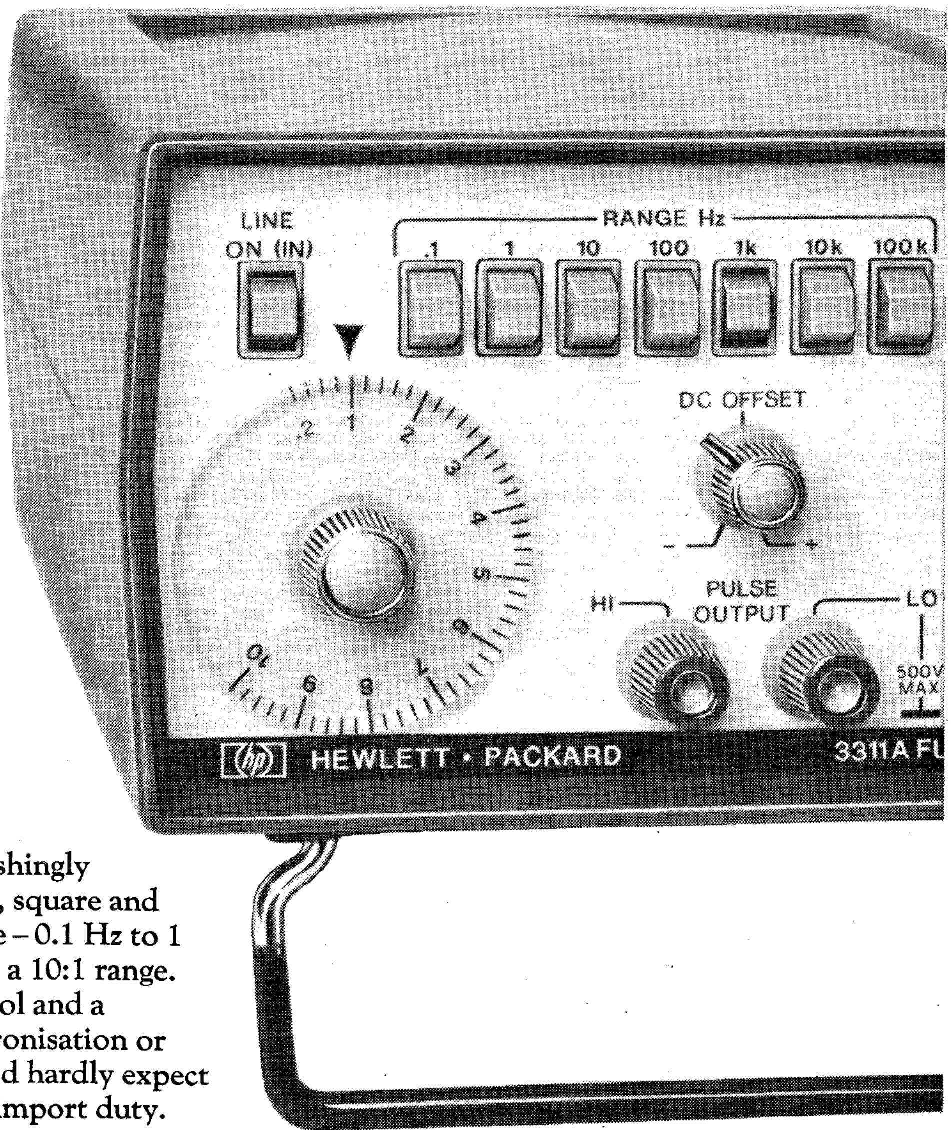

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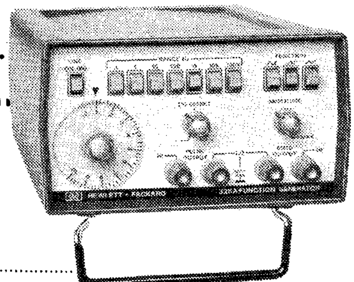

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Wireless World

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Choice of Systems and Standards

The evolutionary process of natural selection, or "survival of the fittest", works reasonably well in determining the design of electronic equipment. Designs which do not suit the customers' needs are not bought and so eventually disappear from the market. There is one situation, however, where successful survival does not necessarily mean that the best solution to technical problems has been found. This is where variation in the design of electronic equipment means much more than different types of hardware for the customer to choose from but implies competing systems of coding and decoding information for transmission, recording and reproduction. We see this situation at present in "quadraphonic" sound equipment and small video recorders.

Is it a good principle that the choice of an information system for widespread use should be left to the fortuitous working out of market forces?

There are several reasons why it is not a good principle. First, the biggest investment in a particular system is likely to be held by a large and powerful manufacturing group with a loud voice in the market place. Having committed itself to the system by heavy expenditure on research and development, this group will naturally be determined to recover these costs and exploit the investment by using all its resources in marketing. And this strength is likely to prevail, regardless of whether the system itself is a good one (e.g. in performance, economics, convenience, reliability) or not. Secondly, a commitment to a particular system will often be determined, or strongly influenced by, the current economics of making the hardware. Engineers may have longer term ideas of what is best, but the commercial interests of the manufacturing company dictate that it must go ahead as soon as possible making and selling hardware. Thirdly, when the choice of a system is left to the outcome of entrepreneurial activity there will inevitably be a period of great waste. Some manufacturers, those who have chosen the unlucky (not necessarily wrong) system, will waste resources in making and attempting to sell the associated hardware, and this waste is likely to be on a larger scale than that resulting from an unsuccessful product not associated with a system choice. And those customers who actually buy the unlucky hardware will, of course, have wasted their money on non-compatible and hence prematurely obsolete equipment.

Ideally the choice of an information system should be determined jointly by all interested parties — by potential users as well as manufacturers. Where the users are large organizations such as broadcasting authorities this does happen to a great extent, simply because the customer is powerful, rich and technically well informed. Where the users are ordinary citizens buying domestic electronic equipment it can be fairly said that the customers do not know what they want because they are not in a position to judge the merits of competing systems. The nearest approach to making co-operative decisions on systems is when a group of interested parties, mainly manufacturers, is formed on a national basis, such as the Japanese E.I.A.J. (e.g. for video recording). Such bodies are formed to promote and protect mutual interests, not to reach truly objective decisions. But perhaps this is the best we can hope for in an imperfect world.

ORACLE — Broadcasting the Written Word

by A. James, F.I.E.E.*

Although public broadcasting is now more than 50 years old, it still consists mostly of the spoken word or of pictures of people speaking, and yet for many purposes the written word is more useful. Written material has the great advantage that the reader can set his own pace, can stop to think, and can re-read the text any number of times, at will.

Several proposals for broadcasting written material have been made in the past. One of them, the B.B.C. Ceefax proposal has already been described in *Wireless World*[1]. The Independent Broadcasting Authority has under development a system for transmitting written material which, like the Ceefax system, transmits the information along with the television pictures. In some other significant respects the system differs from Ceefax, however. Experimental field trials of the IBA system have been taking place in the London area since early April.

"Notes in the margin"

Fig. 1 shows a section of the television signal. On the left are the last few lines of one picture; following it comes the frame synchronizing pulses and then come a number of blank lines which might be termed "the margin" at the top of the next picture. Finally, on the right are the first lines of the next picture. Towards the end of this "margin" in line 19 and sometimes also in line 20, additional test line signals are nowadays inserted[2]. Additional signals are also sometimes accommodated on line 16 and these signals take the form of a binary code used to transmit data along the network[3]. The Independent Television network uses such a digital data signal to identify the source of transmissions on the network. For source identification purposes only a short signal is required but the format chosen readily allows expansion so that a message of some 10 letters can be transmitted on each line. The IBA proposes to use these "Notes in the margin" also for the broadcasting of written material and have coined the code word "ORACLE" (Optional Reception of Announcements by Coded Line Electronics) to describe the proposed system.

* Independent Broadcasting Authority.

What ORACLE does

ORACLE is a system for the assembly, transmission and reception of written material, using the existing television transmission facilities and the ordinary domestic television receiver to display the text. Apart from the data signal mentioned in the paragraph above which in no way affects normal reception, the television transmission is entirely standard. The receiver, however, requires adaptation, either by means of an independent add-on unit or, more cheaply, by an internal modification. The system now undergoing test allows for the transmission of 50 pages of text, each consisting of 22 lines of 40 characters, and the experimental receiver adapter enables the user to select any one of these pages for display. The text may be displayed superimposed on the television picture, like a subtitle, or the viewer may choose to switch the picture off, so that the text is displayed on a neutral background.

At the sending end, the text of a page is prepared in advance on a computer terminal unit. The various pages are then entered and held in the memory of a small computer which allows the information to be inserted into the television signal in the correct format at the appropriate time. When the page has been completed it can be transmitted, the time required by the present experimental system being approximately $1\frac{1}{2}$ seconds, so that the total time for transmitting all 50 pages, in effect a booklet of written material, takes about one minute. At the receiver the viewer can, if he wishes, hold the text indefinitely rather than allowing it to be up-dated. At present the text is restricted to a standard type-face of some 60 characters but the code used will allow for an extension of this. The text could even incorporate non-typographical signs designed to allow the transmission of drawings or even free-hand writing.

Data code

Text is transmitted in segments of ten characters each, and each character is represented by an eight-bit code (see Fig. 2). The character codes are preceded by codes defining (i) the segment of the page currently being transmitted and (ii) the ORACLE page. The system is entirely compatible with other standardized data systems using line 16. The form of modulation used is known as "complemented element" in which "1" is represented by a transition from picture white to black and "0" by the reverse transition. This form of modulation is

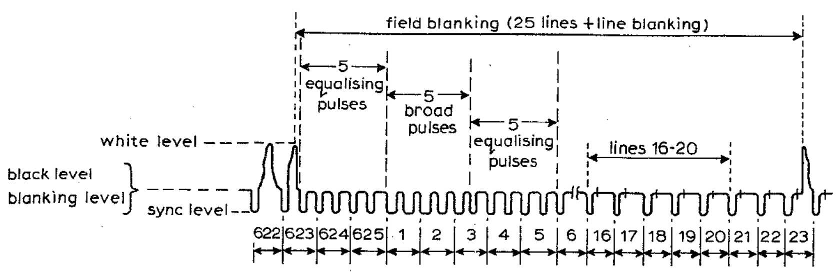


Fig. 1 Part of the television signal showing the vertical interval.

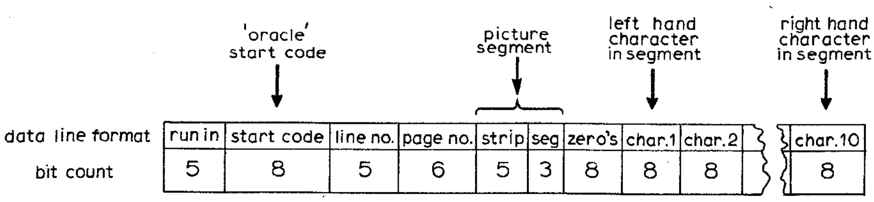


Fig. 2 ORACLE data format for one segment (i.e. one quarter of a line of written information).

particularly rugged and therefore unlikely to suffer from errors during transmission, and has been well tested.

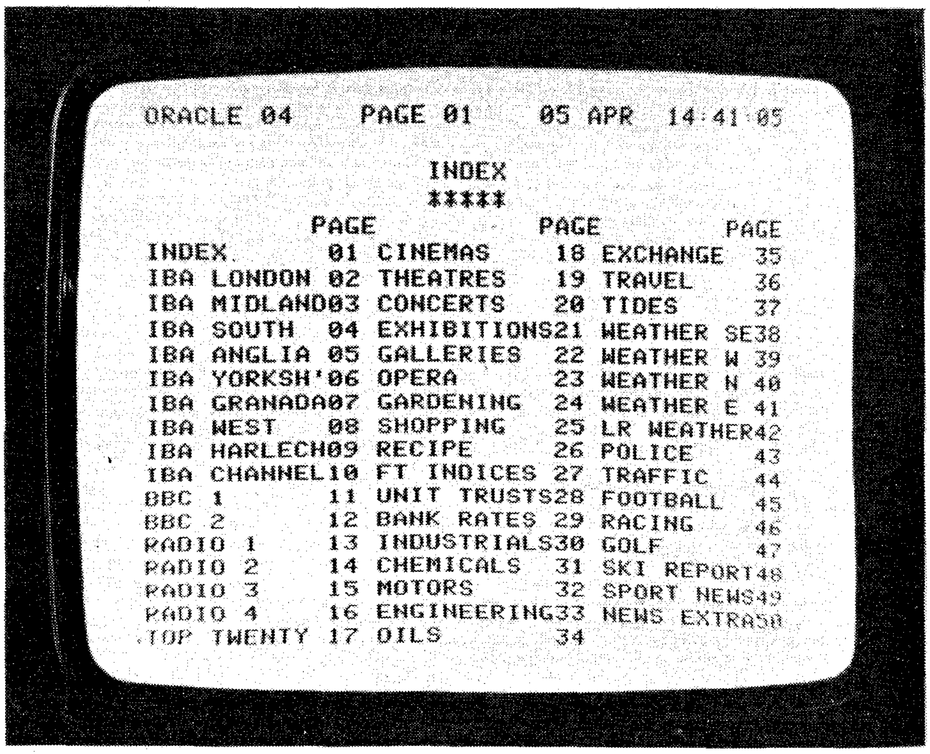
Receiver adapter

The equipment at the receiver (Fig. 3) is in principle simple. The data is extracted from the television signal, and then checked to see whether it is ORACLE data; if it is the page number is read and when this coincides with the page number selected by the viewer, data is fed into a store capable of storing the ten letters transmitted in a single field interval. Subsequently at the appropriate moment, data is fed out of this store into a recirculating store capable of storing one complete ORACLE page of information — that is to say, 880 characters in 88 segments, a total of 5280 bits. A third store is needed to complete the sequence. This store holds a complete line of 40 characters, that is four segments of information, and is updated by the recirculated store. The signal from the third store is presented to the character generator one character at a time.

Each character is based on a matrix of 7 × 5 dots. On the television pictures the characters are built up line by line by remodulating the scanning beam in the appropriate way, i.e. the scanning beam must be modulated in rapid succession by the first row of squares for each of the letters in a line of text, followed by the second row and so on until the complete line of text has been displayed. To achieve this the information from the third store is presented character by character in rapid succession seven times in all. The line of text is followed by space four television lines wide. Before these are scanned the third store is reloaded from the main recirculating store. Pressing the hold text button isolates the recirculating store from the input store. The data is then recirculated and the same page of text is presented until the button is returned to normal. On switching to a different ORACLE page the recirculating store is emptied and then waits until the first segment of the new page is available. The new segment is then written in to the recirculating store in precisely the same place as the first segment of the old page. Further segments are entered as they become available and in the course of approximately $1\frac{1}{2}$ seconds a complete new page is transferred to the recirculating store.

Possible uses for ORACLE

It is foreseen that the type of information services which could be provided by such a public broadcast data service are almost unlimited, and the system has many other potential applications for home or business use. The type of information services which could be provided in this way includes continuous accurate time checks, weather forecasts, news, traffic and local news, stock exchange prices, television and radio programme information, recipes, local and national announcements, exhibitions, theatres, shopping information and advertising messages. One page of



ORACLE's index page.

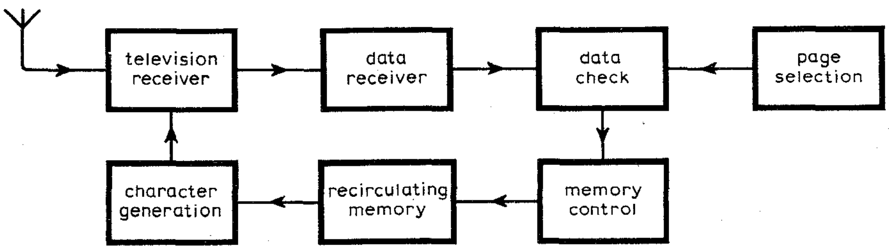
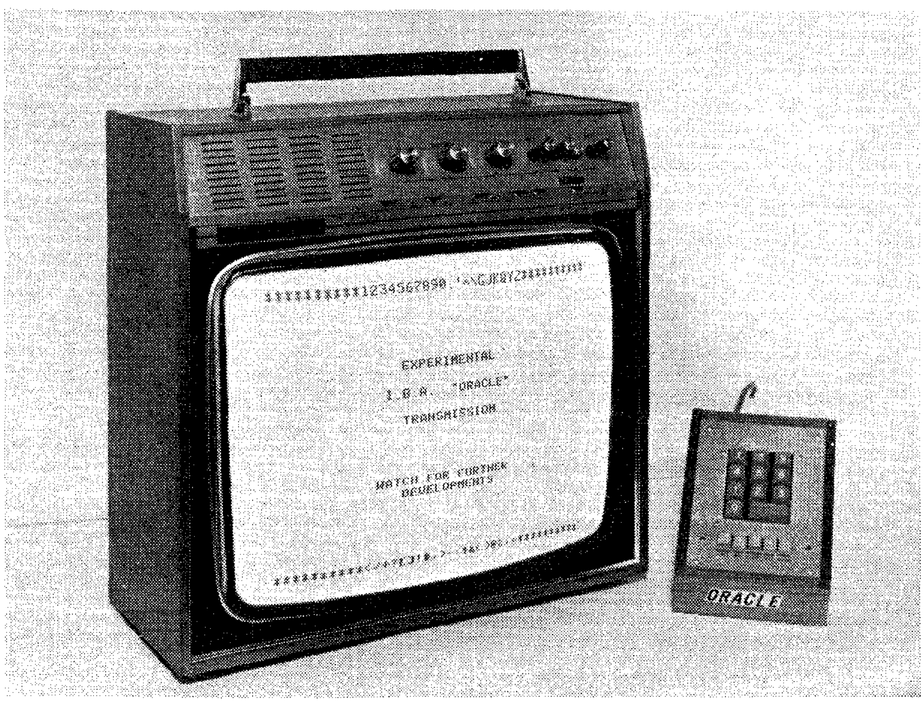


Fig. 3 Block diagram of an ORACLE receiver unit.



Receiver modified for use with the ORACLE system.

information would provide a summary of the services available and the "page number" which would be used by the viewer to "call up" the display on his screen. Other possibilities include the use of the equipment as a home data terminal, the provision of caption material to accompany television programmes for the deaf viewer or for those who do not understand the language of the programme.

At the studios, page information would be kept up-dated by an editorial team using visual display units and keyboards in conjunction with a central computer which would be needed to collate the information so that it can be inserted into the television waveform at the appropriate moments and distributed along with the normal television signals to the transmitting stations. The first line of each page would carry an identification, date and time so that every viewer, no matter which of the services he was watching, would have the equivalent of a highly accurate digital clock always available. For example the first line might read: "ORACLE 33" PAGE 22 21 APR 17: 21: 07. Sufficient flexibility is incorporated in the system to contemplate further possibilities such as the use of individually coloured letters or graphical symbols.

The future

The system described above is currently being field-tested in the London area. Broadcasts of test material are being made from time to time and in addition at other times a test caption is being transmitted. The receiver industry is showing great interest in this development and at least one manufacturer has a receiver adapter in an advanced stage of design.

References

1. "TV Information Service", *Wireless World*, May 1973, p.222.
2. Schaffer, J. and Lever, I., "Insertion Test Signal Equipment", Report of the Joint Conference on Television Measuring Techniques, IERE, May 1970, p.445.
3. Hutt, P. R., "A System for Data Transmission in the Vertical Interval of the Television Signal", IBC Conference Publication, IEE 1972.

Applications of the high-standard l.f. Source

*by J. M. Osborne**

The uses to which the "High-standard Low-frequency Source" (*W.W.* January 1973) can be put are many. The source utilizes the B.B.C. 200kHz Droitwich transmission and provides a range of frequencies up to 20kHz. The following are two applications which the author has found particularly useful.

Watch tester

Most watches tick a whole number per second, typically five ticks per second. Their timekeeping can be accurately and quickly tested using the high standard frequency source with the system shown in Fig.1. The watch is placed in contact with a microphone, preferably in a sound-proof box. The output of the microphone is amplified and applied to one input of a double beam scope which is set to run at about five sweeps per second, so that a noise pulse from the watch ticking appears near the centre of the trace. A 100Hz square wave from the standard frequency source is applied to the other trace and used to trigger the c.r.o. If the watch gains or loses the pulse will drift across the screen and the time taken to gain or lose one hundredth of a second (one complete cycle of the square wave) is readily determined on some other timepiece. It takes a few minutes to see that a watch is accurate to within a minute a month.

The apparatus can be set up using a cheap watch with a loud tick, which is more likely to show a significant error.

*Westminster School

Frequency meter

The l.f. source can readily provide a gating signal for frequency measurement of audio frequencies. The signal to be measured is fed at a suitable level to one input of an SN7400 gate (Fig.2), and the gate output is used to drive a counter. The other input of the SN7400 is connected to the source which is switched to 0.1Hz so that the gate opens for 5 and closes for 5. Thus the counter records the number of cycles of the signal occurring in five seconds. There is a five-second pause to take the reading before the next count. As the counter is cumulative one takes the sum of two counts and divides by ten to obtain the frequency.

As the instrument uses part mechanical counting it can only handle frequencies below about 2kHz. Higher frequencies would have to be divided first to bring them in range, e.g. by the use of SN7490 dividers.

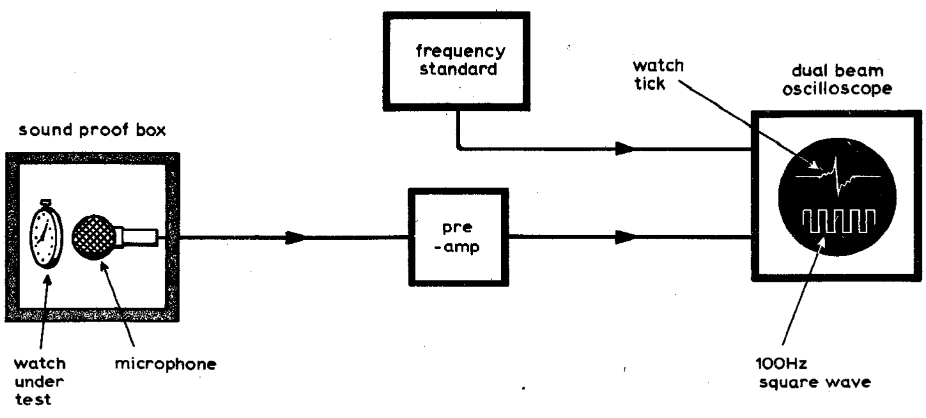


Fig.1. Schematic of the system for checking watch accuracy.

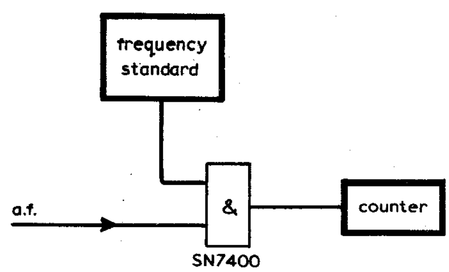


Fig.2. Using the standard in a system for frequency measurement.

Frequency Shifter For "Howl" Suppression

*M. Hartley Jones**, *M.Sc., Ph.D.*

The circuit described increases the stability margin of sound reinforcement systems by up to 8dB. This is achieved by shifting the frequency of signals by 5Hz. The inexpensive and reliable nature of the circuit is made possible by the use of integrated circuits. The technique may be adapted to produce larger frequency shifts for use in electronic music synthesis.

Anyone who is involved with sound reinforcement systems is familiar with acoustic feedback. A sound amplification system where the microphone and speaker are in the same room, is limited in gain by the positive feedback loop formed by the acoustic coupling between loudspeaker and microphone. As the gain is increased, feedback initially causes colorations in the sound, then develops into an audible ringing on transients, finally becoming a continuous "howl-round" when the loop gain reaches unity.

The use of directional microphones and loudspeakers can help in reducing the proportion of sound energy which is fed back to the microphone but, owing to the diffuse nature of the reverberant sound field of a room, acoustic feedback still limits the usable gain of the system.

The reason why feedback usually occurs at one particular frequency is an interesting one. In any sound reinforcement system there will be one frequency at which loop gain is a maximum and this will depend upon the frequency response characteristics of the complete feedback chain, comprising microphone, amplifier, loudspeaker and room, as shown in Fig. 1. If frequency response peaks can be ironed out of every element in the chain, then the mean loop gain can be increased without exciting howl-round at a particular frequency.

Compensation for frequency response irregularities in microphones and loudspeakers by means of tone controls and equalizers in the amplifier is a well-established technique and attention to this point can often improve the stability margin of a system by several decibels. The frequency response of the room is, however, a much more complicated problem owing to the multiplicity of resonant modes. Fig. 2 shows the typically irregular frequency response of a room; only the region just above 500Hz is shown, but the characteristic over the whole audio band is of similar form. The dotted line in Fig. 2 shows the average or mean level of response and it is clear that the peak levels can be more than 10dB above the average. Although it is the average response which determines the subjective sound level in a room, as judged by a listener, it is those 10dB peaks that give rise to howl-round in a sound reinforcement system. Thus, if the peaks could be flattened out, up to 10dB increase in usable gain could be expected.

There have been attempts at electrical equalization of the major room response peaks[1] but, even if the inverse response of Fig. 2 could be exactly synthesized, the peaks and dips shift with variations in microphone position, with temperature and with size of audience, making exact correction impossible.

Schroeder[2,3] has shown that the room frequency response can be effectively smoothed out as far as acoustic feedback is concerned by slightly shifting the frequency

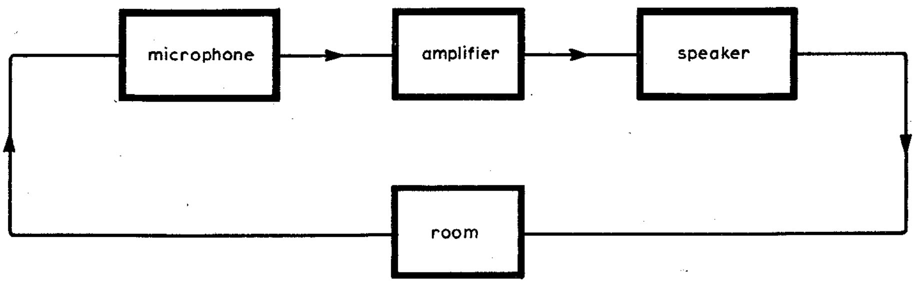


Fig. 1. Acoustic feedback loop in a sound system.

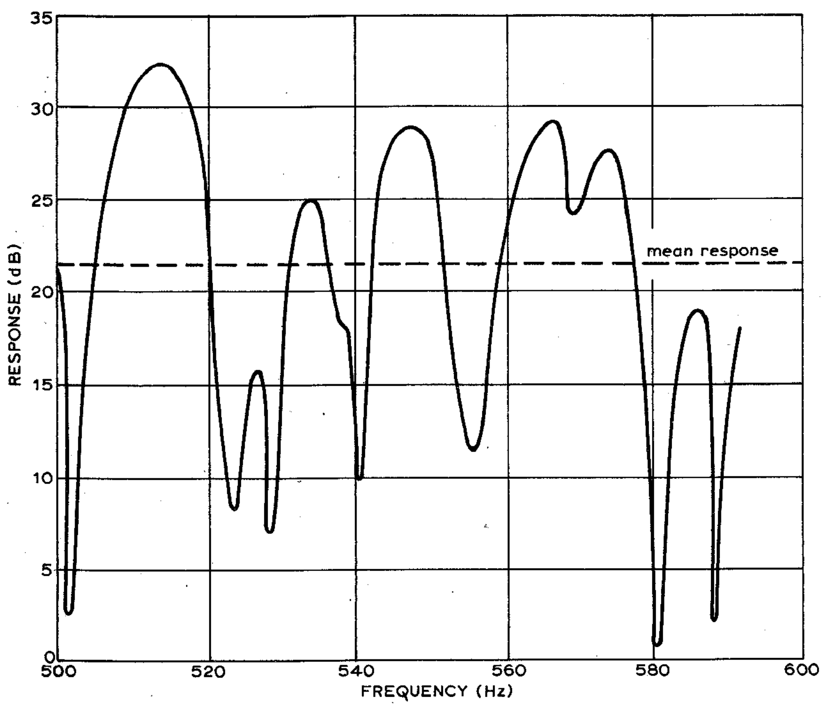


Fig. 2. Small section of a typical frequency response curve of a room.

*University of Manchester Institute of Science and Technology.

of the signal as it goes through the amplifier. This technique ensures that any signal component subject to a very high gain at one of the response peaks, which would normally result in a feedback howl, will be changed in frequency on its next trip round the loop so that it is subject to a much lower gain. As the signal continues to go round the loop it will be changed in frequency each time and therefore be subject to a different loop gain on each trip. After several trips, the mean loop gain experienced by the signal will thus be equal to the average room response shown in Fig. 2. In the same way, if a signal component happens to experience a low gain on its first trip then it will be subject to a much higher gain on its second trip. However, after several trips, the mean loop gain will once again be equal to the average room response. Thus both peaks and dips in the room response are effectively levelled by the frequency shifter.

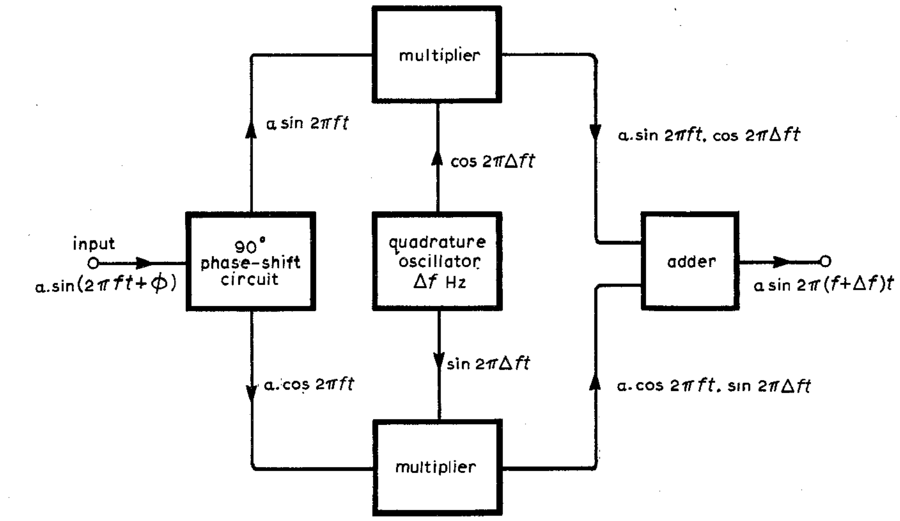


Fig. 3. Block circuit diagram of the frequency shifter.

The amount by which the frequency is shifted is not particularly critical. In order to minimize unnatural effects the shift should be as small as possible, whilst for optimum howl suppression the shift should be of similar order to the average spacing between peaks and their adjacent troughs. Schroeder and Kuttruff[4] have shown theoretically that the average spacing between adjacent peaks is given by:

$$\Delta f_{max} \approx \frac{4}{T}\,\text{Hz}$$

where T is the reverberation time of the room. Thus, on average, in a room with a reverberation time of one second, the spacing between adjacent peaks should be 4Hz and therefore that between a peak and its adjacent trough 2Hz. This average spacing, however, includes tiny irregularities which may be barely measurable; in practice the spacing of major peaks and troughs may be double this figure; in addition, as may be seen in Fig. 2, the peaks are not regularly spaced. The optimum frequency shift for

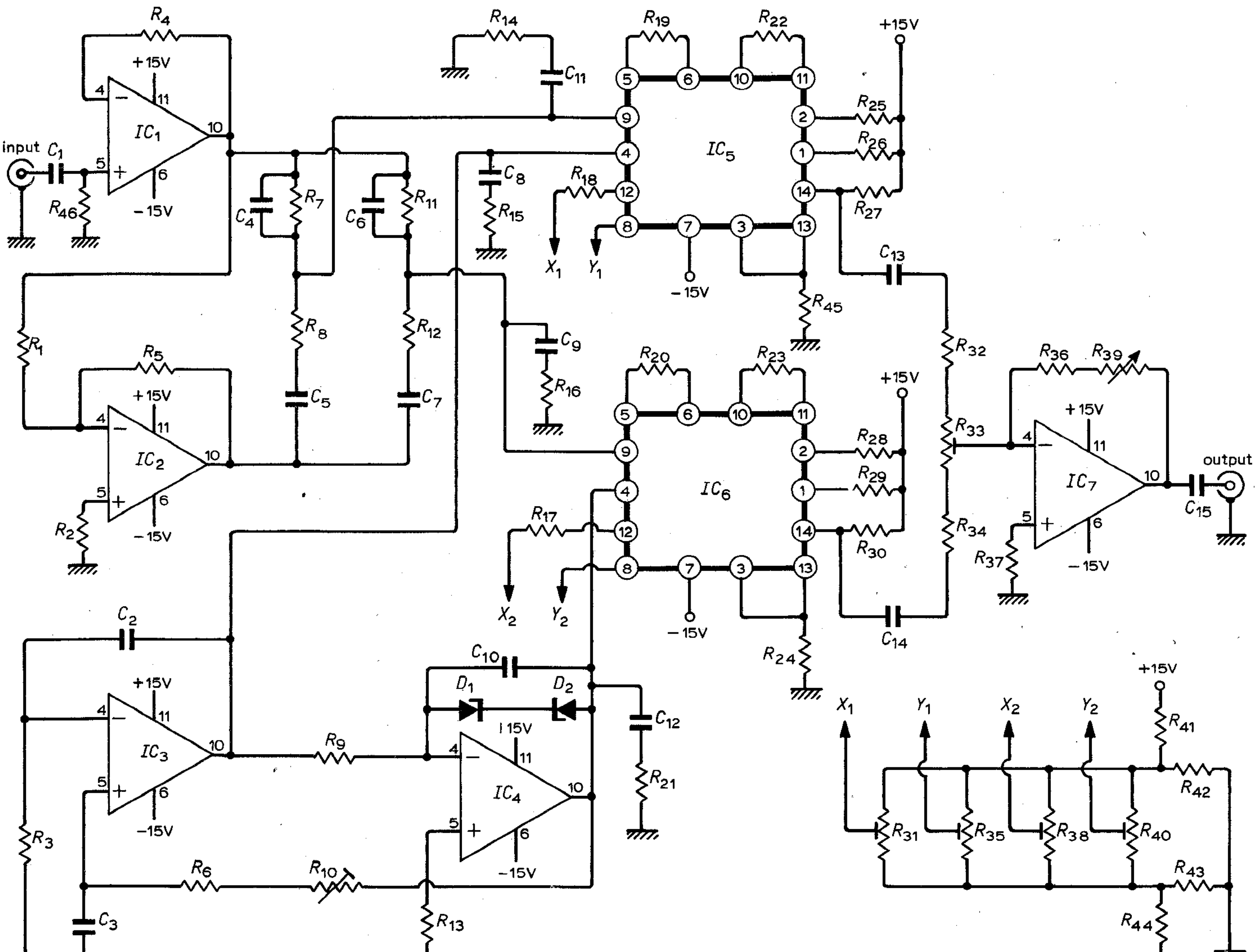


Fig. 4. Complete circuit diagram of the frequency shifter.

howl suppression is therefore best found experimentally; in most applications it turns out that a shift of 5Hz is sufficient, no further advantage being gained by greater shifts. It is conceivable that, in the unlikely event of the reverberation time being very much less than one second, a greater shift might be required.

It is immaterial whether the frequency shift is in the upward or downward direction. The shifter to be described produces a 5Hz increase in frequency.

Frequency shift circuit

Schroeder used in his experiments a frequency shift circuit developed by Prestigiacomo and MacLean[5]. This circuit used suppressed carrier single-sideband modulation of a high frequency carrier by the signal followed by demodulation with a new carrier frequency which differed from the original carrier by 5Hz. The circuit to be described here, however, uses a different technique, exploiting the accurate integrated circuit multipliers now freely available; it requires no tuned circuits, crystals or filters and gives a good signal to noise ratio with a wide frequency response and low distortion.

Consider a sinusoidal input signal of frequency fHz; its instantaneous voltage, v_{in}, is represented by

$$v_{in} = a \sin 2\pi f t \qquad (1)$$

where a is peak voltage.

Now, if the output signal of our circuit has an increased frequency $(f+\Delta f)$Hz but the same peak voltage a, then its instantaneous amplitude v_{out} is

$$v_{out} = a \sin 2\pi(f+\Delta f)t$$
$$= a \sin (2\pi f t + 2\pi \Delta f t) \qquad (2)$$

Expanding this sine function gives:

$$v_{out} = a(\sin 2\pi f t \cos 2\pi \Delta f t + \cos 2\pi f t \sin 2\pi \Delta f t) \qquad (3)$$

Equation 3 is synthesized by the circuit to be described. The cosine functions in the equation are simply sine functions with a $\pi/2$ (90°) phase advance imposed by a phase shift circuit, since $\cos x = \sin(x+(\pi/2))$. Although equations 1 to 3 refer specifically to sinusoidal signals, they may be applied to complex waveforms by Fourier analysis into sine and cosine components.

Fig. 3 shows the basic circuit elements of the frequency shifter. Sinusoidal and cosinusoidal components are derived from the original signal by a broad-band phase shift circuit. An oscillator with quadrature outputs generates sinusoidal and cosinusoidal components of the "shift frequency" Δf. Two analogue multipliers give the products $\sin 2\pi f t . \cos 2\pi \Delta f t$ and $\cos 2\pi f t . \sin 2\pi \Delta f t$ and an operational adder gives the final frequency shifted signal:

$$\sin 2\pi f t . \cos 2\pi \Delta f t + \cos 2\pi f t . \sin 2\pi \Delta f t = \sin(2\pi f t + 2\pi \Delta f t).$$

Circuit description

The complete circuit diagram is shown in Fig. 4. The frequency shifter is designed to give unity voltage gain, but an extra 4dB voltage gain is available if required. The maximum input voltage before clipping occurs is 4V.r.m.s. (+14dBm, where 0dBm = 0.775V.r.m.s.). The unit is thus suitable for connection between the microphone pre-amplifier and main power amplifier of a sound system. A modification is described later which makes the circuit suitable for use directly in a microphone line.

The input signal feeds first into a voltage follower, IC_1, giving a high impedance input to the unit. The broad-band phase shifter uses IC_2 as an inverting amplifier and RC networks R_7, R_8, C_4, C_5 and R_{11}, R_{12}, C_6, C_7 to give two quadrature outputs of equal amplitude. The operation of this circuit is discussed in the appendix.

The sinusoidal and cosinusoidal components of the shift frequency Δf are generated by a quadrature oscillator incorporating amplifiers IC_3 and IC_4. This operates at 5Hz with the component values shown and gives sinusoidal and cosinusoidal outputs of equal amplitude and with less than 1% distortion. The 6.8V zener diodes across C_{10} act as amplitude limiters, the final adjustment of output amplitude being performed by R_{10}.

Analogue multipliers, IC_5 and IC_6, give the products of the input signal components with the shift frequency components. RC networks C_{11} and R_{14}, C_8 and R_{15}, C_9 and R_{16}, C_{12} and R_{21} are connected directly from the multiplier inputs to earth to suppress any tendency towards h.f. instability. Variable resistors R_{31}, R_{35}, R_{38} and R_{40} are the multiplier input offset controls which are adjusted during the setting up procedure to ensure that when one of the inputs of a multiplier is at zero volts then the output is also zero. Capacitors C_{13} and C_{14} on the multiplier outputs block the d.c. component inherent in the output of this type of multiplier chip and couple the a.c. products to the final stage.

IC_7 is used in the final stage as an operational adder with R_{39} in the feedback loop to adjust overall gain. Variable resistor R_{33} is a balance control to compensate for any amplitude difference in the products from the two multipliers.

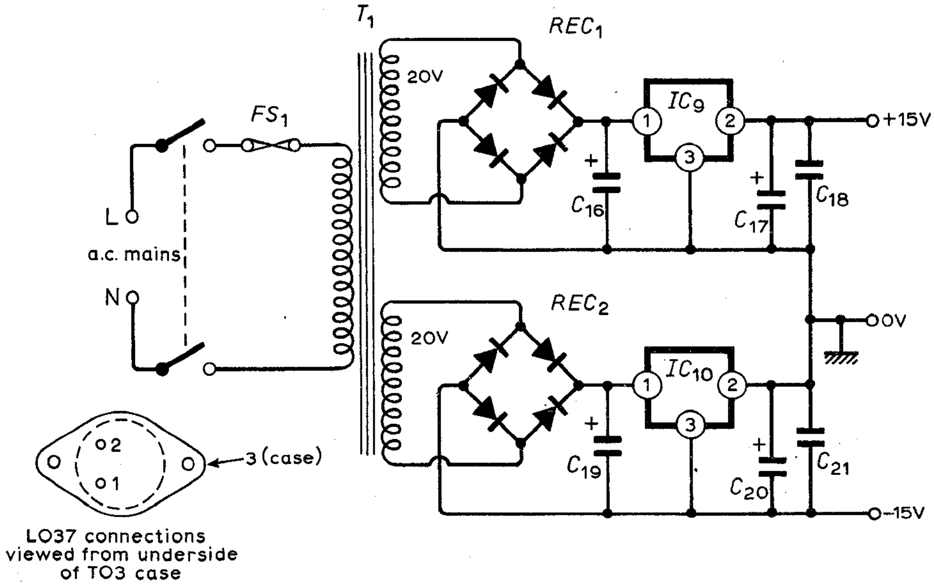


Fig. 5. Power supply circuit.

IC_1, IC_2, IC_3, IC_4 and IC_7 are all type 741 internally compensated operational amplifiers. The Texas Instruments SN72741N 14-pin dual-in-line version was used in the prototype. IC_5 and IC_6, the analogue multipliers, are type MC1495L (Motorola) or SG1495D (Silicon General). All the pin connection numbers on the circuit diagram refer to 14-pin dual-in-line packages.

Resistors are all $\frac{1}{8}$W, ±5% tolerance. Capacitor tolerances are all ±20% with the exception of C_4, C_5, C_6 and C_7 which should be ±5% or better.

Power supplies

All the integrated circuits in Fig. 4 operate from supplies of +15V and −15V; the power supply circuit is shown in Fig. 5. Fixed voltage integrated circuit regulators (SGS LO37 or RS Components MVR 15V) are used to produce stable ±15V supplies from a conventional transformer and bridge rectifier arrangement. In the prototype, T_1 was an RS Components 20V miniature transformer and REC_1 and REC_2 were RS Components REC41A. C_{18} and C_{21} are 0.1μF polyester or ceramic capacitors to ensure a low supply output impedance at high frequencies.

Construction and adjustments

Circuit layout has not been found critical. The circuit was assembled on a piece of 0.1in matrix Veroboard of size 165 × 95mm and housed together with the power supply, which was on a separate matrix board, in a diecast aluminium box of external dimensions 190 × 120 × 50mm.

In the prototype unit, R_{39}, the gain control, was the only front panel potentiometer. Resistors R_{10}, R_{31}, R_{35}, R_{38}, R_{40}, and R_{33} were all skeleton presets mounted on the circuit board and, once these were correctly adjusted, the settings were found to be extremely stable and required no further adjustment. If no external gain control is required, R_{39} could also be pre-set.

When setting up the circuit, an oscilloscope and sine-wave audio generator are of great assistance but, if necessary, the adjustments can be made using an a.c. voltmeter (e.g. AVO model 8) and a sinusoidal signal from radio, TV or record combined with careful listening. Before switching on it is advisable to set all potentiometers to their mid-position; most of them will then be fairly near the correct setting. The best order of adjustment is as follows:

- The 5Hz sine wave amplitude should be adjusted with R_{10} to 9 volts peak to peak, measured on an oscilloscope at pin 10 of IC_4. Approximately the same amplitude, but 90° out of phase, should be present at pin 10 of IC_3. If an oscilloscope is not available for this adjustment, an a.c. voltmeter (1000Ω/V) may be used, the output being set to 3V.r.m.s. This latter method has proved sufficiently accurate despite some oscillation of the meter pointer due to the low frequency.
- With no signal on the input, R_{31} and R_{38}, the multiplier X-input offset controls, are adjusted for minimum 5Hz component in the output. An oscilloscope or electronic millivoltmeter is essential for precise adjustment; however, if the controls are simply left at their mid-position, the 5Hz rejection will be sufficient for most applications. The response of most power amplifiers is much reduced at such low frequencies.
- With a sinusoidal signal of approximately 1kHz frequency on the circuit input, R_{33}, the adder balance, and then R_{35} and R_{40}, the multiplier Y-input offsets, are adjusted for minimum amplitude modulation in the output, viewed on an oscilloscope. This adjustment may, if necessary, be performed fairly accurately on a listening test using a continuous input, such as a radio or TV tuning signal and adjusting for minimum fluctuation in sound output from a power amplifier and speaker connected to the frequency shifter. A random noise signal (e.g. an f.m. tuner between stations) can also be used for a listening test adjustment.

Although R_{33}, R_{35} and R_{40} do not interact, it may be necessary to go through the adjustment procedure two or three times to obtain optimum results. Once the controls are set, no further adjustment should be required.

Measured prototype performance

In the measurements given below, the overall voltage gain of the frequency shifter was set to unity.

Frequency increase
5.3Hz

Max. input signal prior to clipping
4.0V r.m.s.

Noise level ref. 4V r.m.s. output (measured over a band from 30Hz–10kHz)
−73dB

Residual 5Hz component in output ref. 4V r.m.s.
−66dB

Frequency response
1dB down at 85Hz and 19kHz
3dB down at 45Hz

Residual amplitude modulation (applicable at all output levels)
<0.5 dB peak to peak output signal fluctuation from 250Hz to 3kHz
<1dB fluctuation from 220Hz to 13kHz

Total harmonic distortion measured at 1kHz
<0.1% at 3.8V r.m.s. output
<0.01% at 500mV r.m.s. output

Modification for microphone line

The basic frequency shifter design can be used in any medium or high impedance circuit, but, on a low-level microphone line, noise can become obtrusive. Most of the noise originates in the multipliers; hence the signal to noise ratio can be improved at the expense of overload margin by increasing the gain on the input side and attenuating the output by the same factor.

The simple circuit modification shown in Fig. 6(a) increases the gain of the input amplifier from unity to 27dB by reducing the negative feedback. The voltage divider shown in Fig. 6(b) then provides 27dB attenuation on the output to maintain unity gain overall. After the modification the maximum signal input before clipping is reduced to 170mV, but the noise level is reduced by 27dB. This version of the circuit has given good results in a microphone line with negligible noise increase and adequate overload margin. The unit has also been successfully used in a 30Ω balanced line with the addition of 30Ω to high impedance microphone transformers giving a step up at the input and a step down back to balanced line at the output.

Practical applications

It has been found in practice that the use of the frequency shifter in an average sound system makes available an extra 6 to 8dB of usable gain. Although it was indicated previously that the theoretical gain increase may be over 10dB, this figure is not realized in practice because the feedback that does eventually develop in a frequency shifted system has an unnatural "warbling" character which must be avoided. However, this unusual feedback characteristic has a positive advantage in that a sound system becomes easier to set up and operate because the onset of feedback is so readily detected. When the warbling becomes audible, there is normally an extra 3 to 4dB gain still in hand before instability develops, unlike the unpleasant "ringing" colorations heard in a conventional system which often occur only 1 to 2dB below howl–round.

Even when a conventional system is operating well below howl–round, the colorations due to acoustic feedback are often sufficient to degrade the sound reproduction so that high quality equipment is unable to give of its best. In these circumstances, the use of the frequency shifter has been found to give a positive improvement in sound quality, even though extra gain may not be required.

It should be emphasized that the circuit obtains its increase in stability margin by effectively flattening the frequency response of the room. In other words, it provides the greatest improvement when the sound from the loudspeaker arriving back at the microphone is of a reverberant character; i.e. when it has been "processed" by multiple reflections within the room. In most systems, even in relatively dead rooms, this is automatically the case; however, if the microphone is only a short distance from the loudspeaker (2–3 metres), then the available gain increase may be reduced to 2 or 3dB.

The frequency shifter has been used successfully not only with speech but also with music amplification. It is perhaps surprising that the 5Hz shift is not obvious, but the only effect noticed has been a slight 5Hz beat between direct and amplified sound on an occasional long continuous note. The general reduction of coloration in the amplification system with the frequency shift in operation outweighed any possible degradation of quality due to beating effects.

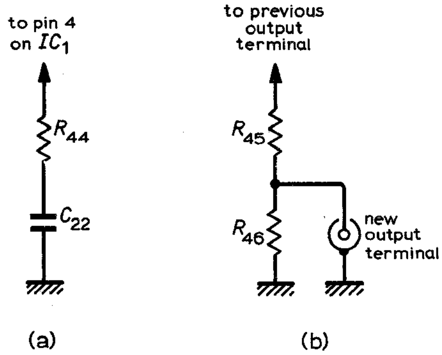


Fig. 6. Circuit modifications for low-level operation: (a) addition to feedback loop of IC_1; (b) output attenuator.

Electronic music

Although the circuit as described produces a fixed increase in frequency of 5Hz, the frequency of the modulating quadrature oscillator can be increased by reducing time constants R_3C_2, R_6C_3 and R_9C_{10} to produce shifts of several hundred hertz or more. As can be imagined, this shifting of a whole band of frequencies introduces weird effects which can be applied to electronic music; all normal harmonic relationships are destroyed because every frequency is shifted by a fixed number of hertz rather than being subject to a given fractional change.

Bode and Moog[6] have recently described a frequency shifter using the same principle as described here, but specifically designed for electronic music; the modulating frequency is generated by a voltage-controlled beat-frequency oscillator giving a continuous range of frequency shift from −5kHz to +5kHz. By using a subtraction circuit as well as the adder at the output, an upward shift and downward shift may be obtained simultaneously from separate outputs for unusual stereophonic effects. There is obvious scope for the modification of the present circuit along these lines for experiments in electronic music synthesis.

Conclusion

The use of a 5Hz frequency shift in a sound reinforcement system can dramatically reduce acoustic feedback, improving stability margin by 6 to 8dB. Although the technique has been known for over ten years, it has not yet achieved the widespread use it deserves. The circuit described gives high quality results and is inexpensive to build; a simple modification can provide large shifts of frequency applicable to special effects in electronic music synthesis. The total cost of the prototype was under £20.

Appendix

Design procedure of the broad-band phase shifter. The frequency shifter is a specialized example of the type of single-sideband modulator which depends for its operation on a broad-band phase shifter producing two components of the audio signal with a 90° phase difference. Such phase shifters are also appearing on the domestic scene in quadraphonic decoders; the design criteria of such circuits are therefore of some interest.

The principles of broad-band phase shifter design have been discussed by Dome[7] and Luck[8] and analyzed in detail by Orchard[9]. Stein[10] has published calculations on an *RC* lattice phase shifting network similar to the type used here.

To obtain two outputs with a constant phase difference over a wide frequency range, the principle used is to derive the outputs from two separate networks each of which produces a frequency-dependent phase shift but where the phase difference between the outputs is constant over the required range. Fig. 7 shows such a circuit in block form and Fig. 8 the type of phase/frequency relationship that will give the required result. It is desirable that the output amplitude from each network should be independent of frequency, i.e. that the network be of the all pass type.

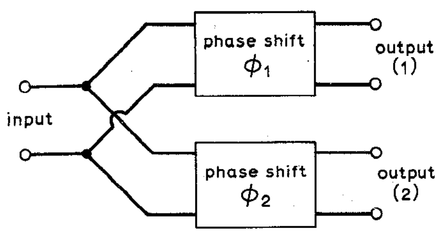


Fig. 7. Block diagram of a broad-band phase shifter.

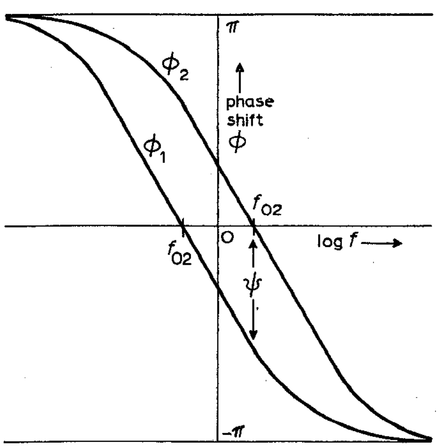


Fig. 8. Graph of phase shifts of individual branches of broad-band phase shifter plotted against frequency.

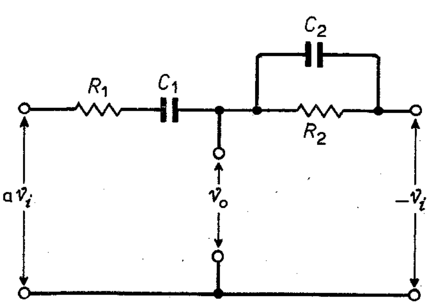


Fig. 9. One branch of the phase-shift network used in the frequency shifter.

Dome[7] has shown that a constant phase difference may be realized if the phase shift angle of each network varies according to the logarithm of frequency.

i.e. if $\phi_1 = C_1 + \log K_1 f$

and $\phi_2 = C_2 + \log K_2 f$

where C_1, C_2, K_1, K_2 are constants and ϕ_1 and ϕ_2 the phase shifts of the two networks, then phase difference $\psi = \phi_2 - \phi_1$

$$= C_2 - C_1 + \log \frac{K_2}{K_1}$$

$$= \text{constant.}$$

Luck[8] has indicated that the desired characteristic may be obtained with a pair of resonant circuits. In the phase angle graphs of Fig. 8, f_{o1} and f_{o2} are the resonant frequencies of the two networks. The required Q-value is very low (<0.5); *RC* networks can therefore be used. Each network used here is of the Wien type shown in Fig. 9. The following calculation shows that this type of network can fulfil the requirements for a broad-band phase shifter.

In Fig. 9, consideration of circuit impedances gives:

$$\frac{(a+1)v_i}{v_o+v_i} = \frac{C_2}{C_1} + \frac{R_1}{R_2} + 1 + j\left(R_1\omega C_2 - \frac{1}{R_2\omega C_1}\right) \quad (1)$$

$$= \alpha + j\beta$$

giving $$\frac{v_o}{v_i} = \frac{a+1-(\alpha+j\beta)}{\alpha+j\beta}$$

Now if constant a is chosen so that:

$$a = 2\alpha - 1$$

then $$\frac{v_o}{v_i} = \frac{\alpha - j\beta}{\alpha + j\beta} \quad (2)$$

$$\therefore \sum \frac{v_o}{v_1} = \sqrt{\frac{\alpha^2+\beta^2}{\alpha^2+\beta^2}} = 1$$

Thus the network is of the all-pass type. Now, when $\omega = \dfrac{1}{R_1C_1} = \dfrac{1}{R_2C_2}$,

$\beta = 0$ and the circuit exhibits resonance.

$$\text{Resonant frequency, } f_o = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi R_2 C_2} \quad (3)$$

It can now be shown that the relationship between phase angle and frequency is of the type required for a broad-band phase shifter.

Substitution for α and β in (2) together with f_o from (3) gives:

$$\frac{v_o}{v_i} = \frac{1 + jQ\left(\dfrac{f_o}{f} - \dfrac{f}{f_o}\right)}{1 - jQ\left(\dfrac{f_o}{f} - \dfrac{f}{f_o}\right)} \quad (4)$$

where $$Q = \frac{1}{\dfrac{R_2}{R_1} + 1}$$

and has its usual significance as the quality factor of the resonant circuit. ($Q = f_o/\delta f$, where δf is the half-power bandwidth.)

From (4) the phase angle, ϕ, between v_o and v_i is obtained:

$$\tan \frac{\phi}{2} = Q\left(\frac{f_o}{f} - \frac{f}{f_o}\right) \quad (5)$$

For small values of ϕ, it may be shown[10] that:

$$\phi \approx -4Q \ln \frac{f}{f_o}$$

which is the type of logarithmic relationship required for a broad-band phase shifter. Two of these networks, of resonant frequencies f_{o1} and f_{o2} may therefore be used to produce a constant phase difference,

$$\psi = \phi_2 - \phi_1.$$

Luck[8] has calculated ψ by applying equation (5) to both networks and has deduced a set of design parameters relating Q, and f_{o1} and f_{o2} with the frequency range over which ψ is to be close to 90°. The greater the permissible deviation from 90°, the wider the frequency range which can be handled.

In the frequency shifter a range from 250Hz to 12kHz is satisfactory and Luck's results indicate that a 90° shift over this range should be possible with maximum deviations of ±5°. The necessary circuit parameters are:

$$f_{o1} = 720\text{Hz}$$

$$f_{o2} = 4{,}000\text{Hz}$$

$$Q = 0.21$$

thus,

$$\frac{R_2}{R_1} = \frac{C_1}{C_2} = 2.7$$

and $a = 2.5$

The circuit impedances chosen are sufficiently high to avoid excessive loading on the outputs of the drive amplifiers and yet low enough for the 20MΩ input impedance of the multipliers to have a negligible effect on performance. Theoretically the phase shifters should see an infinite load impedance.

Fig. 10 shows the measured phase shift performance of the practical circuit. A phase difference of 90°±7° is obtained from 200Hz to 15kHz.

Deviations from 90° in the phase-shift circuit produce amplitude modulation in the output of the frequency shifter; this occurs at twice the shift frequency owing to the generation of an unwanted sideband. The effect only becomes significant below 200Hz and above 15kHz and is not sub-

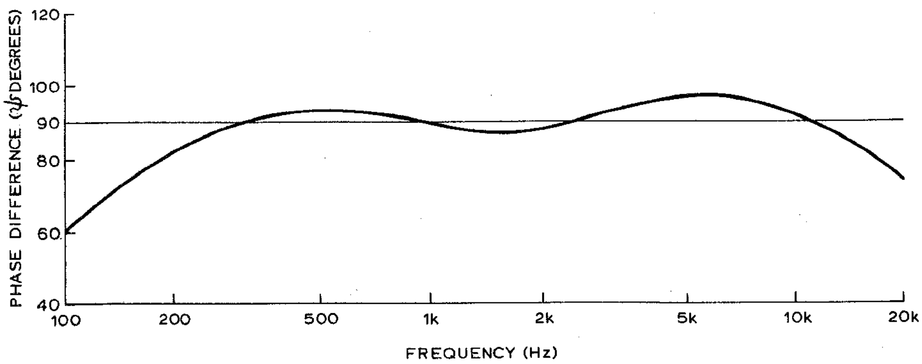


Fig. 10. Graph of measured phase difference plotted against frequency for broad-band phase shift network used in frequency shifter.

jectively troublesome in practice. A closer approximation to a 90° phase difference over a wider frequency range may be obtained if necessary by replacing each Wien network by several such networks in cascade with staggered resonant frequencies.

Components list

Resistors

R_1	33kΩ
R_2	22kΩ
R_3, R_4, R_6, R_{46}	270kΩ
R_5, R_{12}	82kΩ
R_7	43kΩ
R_8	15kΩ
R_9, R_{13}	330kΩ
R_{10}, R_{33}	100kΩ preset pot.
R_{11}, R_{17}	220kΩ
R_{14}, R_{15}, R_{16}, R_{21}	470Ω
R_{18}	39kΩ
R_{19}, R_{20}, R_{22}, R_{23}	8.2kΩ
R_{24}	6.8kΩ
R_{25-30}	3.3kΩ
R_{31}, R_{35}, R_{38}, R_{40}	10kΩ preset pot.
R_{32}, R_{34}	100kΩ
R_{36}	560kΩ
R_{37}	1MΩ
R_{39}	500k preset or panel mounting pot.
R_{41}, R_{44}	10kΩ
R_{42}, R_{43}	3.9k

All resistors $\frac{1}{8}$W ±5% tolerance

Capacitors

C_1, C_2, C_3, C_{10}, C_{13}, C_{14}	100nF
C_4, C_6	1nF
C_5, C_7	2.7nF
C_8, C_9, C_{11}, C_{12}	10pF
C_{15}	470nF
C_{16}, C_{19}	1000μF 40V electrolytic
C_{17}, C_{20}	10μF 16V electrolytic
C_{18}, C_{21}	100nF

Tolerance ±5% or better

Integrated circuits, Semiconductors

IC_{1-4}	Texas SN72741N
IC_5, IC_6	Motorola MC149SL or Silicon General SG1495D
IC_9, IC_{10}	SGS LO37
D_1, D_2	6.8V zener 500mW
REC1, REC2	REC41A RS Components
Transformer	T1 20V Min. transformer RS Components

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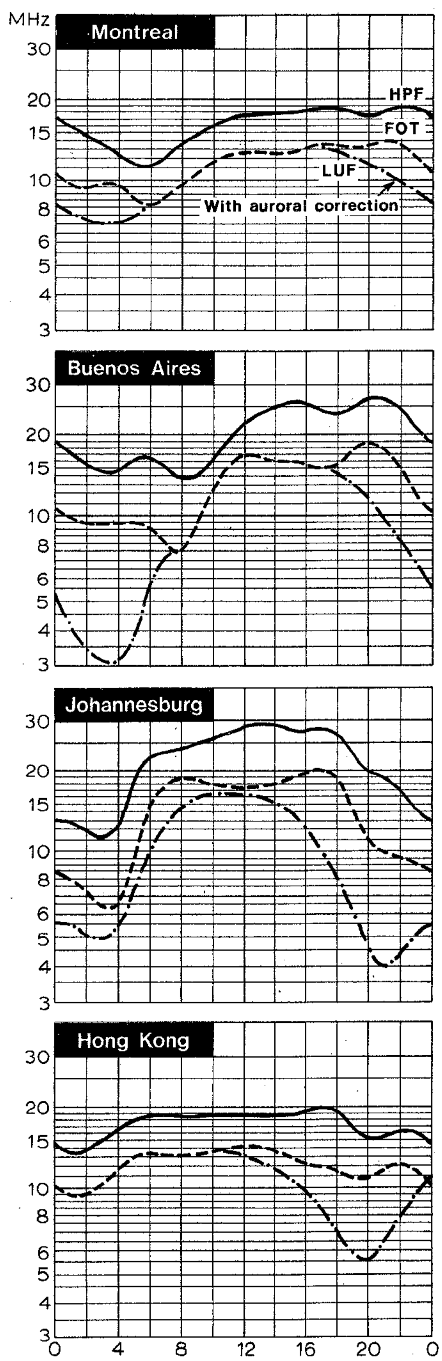
H.F. Predictions for July

The extended periods of magnetic activity which have been observed each month so far this year should now begin to abate. During these periods maximum usable frequencies are reduced and on routes crossing latitudes greater than about forty degrees lowest usable frequencies are increased.

The charts are based on an ionospheric index of 31; this is one third of the value for July of the last year — the effect being to lower HPF and FOT curves one or two megahertz.



News of the Month

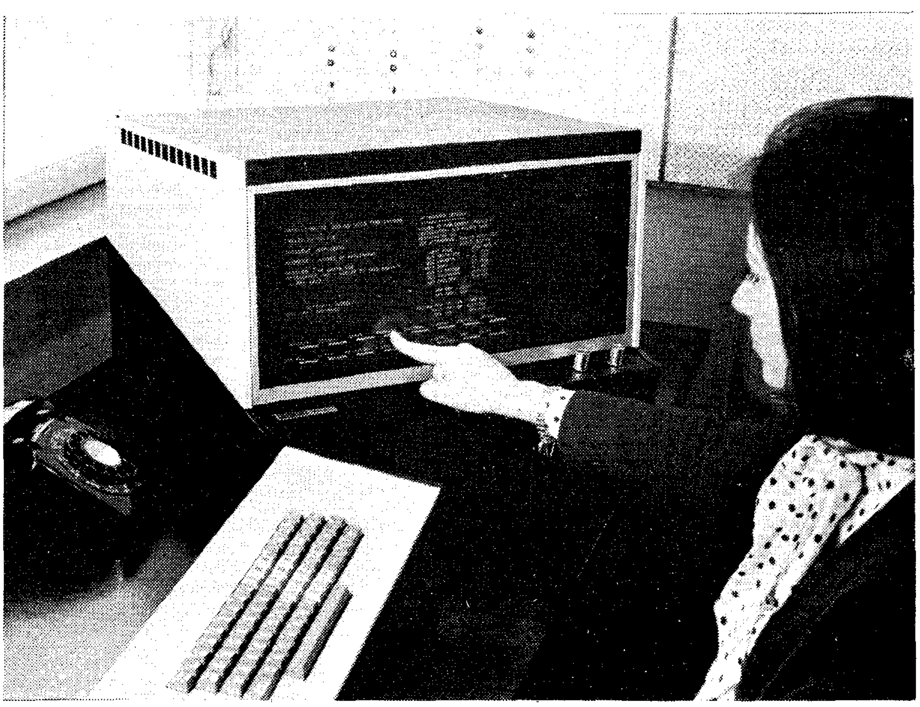
Touch terminal communication

A new concept in computer terminal communications — the touch terminal — has been developed by Ferranti and Plessey Radar. The touch terminal comprises a composite display and touch wire system through which unskilled operators may gain access to a computer memory on a question and answer basis.

Touch communication is made possible by the use of touch points incorporated into a mask on the front of a c.r.t. display. When an operator is required to make a decision the computer presents a set of choices on the display, each one being associated with an appropriate touch point. The choices can be displayed as letters, symbols, words or sentences. To make a selection, the operator merely touches the appropriate touch point and a coded signal informs the computer of the choice. The computer then acts on that choice and presents the operator with the next set of choices and so on until the required data is presented (see photo).

Up to thirty two touch points can be fitted to the mask in any layout which suits the customer's requirements. Connections to the touch points are made by a flexible printed circuit which forms part of the mask. Most Ferranti displays can be supplied as touch terminals and only a minimal amount of re-programming is needed for the computer to use this system. In many cases touch terminals can be used without keyboards as the computer re-annotates the touch points for each set of selections, thus providing the effect of an almost limitless keyboard on the screen of the display.

Communication using the touch terminal is valuable in areas where untrained operators with no typing experience have to communicate quickly and without error with a computer. Typical user areas are information retrieval, process control, air traffic control, reservation systems, simulation, education and many other military and commercial applications.



Sonar intruder detector

Security systems based on conventional sonar devices for detecting movement of intruders in premises, have often suffered from spurious alarms caused by inanimate objects flapping or swinging within their range such as curtains, doors, windows, shutters or signs. To combat this particular problem, AFA-Minerva (EMI) has introduced a sonar detector, the Fidela 3, which is able to reduce this rate of unwanted warnings by discriminating between different types of motion within its range. Its "memory" is able to ignore these typical wavering movements, which previously have triggered off security systems unnecessarily, but is able to identify the approach of an intruder and to sound the alert. Measuring 11in long, 7in wide and 2¼in deep, the device can be fixed to most types of vertical surface. Different patterns of protective field can be provided to meet specific situations.

The Fidela 3 emits ultrasonic waves, and interrogates these signals on their return after deflection from a solid object along their path. Change in frequency of these sound waves caused by any movement within its field of operation is monitored by the equipment's signal processing circuits. These are able to recognize and ignore signals from wavering motions but are designed to trigger the alarm in the event of an intruder entering the protected area.

The detector's basic range pattern is an egg-shaped zone of protection, nominally measuring 25ft long and 17ft at its widest point. This pattern can be easily adjusted to deflect to the right, left or downwards, and be broadened to about 40ft wide with a corresponding reduction in range length to around 12ft.

Local radio frequency changes

Changes of frequency in the v.h.f. services of some of the B.B.C. local radio stations are being made. These changes are necessary in order to conform to a new frequency plan, which will incorporate both B.B.C. and I.B.A. local radio stations.

The changes to B.B.C. stations are in some cases quite small; the new frequencies in MHz are listed below together with the previous frequencies in brackets, and the dates of the changes.

Humberside	96.9 (95.3)	23 May
Bristol	95.5 (95.4)	14 June
Leicester	95.1 (95.2)	14 June
Nottingham	95.4 (94.8)	21 June
Medway	96.7 (97.0)	21 June
London	94.9 (95.3)	28 June
Oxford	95.2 (95.0)	28 June
Brighton	95.3 (95.8)	28 June
Stoke-on-Trent	96.1 (94.6)	6 July

PAL tolerances

The B.B.C. and I.B.A. are making it clear that although they strive to ensure that their transmitted colour television signals remain within tolerance at all times, they cannot take into account receivers which have not been designed to take advantage of the PAL system. The United Kingdom adopted the PAL system of colour television as its national standard in 1966 after the most exhaustive testing and international discussion. It was seen to offer important advantages over the American N.T.S.C. system although it differs very little in most respects: it was also preferred to the SECAM system.

The advantages of the PAL system

depend upon the use of circuit techniques in the colour receiver which confer upon the picture an almost complete immunity to various forms of colour distortion. These can arise from unwanted changes in the transmitted signals during their passage from the television studio to the home. British receiver manufacturers have consistently designed and manufactured receivers to take advantage of the immunity of the PAL system to colour errors arising from this cause and the signals transmitted throughout the United Kingdom by both the B.B.C. and the I.B.A. have tolerances based upon the assumption that the receiver specification is in accordance with the established principles of the PAL system.

It is, however, possible to design and manufacture a colour television receiver which does not take advantage of the special qualities of the PAL system. Very often the performance of receivers designed and manufactured in this way is perfectly adequate, but circumstances may arise where they do not give a fully satisfactory colour reproduction although the broadcast signals are still within the accepted tolerances.

Award for TV standards converter

Among the recently presented Royal Television Society Awards for 1973 was the Geoffrey Parr Award made to John Baldwin and an I.B.A. design team in recognition of a notable contribution to television engineering. The award is for a digital field rate TV standards converter, which changes colour television signals from one system to another. The new converter is a small device occupying no more than two six-foot equipment racks as compared with the seven racks of earlier electronic converters. The new unit uses digital techniques and the standards conversion process is claimed to be virtually distortion-free.

More noise reduction

The Burwen audio noise reduction system was recently introduced to the U.K. at a preview given by the distributors, Feldon Audio. Two products were demonstrated: the "Noise Filter", which works to reduce noise and hum in any recorded signal, producing up to 10dB of noise reduction, and the "Noise Eliminator" which is a complementary device like the Dolby but which claims to give up to 50dB of noise reduction.

First quarter TV and radio deliveries

A new monthly peak of deliveries of colour television receivers to the U.K. market was reached in March, 233,000 sets being delivered to the U.K. trade — giving a total for the first quarter of 629,000 compared with 363,000 for 1972, a rise of 73% according to the latest figures compiled by the British Radio Equipment Manufacturers' Association. Monochrome television deliveries reached 115,000, bringing the total for the first quarter to 397,000, a fall of 17% on 1972 (476,000). Deliveries of radios and radiograms reached 438,000 and 27,000 respectively, giving quarterly totals of 1,373,000 and 90,000, representing respective rises of 5% and 41% over 1972 (1,302,000 and 64,000).

These are estimates of U.K. made and imported deliveries to the home market, including those to specialist rental and relay companies.

The U.K. Skylab project shown here at the launching pad is based on the conventional two-door range-roving saloon. Four wheels and all-round vision make this another British astro-first. Orbit is achieved by towing the space-lab to its position in space. The lab is attached by a piece of string to its launching rocket (right of centre) and to minimize cost, the launch pad consists of the man in the middle, who holds the rocket and points it at the sky. Ear muffs are provided to deaden the roar on launch. Seriously though — Independent Television News is now operating the smallest outside broadcast unit of its kind in the country. It is a two-camera and v.t.r. unit, with full colour capability.

Component service from U.S.A.

A new service designed to obtain U.S. electronic parts for overseas manufacturers more quickly and with less difficulty and expense is offered by Managerial Research, a U.S. consulting firm. Many companies purchase parts in the U.S. but the distances over which communication is required make it costly and difficult to follow up on orders, make substitutions, and arrange for shipments. Managerial Research, working from parts lists supplied by its overseas clients, takes whatever steps are necessary to obtain the needed parts. They are then sent to the client in one shipment, if possible, so as to minimize shipping and handling expenses. More information can be obtained from Managerial Research, Box 240, Wheaton, Illinois 60187, U.S.A.

Briefly

Congratulations to the Association of Public Address Engineers, now 25 years old.

Calculator chip prices. General Instrument Microelectronics have reduced the small quantity price of their calculator single chip C500, to £13.7 — a reduction of £18.

Sixty Years Ago

In an article in our July, 1913 issue on crystal detectors, Dr. A. E. H. Tutton referred to the work of Professor Otto Lehmann on liquid crystals, which are only now being exploited as display elements in digital read-outs. ". . . the act of crystallisation is not merely a question of the closest packing of molecules in a purely mechanical and happy-go-lucky manner, but the result of the operation of definite attractive and repulsive forces. When these are sufficient to cause the molecules to take up positions such that their centres of gravity or those of small groups of molecules occupy the points of a space-lattice, and then to set themselves further so that these grosser units (molecular or polymolecular) become strictly parallel to each other with respect to the configuration of the molecule (as regards the internal arrangements of its atoms), a solid crystal is produced. But in the cases of the extraordinary compounds brought to our notice by Lehmann, most of which are of complicated constitution (long chains of atoms) and of somewhat viscous, oily, or soapy character, the second state is not accomplished, and the grosser units, probably the molecules themselves in these cases, are wobbly about their centres of gravity; the substance, therefore, either forms fluid crystals with rounded edges and mobile form, readily bent or broken, but as readily recovering themselves, or they are drop-like or even unbrokenly liquid in character, and yet exhibit the optical property of double refraction, and afford brilliant colours in polarised light, just like a solid crystal".

Digital Speed Control Servo

by C. W. Ross, * M.I.E.R.E.

A d.c. motor control system is described which uses a retriggerable monostable pulse as a reference source. The period of a tachometer is compared with the monostable pulse in a simple high-gain pulse-width discriminator driving the motor control elements. The servo system is shown applied to a high performance 2in magnetic tape transport where better than 0.1% speed accuracy is required.

Before going on to the circuit description, it is necessary to mention the tachometer used in the design, as this has some bearing on the techniques used in the electronic section of the unit.

Recent advances in flexible-magnet technology contribute to reducing the cost of the electromagnetic a.c. tachometer illustrated in Fig. 1. The rotor is a disc of 0.06 inches thick flexible magnetic sheet, magnetized with 64 poles. The stator is a single-sided printed circuit board bearing the winding pattern. Fig.2 shows the magnetic pattern of the rotor seen by means of a magnetic particle viewer. The rotor was magnetized on a jig referenced to the centre hole, the magnetic pattern being produced by a multiple-pole electromagnet driven by an s.c.r. and capacitor discharge circuit. The rotor disc is cemented to a rigid metal backplate so that the assembly can rotate with the motor shaft. The stator is positioned approximately 0.02 inches from the rotor and is rigidly fixed to the motor housing.

* 3M Company, Camarillo, California.

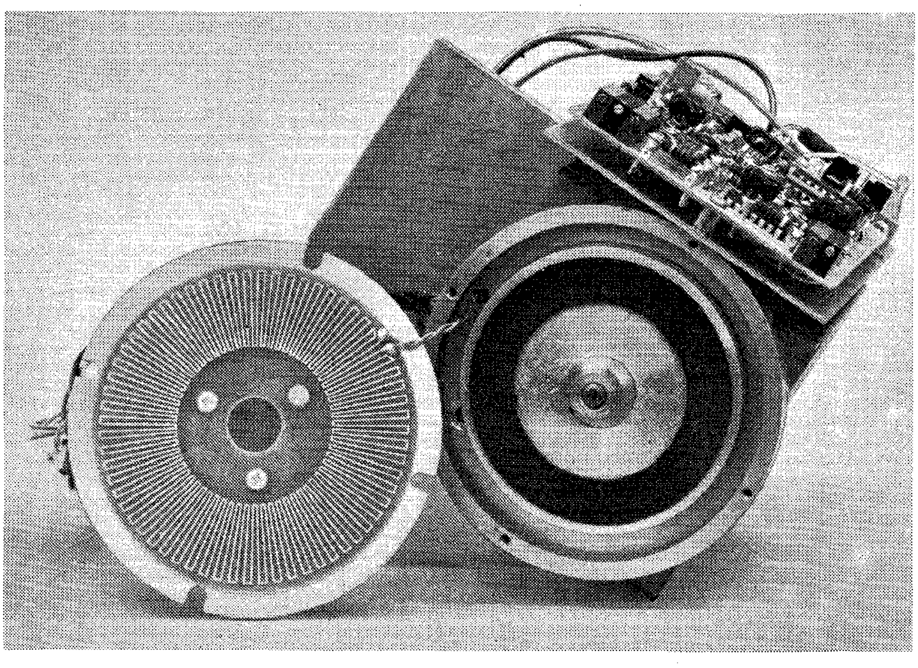
The output voltage is sinusoidal and the frequency is proportional to velocity. The prototype gave 40mV r.m.s. per 1000 r.p.m., with a source impedance of less than 1 ohm at 1kHz. Amplitude is proportional to frequency, following a 6dB/octave slope, and is affected by spacing between magnet and pickup.

Fig.3 shows the complete assembly attached to the motor. Adjustment is provided to minimize alignment error of the stator by checking the flutter of the complete system with the tachometer frequency conveniently adjusted to 3kHz, the centre carrier frequency for most flutter-measuring instruments. Typically, the flutter is below 0.01% r.m.s. using a 0.5 Hz - 200 Hz bandwidth.

Servo

The trend in speed control systems seems to be toward digital techniques, rather than the well-established linear methods of operation.

Consider the basic block diagram in Fig. 4. The alternating signal from the tachometer is amplified and amplitude limited by a differential operational amplifier A_1. The output drives a precision monostable multivibrator that generates a pulse at each positive-going transition of the signal from amplifier A_1. The complementary output of the monostable circuit is used to drive a pulse-width discriminator circuit, in which the charge and discharge rate of the capacitor is controlled by resistors R_1 and R_2, respectively. As the tachometer frequency increases, the period of one cycle of tachometer signal will approach that of the monostable circuit. The monostable produces a progressively narrower pulse, because its complementary output is the *difference* between the uniform "normal" pulse and the period of the tachometer. If the tachometer continues to increase frequency, its period will equal that of the monostable and the complementary pulse will suddenly disappear. The pulse width discriminator circuit senses this rapid change and the charge potential on the capacitor C falls. The potential change across this capacitor is amplified by a high gain d.c. servo amplifier which controls



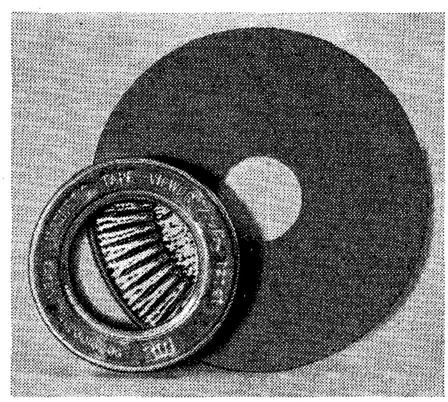


Fig. 2. The magnetic pattern on the rotor, made visible by a particle viewer.

Fig. 1. Tachogenerator, showing the printed-circuit stator winding and the flexible magnetic rotor.

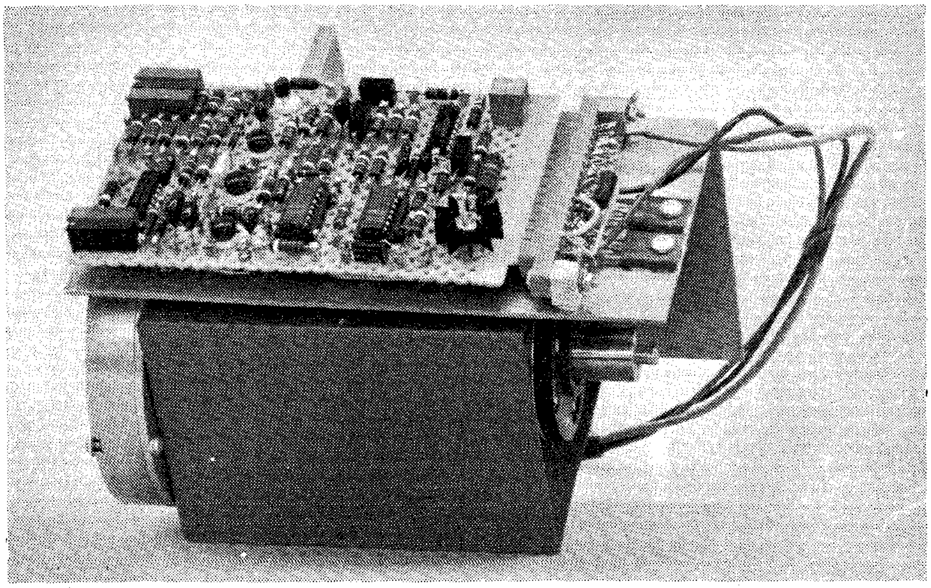


Fig. 3. Complete assembly of motor, tacho and electronic unit.

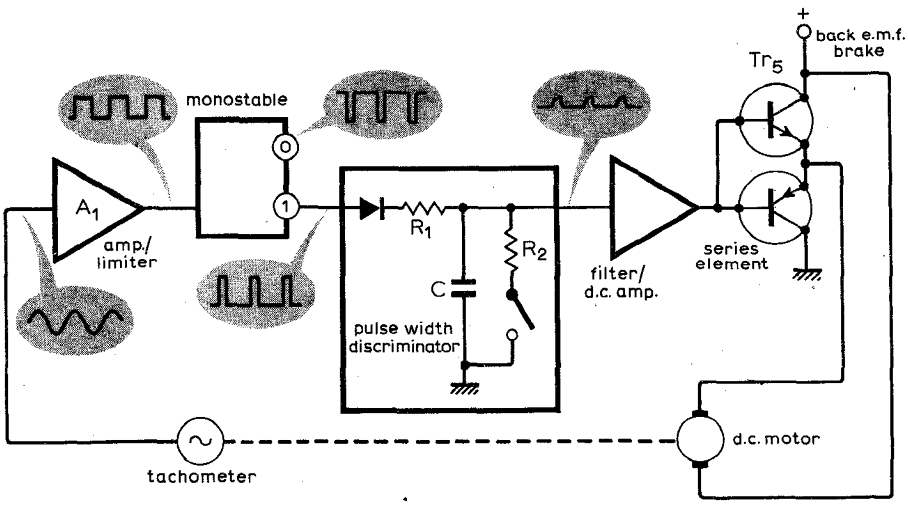


Fig. 4. System block diagram.

the motor. The output of the d.c. power amplifier has complementary transistors connected to enable one transistor to act as a brake; the other is used as the accelerator.

Reviewing this simple system, it can be seen that considerable drift-free gain is available by using the pulse width discriminator driven by the monostable complementary output. Stability and damping are dependent on the *RC* networks, and the phase lag and/or lead characteristics within the loop.

Electronic design

Tachometer amplifier. A μA739 dual operational amplifier was used for the tachometer amplifier and d.c. driver amplifier. This is available in a dual in-line package, providing high open-loop gain and differential inputs. An *RC* network was used to limit the current and voltage output, and to interface it with a 5V logic circuit. The complete servo circuit diagram is shown in Fig.5.

A step-up transformer was used, utilizing the very low impedance of the tachometer to make a larger signal available at the input of the amplifier. The differential inputs are driven push-pull, affording full gain of the i.c. and high common-mode rejection. From very low speeds upwards, the output from the amplifier is a square wave. Only the positive-going edges are used for control purposes, as the particular application for the servo did not warrant use of each zero crossing, which would have added complexity and mark-space adjustment requirements to the design. The design speed range was 600-4800 r.p.m., and half-wave detection (positive-going zero crossings) is adequate.

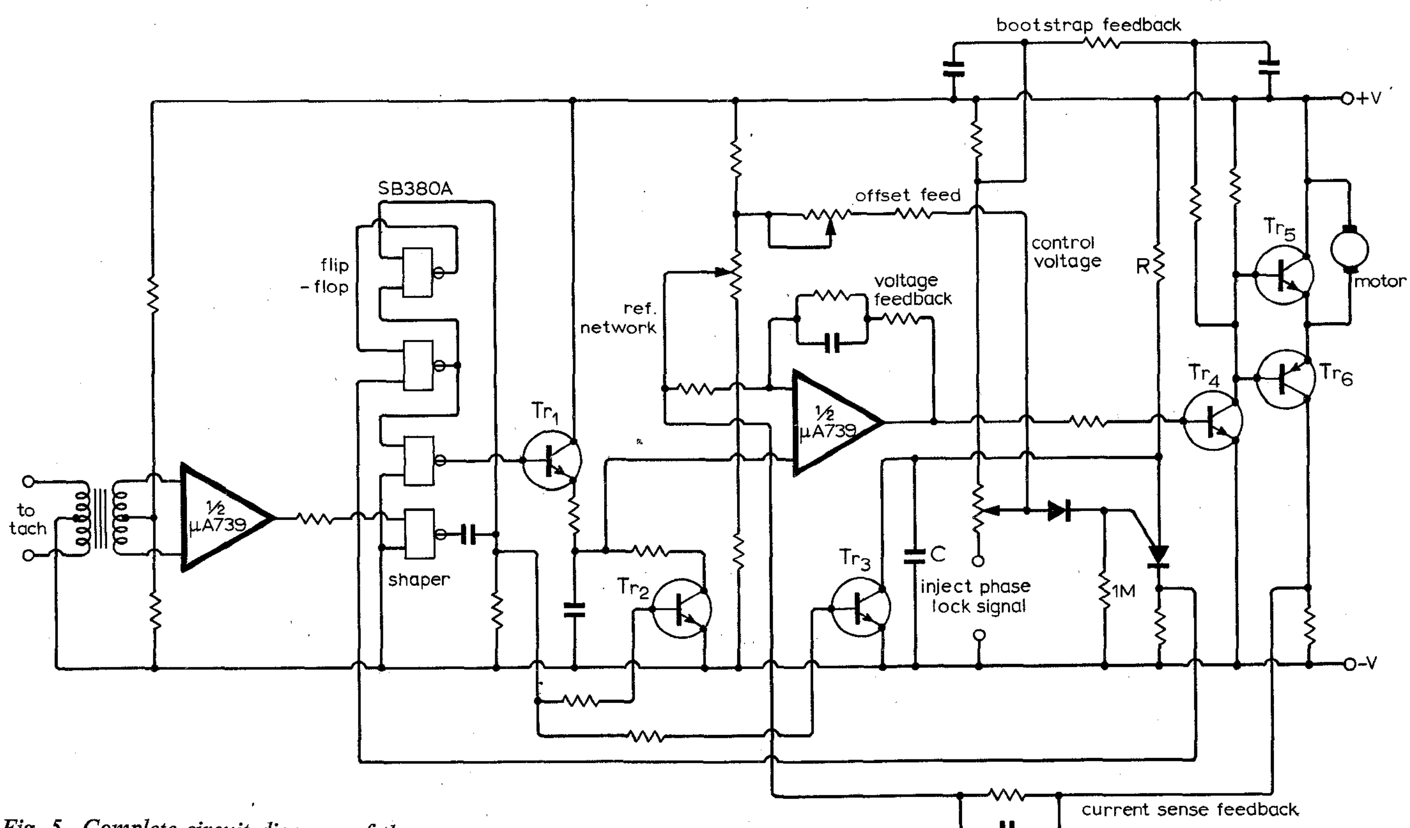


Fig. 5. Complete circuit diagram of the servo.

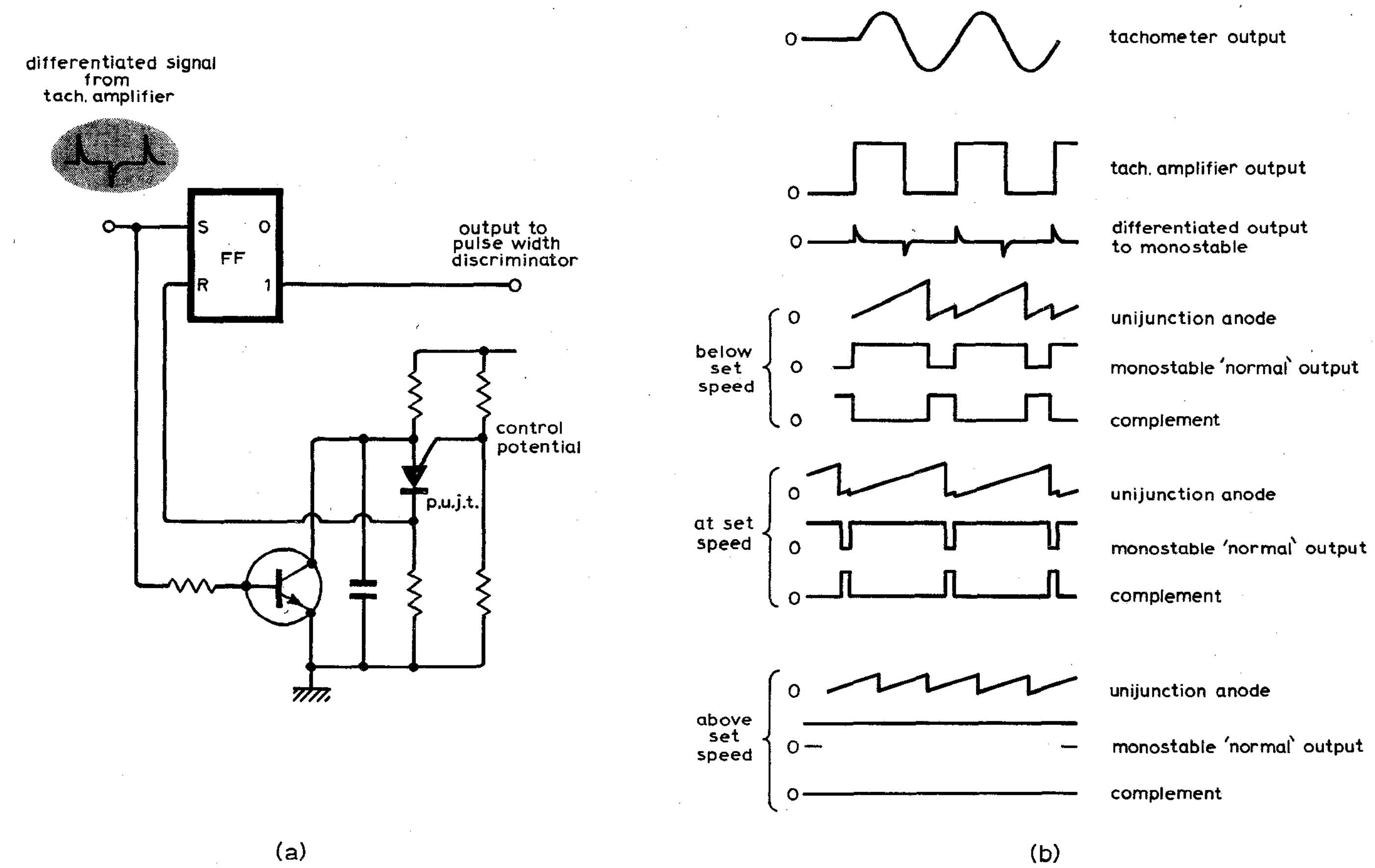


Fig. 6. (a) monostable and control circuit (b) waveforms in the control circuit.

Retriggerable monostable. In the original prototype circuit a 9608 monostable integrated circuit worked well, giving the necessary retriggerable characteristic to enable the 97% or more duty cycle to be achieved. However, temperature stability was found to be a problem when extreme accuracy is required. To overcome temperature stability problems, a lower cost, highly stable circuit was developed. This consists of a quad 2-input gate, interconnected as an R-S flip-flop, and a shaper circuit. The accurate timing pulse is derived from a programmable unijunction transistor, with a switching transistor added to reset the circuit in addition to its self resetting ability when the unijunction fires.

To explain the pulse generation sequence, reference must be made to Fig. 6(a) and (b). Directly upon the application of power, the R-S flip-flop can assume one of its two states. The unijunction timing capacitor charges, and the device avalanches to its negative resistance state, producing a sharp voltage pulse at the cathode resistor. This pulse resets the flip-flop if the set state came up. During this initial period where the tachometer signal is absent, the unijunction operates as a conventional relaxation oscillator. The reset state of the flip-flop is detected as a steady state signal by the pulse width discriminator and the motor accelerates under full power.

The flip-flop is also driven by the positive transitions of the tachometer signal, "setting" the flip-flop at each transition. At speeds below the controlled state, the flip-flop is continuously reset by the unijunction circuit after a precise delay period (determined by the *RC* network of the u.j.t. circuit). Notice that the timing capacitor is deliberately discharged by a transistor switch at each positive transition of the tachometer signal; this transistor is driven from the shaper section of the SP380A i.c. The waveforms appearing at various points of the system are shown in Fig.6(b) for three conditions.

The need for the transistor switch to discharge the timing capacitor, in addition to the natural function of the unijunction, will become obvious if the overspeed condition is examined. The capacitor potential is never allowed to reach the peak voltage point of the unijunction at overspeed, and the control voltage to the d.c. power amplifier is zero. This only occurs when an instantaneous command signal is given to slew to a lower speed, or to stop. At control speed, the pulse width from the monostable section of the servo is in the region of a few microseconds to about 15μs, depending on the stability criteria dictated by the friction, inertia, and compliance of the mechanical loads imposed on the system. The narrow pulses are sufficient to maintain partial charge on the pulse width discriminator capacitor, and the motor power is controlled at the level required to hold the speed selected.

Pulse width discriminator. The pulse width discriminator design is shown in Fig.7. This circuit uses Tr_1 to partially discharge capacitor *C* after the pulse has charged *C* to peak value. The discharge transistor is driven via the differentiating network, using the same pulses that drive the

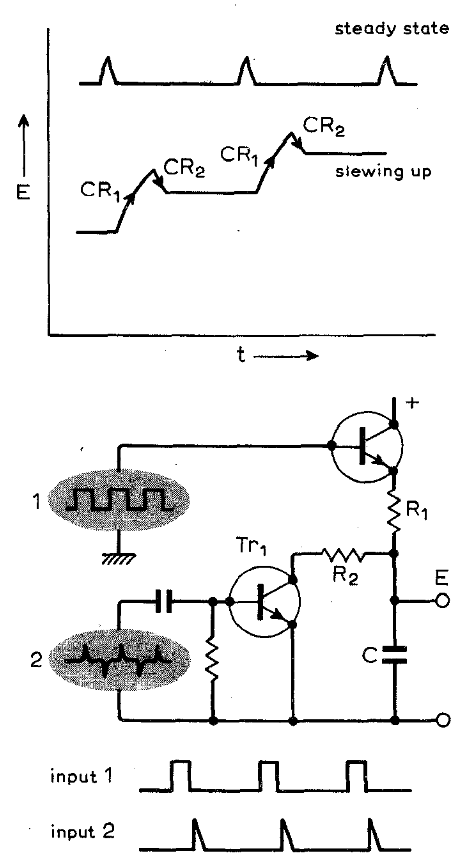


Fig. 7. Pulse-width discriminator, with waveforms.

monostable, hence the time displacement.

The object in this development was to produce a circuit that provided efficient conversion and low, easily filtered ripple content. Ripple can appear as a large portion of the motor current causing a.c. fields around the motor and audible noise at the tachometer frequency, both undesirable when the drive system is used in a magnetic tape transport.

The bandwidth of the servo is dependent on many things: the magnitude of the charge and discharge increments, the pulse width, the value of the capacitor C in Fig.4, and the reference voltage presented to one input of the d.c. amplifier. It was found that this reference voltage required adjustment for each speed, because the average value of capacitor C potential changed with variation of pulse repetition frequency when the optimum pulse width was found. The width of the pulse determines the closed-loop gain of the system, and further d.c. feedback was injected into the reference networks (Fig.5) so that optimum pulse width was obtained over the whole speed range using feedback derived from the main control voltage network. Good tracking was maintained over the required speed range. Measurements made on the pulse width discriminator used in the system illustrated in Fig.5 showed that a 1μs increment in pulse width produced 0.6 amp d.c. change in the motor circuit, which is ample gain to maintain efficient control.

Power amplifier. The d.c. power amplifier section shown in Fig.5 uses the other half of the μA739 operational amplifier, driving an output stage. One input of the μA739 is supplied from a d.c. potential divider; the other input is taken from the pulse width discriminator output filter. The resulting differential is amplified so that a large direct current level is available to energize the motor. Current feedback is obtained by a low value resistor effectively in series with the motor; the resulting voltage is fed back to one input of the preceding μA739 amplifier, reducing the overall gain to a convenient value. Another two feedback paths are used, one being conventional negative feedback and the other a reference tracking voltage derived from the p.u.t. gate control potential. This offset voltage ensures optimum control pulse width over the complete speed range.

Two output transistors are used, in complementary symmetry configuration. The p-n-p transistor controls the motor drive current, while the n-p-n does the braking when slewing to a lower speed or to a stop, using the back e.m.f. of the motor.

Performance

Accuracy. The speed accuracy was, as expected, proportional to the tachometer frequency and directly related to the tachometer pulse width feeding the peak detection network. To maintain the closed loop gain at a high value, a low impedance supply was necessary to supply the conventional permanent magnet motor

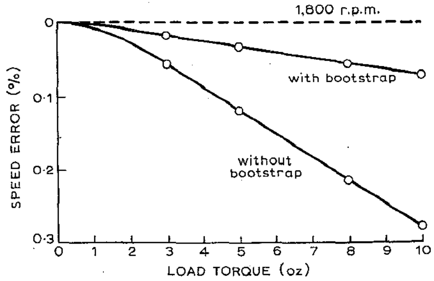


Fig. 8. Speed regulation curve of the system, with and without the bootstrap feedback circuit.

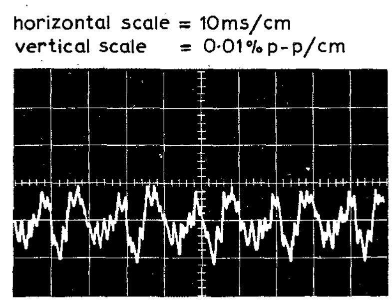


Fig. 9. Residual flutter of the system, showing a fundamental at 50Hz.

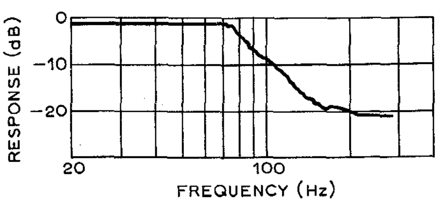


Fig. 10. Bandwidth of the servo only.

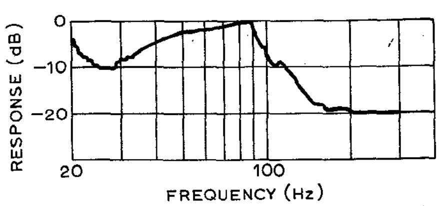


Fig. 11. Bandwidth of the system, showing the effect of compliance and mass of the drive.

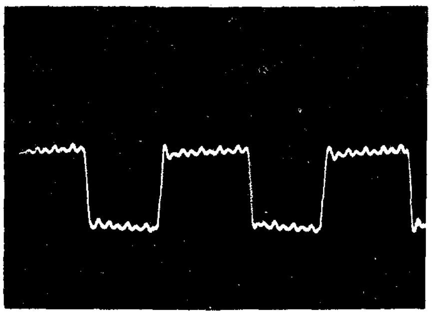


Fig. 12. Response of the system to a 5Hz square wave injected into the control network.

rated at 12 in. oz. continuous torque output.

The speed regulation comparisons are shown in Fig.8 for a midrange speed value. Improvement in speed regulation was achieved by using a d.c. "bootstrap" connection from the collector of the driver transistor Tr_4 in the d.c. amplifier section to the gate control network of the unijunction transistor in Fig. 5. The family of curves shown were obtained by checking speed regulation with and without the "bootstrap" connected.

Bandwidth and transient response. The ability of the servo to follow a sinusoidal speed variation by means of injecting a low frequency signal into the network controlling the p.u.t. timing is a measure of the system bandwidth, or response to a rapidly changing "instruction".

To measure the actual speed fluctuations of the servo, a flutter meter with a centre carrier frequency of 3000Hz was used to monitor the tachometer signal. The servo speed was adjusted to give a 3000Hz signal and the resulting flutter was measured, first without the sinusoidal programme, then with it. The frequency was varied from a few Hz to over 100Hz until the magnitude of the sinusoidal flutter component reduced by 3 dB. The residual flutter of the system alone is shown in Fig.9, which is typical for this design. The bandwidth graph is shown in Fig.10. Transient response was also measured in a similar way, by injecting a low frequency square wave into the control network. The resulting response waveform was displayed on a cathode ray oscillograph, and is shown in Fig.12 demonstrating the inherent near critical damping of this servo system. The response to a 1% step increment of speed was achieved in less than one revolution. The bandwidth of the servo was such that no ill effects were produced by the natural mechanical resonance of the motor shaft and tachometer motor assembly, as the resonance was above 850Hz.

When the motor was coupled to a typical tape transport using a Mylar belt and flywheel arrangement, a new set of conditions became apparent. The flywheel mass and the belt compliance form a resonant circuit of a significant Q value. Should the "gain" of the servo be high, oscillation can occur within the passband of the system, and adjustment of control pulse width ("gain") is required to give optimum stability. The action is analogous to the electronic a.c. amplifier when there is a resonant circuit within the feedback loop. Provided that the gain and phase shift are present, oscillation will commence (if they are present in excess of the classical requirements for stability). At first sight the belt and flywheel of the servo coupling drive is outside the "velocity loop", but it does feedback heavily, using the motor as a transducer to upset the control ability of the device. This results in the modified bandwidth plot of Fig.11.

Application. The reason for developing this particular servo was to incorporate it in a precision tape transport, to replace an a.c. two-speed hysteresis synchronous motor. The 3M professional 16-track recorder was used as a particularly good example to evaluate the servo drive, the two-inch tape producing a high load, and the differential "Isoloop" capstan extremely low wow and flutter performance over a bandwidth of 0.5-200Hz. The servo drive was shown to perform well, giving reliable low flutter performance figures of around 0.035% r.m.s. at 15 inches per second. Long-term speed stability and variations due to load change were found to be better than 0.1%.

The main sources of temperature drift are the base-emitter and saturation potential variations in Tr_1 and Tr_2 (Fig.5). The p.u.t. is compensated by the diode in series with the gate. The variations in Tr_1 and Tr_2 are complementary and tend to cancel as do the p.u.t. gate and diode combination. Typical spread on a pilot run of printed circuit units was $\pm 0.2\%$ speed variations for 0°C to 55°C temperature range. The actual environment seen in studio recorders is likely to be + 20°C to + 40°C. Some drift is also present during "warm-up" due to self-heating of the various components of the servo, but these effects were consistently below 0.1%.

The speed could be continuously varied over a 16:1 range, or switched to set values between 300 and 4800 r.p.m. A single resistor value can control the speed. The gate voltage of the programmable u.t. is the parameter which controls the speed — low voltage at this point produces shorter timing pulses from the hybrid monostable circuit, high voltage produces long pulses, and the servo will run at a speed where the pulse duration corresponds to the period of the tachometer. The limiting factor here is the extremes of voltage at the gate cf the p.u.t. — the device has a low limit of a few volts, the upper limit being a potential few volts below the maximum rating for the device itself.

Another important requirement for range of control is the motor rating. At the high end of the range, there must be a good margin of potential left for the servo circuit to use and to provide effective control. The electromagnetic tachometer output must be high enough at the extreme low end of the speed range to produce the correct limiting action from the tachometer amplifier.

The servo could be phase locked to a sinusoidal signal within 2% of the tachometer frequency. The servo was mildly sensitive to amplitude of the synchronizing signal, the optimum point being about 0.5V r.m.s. injected into the lower end of the control network. This limited capture range is inherent in this type of integrated pulse system, allowing only one pulse to be generated by the monostable per period of tachometer, for satisfactory operation.

The author wishes to thank the 3M Company for giving permission to publish this paper, and credit is due to the engineers of the Mincom Division; Jack Mullin, Pete Amass, Ken Clunis, and others in the Audio Lab for their help and ideas during the development and in the preparation of this paper.

Further reading

Servomechanism Practice, Ahrendt and Savant, McGraw-Hill
General Electric Application Note 90.70
Motorola Application Note AN-445

Appendix

Electrical gain motor-to-tachometer	=64 rad/rad
Electrical gain motor-to-tape	=2880 rad/rad
Discriminator gain	=0.053V/rad
Voltage amplifier gain	=16V/volt
Power amplifier gain	=17.7A/volt
Inertia of motor and tachometer	=0.006 oz in/sec²
Bandwidth, basic servo only	=100 Hz
Bandwidth, total drive system	=90 Hz
Residual flutter of tachometer	=0.01% r.m.s.
Residual flutter from tape	=0.035% r.m.s.
Residual carrier leakage current	=0.07A p-p
Residual rotational errors	=0.05A p-p
No-load direct current	=0.33A
Typical operating system current	=0.7A
On-off slew rate — up, basic servo	=4000 rad/sec²
On-off slew rate — down, basic servo	=800 rad/sec²
Incremental slew rate, up	=270 rad/sec²
Incremental slew rate, down	=113 rad/sec²
Long-term speed accuracy at 25°C	=0.1%
Temperature coefficient	=0.01% per °C
Signal-to-noise ratio r.m.s. ripple/max. drive current	=34dB
Flutter rejection coefficient $\frac{\text{open-loop gain}}{\text{closed-loop gain}}$	=55dB

Obituary

G. G. Gouriet

The early death of Geoffrey Gouriet at the age of 57 is a great loss, not only to his colleagues in the B.B.C., but also to his many friends and associates.

After various jobs as a clerk, service engineer and design and research engineer, he joined the B.B.C. in 1937 as a junior maintenance engineer. He was soon transferred to the medium-wave transmitting station at Penmon in Anglesey, and there spent all his spare time in studying the fundamental aspects of radio and electronic engineering. Most young people aspiring to the heights of an engineering career need a university training or the equivalent, but Mr Gouriet was quite capable of thinking for himself and this contributed to his great capacity for original work — he was the author of 31 patents and he wrote a considerable number of scientific and engineering papers. In 1939 he transferred to the crystal drive section of the B.B.C.'s transmitter department at the research premises in Balham, where his work had a major influence on the success of the method of operating several transmitters on exactly the same wavelength, thus enabling broadcasting to continue during air raids whilst preventing enemy aircraft from using the broadcast signals for direction finding.

In 1943 Mr Gouriet joined the research department, at first in the aerial section and then in television where he became Head in 1950. From that time until, in 1958, he resigned from the B.B.C. to become technical director of Wayne Kerr Laboratories, he made great contributions to the science of television. The method of equalizing the linear distortions imposed upon a television signal by the apparatus through which it passes, by means of a set of time derivatives of the signal was perhaps his most important technical contribution and although the method had been used in certain specific cases, he clarified and generalized the theory, making it available to all. In 1956 he represented the B.B.C. on the International Radio Consultative Committee of the International Telecommunication Union in the U.S.S.R. and Poland.

At Wayne Kerr he maintained his interest in derivative equalization and applied his ideas to the clarification and improvement of certain aspects of feedback and control theory, particularly as they concerned the rapid but precise movement of heavy mechanical equipment.

In 1964, Mr Gouriet rejoined the B.B.C. as head of research, bringing to this work his special gifts of enthusiasm, friendliness, technical integrity and an intuitive but incisive mind. In 1968 he became chief engineer, Research & Development; as overall chief of the research and designs departments. He had been elected chairman of the Electronics Division of The Institution of Electrical Engineers in 1964 and became a member of the Council of that institution in 1967. In 1968 he was chairman of Council of The Royal Television Society; in 1955 he had delivered the Fleming Memorial Lecture of that society. The climax of his career was the delivery of the Christmas Lectures of The Royal Institution in 1972. Shortly after this he was awarded the C.B.E., appointed as Visiting Professor of Electrical Engineering at Imperial College of Science & Technology with effect from 1st October 1973, and was elected to membership of The Athenaeum. He was a very gentle man whose enthusiasm and desire for deep understanding of natural philosophy inspired all who came into contact with him.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Feedback amplifiers

Following the interesting and informed article by Mr Walker on low noise amplifiers (*Wireless World*, May 1972) there has been a protracted and inconclusive series of letters discussing the various merits of shunt and series feedback connections with regard to noise and distortion.

I would almost certainly have been happy to let this die out in its own way had not the discussion gone completely off the rails in John Linsley Hood's letter "Feedback Amplifiers" in the May 1973 issue.

Mr Linsley Hood suggests that the difference between the series and shunt feedback connections in the circuit given arises because in the series feedback case the signal is not normally attenuated much between source and amplifier, whereas in the shunt feedback case it will be attenuated 4–6dB depending on suitable operating parameters.

The effect of a finite input impedance in a feedback amplifier can be considered as a reduction in loop gain, and for the two connections, see Fig. 1, the effect of input impedance are as below.

Series feedback:

$$\frac{E_0}{E_1} = A(s)\left[\frac{R_e+R_{fb}}{(R_e+R_{fb})\left(1+\frac{R_e+R_s}{R_{in}}\right)+A(s)R_e}\right]$$

When $R_e = R_s$ and $R_{in} \rightarrow \infty$, $A(s) \gg 1$

$$= \frac{R_e+R_{fb}}{R_e}$$

Shunt feedback:

$$\frac{E_0}{E_1} = -A(s)\frac{R_{fb}}{(A(s)+1)R_s+R_{fb}(1+R_s/R_{in})}$$

In the limit $R_{in} \rightarrow \infty$, $A(s) \gg 1$

$$= -\frac{R_{fb}}{R_s}$$

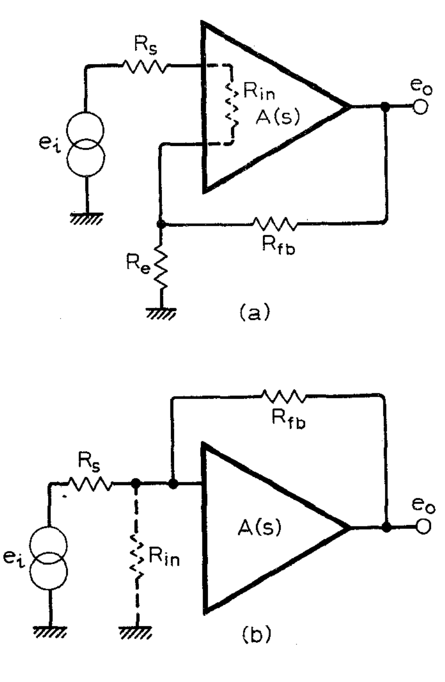
It can be seen that the sensitivity of the two circuits to finite input impedance is similar, with suitable values, e.g. a loop gain of 500 $R_{in} = 15\text{k}\Omega$, $R_s = 50\text{k}\Omega$, $R_{fb} = 500\text{k}\Omega$, the reduction in gain in each case by considering R_{in} finite is: series 1.3dB, shunt 0.8dB.

It is not correct to assert that the intrinsic problem with a shunt feedback amplifier is that its input impedance attenuates the signal by 4–6dB. It is readily seen from the equation that the input impedance becomes insignificant anyway when $R_{in} \rightarrow R_s$ and completely insignificant for $A(s) \gg 1$. It is therefore simply a problem of good design to assure that R_{in} is a suitable value, not a drawback of a feedback connection.

Mr Linsley Hood goes on to say that (in the shunt feedback case) the noise impedance seen by the input is not the input resistor circuit value but the value of the "virtual earth impedance", and suggests that this impedance is 600–1200 ohms. This comment is quite amazing. What is a virtual earth impedance? One can only assume that it is a phantom idea to describe how "earthy" the virtual earth point is.

It is quite misguided to use this idea. The virtual earth is a phenomenon resulting from the feedback connection but it does not have an impedance as such that can generate noise.

A shunt feedback amplifier is a current amplifier, and the low noise condition is with the input open circuited, i.e. in Fig. 1(b) the generator E_1 is open-circuited. The noise of the amplifier here is determined by the thermal noise current generator in R_{fb} and the noise factor of the amplifier with a source resistance of R_{fb}.



In its mode of use (E_1 short circuited) the source resistance is $R_s//R_{fb}$ and the noise current of R_s is significant. Certainly a 47kΩ source resistor will generate a noise voltage of 3.9μV and provided the input is short circuited this will be shown in the amplifier noise performance.

In the case of the pickup amplifier $R_s = 47\text{k}\Omega$, $Z_{fb}(s) \gg R_s$ it can be shown by calculations that the maximum s/n ratio with a cartridge connected is 58dB ref. 2mV.

Experiment and theory clearly show a marked increase in the noise of such an amplifier when the input is short circuited. Perhaps Mr Linsley Hood could explain how connecting a 47kΩ resistor in parallel with a 1000Ω virtual earth impedance can give a 10dB rise in noise?

Finally, on the subject of distortion, good circuit design can easily permit a series feedback amplifier to have a repeatable performance of s/n better than 70dB s/c ref. 2mV and distortion less than 0.01% in the audio range. The fact that this cannot be achieved with a 741 should be considered irrelevant by any engineer concerned with these and any other important design parameters not covered in the arguments to date.

J. R. Stuart,
Lecson Audio Ltd.,
St Ives,
Huntingdon.

May I offer the following points regarding recent correspondence on distortion and noise?

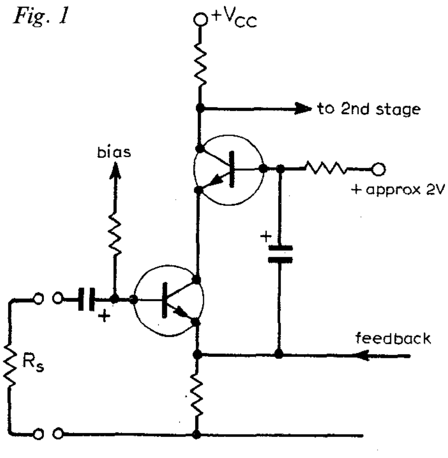
(1) "Common-mode distortion". In many cases of practical interest, it is the variation of C_{cb} of the first transistor with V_{cb} (Early effect) which dominates. Considering a BC214 input stage run at $V_{ce} = 5$ and handling an input of 1 volt r.m.s., the Texas data sheet indicates a capacitance swing of 3pF. This corresponds to a second harmonic distortion of 0.1% at 20kHz if the source impedance is 10kΩ. A considerable reduction in Early effect distortion, and almost complete elimination of the other distortions which are not amenable to reduction by feedback, may be obtained by using a bootstrapped cascode arrangement (Fig. 1).

There is now an Early effect from the upper transistor's C_{cb}, but it is much less than before since it injects distortion into the output, not the input. In fact if the quiescent current through the transistors is chosen for optimum noise figure from R_s, then the Early effect will be reduced by a factor $\sqrt{\beta}$. This circuit permits the lower transistor to be run at a very low V_{ce}, for optimum noise performance, without compromising the ability to handle large signals.

(2) Reduction of distortion by feedback. The statement by Mr Hood and quoted by Messrs Mornington-West and Vereker (May issue), that quadrature components of the feedback are ineffective in reducing the distortion, is absolutely without foundation, as is shown in the appendix to this letter.

To understand the poor high frequency performance of Mr Linsley Hood's *Hi-Fi News* design it is sufficient to consider how much feedback is applied round the output

Fig. 1

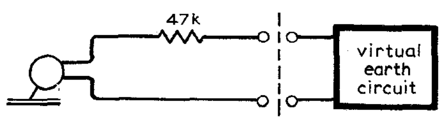


stages. Apart from the usual local feedback, it amounts to $5\frac{1}{2}$dB at 20kHz.

It is not nowadays safe to assume that the effect of a "h.f. stabilising capacitor" is confined to high frequencies. In the design mentioned above, the dominant lag capacitor looks harmless enough at 220pF, yet it gives an open-loop break point of 10Hz.

(3) The measurements reported in Mr Linsley Hood's second letter in the May issue point to interesting possibilities in noise reduction.

Consider a notional dividing line between the 47kΩ resistor and the rest of Mr Linsley Hood's virtual earth circuit (Fig. 2 (a)). The combination on the left will, as he says, produce an open-circuit noise of 3.9μV.



(a) Quiet record, room temperature resistor

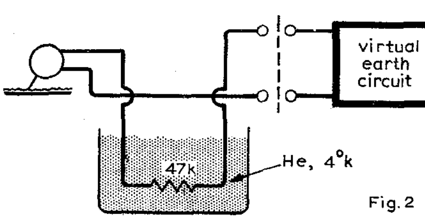


Fig. 2

(b) Noisy record, cooled resistor

Now let us take a gramophone record on which, by some mischance, tape hiss has been recorded, and let us choose a pickup of the right sensitivity so that this hiss appears as exactly 3.87μV on its output terminals. Pickup and resistor will then produce $\sqrt{3.9^2+3.87^2} = 5.5\mu$V of noise, but if we now immerse the resistor in a dewar of liquid helium (Fig. 2 (b)) the open circuit noise will once again be 3.9μV.

The impedance presented to the circuit on the right is of course exactly the same for Fig. 2 (b) as for 2 (a), so it should need only a little fiddling of the frequency spectra to convince the circuit that it is connected as in Fig. 2 (a), when the truth is 2 (b). If now the circuit can achieve the noise value of 0.6μV claimed by Mr Linsley Hood, then a noise reduction of $20\log_{10}\frac{3.87}{0.6} = 16.2$dB will have been obtained.

Perhaps some enterprising record company will consider this technique for revitalising its pre-Dolby LPs?

Peter G. Craven,
Oxford.

Appendix

Let the amplifier have perfect common mode rejection so that V_{out} is a function of V_1 only. Suppose that we are trying to reproduce a sine wave of unit amplitude and that it is possible to predistort V_1 so that V_{out} is a pure sinusoid. Let "X" be the assumption that the gain of the system to a small signal superimposed on the input is not greatly affected by the presence of the large signal. X will be false if the amplifier is near to clipping.

Let the gain (V_{out}/V_1) of the amplifier at the ith harmonic of the sinusoid be A_i and let β_i be the corresponding feedback factor (V_f/V_{out}). To take account of phase shifts, A_i and β_i will be complex. Suppose that we have succeeded in making V_{out} a pure sine-wave and that d_i (also complex) is the amplitude of the ith harmonic of the predistorted signal V_1 necessary to achieve this. Since the feedback network is assumed linear, V_f will be a pure sine wave, and since $V_{in} = V_1 + V_f$, it follows that V_{in} must also have an ith harmonic of amplitude d_i.

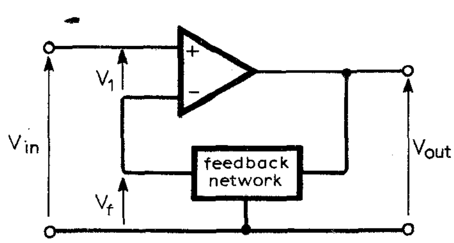
We wish to consider a pure V_{in}, and this we get from the predistorted V_{in} by adding $-d_i$ of the ith harmonic for $i = 1 \ldots \infty$. By assumption X there will appear harmonics at the output, the amplitude of the ith being $-G_i d_i$, where G_i is the gain of the system (including feedback if any) at the ith frequency.

Since d_i does not depend on the feedback, we have proved the well known fact that feedback reduces each distortion product in the same ratio as it reduces the gain at the frequency of the distortion product.

By elementary feedback theory, G_i is given by

$$G_i = \frac{A_i}{1+A_i\beta_i},$$

and comparing with the case $\beta = 0$, it is clear that introducing the feedback has reduced the gain, and hence the distortion



by a factor $|1+A_i\beta_i|$. This factor we now evaluate for an amplifier with a loop gain of 10 ($|A_i\beta_i| = 10$).

No phase shift → $A_i\beta_i$ is real and positive
→ $|1+A_i\beta_i| = 11$

90° phase shift → $A_i\beta_i$ is pure imaginary
→ $|1+A_i\beta_i| = 10.05$

180° phase shift → $A_i\beta_i$ is real and negative
→ $|1+A_i\beta_i| = 9$

Mr Linsley Hood replies:

I am sorry that Mr Stuart feels that the debate on feedback amplifiers "has gone completely off the rails", but he has taken my letter somewhat out of its intended context.

To refer specifically to the main point of this—measurements suggest that the s/n ratio of an amplifying circuit with shunt f.b. is a few dB worse than in the case of the series f.b. circuit with the same value of input resistance.

I believe that this phenomenon is real, and that it is due to the fact that any real amplifying device will require some input energy—significant in a bipolar transistor—and that in the shunt circuit this is obtained from the input signal.

In the latter part of my letter I suggested an alternative method of considering the noise impedance seen at the input—which is a voltage node—in a shunt f.b. amplifier. If one considers the amplifying element, having a known open loop gain, as being detached from the feedback loop but amplifying the noise voltage seen at that point, the noise impedance of the "virtual earth" can be derived, if one is interested to do this.

This observation was not specifically related to the s/n ratio of a shunt feedback circuit, which is best approached by considering it as a current amplifier. In this case the input noise currents decrease as the root of the admittance ($1/Z$) of the input limb, whereas the signal current decreases linearly. Other things being equal the lower the input limb impedance, the better.

In the particular case of a pickup amplifier circuit with R.I.A.A. equalisation, it should be remembered that the effective noise bandwidth is only about 500Hz. Since this allows a s/n ratio with a 47kΩ input resistor and a shunt f.b. circuit to be −72dB ref. 5mV (−64dB ref. 2mV) I suspect that the "calculations" to which Mr Stuart refers assume a wider bandwidth than this. The relative advantage of the series circuit diminishes with frequency when used with an inductive element such as a magnetic p.u. cartridge, from about 11dB at 1kHz to some 3dB at 5kHz. (Assuming a 600mH cartridge inductance, and a series f.b. input d.c. resistance of 2kΩ).

In reply to Mr Craven, on the more important point of the extent of distortion reduction by feedback at phase angles other than 180°, the problem is that the predicted distortion reduction from the formula

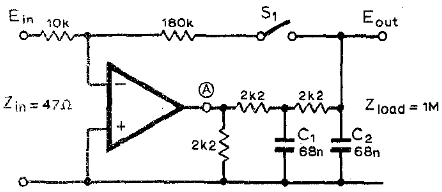
$$\frac{D_F}{D} = \frac{A_F}{A}$$

gives unsound results under these conditions, whether the gain is calculated by the method Mr Craven shows or whether it is derived by the classical formula below.

$$A_F = \frac{A}{\sqrt{1+|\beta A|^2-2|\beta A|.\cos\Phi}}$$

where Φ is the f.b. phase angle.

As an example, a non-linear amplifier element, having a gain of 100×, an input impedance of 4.7kΩ and a t.h.d. of approximately 4% at 1kHz and 1.5 volts r.m.s. output, was set up as shown in the figure, with an output lag circuit whose values were chosen to give a phase lag of 90° at 1kHz.



When S_1 was closed, to apply "negative" feedback (10dB at 20Hz, although the gain reduction was only 2dB at 1kHz) the t.h.d. at 1kHz increased from 4.7% to 6.3%. However, when the phase shift introducing elements (C_1 and C_2) were removed, closure of the switch to introduce true negative feedback reduced the t.h.d. from 4.1% to 1.3%, which is in line with theory. In both cases, when feedback was applied, the input to the amplifier was increased to give the same output at point "A" (1.5V r.m.s.) as in the no-feedback case.
J. L. Linsley Hood,
Taunton,
Somerset.

Car seat belts

As a campaigning member of the relatively small percentage of seat-belt wearing drivers, I nevertheless must add a note of protest against the gleeful hand-rubbing in anticipation of forthcoming contracts which formed the basis of Vector's article in the May issue on the proposed automatic seat belt interlocks involving the use of i.cs.

The i.c. boys have indeed "got it made" as he suggests, and advantage will doubtless be taken of the opportunity to scale new heights of technological overkill with the machines on which many are obliged to depend for personal transport. One needs only to observe the panic of the visitor to London when confronted with automatic ticket barriers at tube stations to judge the total inadequacy of the non-technical majority when faced with mechanisms which demand a specific sequence of human responses in order to perform their function.

I realise that humans adapt gradually to the numerous complexities of modern living, but have you ever tried to fasten an American 3-strap seat belt while lights flash and a mind-numbing buzzer sounds? The experience is the most persuasive inducement to leaving the belts permanently locked behind the seats.

Quite apart from this, many people firmly believe that the individual should retain the right to be hurled through the windscreen of his car at will, and that the burden of his personal safety in this instance should neither be shifted to the already over-intrusive state, nor to the already overworked police force.

Any safety regulations and technological advancements which prevent an individual from endangering others must be applauded, but regulations covering personal safety could never be far-reaching enough to be 100% effective, and until such time as you produce a solid-state system as a substitute for the human brain — there will always be a man prodding wires into an electrical socket with matchsticks, leaping from a bus into the traffic stream, and refusing to wear his seat belt.
Lyn Heigl,
Studley.
Wilts.

Magnetic units

I am much obliged to Dr McCaig for replying in the June issue so informatively, direct from the Permanent Magnet Association at Sheffield, to my articles on magnetism (Jan. and Feb. issues). (At least the P.M.A. hasn't made complete nonsense of my criticism directed at Sheffield by having moved, unknown to me, to Bognor Regis or Lerwick, in keeping with the trend towards dispersal.) My apology is due to the P.M.A. for my having suggested that it, like the incredible referee cited by Dr McCaig, is still unaware of SI units. I do, however, remind readers that my technique of trailing my coat provocatively in order to elicit information is or should be well known by now. And I wish Dr McCaig had made clear what practice has been continued in the majority of P.M.A. publications during the last 20 years. Listing permanent magnet properties in m.k.s. as well as c.g.s. units? If so, it would seem to be as if our Government were to continue for the 20 years after 1971 to give money values in decimal units as well as £.s.d. In short, not much encouragement to make the effort to change over. Which may be one reason why the majority of papers on magnetism continue to use c.g.s. units. (This was actually my essential grouse.) And what units do individuals within the P.M.A. normally use?

However, assuming that the P.M.A. collectively and individually is doing all it reasonably can to encourage abandonment of c.g.s., with renewed apologies to it, I hereby amend my strictures by altering the address of the target from Sheffield to all those places where people use c.g.s. units without reasonable excuse. In this at least I would seem to have the influential backing of Dr McCaig.

Although I'm not altogether convinced that standardizing the unit and symbol for "intensity of magnetization" (or whatever) would make all the difference to acceptance of SI units by workers in magnetism (surely the question arises with any system of units?), I'm at one with Dr McCaig on the desirability of tidying up here. In so far as I have used this quantity (and that is not at all far, as I shall explain in a moment) I have used the symbol M, but I would happily accept J if that is decreed; in fact, I'll accept it now, for although there is unlikely to be any confusion with mutual inductance they do both come into related contexts. And my preferred unit is the tesla, since from a practical point of view one can regard J as the difference between the actual flux density and the corresponding flux density *in vacuo*, both of these being in teslas. But I take Dr McCaig's point that if the chosen measurement technique makes it more appropriate to treat it as a kind of H by reckoning it in A/m, fair enough.

Finally, I must reply to the charge that I ignored the need for the quantity J. I plead guilty. But without remorse. For Dr McCaig is a physicist and represents magnet manufacturers. I am an engineer and, for the purpose under discussion, purport to represent consumers of magnets among a great many other things. So it is hardly surprising if the attitudes to J are quite different. I don't for a moment doubt that to the people Dr McCaig represents J is, as he says, fundamental. Under a disguise, for readers who I assumed were interested in the theoretical physics of magnetism, I myself once found it necessary to introduce J (as M). But I very much doubt that it is a necessary or desirable part of an elementary 7-page treatise on magnetism and magnets for readers to whom this subject is incidental. I've never once needed J to deal with practical problems roughly within the field covered by *Wireless World* — in which of course the word "Wireless" is rather like the "candles" allegedly brought into the House of Commons when it is too dark for Hon. Members to see their order papers clearly. It is interesting to note that although the physicists Bleaney and Bleaney in their substantial volume *Electricity and Magnetism* (using m.k.s. units) deal with J (as M, which is probably where I got it) in the standard theory, they hardly mention it in the sections on magnetic measurements. And in Hvistendahl's book on units, J (or anything like it) and susceptibility are not mentioned. But then he is an engineer.
"Cathode Ray."

Printed circuits the easy way

Most people who have attempted printed circuit work of a one-off nature will admit this can be time consuming and tedious using the normal method of draughtsman's pen together with either brushing Belco or Humbrol as a resist. It requires considerable artistic acumen or the patience of a saint!

This chore finished and drying time allowed, one has then to wait somewhere between 25 and 50 minutes while surplus copper very slowly dissolves in the etching fluid.

The result of all this time and trouble ought to be a neat web of sharp unbroken lines and sensibly circular drilling points, not the sorry bodge which frequently causes the experimenter to revert to tag board or pin board.

There had to be an easier way and out of sheer frustration the following was evolved. Instead of the draughtsman's pen and Belco a fibre tipped waterproof marker pen costing about 22p, called the 'Miracle Pen' (of Japanese origin) was adopted and is a delight to use, producing fine or thick lines with ease. (A 1in × 1½in board took 10 minutes to draw, drill and etch.) Virtually no drying time is required. The pen is refillable, but should last a considerable time provided the cap is replaced when not in use. For professional looking numbering and lettering the self adhesive 'Letraset' used as a resist has proved most effective.

All that remained was to speed up the etching. Apparently some form of effective agitation was required. Eccentric cams were suggested for wobbling the tank but just appeared to cause swirl; supersonic agitation was obviously out for kitchen use. The answer proved to be aeration; this was easily and cheaply provided by an electric aquarium air-pump costing £1 together with a porous air-stone at 5p to disperse the bubbles. A glass water jug, narrow at the bottom and wide at the top, was half filled with a strong solution 60/40 ferric chloride plus 2cc hydrochloric acid*. This is diluted with an equal quantity of water. The jug was placed in a polythene washing-up bowl full of fairly hot water in order to warm the solution the air-stone was placed at the bottom of the jug and connected by its tubing to the aerator.

When switched on, due to the "Vee" shape of the tank, even dispersion of bubbles throughout the fluid was observed. The work to be etched was then suspended in the fluid, etching was completed in five minutes.

Rinse under the cold water tap to remove etching fluid, then remove resist with rag well moistened with cellulose thinners. A final rub with Brasso and the process is complete.

Should you make a mistake when drawing the circuit a rag moistened with cellulose thinners can be used as an eraser.

One other point I feel worth mentioning. After assembly and soldering it is worth while rubbing over with cellulose thinners to remove untidy flux, then applying a coat of Ronseal thinned with slow cellulose thinners as protection.

J. Ferguson,
Penrith,
Cumberland.

*The chemicals used by the writer are dangerous and should be treated accordingly. Ed.

V.H.F. receiver performance

Isn't it time that some "figure of goodness" was instituted for v.h.f. receivers, other than the useless "locks in at $\frac{1}{2}\mu$V" or whatever?

It is a revealing experience to try several different v.h.f. sets on the same aerial. The results — especially on stereo — go all the way from very good to ruddy 'orrible! Yet the specs give no hint at all as to which is which. Nor does a list of semiconductors give any indication.

I own two v.h.f. stereo receivers, one all-germanium with a stereo lock in of 5 μV, lineup r.f.-osc/mixer-3 i.f.-ratio disc; the other all-silicon with a stereo lock in of $\frac{1}{2}$ μV, lineup f.e.t. r.f. and mix-sep-o.s.c-2 i.c. (CA3012)-Foster-Seely disc.

Now which would you expect to be the best? The actual fact is the former! (Though I'm working on the latter.)

Point being that in an advertisement it would be the i.c. one which would seem to be the best.

Given a dozen units to choose from — how do you do it? Advice to "try" is absurd. Surely there should be some British Standard figure that could decide.

Ronald G. Young,
Peacehaven,
Sussex.

Amateur computer club

I feel that you and your readers may be interested to hear that, as a result of advertisement in your journal and other magazines last year, the Amateur Computer Club has been formed.

The club is for those interested in the construction, design or programming of computers as a hobby. At present the main activity is the production of a newsletter (which appears every two or three months) which acts as a databus to distribute information on hardware and software techniques of interest to the members.

Anyone interested in the club may receive further details from me at the address below (s.a.e. appreciated).

M. Lord,
7 Dordells,
Basildon,
Essex.

Power supply design

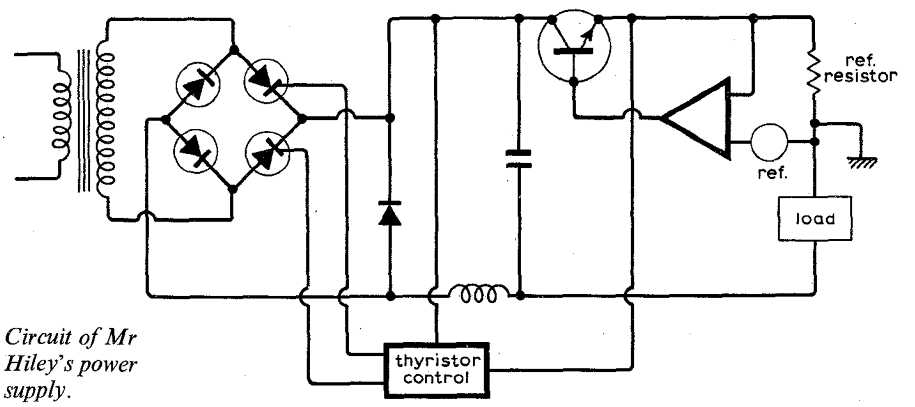
I was interested to read Mr R. Aston's article in the May issue. The idea of a switching pre-regulator controlling the voltage across the series element in the main control loop is not new.

Previous designs in my experience have mostly used thyristors operating at line frequency for the pre-regulator. I was myself involved in such a design for an ultra stable (5 p.p.m.) wide range constant current supply. For reasons of isolation this was operated from a 400Hz motor generator set, but our experience showed that it would operate equally well at 50Hz with suitable adjustment of smoothing components.

The arrangement shown below in the diagram was used. A similar system is to be found in power supplies manufactured by the Harrison Division of H.P. and elsewhere.

With the advent of modern power switching transistors an obvious modification to the above circuit would be their use in a switching pre-regulator. However, I was much discouraged in this line of development by the manufacturers (including Mr Aston's company) of commercial switching supplies who were not interested in my proposal for a system almost identical to Mr Aston's.

J. F. Hiley,
Bishop's Stortford,
Herts.



Circuit of Mr Hiley's power supply.

Audio amplifier design

I read with interest the letters on audio feedback-amplifiers published in the May 1973 issue (Letters pp. 246–248), and would like to comment on one or two of the points raised.

Messrs Mornington-West and Vereker make a useful point regarding the noise contributions due to later amplification stages. While I agree with their analysis, it may be difficult to apply the result in the case when stages are current rather than voltage driven.

This is the case for the second stage of the amplifier shown on p. 236 of my article on low-noise amplifiers (May 1972); I found that current driving gave better linearity in large-signal stages. For these conditions, emitter degeneration in the second stage is undesirable, and in any case major-loop feedback is preferable provided stability margins are met.

The noise contribution of the second stage is readily calculated using Faulkner's concept[1] of noise resistances, and since the second transistor is being current driven only the noise current generator need be considered. Its noise is transformed via the input transistor (a voltage to current converter) to a noise voltage source or series noise resistance at the input, of value:

$$R_{nv2} = g_{m2} \cdot \frac{(1+g_{m1} \cdot R_{e1})^2}{2 \cdot h_{FE2} \cdot g_{m1}{}^2}$$

Reference

1. Faulkner E. A. "The Design of Low-noise Audio-frequency Amplifiers", *The Radio and Electronic Engineer*", vol. 36, 1968, pp. 17–30.

Comparing this with the series noise resistance due to collector current shot noise in the input transistor ($R_{nv1} = 1/2 \cdot g_{m1}$), we see that for R_{nv2} to be negligible (say one tenth),

$$g_{m2} = \frac{h_{FE2} \cdot g_{m1}}{10 \cdot (1+R_{e1} \cdot g_{m1})^2}$$

hence a ratio of collector currents of

$$\frac{I_{C2}}{I_{C1}} = \frac{h_{FE2}}{10 \cdot (1+R_{e1} \cdot g_{m1})^2}$$

This is step 4 in the design procedure given in my article (p. 236).

In practice, the second transistor will contribute excess noise in its noise current generator so a good margin of safety is advisable in shot noise calculations. For the feedback triple given as the example, the second stage contributes a noise resistance of about 60 ohms which is negligible compared with the series resistors and noise resistance in the input circuit. The presence of flicker noise in the second stage may be detected by shorting the input of the amplifier, thus nullifying the effect of excess noise in the first-stage current generator.

I do not wish to reiterate the contents of my article or previous correspondence in connection with Mr Linsley Hood's reply to my April letter, but from a simple "ideal case" analysis it is clear that with a low-impedance source (e.g. a pickup cartridge) the parallel termination offers a very much better noise figure than the series resistor. This follows directly from the noise figure equation,

$$\text{N.F.} = 10\log_{10}\left(1+\frac{R_{series}}{R_{source}}+\frac{R_{source}}{R_{parallel}}\right)\text{dB}$$

and is independent of any attenuation due to finite input impedance of the amplifying device (intrinsic or otherwise).

In fact the attenuation of 4–6dB, quoted by Mr Linsley Hood, due to this cause, is quite incompatible with the achievement of an adequate noise figure which demands a common-emitter transistor input impedance several times greater than the source impedance, i.e. voltage drive conditions (Ref. 1, section 3.2). If he believes the input attenuation to be the problem, why does he not use a field-effect transistor?

When he refers to the "noise impedance" seen by the input does he mean the equivalent noise resistance? Consider a simple inverting operational amplifier of gain A with equal feedback and input resistors and with the input grounded. By summation of currents at the virtual earth, the noise output voltage is $\sqrt{4kT\Delta f \cdot 2R}$ giving a voltage at the amplifier input of $(4kT\Delta f \cdot 2R)/A^2$ mean square volts, or an equivalent resistance of $2R/A^2$. This disagrees with the virtual earth impedance of approximately R/A, the summing point in fact being quieter.

One would not expect the noise at the virtual earth to correspond to the noise voltage across the input resistor since the amplifier is sensing the currents flowing. The presence of a virtual earth (since it is due to n.f.b.) does not affect the noise figure of the input transistor which should be optimised under open-loop conditions (not for the virtual earth impedance) and the feedback used to alter the input impedance (Ref. 1, section 4.1). The virtual earth impedance does not enter into the noise calculations since it is a function of the open-loop amplifier gain which can be chosen arbitrarily from noise considerations.

H. P. Walker,
South Queensferry,
West Lothian.

I thank Mr Walker for his further letter, and concur in general with his comments.

I agree that a high input impedance device such as an f.e.t. would avoid the problem of input energy loss on voltage to current conversion. The difficulty is that the required input impedance for such a device, for optimum device noise figure, is in the megohm range, which is unsuitable for a low input impedance system.

J. L. Linsley Hood,
Taunton,
Somerset.

Distortion reducer

Mr Bollen, in the April issue (Letters, p. 192), has correctly pointed out a term which I omitted in my analysis of his Distortion Reducer. Nevertheless I should like to develop the idea that his system is essentially equivalent to the procedure of increasing conventional negative feedback around the main amplifier and adding a pre-amplifier.

The correct expression for the input to the main amplifier in the basic Distortion Reducer is $-S-S+S+D$. With a gain G_2 in the distortion channel this becomes $-S-G_2S+G_2S+G_2D$, which we may write as $-S(1+G_2)+G_2(S+D)$. The first term is the original signal multiplied by the gain of the equivalent pre-amplifier, and the second term is equivalent to that produced by a conventional negative feedback path.

I also offer the following more general treatment, in the hope that it may be productive and begin to answer Mr Cocking's call for a comparison of the two ways of reducing distortion.

Let the main amplifier have a (complex) gain $-G$, the term D now being reserved for distortion other than a mere quadrature term, let the attenuation at the output (previously $1/G$) be A, and let the distortion channel have a (real) gain G_2, as before. Writing x for the net input to the main amplifier, following the signal round the loop, and solving for x, we find

$$x = -\frac{S(1+G_2)+D}{1+G_2AG} \qquad (1)$$

If G is real (no phase shift in the main amplifier) and A is made equal to $1/G$ as before, this reduces to

$$x = -S-\frac{D}{1+G_2}$$

confirming the earlier result that the equivalent distortion input D is effectively reduced by a factor $(1+G_2)$.

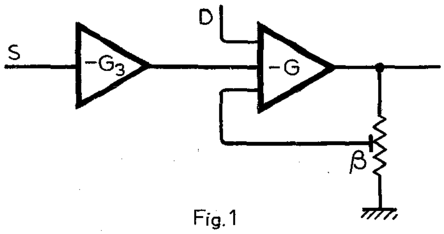


Fig. 1

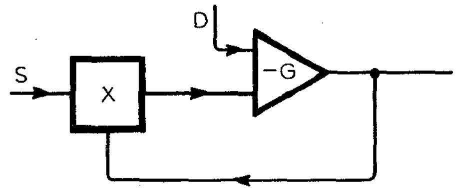


Fig. 2

Now consider the conventional circuit shown in Fig. 1. A similar analysis leads to

$$x = -\frac{G_3S+D}{1+G\beta}$$

If β is chosen to be equal to G_2A, and G_3 to be equal to $(1+G_2)$, this becomes identical to eqn. (1), showing that the two feedback systems are equivalent, even when there is a phase shift in the main amplifier, and that stability should be as good, or as bad, with either system. The relative merits of the two systems may turn out to depend on subtle considerations of linearity in the op-amps, interference with the input circuit of the main amplifier, or the like.

Finally, I offer Fig. 2 for consideration. X is a linear active network. It will be seen that the Distortion Reducer, the conventional circuit, and others as yet unconsidered can all be drawn in this form. One would expect them all to behave similarly.

Richard G. Mellish,
Watford,
Herts.

Quantity names

Since the discussion on my "Unified Dimensional Display" (March 1972), was published in the January 1973 issue, the dimensional position occupied by "magnetic vector potential" has been allotted the name "fluxivity" by John G. McKnight in a project note on test tapes appearing in the *Journal of the Audio Engineering Society* for March 1973. This is in order to describe the quantity "tape flux per unit track width" used in magnetic recording, measured basically in Wb/m, but conveniently referred to nWb/m in actual practice.

In view of this tendency to evolve new quantity names when needed, I suggest the replacement of "1/permittivity", or "reciprocal permittivity", (unit m/F), in my display system by the quantity "forbidivity" (or "forbiddivity"), forbid being an antonym of permit — or can readers suggest something better?

R. N. Baldock,
Harrow,
Middlesex.

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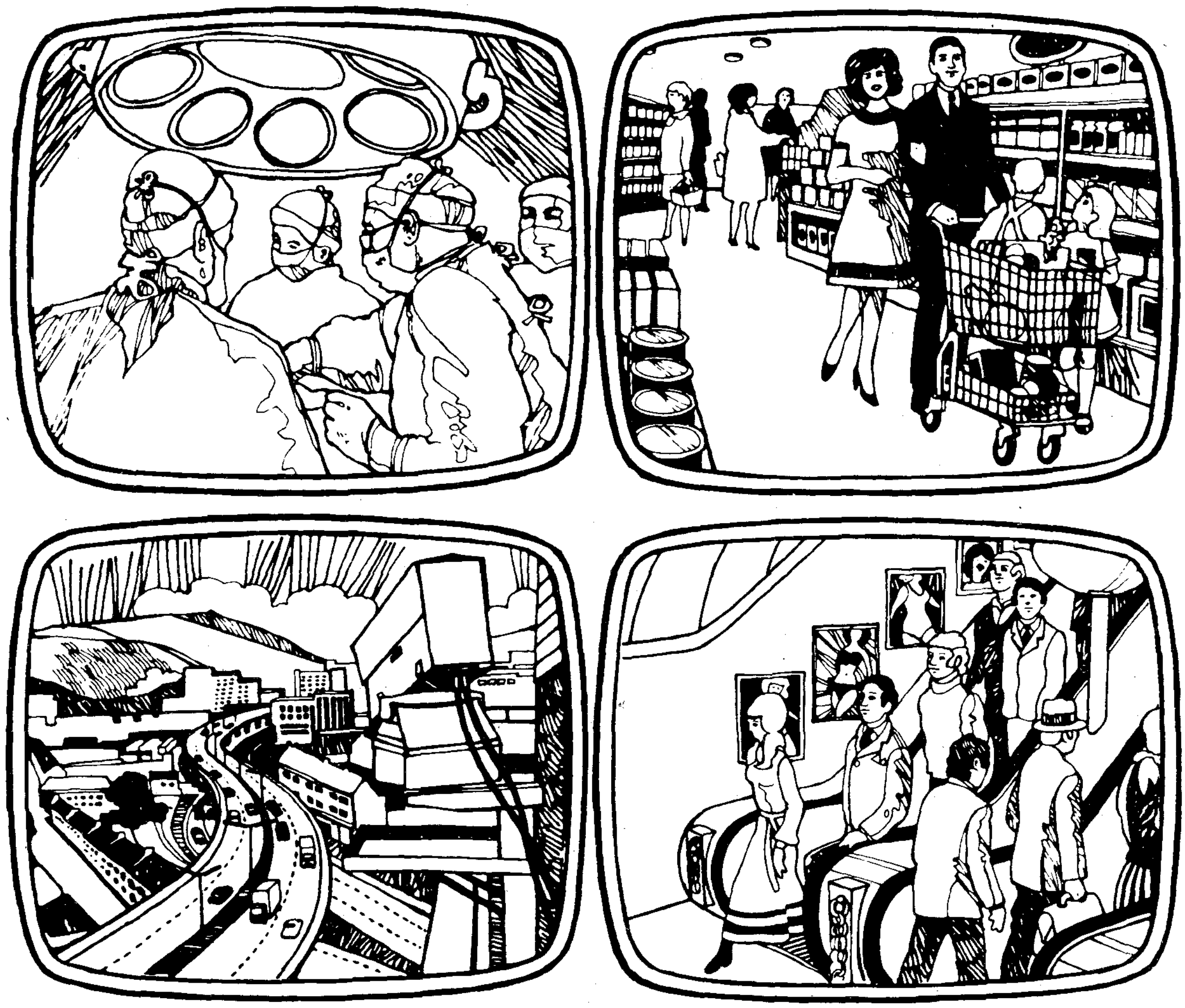

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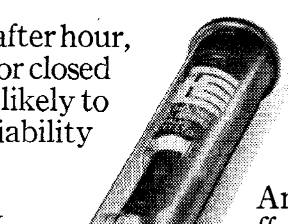

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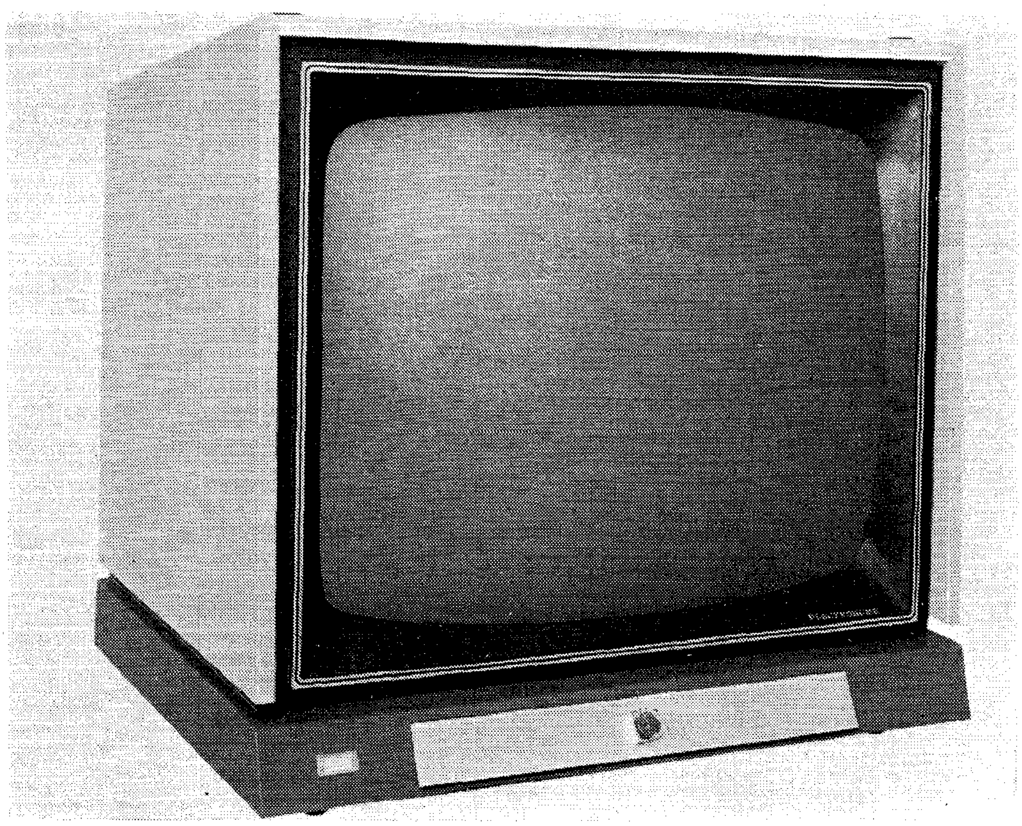

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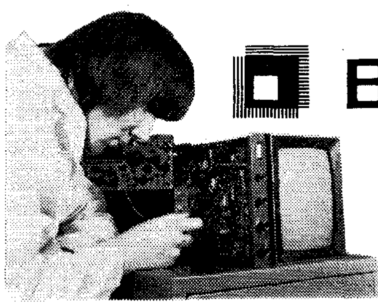

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Montreux Television Symposium

Impressions of the conference, papers and exhibits

by Harold Barnard

It is twelve years since the first International Television Symposium was held in Montreux — originally as part of the Golden Rose television programme festival. There was a very small associated exhibition — little more than baize-top table displays — and 200 or so delegates attended.

What has made this biennial event the Mecca for so many of the world's manufacturers and users of television equipment? It is certainly not the quality of the 100 or more papers presented during this year's meeting (18-24 May). There were undoubtedly highlights, but many of them were little more than sales blurbs on equipment on show. The associated (or perhaps one should say "dominating") exhibition is now indisputably the largest in Europe devoted exclusively to television equipment. Then, of course, there is the venue. How big a part this plays in influencing nearly 2,000 delegates to register (several hundred of them accompanied by their wives), one can only hazard a guess. In all, of course, the delegates and their wives, plus the 500 or so staff of the exhibitors, must have brought a considerable income to the municipality of Montreux who, in collaboration with the Swiss F.T.T., are the organizers. Perhaps here lies the secret — the event is publicized by and has the financial backing of the town's tourist organization.

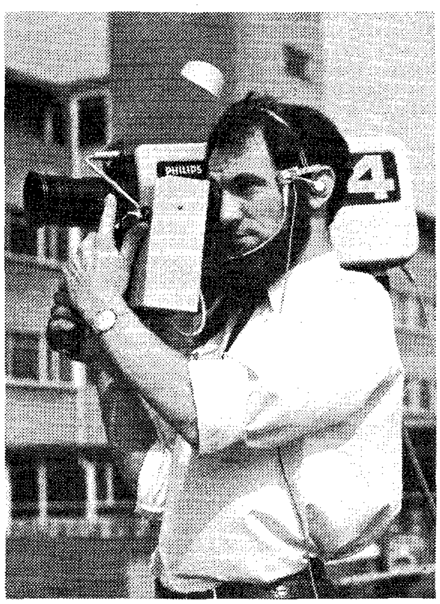
Some measure of the importance attached to the occasion can be judged from the fact that the delegates came from 30 or more countries and that there were special delegations from Australia (over a dozen engineers) and South Africa (nine); each of which will be starting colour services in the next few years.

The exhibition occupied four floors of a recently completed conference and exhibition centre. There were nearly 100 exhibitors from 15 countries; among them 22 from the U.K., 18 from Germany, 16 from Switzerland, 13 from France and 11 from the U.S.A. It should, however, be added that several of the companies shown in the catalogue with addresses in Europe, are in fact, subsidiaries of American concerns. It was gratifying to see so many of the smaller specialist U.K. companies, such as Link Electronics, Crow of Reading, Engineering Designs & Supplies, Prowest Electronics, System Video, and Michael Cox Electronics, competing with the big battalions. Incidentally, when reporting on the second symposium (1962), we recorded that there was only one piece of British Equipment on show and that was part of an American unit!

From what has been said it will be blatantly apparent that the *raison d'etre* was the exhibition. The show and the symposium are complementary but if the organizers are desirous of maintaining the position the occasion has gained, they will have to look more closely at the quality of papers accepted. The criteria should be fewer and better papers. The standard of the papers presented at the biennial London International Broadcasting Convention is much higher, but the I.B.C. exhibition has not so far acquired the international prestige accorded to the Montreux event.

Before dealing with some of the new equipment shown, we will look at a few of the papers presented.

The two sessions (there were 13 in all) which drew the largest attendance of delegates were those devoted to cable television. At one of these, specialists from various countries and international bodies presented reviews of the present position of cable television, or CATV (common antenna television) as it is more commonly called both in Europe and the U.S.A. These were preceded by a survey of the legal problems encountered in the distribution of programme material over cable networks; for example copyright, artists' fees. The speaker, G. Straschnov of the E.B.U., suggested that "the law is always far behind technology".



Prototype of the Philips LDK15 portable colour camera, demonstrated at Montreux, which is fitted with a combined 1-in Plumbicon tube and image intensifier.

Another contentious aspect of cable or relay distribution services is that of programme origination by the operators. If, as in the U.K., operators are hamstrung by regulations limiting the material to be distributed, what chance is there of CATV becoming the multi-channel information/entertainment service envisaged by W. J. Bresnan, of the National Cable Television Association, Washington? He foresaw CATV as a two-way public access system providing not only entertainment and general information, but an educational and advice service. On the question of the number of channels envisaged it was pointed out that in California there is a 40-channel system operating and 11 channels are in use in parts of Belgium where programmes in three languages from neighbouring countries are relayed. According to figures, quoted by Bresnan, seven million of America's 65 million television households receive their programmes via cable.

Several of the formal papers presented at the CATV session were concerned with the need for a two-way data communications capability, linking each subscriber with the system terminal station and/or other service centres, e.g. schools, banks, stores, information centres, etc. As one author expressed it, CATV is no longer a means of providing television reception for viewers in areas of poor or indifferent signal levels, but has come "to the point where we now stand at the threshold of the wired city and the wired world". This was said by Selig Lenfesky, of Coral Inc., whose paper was concerned with bi-directional amplifiers for CATV. The scheme he outlined provides for 31 television channels, each of 6MHz bandwidth, plus a 20MHz band for f.m. sound channels and two pilot carriers in the "forward" direction and, in the return direction, two 6-MHz vision channels and many data channels.

Several of the papers on CATV dealt with specific distribution problems. For instance H. G. Schwarz (RCA) presented a very detailed quantitative analysis of the selectivity requirements necessary in a receiver to avoid visible interference from signals propagated on adjacent channels. Whereas in television broadcasting adjacent channel interference can be alleviated, if not cured, by careful geographic distribution of frequencies, in cable distribution systems signal levels of adjacent channels are nominally equal. It was, in fact, found that the requirements for vestigial sideband attenuation for cable system modulators is considerably more stringent than those established by the F.C.C. for American broadcast transmitters!

Another RCA Laboratories paper (presented by C. M. Wine) described a method of two-way data communication for ancillary services using a cable television system. It is based on polling individual subscriber terminals. Downstream messages consist of a string of bytes or words sent asynchronously at a data rate of 1.25 Mb/s. Each byte consists of a start bit, seven data bits, a parity bit and a stop bit, and has a duration of 0.8μs. The downstream message has the following format: SYN, TID1 TID2 DID, and arbitrary number of data bytes, SYN. The initial and terminal SYN characters indicate to the terminal the start and end of the message. TID1 and TID2 identify the particular terminal being addressed; this allows 16,384 terminals on the system. DID identifies which one of 127 possible service-related devices is being specified, e.g., the security system, an opinion poll keyboard, a teletype terminal, a credit card reader, etc. The data bytes, if required, are then routed to that device.

Upstream messages also consist of a string of bytes sent asynchronously at 1.25 Mb/s. The upstream transmission commences immediately after TID2 (as soon as the particular terminal has been identified). An experimental laboratory version of the system operates on a test-bed v.h.f. cable television system. Data is sent using f.s.k. modems at 112-114MHz downstream and 12.3-13.8MHz upstream. The modem data interface is a conventional bit serial logic level interface and is independent of carrier frequency and modulation method. Thus the same data communications approach could be used in virtually any cable environment including an h.f. switched system.

Recent developments in camera tubes were discussed by W. E. Turk (EEV). He dealt briefly with the light bias leddicon tube, which operates on the principle of improving the beam acceptance curve of the target by artificially raising its general potential level. This is done by including within the tube a small light source to produce uniform background illumination. Mr Turk dealt at greater length with the need for more sensitive tubes in monochrome cameras for industrial television He then did some crystal gazing and demonstrated pictures taken with a pyroelectric vidicon. This experimental tube uses as its sensing target a crystal of triglycine sulphate (t.g.s.) fashioned into a micro-thin slice for mounting as a conventional vidicon target. The degree of polarization of t.g.s. is temperature dependent so that when a thermal image is projected on to it a corresponding voltage pattern is produced on the scanned surface.

There is a constant endeavour to accommodate more and more information in the 5 or 6MHz channels allocated to television. Several examples were discussed or demonstrated. Dr Jorg Irmer, of SEL, Berlin, described a two-carrier technique developed by the Institut fur Rundfunktechnik, Hamburg, which is to be used at the Regensburg u.h.f. station later this year. The normal sound carrier for television systems B & G used in Germany is 5.5MHz above the vision carrier and the output is 10dB below the nominal vision channel power.

The additional sound carrier is located 242kHz above the normal sound carrier and the power level will be 16dB below the vision power. Both sound channels are frequency modulated. In the exciter for the transmitter the audio and f.m. sections are duplicated; the first modulator producing the normal i.f. signal (33.4MHz) and the additional one an i.f. of about 33.15MHz. Both i.f. signals are superimposed in a combiner circuit and then passed to the r.f. mixer/linear amplifier and applied to the klystron power amplifier.

The last, but certainly not the least important, paper to be presented at Montreux was by D. R. Wells, of the Public Broadcasting Service of America. It dealt with a method of transmitting coded caption information (during the vertical blanking period of regular broadcast television signals) for the benefit of viewers with impaired hearing. An adapter at the home receiver decodes the caption information and displays it on the television picture. The system, to be used experimentally later this year by the Public Broadcasting Service in six cities, was developed by the Time and Frequency Division of the U.S. National Bureau of Standards. The N.B.S. has been investigating for some time the possibility of using the American television networks for transmitting precise time and frequency information during the vertical blanking period and, in fact, developed what was called the TvTime system and it was from this that the proposed captions for the deaf emerged.

The proposed signal is transmitted on line 21 of the vertical blanking interval. On odd fields the signal consists of a 1MHz sine wave followed by a 26-bit data stream containing the caption information. On even fields only the 1MHz sine wave is transmitted. It will be possible to transmit about 600 words of captioning per minute. To insure legibility against any background, each letter in the captions, which will be in two rows of capital letters (26 characters per row), has black edges. Even when a picture is noisy, as might be the case in fringe reception areas, the captions are clear because they are generated by the adapter fitted to the standard receiver. Tests using the N.B.S. signal on line 21 have been no more noticeable to viewers using normal receivers than vertical interval test signals (v.i.t.s.) or the vertical interval reference signal (v.i.r.s.). Apparently most home receivers are said to be adjusted by the manufacturers to be overscanned. Annoyance is only likely if a set is slightly underscanned and the caption information would then appear as a line of moving dots.

So much for the papers. What of the exhibition? It is impracticable to do justice in a short article to the galaxy of new equipment shown — monitors, test and measuring equipment, cameras, control consoles, video and sound recorders, telecine and transmitting gear etc.

Among new equipment shown by some of the smaller British companies mentioned earlier was a range of waveform measuring instruments, including a vector monitor, from System Video Ltd, of Chertsey, Surrey, a new company making its debut at Montreux. Also shown were a range of monochrome monitors and a 17-in colour monitor (Prowest, of White Waltham, Berks); a 14-input vision mixer for mobile use (Michael Cox Electronics, Twickenham, Middx); and a new three-tube colour camera with built-in zoom lens (Link Electronics, Andover, Hants).

Thomson-CSF, of France, featured a new video tape recorder, the TTV 3500, which employs a recording angle of 19°. Developed jointly by IVC in America, Thomson-CSF, and Rank-Cintel in the U.K., the machine uses 2-in tape and has *five* longitudinal tracks in addition to the video record. The two main audio tracks are separated by what is called an "arrangement track" to eliminate crosstalk. The fourth and fifth tracks serve for drive control and for the encoded address used for achieving accurate electronic settings. The tape is wound at 180° on an air lubricated drum.

With the extension of television broadcasting hours and the use of unmanned transmitters the need has arisen for testing to be carried out during transmission of the programme signal without affecting the viewer's picture. This has led to a change in emphasis from full-field testing to insertion test signal measurements. Marconi Instruments were showing an automatic monitoring system based on these insertion signals. The two instruments forming the new monitoring system are the insertion signal analyser TF 2914, which permits simultaneous measurement of a variety of signal parameters using standard national or international test waveforms, and the data monitor TF 2915 which provides control for the TF 2914 and the facility for comparison of the measured parameter with a pre-determined limit. As a result of this comparison executive action is automatically taken in the equipment as required either to change the transmitter from main to reserve or to select an alternative video input to the transmitter.

Circuit Ideas

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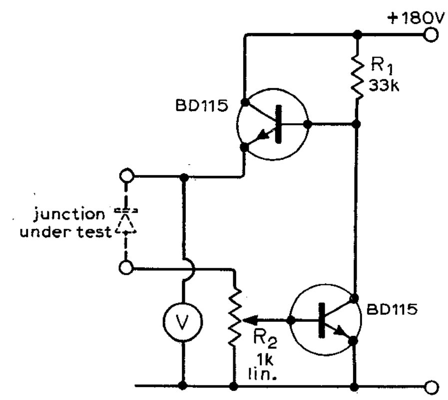
Simple breakdown voltage meter

The circuit will test the V_{CBO}, V_{CEO} and V_{EBO} breakdown voltage of most types of transistors, small signal or power; V_Z of zener diodes and the reverse breakdown voltage of small power diodes. It should fit easily into most instruments which lack this facility with little modification.

Power is supplied by two small 90-V batteries in series. Resistor R_1 biases the upper transistor into conduction and voltage is applied to the junction under test. As this breaks down current flows in R_2 causing the lower transistor to conduct, with a consequent drop in base voltage of the upper one. Thus R_2 may be used to set I_{BR} over a fairly wide range, enabling the user to study the effects of different current (on V_{CEO} breakdown in particular). The voltmeter reads V_{BR} plus the drop across R_2 which is small and can be neglected. Transistors of type BD115 are used but other high voltage types, e.g. MJE340 could be used.

J. W. Brown,
Gateshead, Co. Durham.



Phase-locked loop demodulator

In the November 1972 issue of *Wireless World* Pat Hawker showed a circuit for a low-cost phase-locked loop demodulator using three digital integrated circuits and two transistors ("Synchronous Detection in Radio Reception-2", page 527). Here is an even simpler circuit which can be built for about a third of the price.

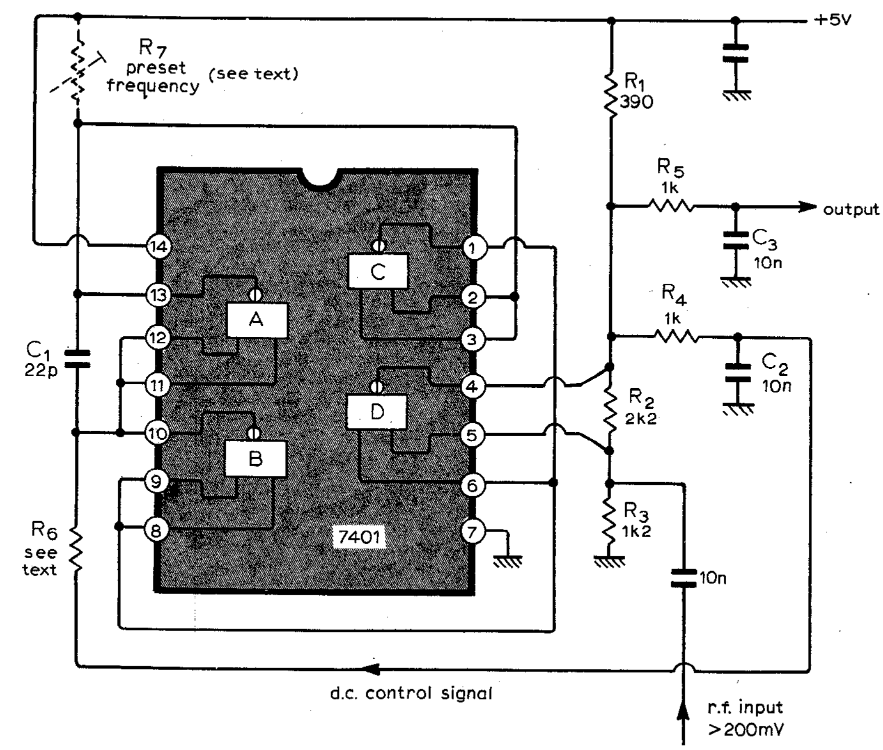
Gates A, B and C constitute a relaxation type of voltage-controlled oscillator whose output frequency is determined by the value of C_1 and positive current sources supplying pins 10 and 13. It should be noted, however, that the inputs to gates A and C supply part and whole of these currents respectively. Similarly, no resistor is required on the output of gate C, pull-up being provided by the input current to gate B.

D is arranged such that when pin 6 is high the gate is biased by R_2 and R_3 to operate as a linear amplifier for the input signal. In operation, however, pin 6 is alternately high and low due to the oscillator output and hence gate D performs as an amplifying phase detector. The output from this stage is fed via the low pass filter R_4 and C_2 to the voltage-controlled oscillator, completing the phase-lock loop. A separate filter R_5 and C_3 provides the audio output.

With C_1 is equal to 22 pF the circuit operates at a frequency of approximately 10 MHz. Making R_6 270 Ω or 10k Ω maintains lock over a frequency range of 2 MHz or 300 kHz respectively. In both cases the output swing is just over 1 volt. An additional component R_7 may be incorporated if desired to obtain fine adjustment of the operating frequency.

Although this circuit is somewhat dependent on the device characteristics which will vary from one sample to another, it is capable of giving satisfactory performance for most amateur experimenters' requirements. The small size and very low cost make it eligible for substitution into existing equipment using other types of demodulation.

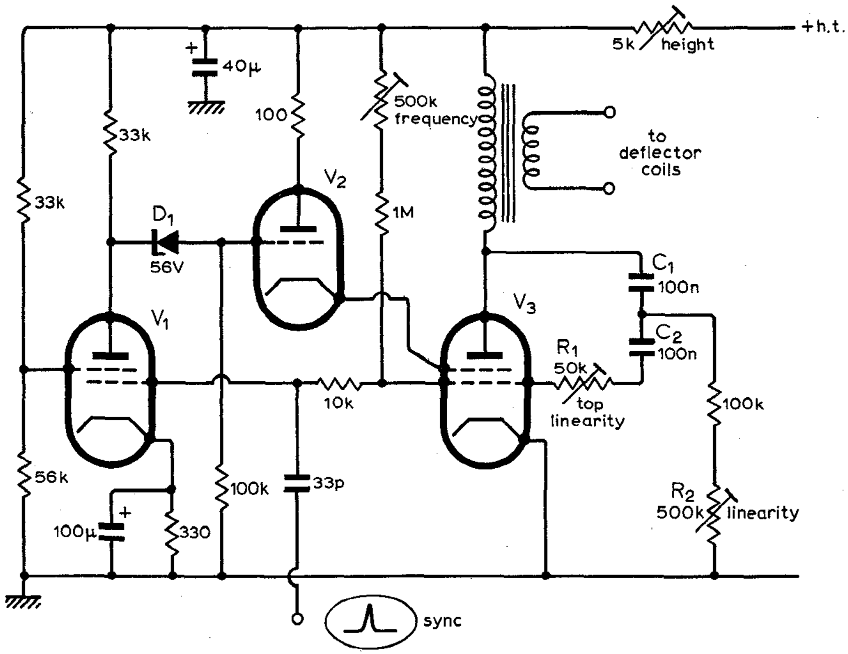
Rodney King,
Hastings, Sussex.



Sanatron current timebase

The circuit is a modification of the well-known Sanatron circuit for use as a current timebase for magnetic deflection. V_3 is the Miller run-down valve, gating being carried out by V_1 and V_2 on the screen grid. To correct for the inadequacies of the output transformer the charging capacitor is split into two halves C_1 and C_2 and two resistors R_1 and R_2 are used in a network to provide an approximately parabolic voltage on the grid of V_3 to correct for the differentiating action of the transformer. The gating pulse from V_1 is applied to the screen grid of V_3 via a cathode follower V_2 to minimize loading and allow the use of valves with high screen current for V_3. The 56-volt zener diode D_1 ensures that V_2 and V_3 are completely cut off when V_1 conducts. Sync can be applied to the grid of V_1 as shown.

The circuit values are appropriate for use as a television field timebase operating at 50Hz. The output transformer should be so chosen to present a load of about 5kΩ to the anode of V_3 when loaded by the scan coils. Different transformers may need different values of feedback components C_1, C_2, R_1, R_2. Almost any valves can be used for V_1, V_2, V_3; a 6U8 triode-pentode has normally been used as V_1 and V_2. Any small output tetrode or pentode will do for V_3, the only proviso being that the grid base of V_3 must be longer than that of V_1, so that V_1 is cut off when V_3 is normally conducting on the rundown. A negative pulse suitable for flyback blanking is available from V_1 anode. None of the resistors in the circuit is suitable for use as a height control, but as the frequency is not very dependent on the total h.t. voltage, variation of this provides a suitable means of controlling amplitude, especially as the current consumption of the circuit is very low.



G. Trice,
Halstead,
Essex.

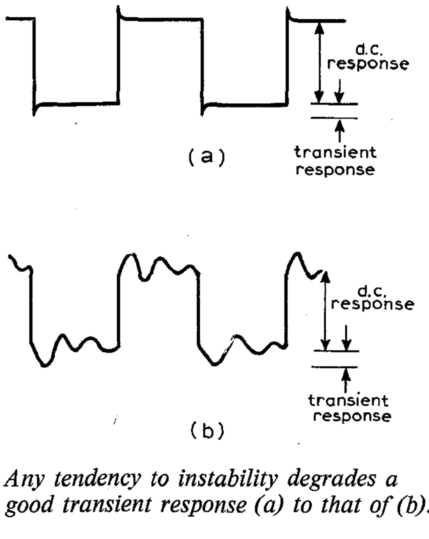
Transient response testing

The accompanying circuit offers a simple means of testing transient response in regulated power supplies.

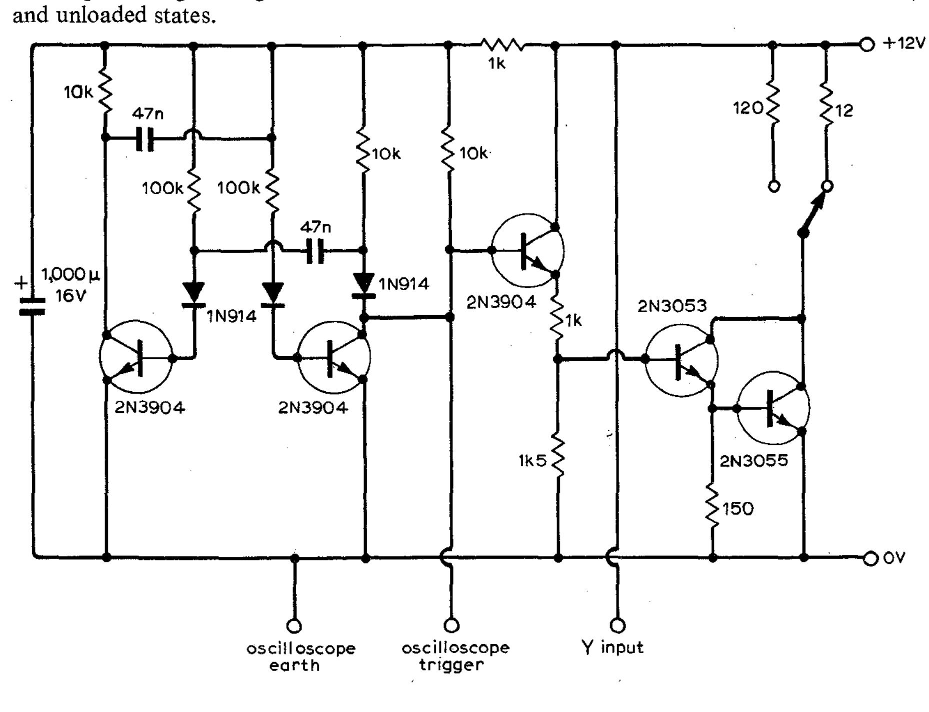
The multivibrator is modified by the addition of a diode and a second load resistor on one side to isolate the compound emitter follower stage from the capacitor charging voltage and thus give a sharp front to the waveform. Two series diodes in the base circuits protect the transistors from excessive voltage swings in the switching cycle. The 1kΩ resistor and 1,000μF capacitor decouple any transients produced by the power supply. The square wave is also taken out to a terminal for oscilloscope synchronization. An emitter follower stage switches the selected load resistor across the output. The transients generated by the supply may be observed on an a.c.-coupled oscilloscope. A good transient response will be similar to that shown in (a), whilst any tendency towards instability would give a response more like that of (b). The d.c. response is the output voltage change between loaded and unloaded states.

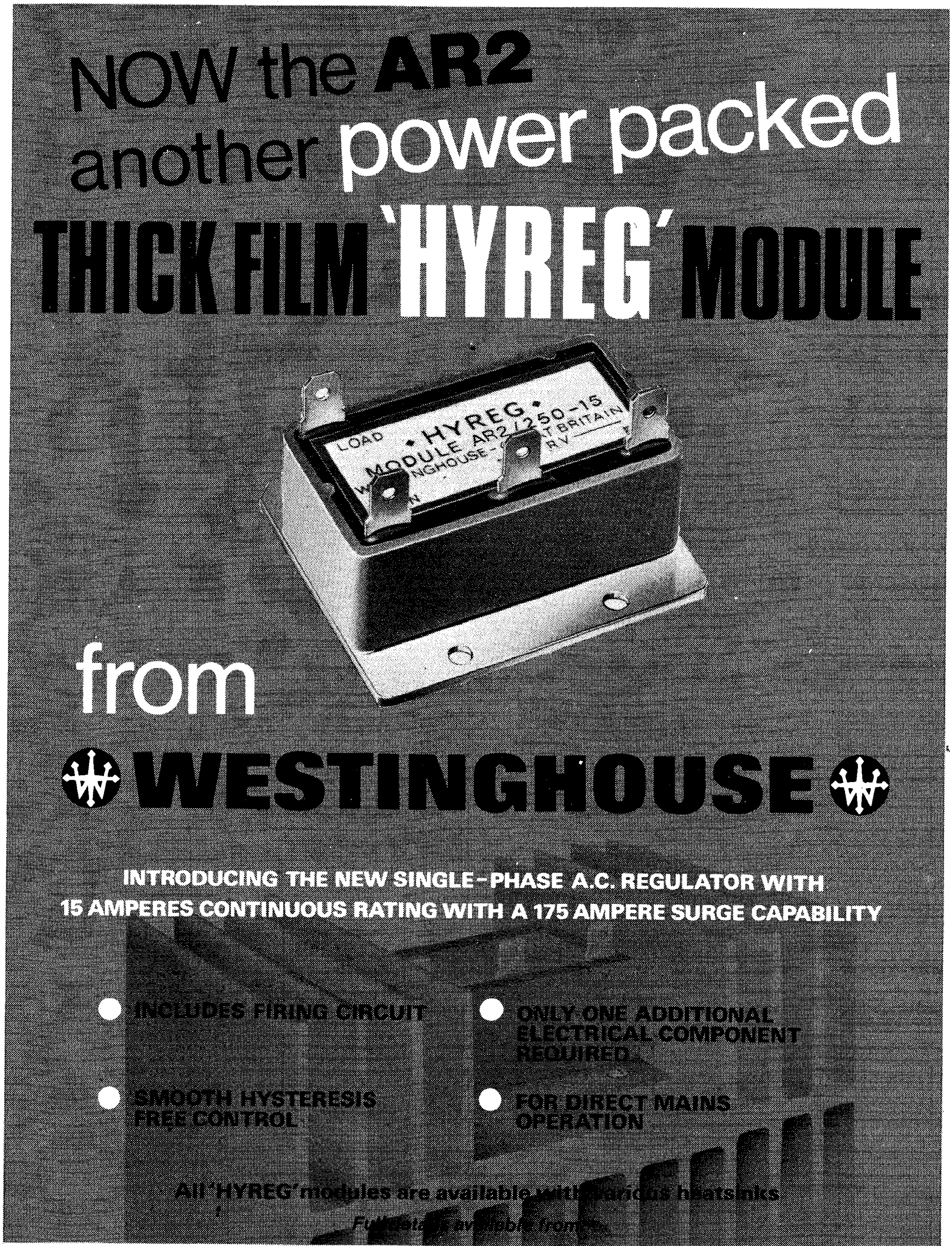
Because the transistors are used in a switching mode the dissipation is low, a 2-in square piece of 16 s.w.g. aluminium being sufficient heatsink for the 2N3055, no heatsink being required for the 2N3053. With the values given a 12V supply may be tested at either 100mA or 1A loading. Other voltages and/or currents may be catered for by altering the load resistors.

H. Macdonald,
Ashford,
Middlesex.



Any tendency to instability degrades a good transient response (a) to that of (b).





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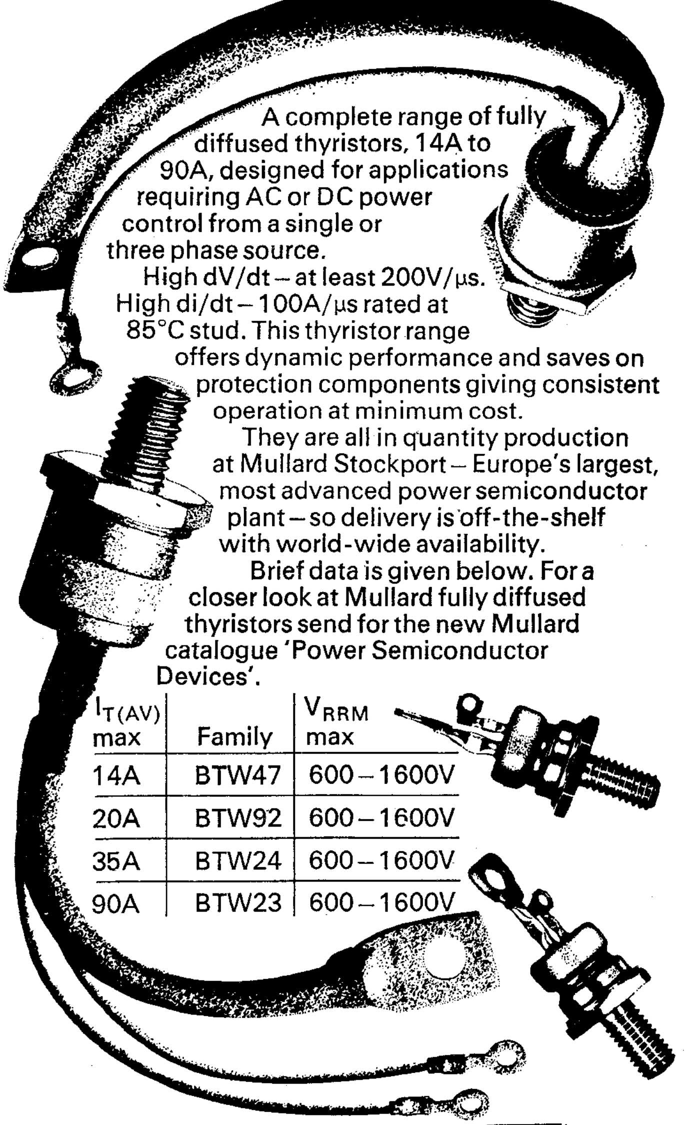

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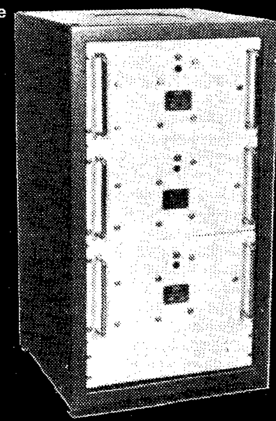

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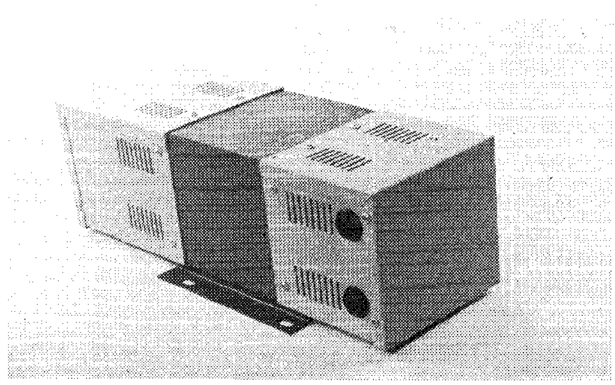

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A.C. Voltage Regulators

A discussion of various techniques for producing a constant a.c. supply voltage

by R. Thompson

This article looks at some methods of regulating a.c. supplies; in particular it addresses the problem of producing a constant level output at nominal value from a 50 Hz supply capable of varying ± 20% from the nominal. The methods all involve the use of thyristors (or triacs) in what may be called synchronous switching. Other forms of regulators have been, and are, used. These include motor-driven variacs, contactor transformer tap changing and ferro-resonant transformers. While these may have advantages for particular applications, they cannot compete in many instances with the speed, accuracy and low cost of the forms of regulator described here.

The most common form of thyristor circuit for a.c. voltage control is shown in Fig.1, (the thyristors could of course be replaced by a triac). This has been widely used in applications such as lamp dimmers, where a wide control range is required for loads tolerant to high levels of distortion. The form of the load voltage raises a point to be considered in regulating a.c. voltage. What parameter of the output voltage is to remain constant? Normally this will be either its r.m.s. or mean value depending on the characteristics of the load. In some particular instances it may be required to regulate the peak value. In discussing the regulators it is assumed that the r.m.s. value is held constant, the implications of operating mean or peak sensing control circuits will generally be obvious.

The simple phase control circuit of Fig.1 will not meet the requirement of producing a nominal output level. This will require the introduction of an auto-transformer as shown in Fig.2. For an r.m.s. output voltage equal to the nominal supply voltage (r.m.s. value of V_o) the thyristor firings must be delayed by about 95° when the supply is at its maximum (1.2 V_o). This delay reduces to zero if the supply is reduced to its lower limit (0.8 V_o).

The current rating of the thyristors must be adequate to carry the full load current under delayed firing conditions. Their voltage rating must be in excess of $\sqrt{2} \times 1.5V_o$. This follows from the requirement to delay firing by more than 90°. When the supply is at 1.2 times its nominal value the auto-transformer steps the voltage up to $1.5V_o$ and the thyristors must withstand the peak value of this voltage. The transformer must have a winding volt-amp capacity of at least $0.6V_oI_L$ as shown in the following expression:

Winding VA rating is given by

AB: $1 \times 0.3\ V_o I_L = 0.3\ V_o I_L$

BC: $0.25 \times 1.2\ V_o I_L = 0.3\ V_o I_L$

Total VA rating $= 0.6\ V_o I_L$

This form of regulator introduces considerable distortion in the output voltage. Under the worst condition, when the supply is at $1.2V_o$ and thyristor firing is held back by 95°, the total distortion is over 50%. Even if the regulation range of the regulator were reduced to ± 5% the distortion would still be over 20%.

Trigger circuits for this regulator, when feeding resistive loads, can use any of the types which have been developed for phase control of thyristors and triacs in lamp dimmers and similar applications. The only difference required is that the control of the firing angle must be operated by a circuit measuring the output voltage. Regulating the "mean" output of the regulator is straightforward since a simple mean detecting rectifier and smoothing circuit can be used. Regulating the r.m.s. output is more difficult, particularly with this type of regulator circuit where there is a large change in the form factor of the output waveform. The form factor increases as the input supply increases and the thyristor firing is retarded. This allows a simple form of compensation to be used, as illustrated in Fig.4. If the output r.m.s. voltage is held constant then the mean and peak values of the output voltage vary as shown. A combination of the mean and peak voltages can therefore generate a resultant which can be used to give quite accurate regulation of the r.m.s. output voltage.

The effect of reactive loads will be to modify the conduction periods of the thyristors. For instance, with inductive loads the thyristors will remain conducting after the time of zero crossing of the supply. The change in load voltage waveform is unlikely to prove significant since the first 45° of control has little effect on the r.m.s. output. A more important problem is the fact that the thyristor trigger pulse may occur before conduction from the previous cycle has ceased. This could cause intermittent firing of the thyristors and a limit on the minimum firing angle or prolonged triggering pulses may have to be adopted.

Two-tap regulators

The use of two taps on the auto transformer as shown in Fig. 4 results in very significant improvements in regulator performance. Its operation when feeding

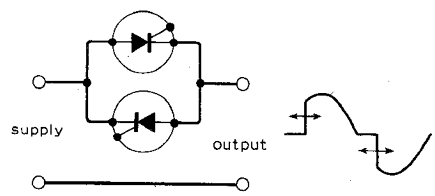


Fig. 1. Simple thyristor phase control and output waveform.

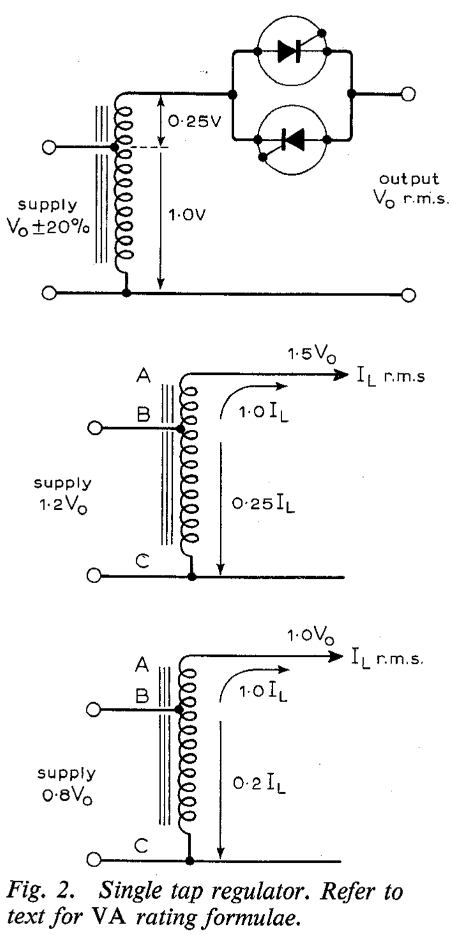


Fig. 2. Single tap regulator. Refer to text for VA *rating formulae.*

resistive loads is quite simple. At the start of each half cycle one of the lower thyristors conducts, supplying voltage to the load. Some time later in the half cycle one of the upper thyristors is triggered. This increases the voltage on the load and by so doing commutates the lower thyristor. At the end of the half cycle the upper thyristor is extinguished.

It can be seen that the output voltage can be continuously varied between the two values available at the transformer taps by altering the time of triggering the upper thyristors. The distortion is considerably lower than the single tap circuit, being zero at both extremes of input voltage and about 15% for the worst condition. There will be a proportionally lower distortion if the regulation range is reduced below ± 20%. The circuit is still quite simple and because only a fraction of the output power is handled directly by the circuit, ratings of the components are relatively low. Both pairs of thyristors must be rated for continuous full load current since the supply could be at either extreme for long periods. However they do not require as great a voltage rating as those in the single tap circuit. As the load is always connected to one or other of the transformer taps the maximum voltage seen by the thyristors is 0.5 times the nominal peak supply voltage. This is a third of that required for the single tap circuit. The transformer ratings (derived in a manner similar to that shown in Fig.2) are required to be about 25% higher than the single tap transformer, but still low in relation to the load power.

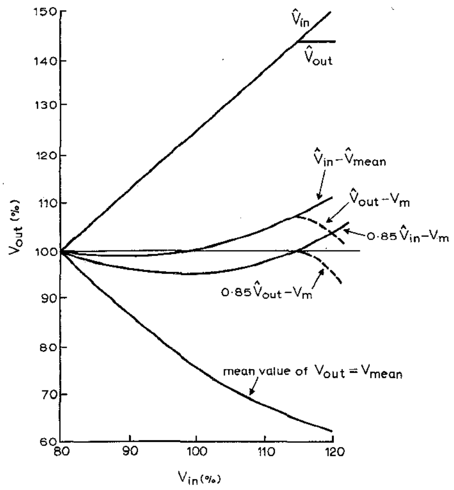


Fig. 3. The characteristics of various methods of generation of the r.m.s. control voltage. The curves are drawn for V_{out} *(r.m.s.) constant.*

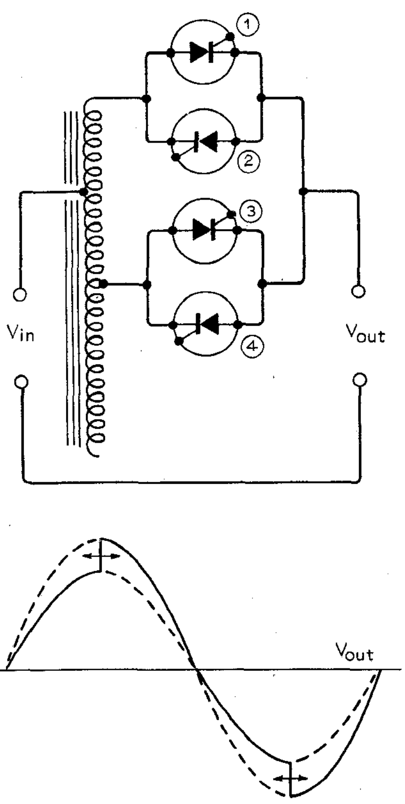


Fig. 4. Two tap regulator and output voltage waveform.

Firing requirements for the thyristors on the upper tap are basically the same as those suitable for single tap regulators. The lower thyristors require prolonged triggering in order to ensure that there is always one or other of the lower thyristors capable of conducting. Provided this prolonged triggering is generated immediately the supply is switched on only the tap-to-tap voltage will ever appear across any of the thyristors. The prolonged triggering can be obtained simply from the trigger windings added to the auto-transformer. A diode and zener clipper can be used for each thyristor as shown in Fig.5.

The problems of reactive loads poses a particular problem for the two tap regulator. This is because of the possibility of causing tap-to-tap short circuits. For instance if the load is very inductive and the input supply low, the triggering of the upper thyristors may occur before the current has reversed from the previous half cycle. The first time this occurs, current will flow only in the lower thyristor for the half cycle. If the current is still flowing in the lower thyristor at the time of triggering the upper thyristor in the next half cycle a tap-to-tap short circuit will occur. Fig.6 illustrates this point.

A typical two tap regulator circuit is shown in Fig.7. The lower thyristors are triggered via windings on the auto-transformer as explained previously. The upper thyristors are simultaneously triggered by a common pulse generated by transistor Tr_3. This transistor is driven by the Shockley diode timing circuits whose charging rate is controlled by the differential amplifier formed by Tr_1, Tr_2. At each supply voltage zero crossing the output voltage of the diode bridge (D_{1-4}) falls near to zero. When this happens C_1 is discharged through D_5 and R_1. This action resets the timing circuit every half cycle of the supply. The purpose of the zener diode in series with the Shockley diode is to ensure that the Shockley is extinguished at this time. When D_5 ceases to conduct, C_1 starts to charge at a rate determined by the collector current of Tr_2. The Shockley eventually breaks down and thyristors 3 and 4 are fired by the pulse which is generated. At the end of the pulse the Shockley may or may not cease to conduct depending on whether the collector current of Tr_2 is less or more than the diode holding current. If it does cease to conduct it may go on to produce further pulses during the same half cycle, but these will not produce any consequent change in the thyristor power circuit. The time in each half cycle when the trigger pulse is produced is determined by Tr_2 collector current. This is controlled by comparing a reference voltage, provided by D_6, with the fraction of the rectified output of the regulator which appears at the base of Tr_1. If the output voltage increases, the current in Tr_2 will be decreased. As a result the trigger pulse will move back in the half cycle, tending to reduce the regulator output. The sum of the currents taken by Tr_1 and Tr_2 remains substantially constant under all conditions and is determined primarily by the common emitter resistor and the voltage of D_6. The common emitter resistor, R_2, therefore provides a convenient method of defining a maximum collector current of Tr_2, this flowing when Tr_1 is cut off. The resistor is selected to ensure that C_1 cannot charge to the triggering level before a specified time in each half cycle. This "dead time" must be greater than the maximum time taken for the regulator load current to reverse after a voltage zero crossing. The minimum firing angle of the circuit can thus be made always greater than the lagging phase angle of the load.

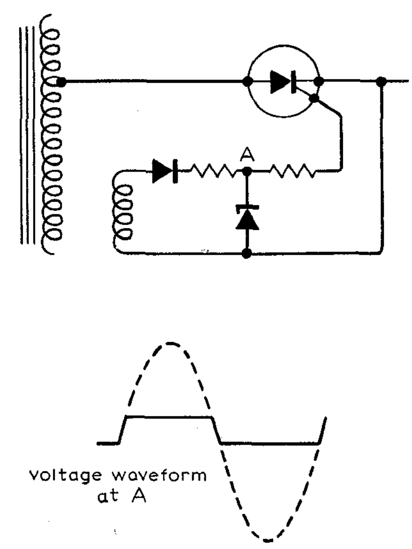


Fig. 5. Thyristor drive circuit.

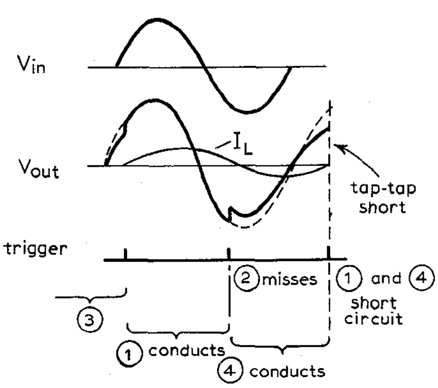


Fig. 6. Conditions under which a tap to tap short circuit can occur.

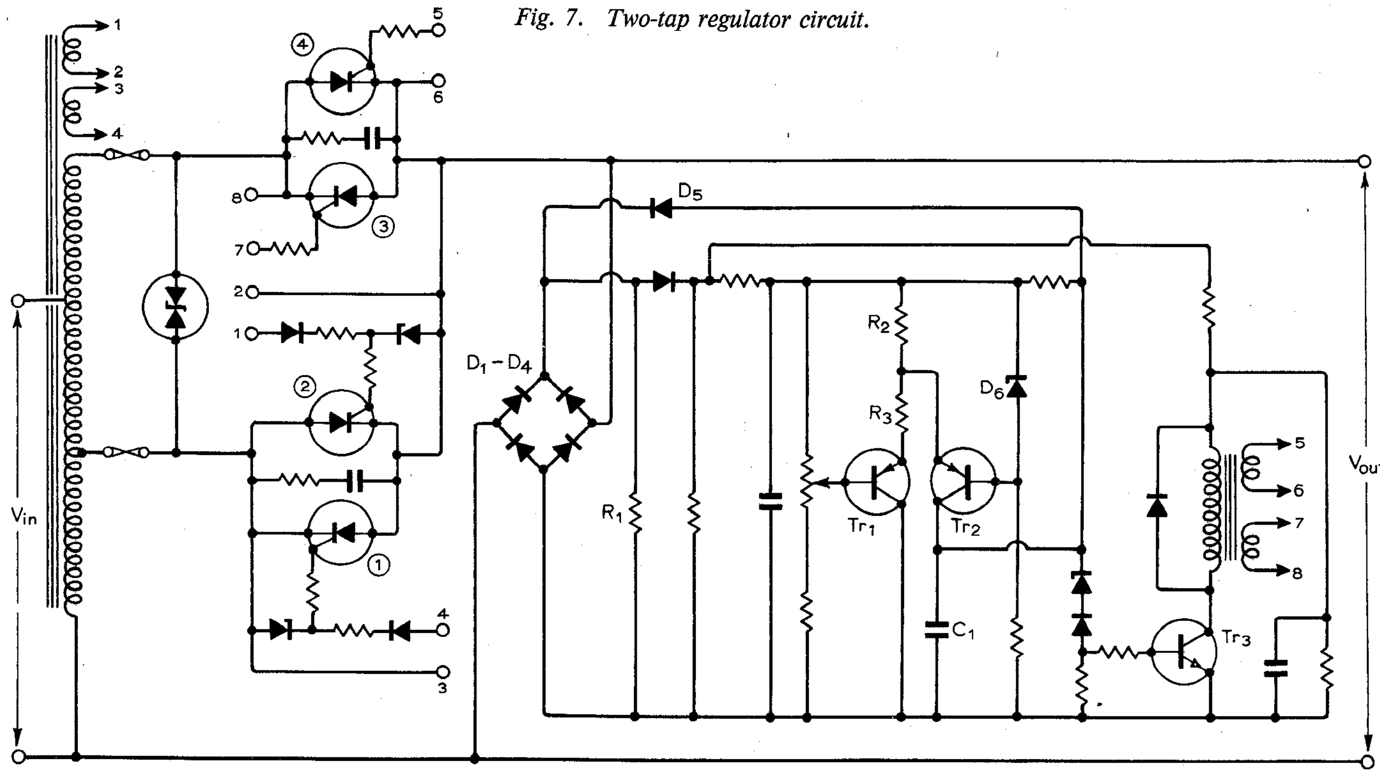


Fig. 7. Two-tap regulator circuit.

This avoids getting into a condition which could produce a tap-to-tap short circuit.

The resistor R_3 in the emitter of Tr_1 controls the regulator loop gain. This gain must be high for good regulation but loop stability consideration imposes a practical limit. The loop has a substantial lag due to the smoothing of the rectified feedback signal and in addition there is the transport delay introduced by the thyristors.

The thyristors are protected by two fast-acting fuses. Two fuses are necessary because of the possibility of tap-to-tap short circuits. If a single primary fuse were used it would be rated at approximately the same current as the secondary fuses. However, because the current in the primary is lower than in the secondary with tap-to-tap short circuits, the thyristors could experience a much higher I^2t surge. A "voltrap" suppressor is connected across the transformer taps to limit voltage transients which may occur on breaking the supply to the transformer. The suppressor will also limit voltage transients which occur in the supply voltage. A resistor capacitor network is connected across the thyristors to limit the rate of rise of forward voltage. High rates of rise may be caused by supply transients and they also occur across the lower tap thyristors due to the switching action of the regulator. If the rate of rise of forward voltage is not restricted it may cause spurious triggering of the thyristors.

An alternative form of trigger control circuit which can be used for the upper thyristors in the two-tap regulator is shown in Fig.8.

The diode bridge rectifies the output of the regulator and except for brief periods around voltage zero crossing the voltage across R_1 is defined by the zener diode voltage. The current through R_1 is therefore substantially constant. The current through R_2 is approximately proportional to the output voltage of the diode bridge and hence to the regulator output voltage. The transistor collector current is thus the difference between the "reference" current in R_L and a current proportional to the regulator output voltage. The pulse circuit formed by C and the Shockley diode free-runs at a frequency set by the charging current. If it is initially assumed that this frequency is exactly equal to twice the supply frequency, a consideration of the circuit action will show how this exact condition is maintained. At some time during a half cycle the Shockley discharges C and triggers an upper thyristor. The Shockley extinguishes and the capacitor commences charging. As no smoothing is provided after the rectifier, the current through R_2, and hence the transistor, will vary considerably during the half cycle. However, capacitor C integrates this varying current and reaches the Shockley breakdown voltage in exactly a half cycle. By its process of integration and discharge, C averages each separate half cycle of output voltage. The exact frequency required of the oscillations can only be maintained for an exact average output voltage. If the average output voltage falls, the average charging current of C will increase causing the frequency of the capacitor-diode pulse circuit to increase. This will bring forward the firing of the upper thyristors and hence reduce the output error. As the error reduces, the pulse frequency returns to its original value. Under steady state conditions the capacitor-diode circuit is thus forced to run at exactly twice supply frequency and no permanent error is required at the regulator output. The loop gain of the system does not control the output error but merely the rate at which the circuit can correct output errors. On a half cycle to half cycle basis the gain must be less than unity, that is a given error in one half cycle must not produce overcompensation on the next, for the system to be stable.

The prolonged triggering requirement of the lower tap thyristors will normally make it inconvenient to use a triac in place of these thyristors. Prolonged triggering applied to a triac on the lower tap would lead to a tap-to-tap short circuit. It will normally be simpler to use two thyristors

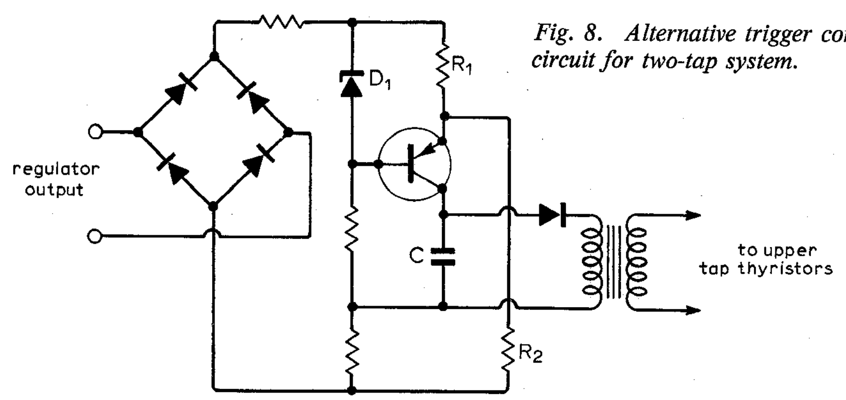


Fig. 8. Alternative trigger control circuit for two-tap system.

and only use a triac on the upper tap.

It is possible to alter the configuration of the two-tap regulator in various ways. For instance, the thyristors can be transferred to the primary of the transformer. It would be worthwhile doing this where the load operates at voltages substantially different to those of the supply. For instance the load may be heaters operating at a fraction of the supply voltage. In these situations the auto-transformer function can be included in the main transformer. It should be remembered, however, that the thyristors must withstand the transformer inrush current.

Another alternative is to rearrange the circuit so that the thyristors operate under high voltage/low current conditions. This is illustrated in Fig.9. The general operation and waveforms are identical to that for the circuit of Fig.4. However, the tap-to-tap voltage seen by the thyristors is now higher and the current lower. There are two problems with this configuration. One is that a short-circuit load will produce very high voltages across the thyristors before any fuses blow. The other is the fact that under "no load" conditions the thyristors handle the magnetizing current of the transformer. Since this could be highly inductive it could cause triggering difficulties.

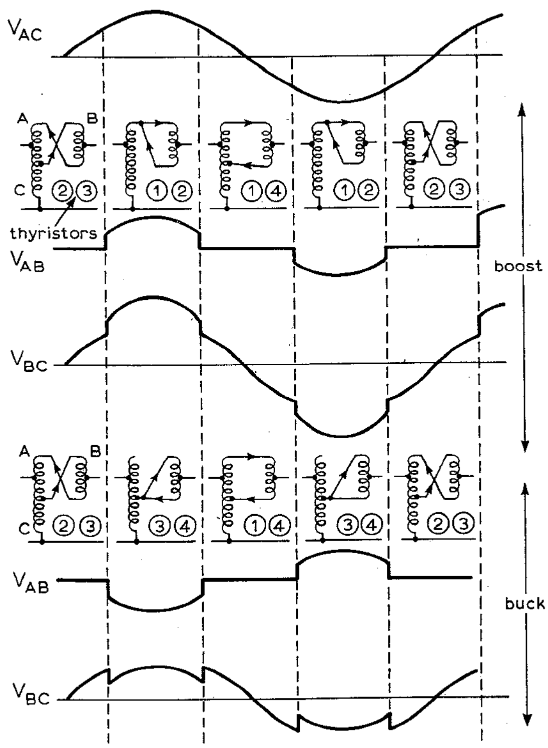


Fig. 11. Regulator switching sequence

Balanced 3-tap regulators

A regulator circuit which can operate over a very wide range of power factor loads is shown in Fig.10. A centre-tapped inductor has been included in the output circuit of the thyristors. This inductor is connected between the thyristors which could otherwise cause tap-to-tap short circuits due to faulty triggering on very reactive loads. Apart from eliminating this particular problem, the inductor also acts as an auto-transformer and effectively provides a third tap on the transformer balanced between the other two. In order that the inductor should present no significant impedance in series with the supply, the current taken by the load must always be able to split evenly between the two halves of the coil. The circuit can satisfy this condition with only four thyristors if a direct current is maintained through the inductor. This current acts as a bias current through the conducting thyristors and in effect allows the load current to flow in either direction through them. Provided the direct current is greater than half the peak load current the load will never determine the time at which a thyristor is extinguished. It will be shown later that control of the circulating current and control of the output voltage are not mutually exclusive.

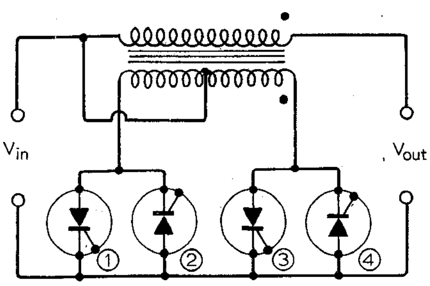


Fig. 9. Circuit arrangement to operate thyristors under high voltage and low current conditions.

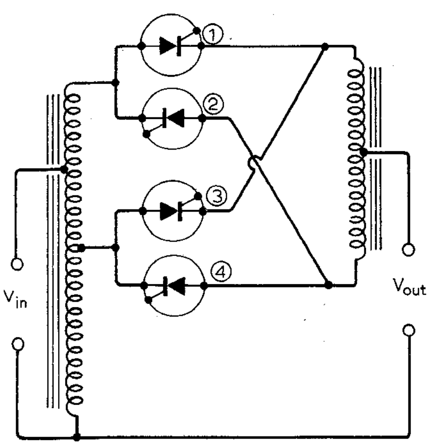


Fig. 10. Balanced three-tap regulator circuit.

Fig.11 illustrates the basic switching sequence of the regulator. The simplified circuits show how the inductor is connected at various times in the cycle (the numbers refer to which thyristors of Fig.10 are conducting). For some time around the centre of each half cycle, the inductor is short circuited and connects the load to the potential of the upper transformer tap, for boosting, or the lower tap for bucking. When the inductor is connected across the taps it behaves as an autotransformer and the output potential is the mean of the two tap voltages. This is equal to the supply voltage if the supply is connected to the transformer midway between the taps. A comparison of the switching sequence shown in Fig.11, with the circuit diagram of Fig.10, will show that commutation from one thyristor to another is obtained simply by triggering the thyristor which must be brought into conduction. For instance, the first transition shown in the boost sequence in Fig.11 involves turning on thyristor 1 and turning off 3. Triggering 1, which will be forward biased at this time, will result in reverse biasing 3. Similar action occurs at all transition in either boost or buck sequences and no additional components are necessary for commutation. It will also be seen that the difference between boosting and bucking is whether 2 is fired before or after 3 on negative half cycles and 1 before or after 4 on positive half cycles. Thyristors 1 and 2 cause transitions in the positive and negative half cycles respectively at similar points in the waveform. Thyristor 2 is already conducting (boost sequence) or reverse biased (buck sequence) when 1 is triggered. In the same way 1 is either conducting or reverse biased when 2 is triggered. Consequently, a common trigger pulse repeating every half cycle may be used for both thyristors. Similar common triggering may be used for thyristors 3 and 4.

The control of output voltage and circulated current is illustrated in Fig.12. The waveforms in (a) show typical boost and buck cycles and it can be seen that the inductor voltage has the same form for either of these conditions. The mean value of this voltage and the inductor winding resistance determine the circulated current. By moving forward both transitions in every half cycle the mean voltage across the inductor is increased, thus increasing the current. This action is shown in (b) and it can be seen that the output voltage is not substantially affected by this change. (The change in waveform symmetry has been exaggerated.) Fig.12 (c) shows the control of output voltage. For this, the two transitions are moved symmetrically about the centre of the half cycle and so do not greatly alter the mean voltage across the inductor. Circulating current and output voltage may thus be regulated with reasonably low interaction between their control loops.

When the supply voltage is near its nominal value, the two transitions coincide and little distortion will be added to the output waveform. The exact voltage at which this happens is determined by the voltage range to be regulated. As the supply voltage decreases, transitions must move further to compensate given changes in voltage. A regulator giving minimum distortion with nominal input will control larger changes in supply voltage above nominal than it can below nominal. Fig.13 shows distortion measured at the output of balanced 3-tap and 2-tap regulators (13(b) and 13(a) respectively) designed to regulate over similar voltage ranges. It can be seen that the regulation range is substantial and distortion would obviously decrease if the regulators were designed for smaller variations in supply voltage.

While the mean voltage across the inductor must be maintained reasonably constant, the alternating voltage across it varies considerably with changes in supply voltage. With a nominal input level, the inductor is continuously connected across the supply, its connections being reversed every half cycle. When the supply voltage is at either extreme of the regulator control range, the inductor will be short-circuited for a large part of each half cycle. The ripple current in the inductor will therefore alter considerably with the supply voltage, and the control circuit must ensure that the minimum instantaneous value of current is always greater than one half the peak load current. If the inductance is chosen on the basis of minimizing the peak energy in the inductor, its value is given by: $L=\frac{2V}{\Omega I_L}$ where I_L is the peak load current, V is the peak voltage across the inductor and Ω is the supply radian frequency. As the load current should always divide between the halves of the inductor winding, it will not contribute to the energy stored in this element.

The balanced 3-tap circuit provides full regulation for any load power factor and produces an output waveform substantially better than that obtained by a 2-tap regulator. The price paid for this improved performance is a reduction in the load volt-amp rating for a given thyristor and transformer cost, (or alternatively a reduced regulation range). The effect on the ratings depends on the exact nature of the load to be accommodated and the design adopted for the inductance. For a given cost, the balanced 3-tap circuit will handle about half the load volt-amps that the 2-tap circuit will.

A control circuit for the balanced 3-tap regulator must be capable of generating two separate trigger pulses in a sequence repeating every half cycle. (It was explained earlier that thyristors may be triggered in pairs.) These two pulses must move symmetrically about the centre of each half cycle to control output voltage and move asymmetrically to control circulated current. The elements of a circuit which provides this action is shown in Fig.14. The two pulses are produced by Shockley diodes D_2 and D_4 discharging ramp generators C_1R_1 and C_2R_2. The time taken for a capacitor voltage to reach the breakdown level of its associated Shockley diode is set by the time constant and aiming potential of the CR circuit and by the level to which the capacitor is reset after each pulse. Each time that C_1 is discharged, diode D_3 conducts and rapidly resets the capacitor to the voltage level of Tr_1 collector. D_3 then turns off and the capacitor voltage continues to rise at a rate set by the current through R_1. A synchronizing pulse occurring at supply voltage zero crossings discharges C_1 to zero each half cycle via diode D_1. The collector voltage of Tr_1, by resetting C_1 through D_3, controls the delay between the end of the synchronizing pulse and the generation of an output pulse at A. Further pulses which may be produced by D_2 before the next synchronizing pulse will not affect the regulator action since they cannot cause the firing of any thyristor. It can be seen that pulse circuit B operates in a similar manner and

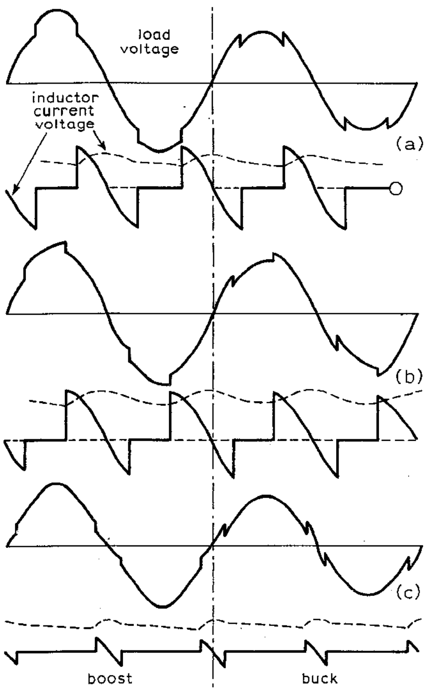


Fig. 12. Control cycle of voltage and current.

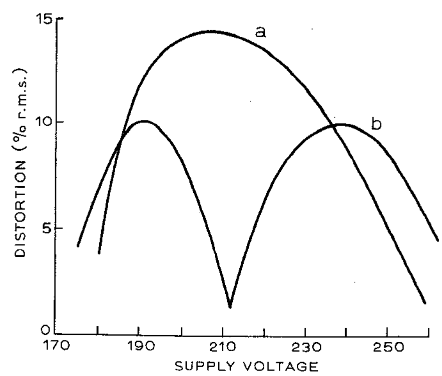
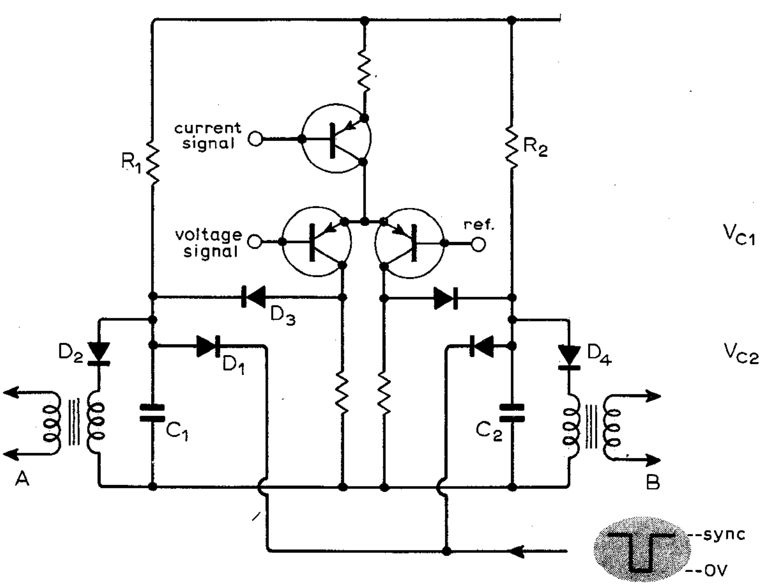


Fig. 13. Output distortion characteristic.



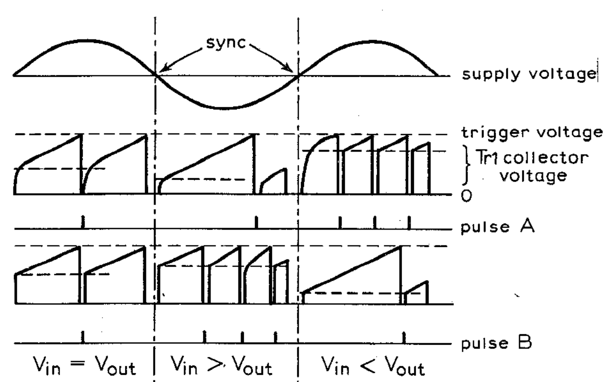


Fig.14. Regulator control circuit

is controlled by Tr_2 collector voltage. The circuit waveforms for the condition $V_{in} = V_{out}$ show that Tr_1 and Tr_2 collectors reset C_1 and C_2 to the same level and pulses at A and B both occur at the centre of each half cycle. If the "voltage" signal to the differential amplifier is altered, the voltages of the two collectors move in opposite directions causing the pulses at A and B to move in opposite directions. For $V_{in} > V_{out}$ pulse B leads A and for $V_{in} < V_{out}$, A leads B. Changes in the "voltage" signal therefore produce the symmetrical movement of pulses which is required to control the regulator output voltage. By varying the "current" signal, the amplifier tail current is altered and the two collector voltages are made to change in the same direction. This causes the two pulses to move in the same direction and alter the circulating current by unbalancing the output waveform. If the current control signal is derived by directly measuring inductor current, both halves of the winding must be monitored so that voltages due to load current can be cancelled. Alternatively, a signal may be derived from the magnetic field of the inductor which will be independent of load current.

General points on thyristor regulators

The characteristics of thyristors and triacs are normally well described in manufacturers' data. However it is worth noting a a few general points with regard to their use in a.c. voltage regulators.

High rates of rise of current through the thyristors during the time that they are being brought into conduction can lead to device failure. In the regulator circuits which have been described the leakage inductance of the transformer will normally provide adequate protection. This should be checked and it is also important to ensure a high level of trigger current during this switching time.

High rates of change of voltage across the thyristors can cause spurious triggering. Step changes of voltage occur across the devices due to the normal operation of the regulator and in addition transients on the supply can also cause sharp changes. Because of this it is advisable to shunt the thyristors by *RC* circuits as shown earlier in Fig.7. It should be remembered that such shunting increases the initial rate of rise of current through the thyristors.

The shunting of the thyristors by *RC* circuits is beneficial in two other respects. Some protection is provided against excessive voltages appearing across the thyristors due to short duration transients such as those caused by switching of the supply or load. Also the slowing of the change in voltage provides an output waveform with a much lower level of radio frequency harmonics.

The difficulty associated with radio frequency interference will of course depend on the application. A good metallic screen for the regulator housing with a balanced choke-capacitor circuit on the output will be adequate for most applications. One thyristor manufacturer recommends that for domestic situations radiated interference will be satisfactory if the rate of change of current in the supply wires is kept below 0.35 A/μs. This will normally require an inductance of a few hundred microhenries.

Finally it is worth making some comparisons between thyristor regulators and the most commonly used alternative, the ferro-resonant constant voltage transformer. Such a comparison can only be made in very approximate terms since aspects such as cost will be highly dependent on the precise requirements — see Tables below. The cost quoted for the thyristor regulator represents a likely production cost of a 2-tap circuit. It should also be remembered that although both forms of regulator carry out a similar task, that of providing a stabilized a.c. voltage, there are important differences in their detailed characteristics. In particular circumstances these detailed differences may be very important and override other considerations. For instance where it is important to minimize weight, the thyristor regulator is an almost automatic choice. Where frequent load short circuits occur the ferro-resonant transformer may have to be used.

TABLE 1
Performance characteristics

Characteristic	Thyristor Regulator	Ferro-resonant transformer
Input voltage range	± 20%	± 15%
Stability of output voltage (for full change of supply voltage and load current)	± 2%	± 3%
Overload protection	Fuse	Can handle continuous short circuit.
Output distortion	< 15%	Approximately 20%

TABLE 2
Weight and cost comparisons

Rating	Thyristor Regulator		Ferro-resonant transformer	
	Weight	Cost	Weight	Cost
500 VA	14 lbs	£25	45 lbs	£33
1000 VA	20 lbs	£35	85 lbs	£65
1500 VA	28 lbs	£50	120 lbs	£100

Books Received

Nomographs for Electronics — Instant calculations for designers by Robert L. Peters, Ph.D. is a collection of nomographs covering areas from basic electrical circuitry to supporting systems components such as motors and generators. The nomographs are for use by engineers, students and technicians to determine the characteristics of electronic circuits and the values of their components. Before presenting the nomographs for each subject area, the author provides a summary of the theories involved, followed by instructions explaining how each nomograph is used. The subject areas covered include a.c. and d.c. networks, semiconductor devices, valves, filters, relays, passive devices, transformers, generators, motors, servosystems, instrumentation, and aerials. Most of the nomographs are of the simple linear-alignment variety to increase accuracy and reduce the chance of error. Price £11.25 (incl. p/p). Pp.276. Cheques and money orders payable to Business Books Centre Ltd, should be sent to Wireless World, Room 23, Dorset House, Stamford Street, London SE1 9LU.

Simplified Statistical Analysis — handbook of methods, examples and tables by Harry H. Holscher is designed to help the reader get the maximum amount of information from a minimum amount of experiment and effort. It should be particularly useful for engineers, managers, scientists, teachers or social scientists who need to do statistical analysis. The author provides methods of analysis, 107 examples, 122 tables and 39 graphs. In the case of worked examples, graphic or tabular visual presentation is used in preference to complex mathematics. Chapter headings include: the principle of randomization; planning of experiments; analysis of experimental data and comparison of sets of data for significant differences or for precision in measurement. Price £6.20 (incl.p/p). Pp.235. Cheques and money orders, payable to Business Books Centre Ltd, should be sent to Wireless World, Room 23, Dorset House, Stamford Street, London SE1 9LU.

Television Engineers' Pocket Book by P. J. McGoldrick (6th edition) has been necessitated by the dramatic change that has taken place in broadcasting following the introduction of colour transmissions. It is hoped that this edition will provide all the information that the TV engineer requires, whether he is servicing a monochrome or a colour receiver. In addition to the general revision and updating of the book, a considerable amount of new material has been added particularly on the subject of receiver circuitry and colour, integrated circuits and servicing. The aim has been to provide all concerned with, or interested in, the installation and servicing of modern television receivers with a useful summary of basic facts, circuit techniques and technical data for everyday reference. Price £2.50. Pp.372. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

Beginners' Guide to Colour Television (2nd edition) by Gordon J. King has been completely rewritten by the author and will be of value to all those who wish to understand how and why a colour TV works. Chapter headings include: historical outline; colours and signals; pictures and signals; complete signal; PAL signal; colour transmission; the PAL receiver; SECAM basics. Price £1.95. Pp.189. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

Circards — 8

Astable circuits

*by J. Carruthers, J. H. Evans, J. Kinsler & P. Williams**

Many circuits generating periodic rectangular waveforms depend on changing the charge on a capacitor. This rate of change of charge is frequently determined by an *RC* circuit, which inherently produces exponential waveforms when connected to a voltage source (Fig. 1). Such waveforms may be used to control the switching on and/or off instants of an active device.

An astable multivibrator using discrete components is a commonly occurring example of a circuit employing this principle (Fig. 2). This uses two transistors, cross-coupled via capacitors C_1 and C_2. Normally this circuit has no stable states (they may be called quasi-stable states), but switches alternately from the one state of Tr_1 saturated, Tr_2 off, to the state of Tr_2 saturated, Tr_1 off. For a given value of V_{CC}, the rate of switching depends on the time constant C_1R_4, C_2R_3, and on the potential to which the base resistors R_3 and R_4 are returned. The more conventional configuration will return R_3 and R_4 to the $+V_{CC}$ rail to give a period independent of rail voltage.

Fig. 3 shows that the output rectangular waves available at the collectors are in anti-phase, and their mark-to-space ratio may be varied by adjusting the C_1R_4 and C_2R_3 time constants. Some astables are attractive due to the small number of components required, but they might be considered to have certain disadvantages. The use of a single *CR* network gives an output waveform having a non-unity mark-to-space ratio which may be difficult to closely control. Also a second anti-phase output is not available. A circuit using a single capacitor that overcomes these objections to an extent is the emitter-coupled astable of Fig. 4. In this arrangement, two emitter resistors are used to allow independent adjustment of the mark and space times of the two output waveforms.

Another group of astable circuits apparently different from each other fit into the form of the general bridge network shown in Fig. 5. The amplifier block is provided with two external networks. One network, providing negative feedback, ensures that the d.c. conditions in the amplifier are such that it sits near the middle of its operating region

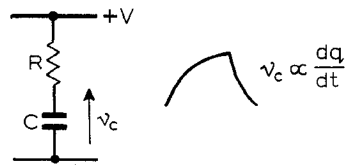


Fig. 1. Series RC produces an exponential waveform across the capacitor.

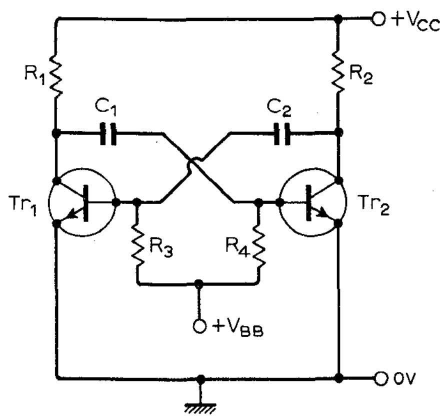


Fig. 2. Basic astable multivibrator. Variation of V_{BB} changes the period.

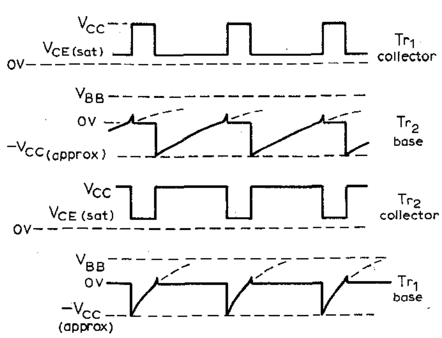


Fig. 3. Waveforms encountered in the circuit of Fig. 2, where C_1R_4 is longer than C_2R_3.

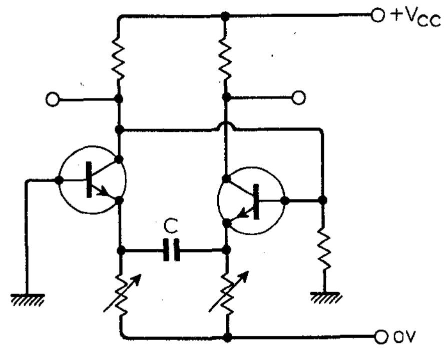


Fig. 4. A single-capacitor astable multivibrator providing mark-to-space ratio adjustment and antiphase outputs. Circuits using one capacitor are normally less flexible.

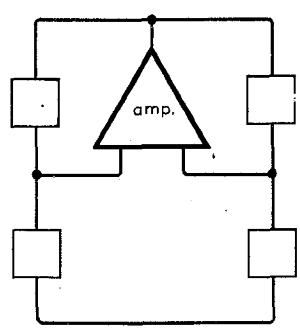


Fig. 5. Basic diagram of the group of oscillators using both positive and negative feedback. The circuit is seen to be a bridge network with a sustaining amplifier.

* All at Paisley College of Technology.

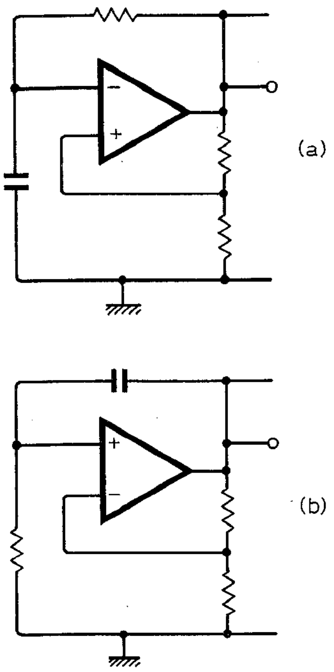


Fig. 6. Two possible combinations of feedback types using a single differential amplifier.

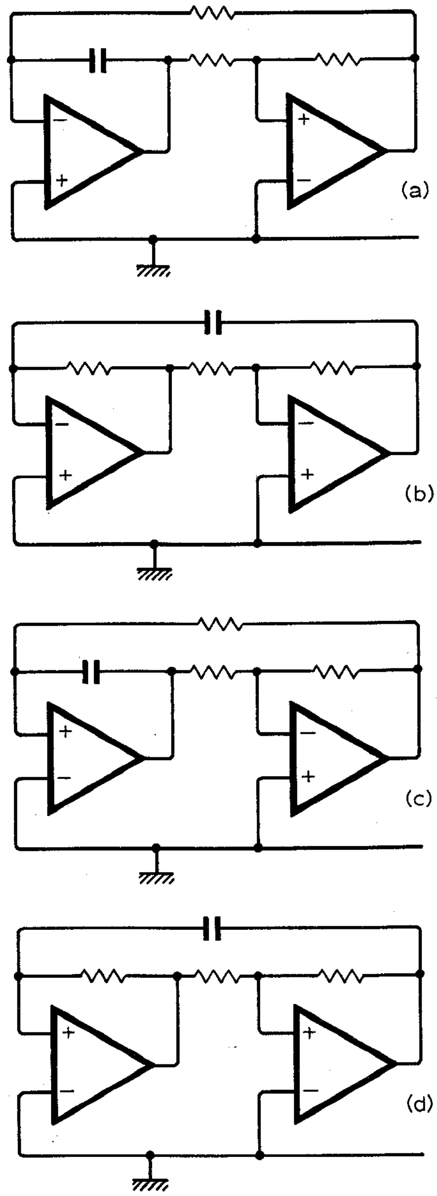


Fig. 7. Four combinations of RC feedback and amplifiers used in the single-ended mode.

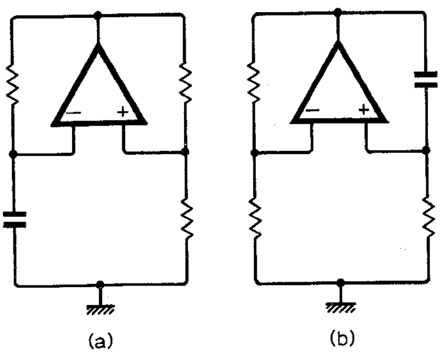


Fig. 8. Circuits of Fig. 6 redrawn to show that they conform to the general bridge circuit of Fig. 5.

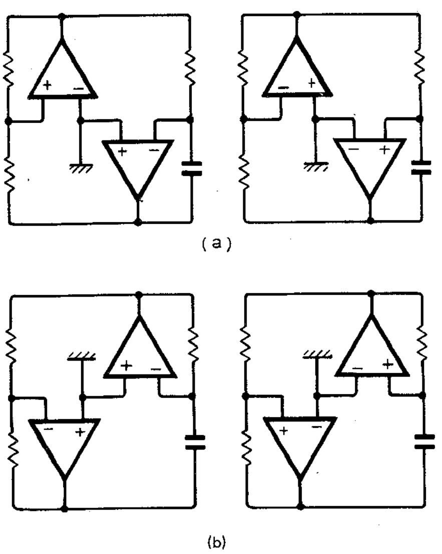


Fig. 9. The four twin-amplifier circuits are also examples of the general bridge circuit.

where the gain is high. The other network, which provides positive feedback, forces the amplifier to switch between two distinct states. This amplifier block may comprise either a single differential-input amplifier or two single-ended types. In conjunction with the different combinations of feedback components, this leads to the apparently different configurations shown in Figs. 6 and 7. These circuits have been redrawn in Figs. 8 and 9 respectively to show their relationship to the bridge arrangement. Circuit 7(d) does not operate as an astable because it will permanently latch into one state, since positive feedback is applied across each single-ended amplifier.

The output waveform from an astable multivibrator is not necessarily rectangular. A self-retriggering action can be obtained by using an electronic switch to discharge a capacitor when its potential exceeds a preset d.c. bias which holds the switch open.

To provide circuits compatible with logic levels, many astables operate in their saturated mode to give well-defined voltage limits. This is achieved at the expense of the switching rate, but may be avoided by the use of current mode switching techniques.

Other applications demand long periods with accurately defined transition times, and this requires high stability passive components. Reasonably small value but stable capacitors can be used in conjunction with field-effect transistors to provide the long time constants necessary. It should be remembered that if an astable multivibrator has good frequency stability, it may prove difficult to synchronize it from an external source.

The reader will have noted that inductive timing elements are conspicuous by their absence. The reason behind this is that, in comparison with capacitors, inductors tend to be more costly and physically larger. One type of inductively coupled circuit worthy of mention is the astable blocking oscillator, which is capable of producing output pulses having a very small mark-to-space ratio.

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The Realm of Microwaves

4. Microwave integrated circuit technology and lumped element design

by M. W. Hosking, M.Sc.*

Five years ago, hybrid microwave circuit design existed mainly within the laboratory and there were very few examples of production-standard circuitry. Now, most companies engaged in microwave subsystem design have experience of microwave integrated circuits and their commercial applications have been, and still are, rapidly increasing. For this to happen, four basic things were needed:

—an accurate design theory
—a high-definition pattern technology
—a ready supply of consistently high-quality substrate materials
—availability of semiconductor devices in suitable and well-defined encapsulations.

This pre-supposes that sufficient potential exists to make all the effort worthwhile and the incentive has been the saving in size and weight possible with this type of circuitry. In particular, emphasis has been placed on lightweight receiver design for satellite and airborne installations and on the high-volume application in phased-array radar.

When referring to microwave i.cs, the type of transmission line inferred is the microstrip form described in the March and June installments. That is, a high dielectric-constant substrate metallised on one side to form a ground plane and with the microwave components defined by suitably shaped conductor patterns on the other side. The microwave electromagnetic field is largely confined to within the substrate, the properties of which thus become of great interest.

Apart from lumped elements, dealt with later in this article, the passive components used are of the same order of size as the microstrip wavelength. This means that inductances, capacitances and resonant circuits can be produced by discrete lengths of transmission line. Also, abrupt changes in the linear dimensions of the line produce local disturbances of the field and have the effect of reactive elements.

Microwave design theory is thus much more complex than that used at lower frequencies and is particularly so in the microstrip form of circuit. The significant theoretical advances made have now enabled the first-listed condition to be satisfied, especially for the cases of coupled pairs of lines and the deduction of equivalent circuits for various transmission line discontinuities.

Fabrication of microstrip conductor patterns has benefited from mask-making and etching techniques already in existence in the vacuum deposition and i.c. fields. These techniques have been capable of direct application to microwave i.cs with the result that very little development work has been necessary, together with little modification of existing equipment.

The overall requirement is for consistently accurate linewidths and spacings together with fine edge definition. This last condition depends on the metallization thickness, method of production and the surface finish of the substrate. As well as good surface finish, the substrate must also be dimensionally accurate and have a well-defined and consistent dielectric constant together with low loss.

Thanks to the steadily increasing demands for substrates, more suppliers are marketing materials with well-enough controlled properties; whereas previously the circuit designer had to cut, grind and polish his own materials. Finally, demand has tended to create the supply of semiconductor devices in package forms suitable for bonding to the high-dielectric constant substrates. There is now a large variety of styles, well defined as to their parasitic reactances and capable of being handled by existing hybrid equipment and bonding methods.

Skin effect

When a steady current flows through a conductor, it is distributed uniformly throughout the conductor's cross section. However, under alternating conditions, there is a tendency for the current to concentrate near the surface, resulting in an uneven distribution. Moreover, as the bulk of the current flows in a more restricted space, the effective resistance of the conductor is increased from its d.c. value and keeps on increasing as the frequency is raised.

Starting from the surface, the current density decreases exponentially towards the centre of the conductor and the distance at which its value has decreased to $1/e$ ($e = 2.7182$) of its surface value is called the skin depth. At this point, incidentally, its phase lags behind the surface phase by one radian.

Skin depth is inversely proportional to the square root of both frequency and conductivity and can be very small in the microwave region, resulting in high current densities and high resistive losses. These losses become severe if the conductor thickness is less than the skin depth and conductor patterns on microstrip line are usually made four to five times the skin depth. Fig. 1 shows the relationship between skin depth and frequency for some commonly-used microwave conductors, based on the equation

$$\text{skin depth, } d = \left(\frac{1}{\pi f \sigma \mu}\right)^{\frac{1}{2}}$$

where f is frequency, σ conductivity and μ the absolute permeability of the materials given by $\mu = \mu_0\mu_r$. To compare conductor losses, the surface resistivity R_s is often quoted and this is the resistance of a square section of conductor one skin depth thick.

Why should the current concentrate near the surface, just because the frequency is

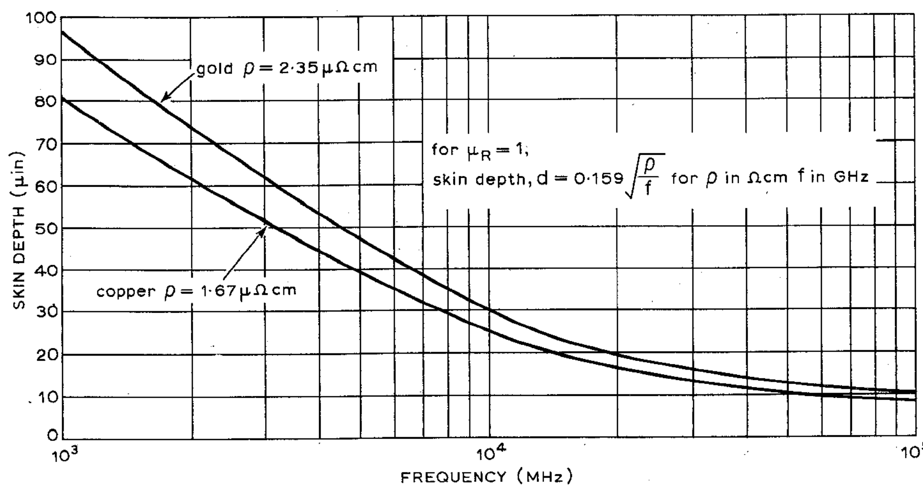

Fig. 1. Skin depth indicates extent to which h.f. current penetrates the conductor. To minimize resistive loss the conductor thickness should be several skin depths.

*British Aircraft Corporation

increased? Taking the flat strip case drawn in Fig. 2, there will be lines of magnetic flux associated with a current flowing in the strip. This gives rise to inductive effects because an inductance is produced by flux-linkages and is directly proportional to the number of such linkages.

Current near the centre of the conductor is encircled by more lines of magnetic flux than is the current near the ends of the strip and so the centre of the strip has a higher inductance than the surface. As the frequency increases, so too does the inductive reactance of the conductor, with the result that the centre has a higher impedance than the sides. So, taking the path of least resistance, the high-frequency current concentrates near the surface; in this example, most current is at the edges.

If the conductor were circular in section instead of a strip, then the current would be evenly distributed around the surface; implying that not only must the electrical properties of a conductor be taken into account, but so must its geometry.

Now you know why a good surface finish is required from a microwave i.c. substrates.

Substrate materials

The number of materials suitable for general microstrip and microwave i.c. usage is really quite limited. To keep circuits small, a high dielectric constant is desirable, but this is kept from being too high by the present capabilities of line-definition technology. For, as the dielectric constant increases, then so must the substrate thickness decrease to prevent the exitation of higher-order modes. This in turn means that, for a given impedance, the linewidth must reduce proportionally, hence the limit.

A low dielectric loss is a further requisite which, together with providing both a good surface finish and good adherence for conductors, severely limits the range of suitable materials. The table lists the four types of substrate generally used, in order of popularity, together with some relevant properties. Alumina has become the standard substrate and can be obtained now from many vendors. Although almost any shape and size can be made, dimensions in multiples of $\frac{1}{2}$ inch and a 0.025 inch thickness have become stock sizes. The alumina can be obtained in a range of purities, typically between 94% and 99.9%, with 99.5% being the preferred compromise between the electrical and mechanical properties.

Sapphire is capable of yielding a better surface finish than alumina, enabling a better line definition to be obtained and giving slightly lower conductor losses. But, apart from its use at the higher frequencies,

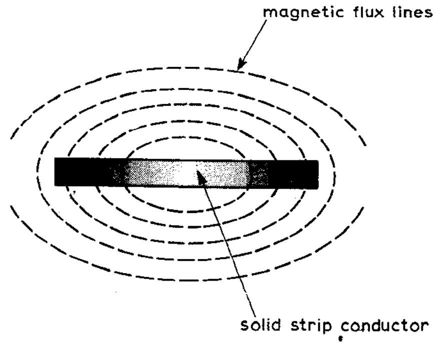

Fig. 2. Current flows nearer to surface because of lower inductive reactance in this region, but conductor geometry plays a part as indicated by the flat strip.

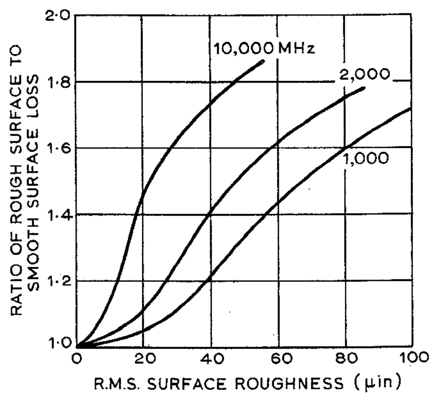

Fig. 3. Surface roughness is important and increases conductor loss. Good-quality microwave i.cs have a surface roughness better than 5μin.

above about 20,000 MHz, where such factors have more significance, it is seldom used in place of alumina for microwave i.cs.

However, for lumped-element circuits, wherein component dimensions tend to be smaller and the detail finer than in microwave i.cs, sapphire is often used for the substrate. In cases where a very thin, say 0.005–0.010 inch, substrate was required, sapphire would be preferred because of the strength afforded by its crystalline structure, as opposed to the sintered structure of alumina. Ferrite substrate is steadily gaining in application as a dual-purpose medium: acting as a normal transmission line and also one whose properties can be locally varied by applying a magnetic field.

In this way, components like isolators, circulators and phase shifters can be produced on a continuous substrate. The widely-used alternative is to cut a hole in the alumina or sapphire circuit and insert a piece of ferrite material to produce such components; but this involves a high degree of mechanical skill and extra electrical design complexity in compensating for the abrupt change in dielectric constant. Fused quartz is not so widely used as the other materials, partly because of its higher loss, but it finds application when a low dielectric constant is required together with a high-temperature capability. Because of its good surface finish it is also used as a lumped-element substrate. Finally, beryllium oxide is used only when all else has failed and then only for its superior thermal conductivity, which is a factor of 10 better than alumina. This makes it suitable for the heat-sinking of high-power devices—usually transistor chips—but the material needs special handling due to the health hazard from BeO dust.

Conductor technology

Three main properties are required of microwave i.c. conductors:

—good adhesion to the substrate
—low resistivity
—easily bonded to the active devices

and there are two different processes used to produce the conductors themselves: thick film and thin film. In the thick film process, the conductor consists of a proprietary mixture of metal powder, glass and binders in ink form which is screen-printed onto the substrate and then fired. From the skin-effect loss considerations mentioned previously, the conductor thickness is made at least 4–5 skin depths. It is best to keep the conductor thickness as small as the skin depth limit permits in order to obtain better line definition and freedom from under-cutting. Also, once the thickness becomes more than about 1% of the substrate thickness, it starts to noticeably influence the electromagnetic fields and so must be taken into account during circuit design.

The thin film process implies vacuum deposition of the conductor material by such standard methods as evaporation and sputtering. Silver, copper and gold are the most often used metals but, unfortunately, these do not adhere very well to the substrates.

Adhesion can be improved by using a coarser surface finish: giving more of a mechanical bond to the film, but this is not the only consideration. Surface roughness interrupts the conductor skin current and, especially transversely to the current flow, will cause eddy current losses. These can increase the theoretical loss very substantially at microwave frequencies as can be seen from Fig. 3. A 20 microinch finish at 1,000 MHz gives about 5% extra loss, but this has increased to 45% at 10,000 MHz.

This band represents the portion of the spectrum in which most work to date on microwave i.cs has concentrated. So, at the higher end, a surface roughness of 5 microinches or less is required. In addition to the increase in conductor loss, surface roughness sets a limit on the attainable line and spacing definition. Exact correlation is difficult, as processing "technique" plays a part, but one would not expect good line-spacing definition below about 10 times the r.m.s. surface roughness.

From these considerations, surface roughness is not used to improve the adhesion of thin films. Instead, a chemical bond can be formed by vacuum depositing

Properties of substrates

Substrate	Tan δ at 10,000MHz	ε_r at 10,000MHz	Thermal cond ($Wcm^{-1}\,^{\circ}C^{-1}$)
alumina	2×10^{-4}	9.7	0.2
garnet ferrite	2.5×10^{-4}	15.5–16.5	0.03
sapphire	2×10^{-4}	11.0	0.48
fused quartz	1.5×10^{-3}	3.78	0.09
beryllium oxide	10^{-4}	6.0	2.5

the film onto a substrate which has been previously coated with a metal oxide. Of course, this metal in turn must have good adhesion and an eminently suitable one is chromium. This is first deposited as a seeding layer about 200Å thick (1Å = 10^{-8} cm) onto which is then evaporated the main conductor. It is not generally satisfactory, due to film stresses and definition problems, to build up the full conductor thickness by vacuum deposition. Instead, a nominal thickness, sufficient to cover the peaks in the surface roughness, is deposited and then the remaining material is formed by a normal electroplating process. If the microwave i.c. were for use at 1,000 MHz, with gold as the conductor, then the skin depth is 100 microinch or 1/10 of a thou. This much might be applied by vacuum deposition and subsequently built up to five skin depths, $\frac{1}{2}$ a thou., by plating.

Gold is used as the top metal because of its non-tarnishing properties which, in turn, enables good bonds to be easily made with active devices. Copper and silver, though, have slightly better electrical conductivity, but are easily tarnished and more difficult to bond. So, while the Cr-Au system is most commonly used, slightly lower conductor loss can be obtained by a Cr layer, followed by deposited Cu, plated up with more Cu and topped off with a flash of Au for bonding.

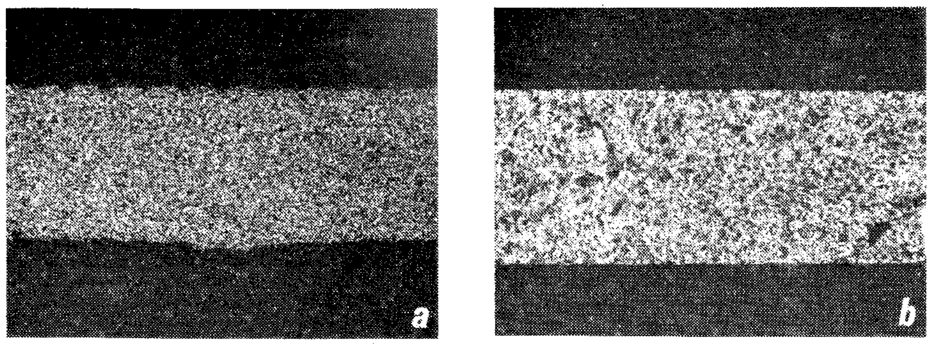

Fig. 4. Comparison of (a) an high-quality thick-film gold line and (b) a thin-film photo-etched one, both on alumina substrate. Mesh size limits edge definition of the thick-film line which is about 0.020in wide. The thick-film line was provided by J. R. Corkhill of R.A.E.

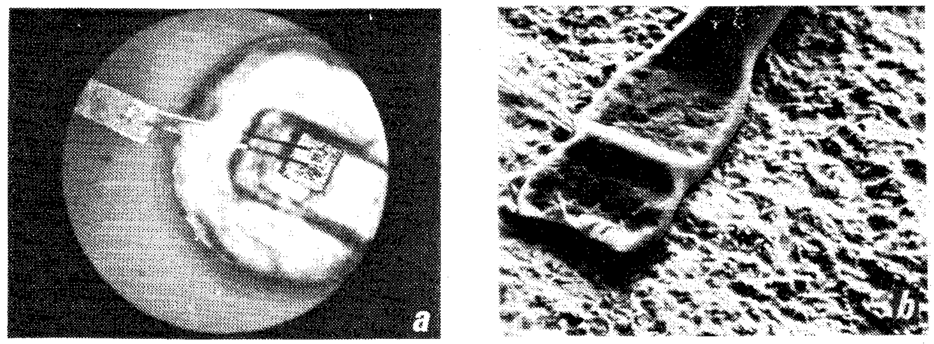

Fig. 5. Photograph is of a 0.001-in dia. aluminium wire, ultrasonically bonded to a semiconductor chip, (a), and an electron microphotograph of a similar bond (b).

Producing the conductor pattern

Using either the thick or thin film process, there are two methods of defining the actual microwave circuit pattern: it can be formed directly on the surface, or it can be etched out from a completely covered substrate.

The former method involves production of a mask through which the conductor is either screen printed or evaporated and the latter can be carried out with conventional photo-etching techniques. The direct method is more suited to thick films, as the fired inks are more difficult to etch accurately and it is not used very often with vacuum deposition because of the definition problems in building up the thick metal.

In the other, photo-etching process, the required circuit is first of all drawn say 20 times full size using an opaque tape on a transparent background. With care, the dimensional accuracy can be kept better than 0.020in, so that on completion of the next stage, which is photographic reduction to a full-sized negative, the error reduces to 0.001in. By taking additional time, trouble and mechanical aid within a controlled environment, accuracies considerably better than this can be obtained.

The substrate, completely coated with metal, is then covered with photoresist, usually a u.v.-sensitive type, and dried. The negative is then laid on top, emulsion side down to avoid shadowing, and exposed; with the result that the clear areas, representing the conductor pattern, allow the light through to chemically cross-link the resist. These exposed areas are now resistant to solvent attack and remain fixed to the metal while the remainder of the resist is washed off. Thus, in the next stage, which is etching, all of the conducting metal will be removed apart from those areas protected by the resist. If it was decided to vacuum deposit the pattern then this process could be used to make the metal mask.

There are, therefore, two techniques which can be used to deposit the conductor pattern and two techniques for etching it away. Of the former, the thick film process has not been so widely used at microwave frequencies as the thin film, but improvements to the technology are steadily making it more popular.

The main disadvantage of the thick film process is the difficulty in obtaining fine edge definition, together with small linewidths and spacings of less than about 0.002in. This is partly due to the slightly porous nature of the fired inks, but mainly because of the finite size of the printing screen mesh. Fig. 4 gives an idea of the difference between a thick and thin film gold line on alumina substrate. It is, however, not unusual to find thick film resistors used with hybrid microwave i.cs either as the d.c. bias resistors for a transistor oscillator or perhaps in the i.f. circuitry of a receiver.

The thin film vacuum deposition process is at present the most popular one and there are the two methods open of forming the actual pattern. Of these, the photo-etching process is the one most widely used for the following reasons: during prototype development, having to re-design a metal mask is more costly and inconvenient than producing another photograph; finer definition can be achieved with etching; definition can be lost during the plating-up stage of a mask-deposited pattern.

In summary, microwave i.cs are formed on the substrates listed in the table by photo-etching the conductor patterns from a vacuum deposited film, then plated up to several skin depths in thickness. The difference between low frequency printed circuit design and microwave i.c. design is largely a matter of degree. In the latter, everything is of great importance electrically: the dimensional accuracy and purity of the substrate and conductor as well as dimensional accuracy of the circuit pattern.

Device bonding

In response to the increasing use of hybrid circuits, semiconductor manufacturers have widened their range of encapsulations in which the active devices can be bought. The area in which this was most needed was for package styles suitable for series-mounting with a microstrip line. Shunt-mounting is necessary for good heat-sinking, but involves drilling holes through the very hard substrate and is to be avoided when possible.

Package styles now available vary from just the chip itself, which might be a 0.015in cube with metallization on two sides, to the beam-lead type shown in Fig. 7(b) of Part 3 and on to various low-profile, hermetically sealed packages with flying leads. A widely used method of attaching the active devices to the substrate is thermo-compression bonding and can be used for fixing both the chips and the leads. Once again, this particular technique was already in use with the low frequency i.cs and did not have to be specially developed for microwave i.cs. For the bonding of a chip, the substrate with the etched-out conductor pattern is heated to about 320°C and the gold-plated side of the chip is pressed down in contact with the gold-plated conductor. Using a contact pressure of a few hundred grams, the two gold surfaces will fuse together to produce a good bond. The holder which carries the chip is often ultrasonically vibrated to "scrub" the two surfaces together and, when this is done, a slightly lower bonding temperature can be used. To attach a wire to the bonded chip, or to attach devices already possessing leads, to the substrate, thermo-compression bonding is again most commonly used. In this case, a probe either heated or unheated is used to press the lead and substrate together. The geometry of the probe tip is an important factor in the bonding process and ultrasonic vibration can be applied to permit the best compromise between bonding area, pressure, temperature and time to be made. An example of wire bonding is given in Fig. 5.

Lumped elements

Readers following this series will recall the general description of distributed microwave circuit elements in Part 3 and it has been the intention, so far, to emphasise the vast difference between the practical realization of a microwave circuit and that of its lower-frequency counterpart. Our earlier definition of the microwave spectrum indicated a wavelength range of 30cm to 1mm; so that, in a conductor system supporting microwave fields, this means that significant changes in phase can occur within quite a small physical distance. Thus, as we have seen, inductive and capacitive effects can be produced from a length of transmission line, as opposed to the discrete (or lumped) elements used at lower frequencies. Take, for example, a length of 50ohm microstrip transmission line on alumina operating at a frequency of 3,000MHz. We have seen that this requires a width to thickness ratio of unity, so that, using the effective dielectric constant given by Fig. 4 of Part 2, the transmission line wavelength is about 4cm. A distance of 1cm, therefore, represents a phase shift of 90°—sufficient to change an inductive reactance into a capacitive reactance. In a conventional electronic circuit though, operating at, say, 300kHz, the same distance of 1cm might be typical of the size of a resistor or capacitor. But the phase change across this component would be a negligible 0.0036° and would not affect its particular value of *R*, *C* or *L*. A lumped element, therefore, is one whose value does not change significantly with frequency; and what is considered as being significant must depend on the particular application.

Generally, lumped elements are smaller than about 1/40 of the transmission line wavelength. Conventional components start to show distributed effects above a few hundred MHz and they also become very lossy, so that different techniques must be used to produce the circuits. Fortunately, the higher the frequency, the smaller the value of inductance and capacitance necessary to produce a given effect and, at microwave frequencies, one is usually concerned with values of a few nH and fractions of a nH and a few pF and fractions of a pF.

Fabrication of the lumped elements is carried out using the photo-etching process to define the circuits on good-quality substrates. The technology used is most important as, in order to be competitive with distributed circuits, high *Q* factors and correspondingly low losses must be achieved. Inductors are formed from a length of narrow conductor ribbon as in Fig. 6(a) which, for inductances greater than about 1nH, can be extended into a planar spiral.

Single-layer capacitances can be formed from the etched conductor ribbon by an interdigital arrangement shown in Fig. 6(b), where use is made of the microwave fringing fields. This makes circuit processing simpler but, if a higher capacitance per unit area is required, then a three-layer metal-dielectric/metal sandwich can be used as in Fig. 6(c).

Lumped inductors

Any conductor possesses inductance, the value depending upon its geometry, and a commonly used formula for predicting the inductance of an etched strip is that given by F. E. Terman[15]. For a strip whose thickness is very much smaller than its width, the inductance per unit length is a function of the length to width ratio, *l/w*. If the operating wavelength were, say, 10cm (~4in), and the restriction that a component must be smaller than 1/40 of a wavelength were applied, then the permissible inductor length would be 0.1in. For a width of 0.010in the *l/w* ratio is 10 and, from the formula mentioned, the attainable inductance is 1.8nH.

If the conductor had been 0.005in wide, the inductance would have been about 2.6nH or, alternatively, the original inductance could have been obtained with a shorter strip. However, another factor must be taken into account before reducing the size too much and that is the inductor *Q*. This can be represented as the ratio of the reactance to the resistance and this resistance is the high-frequency value, which takes into account the skin effect.

It has already been shown that the skin effect increases the nominal d.c. resistance and is also a function of conductor geometry, the lowest resistance being obtained with a wide strip. In addition, the conductor thickness must be several times the skin depth. Theoretically, the *Q* factor of a lumped element inductor increases as the square root of frequency and this relationship is achieved in practice for a strip inductor at frequencies well into S-band (2,000–4,000MHz). Thereafter, the rate of increase of *Q* slows down as, for the same *l/w* ratio, the inductor becomes less "lumped". *Q* factors greater than about 50 are required in order to achieve element losses of several tenths of a dB and, by taking care with substrate and conductor, such values can be obtained at 1,000MHz, rising to a maximum of about 100 as the frequency increases.

So far, attention has been confined to the strip inductor but, for higher inductance values, this can be formed as a circular or square spiral such as that shown in Fig. 7. Provided that the outside dimensions meet the size requirements, such an element will still appear as lumped. Its inductance, however, will be less than that of a strip of the same unwound length, due to the mutual proximity of the turns. Once again, the highest *Q* factor results from wide strips which, for a given inductor size, results in

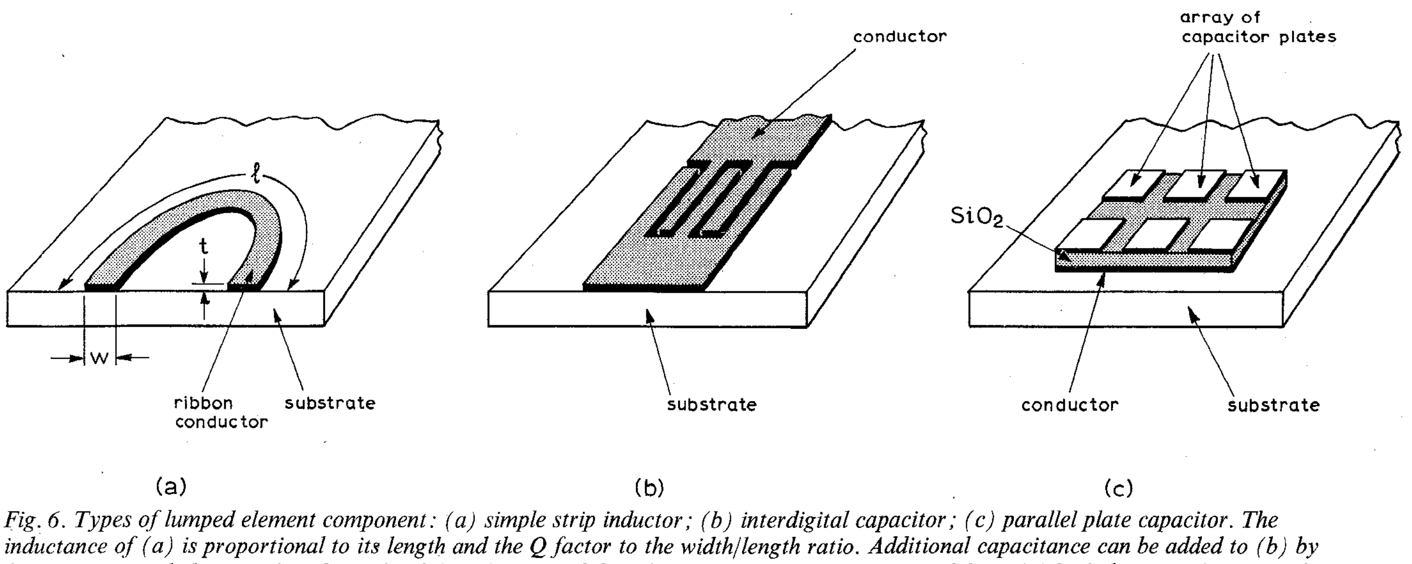

Fig. 6. Types of lumped element component: (a) simple strip inductor; (b) interdigital capacitor; (c) parallel plate capacitor. The inductance of (a) is proportional to its length and the Q factor to the width/length ratio. Additional capacitance can be added to (b) by forming a ground plane on the other side of the substrate, while a degree of tuning can be obtained from (c) by linking numbers of pads together.

small, inter-turn spacings of the order of 1 or 2 thousandths of an inch. Typically, circuits at L band (1,000–2,000MHz) or S band (2,000–4,000MHz) frequencies require inductances of less than 5nH, which can be produced by less than two turns.

However, when printed d.c. bias lines are also included on the substrate, it is necessary to provide an r.f. choke (low-pass filter) to keep the r.f. out of the bias circuit, and inductances of 20–40nH are commonly used. The inductance of Fig. 7 is of this type, having an inductance of about 20nH within an external dimension of 0.110in. Square or rectangular spirals have a higher inductance per unit area than their circular counterparts, but exhibit slightly lower Q factors.

Connection to the centre of multi-turn spirals can be made either by a conductor track deposited beneath the coil and insulated from it or by a bonded wire looped directly over the turns. In this way, some circuit tuning is possible either by shorting out part of the turns or by bonding to different parts of the spiral.

Capacitors

Capacitors can be produced by the thin-film, vacuum deposition technique in the two forms shown in Fig. 6(b) and (c). The interdigital capacitor is economical to construct as it involves no more processing steps than are normally used with microwave i.cs, that is, one plating and one etching operation. On the other hand, the parallel-plate capacitor involves the deposition and etching of both a dielectric layer and another conductor. The interdigital capacitance is produced by the r.f. fringing fields across the gap between fingers and means that, in order to achieve usable values, the spacing must be small. Typically, the finger gaps range from 0.0005in to 0.001in and, by also varying the number of fingers, capacitance values of up to 1pF are conveniently produced. Having to use such small gaps means that, for consistent results, great attention has to be paid to the substrate surface finish, conductor thickness and the photo-etching process. Values of capacitance less than 1pF generally find circuit application at frequencies into X band (8,200–12,400MHz) and this type of structure can still remain a lumped element at these frequencies. Should higher values of capacitance be required with this interdigital construction, a ground plane can be introduced on the other side of the substrate. This has the effect of producing a transmission line structure like microstrip and, indeed, is particularly suitable when lumped element and distributed element circuits have to be combined. Shunt elements of capacitance are produced, giving lumped element values of several pF.

Considerably higher values of capacitance can be produced by using the parallel plate type of Fig. 6(c); it does; however, involve additional deposition and etching. For compatibility with the vacuum deposition process, a commonly used dielectric material is silicon dioxide (S_iO_2), although this has its own problems in achieving a non-porous layer having good adhesion.

The capacitance of this type of structure is directly proportional to the area and, with a good quality SiO_2 film, one micron (40 microinches) thick, $0.022\mu F/in^2$ can be obtained. Thus, even a large r.f. bypass capacitor of, say, 40pF, is only about 0.040in square.

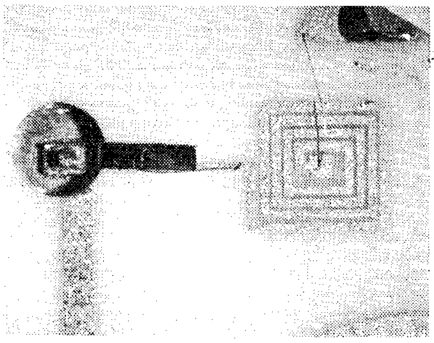

Fig. 7. For higher values of inductance, the simple ribbon can be wound into a spiral. This one is photo-etched on alumina and is about 0.1in square with 0.005in lines.

Within the range of frequencies so far mentioned, the Q factors of capacitors tend to be higher than those for inductors. In the case of the parallel plate and ground plane aided types, the losses due to the dielectric must be taken into account as well as those for the conductor. However, with good quality dielectrics, most of the loss can be attributed to the conductor material and the Q factor decreases with increasing frequency. At 1,000MHz, Qs of 1,000 or more can be achieved depending on technique, falling to 100 or less at 10,000MHz. The loss of these lumped elements compares well with the loss achieved in practice with distributed microstrip circuits and this is important when designing such circuits as amplifiers. High power transistors, for example, have low output impedances of a few ohms and, besides the inherent waste of power in the external circuit, the loss limits the degree of impedance matching, and hence power output, that can be achieved.

How far lumped elements will go towards replacing their distributed counterparts and at what frequency they cease to be practicable still remains to be seen. Much more work is required, particularly in the characterisation of stray circuit reactances and the mutual interaction of many elements. At the lower microwave frequencies, though, many successful designs of active and passive circuits have been made and, here, lumped elements can afford a considerable size reduction over even the microstrip form of distributed circuit.

Further reading

Parts 2, 3 and 4 of this series have dealt with the properties of several forms of transmission line, the formation of reactive elements and microwave i.c. technology. Attention has been deliberately focused on the topical microstrip circuitry to the (unashamed) neglect of the other types. To the best of my knowledge, there is no comprehensive textbook treatment of microstrip and microwave i.cs yet available. So, for those who would like to follow up the subjects in more detail, I provide the following list of important contributions to the technical literature, together with some more general microwave texts.

General

1. For a first-reader on transmission line theory and components, except for stripline and microstrip: "Introduction to Microwave Practice" by P. F. Mariner, Heywood & Co. Ltd, 1961. The appendix contains an excellent introduction to vector calculus and the formation of Maxwell's equations, culminating in the derivation of the waveguide field functions.
2. A detailed coverage of properties of waveguide and coaxial lines with the design of reactive elements is given in: "Microwave Transmission Design Data" by T. Moreno, McGraw-Hill, 1948.
3. "Microwave Measurements" by H. M. Barlow and A. L. Cullen, Constable & Co., 1950, is self-explanatary and provides a good coverage of transmission line fundamentals in addition to the measurements.
4. A worthy tome which covers the whole of the microwave field is "Microwave Engineering" by A. F. Harvey, Academic Press, 1963. Because of its vast range of contents, each topic is only briefly sketched, but a total of over 10,000 supporting references is provided. Much of the information on microstrip has now been superseded and, at the time the book was compiled, there was not the wealth of solid state devices that there is now.
5. For further details on filters and directional couplers, one can do no better than: "Microwave Filters, Impedance—Matching Networks and Coupling Structures" by G. L. Matthaei, L. Young and E. M. T. Jones, McGraw-Hill, 1964. This gives the basic theory and then the practical realization of the components in microwave form with the aid of numerous worked examples.

Stripline and microstrip

6. Much of the basic stripline theory is contained in a special issue of *I.R.E. Trans. on Microwave Theory and Techniques*, Vol. MTT3, March, 1955, and is still applicable.
7. The theory of coupled lines for various stripline geometries is contained in: "Shielded Coupled-Strip Transmission Lines" *I.R.E. Trans.* MTT3, Oct., 1955.
8. The impedance of microstrip is deduced in a standard article by H. A. Wheeler: "Transmission-Line Properties of Parallel Strips Separated by a Dielectric Sheet". *I.E.E.E. Trans.* MTT13, 1965.
9. Coupled microstrip line analysis is given in: "Parameters of Microstrip Transmission Lines and of Coupled Pairs of Microstrip Lines" by T. G. Bryant and J. A. Weiss, *I.E.E.E. Trans.* MTT16, Dec., 1968. This is suitable only for computer evaluation and a programme is now available from the I.E.E. Programme Library.
10. Further information on the properties of microstrip is contained in: "Microstrip Lines for Microwave Integrated Circuits" by M. V. Schneider, *Bell System Tech. J.*, May–June 1969 and
11. "Losses in Microstrip" by R. A. Pucel, D. J. Massé and C. P. Hartwig, *I.E.E.E. Trans.* MTT16, June 1968.

Lumped elements

12. "Status of Lumped Elements in Microwave Integrated Circuits" by M. Caulton, B. Hershenov, S. P. Knight and R. E. DeBrecht, *I.E.E.E. Trans.* MTT19, June 1971.
13. "Lumped-Circuit Elements at Microwave Frequencies" by C. S. Aitchison *et al. I.E.E.E. Trans.* MTT19, Dec. 1971.
14. "Effect of Process Variables on the Microwave Conductivity of Thick-Film Conductors" by J. R. Corkhill and E. R. O. Donnell, *Electronics Letters*, 5th Oct. 1972.
15. "Electrical and Electronic Engineering" by F. E. Terman, McGraw-Hill, 1943.

World of Amateur Radio

Aerial gain — fact or fiction?

Many v.h.f. operators use aerial arrays that are designed to give 10 dB or more gain relative to a half-wave dipole. But sometimes the gain is more theoretical than real — many factors can in practice reduce the gain achieved. Should more effort be made to check the gain figures? For several years American rallies and conventions have featured aerial gain contests with amateurs bringing along their arrays to compete under specified conditions. Winning entries may feature gains as high as 20 dB or more.

Such contests are not often held in the U.K. but we were interested to read in *Break-In* (journal of the New Zealand association of radio amateurs) some detailed results of a 144 MHz aerial measuring contest held recently at Christchurch — results which we suspect must have come as a shock to some entrants. For example a nine-element quad beam had a 30 dB front-to-back ratio, but its forward gain over the reference dipole was only 3 dB; a 14 dB f/b ratio on a 7-element Yagi array was accompanied by only 1 dB forward gain, whereas a 6-element Yagi with 10 dB f/b ratio had an 8 dB gain. A four-element Yagi with an f/b ratio of 4 dB actually had a loss of 11 dB compared with the dipole.

These measurements were made using a low-power transistor transmitter (100 mW output with 40 dB attenuation) spaced a quarter of a mile from the receiving site with both aerials on 20 ft aluminium masts and using a high-grade variable attenuator. Fixed attenuators were used either side of the variable attenuator to help overcome the effects of mis-matches, and the power of the transmitter was kept low to prevent direct leakage into the receiver.

Licences and operational news

Two relaxations have been made by MPT in the terms of the Class C licences issued to foreign amateurs for operation in the U.K. In future, these operators will be able to use r.t.t.y. (radio teleprinting) and to operate on telephony in any recognised spoken language instead of being confined to the English language.

Class B amateur licences for v.h.f. operation now number over 3850 and represent more than 20 per cent of the total of about 18,650 U.K. licences for fixed-station operation. The number of new Class B licences continues to increase considerably faster than the general Class A licence.

Since the re-siting of the 144 MHz GB3PI repeater station — licensed experimentally by the MPT for one year — on a 200 ft tower one mile west of Barkway in north Hertfordshire the operational range has increased considerably. Mobiles at distances up to 45 miles (60 miles to the north) are now working through GB3PI, so allowing contacts to be made between vehicles as far apart as Lincolnshire and north London. The present experimental licence expires on August 11 and a decision will have to be made soon whether the experiment will continue and perhaps be extended to include other repeaters and u.h.f. facilities, or whether the experiment be wound up.

The Oscar 6 satellite repeater schedule has again been changed; the transposer is now usually working only on Thursdays, Saturdays and Mondays. Two more British amateurs have recently obtained the Oscar 6 "1000" Award: D. E. Davies, GW3FSP of Bridgend and R. G. D. Holmes, G6RH of Bexley, Kent.

R.S.G.B. Diamond Jubilee

The London Wireless Club — later to become the Wireless Society of London and then (in 1922) the Radio Society of Great Britain — was formed on the evening of July 5, 1913 at a meeting of about half-a-dozen amateurs at the home of Rene Klein (RKX later G8NK) at 18 Crediton Road, West Hampstead. In its August 1913 issue, *Wireless World* commented: 'London has hitherto been without a wireless club, but at a meeting held on July 5 an association was formed under the title of "The London Wireless Club" having for its object the "bringing together of all amateurs interested in wireless telegraphy and telephony".'

In Brief

Derby and district amateur radio society recently ran a direction finding contest in which participants worked on foot rather than the usual combined "car/foot" hunt. This was done to give younger members a chance to take part on their own; the society has also co-opted to its committee a junior member, Robert Bebe. . . . Another broadcast intruder in the 3.5 MHz band is HCVG8, operating from the Galapagos Islands on 3520 kHz. . . . The BBC World Radio Club, which recently enrolled its 14,000th member, is now transmitted on medium-waves (1088 kHz) at 2315 G.M.T. on Fridays instead of 2345 G.M.T. After 2½ years as producer Joy Boatman has handed the programme over to Reg Kennedy, with Colin Marchant and Henry Hatch, G2CBB, continuing as regular participants. . . . A group of Swedish amateurs (SM7AED, SM7DBI and SM7FJE) will be operating at weekends, including early mornings, this summer from a site 215 metres a.s.l. with high-power c.w. (144.011 MHz) and s.s.b./c.w. (145.375 MHz). . . . The R.S.G.B. national mobile rally takes place at Woburn Abbey on Sunday, August 5. The rally will include a large trade exhibition; R.S.G.B., B.A.R.T.G. and "Raynet" information stands; a GB3PI repeater demonstration stand and a "bring-and-buy" stand, all in a large marquee. Talk-in stations will include GB3RS (1910 kHz a.m., 3700 kHz s.s.b.); G3VHF (70.26 MHz a.m., 144.48 MHz f.m., 145 MHz a.m. and 145.41 MHz s.s.b.); and via GB3PI. . . . July mobile rallies include: South Shields (July 1); Newquay, Cornwall and Upton-on-Severn (July 8); Scarborough (July 15); and Ipswich (July 22). . . . Two U.K. microwave records were broken when Les Sharrock (G3BNL) and A. Wakeman (G3EEZ) made contacts over the 98-mile path between Dartmoor and the Prescelly mountains, South Wales, on the 13, 9, 6 and 3 cm bands. Excellent signals were received on all bands. . . . Twelve v.h.f. repeaters are in operation in Australia: New South Wales (5), Victoria (3), Queensland, South Australia, Western Australia and Tasmania with input and output channels separated by 500 kHz. . . . Polish stations on the 432 MHz band include SP2DX, SP2AOZ, SP3BBN, SP6LB and SP6BPR. . . . The June 30 eclipse propagation experiment (see last month) will be based on transmissions from 5T5SOL operating as a beacon station on 14050 and 21050 kHz from 0930 to 1130 G.M.T. . . . The MPT says there is a growing tendency for stations operating in s.s.b. nets to ignore the requirement that callsigns should be announced at least every 15 minutes. . . . The Barking Radio Electronic Society will operate an amateur station at the Dagenham Town Show on July 7 and 8 on all bands from 1.8 to 145 MHz, and with GB2DTS as the talk-in station on 145 MHz.

PAT HAWKER, G3VA

Industrial Electronics — 4

Electronic weighing

by Richard Graham

It is a remarkable thought that the kind of measurement which must have been one of the first that man ever made is the one which has resisted the attentions of electronic engineers the longest. It is probably not much more important to weigh things accurately today than it was when the brontosaurus steaks had to be shared out equally, but it is now considered to be insufficient to read the weight from a weighing machine; the result of the measurement must be printed, transmitted, used in computation or used to control a blending process.

The call for electronic weighing is therefore not primarily motivated by its potential accuracy, but rather by its direct provision of an electrical signal — analogue or digital — which can be used to fulfil the ancillary functions of weighing. This is, perhaps, just as well, because the achievement of accuracy in an electronic weighing system is a difficult and expensive business; only in the last few years have electronic machines reached a performance comparable in accuracy to that of the mechanical type of scale.

Hybrid weighers

The first attempts at deriving an electrical output from a weighing process were, as seen in Fig. 1, hybrid in nature. The spindle of an ordinary dial scale was fitted with a rotary displacement transducer, which produced either analogue or digital signals corresponding to the position of the scale pointer. The transducer could be either a photocell-scanned diffraction grating or a refined type of slide-wire potentiometer, the former possessing the considerable advantage of friction-free operation and direct digital output.

These systems combine the advantages (and the disadvantages) of electrical and mechanical operation, and the feeling was that the benefits of electronics were not being properly exploited. For instance, the construction of a mechanical weighbridge consists of unbelievably large lumps of steel, supported on knife-edge bearings. When new, the whole edifice is capable of weighing extremely accurately and with excellent repeatability. Unfortunately, this state of affairs does not last indefinitely; knife edges and the dial mechanism wear and the pointer begins to "stick", maintenance is therefore required. Moreover, since the platform of the weighbridge must usually be flush with the ground, a sizeable hole in the ground is needed to house the lever mechanism.

On the other hand, a purely electronic weighbridge consists of the platform, a number of load cells, and a box of instrumentation, as shown in Fig. 2. Admittedly, the pit remains, but can be considerably shallower and, in some cases, can be dispensed with altogether, a ramp being used instead. The output of the instrumentation can be either analogue or digital, and no "sticking" will be observable.

Electronic weighers

The device which has made possible the present state of electronic weighing is the strain gauge used in a load cell. Other types of load cell have been proposed, but strain-gauge cells presently reign supreme. In essence, the device is simple, but it has taken at least twenty years to reach the current state of parity with mechanical weighers, and even now there are problems to be solved. After many years of development, the strain gauge has now stabilized into several forms. It is yet another illustration of a simple idea which is ferociously difficult to implement, and its development was retarded by the fact that most of the early workers in the field spent a lot of time industriously measuring and recording the wrong parameters, neglecting vital information.

If one considers a piece of metallic material of length L, cross-sectional area A and specific resistance p, its resistance end-to-end is expressed as pL/A. If it is deformed, becoming shorter and fatter, its resistance therefore decreases, deformation by stretching giving an increase in resistance. To apply this effect to a weigh-

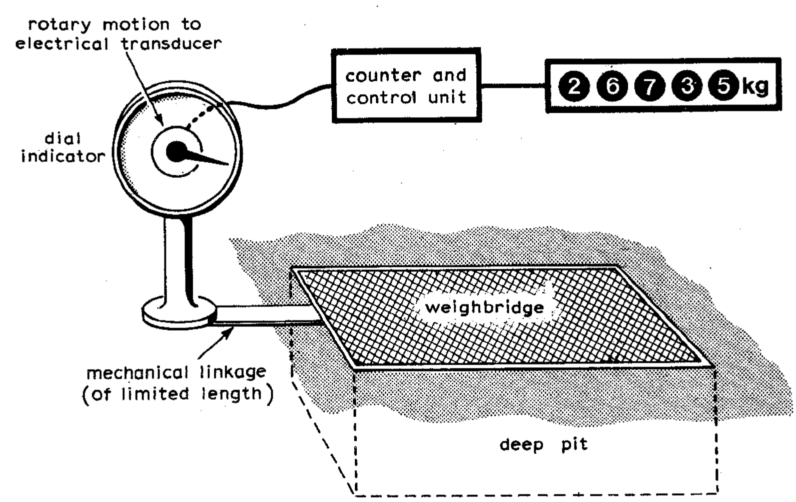

Fig. 1. A hybrid mechanical/electrical weigher.

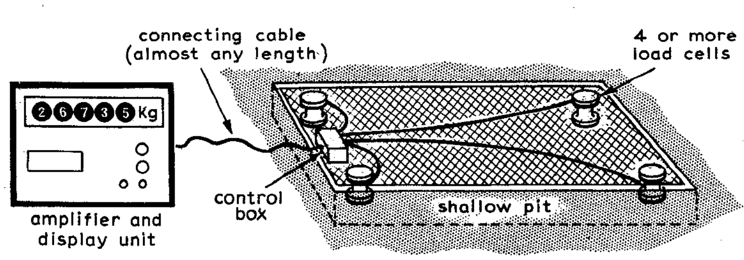

Fig. 2. Electronic weighing system.

ing system, the strain gauge is used in conjunction with a deforming spring structure, the load cell. Fig. 3 shows one form of load cell, the "active" part being the narrow centre section. As a load is applied to the button at the top, the neck becomes very slightly deformed or squashed — by a matter of a few hundredths of a centimetre decrease in height. This deformation is accurately proportional to the applied load until the elastic limit is reached, and is measured by the strain gauges bonded to the neck. The gauges, in the simplest configuration, are arranged in the form of a wheatstone bridge and the output signal is around 2mV per input volt. The signal is amplified, usually digitized and displayed. Many companies use a dial display, but this always seems to be a throwback in much the same way as cars having their engines at the front because that is where the horses used to be.

That is a typical electronic weigher in principle. As may be suspected, there is a lot more to it than that. For instance, a load cell would, if precautions were not taken, do a reasonably good job of being a thermometer; it could also suffer from the bonding of the gauges being imperfectly done and the ingress of moisture would not help. The metal of the billet must be of the correct type and the proper application of the load to the cell is a matter of vital importance.

For normal, mid-range temperature operation, the foil type of gauge is used. Fig. 4 shows the general arrangement of such a gauge. The gauges are manufactured by a process similar to that by which printed circuits are made. An extremely thin (about 5 microns) strip of constantan, or whatever metal is chosen, is coated on one side with synthetic resin and on the other side with a photo-sensitive resist. The resist is exposed to the required pattern through a negative, the exposed parts hardened and the rest removed. The remaining pattern can be etched away chemically, leaving the final gauge on a synthetic resin carrier, which is then bonded to the load cell billet and leads are welded or soldered to the pads. Resistance wire gauges are used for higher temperatures and many different patterns of gauge are used for other applications.

Two-component bonding materials are often used, consisting of a monomer and hardener, polymerization taking place on mixing and setting occurring in a short time with heat applied. The important features of a bonding agent are its life and creep properties, sensitivity to moisture and resistance to radiation. (Creep is the effect observed when a suddenly-applied load is reflected in a gradual approach to the final resistance value of the gauge.)

It is obvious that at least three load cells must be used to form a stable support for the weighing platform, and it is usual to use a minimum of four and sometimes eight, depending on the size of the platform. The way the cells are connected together to give a signal output determines the sensitivity of the system, and also, to some extent, the type of supply used.

If cell outputs are connected in series, with separate drive inputs, then the combined output is that of one cell. The output impedance is high and three supplies are required. On the other hand, if the outputs are in parallel, the signal is $1/n$ that of one cell, where n is the number of cells. The output impedance is low and only one supply is needed. It is common practice to use a series-parallel combination of cells, giving reasonably low impedance, adequate sensitivity and not too much trouble with power supplies.

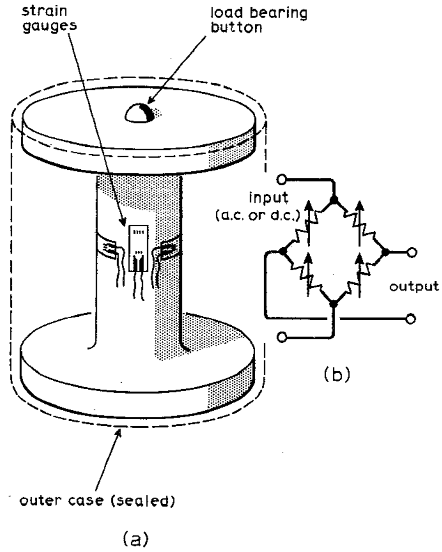

Fig. 3. A typical load cell.

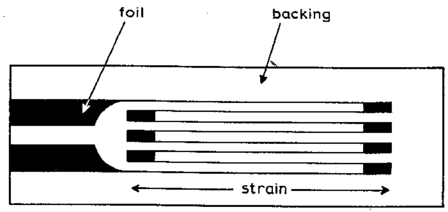

Fig. 4. One type of etched-foil strain gauge.

The type of cell described is one of several different styles: they are also made in the form of rings and horizontal beams, depending on the range of weights to be measured and on the method of applying the compressive or tensile force to the transducer. Accuracies are usually grouped into two classes — general-purpose and precision. A precision cell, used in weighbridges which must satisfy official requirements, is capable of calibration error, non-linearity, hysteresis, and creep of around 0.05% of full output, while the general-purpose variety will give calibration errors and non-linearity of 0.1 to 0.25% full rated output. Temperature effects vary from 0.001% to 0.005% of rated output.

That, then, is a very brief description of the basic weighing element. There remains its application to the business of weighing, the ancillary instrumentation and the use of complete systems in industry. I will try to cover as much of this as possible in the next article.

Announcements

A course for experienced standards engineers will be held at the University of Edinburgh from 25th to 27th June under the joint sponsorship of the Standards Associates Section of the British Standards Institution, 2 Park Street, London W1A 2BS and the University's Centre for Consultancy and Liaison. It is designed to bring standards engineers up to date on standardization matters and provide a forum in which they can discuss their problems, and exchange ideas.

Burndept Electronics (ER) Ltd, St. Fidelis Road, Erith, Kent DA8 1AU, has acquired the land mobile radio communications business of Cossor Electronics. The equipment involved comprises the "Consort" solid-state control system and u.h.f. fixed point-to-point links for communication and telemetry.

Sales office of **ITT Components Group's Thermistor Division,** formerly in Harlow, has moved to Steven Street, Taunton, Somerset. It is now at the same location as the factory.

Full qualification approval to the Post Office D3000 Class One specification has been gained by the Electronic Components Division of Ferranti Ltd, Gem Mill, Chadderton, Oldham, Lancs, for their **low-power, t.t.l.** integrated circuits. To obtain this approval, it must be demonstrated that cumulative failures over 40 years will not exceed 2% in an environment of 70% relative humidity, and 55°C ambient temperature.

Two new **undersea telephone cables** are to link Britain and France in a project which will cost between £5M and £6M. The British Post Office and the French Ministry of Posts and Telecommunications are to share equally the cost of the new cables, which will double the number of telephone circuits between the U.K. and France.

Thorn Colour Tubes Ltd, Skelmersdale, Lancs, have announced a £4.5M expansion programme. Current output is running at 750,000 tubes per year and the new expansion programme, designed to take effect early in 1974, will eventually increase output to 1.2M tubes per year.

British Aircraft Corporation, Electronic and Space Systems, Brooklands Road, Weybridge, Surrey KT13 0RN, have received a £1.2M export order from Hughes Aircraft Company for the manufacture of satellite subsystems for the latest global communication satellites Intelsat IVA.

Two new Boyd Line trawlers being built in Poland, B420/1 and B420/2, are both to be supplied by **Marconi Marine,** a GEC-Marconi Electronics company, Marconi House, Chelmsford CM1 1PL, with major electronics packages which will include communications equipment and navigational aids.

ITT Semiconductors have appointed **W. S. McMillan & Co,** 61 Colvilles Place, Kelvin Industrial Area, East Kilbride G75 0TA, Glasgow, as franchized distributor for Scotland and the N.E. of England. Also appointed as specialist distributor for the radio and TV industry are **Best Electronics (Slough) Ltd,** Michaelmas House, Salt Hill, Bath Road, Slough, Bucks SL1 3UZ.

Marconi Communication Systems Ltd, a GEC-Marconi Electronics company, Marconi House, Chelmsford, have received a £3½M contract from the Yugoslav Joint Radio Television Committee, to provide the largest single share of an order for studio and transmitting equipment to put Yugoslavia's second TV service on the air.

Plessey Semiconductors has appointed Gothic Electronic Components, a division of ERD (Midlands) Ltd, Beacon House, Hampton Street, Birmingham 19, as authorised U.K. distributors for the complete range of Plessey integrated circuits.

BURNDEPT HAVE PLANS TO SPEED UP A BUSINESS ON THE MOVE

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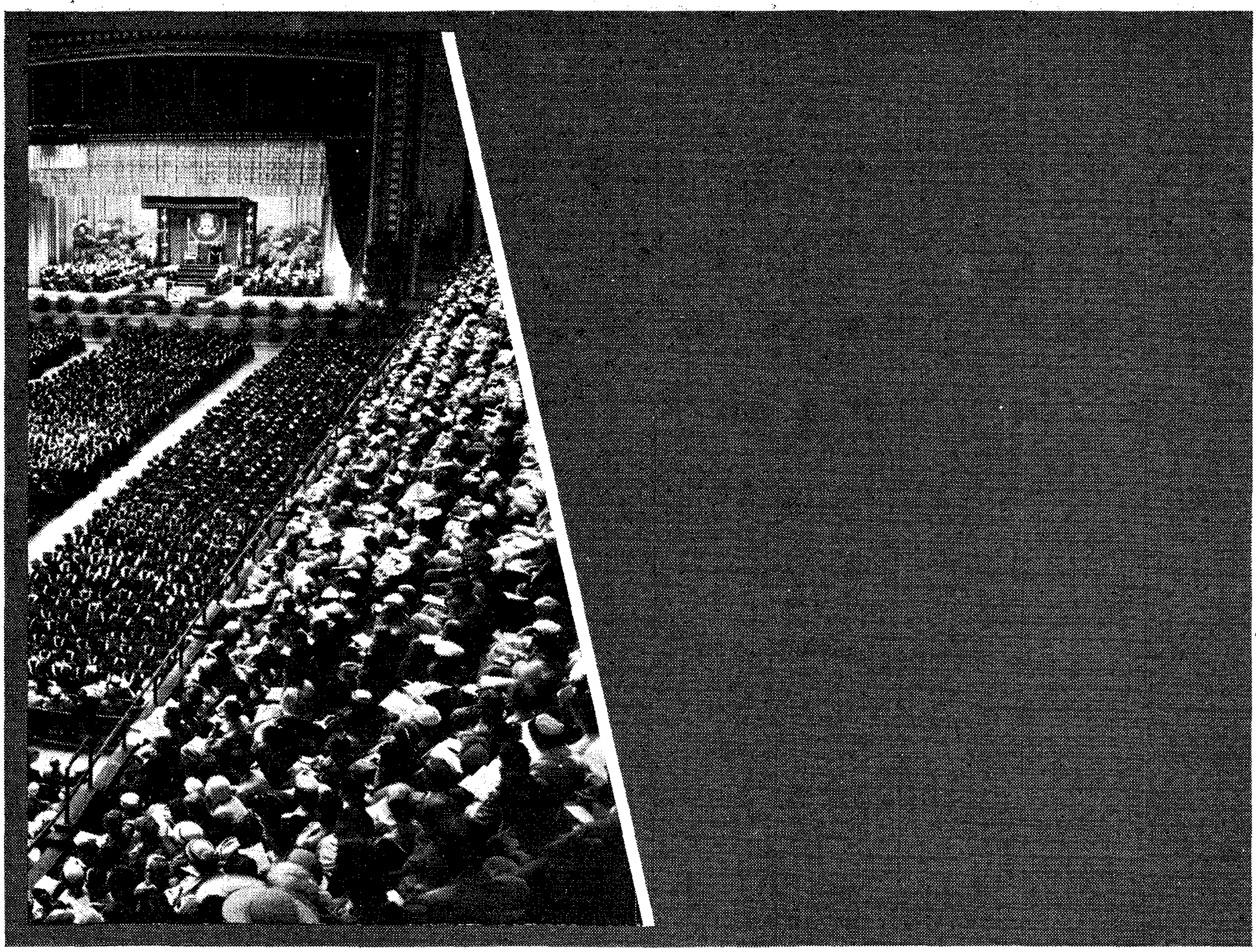
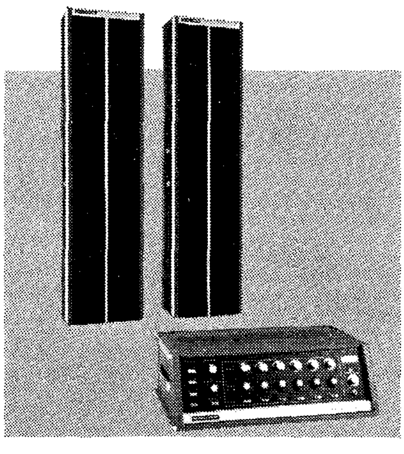
WW—080 FOR FURTHER DETAILS



Vocal Master of Ceremonies



There are precious few ceremonies, functions, meetings or entertainment events that *Shure Vocal Master Sound Systems* can't cover — regardless of room size or apparent acoustic difficulties. The Vocal Master is designed to project the voice with intelligibility and authority to the rear of large areas without overwhelming the listeners up front. It's versatile, easy to operate, and totally reliable. It's the system that earned its reputation for superb sound amplification by meeting the standards of professional entertainers — and is now used in hotels, churches, schools, executive meeting rooms and entertainment facilities from Land's End to John O'Groats in preference to built-in "custom" systems costing *many* times more.

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WW—081 FOR FURTHER DETAILS

Experiments with operational amplifiers

11. An op-amp used as a phase sensitive detector

*by G. B. Clayton** B.Sc., F.Inst.P.

A phase sensitive detector (p.s.d.) is a system which produces a d.c. output signal in response to an a.c. input signal of a defined frequency equal to the frequency of an a.c. reference signal. The d.c. output is proportional to both the amplitude of the a.c. input signal and the cosine of its phase angle relative to that of the reference signal. P.s.ds are used as synchronous rectifiers in chopper d.c. amplifiers; they are also used for the accurate measurement of small a.c. signals obscured by noise.[1]

A p.s.d. acts essentially as a multiplier giving an output proportional to the product of the input signal and the reference signal. It is instructive to analyse this multiplication process. We consider a sinusoidal signal $e_s = E_s \sin(\omega_s t+\phi)$ multiplied by a square wave reference signal. The square wave is assumed to be symmetrical about zero and to have unit amplitude and unity mark-space ratio.

The Fourier series for a unit amplitude square wave is

$$v_r = \frac{4}{\pi}\left[\sin \omega_r t + \frac{1}{3}\sin 3\omega_r t + \frac{1}{5}\sin 5\omega_r t + \dots\right] \quad (11.1)$$

and

$$e_s v_r = \frac{4}{\pi}E_s\left[\sin(\omega_s t+\phi)\sin\omega_r t + \sin(\omega_s t+\phi)\frac{1}{3}\sin 3\omega_r t + \dots\right]$$

$$= \frac{2}{\pi}E_s\left[\cos[(\omega_s-\omega_r)t+\phi] - \cos[(\omega_s+\omega_r)t+\phi] + \frac{1}{3}\cos[(\omega_s-3\omega_r)t+\phi] - \frac{1}{3}\cos[(\omega_s+3\omega_r)t+\phi] + \frac{1}{5}\dots \text{etc.}\right] \quad (11.2)$$

It can be seen that the product gives rise to d.c. terms for signal frequencies $\omega_s = \omega_r$; $3\omega_r$; $5\omega_r$; etc.

For $\omega_s = \omega_r$ the d.c. term is $\frac{2}{\pi}E_s\cos\phi$

for $\omega_s = 3\omega_r$ the d.c. term is $\frac{2}{\pi}E_s\frac{1}{3}\cos\phi$ . . . etc.

In a p.s.d. the multiplication process is followed by low pass filtering. The low pass filtering may be performed by a simple *RC* filter which is used to attenuate all a.c. components of the product. The effective bandwidth of the system is then set at $2/T$ radians/sec. where $T = CR$, the time constant of the filter.

The noise rejection properties inherent in phase sensitive detection arise in large part from the extremely narrow bandwidth which is so readily obtained by selection of filter time constant. A p.s.d. acts as a rectifier tuned to the reference frequency, but its noise rejection properties are in fact superior to a filter rectifier combination. It would be quite impractical to obtain the narrow bandwidth of a p.s.d. with a conventional filter.

Noise passed by a conventional filter circuit gives rise to d.c. in the normal rectification process. In a p.s.d. unwanted signals, like random noise, produce fluctuations about the d.c. output level given by the wanted signal at the reference frequency.

Many p.s.d. designs of varying degrees of complexity have been described in the literature (Refs. 2, 3, 4, 5). In general it is convenient if the signal input, the reference voltage input and the output from the detector share a common earth line. This condition is not fulfilled in all p.s.d. designs but

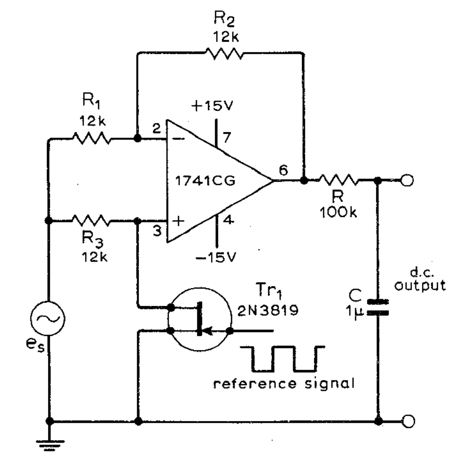

Fig. 11.1 Op-amp phase sensitive detector.

may be readily fulfilled by using an operational amplifier as a p.s.d.

In the circuit of Fig. 11.1 the closed loop gain of the operational amplifier is switched between plus and minus unity by a square wave reference signal applied to the gate of the f.e.t. Tr_1. The circuit is very convenient for illustrating p.s.d. operation.

Conditions in the circuit with the f.e.t. biased off and on are shown in Figs 11.2(a) and 11.2(b) respectively. Referring to Fig. 11.2(a) and assuming the amplifier behaves ideally we have

$$e_- = e_+ = e_s$$

Thus $I_i = I_f = 0$ and e_o must be equal to e_s. The closed loop gain is plus unity and

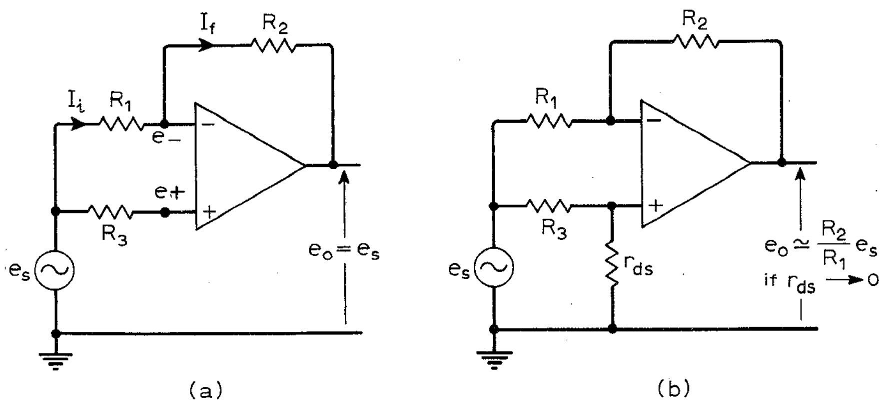

Fig. 11.2 Conditions in the p.s.d. of Fig. 11.1 with (a) the f.e.t. biased off, (b) the f.e.t. biased on.

*Department of Physics, Liverpool Polytechnic.

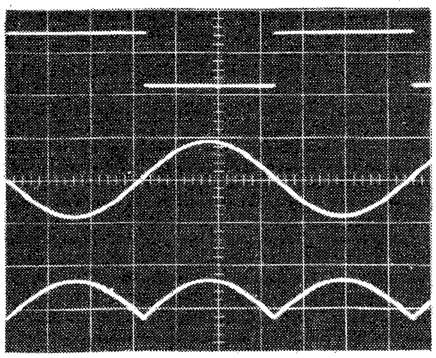

Fig. 11.3 *Signal (sine wave) and reference (square wave) in phase. (Upper trace 10V/div.; middle and lower traces 5V/div.; horizontal scale 2ms/div.)*

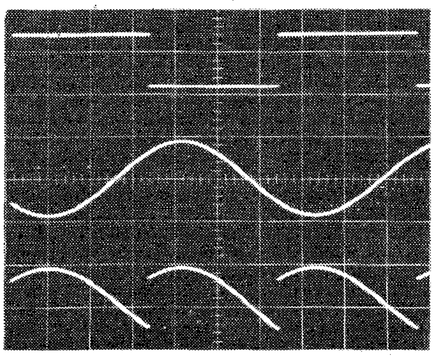

Fig. 11.4 Signal (sine wave) and reference (square wave) phase shifted by 45°. (Scales as in Fig. 11.3.)

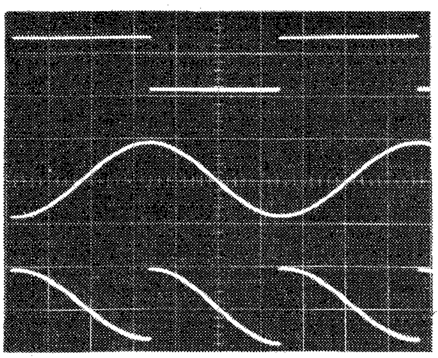

Fig. 11.5 Signal (sine wave) and reference (square wave) phase shifted by 90°. (Scales as in Fig. 11.3.)

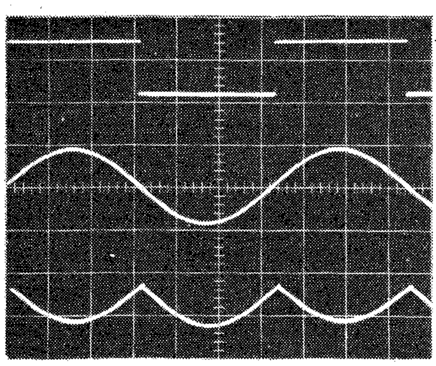

Fig. 11.6 Signal (sine wave) and reference (square wave) phase shifted by 180°. (Scales as in Fig. 11.3.)

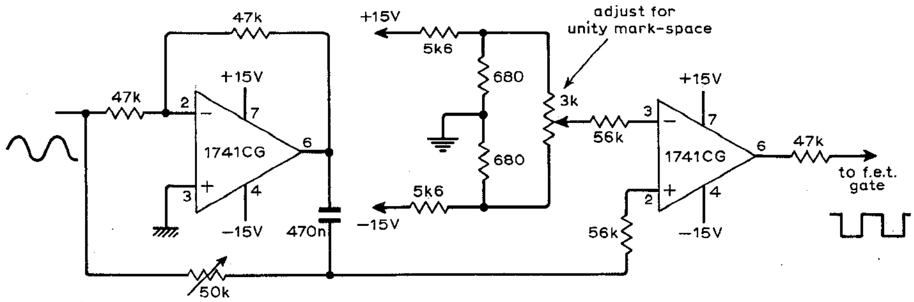

Fig. 11.7 Phase shifting and squaring circuit

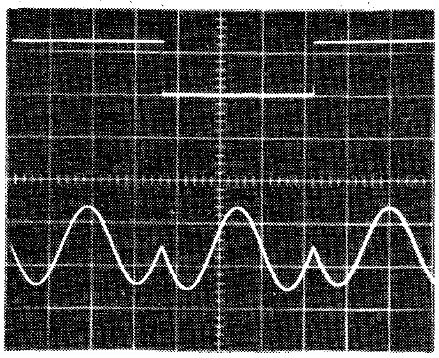

Fig. 11.8 Response of p.s.d. to 3rd harmonic of reference signal.

under the conditions in Fig. 11.2(a) its value is independent of resistor values.

In Fig. 11.2(b) r_{ds} represents the effective drain source resistance of the conducting transistor. If $r_{ds} \to 0$ the non-phase-inverting input terminal is effectively earthed and the closed loop gain is equal to $-R_2/R_1$. A non-zero value for r_{ds} allows a small fraction of the input signal to appear at the non-phase-inverting input terminal of the amplifier and R_2 must be made slightly greater than R_1 for a closed loop gain of minus unity.

The action of the p.s.d. is illustrated by the oscillograms, Figs 11.3 to 11.6, which show circuit waveforms for various phase relationships between input and reference signal. In each case the upper trace shows the reference square wave which is applied to the gate of the f.e.t., the middle trace shows the sinusoidal input signal and the lower trace shows the waveform which appears at the output terminal of the amplifier. The average value of the output is read by a d.c. voltmeter which follows the low pass filter *RC*.

Note that when the square wave is at its negative value the f.e.t. is switched off and the sinusoidal signal is multiplied by plus unity. When the square wave is at its upper level the sinusoidal signal is multiplied by minus unity. The unity amplitude square wave reference multiplier of eq. 11.1 is phase shifted by 180° on the actual reference square wave.

In order to check the relationship

$$E_{d.c.} = \frac{2}{\pi} E_s \cos \phi$$

it is convenient to derive the phase shifted reference square wave and the input signal from the same signal source.

A phase shifting and squaring circuit suitable for this purpose is illustrated in Fig. 11.7.

It is instructive to observe the behaviour of the p.s.d. for input signals at frequencies other than that of the reference signal. Two separate sources are required for this purpose, a reference square wave and an input sinusoid. The oscillogram in Fig. 11.8 shows waveforms which illustrate the response of the system to an input signal at a frequency equal to the third harmonic of the reference signal. It is clear that the output waveform has a non-zero average. Its value is

$$\frac{2}{\pi} E_s \frac{1}{3} \cos \phi$$

where in this case $\phi = 180°$.

References

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2. Williams, P., *J. Sci. Instrum.*, 1965, *42*, 474–476.
3. Lacy, J. G., *Electronic Engineering*, March 1967.
4. Danby, P. C. G., *Electronic Engineering*, December 1968.
5. Linsley Hood, J. L., *Electronic Engineering*, April 1970.

About People

Professor John Bardeen, For.Mem.R.S. In recognition of his development of the basic theory leading to the invention of the transistor and of his research on the theory of solids, John Bardeen has been elected a Foreign Member of the Royal Society. In 1956, Professor Bardeen shared with William Shockley and Walter Brattain the Nobel Prize for physics, and was awarded the I.E.E.E. Medal of Honour in 1971. He is Professor of Electrical Engineering and Physics in the University of Illinois, Urbana.

Richard Foxwell, C.B.E. has been appointed a director of Marconi Instruments. Mr. Foxwell, who was a founder and chairman of Wayne Kerr, was a past president of the Scientific Instrument Manufacturers Association, is deputy chairman of the Advisory Council on Calibration and Measurement, deputy chairman of the Conference of the Electronics Industry and U.K. co-chairman of the Anglo-Soviet Joint Working Group on Instruments. He has recently been nominated as the U.K. representative on the Presidents Committee on the Comité des Industries de la Mesure Electrique et Electronique de la Communauté (CIMEC).

The Metre Waves Now

A progress report on amateur-radio activity above 30MHz

by J. Hum G5UM

Officially, v.h.f. begins at 30MHz, u.h.f. at 300MHz and so on upwards. Colloquially, the whole of this spectrum is known as the metre wavelengths by the amateur radio transmitting operators who inhabit it, to distinguish it from the "h.f. bands" of 30MHz and below. We shall use the terminology in this broad sense for the remainder of this article.

Over the last half dozen years the exploration of the metre wavelengths by U.K. transmitting amateurs bears some resemblance to the pioneer work done by their forebears almost half a century earlier in opening up the ostensibly useless short waves. But there is a significant measure of difference: in the "way back" days amateur signals were almost the only ones to be heard on the virtually vacant intercontinental wavebands. Today the world above 30MHz has a population problem so intense that official specifications for professional communications equipment become tighter almost year by year. Once-spacious 50kc/s channelling (in the days of kilocycles, before "hertzes" came in) gave way first to 25kHz and then to 12½kHz bandwidths that told their own story of the congestion which had built up on the very high frequencies.

To the amateur transmitting practitioner these circumstances carry certain implications. No longer alone on the metre wavelengths, as his father was on the short waves, he is well aware of the need to justify his retention of them under such pressures. But what he also observes is the professionals' quite understandable preoccupation with providing as near 100% reliable communication as the noted intransigence of electronic equipment will permit, both in terms of actual electromechanical reliability and in the sustaining of high level voice communication come what may, and no outages (reversion by the customer to landline communication is not only a stigma on the escutcheon of the business-radio manufacturer but carries the awkward possibility that it might become permanent).

This is not to say that the amateur operator puts a low priority on reliability: in a situation where large numbers of inter-city and inter-county nets on the 144 and 432MHz bands go into action nightly, instant communication is a *sine qua non.* But it *is* to say that the amateur v.h.f. communicator today detects, just as his father did fifty years ago, a number of challenges to his technique which in the nature of things can be of only minimal interest to the professional providers of short haul traffic facilities.

Anomalous propagation

Just above the upper limit of television Band I lies the amateur 70MHz allocation, popularly known as "Four Metres", apparently capable of giving no more than line of sight range if considered in conventional engineering terms. To questing experimenters it has shown that it can give much more. Early in their experience of "Four" (it was granted to them 17 years ago), British amateurs discovered that it held propensities for anomalous propagation, even with transmitter inputs restricted to the 50W allowed on this band, that were truly surprising. The value of the band to amateur v.h.f. men, and the value of the propagation observations they were conducting on it, persuaded the licensing authority progressively to extend the available space from a bare 200kHz to 675 kHz today. Latterly, a few overseas countries have followed the U.K. lead and made this special band available to non-professional users, "special" because it is not an official I.T.U. amateur allocation.

The effect of these concessions was startling. Communication from the U.K. to Iceland in one direction and Gibraltar in the other became almost a matter of routine during the equinoctial months of certain years when it was possible to use the sporadic-E manifestations that generate reflective ionized patches along the propagation paths.

Another aid to long distance communication on supposedly optical frequencies is the tropospheric or warm weather effect, generally associated with stable high pressure weather systems and temperature inversions, and the appearance on the domestic television set of the "We regret continental interference" caption. Whereas tropo-propagation can be predicted by the sixth sense which amateur v.h.f. men develop in relating weather conditions to radio conditions — a look at the barometer and then the sky is enough — it is not so easy to forecast when sporadic-E will occur (except, broadly, in the equinoctial seasons). When it does it is supremely exciting and brings hundreds of v.h.f. workers off the garden — or early home from work — in order to participate in what is always a short-period occurrence: a characteristic of sporadic-E is its habit of "turning on" without warning and later of "going out like a light".

Equally intriguing is the possibility of communication via the Auroral curtain upon its appearance after periods of intense solar activity. Radio noise from the sun, a harbinger of aurorae, alerts the amateur observer to the possibility that Northern Lights may be present even though they may be invisible. On these occasions directional aerials pointed northwards transmit v.h.f. signals to be returned by the aurora and received on other aerials orientated the same way. Such signals are rendered characteristically rough in tone quality by the discrete nature of the reflecting surface ("super multipath" propagation), and for this reason a.m. telephony becomes unintelligible. Either c.w. or single sideband telephony is essential.

All these propagation abnormalities occur in the 70MHz band and have been thoroughly exploited by amateur operators. Their appearance in "the next band up", 144MHz, is less frequent, and on 432MHz (70cm) and 1296MHz (23cm) rare indeed except under special conditions of "warm weather tropo" that extend the range of the ultra-high frequencies in a manner likely to bring delight to the amateur but dismay to the professional planners of short haul communication.

Class B licence

Of the four bands so far referred to, that extending from 144 to 146MHz is by far the most heavily populated. A prime reason for this is the advent of the Amateur Class B licence which requires no morse qualification, but confines the holder to the bands 144MHz and upwards. When introduced in 1964 this licence permitted operation on telephony in the 432MHz (70cm) band and above. In March, 1968, the then Postmaster General announced that in response to representations made by the Radio Society of Great Britain he had decided to include the 144-146MHz band within the terms of the Class B licence. An immediate acceleration in the rate of issue of Class B licenses so galvanised the activity and occupancy of "Two" that now it is no longer necessary to tune over the band for a long time before a contact can be made: at any time of the day there will always be somebody on — and the chances are that he will be a Class B man using the characteristic G8-plus-3 callsign. This callsign block, which started at G8AAA in 1964, is approaching the end of the G8HAA-HZZ series, to bring the total of Class B licensees to almost 4000, most of them having come into amateur radio within the last four years, and now operating primarily in the 144-146MHz band.

It is not surprising in these circumstances that the 432MHz band is being rediscovered by large numbers of operators who "want a change from Two". Nor is it to be wondered at that a lively awareness exists that heavy band occupancy demands good manners allied to impeccable equipment design (whether home built or bought) if users of the v.h.f. world are to remain at peace with one another.

On the latter point the R.S.G.B recommends its members to strive for a rejection figure of -90dB in respect of unwanted transmitter products which is -30dB more stringent than professional requirements.

Global DX

Remaining a Class B licensee and staying permanently on telephony on the metre wavelengths suits a sizeable proportion of the G8-plus-3 operators. Others regard Class B status as an interim one preparatory to passing the morse test and acquiring the Class A licence that confers permission to use the lower frequency bands.

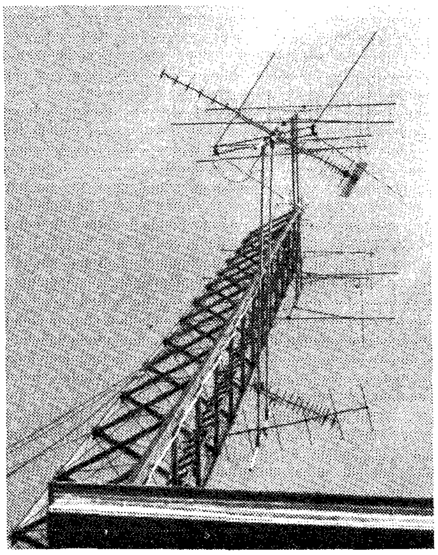
These operators are seldom lost to v.h.f. All have metre-wave equipment dating from their Class B days, and they continue to use it between spells of savouring the condition of the world below 30MHz.

To acquire a Class A licence, and the freedom to use the morse code, greatly extends the range over which a v.h.f. operator may expect to work, for telegraphy provides readability at remote points where telephony, even penetrative single sideband, can no longer be resolved.

Additionally, there are two sophisticated areas of communication ("rarefied" is probably a more appropriate adjective) where the use of telegraphy is mandatory. These are meteor scatter and Moonbounce.

Meteor showers release in the upper atmosphere tiny patches of ionization which may be used for radio communication purposes as if they were sporadic-E accumulations. Being infinitesimally smaller and more fleeting, they produce a barely audible bounced signal at a distant point; yet several U.K. stations have communicated on 144MHz as far as Russia by this means. The key (literally) to success with meteor scatter v.h.f. propagation is the ability to effect very rapid morse exchanges over a period of perhaps some hours so that bits of received information may be assembled to build complete messages.

The ultimate in global DX working is to be realised by bouncing a signal off the Moon as far as the Antipodes, a feat achieved on a world wide basis by no more than a handful of dedicated experimenters. For technical reasons the 432 and 1296MHz bands are favoured for this work, for the larger the aerial dish the better the chances of success. The challenge of this kind of ultimate DX is such that, not content with achieving it by the morse key, one or two operators have Moonbounced single sideband telephony, with by no means discouraging results.



Although a profusion of commercial designs is available to v.h.f. radio amateurs, many continue to prefer to build their own equipment. Rather fewer go so far as the Belgian enthusiast who constructed this 65ft mast himself, together with four 10-element aerials for 144MHz and four 15-element aerials for 432MHz arranged in a box formation, plus a multiplicity of other aerials for television reception.

Microwaves

In a more earthbound context the increasing activity now apparent on the amateur microwave frequencies prompts the thought that centimetric parabolas will become a more established part of the amateur radio scene than they are at present. In spite of exacting aerial alignment requirements in the 13, 9 and 3cm bands, and the cut-off effect of local topography, it is to be expected that urban chimneys will assume a modestly "space-age" look as more aerial dishes go up.

To promote further experimentation in these amateur microwave bands the R.S.G.B. offers special certificate awards to operators who communicate over certain minimum distances in the gigahertz spectrum. These are not easily won: for example users of 13cm must provide proof of two-way communication over a distance of 500km. Even at 3cm (the "ten gig" band is for a number of equipment reasons the most popular of the microwaves) the minimum distance requirement is 150km, or effectively 100 miles, achievable in certain parts of the U.K. between line of site hilltops, rarely from home.

Healthy competition stimulated in this way is a noted incentive to experimenters to improve their equipments and to further the state of the microwave art in general.

Artificial aids

Of the methods of metre-wave propagation so far discussed, whether by morse key or microphone, or via the Moon, meteor trails, aurorae, sporadic-E or warm weather tropo, all are achieved by natural means. Now artificial aids to extend transmission ranges are coming into the picture, especially in the shape of Orbital Satellites Carrying Amateur Radio, personified as Oscar.

It was as long ago as December, 1961, that Oscar 1, launched from a site in California, prompted the thought in the minds of many v.h.f. workers that herein lay the possibility of world wide communcation on line of site paths if the project could be suitably developed. The simple 3-transistor Oscar 1 delivered no more than 100mW into a monopole aerial, transmitted the basic telemetry symbol HI, and orbited the earth every 91 minutes. It has been succeeded by a range of amateur communication satellites of increasing sophistication, the latest of them, Oscar 6, being launched at the end of 1972, up-channel centred on 145.9MHz and a down channel after transponding at 29.6MHz. Global communication has proved to be so easy to achieve via Oscar 6 that the appearance of the satellite over the radio horizon precisely at the predicted orbital times no longer excites unusual interest.

The secret of success with Oscar 6 has been to transmit in the 2m band at the critical moment when the satellite was midway between the observer and the distant station he wished to work, possibly up to 7,000 miles away, and to listen for the transponded reply on 10m before the satellite moved out of range in a matter of ten minutes or less.

Beacon signals on 10m and 70cm planned for Oscar 6 will be a feature of its successor, Oscar 7. But instead of one translation system there will be three, two of them 2m to 10m and the third 70cm to 2m. Only one will be in operation at any given time during the planned three year life-cycle of this satellite.

Repeaters

It is not only in space that amateur-band repeater services are operational: back at ground level intercommunication will be extended by the provision of hilltop talk-through repeaters to give poor-sited operators a better chance to speak to the outside world than they have ever enjoyed before. "Poor sited" includes operators of vehicle-borne equipment.

A well sited automatic repeater station enormously extends the potential range of any mobile radio communication installation operating through it. The first U.K. repeater beacon, designed by radio amateurs at the Pye works at Cambridge, licensed as GB3PI by the Ministry of Posts and Telegraphs through the R.S.G.B., and installed at an elevated site in north Hertfordshire, has virtually quadrupled the service area to be expected by a mobile operator using the 2m band.

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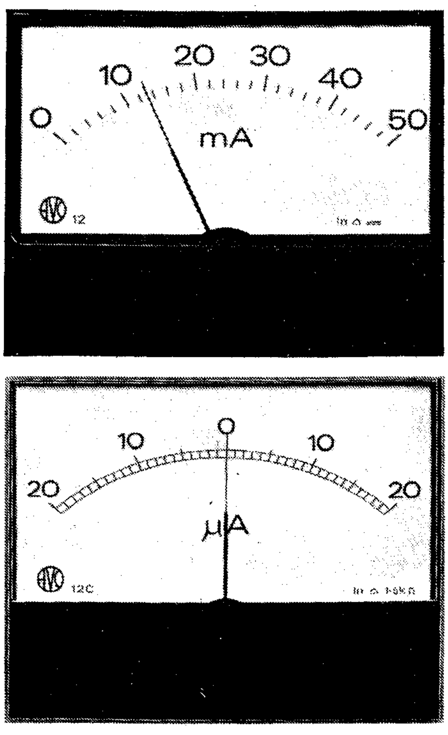

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WW—082 FOR FURTHER DETAILS

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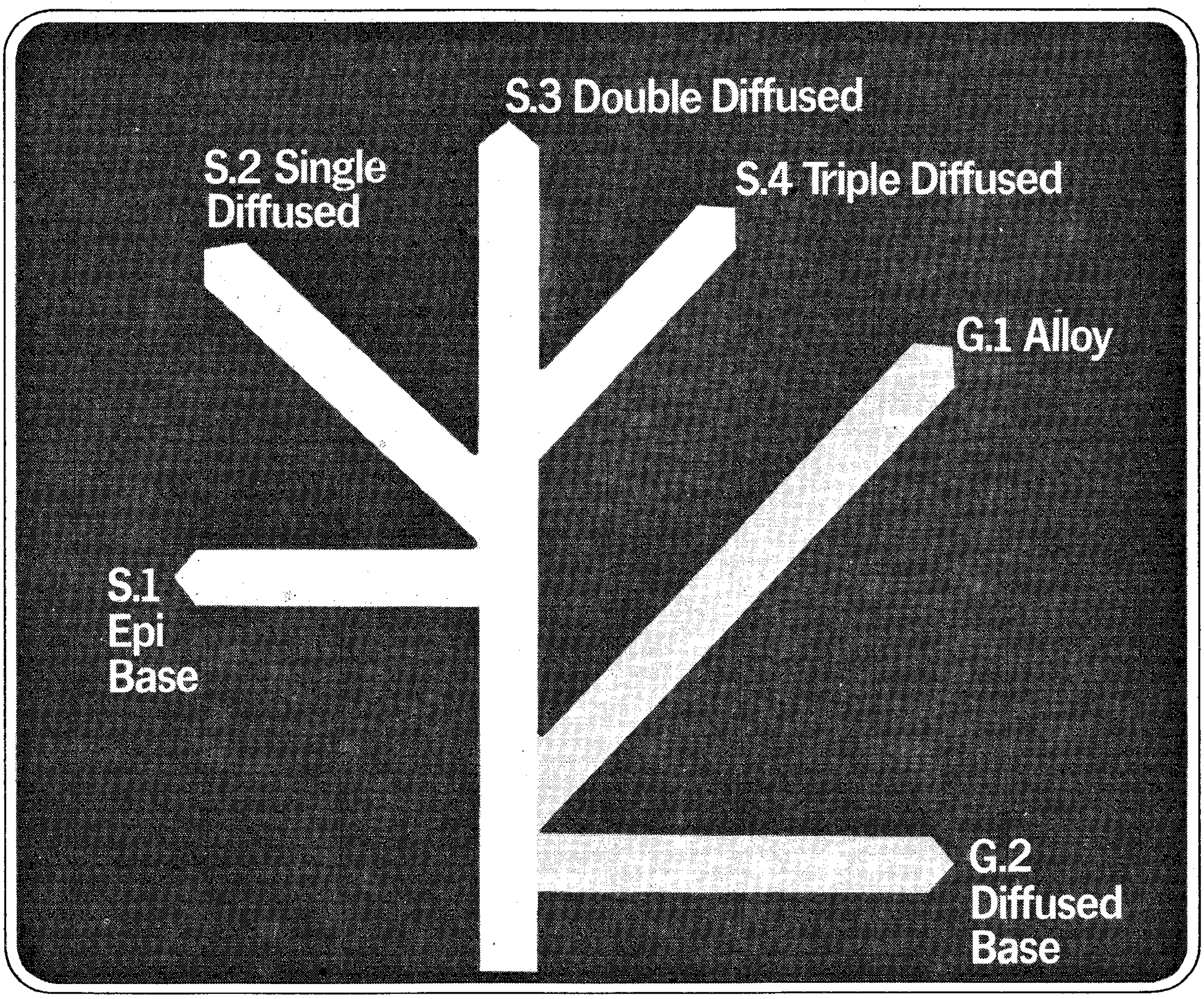

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WW—083 FOR FURTHER DETAILS

New Products

Integrated circuit power supplies

Best Electronics announce the Westinghouse VR1 series of rectifier/regulator modules, which are fully protected against over-current and short circuits. The five standard units provide from 1.25V to 30V regulated d.c., up to 2A direct from a low voltage a.c. input, provided by the HRT-1 transformer. This transformer provides secondary taps to cover all Hyreg input voltages within 3.5%. Precise output voltages and current limiting are set by three external resistors.

For a complete power supply a Hyreg VR1 module, the HRT-1 transformer, three resistors and a smoothing capacitor are required. Prices, including post and packing of the VR1 regulator modules and the HRT-1 transformers are as follows:— VR1/1.25 — 6.5V £6.25 each, VR1/18 — 24.5V £6.95 each, VR1/6 — 12.5V £6.25 each, VR1/24 — 30V £6.95 each, VR1/12 — 18.5V £6.95 each, HRT — 1 £3.95 each. Best Electronics (Slough) Ltd, Michealmas House, Salt Hill, Bath Road, Slough, Bucks SL1 3UZ.
WW 310 for further information.

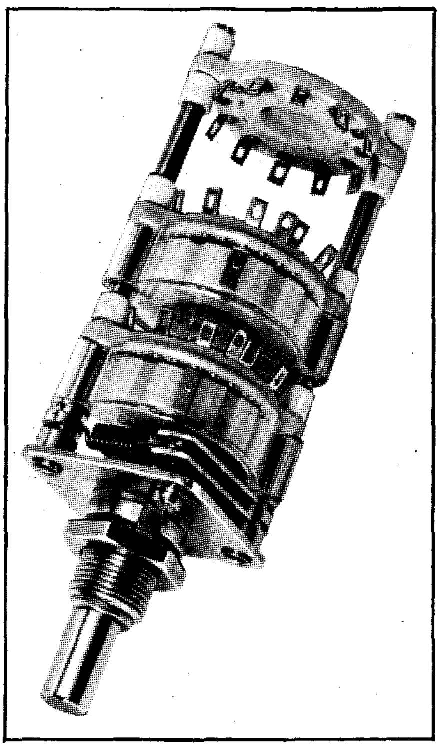
Rotary stud switch

Elma claim improvements to their 03 miniature rotary stud switch which have resulted in reducing 'switching noise' still futher and enhancing operating life — better than 25,000 rotations — to give even greater reliability. Radiatron Components, who market Elma products in the U.K., are now introducing the improved 03 version to their customers. Radiatron stress that it is mechanically interchangeable with the former type.

A choice of contact materials is offered to meet specific applications: gold flash on silver, 3μm hard gold and 5μm hard gold. The latter type has recently received Post Office approval.

Other significant 03 features include: Contact resistance typically 5mΩ, up to 24 ways on 1in wafer, up to 12 wafers, shorting or non-shorting, concentric spindles.

Design improvements have been made to the rotor and contact housing, contact



wiper, contact spring and stud, and the wafer rotor guide. Radiatron Components Ltd, 76 Crown Rd., Twickenham, Middlesex.
WW 314 for further information.

U.H.F. passive equalizer

A passive channel equaliser for four channel u.h.f. operation designed by Wolsey Electronics allows compensation for variations between the input levels of channels and losses in the distribution circuitry, so that the signal inputs to a head end amplifier system are suitably balanced. The filter system has a constant impedance potentiometer to control each channel.

Good inter-channel selectivity is claimed for this method, with excellent response curves and input and output v.s.w.r. Although the through loss is acceptable at the head end in most cases, the Wolsey u.h.f channel equalizer is line-power bypassed to allow mast head or prior amplification powered through the unit. The equalizer can be used to provide a chosen equalizing slope to compensate for differential losses throughout a master aerial TV system, and wherever a channel filter is necessary to improve selectivity. The bandwidth of the equalizer is 9MHz at 3dB. Wolsey Electronics, Cymmer Road, Porth, Rhondda, Glamorgan CF39 9BT.
WW 317 for further information.

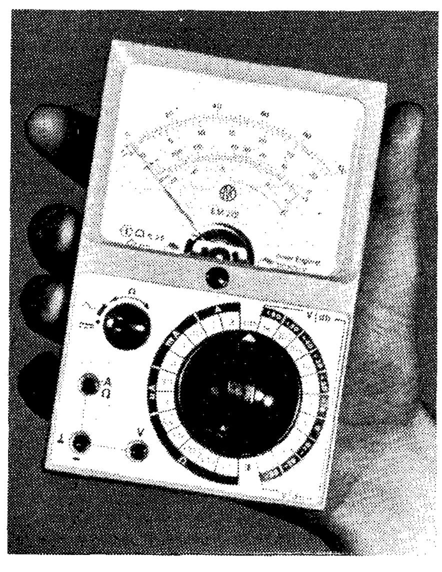
Low-pass filters

A series of low-pass filters (the FLC series) have been introduced by American Electronic Laboratories. Suited for elimination of undesired harmonics from a signal source, the FLC 1000 sector of the series is an eleven element filter with a 2MHz to 300MHz cutoff frequency range and a Chebychev response in the passband.

The FLC 3000 group of this series is a nine branch elliptic function filter with a Chebychev response in both the passband and stopband. Featuring a 2MHz to 150MHz cutoff frequency range, their greater selectivity can be used to facilitate receiver operation in the presence of a nearby transmitter. Filters in both the FLC 1000 and 3000 series have an input and output impedance of 50Ω. Low ripple design ensures a v.s.w.r. of 1.5:1 maximum for frequencies below 80% of cutoff frequency. American Electronic Laboratories, Inc., MS/1123, P.O. Box 552, Lansdale, Pa.19446, U.S.A.
WW 301 for further information.

Electronic multimeter

Avo claim to have produced one of the cheapest electronic multimeters ever for the professional market. This latest addition to the new Avometer generation is called the EM 272. A high input impedance of 316kΩ/V, a wide range of measurement and a good frequency response to 20kHz are offered with a.c. and d.c. voltage ranges from 30mV to 1000V f.s.d., a.c. and d.c. current from 3μA to 3A f.s.d. and resistance between 1Ω and 40MΩ, the high impedance of the instrument ensuring accuracy of measurement in high impedance circuits.

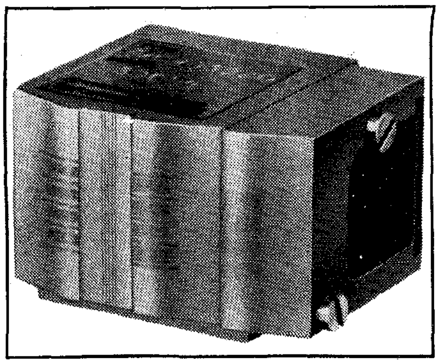


Printed circuit shunts and thick-film resistor modules provide high reliability comparable to that of the small centre-pole movements. The moulded shatterproof case, identical to that of the already popular Avometer model 72, can be held in one hand. Available from wholesale distributors at the U.K. trade price of £24.85 plus VAT £2.49. Avo Ltd, Avocet House, Archcliffe Road, Dover, Kent.
WW 316 for further information.

Cartridge/cassette recording head

To meet the rapidly increasing use of cartridge/cassette tape drives in mini computer systems, Gresham Infomag Limited have announced a new four-track read after write magnetic recording head for ¼in tape.

Utilizing 0.064in track centres, the write head track width is 0.050in and the read width 0.030in. Bit densities up to 1600

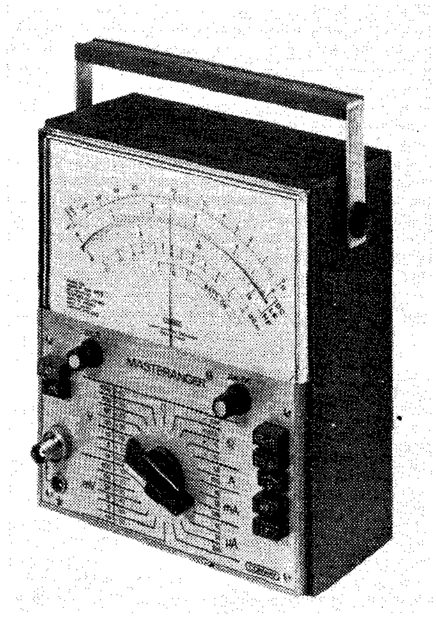


b.p.i., phase encoded, can be handled by the head, the standard product in the range being aimed at 30 i.p.s. drives. Excellent feedthrough (crossfed) and resolution are claimed for the head, whose overall mechanical dimensions are 0.650in wide × 0.775in high × 0.725in deep. Gresham Infomag Ltd, Weybridge Trading Estate, Weybridge, Surrey KT15 2RN.
WW 319 for further information

Multitestset

A new high input impedance multitestset has been released by Conway Electronic Enterprises. This instrument, now internationally offered, has been given the trademark registered name "Masteranger" model 639. It possesses a floating input entirely obviating user hazard particularly when measuring from circuits which are not necessarily at ground potential on the low side.

The instrument features an input resistance of 100MΩ and incorporates ranging giving measurement capability from 50µV up to 1500V a.c. and d.c., plus r.f. measurement. A.c. and d.c. current can be measured from 150nA full scale up to 150A. Resistance measurement is up to 10,000MΩ and dBm measurement is from −80dBm to +66dBm. It is energized by



its own internal long-life batteries which can be zinc carbon, mercury, alkaline or, optionally, can be a.c. mains powered by a "line power cassette" insertable in the rear of the instrument in lieu of the battery cassette.

"Masteranger" model 639 has a six inch mirror scale and accuracy is 1.5% of full scale. The line power cassette makes use of a new type of transformer with separated windings and therefore completely isolates from each other which has resulted in implicit safety in measurement and guarantees against hazard. "Masteranger" with its total of 80 main ranges plus auxiliary ranges, will operate from batteries or 115/230V ±15%, 50/400Hz ±10% and thus is useful for operation anywhere in the world and even from aircraft 400Hz supplies. The instrument is lightweight and comes complete in a genuine bridle leather carry case with shoulder and neck strap and can be used suspended from the neck of the operator ensuring hands-free operation. Conway Electronic Enterprises Ltd, 88-90 Arrow Rd, Weston, Ontario, Canada M9M 2L8.
WW 323 for further information.

Half-tone storage c.r.t.

A new cathode ray tube announced by Mullard is designed for use in laboratory oscilloscopes that require a half-tone storage facility. Designated type L14-110GH/55, it is a 14cm rectangular tube with a storage time of at least 1.5 minutes; the phosphor used to present signals without storage has a persistence of short-to-medium duration.

The new tube is only a few millimetres longer than types D14-120, D14-121 and D14-160, other dimensions being the same. Hence, the L14-110GH/55 can easily replace them in existing oscilloscopes which will then gain the facility of image storing. As the new tube has greater horizontal deflection sensitivity than the earlier types, an improved performance is also gained in the oscilloscopes.

The L14-110GH/55 has a useful scan area of 90 × 72mm (10 × 8 divisions of 9mm). Correction coils supplied with the tube enable the raster to be aligned with the internal graticule. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
WW 318 for further information.

Modulation meter

An automatic modulation meter with a frequency range sufficient to cover all the mobile radio bands is announced by Sayrosa Engineers Ltd. The instrument, model 251, employs circuitry which eliminates manual tuning and level setting so that as long as the input signal is above a minimum level (typically 10mV), the circuitry will lock-on and provide an immediate measurement of the modulation present. F.M. deviation ranges from 3kHz to 100kHz full scale are provided and for a.m. there are full scales of 30% and 100%. Mode and range selection can be made manually, or by logic input an analogue output proportional to the measurement is provided for systems use. The unit is half-rack width, 4in height and weighs less than 8lbs. Sayrosa Engineers Ltd, P.A. Box 50, Bracknell, Berkshire RG12 4YT.
WW 307 for further information

Frequency analyser

B & K Laboratories have announced a new frequency analyser. This model, known as the 2120, is a constant percentage bandwidth analyser for use in the frequency range 2Hz to 20kHz with provision for the connection of external filters extending the range to 180kHz. It consists of a measuring amplifier combined with a built-in active filter complex which is continuously variable and can be switched into four basic modes:

1. As a constant relative bandwidth filter having four selectable bandwidths of 1%, 3% , 10% and 1/3 octave.
2. As a tunable bandstop filter which will suppress any chosen frequency more than 60dB; suppression at $0.5f_0$ and $2f_0$ being less than 1dB.
3. As a tunable high-pass filter.
4. As a tunable low-pass filter.

The internationally standardized weighting networks for sound measurements — A, B, C and the proposed D network — are included and are selectable as required.

The linear frequency range of the instrument is 2Hz to 200kHz, and the measuring range from 10µV to 300V r.m.s. or 700V peak. Noise level can be reduced to 0.4µV.

The many refinements incorporated in the model 2120 combine to make it a very versatile instrument indeed.

The meter and its rectifying system for instance, provides a choice of 6 indications in either logarithmic or linear form. These are r.m.s., impulse hold, +ve peak, −ve peak or maximum peak and in addition a switch provides a choice of averaging times from 0.1 to 300 seconds as well as "fast" and "slow" in accordance with I.E.C. recommendations. Thus, if used in conjunction with suitable B & K microphones, the 2120 can be used as either a precision sound level meter or a precision impulse sound level meter. Shock and vibration can also be measured over wide dynamic and frequency ranges when the 2120 is used with one of the B & K vibration transducers. Its peak indication is particularly useful in this instance for the measurement of short duration shocks down to 20 microseconds.

Sound analysis and recording is claimed as another use for the 2120 and this is simplified by the provision of a flexible shaft for connection to a B & K level recorder so that the frequency sweep can be driven continuously. In this manner amplitude/frequency spectrograms can be obtained on preprinted frequency calibrated charts. The 2120 can also be used for distortion measurements down to 0.1% with the filters switched to the bandstop mode.

In spite of its sophistication, the 2120 is claimed to be practically foolproof to operate. The calibration procedure is simple and is aided by the provision of a built-in 1kHz reference oscillator. Once calibrated the instrument is extremely stable over very long periods. Seven calibrated interchangeable meter scales are provided with each instrument and these cover almost every possible application. B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middlesex.

WW 321 for further details.

Precision graticules

Chequers Engraving specializes in the production of high-quality, close-tolerance graticules for oscilloscope and instrument applications. The products feature fine-line techniques (for filled or unfilled use) down to 0.005in line width, and cumulative tolerances over 6in are maintained to within 0.002in. Graticules and separate or associated filters are manufactured from Oroglass, which has been found to be the only proprietary brand capable of sustaining the required high standards of surface finish. Chequers Engraving Ltd, 10 Christina Street, London EC2.

WW 311 for further details

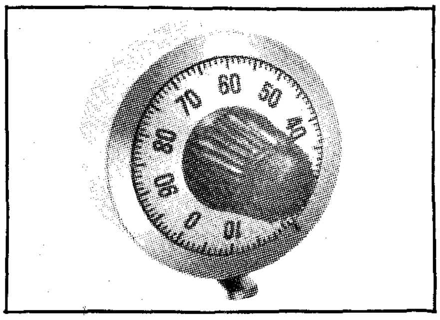
Electrical/electronic aerosols

New from PBRA is a range of aerosols with applications in the electrical/electronics industries. The aerosols — part of PBRA's Crown range — include switch and contact cleaners; an anti-static spray; a magnetic tape head cleaner; insulating varnishes and an inner electric motor cleaner. Also in the range is an aerosol called Electrical 88, which deposits a hydrophobic film — displacing and repelling moisture. The film will not emulsify or harden, will not flake and is non-staining. Effective from −10°C to +204°C, Electrical 88 conforms to MIL-C-81309(WP). PBRA Ltd, 33 Holmethorpe Avenue, Redhill, Surrey.

WW 302 for further details

Locking dial

R. C. Knight have introduced a new design of single turn locking dial incorporating the "Digitool" collet mounting system which ensures a positive lock to component shaft without the use of a grub screw. Designated type 25B this dial has an o.d. of 1in and can be used on



several spindle sizes up to a maximum of $\frac{1}{4}$" dia. Standard colours are silver satin and black and other colours are available on request. Prices range from 90p each and deliveries in the majority of cases can be made from stock. R. C. Knight Ltd, 20 Solent Avenue, Lymington, Hampshire SO4 9SD.

WW 320 for further information.

Audio tape

In response to changing recording techniques EMI Tape Ltd have added a matt-backed tape with a dynamic range of 76.5dB to their range of professional recording tapes. Known as Emitape 817 it can be used on sideless tape hubs or single sided spools. A polyester base with a matt back makes high-speed spooling and uniform wind possible even when using hubs or single-sided spools. Amplitude modulation noise level does not exceed 38.5dB during operation at both 38.1cm/s (15in/s) and 19.05cm/s (7.5in/s) recording speeds.

The tape is available in four standard widths 6.25mm ($\frac{1}{4}$in), 12.70mm ($\frac{1}{2}$in), 25.4mm (1in) and 50.8mm (2in), for all mono and stereo recording requirements at 38.1cm/s (15in/s) and 19.05cm/s (7.5in/s). It is supplied in lengths up to 1000m, and has an ultimate tensile strength of 210N/mm^2 (4.2kg/$\frac{1}{4}$in width) with a yield strength (F3) of 110N/mm^2 (2.3kg/$\frac{1}{4}$in width). The nominal overall thickness of the new tape is 56μm (with a nominal magnetic coating thickness of 18μm).

At 38.1cm/s (15in/s) the tape's dynamic range is 76.5dB, for full track width, and 72.5dB for a stereo track. Signal-to-print level at both recording speeds is 56.5. EMI Tape Ltd, Blyth Road, Hayes, Middlesex.

WW 312 for further details

Digital electrometer

Keithley Instruments has just introduced a new digital electrometer, the model 616. It features voltage sensitivity from 10V per digit to 200V with an input resistance of greater than 2 × 10$^{14}\Omega$. The instrument can be ranged either automatically, manually, or remotely (with an optionally available digital output/control).

Current sensitivity of the model 616 is 10^{-16}A per digit to 100mA. In addition to current and voltage it is also capable of measuring resistance (up to 2 × 10$^{14}\Omega$), and it will also integrate current (measure charge) from 10^{-15} coulomb per digit to 10^{-5} coulomb. The 6162 outputs are fully isolated and provide complete data, timing outputs, and strobe lines. The open collector b.c.d. outputs are fully compatible with most t.t.l. and d.t.l. circuits presently used on printers and computers. Keithley Instruments Ltd, 1 Bolton Road, Reading, Berks RG2 0NL.

WW 304 for further details

Unwrapping tool

As part of the O.K. Machine and Tool Corporation range of wire wrapping equipment, Vero Electronics are now able to offer deliveries from stock of a speed unwrap tool. The SU2026 unwrapping bit with the G100/R3394 speed unwrap tool has been designed to remove conventional right hand solderless wire wrap connections from 20 to 26 gauge wire without damage to the terminal post. By using the SU2832 bit 28 to 32 gauge wire is removed. The tool is specially useful where a large number of connections require removal in the minimum time. Vero Electronics Ltd, Industrial Estate, Chandler's Ford, Eastleigh, Hampshire.

WW 305 for further details

Trimming capacitors

Jackson Brothers (London) announce a a new range of miniature trimming capacitors, which have a thickness of only 2.8mm. The base of the trimmer is a glass fibre board 10.5 × 8mm. Terminations can be made direct to the board, alternatively pins are supplied so that the user may mount the device on to printed circuit boards, the mounting centres are 5.1mm (0.2m). The nominal capacitance ranges offered are from 2.5 to 10pF, 3.5 to 14pF, 6 to 25pF and 8 to 40pF. Operating temperature is from −20°C to +70°C and the devices have a breakdown voltage of 1.5kV at maximum capacitance. Jackson Brothers (London) Ltd, Kingsway, Waddon, Croydon, Surrey CR9 4DG.

WW 306 for further details

Seen at the London Components Show

Character generator

Motorola have introduced the MCM6571L, claimed to be one of the most comprehensive read-only memory character generators in a standard range, and using Motorola's n-channel metal gate m.o.s. process to ensure direct c.m.o.s. and t.t.l. compatibility and high operating speed.

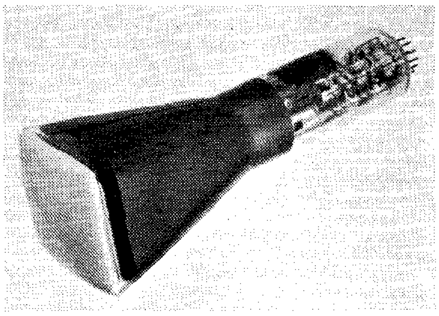
The MCM6571L contains 128 characters, each character being formed by a matrix of seven horizontal and nine vertical dots. Each character is addressed by seven input lines in a modified USASCII code. Once a character has been addressed, the individual rows of seven bits appear on seven output pins under control of a four-bit row select input. Address access and row select times are typically 350ns (500ns max).

In addition to the 8192 bits of memory used to store symbols and characters, the MCM6571L incorporates a 128-bit matrix which controls character position automatically. Certain characters normally extend below the base line (j, y, p and q for example) and the 128-bit matrix causes these characters to appear in their correct positions relative to the other characters. Each 7 × 9 character is in fact stored in one of two positions in a 7 × 16 matrix (the lower position allowing portions of characters to appear below the base line). The 128-bit matrix automatically informs the addressing circuitry if the character is in the upper or lower position, thereby replacing a substantial amount of external circuitry. Housed in a 24-lead package, the MCM6571L has a typical input capacitance of 4pF and dissipates 600mW. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middlesex.
WW353 for further details

Cathode ray tubes

New tubes from Brimar include: a 7cm diagonal rectangular instrument tube, the D7-201 (see photograph) which is an improved version of the D7-200. The improvements include modified glassware and higher *y*-plate sensitivity. The suitability of this tube for low power transistorized equipment has been improved by the introduction of a low wattage heater (6.3V, 0.12A).

The requirement to present high densities of information on large area displays and the need to minimize the overall



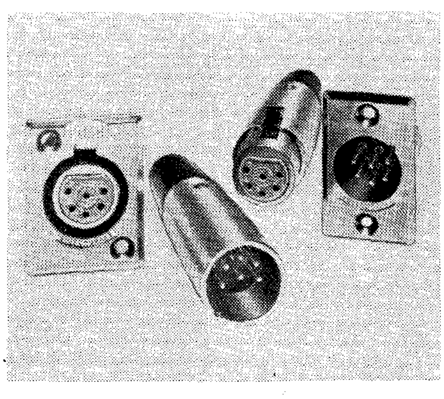
length of data terminals have led to the development of the M38-140. This rectangular tube of 38cm diagonal uses 110° deflection and has a neck diameter of 28mm.

The D10-230 is a 10cm round, single accelerator tube intended for low-cost oscilloscopes and waveform monitoring applications. Features include a flat face, small neck diameter and overall length, 80 × 64mm useful screen area and a low deflection voltage requirement. Thorn Radio Valves & Tubes Ltd, Mollison Avenue, Brimsdown, Enfield, Middlesex EN3 7NS.
WW357 D7-201
WW358 M38-140
WW359 D10-230

Audio connectors

F. W. O. Bauch, as sole U.K. distributor, displayed selections from the Switchcraft Q-G range of audio connectors, featuring a streamlined design, rugged construction and simple snap-in positive connection. They are fully compatible with other leading makes, permitting ready changeover and/or extension.

Included in the range is a connector adaptor with a male insert at one end and



a female insert at the other. With 3, 4, or 5 contacts, this connector is particularly designed for use in situations requiring a transformer, attenuator circuit or other electronic circuitry in line with a microphone input.

Also available is the series of cord plugs for direct connection with microphones. The slide switch, in-built into the connector shell, permits finger-tip switching control of microphones and in-line audio and control circuits. The cord plug incorporates a shielding feature which protects the mated shell, thereby making all contacts available for control of audio circuits. F. W. O. Bauch, Ltd, 49 Theobald Street, Boreham Wood, Herts WD6 4RZ.
WW368 for further details

Varicap TV tuner

New from AB Electronic Components is a thick film v.c.d. tuner for television receivers. The tuner is claimed to be the first in Europe using thick film techniques, and possibly the first in the world. It is of small size, 65 × 34 × 17mm, and offers a British second source supply for Continental products. Complete compatibility with these other products is given by special adaptor printed circuit boards which, if necessary, ensure correct supply voltages and pin connections. AB Electronic Components Ltd, Abercynon, Glamorgan.
WW364 for further details

Transmitter transistor

Among new transistors developed by Mullard for use in transmitters is the BLX95. This is an n-p-n, silicon, planar, epitaxial device that can be used under class A, B or C conditions with a supply voltage of 28V. It has a capstan envelope with its leads isolated from the mounting stud. In an un-neutralized, common-emitter, class B circuit, a typical performance for the BLX95 under c.w. input conditions would be:

V_{cc} — 28V
f_T — 470MHz
P_L — 40W
I_C — 2.4A
Efficiency — 60%

Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
WW 361 for further details

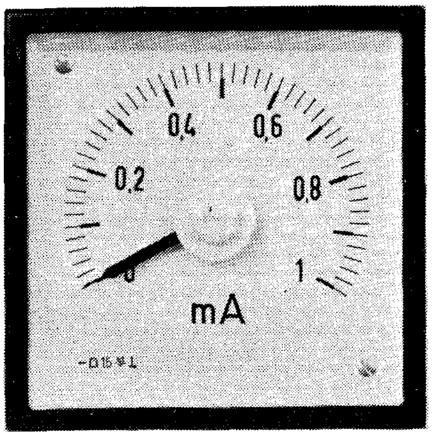
25MHz dual trace scope

A new addition to the Scopex range of oscilloscopes is a solid-state dual trace version, the 4D-25 at £175 with 3% measuring accuracy on both vertical and horizontal deflection systems. Bandwidth is d.c. to 25MHz, but more significantly, 25MHz measured at full screen can be displayed over the total screen area. Signal delay is operative on both vertical channels and permits the leading edge of

a displayed waveform to be investigated. The timebase has 19 ranges from 200ns/cm to 200ms/cm plus a ×5 magnifier to increase the fastest range to 40ns/cm. Trigger level and polarity are both selected on one control and in the absence of a trigger signal the 4D-25 goes to bright line auto. A tunnel diode stage is used for reliable stable triggering over the full range of sweep speeds. The dimensions of the 4D-25 are 15.3cm (height) × 31.2cm (width) × 43.5cm (depth). Scopex Instruments Ltd, Pixmore Industrial Estate, Pixmore Avenue, Letchworth, Herts SG6 1JJ.
WW360 for further details

Long scale meters

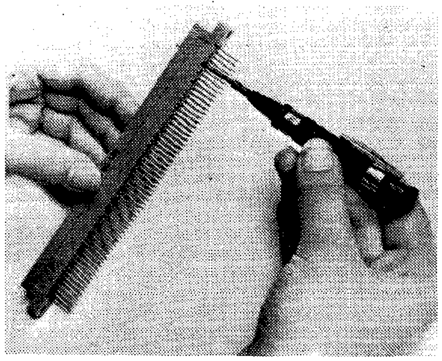
The range of meters by British Physical Laboratories included moving-coil panel versions, hermetically sealed meters, long-scale meters, and switchboard meters, also including three new Europa types — the E31G panel meter, available both for panel and sub-panel mounting, with 95° arc movement in a small barrel attractive rectangular case assembly. The E72F (in photo) and E96F square Fulscale meters, with 250° arc movement,



are in standard DIN-size cases. Other new products included non-linear (logarithmic) moving-coil movements, a large dual movement 270° arc switchboard meter being designed for use on the Advanced Passenger Train, Fulscale meters with illumination designed for the boating instrumentation market, and two sizes of flat stackable edgewise meters. British Physical Laboratories, Radlett, Herts WD7 7HJ.
WW367 for further details

Edge connectors

A new edge connector by Carr Fastener is available with up to 90 contacts, single or double sided, on a 0.1in, 2.54mm pitch. The one piece single cantilever contact is a new Cinch design with a narrow face width ensuring low insertion force characteristics over the full printed circuit board thickness range of 0.054in to 0.072in. A firm even pressure is claimed to provide optimum conductivity while



ensuring minimum wear on the foil and a rigid wiring terminal of 0.63mm square section allows for mini-wrap or solder wiring.

A feature offered is the ease with which contacts can be removed and replaced. Removal can be done without disturbing wiring, even when connectors are mounted closely side-by-side.

The polyester moulding is designed to resist all known solvents and has suitable temperature properties to permit solder wiring. Moulded brackets are ultrasonically welded to the body to give the advantages of integral moulded fixings. Working voltage is 600V d.c. or a.c. and current rating is 5A d.c. and a.c. Contact identification and polarization keys are optional. Carr Fastener Company Ltd, Nottingham Road, Stapleford, Nottingham NG9 8AJ.
WW363 for further details

Microwave p-i-n diodes

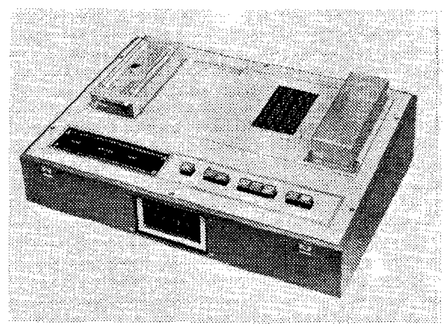
Intended for 50-ohm broadband stripline circuits, new microwave diodes by AEI Semiconductors, types DC2418A and DC2419A offer a choice of bias polarity and both switch in 50ns. Capable of handling 30 watts c.w., they have an isolation of 25dB at 10GHz and are useful to 20GHz with an insertion loss of 0.5dB. Although having a higher insertion loss, 1dB, and a lower isolation, 20dB, the DC2412A switches in 5ns while handling 12 watts c.w. AEI Semiconductors Ltd, Carholme Road, Lincoln LN1 1SG.
WW 352 for further details

Large-screen oscilloscopes

Lan-Electronics have announced the availability of two new large-screen oscilloscopes, intended for demonstration, education, medical investigation and any other applications requiring large, low-frequency display. The display units themselves are either 20inch or 11inch 110° tubes, with either green long-persistence or white short-persistence traces, and are designed to work in conjunction with local or remote control preamplifiers, which offer four channel operation. Additionally, the display units can be used as self-contained instruments and flexibility is enhanced by the t.t.l.-compatibility of their interfaces. Bandwidth in the y direction is 0-45kHz at −3dB at a sensitivity of 67.5mV/cm. The x amplifier covers 0-15kHz (−3dB) at 50mV/cm and z modulation is directly coupled to 4.5MHz, requiring 4.5V for full modulation. The Model A control unit, the first of a series, offers a four-channel y preamplifier and triggered timebase providing a maximum sweep speed of 20μs/cm. An unusual feature of the y channel switching circuitry is that all channels may be displayed in turn by the use of a "mechanical trigger" input. Lan-Electronics Ltd, 95 Farnham Road, Slough, SL2 3AF, Bucks.
WW351 for further details

Digital tester

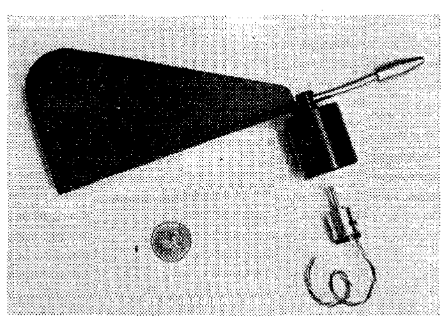
The Wayne Kerr "Swift" tester for digital p.c.bs compares the performance of two boards – one of which is known – and checks for any non-parity of outputs for all combinations of up to 27 inputs. It accepts double or single-sided boards with



up to 64 ways on the edge connector. Programming is by patch-panel for experimental testing or short production runs. A pre-wired matrix plug is used for longer test runs. Wayne Kerr Co Ltd, Durban Road, Bognor Regis, Sussex PO22 9RL.
WW 356 for further details

Wind vane potentiometer

One of the features displayed by May Precision Components was a wind direction indication system for marine and similar applications. The Deswynn System, which is one of the commercial designs available for yachting and in-shore shipping, is a d.c. system in which a mast-mounted wind vane provides direct drive to a lightweight potentiometer. As



the vane reacts to each change of direction, so the potentiometer reflects this on a cockpit console. The potentiometer MR 101 was designed specifically for this application, and features low-torque, low-weight factor, high linearity and is environmentally sealed. May Precision Components Ltd, Bowlers Croft, Honywood Road, Basildon, Essex.

WW 366 for further details

Counter frequency divider

AMF Venner have produced a 500MHz non-displaying frequency divider for use with their own "77" range of counters and other types capable of measuring frequencies of 5MHz and over. The input to the unit is divided in frequency by factors of 100 and 10, the two outputs being provided simultaneously at two front-panel sockets. Signals of 10mV r.m.s. into 50 ohms are acceptable, and an indication is given when the input is greater than 20mV. The output to the counter is a 500mV p.p. square wave when terminated by a normal counter input circuit. A built-in mains power supply is provided. AMF Venner Ltd, Kingston by-pass, New Malden, Surrey.

WW 355 for further details

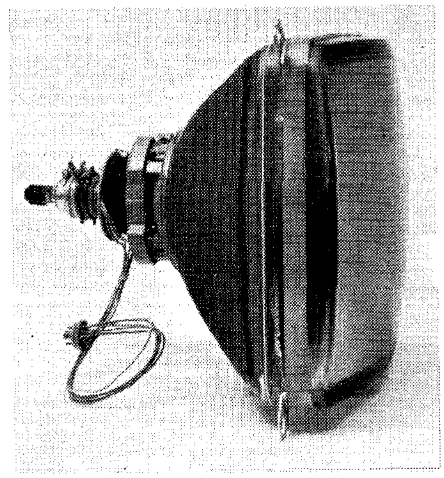
High stability signal generator

A synchronized signal generator, the Marconi TF2006/1, provides locking over the frequency range 10 to 500MHz in 100Hz steps with all possibilities of false locking removed. Seven front panel switches are used to set up the required frequency and a separate two-position switch is set to the "tune" position. The frequency is then adjusted so that two front-panel lamps are both flashing and with the switch then set to the "lock" position the generator is automatically locked to the required frequency with no possibility of ambiguity. With digital synchronizer incorporated, TF2006/1 renders unnecessary the use of an external counter with associated leakage problems at low output levels. Marconi Instruments Ltd, Longacres, St. Albans, Herts AL4 0JN.

WW 362 for further details

Colour TV tube

An unusual colour television cathode-ray tube shown by Thorn Colour Tubes Ltd has the deflection, convergence and purity components supplied integral with the tube and already set up — the idea being to eliminate the convergence and purity setting-up operations that are normally necessary during receiver manufacture, subsequent tube replacement or receiver servicing. Two other features which distinguish it from the conventional shadow-mask tube are a vertically striped



three-colour phosphor screen and corresponding slotted shadow-mask, and a horizontal in-line electron gun. Known as the Precision In-line Colour TV Tube assembly, the device appears to be similar to an RCA tube described in our October 1972 issue (p.466). It has a 51cm (diagonal) screen, a 90° deflection angle and a 29mm neck diameter, the overall length of the tube being 417mm. Designated A51-160X, the colour tube will be available in the Autumn of 1974. Thorn Colour Tubes Ltd, Mollison Avenue, Brimsdown, Enfield, Middx.

WW 365 for further details

Digital voltmeter

A new digital voltmeter, the Advance DVM44, is a small multi-range integrating d.c. digital instrument incorporating a $3\frac{1}{2}$-digit display with automatic polarity indication. Analogue to digital conversion is achieved using a dual-slope integration system. Five ranges extend from 0 (to 199.9mV, 1.999V, 19.99V, 199.9V) to 1000V, and power input requirements are 100-125V or 200-250V at 45-65Hz. Advance Electronics Ltd, Raynham Road, Bishop's Stortford, Herts.

WW 350 for further details

I.C. logic checker

A new i.c. logic checker by Jermyn Manufacturing gives immediate display of the logic state of each pin in a d.t.l. or t.t.l. dual-in-line integrated circuit. It replaces laborious alternative methods of testing, for example with a single probe and cathode ray tube. The checker – $2\frac{1}{2}$ inches long and weighing just $1\frac{1}{2}$ oz – is clipped over a 5V i.c. (up to 16 pins) and monitors and displays the logic state of each terminal on an array of 16 light emitting diodes. A lamp on means logic state 1 or open circuit on that pin, a lamp off means logic state 0 (or ground), and unused terminals and the 5V supply pins also show logic state 1. The checker takes its power – only 200mA with all lamps on – from the two pins on the i.c. carrying the 5V supply, and gives an identical reading whichever way round it is clipped. It is suitable for most t.t.l. and d.t.l. devices and is supplied with 24 masks to help check the most common logic configuration. An i.c. insertion tool is included in the kit. Jermyn Manufacturing, Vestry Estate, Sevenoaks, Kent.

WW 354 for further details

Precision resistors in TO-5 cans

Originally developed for military use, Alma type SN precision wirewound resistors will be in production later this year. The resistors feature bobbinless construction, all-welded terminations, are housed in TO-5 cans and meet nearly all military specifications. Values, in the range ten ohms to two megohms, can be set to 0.01% with a long-term stability of 50 parts per million (0.005%) per year, reducing to 20 parts per million after the first year. Rated for $\frac{1}{8}$-watt dissipation at 70°C, temperature coefficient is nominally 10 parts per million, with 2 and 5 parts to special order. Alma Components Ltd, Park Road, Diss, Norfolk IP22 3AY.

WW 372 for further details

Yagi array for 1500MHz

Thought to be the cheapest 1500MHz aerial available for point-to-point links, the J Beam 7127 is unusual in adopting a Yagi construction. Conventional horn or dish aerials normally require mounting on towers because of wind loading, but using a Yagi array means the aerial can be pole mounted (this model having a wind loading of about 40 lb). Over the band 1450 to 1535MHz (used in the main service industries for point-to-point communication) the aerial, using the J Beam slot-fed radiator with 18 parasitic elements, shows a gain of 16dB with less then 0.5dB variation and with a v.s.w.r. of between 1.2 and 1.3. Front-to-back ratio is 26dB and half-power angle is 26° in the E-plane. It measures five feet in length and the 5-in dia. glass fibre "radome" gives protection against icing. Cost is around £100. J Beam Engineering Ltd, Rothersthorpe Crescent, Northampton.

WW 369 for further details

Accurate sine/cosine potentiometers

Using a conductive plastics material, Penny & Giles achieve a very accurate sine/cosine law in their latest potentiometers. Designed primarily for providing range circles in radar displays, they conform to a sinusoidal law to within 0.1% pk-pk. They are available in six values from 1 to 10kΩ at ±10% tolerance. Other conformity values of 0.5 and 1% are also available. Penny & Giles Conductive Plastics Ltd, Blackwood, Mon.

WW 370 for further details

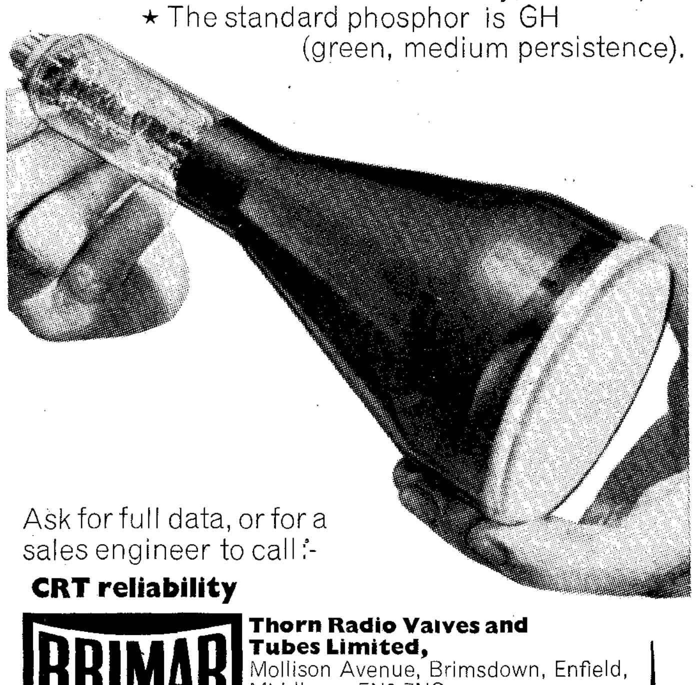
Save millimetres AND money with this new Brimar Tube

If you're planning an oscilloscope – or any instrument for waveform monitoring – Brimar has good news for you. The **Brimar D10-230** mono-accelerator tube is a real winner where low cost and small size are important considerations.

Short in length, small around the neck, it can save you a whole lot of space . . . give you far greater freedom in your designing. The flat 4″ diameter face offers minimum total scans of 80mm and 64mm, in X and Y directions respectively. And its voltage requirements are within the capability of normal, low-cost, transistorised circuits.

This tube with its Standard B14G Colour tube base also allows economies to be made in Socket costs and, being round, requires no twist coil.

- ★ Maximum overall length: 260mm
- ★ Maximum neck diameter: 38mm
- ★ First anode voltage: Va1, 1500V
- ★ Second anode voltage for focus: Va2, 230 to 380V
- ★ Grid voltage for spot cut-off (approx.): Vg −30 to −65V
- ★ X plate deflection coefficient: Dx, 21 to 26V/cm
- ★ Y plate deflection coefficient: Dy, 13 to 16V/cm
- ★ The standard phosphor is GH (green, medium persistence).



Ask for full data, or for a sales engineer to call :-

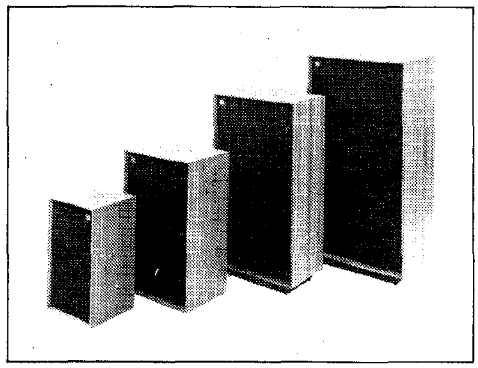
CRT reliability

BRIMAR

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

THORN

WW—084 FOR FURTHER DETAILS



The Mordaunt-Short range of quality loudspeaker systems (£29.15 - £90.75, inc. V.A.T.)

Amid the wealth of accomplishment of audio technology world-wide, the design of quality loudspeaker systems remains uniquely a sphere of British eminence. Whether you be primarily music-lover, high-fidelity enthusiast or home-maker, these superlative products have a great deal to offer you.

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WW—085 FOR FURTHER DETAILS

Sinclair Project 60

Now–the Z.50 Mk.2

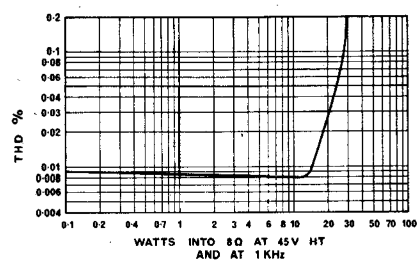
with built-in automatic transient overload protection

When originally introduced, the Sinclair Z.50 proved how it was possible to design and produce a popularly priced modular power amplifier having characteristics to challenge the world's costliest amplifiers. Many thousands of Z.50's are now giving excellent service day in, day out. But we have also learned that constructors do not always use their Z.50's ideally. That is why we have introduced modifications whereby risk of damage through mis-use is greatly reduced and performance further enhanced. The Z.50 Mk.2 has improved thermal stability, more accurately regulated D.C. limiting to ensure more symetrical output voltage swing and clipping and still less distortion at lower power. Z.50 Mk.2 is compatible with all other Project 60 modules, and may be incorporated to advantage in existing systems. Eleven silicon epitaxial planar transistors are now used, two more than in the original Z.50; circuitry has been re-designed, making this versatile high performance amplifier better than ever.

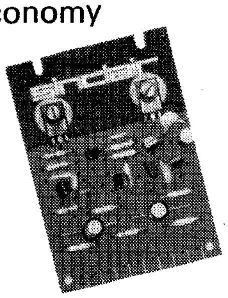
with free manual
£5.48

Brilliant new technical specifications

Input impedance 100 KΩ
Input (for 30w into 8Ω) 400mV
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better
Distortion 0.02% up to 20W at 8Ω. See curve
Frequency response 10Hz to more than 200 KHz ±1dB
Max. supply voltage 45v (4Ω to 8Ω speakers) (50v 15Ω speakers only)
Min. supply voltage 9v
Load impedance – minimum: 4Ω at 45v HT
Load impedance – maximum: safe on open circuit



Z.30 the power amplifier for quality and economy



with free manual
£4.48

The Z.30 provides excellent facilities for the constructor requiring a high fidelity audio system of less power than that available from Z.50's. Using a power supply of 35 volts, Z.30 will deliver 15 watts RMS into 8 ohms, or 20 watts RMS into 3 ohms using 30 volts. Total harmonic distortion is a fantastically low 0.02% at 15 watts into 8 ohms with signal to noise ratio better than 70 dB unweighted. Input sensitivity 250mV into 100K ohms. Size 80 x 57 x 13 mm ($3\frac{1}{8}$ x $2\frac{1}{4}$ x $\frac{1}{2}$) Z.30, Z.50 and Z.50 MK.2 modules are compatible and interchangeable.

Typical Project 60 applications

System	The Units to use	together with	Units cost
Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control, etc.	**£4.48**
Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control, etc.	**£9.45**
12W. RMS continuous sine wave stereo amp. for average needs	**2 x Z.30s, Stereo 60; PZ.5**	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	**£23.90**
25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	**2 x Z.30s, Stereo 60; PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms)	**2 x Z.50s, Stereo 60; PZ.8, mains transformer**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. **(£5.98)** may be added as required.

Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

Each Project 60 module is tested before leaving our factory and is guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you, if it is returned within two years from the date of purchase. Outside this period of guarantee a small charge (typically £1.00) will be made. No charge is made for postage by surface mail. Air Mail is charged at cost.

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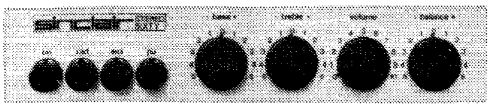
the world's most advanced high fidelity modules

Stereo 60 Pre-amp/control unit

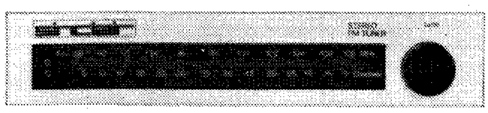


Designed specifically for use on Project 60 systems, the Stereo 60 is equally suitable for use with any high quality power amplifier. Since silicon epitaxial planar transistors are used throughout, a really high signal-to-noise ratio and excellent tracking between channels is achieved. Input selection is by means of press buttons, with accurate equalisation on all input channels. The Stereo 60 is particularly easy to mount.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ±1dB:20 to 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE+12 to —12dB at 10KHz: BASS +12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.

Built, tested and guaranteed. **£9.98**

Project 60 Stereo F.M. Tuner

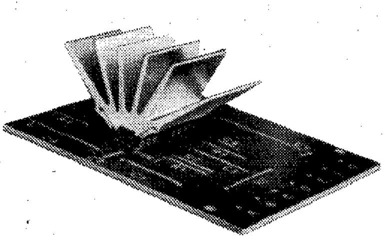


The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other advanced features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stero decoder and switchable squelch circuit for silent tuning between stations. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with most other high fidelity systems.

SPECIFICATIONS—Number of transistors: 16 plus 20 in I.C. **Tuning range:** 87.5 to 108MHz. **Sensitivity:** 7μV for lock-in over full deviation. **Squelch level:** Typically 20μV. **Signal to noise ratio:** >65dB. **Audio frequency response:** 10Hz – 15KHz (±1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2μV. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S. maximum **Operating voltage:** 25–30VDC. **Indicators:** Stereo on; tuning. **Size:** 93 x 40 x 207mm.

Built and tested. Post free. **£25**

Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, the first time an IC had ever been made available for such purposes, we have followed it with an even more efficient version, the Super IC.12, a most exciting advance over our original unit. This needs very few external resistors and capacitors to make an astonishingly good high fidelity amplifier for use with pick-up, F.M. radio or small P.A. set up, etc. The free 40 page manual supplied, details many other applications which this remarkable IC. make possible. It is the equivalent of a 22 transistor circuit contained within a 16 lead DIL package, and the finned heat sink is sufficient for all requirements. The Super IC.12 is compatible with Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

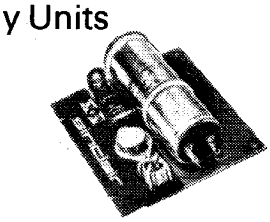
SPECIFICATIONS

Output power: 6 watts RMS continuous (12 watts peak). 6–8Ω. **Frequency Response:** 5Hz to 100KHz±1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0·1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22×45×28mm including pins and heat sink..

Manual available separately 15p post free.

With FREE printed circuit board and 40 page manual.
£2.98 Post free

Power Supply Units The new PZ.8 Mk.3



The most reliable power supply unit ever made available to constructors. Brilliant circuitry makes failure from over load and even direct shorting of the output impossible. This is due to an ingenious re-entrant current limiting principle which, as far as we know has never before been available in any comparable unit outside the most expensive laboratory equipment. Ripple and residual noise have been reduced to the point of almost total elimination. This is, of course, the perfect unit for Project 60 assemblies, particularly where the new Z.50 MK.2 amplifiers are used. Nominal working voltage – 45.

PZ.8 Mk.3—£7.98
(Mains transformer, if required) £5.98
PZ.5 30v. unstabilised
(not suitable for Project 60 tuner) **£4.98**
PZ.6 35v. stabilised
(not suitable for IC. 12) **£7.98**

Project 605

the easy way to buy and build Project 60 without soldering

Project 605 in one pack contains: one PZ.5, two Z.30's, one Stereo 60 and one Masterlink, which has input sockets and output components grouped on a single module and all necessary leads cut to length and fitted with clips to plug straight on to the modules thus eliminating all soldering.

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DESPATCH GUARANTEED WITHIN 72 HOURS, complete with lucid instructions.

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(as in Wireless World, July 1972)

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(1) Connect decorder to your tuner, possibly disconnecting one or two de-emphasis components.
(2) Provide 10 to 16 volts D.C. either from your tuner or a separate power supply.
(3) Tune to a stereo broadcast.
(4) Turn a "preset" resistor until the stereo beacon lights up. You then have stereo radio.

Comprehensive instructions provided, but if you are in doubt, just ask us!

£3.40 post free + **34p** V.A.T. (Beacon **34p** + **4p** V.A.T.)

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£4.40 post free + **44p** V.A.T. Why pay more?

Why not call on us for a demonstration of quadraphonic and stereo hi-fi. The demonstration lounge in our new factory will be open on MAY 1st.

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☐ Phase locked loop decoder

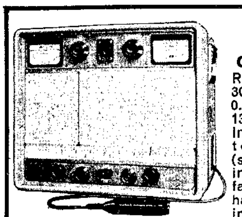
I enclose cheque/postal order for £..............................

Name ....

Address ....

....(BLOCK CAPITALS PLEASE)

WW—088 FOR FURTHER DETAILS



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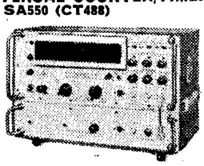
RACAL UNIVERSAL COUNTER/TIMER SA550 (CT488)



8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. and price on request.

OA 1094A/S H.F. SPECTRUM ANALYSER Carrier range: 3 to 30 Mc/s. Sweep width: up to 30 Kc/s. 60 dB amplitude differences measurable. P.O.A.
THERMOCOUPLES. Mineral Insulated Metal Sheathed. Conductors: Positive Nickel—Chromium. Negative Nickel—Aluminium. Conductor Diameter: ·011 inch nominal. Tolerance: ± 3°C. up to 400°C. ± ¾% between 400°C. and 1000°C. Length 3ft. 2in. (96 cm. approx.). **£2·25** post paid.
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AMPLIFIER ASSEMBLY Mk. 112AA for Monitoring Equipment Type IN.C.A.
ALPHA COUNTER Mk. INH.
More Information and Price on request.
L.F. SOLATRON DECADE OSCILLATOR TYPE OS103.2. Frequency range: 0·01 c.p.s.—11·1 c.p.s. In steps of 0·01 c.p.s. with multipliers of 10, 100 and 1000 giving a maximum frequency of 11·1 Kc/s. Frequency accuracy ±1·5%. **£90.**
"WESTON" clear plastic meters 50-0-50µA type S.221.3.150 size 120 ×120 mm. **£2·50** postage included.
Also as above 20 V. M.C. size 60 × 60 mm. type S.2193.254. **£1·95** post paid.

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515A, 524AD, 543, 545, 545A, 545B.
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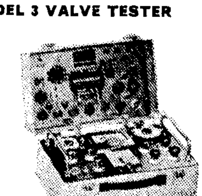
QUANTIZATION DISTORTION TESTER. Checks a.f. to a.f. distortion of p.c.m. systems. Utilises system power supply. Output level: Variable in 1 dB steps, from —50 to +2 dBm. Accuracy: ±0·2 dB at +2 dBm, ±0·5 dB incremental. Quantization distortion: 0 to —40 dB in 0·5 dB steps. Meter indication: True r.m.s. Input Impedance: 600Ω ±10% balanced.

AVO MODEL 3 VALVE TESTER



Enables comprehensive characteristics to be plotted, or measures valves on a simple good/bad basis. **£55** incl. carr.
AVO CT 160 VALVE TESTER As above but in portable valise form as illustrated. Price **£65** incl. carr.
AVO TRANSISTOR ANALYSER CT 446. £70 incl. carr.
GALVANOMETER by "Weston" scale 0-100 M.c. F.S.D. 200 µA, round 2⅝in. **£1·50** post paid.

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AC107	0·22
AC113	0·22
AC115	0·26
AC117K	0·22
AC122	0·13
AC125	0·19
AC126	0·19
AC127	0·19
AC128	0·19
AC132	0·16
AC134	0·16
AC137	0·16
AC141	0·16
AC141K	0·19
AC142	0·16
AC142K	0·19
AC151	0·17
AC154	0·22
AC155	0·22
AC156	0·22
AC157	0·27
AC165	0·22
AC166	0·22
AC167	0·22
AC168	0·27
AC169	0·16
AC176	0·22
AC177	0·27
AC178	0·31
AC179	0·31
AC180	0·19
AC180K	0·22
AC181	0·19
AC181K	0·22
AC187	0·24
AC187K	0·22
AC188	0·24
AC188K	0·22
ACY17	0·28
ACY18	0·22
ACY19	0·22
ACY20	0·22
ACY21	0·22
ACY22	0·18
ACY27	0·20
ACY28	0·21
ACY29	0·39
ACY30	0·31
ACY31	0·31
ACY34	0·23
ACY35	0·23
ACY36	0·31
ACY40	0·19
ACY41	0·20
ACY44	0·39
AD130	0·42
AD140	0·53
AD142	0·53
AD143	0·43
AD149	0·55
AD161	0·37

AD162	0·37
AD161 & AD162 (MP)	0·61
ADT140	0·55
AF114	0·27
AF115	0·27
AF116	0·27
AF117	0·27
AF118	0·39
AF124	0·33
AF125	0·28
AF126	0·31
AF127	0·31
AF139	0·33
AF178	0·33
AF179	0·55
AF180	0·55
AF181	0·50
AF186	0·50
AF239	0·41
AL102	0·72
AL103	0·72
ASY26	0·28
ASY27	0·33
ASY28	0·28
ASY29	0·28
ASY50	0·28
ASY51	0·28
ASY52	0·28
ASY54	0·28
ASY55	0·28
ASY56	0·28
ASY57	0·28
ASY58	0·28
ASZ21	0·44
BC107	0·10
BC108	0·10
BC109	0·11
BC113	0·11
BC114	0·17
BC115	0·17
BC116	0·17
BC117	0·17
BC118	0·11
BC119	0·33
BC120	0·88
BC125	0·13
BC126	0·20
BC132	0·13
BC134	0·20
BC135	0·13
BC136	0·17
BC137	0·17
BC139	0·44
BC140	0·33
BC141	0·33
BC142	0·33
BC143	0·33
BC145	0·50
BC147	0·11

BC148	0·11
BC149	0·13
BC150	0·20
BC151	0·22
BC152	0·19
BC153	0·31
BC154	0·33
BC157	0·20
BC158	0·13
BC159	0·13
BC160	0·50
BC161	0·55
BC167	0·13
BC168	0·13
BC169	0·13
BC170	0·13
BC171	0·16
BC172	0·16
BC173	0·16
BC174	0·16
BC175	0·24
BC177	0·21
BC178	0·21
BC179	0·21
BC180	0·27
BC181	0·27
BC182	0·11
BC182L	0·11
BC183	0·11
BC183L	0·11
BC184	0·13
BC184L	0·13
BC186	0·31
BC187	0·31
BC207	0·12
BC208	0·12
BC209	0·13
BC212L	0·12
BC213L	0·12
BC214L	0·16
BC225	0·28
BC226	0·39
BCY30	0·27
BCY30	0·27
BCY31	0·29
BCY32	0·33
BCY33	0·24
BCY34	0·28
BCY70	0·16
BCY71	0·20
BCY72	0·16
BCZ10	0·22
BCZ11	0·28
BCX12	0·28
BD121	0·66
BD123	0·72
BD124	0·66
BD131	0·55
BD132	0·66
BD133	0·72
BD135	0·44

BD136	0·44
BD137	0·50
BD138	0·55
BD139	0·61
BD140	0·66
BD155	0·88
BD175	0·66
BD176	0·66
BD177	0·72
BD178	0·72
BD179	0·77
BD180	0·77
BD185	0·83
BD186	0·72
BD187	0·77
BD188	0·77
BD189	0·99
BD190	0·83
BD195	0·94
BD196	0·94
BD197	0·99
BD198	0·99
BD199	1·05
BD200	1·05
BD205	0·88
BD206	0·88
BD207	1·05
BD208	1·05
BDY20	1·10
BF115	0·27
BF117	0·50
BF118	0·77
BF119	0·77
BF121	0·50
BF123	0·55
BF125	0·50
BF127	0·55
BF152	0·61
BF153	0·50
BF154	0·50
BF155	0·77
BF156	0·53
BF157	0·61
BF158	0·61
BF159	0·66
BF160	0·44
BF162	0·44
BF163	0·44
BF164	0·44
BF165	0·44
BF167	0·24
BF173	0·24
BF176	0·34
BF177	0·39
BF178	0·33
BF179	0·33
BF180	0·33
BF181	0·33
BF182	0·44
BF183	0·44
BF184	0·28

BF185	0·33
BF188	0·44
BF194	0·13
BF195	0·13
BF196	0·16
BF197	0·16
BF200	0·50
BF222	1·05
BF257	0·50
BF258	0·66
BF259	0·94
BF292	0·61
BF263	0·61
BF270	0·39
BF271	0·33
BF272	0·38
BF273	0·39
BF274	0·39
BFW10	0·66
BFX29	0·30
BFX84	0·24
BFX85	0·33
BFX86	0·24
BFX87	0·27
BFX88	0·24
BFY50	0·22
BFY51	0·22
BFY52	0·22
BFY53	0·19
BPX25	0·94
BSX19	0·17
BSX20	0·17
BSY25	0·17
BSY26	0·17
BSY27	0·17
BSY28	0·17
BSY29	0·17
BSY38	0·20
BSY39	0·20
BSY40	0·31
BSY41	0·31
BSY95	0·14
BSY95A	0·14
Bu105	2·20
C111E	0·55
C400	0·33
C407	0·28
C424	0·22
C425	0·55
C426	0·39
C428	0·22
C441	0·33
C442	0·33
C444	0·39
C450	0·24
MAT00	10·21
MAT101	0·22
MAT120	0·21
MAT121	0·20
MPF102	0·46
MPF104	0·41

MPF105	0·41
OC19	0·39
OC20	0·70
OC22	0·42
OC23	0·46
OC24	0·62
OC25	0·42
OC26	0·28
OC28	0·55
OC29	0·55
OC35	0·46
OC36	0·55
OC41	0·22
OC42	0·27
OC44	0·17
OC45	0·14
OC70	0·11
OC71	0·11
OC72	0·16
OC74	0·16
OC75	0·17
OC76	0·17
OC77	0·28
OC81	0·17
OC81D	0·17
OC82	0·17
OC82D	0·17
OC83	0·22
OC84	0·22
OC139	0·22
OC140	0·22
OC169	0·28
OC170	0·28
OC171	0·28
OC200	0·28
OC201	0·31
OC202	0·31
OC203	0·28
OC204	0·28
OC205	0·39
OC309	0·44
OCP71	0·48
ORP12	0·48
ORP60	0·44
ORP61	0·44
P346A	0·22
P397	0·46
ST140	0·46
ST140	0·14
ST141	0·19
TIS43	0·33
UT46	0·30
2G301	0·21
2G302	0·21
2G303	0·21
2G304	0·27
2G306	0·44
2G308	0·39
2G309	0·39
2G339	0·22
2G339A	0·18

2G344	0·20
2G345	0·18
2G371	0·18
2G371B	0·13
2G373	0·19
2G374	0·19
2G377	0·33
2G378	0·18
2G381	0·18
2G382	0·18
2G401	0·33
2G414	0·33
2G417	0·28
2N388	0·39
2N388A	0·61
2N404	0·22
2N404A	0·31
2N524	0·46
2N527	0·54
2N598	0·46
2N599	0·50
2N696	0·14
2N697	0·15
2N698	0·27
2N699	0·39
2N706	0·09
2N706A	0·10
2N708	0·13
2N711	0·33
2N717	0·39
2N718	0·27
2N718A	0·55
2N726	0·31
2N727	0·31
2N743	0·22
2N744	0·22
2N914	0·16
2N918	0·33
2N929	0·23
2N930	0·23
2N1131	0·22
2N1132	0·24
2N1302	0·16
2N1303	0·16
2N1304	0·19
2N1305	0·19
2N1306	0·23
2N1307	0·23
2N1308	0·26
2N1309	0·26
2N1613	0·22
2N1711	0·22
2N1889	0·35
2N1890	0·50
2N1893	0·41
2N2147	0·79
2N2148	0·63
2N2160	0·66
2N2192	0·39
2N2193	0·39
2N2194	0·39

2N2217	0·24
2N2218	0·22
2N2219	0·22
2N2220	0·24
2N2221	0·22
2N2222	0·22
2N2368	0·19
2N2369	0·16
2N2369A	0·16
2N2411	0·27
2N2412	0·27
2N2646	0·52
2N2711	0·23
2N2712	0·23
2N2714	0·23
2M2904	0·19
2N2904A	0·23
2N2905	0·23
2N2905A	0·23
2N2906	0·17
2N2906A	0·20
2N2907	0·22
2N2907A	0·24
2N2923	0·16
2N2924	0·16
2N2925	0·16
2N2926(G)	0·14
2N2926(Y)	0·12
2N2926(O)	0·11
2N2926(R)	0·11
2N2926(B)	0·11
2N3010	0·77
2N3011	0·16

2N3053	0·19
2N3054	0·51
2N3055	0·55
2N3391	0·16
2N3391A	0·18
2N3392	0·16
2N3393	0·16
2N3394	0·16
2N3395	0·19
2N3402	0·23
2N3403	0·23
2N3404	0·31
2N3405	0·46
2N3414	0·17
2N3415	0·17
2N3416	0·31
2N3417	0·31
2N3525	0·63
2N3646	0·10
2N3702	0·11
2N3703	0·11
2N3704	0·12
2N3705	0·11
2N3706	0·10
2N3707	0·12
2N3708	0·08
2N3709	0·10
2N3710	0·10
2N3711	0·10
2N3819	0·31
2N3820	0·55
2N3821	0·39
2N3823	0·31
2N3903	0·31
2N3904	0·33
2N3905	0·31
2N3906	0·30
2N4058	0·13

2N4059	0·11
2N4060	0·13
2N4061	0·13
2N4062	0·13
2N4284	0·19
2N4285	0·19
2N4286	0·19
2N4287	0·19
2N4288	0·19
2N4289	0·19
2N4290	0·19
2N4291	0·19
2N4292	0·19
2N4293	0·19
2N5172	0·13
2N5457	0·35
2N5458	0·35
2N5459	0·44
2S301	0·55
2S302A	0·46
2S302	0·46
2S303	0·61
2S304	0·77
2S305	0·93
2S306	0·93
2S307	0·93
2S321	0·62
2S322	0·46
2S322A	0·46
2S323	0·62
2S324	0·77
2S325	0·77
2S326	0·77
2S327	0·77
2S701	0·46
40361	0·46
40362	0·50

DIODES AND RECTIFIERS

AA119	0·09	BY133	0·23	OA10	0·39
AA120	0·09	BY164	0·55	OA47	0·08
AA129	0·09	BYX38/30		OA70	0·08
AAY30	0·10		0·46	OA79	0·08
AAZ13	0·11	BYZ10	0·39	OA81	0·08
BA100	0·11	BYZ11	0·33	OA85	0·10
BA116	0·23	BYZ12	0·33	OA90	0·07
BA126	0·24	BYZ13	0·28	OA91	0·07
BA148	0·16	BYZ16	0·44	OA95	0·08
BA154	0·13	BYZ17	0·39	OA200	0·07
BA155	0·16	BYZ18	0·39	OA202	0·08
BA156	0·15	BYZ19	0·31	SD10	0·06
BY100	0·17	CG62		SD19	0·06
BY101	0·13	(OA91 Eq.)		1N34	0·8
BY105	0·19		0o06	1N34A	0·08
BY114	0·13	CG651		1N914	0·07
BY126	0·16	(OA70-0A79		1N916	0·07
BY127	0·17	Eq.)	0·07	1N414B	0·07
BY128	0·17	OA5	0·39	1S021	0·11
BY130	0·18	OA5SL	0·23	1S951	0·07

FULL RANGE (
ZENER DIODES
VOLTAGE RANGE
2-33V. 400mV (DO
Case) **15p** ea. 1½W (To
Hat) **20p** ea. 10W (SO-
Stud) **33p** ea. All ful
tested 5% tol. a
marked. State volta
required.

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BRIDGE RECTIFIE
on heat sink.
100PIV. 99p each

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Plastic Encapsulated
2 Amp. BRIDGE RECT
50v RMS **35p** ea
100v RMS **40½p** „
400v RMS **50½p** „
Size 15 mm × 6 m

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UT46. Eqvt. 2N264
Eqvt. TIS43. BEN30
30p each, 25-99 27
100 UP **22p.**

CADMIUM CELL
ORP12 **47½p**
ORP60, ORP61 **44p** ea

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NPN SILICON SWITC
ING TRANS. TO-
SIM. TO 2N706/8. BS
27/28/95A. A.I.I usab
devices no open or sho
circuits. ALSO AVAI
ABLE in PNP Sim.
2N2906, BCY70. Wh
ordering please sta
preference NPN or PN

		£
20	For	0·
50	For	1·
100	For	1·
500	For	8·
1000	For	14·

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Satisfaction GUARANTEED in Every Pak, or money back.

Pak No.		Description	Price
U 1	120	Glass Sub-Min. General Purpose Germanium Diodes	0·55
U 2	60	Mixed Germanium Transistors AF/RF	0·55
U 3	75	Germanium Gold Bonded Sub-Min. like OA5, OA47	0·55
U 4	40	Germanium Transistors like OC81, AC128	0·55
U 5	60	200mA Sub-Min. Silicon Diodes	0·55
U 6	30	Sil. Planar Trans. NPN like BSY95A. 2N706	0·55
U 7	16	Sil. Rectifiers TOP-HAT 750mA VLTG. RANGE up to 1000	0·55
U 8	50	Sil. Planar Diodes DO-7 Glass 250mA like OA200/202 ..	0·55
U 9	20	Mixed Voltages, 1 Watt Zener Diodes	0·55
U10	20	BAY50 charge storage Diodes DO-7 Glass	0·55
U11	25	PNP Sil. Planar Trans. TO-5 like 2N1132, 2N2904	0·55
U12	12	Silicon Rectifiers Epoxy 500mA up to 800 PIV.........	0·55
U13	30	PNP-NPN Sil. Transistors OC200 & 2S 104	0·55
U14	150	Mixed Silicon and Germanium Diodes................	0·55
U15	25	NPN Sil. Planar Trans. TO-5 like BFY51, 2N697.......	0·55
U16	10	3 Amp Silicon Rectifiers Stud Type up to 1000PIV	0·55
U17	30	Germanium PNP AF Transistors TO-5 like ACY 17-22	0·55
U18	8	6 Amp Silicon Rectifiers BYZ13 Type up to 600 PIV ...	0·55
U19	25	Silicon NPN Transistors like BC108	0·55
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U21	30	AF. Germanium Alloy Transistors 2G300 Series & OC71.	0·55
U23	30	MADT's like MHz Series PNP Transistors	0·55
U24	20	Germanium 1 Amp Rectifiers GJM Series up to 300 PIV	0·55
U25	25	300 MHz NPN Silicon Transistors 2N708, BSY27	0·55
U26	30	Fast Switching Silicon Diodes like 1N914 Micro-Min. ...	0·55
U27	12	NPN Germanium AF Transistors TO-1 like AC127	0·55
U29	10	1 Amp SCR's TO-5 can, up to 600 PIV CRS1/25-600 ..	1.10
U30	15	Plastic Silicon Planar Trans. NPN 2N2926	0·55
U31	20	Silicon Planar Plastic NPN Trans. Low Noise Amp 2N3707	0·55
U32	25	Zener Diodes 400mW DO-7 case 3-18 volts mixed	0·55
U33	15	Plastic Case 1 Amp Silicon Rectifiers IN4000 Series	0·55
U34	30	Silicon PNP Alloy Trans. TO-5 BCY26 2S302/4	0·55
U35	25	Silicon Planar Transistors PNP TO-18 2N2906	0·55
U36	25	Silicon Planar NPN Transistors TO-5 BFY50/51/52.....	0·55
U37	30	Silicon Alloy Transistors SO-2 PNP OC200, 2S322	0·55
U38	20	Fast Switching Silicon Trans. NPN MHz 2N3011	0·55
U39	30	RF. Germ. PNP Transistors 2N1303/5 TO-5	0·55
U40	10	Dual Transistors 6 lead TO-5 2N2060	0·55
U41	25	RF Germanium Transistors TO-5, OC45, NKT72	0·55
U42	10	VHF Germanium PNP Transistor TO-1 NKT667, AF117	0·55
U43	25	Sil. Trans. Plastic TO-18 A.F. BC113/114.............	0·55
U44	20	Sil. Trans. Plastic TO-5 BC115/NPN................	0·55
U45	7	3A SCR. TO66 up to 600PIV	1·10

Code No's. mentioned above sre given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

QUALITY TESTED SEMICONDUCTORS

Pak No.			Price £p
Q1	20	Red spot transistors PNP	0·55
Q2	16	White spot R.F. transistors PNP	0·55
Q3	4	OC 77 type transistors	0·55
Q4	6	Matched transistors OC44/45/81/81D........	0·55
Q5	4	OC 75 transistors..........................	0·55
Q6	5	OC 72 transistors..........................	0·55
Q7	4	AC 128 transistors PNP high gain	0·55
Q8	4	AC 126 transistors PNP.....................	0·55
Q9	7	OC 81 type transistors	0·55
Q10	7	OC 71 type transistors	0·55
Q11	2	AC 127/128 Complementary pairs PNP/NPN	0·55
Q12	3	AF 116 type transistors	0·55
Q13	3	AF 117 type transistors	0·55
Q14	3	OC 171 H.F. type transistors	0·55
Q15	7	2N2926 Sil. Epoxy transistors mixed colours	0·55
Q16	2	GET880 low noise Germanium transistors..	0·55
Q17	5	NPN 2 × ST.141 & 3 × ST.140	0·55
Q18	4	MADT'S 2 × MAT 100 & 2 × MAT 120....	0·55
Q19	3	MADT'S 2 × MAT 101 & 1 × MAT 121....	0·55
Q20	4	OC 44 Germanium transistors A.F.	0·55
Q21	4	AC 127 NPN Germanium transistors........	0·55
Q22	20	NKT transistors A.F. R.F. coded	0·55
Q23	10	OA 202 Silicon diodes sub-min.	0·55
Q24	8	OA 81 diodes	0·55
Q25	15	1N914 Silicon diodes 75 PIV 75mA	0·55
Q26	8	OA95 Germanium diodes sub-min. IN69	0·55
Q27	2	10A PIV Silicon rectifiers IS425R	0·55
Q28	2	Silicon power rectifiers BYZ 13	0·55
Q29	4	Silicon transistors 2 × 2N696, 1 × 2N697, 1 × 2N698..............................	0·55
Q30	7	Silicon switch transistors 2N706 NPN......	0·55
Q31	6	Silicon switch transistors 2N708 NPN......	0·55
Q32	3	PNP Silicon transistors 2 × 2N1131, 1 × 2N 1132	0·55
Q33	3	Silicon NPN transistors 2N1711	0·55
Q34	7	Silicon NPN transistors 2N2369, 500MHz (code P397)	0·55
Q35	3	Silicon PNP TO-5, 2 × 2N2904 & 1 × 2N2905	0·55
Q36	7	2N3646 TO-18 plastic 300 MHz NPN......	0·55
Q37	3	2N3053 NPN Silicon transistors	0·55
Q38	7	NPN transistors 4 × 2N3703, 3 × 2N3702..	0·55

ELECTRONIC SLIDE-RULE

The MK Slide Rule, designed to simplify Electronic calculations features the following scales:— Conversion of Frequency and Wavelength. Calculation of L, C and fo of Tuned Circuits. Reactance and Self-Inductance. Area of Circles. Volume of Cylinders. Resistance of Conductors. Weight of Conductors. Decibel Calculations. Angle Functions. Natural Logs and 'e' Functions. Multiplication and Division. Squaring, Cubing and Square Roots. Conversion of kW and Hp. A must for every electronic engineer and enthusiast. Size: 2 cm. × 4 cm. Complete with case and instructions. Price each: £3·68½

NEW LOW PRICE TESTED S.C.R.'s

PIV	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	03A TO48
50	0·26	0·28	0·39	0·39	0·52	0·55	0·59	1·27
100	0·28	0·37	0·52	0·52	0·55	0·64	0·70	1·54
200	0·39	0·41	0·54	0·54	0·63	0·67	0·83	1·76
400	0·48	0·52	0·62	0·62	0·74	0·83	1·03	1·93
600	0·59	0·63	0·75	0·75	0·85	1·07	1·38	—
800	0·70	0·77	0·88	0·88	0·99	1·32	1·65	4·40

SIL. SECTS. TESTED

50	0·04	0·06	0·06	0·08	0·16	0·23	0·66
100	0·04	0·07	0·06	0·15	0·18	0·26	0·83
200	0·06	0·10	0·07	0·16	0·22	0·27	1·10
400	0·07	0·15	0·08	0·22	0·30	0·41	1·38
600	0·08	0·18	0·11	0·26	0·38	0·50	2·05
800	0·11	0·19	0·12	0·28	0·41	0·61	2·20
1000	0·12	0·28	0·16	0·33	0·51	0·70	2·75
1200	—	0·37	—	0·42	0·63	0·83	—

POWER TRANS BONANZA!

GENERAL PURPOSE GERM. PNP

Coded GP100. BRAND NEW TO-3 CASE. POSSIBLE REPLACE:—OC25–28–29–30–35–36. NKT 401–403–404–405–406–430–451–452–453. TI3027–3028, 2N250A 2N456A–457A–458A, 2N511 A & B. 2G220–222, ETC. VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30–170.

PRICE	1-24	25-99	100 up
	47½p each	44p each	39½p each

SILICON High Voltage 250V NPN
TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250/VCEO 100/IC 6A/30 Watts. HFE type 20/fT 5MHZ.
OUR PRICE EACH:

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55p	49½p	44p

2N3055
115 WATT SII POWER NPN 55p EACH.

SILICON 50 WATTS MATCHED NPN/PNP
BIP 19 NPN TO-3 Plastic. BIP 20 PNP. Brand new. VCBO 100/VCEO 50/IC 10A. HFE type 100/ft 3mHZ.
OUR PRICE PER PAIR:
1–24 prs. **66p** 25–99 prs. **61p** 100 prs. **55p**

AD161/162 *PNP*
M/P COMP GERM TRANS. OUR LOWEST PRICE OF **60p** *PER PAIR*

SILICON PHOTO TRANSISTOR
TO-18 Lens end NPN Sim. to BP × 25 and P21. BRAND NEW. Full data available. Fully guaranteed.

Qty.	1-24	25-99	100 up
Price each	49p	44p	38p

F.E.T.'S

2N3819	31p	2N5458	35p
2N3820	55p	2N5459	44p
2N3821	39p	BFW10	66p
2N3823	31p	MPF105	41p

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Exceptionally good value

Resistors, capacitors, pots, electrolytics and coils plus many other useful items. Approximately 3lbs in weight. Price incl. P. & P. **£1·65** only.

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40PIV(Min.)	100..1·
Sub-Min.	500..5·
Full Tested	1,000..9·

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	£p	£p	£p
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BR100 (D32) **40½p** ea

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T3	8	D1216	OC8
T4	8	2G381T	OC
T5	8	2G382T	OC
T6	8	2G344B	OC
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All **55p** each pak.

2N2060 NPN SIL. DU TRANS. CODE D16 TEXAS. **Our price** 2 **each.**

120 VCR NIXIE DRIV TRANSISTOR. Si BSX21 & C407, 2N18 FULLY TESTED AN CODED ND 120, 1- **19p** each. TO.5 NI 25 up **17p** each.

Sil. trans. suitable P.E. Organ. Metal TO- Eqvt. ZTX300 **5½p** ea Any Qty.

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SN7408	0·20	0·19	0·18	SN7474	0·41	0·39	0·35	SN74157	£2·09	£1·98	£1·87
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SN7410	0·17	0·16	0·18	SN7476	0·44	0·43	0·42	SN74161	£1·98	£1·87	£1·76
SN7411	0·28	0·27	0·26	SN7480	0·74	0·71	0·64	SN74162	£4·40	£4·13	£3·85
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SN7413	0·32	0·29	0·27	SN7482	0·96	0·95	0·94	SN74164	£2·43	£2·37	£2·31
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SN7417	0·48	0·44	0·42	SN7484	£1·10	£1·05	0·99	SN74166	£3·85	£3·58	£3·30
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SN7426	0·50	0·46	0·44	SN7491	£1·10	£1·05	0·99	SN74180	£2·20	£1·76	£1·54
SN7427	0·50	0·46	0·44	SN7492	0·74	0·71	0·64	SN74181	£6·05	£5·50	£5·23
SN7428	0·77	0·72	0·66	SN7493	0·74	0·64	0·64	SN74182	£2·20	£1·98	£1·76
SN7430	0·17	0·16	0·13	SN7494	0·85	0·82	0·75	SN74184	£3·85	£3·58	£3·30
SN7432	0·50	0·46	0·44	SN7495	0·85	0·82	0·75	SN74190	£2·15	£2·09	£2·04
SN7433	0·88	0·83	0·77	SM7496	0·96	0·93	0·86	SN74191	£2·09	£2·04	£1·98
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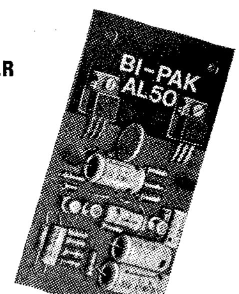
SN7448	£1·10	£1·07	£1·05	SN74123	£3·08	£2·97	£2·86				

3 Terminal Pos Volt Reg. TO.3 Plastic O/P 1.5 Amps. uA7805 5V. & uA7812 12V. £1·76 each.

The AL50 HI-FI AUDIO AMPL
50W pk 25w (RMS)
0·1% DISTORTION ! HI-FI AUDIO AMPLIFIER



- Frequency Response 15Hz to 100,000—1dB.
- Load—3, 4, 8 or 16 ohms.
- Supply voltage 10-35 Volts.
- Distortion—better than 0·1% at 1kHz.
- Signal to noise ratio 80dB.
- Overall size 63 mm × 105 mm × 13 mm.

Tailor made to the most stringent specifications using top quality components and incorporating the latest solid state circuitry conceived to fill the need for all your A.F. amplification needs.
FULLY BUILT—TESTED—GUARANTEED.

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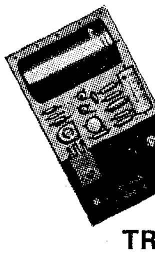
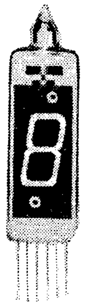
STABILISED POWER
MODULE SPM80 £3·25



AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2·15 p. & p. 25p

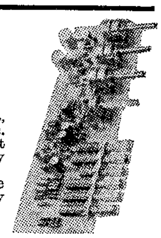
NUMERICAL INDICATOR TUBES



MODEL	CD66	GR116	3015F Minitron
Anode voltage (Vdc)	170min	175min	5
Cathode Current (mA)	2·3	14	8
Numerical Height (mm)	16	13	9
Tube Height (mm)	47	32	22
Tube Diameter (mm)	19	13	12 wide
I.C. Driver Rec.	BP41/14 141	BP41 or 141	BP47
PRICE EACH	£1·87	£1·70	£1·50

All indicators 0·9 + Decimal point. All side viewing. Full data for all types available on request.

STEREO PRE-AMPLIFIER TYPE PA100



Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	1·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	35mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	1·5mV into 50KΩ	Signal/noise ratio	better than +65dB
All input voltages are for an output of 250mV.		Input overload	+26dB
Tape and P.U. inputs equalised to RIAA curve		Supply	+35 volts at 20mA
within ±1dB from 20Hz to 20kHz.		Dimensions	292×82×35 mm

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, I SPM80, I BMT80 & I PA100 ONLY £25.30 FREE p.&p

only £13·15

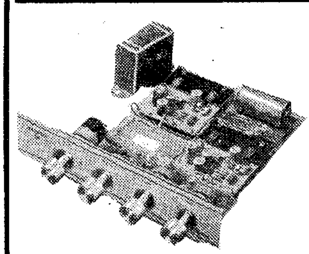
INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price	Pak No. Contents	Price	Pak No. Contents	Price
UIC00=12±7400	0·55	UIC46=5×7446	0·55	UIC86=5×7486	0·55
UIC01=12×7401	0·55	UIC47=5×7447	0·55	UIC90=5×7490	0·55
UIC02=12×7402	0·55	UIC48=5×7448	0·55	UIC91=5×7491	0·55
UIC03=12×7403	0·55	UIC50=12×7450	0·55	UIC92=5×7492	0·55
UIC04=12×7404	0·55	UI351=12×7451	0·55	UIC93=5×7493	0·55
UIC05=12×7405	0·55	UIC53=12×7453	0·55	UIC94=5×7494	0·55
UIC06=8×7406	0·55	UIC54=12×7454	0·55	UIC95=5×7495	0·55
UIC07=8×7407	0·55	UIC60=12×7460	0·55	UIC96=5×7496	0·55
UIC10=12×7410	0·55	UIC70=8×7470	0·55	UIC100=5×74100	0·55
UIC13=8×7413	0·55	UIC72=8×7472	0·55	UIC121=5×74121	0·55
UIC20=12×7420	0·55	UIC73=8×7473	0·55	UIC141=5×74141	0·55
UIC30=12×7430	0·55	UIC74=8×7474	0·55	UIC151=5×74151	0·55
UIC40=12×7440	0·55	UIC75=8×7475	0·55	UIC154=5×74154	0·55
UIC41=5×7441	0·55	UIC76=8×7476	0·55	UIC193=5×74193	0·55
UIC42=5×7442	0·55	UIC80=5×7480	0·55	UIC199=5×74199	0·55
UIC43=5×7443	0·55	UIC81=5×7481	0·55		
UIC44=5×7444	0·55	UIC82=5×7482	0·55	UICXI=25 Assorted 74's	1·55
UIC45=5×7445	0·55	UIC83=5×7483	0·55		

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

The STEREO 20



The 'Stereo 20' amplfier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm This compact unit comes complete with on/off switch, volume control, balance, bass and treble controls. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet.

Output power 20w peak	Input 1 (Cer.) 300mV into 1M
Freq. res. 25Hz-25kHz	Input 2 (Aux.) 4mV into 30K
Harmonic distortion	Bass control ±12dB at 60Hz
typically 0·25% at 1 watt	Treble con. ±14dB at 14kHz

£13·47 free p. & p.

NEW COMPONENT PAK BARGAINS

Pack No.	Qty.	Description	Price
C 1	250	Resistors mixed values approx. count by weight	0·55
C 2	200	Capacitors mixed values approx. count by weight	0·55
C 3	50	Precision Resistors 1%, mixed values	0·55
C 4	75	⅛th W Resistors mixed preferred values	0·55
C 5	5	Pieces assorted Ferrite Rods	0·55
C 6	2	Tuning Gangs, MW/LW/VHF	0·55
C 7	1	Pack Wire 50 metres assorted colours	0·55
C 8	10	Reed Switches	0·55
C 9	3	Micro Switches	0·55
C10	15	Assorted Pots & Pre-Sets	0·55
C11	5	Jack Sockets 3 × 3·5mm 2 × Standard Switch Types	0·55
C12	40	Paper Condensers preferred types mixed values	0·55
C13	20	Electrolytics Trans. types	0·55
C14	1	Pack assorted Hardware—Nuts/Bolts, Grommets etc.	0·55
C15	4	Mains Toggle Switches, 2 Amp D/P	0·55
C16	20	Assorted Tag Strips & Panels	0·55
C17	10	Assorted Control Knobs	0·55
C18	4	Rotary Wave Change Switches	0·55
C19	3	Relays 6—24V Operating	0·55
C20	4	Sheets Copper Laminate approx. 10″ × 7″	0·55

Please add 10p post and packing on all component packs, plus a further 10p on pack Nos. C1, C2, C19, C20.

RTL MICROLOGIC CIRCUITS

	Price each 1–24	25–99	100 up
Epoxy TO-5 case uL900 Buffer	38p	36p	29p
uL914 Dual 2i/p gate	38p	36p	26p
uL923 J-K flip-flop	55p	51p	49p

Data and Circuits Booklet for IC's Price 8p.

DUAL-IN-LINE IC's. TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No.	1–24	25–99	100 up.
TSO 14 pin type	33p	30p	27½p
TSO 16 „ „	38½p	35p	33p
LOW COST No.			
BPS 14	16½p	14½p	12p
BPS 16	17½p	15½p	13p

LINEAR I.C.'s—FULL SPEC.

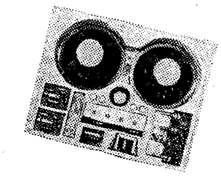
Type No.	Price 1–24	25–99	100 up
BP 201C—SL201C	69½p	58½p	49½p
BP 701C—SL701C	69½p	55p	49½p
BP 702C—SL702C	69½p	55p	49½p
BP 702—72702	58½p	49½p	44p
BP 709—72709	39½p	37½p	33p
BP 709P—µA709C	39½p	37½p	33p
BP 710—72710	48½p	46p	44p
BP 711—µA711	49½p	47½p	44p
BP 741—72741	55p	50p	45p
µA703C	31p	28½p	26½p
TAA 263—	77p	66p	60½p
TAA 293—	99p	82½p	77p
TAA 350	£1·87p	£1·74p	£1·65p
S.G.S. EA1000 £2·89½			

ROCK BOTTOM PRICES LOGIC DTL 930 Series I.C's

Type No.	Price 1–24	25–99	100 up
BP930	13p	12p	11p
BP932	14p	13p	12p
BP933	14p	13p	12p
BP935	14p	13p	12p
BP936	14p	13p	12p
BP944	14p	13p	12p
BP945	27½p	26½p	24p
BP946	13p	12p	11p
BP948	27½p	26½p	24p
BP951	71½p	66p	60½p
BP962	13p	12p	11p
BP9093	44p	42p	38½p
BP9094	44p	42p	38½p
BP9097	44p	42p	38½p
BP9099	44p	42p	38½p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only).

SYSTEM 12 STEREO



Each Kit contains two Amplifier Modules, 3 watts RMS, two loudspeakers, 15 ohms, the pre-amplifier, transformer, power supply module, front panel and other accessories, as well as an illustrated stage-by-stage instruction booklet designed for the beginner. Further details available on request.

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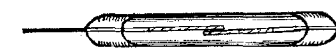

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DY802	0·30
E88CC/01	1·08
E180CC	0·37
E180CC	0·90
E182CC	1·08
EA50	0·18
EABC80	0·27
EAF42	0·46
EB91	0·20
EBC33	0·45
EBC41	0·50
ECC81	0·31
EBF80	0·36
EBF83	0·36
EBF89	0·27
ECC81	0·27
ECC82	0·25
ECC83	0·27
ECC84	0·27
ECC85	0·36
ECC86	0·75
ECC88	0·40
ECC189	0·55
ECF80	0·31
ECF82	0·31
ECF83	0·67
ECF801	0·56
ECH81	0·25
ECH83	0·40
ECH84	0·40
ECL80	0·40

Type	£
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ECL83	0·63
ECL86	0·36
EF36	0·50
EF37A	0·85
EF40	0·50
EF41	0·65
EF80	0·25
EF83	0·60
EF85	0·31
EF86	0·27
EF89	0·25
EF91	0·27
EF92	0·31
EF95	0·31
EF183	0·26
EF184	0·31
EFL200	0·67
EL34	0·45
EL41	0·55
EL84	0·21
EL85	0·37
EL86	0·36
EL90	0·31
EL95	0·31
EL500	0·76
EL504	0·76
EM31	0·22
EM80	0·36
EM84	0·31
EM87	0·63
EY51	0·36
EY86	0·40
EY81	0·40
EY88	0·40
EZ41	0·45
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EZ81	0·24
GZ34	0·52
GZ37	0·63
KT66	2·35
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OA2	0·38

Type	£
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PABC80	0·35
PC97	0·41
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PCC89	0·45
PCC189	0·49
PCE800	0·75
PCF80	0·25
PCF82	0·27
PCF84	0·54
PCF86	0·50
PCF200	0·60
PCF201	0·60
PCF801	0·40
PCF802	0·45
PCF805	0·80
PCF806	0·65
PCF808	0·85
PCH200	0·65
PCL81	0·40
PCL82	0·30
PCL83	0·60
PCL84	0·35
PCL85	0·35
PCL86	0·43
PFL200	0·60
PL36	0·50
PL81	0 40
PL82	0·35
PL83	0·36
PL84	0·30
PL500	0·62
PL504	0·62
PL508	0·70
PL509	1·05
PL802	0·95
PX4	2·50
PY33	0·55
PY80	0·35
PY81	0·30
PY82	0·30
PY83	0·35
PY88	0·32
PY800	0·35
PY801	0·45
QQVO 3-10	1·10

Type	£
R17	0·45
R19	0·35
STV 280/40	3·20
STV 280/80	8·20
TT21	3·80
U25	0·70
U26	0·70
U27	0·45
U191	0·68
U801	0·70
UABC80	0·30
UAF42	0·50
UBC41	0·48

Type	£
UBF80	0·35
UBF89	0·34
UCC85	0·35
UCF80	0·60
UCH42	0·60
UCH81	0·35
UCL82	0·35
UCL83	0·55
UF80	0·30
UF89	0·35
UL41	0·60
UL84	0·35
UU5	0·65
UY41	0·45
UY85	0·35
VR105/30	0·35

Type	£
VR150/30	0·35
2800U	1·40
Z801U	1·40
Z803U	1·10
Z900T	0·90
1L4	0·13
1R5	0·35
1S4	0 30
1S5	0·30
1T4	0·30
1X2A	0·36
1X2B	0·50
2K25	7·50
3A4	0·40
3D6	0·15
3Q4	0·55
3S4	0·33
3V4	0·48

Type	£
5B254M	2·75
5B/255M	3·10
5R4GY	0·65
5U4G	0·30
5V4G	0·45
5Y4G	0·35
5Y3GT	0·35
5Z3	0·70
5Z4	0·75
5Z4GT	0·32
6AB7	0·25
6AC7	0·45
6AH6	0·50
6AK5	0·35
6AK8	0·30
6AL5	0·18
6AL5W	0·35
6AM6	0·35
6AN8	0·60

Type	£
6AQ5	0·36
6AQ5W	0·45
6A86	0·30
6AT6	0·30
6AU6	0·20
6AX4GT	0·50
6AX5GT	0·60
6B7	0·35
6BK7	0·60
6BA6	0·25
6BE6	0·25
6BG6G	0·47
6BJ6	0·45
6BQ7A	0·43
6BR7	0·85
6BW6	0·80
9BW7	0·80

Type	£
6C4	0·25
6C6	0·20
6CH6	0·55
6CL6	0·50
6D6	0·15
6EA8	0·60
6F23	0·80
6F33	1·35
6H6M	0·25
6J4WA	0·65
6J5	0·35
6J5GT	0·30
6J6	0·25
6J7G	0·30
6J7M	0·35
6K6GT	0·55
6K7	0·40

Type	£
6K7G	0·17
6K8GT	0·40
6K25	0·70
6L6M	1·35
6SA7	0·40
6SA7GT	0·25
6SC7GT	0·20
6SG7	0·40
6SJ7	0·40
6SJ7GT	0·28
6SK7	0·45
6SL7GT	0·35
6SN7GT	0·35
6SQ7	0·45
6SQ7GT	0·30
6V6G	0·15
6V6GT	0·35
6X4	0·33
6X5G	0·25
6X5GT	0·35
6Y6G	0·75
6-30L2	0·85
6Z4	0·40
7B7	0·50
7Y4	0·60
9D6	0·30
11E2	3·70
12AT6	0·35
12AT7	0·35
12AU7	0·24
12AV6	0·40
12AX7	0·25
12BA6	0·25
12BE6	0·35
12BH7	0·23
12C8	0·30
12E1	2·85
12K5	0·95
12K7GT	0·45
12K8GT	0·40
12Q7GT	0·40
12SG7	0·40
14S7	0·70
19AQ5	0·40
19G3	5·75
19G6	5·75
19H4	5·25
20P4	1·00
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30L17	0·80
30P12	0·75
30P19	0·80
30PL1	0·70
30PL13	0·90
30PL14	0·85
35L6GT	0·50
35W4	0·30
36Z4GT	0·55
50C5	0·45
50CD6G	1·10
50EH5	0·55
75	0·50
76	0·55
78	0·50
80	0·55
723A/B	7·00
803	5·50
805	12·00
807	0·50
813	4·00
832A	2·70
866A	1·25
931A	4·75
954	0·35
955	0·35
956	0·30
957	0·35
991	0·40
2051	0·70
5933	1·00

Type	£
6057	0·55
6060	0·50
6064	0·45
6065	0·65
6080	1·55
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9002	0·40
9003	0·45
9004	0·12
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OA70	0·10
OA71	0·10
OA73	0·07
OA74	0·07
OA79 (GD15)	0·10
OA81	0·08
OA91	0·07
OA200	0·07
OA202	0·10
OA210	0·25
OA211	0·30
OAZ200	0·55
OAZ201	0·50
OC22	0·50
OC25	0·40
OC26	0·25
OC28	0·60
OC29	0·60
OC35	0·50
OC36	0·56
OC38	0·42
OC44	0·17
OC45	0·12
OC70	0·12

Type	£
OC71	0·12
OC72	0·20
OC73	0·30
OC75	0·25
OC76	0·25
OC81	0·20
OC81D	0·20
OC81DM	0·20
OC82	0·25
OC82DM	0·30
OC83	0·25
OC83B	0·15
OC84	0·25
OC122	0·50
OC139	0·25
OC140	0·40
OC170	0·25
OC171	0·30
OC172	0·37
OC200	0·40
OC201	0·75
OC206	0·95
1N21B	0·30
1N25	0·60
1N43	0·10
1N70	0·07
1N677	0·12

Type	£
1N702-725	0·36
1N823A	1·30
1N4785	0·50
1ZMT5	0·35
1ZMT10	0·33
1ZT5	0·67
1ZT10	0·63
2G385	0·51
2G403	0·51
2N918	0·37
2N1304	0·22
2N1306	0·25
2N1307	0·25
2N2147	0·64
2N2411	1·50
2N2904A	0·25
2N2989	4·00
2N3053	0·20
2N3054	0·50
2N3055	0·64
2N3730	0·50
2N3731	2·75
2N4172	0·50
S2303	0·50
3F100	0·62
3FR5	0·32
3N128	0·87

Type	£
3N139	1·75
3N140	0·97
3N154	0·95
3N159	1·45
6FR5	0·45
12FR60	0·73
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40595	1·25
40636	1·25
40668	1·25
40669	1·40
AC126	0·25
AC127	0·25
AC128	0·20
AC176	0·20
ACY17	0·25
ACY28	0·17
AD149	0·50
AD161	0·35
AD162	0·35
AF118	0·50
AF127	0·20
AF139	0·30
AF178	0·48
AF186	0·40
ASY26	0·25
ASY28	0·25

Type	£
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BAW19	0·28
BC107	0·10
BC108	0·10
BC113	0·10
BC118	0·20
BCY72	0·15
BF115	0·25
BF173	0·20
BFY51	0·20
BFY52	0·20
BS	0·45
BS2	0·47
BSY29	0·25
BU100	1·80
BYZ13	0·25
BYZ16	0·63
CRS1/10	0·25
CRS1/20	0·38
CRS1/30	0·40
CRS1/35	0·43
CRS1/40	0·48
CRS3/05	0·30
CRS3/20	0·38
CRS3/30	0·43
CRS25/025	0·55

Type	£
CRS3/40	0·50
CS2A	0·65
CV102	0·25
GET103	0·23
GET115	0·45
GET116	0·50
GEX66	1·50
NKT222	0·20
NKT304	0·50
RAS310AF	0·33
SD91S	0·26
SD92S	0·31
SD93S	0·32
SD94	0·21
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V405A	0·40
Z2A51CF	0·78
ZR11	0·33
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ZR22	0·42

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1W	0·37
1·5W	0·25
7W	0·40

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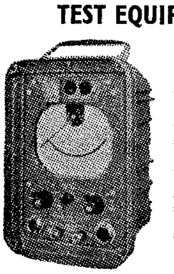


VALVE VOLTMETER TYPE TF 958. Measures AC 100mV; 150V DC 50mV to 100V, multiplier extends ac range to 1·5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. **£27·50.**

TF 1066 B/2 F.M. SIGNAL GENERATOR. Frequency range 400-555MHz in one band. Crystal calibration: 1MHz and 10MHz. Output: piston attenuator 0·1µV-100mV at 50 ohms. Int. mod. freq. 1 to 10kHz, ext. mod. freq. 100Hz to 100kHz. Freq. dev. up to 300kHz. **£225.** Carriage £1·50.

TF 1258A VHF SPECTRUM ANALYSER for analysis and measurement of Radar Equipment. Frequency range 190 to 230MHz with crystal check points. Sweep width 0·5 to 5MHz, output pulse delay (*a*) 85-175 µSec, (*b*) 0·7-1·4 mSec with ×1 and ×2 multiplier and ÷2, ×1, ×2 multiplier. Output 2µV to 20mV with ×10 multiplier. **£200.** Carriage at cost.

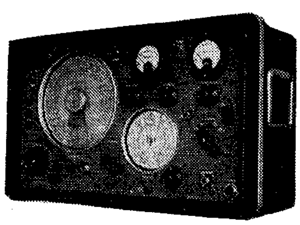
MUIRHEAD PHASEMETER. Type D729/AM and P.S.U. D729 A/S. Complete with manual, leads, as new **£200.**

TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. frequ. 10Hz to 100 kHz, pulse width 0·1 to 100µ sec., delay —1·5 to +3000µ sec., rise time < 30N sec. **SPEC. TM 6600/S.** As for TF1400S except pulse width 0·5 to 25µ sec, delay 0 to + 300µ sec. **£230.**

SIGNAL GENERATOR TYPE AN/USM-16 (MODEL BJ75A)
A precision HF/VHF signal generator embodying facilities seldom found or contained in one instrument, namely outputs of **CW/AM/PM and swept carrier,** in the frequency range **10 to 440 MHz.** Some of the features of the instrument are: **AUTOMATIC FREQUENCY STABILISATION** (locks output signal to selected frequency), **AUTOMATIC LEVEL CONTROL** (holds output constant ±1db) **INTERPOLATION OSCILLATION** (for precise tuning between crystal check points) **MARKERS** (for S.F.M.)
Brief specifications, Frequency 10 to 440MHz, RF output 0.1uV to 0.224V at 50 ohms. Modes of operation CW-HI, CW, CW (calibrated and stabilised), AM-400Hz and 1kHz and external, FM-400Hz and 1kHz and external 0.75 kHzdev., S.F.M. —x1, x10, x100, 0-75, 750 & 7500kHz dev. resp., P.M. —50 to 5000 pps at 1 to 30µsec. width int. or ext., 150 to 5000Hz rep rate. 3 meters for; mod. and dev., frequency discrimination pulse level output. With manual. Complete specification and price on application.

★ **Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.** ★

TF 801B/3/S SIGNAL GENERATOR.
Spec. as for TF 801D/1/S except for minor circuit changes e.g. 1 and 2 MHz switched calibrator. P.O.A.



TF 801D/1/S SIGNAL GENERATOR. Range 10-485 MHz in five ranges. R.F. output 0·1 µV-IV source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator. 50Ω output impedance. Internal modulation at 1 kHz at up to 90% depth, also external sine and pulse modulation. Built-in 5MHz crystal calibrator. Separate R.F. and mod. meters. P.O.A.

TF 562B/3 Oscillator and Detector Unit.

TF 1226B
TF 1225A } White Noise Test Set.
TM 577A

TF 1104 VHF ALIGNMENT OSCILLOSCOPE combining sweep generator, markers etc. Frequency range 5kHz to 10MHz, 10MHz to 40MHz and 41 to 216MHz. Sweep width 500kHz to 10MHz, output 100$V to 10mV. Markers 0·5, 1& 5MHz. Price **£120.**

TR 1143 TRANSMITTER RECEIVER 100/126 mcs, requires separate PSU for 28V. Price **£12.00.** Carriage £1.50.

HEWLETT—PACKARD
185A 800 MHz SAMPLING OSCILLOSCOPE WITH 188A DUAL TRACE PLUG-IN. Full spec. and P.O.A.

5248 COUNTER FREQUENCY MEASUREMENT: 10Hz to 10,1MH₂. Accuracy ± 1 count. Automatic positioning of decimal point. Period measurement: 0-10kHz, reads in seconds, milliseconds or microseconds, decimal point automatically positioned. Display on 6 neon lamp decades and 2 meters. Complete with manual and following plug-ins: **525A** 10 to 100MHz, **525B** 100 to 220MHz, **526A** video amplifier. Price on application.

540B TRANSFER OSCILLATOR. Extends range of 524 and 5245 series counters to 18 gHz, or on its own, measures frequencies below 4gHz with 0.5% accuracy.

430C MICROWAVE POWER METER. Complete with **476A** bolo mount, **475B** tunable bolo, **BM16** waveguide, **£95.**

205AG AUDIO OSCILLATOR. Low distortion, 20 Hz to 200 kHz, metered and attenuated inputs and outputs enabling a very wide range of measurements to be made on amplifiers, filters, etc. **£125.**

200CD WIDE RANGE OSCILLATOR. 5 Hz to 600 kHz, **£60.**

BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT. Single items or quantities. Private or Industrial.

SPECTRUM ANALYSER TYPEOA1094
Freq. range: 3 to 30MHz in 9 bands. Selectivity: 6 30 and 150Hz, at 3db. Spectrum width: 0-30kHz. Sweep Duration: 0.1, 0,3, 1, 3, 10 & 30 secs. Complete as illustrated, with manuals, etc. **and L.F. Adaptor.**
Price upon application.

TF 1370 R-C OSCILLATOR, SQUARE AND SINE WAVE. Freq.: Sinewave 10Hz-10MHz, squarewave 10Hz-100kHz. Direct output: sinewave: 0-31.6V rms., 10Hz-1MHz, squarewave: 0-73.2pp 10Hz-100kHz. Attenuator range: —50d8 to +10dB. Impedance: 75, 100, 600Ω. Price upon application.

BC 624 RECEIVER (Part of SCR 522 TX/RX) 100-156 mcs, no valves, requires separate PSU for 28V. £2.50. Carriage 50p.

H.F. ABSORPTION WATTMETER TF 957. Range: 1 to 100MHz, Power: 0, 1 to 25w, Impedence 52Ω on 1W range, 70Ω on 25W ange. £22.50. Carriage 75p.

TEKTRONIX OSCILLOSCOPES.
541A—33MHz, plug-in Y amps.
531-57—60MHz, separate P.S.U.
561A—10MHz, solid state, compact, takes the following plugs-ins: X, Y, differential, sampling, spectrum analyser.
PLUG-IN UNITS
CA—24 MHz dual trace 50MV-20V.
G—20 MHz differential 50MV-20V.
L—30 MHz fast rise time 5MV-20V.
D—High gain differential 1MV-50V.
N 600MHz sampling 10mV-cm.
R Transistor measurement.
P type callibration.
3A1—Dual trace 10mV-10V.
3B3—Delayed sweep time base.
134—P6021 probe and current probe amplifier, 1mA-15A p. & p., new and boxed, **£125.**
EQUIPMENT
162 wave form generator.
163 Pulse generator.

500/250W MEDIUM WAVE BROADCAST TRANSMITTERS. Price and details on application.

M.O. for ET 4336 TX (see description in previous issues) **£8·50.** P. & P. £1·50.

AR88 SPARES. We hold the largest stock in U.K. Write for list.

5 PHASE AUTO TRANSFORMER, wye input 400v, wye output 241.5/230/218.5v 50c 18kVA. Made by Westinghouse of USA. Brand new in original cases £60.00 including UK transport.

PLEASE NOTE

Unless offered as "as seen"

ALL EQUIPMENT

ordered from us is completely overhauled mechanically and electrically in our own laboratories

FOR EXPORT ONLY
TRANSMITTERS:
BC 610 Hallicrafters.
RCA ET 4336 also modified version of increased output to 700w.
COLLINS TYPE 231D 4/5kw., 10 channel, autotone and manual tuning. All above complete installation and spare parts.
TRANSCEIVERS
19, 19HP, 38, 62.
C-11 TRANSMITTERS
C-13 TRANSMITTERS

V.A.T.
PLEASE ADD 10% TO ALL ORDERS

REMSCOPE TYPE 741 STORAGE OSCILLOSCOPE. On trolley, complete with plug-in trace shifter and two plug-in Y amplifiers. **£180** plus carriage.

HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

R.F. METER 0-8 amp. 2½" (U.S.A.) **£1·80** P. & P. 15p.

29/41FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag. **£7.50.** Carriage £1.50.

METERS Full List of our very large stock of meters on request.

INTEGRATED CIRCUITS Texas SN 76131N Stereo pre-amp **£0·65.**

TELEPHONE TYPE "J" (Tropicalised) 10 line **MAGNETO TELEPHONE SWITCHBOARD**

100 line **AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD**

50 line **AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD**

Price of each of the above on application.

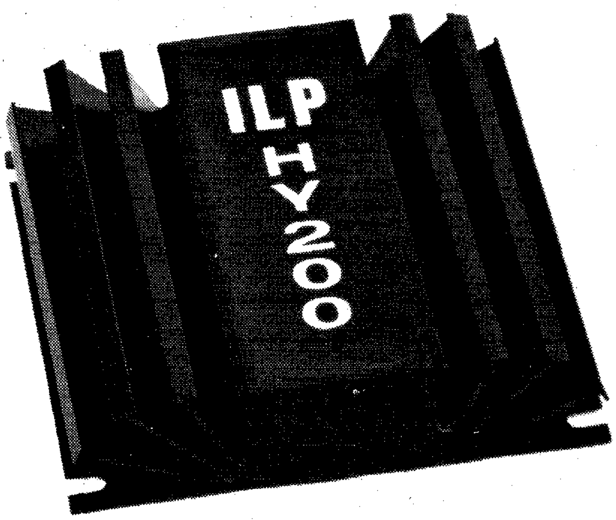
RADAR SCANNER ASSEMBLY TYPE C368 Parabolic assembly 17". Complete with motor for 26V 600W, etc. **£22·50.** Carriage £2·50.

TELEPHONE ENQUIRIES relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23.
To view **TEST EQUIPMENT** please phone for appointment

COLOMOR (ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
Tel. 01 - 743 0899

I.L.P. (Electronics) Ltd

100 WATTS!



- ★ NO EXTERNAL COMPONENTS
- ★ MECHANICALLY & ELECTRICALLY ROBUST
- ★ INTEGRAL HEATSINK
- ★ HERMETICALLY SEALED UNIT
- ★ ATTRACTIVE APPEARANCE
- ★ LOW COST
- ★ BRITISH BUILT

With the development of the HY200, ILP bring you the first COMPLETE Hybrid Power Amplifier.
COMPLETE: because the HY200 uses no external components!
COMPLETE: because the HY200 is its own heatsink!

By the use of integrated circuit technique, using 27 transistors, the HY200 achieves total component integration. The use of specially developed high thermally conductive alloy and encapsulant is responsible for its compact size and robust nature.

The module is protected by the generous design of the output circuit, incorporating 25amp transistors. A fuse in the speaker line completes protection.

Only 5 connections are provided, input, output, power lines and earth.

Output Power: 100 watts RMS; 200 watts peak music power
Input Impedance: 10KΩ
Input Sensitivity: ODbm (0.775volt RMS)
Load Impedance: 4-16Ω
Total Harmonic Distortion: less than 0.1% at 100 watts typically 0.05%
Signal: Noise: Better than 75Db relative to 100 watts
Frequency response: 10Hz-50KHz ±1Db
Supply Voltage: ±45volts
APPLICATIONS: P.A., Disco, Groups, Hi-Fi, Industrial.

PRICE: £14.90 inc. VAT & P & P
Trade applications welcomed
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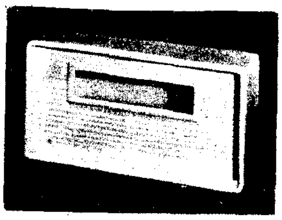
P/P 10p. Price list S.A.E. (Saturday callers welcome)

ALL PRICES INCLUDE VAT

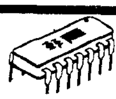
£19·50 ELECTRONIC DIGITAL CLOCK

(For complete kit of parts including case.)



This 4 digit 24 hour clock is available to readers at this special price. Parts would normally cost over £25. Kit of parts includes twelve IC's, indicators, a smart white plastic case and P.C.B.

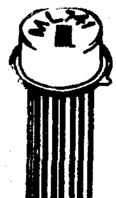
74 Series TTL



	1	25		1	25		1	25		1	25
SN7400	16p	15p	SN7423	55p	50p	SN7450	16p	15p	SN7489	6·05p	5·85p
SN7401	16p	15p	SN7425	55p	50p	SN7451	16p	15p	SN7490	74p	72p
SN7402	16p	15p	SN7427	49p	46p	SN7453	16p	15p	SN7491	1·10p	1·04p
SN7403	16p	15p	SN7428	77p	72p	SN7454	16p	15p	SN7492	74p	72p
SN7404	16p	15p	SN7430	16p	15p	SN7460	16p	15p	SN7493	74p	72p
SN7405	16p	15p	SN7432	49p	46p	SN7470	33p	29p	SN7494	85p	72p
SN7406	38p	35p	SN7433	94p	82p	SN7472	33p	29p	SN7495	85p	72p
SN7407	38p	35p	SN7437	72p	69p	SN7473	41p	39p	SN7496	95p	92p
SN7408	20p	18p	SN7438	72p	69p	SN7474	41p	38p	SN74100	1·80p	1·75p
SN7409	20p	18p	SN7440	16p	15p	SN7475	50p	47p	SN74104	1·09p	1·06p
SN7410	17p	15p	SN7441	74p	70p	SN7476	44p	43p	SN74105	1·09p	1·06p
SN7411	27p	25p	SN7442	74p	70p	SN7480	73p	70p	SN74107	44p	42p
SN7412	38p	35p	SN7443	1·43p	1·37p	SN7481	1·32p	1·26p	SN74110	61p	59p
SM7413	32p	29p	SN7444	1·43p	1·37p	SN7482	97p	95p	SN74111	1·37p	1·27p
SN7416	47p	43p	SN7445	2·00p	1·92p	SN7403	1·20p	1·15p	SN74118	1·10p	1·05p
SN7417	47p	43p	SN7446	1·07p	1·02p	SN7484	1·10p	1·05p	SN74119	1·47p	1·37p
SN7420	16p	15p	SN7447	1·10p	1·03p	SN7485	3·96p	3·85p	SN74121	44p	41p
SN7422	55p	50p	SN7448	1·10p	1·03p	SN7486	36p	35p	SN74122	1·54p	1·43p

* Devices may be mixed to qualify for Price Breaks
* 100 Plus less 10% off 25 plus break

Linear Integrated Circuits



301	DIL	50p	723c	DIL	99p
301	TO99	55p	723c	TO99	95p
301	8 PIN DIL	46p	741c	8 PIN DIL	38p
301A	DIL	69p	741c	14 PIN DIL	39p
301A	TO99	69p	741c	TO99	41p
301A	8 PIN DIL	66p	747c	DIL	46p
307	DIL	69p	748c	DIL	39p
307	TO99	69p	748c	TO99	41p
307	8 PIN DIL	66p	1437	DIL	1·27p
308	TO99	6·45p	1458	TO99	1·27p
308A	TO99	6·40p	3046	DIL	84p
709c	DIL	35p	7503	DIL	1·27p
709c	TO99	31p			

Transistors

								Diodes & Rectifiers	
AC107	16p	BC138	36p	BF260	29p	OC44	14p	IN914	8p
AC126	14p	BC142	33p	BF329	18p	OC45	14p	IN916	8p
AC127	13p	BC143	33p	BF330	18p	OC70	23p	IN4148	8p
AC128	13p	BC144	30p	BF390	37p	OC71	14p	IS44	10p
AC142K	22p	BC145	26p	BFX84	28p	OC72	14p	IN4007	22p
AC141K	20p	BC147	9p	BFX85	35p	OC81	14p	IS113	17p
AC176	15p	BC148	9p	BFX86	22p	OC83	22p	IS120	17p
AC187	13p	BC149	9p	BFX87	28p	OC84	28p	IS121	15p
AC187K	20p	BC153	16p	BFX88	26p	TIP29A	53p	IS130	9p
AC188	13p	BC154	17p	BFY50	21p	TIP30A	64p	IS131	11p
AC188K	20p	BC157	13p	BFY51	17p	TIP31A	64p	IS132	13p
ACY17	24p	BC158	12p	BFY52	17p	TIP32A	73p	IS920	8p
ACY18	21p	BC159	14p	BFY64	39p	TIP33	£1·95	IS922	9p
ACY19	25p	BC167	13p	BFY90	72p	TIP34A	£1·54	IS923	13p
ACY20	22p	BC168	11p	BSX20	19p	TIP35A	£2·53	IS940	6p
ACY21	23p	BC169	11p	C407	22p	TIP36A	£3·19	AA119	11p
ACY22	18p	BC177	15p	C426	33p	TIP41A	79p	AA129	11p
ACY39	68p	BC179	15p	C428	31p	TIP42A	91p	AAZ13	11p
AD140	40p	BC182L	9p	C450	17p	2N706	13p	AAZ15	14p
AD142	44p	BC183L	9p	MP8111	35p	2N930	23p	AAZ17	14p
AD143	39p	BC184L	9p	MP8112	42p	2N1131	22p	BA100	16p
AD149	38p	BC186	33p	MP8113	35p	2N1132	28p	BA102	25p
AD150	60p	BC212L	11p	MP8121	33p	2N1613	22p	BA115	8p
AD161	35p	BC213L	11p	MP8122	44p	2N1711	26p	BA144	14p
AD162	35p	BC214L	11p	MP8123	50p	2N2904	40p	BA145	22p
AD M/P	65p	BC258	9p	NKT211	28p	2N2904A	44p	BA154	14p
AF114	14p	BC259	9p	NKT212	28p	2N2905	46p	BAX13	14p
AF115	14p	BC267	14p	NKT214	25p	2N2924	18p	BAX16	14p
AF116	14p	BC268	15p	NKT217	55p	2N2926	10p	BAY18	19p
AF117	14p	BC300	40p	NKT261	23p	2N3053	26p	BAY31	9p
AF118	92p	BC301	32p	NKT271	20p	2N3054	55p	BY100	19p
AF124	27p	BC302	30p	NKT274	20p	2N3055	52p	BY126	16p
AF139	39p	BC303	50p	NKT275	25p	2N3405	44p	BY127	19p
AF239	41p	BC304	40p	NKT403	71p	2N3663	57p	BYK10	24p
AL100	77p	BCY70	17p	NKT405	83p	2N3702	9p	OA5	19p
AL102	66p	BCY71	37p	NKY603F	66p	2N3703	9p	OA9	11p
AL103	55p	BCY72	17p	NKT613G	33p	2N3704	9p	OA10	24p
ASY26	31p	BC123	66p	NKT674	26p	2N3705	9p	OA47	9p
ASY27	40p	BD123	66p	NKT677G	24p	2N3706	9p	OA70	8p
AU103	99p	BD130	50p	NKT713	32p	2N3707	9p	OA73	11p
AU110	£1·10	BD131	68p	NKT773	27p	2N3708	9p	OA79	8p
AU111	77p	BD132	90p	OC19	36p	2N3709	9p	OA81	9p
BC107	9p	BD135	42p	OC20	65p	2N3710	9p	OA85	11p
BC108	9p	BD136	50p	OC23	40p	2N3711	9p	OA90	8p
BC109	9p	BD141	£1·87	OC25	38p	2N3794	17p	OA91	8p
BC113	15½p	BD142	50p	OC28	49p	2N3819	28p	OA95	8p
BC116	16p	BF159	33p	OC29	49p	40361	50p	OA200	11p
BC125	16p	BF173	29p	OC35	45p	40362	50p		
BC126	25p	BF177	28p	OC36	50p	40636	50p		
BC132	16p	BF178	29p	OC41	14p				
BC134	16p	BF179	35p						
BC135	16p	BF194	15p						
BC137	16p	BF195	17p						
		BF244	27p						

Electrolytic Capacitors

4 VOLT

47μF	6½p
100μF	6½p
220μF	6½p
330μF	6½p
1000μF	13p
4700μF	29p

6·3 VOLT

33μF	6½p
68μF	6½p
150μF	6½p
470μF	11p
680μF	13p
1500μF	18p
2200μF	18p
3300μF	26p

10 VOLT

22μF	6½p
47μF	6½p
100μF	6½p
220μF	8p
330μF	10p
470μF	10p
1000μF	11p
1500μF	20p
2200μF	24p

16 VOLT

15μF	6½p
33μF	6½p
150μF	6½p
150μF	8p
220μF	9p
680μF	17p
1000μF	17p
1500μF	25p
2000μF	43p

25 VOLT

10μF	6½p
22μF	6½p
47μF	6½p
100μF	8p
150μF	8p
220μF	10p
470μF	13p
680μF	20p
1000μF	22p
2200μF	39p
5000μF	68p

40 VOLT

6·8μF	6½p
15μF	6½p
33μF	6½p

40 VOLT

47μF	6½p
100μF	9p
68μF	10p
220μF	11p
470μF	19p
680μF	25p
1000μF	25p
2200μF	44p

63 VOLT

1μF	6½p
2·2μF	6½p
4·7μF	6½p
6·8μF	6½p
10μF	6½p
22μF	6½p
68μF	10p
100μF	11p
150μF	13p
220μF	19p
330μF	22p
470μF	26p
1000μF	44p

MULLARD POLYESTER'S

MULLARD POLYESTER CAPACITORS C280 SERIES
250V P.C. mounting: 0·01μF, 0·015μF, 0·22μF, **3½p.** 0·33μF, 0·047μF, 0·068μF, **4p.** 0·1μF, **4½p.** 0·15μF, 0·22μF, **5½p.** 0·33μF, **7p.** 0·47μF, **9½p.** 0·68μF, **12p.** 1·0μF, **14p.** 1·5μF, **22p.** 2·2μF, **27p.**

MULLARD POLYESTER CAPACITORS C296 SERIES
400V: 0·001μF, 0·0015μF, 0·0022μF, 0·0033μF, 0·0047μF, **2½p.** 0·0068μF, 0·01μF 0·015μF, 0·022μF, 0·033μF, **3½p.** 0·047μF, 0·068μF, 0·1μF, **4½p.** 0·15μF, **6½p.** 0·22μF, **8½p.** 0·33μF, **12p.** 0·47μF, **14p.**
160V: 0·01μF, 0·015μF, 0·22μF, 0·033μF, 0·047μF, 0·068μF, **3p.** 0·1μF, **3½p.** 0·15μF, **4½p.** 0·22μF, **5½p.** 0·33μF, **6½p.** 0·47μF, **8½p.** 0·68μF, **12p.** 1·0μF, **14½p.**

VOLUME CONTROLS
Potentiometers
Carbon track 500Ω to 2·2MΩ
Log or Linear
Single **13p.** Dual gang (stereo) **44p**
Single type with D.P. switch **13p** extra

SLIDE POTENTIOMETERS
58mm. TRACK
SINGLE GANGED, LOG or LIN 1k to 1M. **45p** each.
TWIN GANGED, LOG or LIN 1k to 500k. **66p** each.

CARBON SKELETON PRESETS
Small high quality type (linear only).
All valves 100-5 meg ohms.
-·1 watt 5½p each
-2·5 watt 6½p each

VEROBOARD

	0·15 Matrix	0·1 Matrix
2½in. × 3¾in.	19p	26p
2½in. × 5in.	28p	28p
3¾in. × 3¾in.	28p	28p
3¾in. × 5in.	33p	32p
5in. × 17in (plain)	94p	—

Vero Pins (bag of 36), **22p**
Vero cutter, **50p**; Pin insertion Tools (0·1 and 0·15 matrix) at **61p.**

SLIDE SWITCH
SPST **11p** each. D.P.D.T. **13p** each.

MINIATURE NEON LAMPS
240V or 110V 1-4 **5p,** 5 plus **4½p** each.

MINITRON DIGITAL INDICATOR TYPE 3015F
Reads 0-9 and decimals
(Data Sheet on request)
ONLY £1·80.
16 DIL Socket **33p**
Driven by 7447 **£1·05**

RECTIFIERS

P.I.V.	1 AMP	1·5 AMP
50	IN4001 4½p	PL4001 8p
100	IN4002 4½p	PL4002 9p
200	IN4003 5½p	PL4003 10p
400	IN4004 6½p	PL4004 10p
600	IN4005 8p	PL4005 13p
800	IN4006 9p	PL4006 15p
1000	IN4007 10p	PL4007 20p

BRIDGE RECTIFIERS

P.I.V.	1 AMP	2 AMP	5 AMP	10 AMP
50	33p	53p	£1·76p	£2·20p
100	35p	57p	—	—
200	37p	60p	£1·98p	£2·31p
400	40p	64p	£2·15p	£2·42p
600	44p	66p	£2·42p	£2·75p
800	49p	—	—	—

THYRISTORS

P.I.V.	50	100	200	300	400
1 Amp	28p	25p	41p	44p	53p
3 Amps	44p	50p	60p	—	66p
7 Amps	—	96p	£1·01	—	£1·24

RESISTORS
¼ watt 5% carbon **1p** each
½ watt 10% carbon **1p** each
1 watt 10% carbon **2½p** each
Range 10 ohms to 4·7 meg.
½ watt m/o 2% **3p** each
Range 10— meg ohms

BARGAIN PACKS

Unmarked Packs
Pack of 25
IN4148
55p

Pack of 10
BC108 **65p**
BC107 **65p**
(Plastic can)

Pack of 10
Plastic BC109
65p

Pack of 10
BC169 **65p**
(unmarked)
but tested

2N2646
(unmarked)
33p each

Pack of 10
2N2926G **65p**
unbranded but tested

Unmarked but fully tested
2N3055
1-9 **33p**
10 plus **27p**

FULLY MARKED TYPES

AD161, AD162
M/P
1-9 **65p**
10 plus **60p**

BC107-BC108
BC109
1-9 **10p**
10-99 **9p**
100 plus **8p**

BC 182L: 3-4-212-4
1-9 **11p**
10 plus **10p**

AC127 or AC128
1-9 **13p**
10 plus **12p**
100 plus **11p**

ZENER DIODES
400 M/W 5%
Miniature
BZY 88 Range
All voltages
3·3-33 Volt
9p each

1 watt 5%
All voltages
6·8-200 Volts
14p each

10 watt 5%
All Voltages
7·5-100 Volts
51p each

NEW BRANCHES NOW OPEN **COVENTRY SUNDERLAND STOCKPORT**

BIRMINGHAM 30-31 Gt. Western Arcade (Closed Wed.)
BOLTON 23 Deansgate Opens soon
BRADFORD 10 North Parade (Closed Wed.)
COVENTRY 17 Shelton Square Tel : 25983
DARLINGTON 19 Northgate (Closed Wed.)
DERBY The Spot, 26 Osmaston Rd. (Closed Wed.)
EDINBURGH 101 Lothian Road (Closed Wed.)
GLASGOW 326 Argyle St. (Closed Tues.)
HULL 7 Whitefriargate (Closed Thurs.)
LEEDS 5-7 County (Mecca) Arcade, Briggate (Closed Wed.) Tel. 28252
LEICESTER 32 High St. (Closed Thurs.)
LIVERPOOL 73 Dale St. (Closed Wed.)
LONDON 238 Edgware Rd., (Closed Thurs.)
MANCHESTER 60a Oldham St. (Closed Wed.)
MIDDLESBRO 106 Newport Rd (Closed Wed.)
NEWCASTLE 24 Newgate Shopping Centre (Closed Wed.) Tel. 21469

RSC HI-FI CENTRES LTD

MAIL ORDERS to:
106 HENCONNER LANE, LEEDS 13.
Terms C.W.O. or C.O.D. Postage 28p extra under £2. 33p extra over £2, or as stated. Trade supplied. S.A.E. with enquiries.

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BRANCHES OPEN ALL DAY SATURDAYS AND OPERATE A 5-DAY WEEK
MAIL ORDERS NOT TO BE SENT TO SHOPS.

NOTTINGHAM 19 Market St. (Closed Thurs.)
SHEFFIELD 13 Exchange St. (Closed Thurs.)
STOCKPORT 8 Little Underbank Tel. 480 0777
SUNDERLAND 5 Market Square (Closed Wed.)

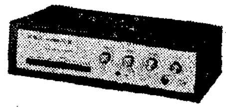
R.S.C. G66 MkII 6+6 WATT STEREO AMPLIFIER

High Quality Output. Rating I.H.F.M. Ind. Ganged Controls Bass Treble, Vol. and Balance. Solid state constr. employing 10 Trans plus diodes. Range 20-20,000Hz. Bass control ± 12 dB Treble ± 13 dB. Selector switch P.U. or Tape/Radio. Output for 3-15 ohm speakers. Standard 200-250v. 50 Hz mains operation. Attractive Black/Silver metal face plate and matching knobs.

COMPLETE KIT OF PARTS INC. FULLY WIRED PRINTED CIRCUIT £12·65 **OR FACTORY BUILT IN TEAK VENEERED CABINET £16·50**

R.S.C. SUPER 30 MkIII HIGH FIDELITY STEREO AMPLIFIER

BUILD AN AMPLIFIER WORTH APPROXIMATELY DOUBLE THE KIT PRICE INCLUDING CABINET
Only high grade components by leading manufacturers



- Push Button Selector Switching
- Jack Socket for Headphones
- Neon Indicator
- Satin Silver Finish Metal Fascia
- Solid State Circuitry
- Twenty Silicon Transistors
- Four Diodes, Four Rectifiers

For Magnetic or Ceramic Pick-Ups regardless of Price
Output (per channel) 15 watts RMS into 8Ω
Frequency Response 7 Hz to 70 KHz ± 1½ dB

COMPLETE KIT (less cabinet). Carr. 70p Cabinet if req. £5 extra **£27·50**

FACTORY BUILT UNIT INC. CABINET with 12 months' guarantee. Or Dep. £7 and 9 monthly payments £4·54 (Total £47·86) **£42·50**

Send S.A.E. for full descriptive leaflet

R.S.C. STEREO FM III TUNER. Visually matches Super 30 Mk. III in cabinet **£37·50**

FANE ULTRA HIGH POWER LOUDSPEAKERS

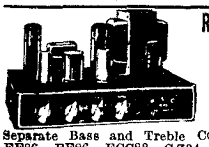
Power Rating R.M.S. continuous. 2 years guarantee. Carr. free

12" 'POP' 50 50 Watts 15Ω 13,000 Gauss **£11·99**
Or Dep. £2 and 9 monthly payments £1·33 (Total £13·97)

15" 'POP' 60 60 Watts 8/15Ω 14,000 Gauss **£14·75**
Or Dep. £3·30 and 9 monthly payments £1·50 (Total £16·80)

18" 'POP' 100 100 Watts 8/15Ω 14,000 Gauss **£25·95**
Or Dep. £6·00 and 9 monthly payments £2·49 (Total £28·41)

Pair suitable for all purposes. SUITABLE FOR BASS GUITAR, ELECTRONIC ORGAN, etc.



R.S.C. AIO 30 WATT HI-FI AMPLIFIER

Including 2 ind. controlled inputs
Separate Bass and Treble Controls. Valves EF86, EF86, ECC83, GZ34, EL34, EL34. Sensitivity 36mV. For High Imp. mic. or pick-ups. Designed to high fidelity standards for CLUBS, SCHOOLS, THEATRES, DANCE HALLS, DISCOTHEQUES, etc. For use with Electronic Organ, Bass or Lead Guitar. For Gram, Radio or Tape. For 3 or 15 ohm speakers.
Twin-handled metal cover £2·10
FACTORY BUILT with 12 months' guarantee. Or Dep. £4 and 9 monthly payments £2·27 (Total £24·43) S.A.E. for leaflet **£21·75**

FANE SPEAKERS 'POP' 25/2

12" 25 WATT Dual Cone 15 ohms NOT for Bass Guitar. **£7·95** Or Dep. £1·25 and 9 monthly payments 89p (Total £9·26)

HI-FI SPEAKER ENCLOSURES

Teak veneer finish. Pleasing design. Acoustically lined. All sizes approx.

JE8 16×11×9 in. Pressurised. Excellent results with 8 in. Hi-Fi Speaker. **£5·50**
SE8 for optimum results with any 8 in. Hi-Fi Speaker. 19×10½×9 in. **£6·50**
SE10 outstanding performance with Hi-Fi 10-in. speaker. 25½×16×9 in. Ported. **£6·75**
SE12 for high grade results with 12 in. Hi-Fi speaker and Tweeter. 25½×16×9 in. Pressurised. **£7·95**

R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impreg where necessary. Primaries 200-250v. 50 Hz. Screened

MIDGET CLAMPED TYPE 2½×2½ ×2½in.

250v., 60mA, 6.3v. 2a.	£1·10
250-0-250v., 60mA, 6.3v. 2a.	£1·16

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	£1·55
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 130mA, 6.3v. 4a., c.t., 6.3v 1a. For Mullard 510 Amplifier	£2·95
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a.	£2·95
425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a.	£5·45
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a, 5v. 3a	£5·60
450-0-450v. 250mA. 6.3v. 4a., c.t., 5v. 3a.	£6·00

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v 70mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·49
250-0-250v. 100mA, 6.3v. 3.5a.	£1·71
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	£1·75
350-0-350v. 80mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·81
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 130mA, 6.3v. 4a. c.t. 6·3v. 1a. Suitable for Mullard 510 Amplifier	£2·85
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
350-0-350v. 150mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·85

FILAMENT or TRANSISTOR POWER PACK Types 6.3v. 1.5a. 55p; 6.3v. 2a. 60p; 6.3v. 3a. 85p; 6.3v. 6a. £1·45; 12v. 1a. 61p; 0-9-18v. 1½a. £1·25; 0-12-25-42v. 2a. £1·95; 12v. 3a. or 24v. 1.5a. £1·50;
CHARGER TRANSFORMERS 0-9-15v. 1½a. £1·10; 2½a., £1·25; 3a., £1·40; 5a., £1·60; 6a., £1·85; 8a., £2·20.
AUTO (Step UP/Step DOWN) Transformers 0-110/120v., 200-230-250v. 50-80 watts £1·25; 150w., £2·10; 250w., £3·00; 500w., £6·40

OUTPUT TRANSFORMERS

Standard Pentode 5,000Ω to 7,000Ω to 3Ω	55p
Push-Pull 8 watts EL84 to 3Ω or 15Ω	95p
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω	£1·55
Push-Pull EL84 to 3 or 15Ω 10-12 watts	£1·50
Push-Pull Ultra Linear for Mullard 510, etc.	£2·45
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω	£2·20
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω	£3·65

BATTERY/MAINS CONVERSION UNITS

R.S.C. BM1 battery eliminator completely replaces 1·5v. and 90v. Radio batteries where normal 200-250v. AC mains is available. Ready for use **£4·15**

FANE 807T HIGH FIDELITY SPEAKER 8" 10 WATT

A full range unit to provide excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance of 30 Hz. Tweeter cone extends high note response. Frequency range 25-15,000 Hz. Imp. 3 or 8/15Ω. (state requirement.) **REMARKABLE VALUE £3·70**

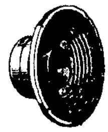
MODEL 803T 8" 15w. with parasitic Tweeter. Response 25 Hz to 15 KHz. Gauss 13,000 Imp 3 or 8-15 ohms. ONLY **£4·95**

FANE MODE ONE HI-FI SPEAKER KIT

inc. 803 8" unit, 303 Pressure Tweeter, Printed circuit, inductive capacitive cross-over, acoustic filling panels, screws, etc. Post free Response 30-20,000 Hz **ONLY £9·96**

HIGH FIDELITY SPEAKERS

AUDIOTRINE RANGE



Heavy construction. Highly efficient ceramic magnets. Plastiflex cone surrounds. "D" indicates Tweeter cone providing frequency range up to 15 KHz. Exceptional performance at low cost.

HF 808T	8"	10W	£2·98
HF 102D	10"	10W	£3·30
HF 120	12"	15W	£4·95
HF 120D	12"	15W	£5·50
HF 126	12"	15W	£6·35
HF 126D	12"	15W	£6·85

Please state impedance required. 3 or 8-15 ohm.

HI-FI SPEAKER SYSTEMS

Audiotrine 121K. 12 in. 15 watt. 11,000 Gauss bass unit. Cross-over unit and Tweeter. Smooth response and wide frequency range ensure realistic sound reproduction. Carr. 33p **£6·50**
Audiotrine 125K with extra sensitive 15,000 Gauss 12 in. speaker. **£7·65**

MAGNETIC HEADS P.O.A.

210028 RCA ....9 TRACK	303462 RCA ....7 TRACK
259019 RCA ....7 TRACK	1215872 TYPE 1301 ....7 TRACK
257124 RCA ....8 TRACK	5007821 POTTER ....7 TRACK
282812 RCA ....8 TRACK	19467 EPSYLON ....8 TRACK
303489 RCA ....7 TRACK	76815/948 BURROUGHES 9 TRACK
73927 RCA ....7 TRACK	652623DRI 12/101 ....12 TRACK
303464 RCA ....7 TRACK	L651922 DRI FR3000 ....16 TRACK

TRANSISTORS & DIODES

2N457 ....75p	AF116 ....25p	2N356/OC139 ....25p
2N1545 ....50p	AF117 ....25p	Get110 ....20p
2N1542 ....50p	BC107 ....8p	2G106/2N711B ...43p
2N1557 ....50p	BC108 ....8p	OA5 ....20p
2N3055 ....45p	BC109 ....8p	OA10 ....25p
2N3322 ....£1·00	OC35 ....40p	RAS508AF 800PIV 50p
2N3553 ....£1·00	OC42 ....40p	RAS310AF 1000v Av. 1.5a 2 for 50p
2N5322 ....50p	OC71 ....12p	STC Wire ended 400PIV 1a 4 for 50p
AC126 ....20p	CV7006/OC72 ....20p	
AC127 ....25p	OC75 ....25p	
AC128 ....20p	OC77 ....45p	
AF115 ....25p	OC83 ....25p	

RCA PHOTOMULTIPLIER C31005B Checked and tested .... **£37·50**

BRIDGE RECTIFIERS 1B40KO5 50v 4a **95p**

RECTIFIER STACKS

GEX541B1P2 ..... £6·88
GEX541B1P1 ..... £3·50
GEX541D2P1 ..... £3·50
GEX541NB1P1F ... £6·00
GEX541HP3F ..... £6·00
SX751N1B1P1F ... £6·00

DIGITAL COUNTERS

Veeder Root Zero Reset 6 dig. 110v. dc .... £4·75
Veeder Root Mech. Reset 4 dig. 50p
Hengstler Reset 6 dig. 210Ω 24v. .... £3·50
Hengstler Reset 6 dig. 110v. Type 400 with suppressor .... £5·50

INTEGRATED CIRCUITS

MC3544 .... £1·10
MC353G .... £2·00
MC358AG .... £5·00
MC365G .... £5·00
CA3020 .... 93p
CA3021 .... £1·15
CA3055 .... £1·24
CD4035AE .... £1·91

THYRISTORS

GE2N1774 200v. 5a. £1·20
CR1-021C 20v. 1a. ... 25p
CR10-101B 100v. 10a. .... £1·00
CR10-021 10a. .... £1·00
CR10-40B 10a. .... £1·00
CR10-051 10a. .... £1·00
CR10-017 10a. .... £1·00
BTX-82-300R 300v. 26a. .... £2·00
STC 3/40 400v. 3a. ... 50p

SWITCHES

Edwards High Vacuum "Speedivac" model VSK1B range 25·760 torr contact ratings 250v. 5a. volume 4·2 cu. cm. max. working pressure 15lb/sq. in. gauge net weight 17 ozs. .... **£6·20**
Belling Delay hand reset L415 .... **£1·10**
Stackpole min. rocker 125v. 10a. 250v. 5a. **20p**
Tippalite Rocket 12v. **60p**
Securex 5000 press button 250v. ac. **£1·20**

TELEPRINTERS

Creed model 75 Receiver — 5w Mk 4 unused with connectors handbook & computer wiring diagram **£35.00** carr. £1.00.

RELAYS

Varley Min. 700Ω 12v. **50p**
Siemens Min. 12/15v. **50p**
Magnetic Dev. Type 596E .... **£2·00**
BR Type M51 240v. **65p**

VARIACS

Zenith Duratrak Type V6M Inp. 135v. & 115v. Outp. 135v. at 6a. .... **£6·00**
Philips Series E401 Inp. 240v. Outp. 0-270v. at 8 amps .... **£15·00** carr. 67p

KEYBOARDS — special sale of Limited Quantity

ICT Alpha Verifier .... **£6.00** carr. 50p
ICT Numerical .... **£3.50** carr. 35p
ICL Alpha Verifier (PN7035 130) ..... **£27.50** carr. £1.00

"DIMMIT" Module PMSD-1000
1KW Dimmer used by industry Theatre Disco 240v Full Radio & TV Interference Suppression Fibreglass PCB 60mm slider pot. permits linear control from min. to max. power using Triac Phase Control fused for O/L protection Dimen. 12 × 5 × 4 cm knob faceplate screws supplied **£6.50** pp 20p.

CONNECTORS

McMurdo Red Range. Plug RP24 .... **56p**
McMurdo Red Range. SKT RS32 .... **90p**
Eng. Elect. Edge. 36 way 0·2mm .... **£1·00**
Sylvania Edge. 48 way 0·1mm .... pair **£1·40**
Ultra Gold-plated Contacts. 0·1mm Type 10M 54631263C 38 way .... pair **£2·00**
20 way .... pair **£1·60**

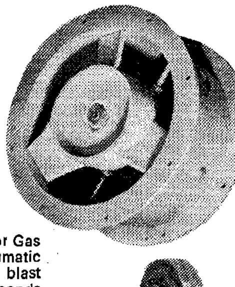
CAPACITORS

Daly Electrolytic 9000 uf 40v **50p;** CCL Electrolytic 2500 uf 100v DC **75p;** Dubilier Metallised Paper Type 426 100uf 150v. DC **50p;** R.I.C. type 1297 1.8uf 440v. AC **35p.**

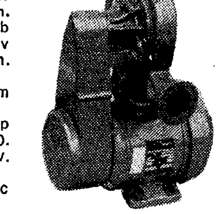
MOTORS

Crompton Parkinson 240v. 1ph 50c 0·125hp 1400rpm .... **£5·00** carr. 67p
GEC fractional 1/12 hp 230/250v 1ph 50c 2850rpm .... **£3·50** carr. 67p
E.E. ⅓hp 230v. 50c 1ph 50c. 1440rpm complete with cap 80/100uf 275v. ... **£13·00** carr. £1·00
76813-393 Potter Instr. 110v. DC 4amp 0·2hp. Cont. flange mounting precision tape transport motor (£80 value) .... **£25·00** incl. carr.

FANS, CENTRIFUGAL BLOWERS AND STARTERS



Airmax Type M1/Y3954 (3 blades) Cast Aluminium alloy impeller & casing (corresponds to current type 3965 7½") 230v. 1ph 50c 2900rpm Class "A" insulation 425cfm free air weight 9½lbs. incl. p.p. **£21·00.**
Woods Aerofoil short casing type "S" 2700rpm 220/250v 1ph 50c 6" plastic impeller incl. p.p. **£11·50.**
Woods Aerofoil Code 7.5 280K 200/250v. 1·0a 1ph 50c 2700rpm 7½" impeller 14 blades incl. p.p. **£13·50.**
Service Electric Hi-Velocity Fans, suitable for Gas combustion Systems. Steam exhausting, Pneumatic conveying, Cooling Electronic equipment, Air blast for Oil burners. **Secomak** Model 365 (corresponds to 575) Airblast Fan, 440v 3ph 50c 0·75hp 2850rpm. continuous 160cfm 12 in w.g. nett weight 44lb price incl. carr. **£41.00. Secomak** model 350 250v 1ph 50c 0·166hp, 2800 rpm continuous 50cfm 2 in. w.g. net weight 34lbs, price incl. carr. **£26·00.**



Air Controls type VBL4 200/250v 1ph 50c. 110cfm free air weight 7½lbs price incl. p.p. **£14·50.**
William Allday Alcosa Two Stage Vacuum Pump Model HSPOB 8hg up to 29 in. mercury rpm 1420. E.E. 3 phase induction, motor ⅓hp cont. 220/250v. 380/440v. **£21·00** incl. carr.
Alan West Direct-On SCF Starters 240v. 1ph 50c hp. 0·5 & 0·25, new, unused **£5·75** p.p. 29p.

Where p.p. not advised add 10p per £ handling and post (in UK). Cash with order. Personal callers welcome. Open Mon-Wed. Fri.-Sat. 9.30-5.00. Closed Thursday. Free Car Park adjacent.
PRICES SHOWN ARE EXCLUSIVE OF V.A.T.

W. & B. MACFARLANE

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ATTRACTIVE DISCOUNTS
ON VERY MANY ITEMS WHEN YOU BUY FROM US

ELECTROVALUE
Electronic Component Specialists

RESISTORS—10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99 (see note below)	100 up
C	1/20W	5%	82Ω–220KΩ	E12	9	8	7·5
C	1/8W	5%	4·7Ω–470KΩ	E24	1	0·9	0·75 nett
C	1/4W	5%	4·7Ω–10MΩ	E12	1	0·9	0·75 nett
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·9 nett
C	1W	5%	4·7Ω–10MΩ	E12	2·5	2	1·6 nett
MO	1/2W	2%	10Ω–1MΩ	E24	4	3	2 nett
WW	1W	10%±1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	1Ω–10KΩ	E12	7	7	6
WW	7W	5%	1Ω–10KΩ	E12	9	9	8

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.
Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series, as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.)

TRANSISTORS BY SIEMENS AND NEWMARKET

2N3055 npn silicon power **60p**
AC153K pnp germanium low power **32p**
AC176K npn germanium low power **32p**
AD161 npn germanium medium power **42p**
AD162 pnp germanium medium power **40p**
AF139 pnp germanium UHF **33p**
BC107—**13p**; BC108—**12p**; BC109—**13p**] npn
BC167—**11p**; BC168—**10p**; BC169—**11p**
BC177—**21p**; BC178—**19p**; BC179—**22p**] pnp
BC257—**12p**; BC258—**11p**; BC259—**13p**
Standard groupings available.

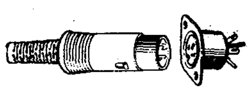
BD135 npn medium power **37p**
BD136 pnp medium power **38p**

DIODES
OA90, OA91, OA95 each **6p**
OA200—**9p**; OA202—**10p**

Other semi-conductors
AC128—**21p** AF117—**32p**
BFY51—**19p**

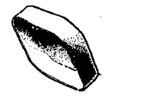
Very many other types listed, described and illustrated in catalogue.

DIN CONNECTORS by Hirshmann 4A rating

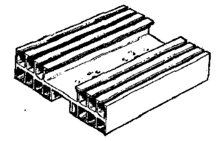


2 way loudspeaker Socket **10p** Plug **12p**
3 way audio Socket **10p** Plug **12p**
5 way audio 180° Socket **12p** Plug **15p**
5 way audio 240° Socket **12p** Plug **15p**
6 way audio Socket **13p** Plug **15p**
Lockable types, phono connectors, etc.

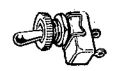
COVERS & HEATSINKS



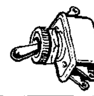
T03 Transistor cover, clip-on **7p**
HEATSINK
Type 6WI Extruded aluminium 1° C/W, undrilled **60p**



TOGGLE SWITCHES



1011C SPST toggle **19p**; **409** DPDT toggle **28p.** (These are chrome plated, 2.5A rating). **7201** Sub-miniature DPDT 250V a.c./2A **48p**



TTL ICs

	Nett Price
7400	20p
7401	20p
7402	20p
7403	20p
7404	25p
7405	20p
7408	25p
7409	25p
7410	20p
7413	35p
7420	20p
7430	20p
7440	20p
74141 (16)	99p
7442 (16)	87p
7443 (16)	£1·00
7444 (16)	£1·00
7447	£1·36
7450	20p
7451	20p
7453	20p
7454	20p
7466	20p
7470	33p
7472	30p
7473	36p
7474	36p
7475 (16)	60p
7476 (16)	45p
7480	68p
7482	87p
7483 (16)	£1·32
7485	£1·70
7486	35p
7490	60p
7491AN	£1·00
7492	70p
7493	65p
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74192 (16)	£1·74
74193 (16)	£1·74

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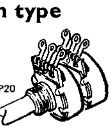
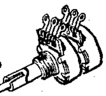
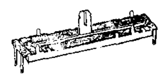
long spindles. Double wipers for low noise.
SINGLE GANG P20 linear 100Ω to 2·2MΩ, **12p**, JP20 Log, 4·7KΩ, to 2·2MΩ **12p.**



DUAL GANG linear 4·7KΩ to 2·2MΩ, **42p**; Dual gang log, 4·7KΩ to 2·2MΩ, **42p**; Log/antilog, 10K, 22K, 47K, 1MΩ only **42p**; Dual antilog, 10K only, **42p.** Any type with 2A D.P. mains switch, **12p** extra.



Only decades of 10, 22 & 47 available in ranges quoted.
DUAL CONCENTRIC DP20 in any combination of P20 values, **60p**; with switch, **72p.**



SLIDER POTS. In values from 4K7Ω to 1MΩ, linear or log, **26p.** Escutcheon, white, grey, black, **10p.** Knobs, flat, grip type, in 7 colours, **5p each.**
SKELETON PRE-SETS. Small high quality, type PR linear only: 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 470K, 1M, 2M2, 5M, 10MΩ. Vertical or horizontal mounting, **5p each.**

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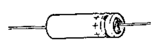
Screws roundheaded, cheese headed or countersunk. Other sizes available. Also tags, washers, spacers, etc.

ELECTROLYTICS



Prices in pennies

μF	3V	6.3V	10V	16V	25V	40V	63V	100V
0.47							10	7
1.0						10		7
2.2					10		7	8
4.7				10		7	8	7
10					7	8	7	8
22			7		8	7	7	9
47	7		8	7	7	7	9	12
100	8	7	7	7	7	9	11	19
220	7	8	8	8	9	10	17	27
470	8	9	9	10	12	17	24	43
1000	10	12	12	17	20	24	40	
2200	14	17	22	25	36	40		
4700	25	28	37	41	54			
10,000	40	43						

Smallest size 3·7mm x 12mm. Largest size 25·5mm x 41mm. Full ranges of many other types of capacitors stocked.

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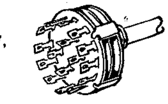
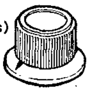
Radiospares Miniature Makaswitch (in assembly kit form). Shaft **48p.** Wafers, MBB—2P5W, 1P 11W; BBM1P12W, 2P6W, 3P4W, 4P3W, 6P2W, each **32p.**

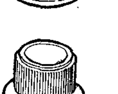
Wavechange switches 1P12W, 2P6W, 3P4W, 4P3W, each **24p.**



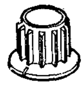
KNOBS
(for 0.25 shafts)



K.30/3 Solid aluminium 17mm.



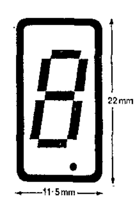
F.14 skirt dia. 20mm. pack of 2 **32p**
F.13 skirt dia. 26mm. pack of 2 **38p**
F.12 skirt dia. 33mm. pack of 2 **40p**
F.19 engraved 20mm.—two **32p**
F.18 engraved. 26mm.—two **38p**
F.17 engraved. 33mm.—two **40p**



KB.4 Ribbed Skirt dia. 20mm. 4 in pack. **40p**

Very many other types in stock—see Catalogue.

Minitron DIGITAL INDICATOR



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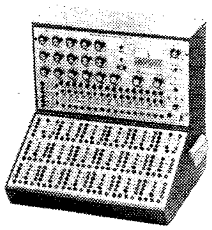

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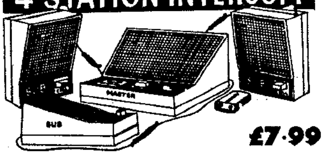

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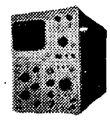

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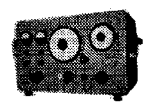

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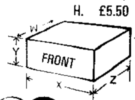

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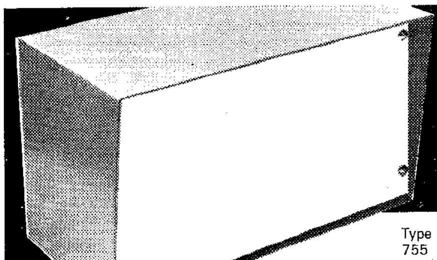

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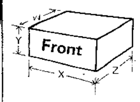

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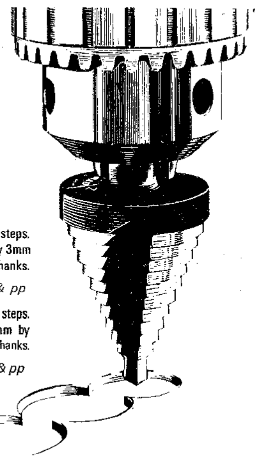

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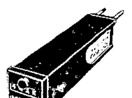

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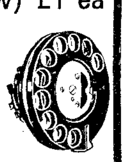

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1L4	0·13
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1LN5	0·66
1N5GT	0·37
1R5	0·26
1S4	0·33
1S5	0·22
1U4	0·44
1U5	0·80
2D21	0·44
2GK5	0·55
3A4	0·36
3B7	1·00
3D6	0·19
3Q4	0·49
3Q5GT	0·55
3S4	0·26
4CB6	0·55
5CG8	0·55
5R4GY	0·70
5T4	0·30
5U4G	0·30
5V4G	0·34
5Y3GT	0·30
5Z3	0·45
5Z4G	0·33
5Z4GT	0·38
6/30L2	0·53
6A8G	0·33
6AC7	0·15
6AG5	0·25
6AH6	0·50
6AJ5	0·75
6AJ8	0·25
6AK5	0·25
6AK6	0·30
6AK8	0·29
6AL5	0·10
6AM8A	0·50
6AN8	0·49
6AQ5	0·21
6AQ8	0·32
6AR5	0·30
6AR6	1·00
6AS7	1·00
6AT6	0·18
6AU6	0·19
6AV6	0·28
6AW8A	0·54
6AX4	0·39
6B8G	0·13
6BA6	0·19
6BC8	0·50
6BE6	0·20
6BG6G	1·05
6BH6	0·43
6BJ6	0·39
6BK7A	0·50
6BQ5	0·21
6BQ7A	0·38
6BR7	0·79
6BR8	0·63
6BS7	1·25
6BW6	0·72
6BW7	0·50
6BX6	0·21
6BY7	0·25
6BZ6	0·31
6C4	0·28
6C6	0·19
6C9	0·73
6CB6A	0·26
6C12	0·25
6C17	0·63
6CD6G	1·06
6CG8A	0·50
6CH6	0·55
6CL6	0·43
6CL8A	0·50
6CM7	0·50
6CU5	0·30
6CW4	0·63
6D3	0·38
6D6	0·15
6DE7	0·50
6DT6	0·50
6EW6	0·55
6E5	0·55
6F1	0·59
6F6G	0·35
6F12	0·17
6F13	0·33
6F14	0·40
6F15	0·65
6F18	0·45
6F23	0·65
6F24	0·68
6F25	0·51
6F26	0·25
6F28	0·60
6F32	0·15
6G6G	0·25
6GH8A	0·50
6GK5	0·50
6GU7	0·50
6H6GT	0·15
6J5GT	0·29
6J6	0·18
6J7G	0·24
6J7(M)	0·38
6JU8A	0·50
6K7G	0·12
6K8G	0·33
6L1	0·98
6L6GT	0·50
6L7(M)	0·38
6L12	0·32
6L18	0·44
6L19	1·38
6LD12	0·29
6LD20	0·48
6N7GT	0·40
6P1	1·50
6P15	0·21
6P28	0·59
6PL12	0·28
6Q7G	0·35
6Q7GT	0·43
6Q7(M)	0·43
6R7G	0·35
6R7(M)	0·55
6SA7M	0·35
6SC7GT	·33
6SG7(M)	·33
6SH7	0·53
6SJ7GT	·35
6SK7GT	·23
6SQ7GT	·38
6U4GT	0·60
6U7G	0·53
6V4	0·19
6V6G	0·17
6V6GT	0·27
6X4	0·20
6X5GT	0·25
6Y6G	0·55
6Y7G	0·63
7A7	0·88
7B6	0·58
7B7	0·32
7F8	0·88
7H7	0·28
7R7	0·65
7V7	0·25
7Y4	0·60
7Z4	0·50
9BW6	0·50
9D7	0·78
10C2	0·49
10C14	0·29
10D1	0·50
10DE7	0·50
10F1	0·75
10F9	0·45
10F18	0·35
10L14	0·33
10LD11	0·53
10LD12	·30
10PL12	0·30
10P13	0·54
10P14	1·08
10P18	0·28
12A6	0·63
12AC6	0·40
12AD6	0·40
12AE6	0·48
12AT7	0·16
12AU6	0·21
12AU7	0·19
12AV6	0·28
12AX7	0·21
12AY7	0·68
12BA6	0·30
12BE6	0·30
12BH7	0·27
12J5GT	0·30
12J7GT	0·33
12K5	0·50
12K7GT	·34
12Q7GT	0·28
12SA7GT	·40
12SC7	0·35
12SG7	0·23
12SH7	0·15
12SJ7	0·23
12SK7	0·24
12SQ7GT	0·50
14H7	0·48
14S7	0·75
18	0·63
19AQ5	0·24
19BG6G	·80
19G6	0·50
19H1	2·00
20D1	0·49
20D4	1·05
20F2	0·65
20L1	0·98
20P1	0·50
20P3	0·76
20P4	0·89
20P5	1·00
25A6G	0·29
25L6G	0·20
25Y5	0·38
25Y5G	0·43
25Z4G	0·28
25Z5	0·40
25Z6G	0·43
30A5	0·44
30C1	0·26
30C15	0·55
30C17	0·74
30C18	0·69
30F5	0·61
30FL1	0·58
30FL2	0·60
30FL12	0·67
30FL13	0·47
30FL14	0·66
30L1	0·27
30L15	0·55
30L17	0·65
30P4MR	0·95
30P12	0·69
30P16	0·28
30P19/	
30P4	0·65
30PL1	0·57
30PL12	0·29
30PL13	0·75
30PL14	0·75
30PL15	·87
35A3	0·48
35A5	0·75
35D5	0·70
35L6GT	·42
35W4	0·23
35Z3	0·50
35Z4GT	·24
35Z5GT	·30
50B5	0·35
50C5	0·32
50CD6G	2·17
50EH5	0·55
50L6GT	·45
72	0·33
77	0·53
85A2	0·43
85A3	0·40
90AG	3·38
90AV	3·38
90CG	1·70
90CV	1·68
90C1	0·59
150B2	0·58
150C2	0·33
215SG	0·33
301	1·00
302	0·83
303	0·75
305	0·83
807	0·59
956	0·10
1821	0·53
5702	0·80
5763	0·50
6060	0·30
7193	0·53
7475	0·70
A1834	1·00
A2134	0·98
A3042	0·75
AC2PEN	0·98
AC2PENDD	0·98
AC6/PEN	0·38
AC/PEN(7)	0·98
AC/THI	·50
AC/TP	0·98
AL60	0·78
ARP3	0·35
ATP4	0·40
AZ1	0·40
AZ31	0·46
AZ41	0·52
B319	0·27
BL63	0·50
CL33	0·90
CV6	0·53
CV63	0·53
CV988	0·10
CY1C	0·53
CY31	0·29
D63	0·20
DAC32	0·55
DAF96	0·36
DC90	0·60
DD4	1·00
DF91	0·14
DF96	0·36
DH76	0·28
DH77	0·18
DH81	0·58
DK32	0·33
DK40	0·55
DK92	0·50
DK96	0·45
DL92	0·26
DL96	0·38
DM70	0·30
DM71	0·50
DW4/350	0·38
DY87/6	0·22
DY802	0·29
E80CC	1·65
E80F	1·20
E83F	1·20
E88CC	0·60
E92CC	0·40
E180F	0·90
E182CC	1·00
E1148	0·53
EA50	0·27
EA76	0·88
EABC80	0·29
EAC91	0·38
EAF42	0·48
EAF801	·50
EB34	0·20
EB91	0·10
EBC41	0·48
EBC81	0·29
EBC90	0·18
EBC91	0·28
EBF80	0·30
EBF83	0·38
EBF89	0·26
EBL21	0·60
EC53	0·49
EC54	0·50
EC86	0·59
EC88	0·59
EC92	0·34
ECC32	1·50
ECC33	1·50
ECC35	0·95
ECC40	0·68
ECC81	0·16
ECC82	0·19
ECC83	0·21
ECC84	0·28
ECC85	0·32
ECC86	0·40
ECC88	0·35
ECC189	·48
ECC804	·53
ECC807	1·00
ECF80	0·27
ECF82	0·25
ECF86	0·64
ECF804	2·10
ECH21	0·63
ECH35	0·50
ECH42	0·57
ECH81	0·25
ECH83	0·38
ECH84	0·34
ECL80	0·28
ECL82	0·28
ECL83	0·52
ECL84	0·54
ECL85	0·54
ECL86	0·33
EF22	0·63
EF40	0·49
EF41	0·58
EF42	0·33
EF73	0·75
EF80	0·21
EF83	0·54
EF85	0·25
EF86	0·27
EF89	0·23
EF91	0·17
EF92	0·28
EF94	0·19
EF97	0·55
EF98	0·65
EF183	0·25
EF184	0·27
EF804	1·20
EFP60	0·50
EH90	0·34
EK90	0·20
EL32	0·18
EL34	0.48
EL35	1·00
EL41	0·53
EL81	0·50
EL83	0·38
EL84	0·21
EL85	0·40
EL86	0·38
EL91	0·23
EL95	0·32
EL360	0·49
ELL80	0·75
EM80	0·37
EM81	0·37
EM83	0·75
EM84	0·31
EM85	1·00
EM87	0·49
EY51	0·35
EY81	0·35
EY83	0·54
EY84	0·50
EY87/6	0·27
EY88	0·40
EY91	0·53
EZ35	0·25
EZ40	0·40
EZ41	0·42
EZ80	0·19
EZ81	0·20
EZ90	0·20
FW4/500	0·75
FW4/800	0·75
GY501	0·75
GZ30	0·33
GZ32	0·39
GZ33	0·70
GZ34	0·47
GZ37	0·67
HABC80	0·44
HL13C	0·20
HL23DD	0·40
HL41DD	0·98
HL42DD	0·50
HN309	1·40
HVR2	0·53
HVR2A	0·53
IW3	0·38
KT2	0·25
KT8	1·75
KT41	0·98
KT44	1·00
KT63	0·35
KT66	0·80
KT74	0·63
KT76	0·63
KT81	2·00
KTW61	·63
KTW62	·63
KTW63	·50
LN119	0·30
LZ319	0·26
LZ329	0·26
LZ339	0·55
M8162	0·63
MHL4	0·75
MHLD6	·75
MKT4	0·98
MU12/14	0·38
N308	0·95
N339	0·44
N379	0·28
N709	0·21
P61	0·40
PABC80	0·32
PC86	0·44
PC88	0·44
PC95	0·53
PC97	0·36
PC900	0·29
PCC84	0·27
PCC85	0·24
PCC88	0·39
PCC89	0·42
PCC189	0·46
PCF80	0·26
PCF82	0·30
PCF84	0·40
PCF86	0·44
PCF87	0·74
PCF200	0·67
PCF800	0·55
PCF801	0·28
PCF802	0·37
PCF805	0·69
PCF806	0·55
PCF808	0·66
PCH200	·62
PCL82	0·29
PCL83	0·54
PCL84	0·32
PCL86	0·36
PCL88	0·75
PCL800	·75
PCL801	0·57
PCL805/	
PCL85	0·37
PD500	1·44
PEN4DD	1·38
PEN45	0·40
PEN45DD	0·75
PEN46	0·20
PEN453DD	0·98
PENA4	0·98
PENDD /4020	0·88
PFL200	0·50
PL33	0·38
PL36	0·46
PL81	0·42
PL81A	0·48
PL82	0·28
PL83	0·30
PL84	0·28
PL302	0·65
PL504/	
PL500	0·60
PL508	0·90
PL801	0·69
PM84	0·31
PY33/2	·50
PY80	0·33
PY81	0·24
PY82	0·23
PY83	0·26
PY88	0·31
PY301	0·65
PY800	0·31
PY801	0·31
PZ30	0·48
QP21	0·50
QQV03/10	1·20
QS75/20	0·63
QS95/10	·49
QS150/15	0·63
QV04/7	0·63
R11	0·98
R16	1·75
R17	0·88
R18	0·50
R19	0·28
R20	0·60
R52	0·33
RK34	0·38
SP13C	0·63
SP61	0·75
TH4B	0·50
TH233	0·98
TP2620	·98
UABC80	·30
UAF42	0·49
UBC41	0·45
UBC81	0·40
UBF80	0·33
UBF89	0·33
UBL21	0·55
UC92	0·35
UCC84	0·33
UCC85	0·33
UCF80	0·31
UCH21	0·60
UCH42	0·57
UCH81	0·29
UCL82	0·30
UCL83	0·54
UF41	0·50
UF42	0·60
UF80	0·35
UF85	0·34
UF86	0·63
UF89	0·27
UL41	0·54
UL84	0·28
UM80	0·33
UR1C	0·55
UU5	0·38
UU9	0·40
UU12	0·20
UY41	0·38
UY85	0·23
U10	0·45
U12/14	·38
U16	0·75
U17	0·85
U18/20	0·75
U19	1·73
U22	0·39
U25	0·65
U26	0·60
U31	0·30
U33	1·50
U35	0·83
U37	1·75
U45	0·78
U47	0·65
U49	0·60
U50	0·30
U76	0·24
U78	0·20
U153	0·24
U191	0·65
U192	0·23
U193	0·31
U251	0·62
U281	0·40
U282	0·40
U291	0·50
U301	0·40
U329	0·62
U381	0·23
U403	0·33
U404	0·38
U801	0·76
U4020	0·55
VP2	0·53
VP13C	0·35
VP23	0·40
VP41	0·38
VT61A	0·35
VT501	0·15
VU111	0·44
VU120	0·60
VU120A	·60
VU133	0·35
W76	0·34
W81M	0·68
W107	0·50
W729	0·60
XE5	5·00
XFY12	0·48
XH1-5	0·48
X41	0·50
X61	0·50
X65	0·50
X66	0·50
Z329	0·61
Z729	0·27
Z749	0·65
Transistors and Diodes	
1N1124A	·58
1N4952	0·55
2N404	0·20
2N966	0·58
2N1756	0·55
2N2147	0·94
2N2297	0·25
2N2369A	·24
2N2613	0·43
2N3053	0·36
2N3121	2·75
2N3703	0·21
2N3709	0·22
2N3866	1·10
2N3988	0·55
2S323	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
ADT140	·69
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	0·28
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
BC113	0·28
BC115	0·17
BC116	0·28
BC118	0·25
BCZ11	0·42
BF154	0·28
BF158	0·32
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
GET116	·44
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	·48
OA5	0·31
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
OC35	0·35
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
OC202	0·47
OC203	0·33
OC204	0·33
OC205	0·47
OC206	0·55
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	·10

MATCHED TRANSISTOR SETS
LP15 (AC113, AC154, AC157, AA120). 58p per pack.
1—OC81D and 2—OC81, 47p.
1—OC44 and 2—OC45, 47p.
1—OC82D and 2—OC82, 53p. Set of 3—OC83 72p.
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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CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS. FULLY SHROUDED (*excepted*) TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v.

Type No.	Sec. Volt Taps.	Amps.	Price	Carr.
1A	25-33-40-50	15	£13·00	75p
1B	25-33-40-50	10	£11·00	50p
1C	25-33-40-50	6	£7·75	50p
1D	25-33-40-50	3	£5·75	50p
2A	4-16-24-32	12	£8·75	50p
2B	4-16-24-32	8	£7·60	50p
2C	4-16-24-32	4	£4·75	40p
2D	4-16-24-32	2	£3·20	30p
3A	24-30-36	10	£8·25	60p
3B	24-30-36	5	£6·25	40p
3C	24-30-36	2	£3·25	30p
4A	12-20-24	20	£10·95	75p
4B	12-20-24	10	£6·50	40p
4C	12-20-24	5	£4·35	30p
5A	3-12-18	20	£9·76	50p
5B	3-12-18	10	£6·00	45p
5C	3-12-18	5	£4·10	35p
6A	48-56-60	2	£4·10	35p
6B	48-56-60	1	£3·00	30p
7A	6-12	20	£7·50	50p
7B	6-12	10	£4·10	40p
7C	6-12	5	£2·75	30p
8A	12-24	1	£2·10	25p
9A	17-32	8	£7·00	45p
10A	9-15	2	£2·10	25p
11A	6·3	15	£4·10	30p

Note: By using the intermediate taps many other voltages can be obtained.
Example: No. 1 .. 7-8-10-15-17-25-33-40-50v.
No. 2 .. 4-8-12-16-20-24-32v.
No. 5 .. 3-6-9-12-15-18v.

30-25-0-25-30v. 2a. with Screen **£4·30**, carr. 35p. 36-0-36v. 5a. **£9·40** carr. 50p. As recommended for Linsley Hood Amplifiers.

HEAVY DUTY UNSHROUDED TYPE 9 INCH FLYING LEADS ALL PRIMARIES 240v.

Type No.	Sec. Volt Tap.	Amps.	Price	Carr.
1	24-30-36	20	£14·00	75p
2	12-20-24	30	£13·00	75p
3	3-12-18	30	£13·00	75p
4	6-12	50	£14·00	75p
5	20	30	£12·00	75p

DAVENSET ISOLATION TRANSFORMERS
Pri. 10-0-200-220-240v. Sec. 240v. Centre tapped 1·2kva. Conservatively rated. Size 8½ x 7 x 8¾ ins. Wgt. 59 lbs. Open frame type, terminal connections. Fraction of maker's price. **£17·00** carr. £1·00.

H.T. TRANSFORMERS BY FAMOUS MANUFACTURERS

PARMEKO. All primaries 220-240v. Type 1. Sec. 630-0-620v. 105m/a 5v. 4A. 5v. 2A. Potted type **£3·00.** Carr. 50p. Type 2. Sec. 1,875v. 60m/a. 4·2kv. wkg. and 500v. 31m/a. Potted type **£3·50.** Carr. 50p. Type 3. Sec. 310-0-310v. 35m/a and 200-0-200v. 20m/a. 6·3v. 1A. 6·3v. 1A. Potted type **£2·75.** P.P. 50p. Type 4. Sec. tapped 760-700v. 50m/a. 6·3v. 1·5a. **£1·75.** P.P. 30p.

WODEN. All primaries 220-240v. Type 1. Sec. 890-710-0-710-890v. 120m/a. unshrouded table top connections, tropicalised **£2·50.** P.P. 50p. Type 2. Sec. 190v. 60m/a. 6·3v. 3a. **£1·25.** P.P 25p. Type 3. Sec. tapped 150-165v. 4 amps unshrouded table top connections **£3·75.** P.P. 75p. Type 4. Sec. 130v. 450m/a. three times. "C" core, table top connections **£3·50.** P.P. 50p. Type 5. 63v. 1·6a. and 24v. 0·8a. and 6·3v. 1a. unshrouded table top connections **£2·50.** Carr. 50p.

GARDNERS. All primaries 220-240v. Type 1. 350-0-350v. 60m/a. 6·3v. 4a. 5v. 2·5a. shrouded **£1·50.** P.P. 30p. Type 2. 300-0-300v. 60m/a. 6·3v. 4a. "C" core. **£1·50.** P.P. 30p. Type 3. 450-400-350-0-350-400-450v. 50m/a. "C" core **£1·25.** P.P. 25p. Type 4. 250-0-250v. 100m/a. 6·3v. 3a. 6·3v. 3a. 5v. 3a.. Potted type **£2·50.** P.P. 50p. Type 5. 350v. 44m/a. 20v. 10m/a. 6·3v. 3a. "C" core **£1·50.** P.P. 30p.

L.T. TRANSFORMERS
WODEN Pri. 220-230-240-250v. Sec. 25v. 2a. Twice, 16v. 4a. twice, 26v. 4a., 31v. 7a. All separate windings. Conservatively rated. Open frame type table top connections. Size 6½ × 6 × 6in. **£8·50,** carr. 50p.
AMOS 'C' core type. Pri. 200-220-240v. Sec. 18-0-18v. 5a., and 18-0-18v. 3a. Conservatively rated table top connections. **£3·50** P.P. 50p.
REDCLIFFE 'C' core types. Pri. 220-240v. Sec. 11v. 9a. **£2·50** P.P. 35p. Pri. 220-240v. Sec. 36v. 350 m/a. **75p** P.P. 25p. Pri. 220-240v. Sec. tapped 370-390-400v. 6 m/a. **50p** P.P. 20p.

G.E.C. L.T. TRANSFORMERS
All Primaries 220-240v. Type 1 tapped. 63-68-74v. 3a. and 6·3v. 4a. terminal block connections. Unshrouded **£3·00.** P.P. 50p. Type 2 tapped. 59-61-65-67-69v. 10a. T blocks connections. Unshrouded **£6·00** carr. 75p. Type 3 tapped. 56-58-60v. 3a. T block connections. **£2·95.** P.P. 50p. Type 4 100-0-100v. 65m/a. and 61-64-67v. 150m/a. and 6v. 1a. **£1·75.** P.P. 25p. Type 5 tapped. 11·5-13·5v. 14a. and 13·5v. 1·4a. twice. Unshrouded, T block connections. **£4·50** carr. 75p. Type 6 10v. 2a. and 50v. 0·6a. T block connections. Unshrouded. **£1·50** carr. 25p. Type 7 15v. 4a. and 13v. 6a. T block connections. Unshrouded. **£3** carr. 50p. Type 8 17v. 2a. twice, unshrouded. **£1·75.** P.P. 30p.

AMOS 'C' CORE TRANSFORMERS
Pri. 220-240v. Sec. 53·6v. 6a. **£3·75.** P.P. 50p. Pri. 240v. 17·5v. 6a. **£2·25.** P.P. 35p.

CRESHAM POTTED OIL-FILLED CHOKES
9 henries 500m/a. 5kv. wkg. **£7·50** carr. £1·50.

AMOS L.T. CHOKES
'C' core type. 140m/h. 5 amps. **£4·50** carr. 50p.

G.E.C. LT TRANSFORMERS
Pri. 200-220-240v. Three separate Secs. 27v. 9A., 9v. 9A., 3v. 9A. The following voltages can be obtained: 3-9-12-27-30-36-39v. 9A. Open frame. Fully tropicalised. Table top connections. **£4·50** carr. 50p. As above at 1·8A. conservatively rated **£1·35.** P.P. 35p.

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PARMEKO. Pri. 240v. Sec. 250-0-250v. 50 m/a. 6·3v. 1a. **£1·25.** P.P. 35p., size 4 × 3 × 2½ ins.
GARDNERS. 'C' core. Pri. 240v. Sec. 300-0-300v. 66 m/a. 6·3v. 4a. **£1·50.** P.P. 35p.
A.C.I. Pri. 240v. Sec. 250v. 60 m/a. 15v. 1·2a. 6·3v. 4·5a. **£1·25.** P.P. 35p., open type table top connections. Size 4 × 3¼ × 3 ins.

PARMEKO POTTED TRANSFORMERS BRAND NEW. FRACTION OF MAKER'S PRICE
Type 1: Pri. 110-230-250v. Sec. 24v. 1a. 12·6v. 0·7a. 6·3v. 0·5a. **£1·75.** P.P. 35p. Type 2: Pri. 110-220-240v. Sec. 13·5v. 6·5a. **£2·50.** P.P. 40p. Type 3: Pri. 230v. Sec. 4·2v. 1 amp. **75p.** P.P. 25p. Type 4: Pri. 110-220-240v. Sec. 29·7v. 5a. 23v. 500m/a. 180v. 100m/a. 78v. 60m/a. **£4·50** carr. 75p. Type 5: Pri. 200-220-240v. Sec. 140v. 195m/a. 50v. 1a. 6·3v. CT 1·25a. **£2·00.** P.P. 40p. Type 6: Pri. 110-220-240v. Sec. 230v. 200m/a. 6·3v. 7a. **£2·50** carr. 50p. Type 7: Pri. 115-230v. Sec. 9-10v. 0·42a. 6·3v. 3·5a. 6·3v. 1·2a. **£1·50.** P.P. 35p. Type 8: Pri. 110-220-240v. Sec. 660-680-700-720-740-760v. 50m/a. 6·3v. 1·5a. **£2·00.** P.P. 35p.
115v. Pri. only
Type 1: Sec. 3700-0-3700v. 44m/a. **£4·50** carr. £1. Type 2: Sec. 6·3v. 11a. 1·4kv. wkg. 4v. 13a. 7kv. wkg. **£2·50** carr. 50p. Type 3: 530-0-530v. 330m/a. 6·5v. 6a. **£4·50** carr. £1. Type 4: 6·3v. 4a. 6·3v. 0·9a. 6·3v. 0·6a. **75p.** P.P. 25p.
LINE O.P. TRANSFORMERS
Input 10KΩ 50m/a. d.c. Eight 600Ω outputs P/S turns ratio 11·5/1 + or — 3 DB. 20 c/s-3500 c/s. **£3·50.** P.P. 50p.

SPECIAL OFFER OF MULTI TAPPED L.T. TRANSFORMERS VERY CONSERVATIVELY RATED

Gresham Pri. 200-220-240v. Sec. 29·5v. 2·6a. twice. 20v. 5a. twice. 15v. 0·1a. four times. 'C' Core. Table top connections **£6·95** carr. 75p.

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Pri. 200-220-240v. Sec. tapped 63-68-74v. 3a. and 6v. 4a. Open frame terminal block connections **£3·00** carr. 50p.

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PARMEKO HT TRANSFORMERS NEPTUNE OIL-FILLED TYPE. Pri. 230v. Sec. 350-0-0350v. 200 m/a, 6·4v. 6ar 5v. 3a. Size 5¼ × 4½ × 4 ins. **£3·00** car., 50p.

RICH AND BUNDY TRANSFORMERS
Pri. 220-380-415-440v. Sec. 250v. 50 watts conservatively rated. Open frame type. Terminal block connections. **£2·95** carr. 35p.

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4mfd. 4·5kv. D.C. wkg. **£3·00** carr. 75p. 0·5mfd. 10kv. D.C. wkg. **£2·50.** P.P. 50p. 4mfd. 1250v. D.C. wkg. **50p.** P.P. 20p. 4mfd. 2kv. wkg. **75p.** P.P. 20p. 1mfd. 5kv. D.C. wkg. **£1·00.** P.P. 25p. 8mfd. 200v. D.C. wkg. Three for **75p.** P.P. 25p. 8mfd. 750v. D.C. wkg. **50p.** P.P. 20p. 6mfd. 750v. D.C. wkg. **40p.** P.P. 20p. 4mfd. 500v. D.C. wkg. **30p.** P.P. 10p. 1mfd. 2500v. D.C. wkg. **40p.** P.P. 10p. 0·5mfd. 500v. D.C. wkg. Six for **50p.** P.P. 25p.

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Primary 200-250 Volts Secondary 240 Volts Centre Tapped (120V) and Earth Shielded
ALSO AVAILABLE WITH 115/120V SECONDARY WINDING

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	£	P & P p
07	20	1	11	7·0 × 6·0 × 6·5	1·77	30
100	60	3	8	8·9 × 8·0 × 7·7	2 62	36
61	100	5	12	10·2 × 8·9 × 8·3	2·88	52
30	200	9	8	12·0 × 10·3 × 10·0	4·83	52
62	250	12	4	9·5 × 12·7 × 11·4	6·38	67
55	350	15	0	14·0 × 10·8 × 12·4	8·55	82
63	500	27	0	17·1 × 11·4 × 15·9	12·32	*
92	1000	40	0	17·8 × 17·1 × 21·6	22·70	*
128	2000	63	0	24·1 × 21·6 × 15·2	37·50	*
129	3000	84	0	21·6 × 21·6 × 20·3	58·67	*
190	6000	178	0	31·1 × 35·6 × 17·1	96·27	*

440V 300VA ISOLATOR, Primary 440V Secondary 240V, Centre Tapped Screened and Shrouded, £10·37. P & P 67p.

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	£	P & P p
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	0·93	22
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·82	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	2·20	36
66	300	6	0	10·2 × 10·2 × 9·5	" "	4·28	52
67	500	12	8	14·0 × 10·2 × 11·4	" "	6·35	67
84	1000	16	0	11·4 × 14·0 × 14·0	" "	11·54	82
93	1500	28	9	13·5 × 14·9 × 16·5	" "	16·72	*
95	2000	40	0	17·8 × 16·5 × 21·6	" "	21·82	*
73	3000	45	8	17·4 × 18·1 × 21·3	" "	29·70	*

TOTALLY ENCLOSED 115V AUTO TRANSFORMERS

115V 500 Watt totally enclosed auto transformer, complete with mains lead and two 115V outlet sockets, £8·63. P & P 67p
Also available a 20 Watt version. £1·84. P & P 22p.

LOW VOLTAGE SERIES (ISOLATED)
PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	24V	Weight lb	oz	Size cm.	Secondary Windings	£	P & P p
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	0·93	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	1·11	22
71	2	1	1	9	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·46	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	2·04	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	2·46	42
108	8	4	5	4	10·0 × 8·3 × 8·2	0-12V at 4A × 2	2·73	52
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	3·23	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	4·99	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	6·35	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	11·73	82
226	60	30	34	0	17·0 × 14·5 × 12·5	0-12V at 30A × 2	21·57	*

30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz.	Size cm.	Secondary Taps	£	P & P p
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-20-24-30V	1·11	22
79	1·0	2	0	7·0 × 6·4 × 6·0	" "	1·48	36
3	2·0	3	2	8·9 × 7·0 × 7·6	" "	2·21	36
20	3·0	4	6	10·2 × 8·9 × 8·6	" "	2·72	42
21	4·0	6	0	10·2 × 10·0 × 8·6	" "	3·23	52
51	5·0	6	8	12·1 × 10·0 × 8·6	" "	4·02	52
117	6·0	7	8	12·1 × 10·0 × 10·2	" "	4·80	52
88	8·0	10	0	14·0 × 11·7 × 10·0	" "	6·20	67
89	10·0	12	2	14·0 × 10·2 × 11·4	" "	7·85	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P p
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·46	30
103	1·0	2	10	8·3 × 7·3 × 7·0	" "	2·13	36
104	2·0	5	0	10·2 × 8·9 × 8·6	" "	2·96	42
105	3·0	6	0	10·2 × 10·2 × 8·3	" "	4·01	52
106	4·0	9	4	12·1 × 11·4 × 10·2	" "	5·31	52
107	6·0	12	4	12·1 × 11·1 × 13·3	" "	7.85	67
118	8·0	18	9	13·3 × 13·3 × 12·1	" "	10·25	97
119	10·0	19	12	16·5 × 11·4 × 15·9	" "	12·85	97

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Taps	£	P & P p
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·48	36
126	1·0	3	0	8·9 × 7·6 × 7·6	" "	2·06	36
127	2·0	5	6	10·2 × 8·9 × 8·6	" "	3·23	42
125	3·0	8	8	11·9 × 9·5 × 10·0	" "	4·92	52
123	4·0	10	6	11·4 × 9·5 × 11·4	" "	6·35	67
120	6·0	16	12	13·3 × 12·1 × 12·1	" "	9·20	82
122	10·0	23	2	16·5 × 12·7 × 16·5	" "	15·23	*

EQUIPMENT TRANSFORMER

REF 238 PRI 0240 SCREEN SEC 3·0 3V RMS at 200mA SIZE CM 2·8 x 2·6 x 2·0 WEIGHT 2oz £1·08 P & P 10p.

LEAD ACID BATTERY CHARGER TYPES
PRIMARY 200-250 VOLT FOR CHARGING 6 OR 12 VOLT BATTERIES

Ref. No.	Amps.	Weight lb	oz	Size cm.		£	P & P p
45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifier.	1·47	30
5	4·0	3	11	10·2 × 7·0 × 8·3		2·23	42
86	6·0	5	12	10·2 × 8·9 × 8·3		3·37	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·84	52
50	12·5	11	14	13·3 × 10·8 × 12·1		5·72	67

All ratings are continuous. Standard construction: open with solder tags and wax impregnation. Enclosed styles to order.

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BC107/108/109 **10p** each

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AD 161/162 **60p** pair with mica and bushes

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VALVES

AZ31 0·55	DY802 0·37	ECF82 0·40	EF98 0·75	EZ80 0·28	OA2 0·40	PD500 1·30	PY82 0·35	UCH42 0·70	1T4 0·30	6BR7 0·90	6U5G 1·00	12BH7 0·50	80 0·60
AZ41 0·60	EABC80 0·38	ECH35 1·00	EF183 0·30	EZ81 0·29	OB2 0·49	PEN45DD 0·75	PY83 0·38	UCH81 0·40	3S4 0·40	6BW6 0·90	6V6GT 0·45	30C15 1·00	807 0·50
CBL31 1·00	EAF42 0·60	ECH42 0·75	EF184 0·35	EZ90 0·40	OZ4 0·45	PFL200 0·65	PY500 1·00	UCL82 0·35	3V4 0·48	6BW7 0·90	6X4 0·40	30C17 1·10	6080 1·75
CL33 1·50	EAF801 0·50	ECH81 0·30	EH90 0·50	GY501 0·80	PC86 0·60	PL36 0·55	PY800 0·47	UCL83 0·65	5R4GY 0·75	6C4 0·35	6X5GT 0·45	30C18 0·90	6146 1·60
CY31 0·50	EBC33 0·60	ECH83 0·45	EL33 1·75	GZ30 0·45	PC88 0·60	PL38 2·25	PY801 0·50	UF41 0·65	5U4G 0·40	6CD6G 1·30	7B6 0·75	30F5 1·00	TUBES
DAF91 0·30	EBC41 0·65	ECH84 0·45	EL34 0·50	GZ32 0·50	PC900 0·48	PL81 0·50	SP41 3·00	UF89 0·40	5V4G 0·50	6CH6 0·60	7B7 0·70	30FL1 0·80	2AP1 4·00
DAF96 0·50	EBC81 0·33	ECL80 0·50	EL37 2·05	GZ34 0·60	PCC84 0·40	PL82 0·45	SP61 0·75	UL41 0·65	5Y3GT 0·45	6E5 1·00	7C5 1·13	30FL14 0·[illegible]	3BP1 3·50
DCC90 1·35	EBF80 0·40	ECL82 0·35	EL41 0·75	H63 0·90	PCC89 0·50	PL83 0·45	T41 1·00	UL84 0·43	5Z4G 0·45	6F23 0·90	7C6 0·75	30L15 0·95	3DP1A 3·50
DF91 0·30	EBF83 0·40	ECL86 0·40	EL42 0·65	HL41DD 0·70	PCC189 0·60	PL84 0·40	U25 0·85	UY41 0·48	6/30L2 0·90	6J5GT 0·40	7H7 0·70	30L17 0·95	3EG1 10·00
DF96 0·50	EBF89 0·32	ECLL800 2·25	EL84 0·25	HN309 1·50	PCF80 0·30	PL500 0·80	U26 0·85	UY85 0·40	6AL5 0·22	6J7GT 0·45	7S7 2·25	30P12 1·00	3FP7 1·50
DK91 0·45	EBL31 1·50	EF37A 1·20	EL91 0·40	KT61 1·75	PCF86 0·60	PL504 0·80	U191 0·75	VP4B 1·25	6AQ5 0·42	6K6GT 0·75	7Y4 0·75	30P19 0·95	3GP1 3·50
DK92 0·70	ECC40 1·00	EF39 0·60	EL95 0·35	KT66 2·35	PCF801 0·50	PL508 0·90	U404 0·70	VR75/30 0·48	6AS7 0·85	6K7GT 0·35	12AC6 0·60	30PL1 0·95	5BP1 4·00
DK96 0·60	ECC81 0·40	EF41 0·65	EL360 1·20	KT81 (7C5) 1·13	PCF802 0·50	PL509 1·60	U801 1·18	VR105/30 0·40	6AT6 0·38	6K8GT 0·50	12AD6 0·60	30PL13 1·10	5CP1 5·00
DL92 0·40	ECC82 0·33	EF52 1·25	ELL80 1·00	KT88 2·25	PCF805 0·90	PL801 1·00	UABC80 0·40	VR150/30 0·40	6AU6 0·30	6P25 1·75	12AE6 0·60	30PL14 1·25	5FP7 3·00
DL94 0·48	ECC83 0·33	EF80 0·25	EM80 0·45	KTW61 1·00	PCF806 0·75	PL802 0·95	UAF42 0·55	Y63 1·25	6AV6 0·40	6Q7GT 0·43	12AT6 0·40	35L6GT 0·75	88D 10·00
DL96 0·55	ECC85 0·40	EF85 0·35	EM81 0·60	KTW62 1·00	PCF808 0·90	PY32 0·63	UBC41 0·55	1R5 0·45	6BA6 0·28	6SG7M 0·45	12AT7 0·40	35W4 0·40	CV429 22·00
DM70 0·60	ECC88 0·40	EF86 0·30	EM84 0·35	N78 1·60	PCL82 0·35	PY33 0·63	UBF80 0·40	1S5 0·30	6BE6 0·32	6SJ7GT 0·30	12AU6 0·45	35Z3 0·75	CV960 8·00
DY86 0·35	ECF80 0·35	EF89 0·28	EY51 0·40		PCL83 0·65	PY81 0·30	UBF89 0·40		6BH6 0·75	6SL7GT 0·45	12AU7 0·33	35Z4GT 0·70	DG7-5 8·00
DY87 0·36		EF91 0·37	EY86 0·40		PCL84 0·45		UCC85 0·45		6BJ6 0·55	6SN7GT 0·45	12AX7 0·33	50C5 0·60	DG7-6 10·00
		EF92 0·40	EZ40 0·50		PCL85 0·50				6BQ7A 0·55	6U4GT 0·70	12BA6 0·45	50CD6G 1·20	VCR138 8·00
			EZ41 0·75		PCL86 0·45						12BE6 0·50		

TRANSISTORS

1N21 0·17	2N708 0·15	2N3709 0·10	AF116 0·25	BF195 0·15	CRS3/40 0·50	GJ7M 0·37	NKT128 0·35	NKT403 0·75	OA95 0·07	OC26 0·25	OC71 0·12	OC84 0·25	ORP60 0·40
1N23 0·20	2N1302 0·18	2N3710 0·10	AF117 0·25	BF196 0·15	CS10B 3·13	KS100A 0·20	NKT211 0·25	NKT404 0·55	OA200 0·07	OC28 0·60	OC72 0·20	OC123 0·65	ORP61 0·42
1N4001 0·07	2N1303 0·18	2N3711 0·10	AF139 0·30	BF197 0·15	CV102 0·18	MAT101 0·30	NKT213 0·25	NKT713 0·25	OA202 0·10	OC29 0·60	OC73 0·30	OC139 0·25	SX640 0·50
1N4002 0·08	2N1304 0·22	2N3819 0·35	AFZ12 1·00	BFS61 0·28	CV103 0·18	MAT120 1·25	NKT214 0·15	OA5 0·20	OA210 0·25	OC30 0·40	OC74 0·30	OC140 0·35	SX642 0·60
1N4003 0·10	2N1305 0·22	2N4286 0·15	BC107 0·10	BFS98 0·28	CV253 1·00	MAT121 0·30	NKT216 0·37	OA6 0·12	OA211 0·20	OC35 0·50	OC75 0·25	OC141 0·60	SX643 0·70
1N4004 0·10	2N1306 0·25	2N4289 0·15	BC108 0·10	BFY50 0·22	CV2154 1·63	MJE370 0·97	NKT217 0·35	OA7 0·15	OAZ202 0·42	OC36 0·60	OC76 0·25	OC169 0·20	ZS21 0·15
1N4006 0·15	2N1307 0·25	AC126 0·20	BC109 0·10	BFY51 0·20	CV2155 1·63	MJE520 0·87	NKT218 1·13	OA9 0·10	OAZ210 0·32	OC41 0·25	OC77 0·40	OC170 0·25	ZS22 0·45
1S111 0·13	2N2147 0·75	AC127 0·25	BC115 0·20	BFY52 0·22	CV7108 4·00	MJE2955 1·37	NKT301 0·04	OA10 0·25	OAZ211 0·32	OC42 0·30	OC78 0·20	OC171 0·30	ZS170 0·10
1S131 0·13	2N2218 0·20	AC128 0·20	BC116 0·25	BTY79/100B 0·75	CV7109 3·75	MJE3055 0·87	NKT304 0·75	OA47 0·10	OAZ242 0·23	OC43 0·40	OC78D 0·20	OC200 0·40	ZS178 0·40
1S132 0·13	2N2444 1·91	AC176 0·20	BC117 0·50	BY100 0·15	DD000 0·15	MPF102 0·42	NKT401 0·87	OA70 0·10	OAZ244 0·22	OC44 0·17	OC79 0·22	OC201 0·70	ZS271 0·18
2G220 0·63	2N2646 0·45	AC187 0·25	BC169C 0·15	BY126 0·15	DD006 0·18	MPF103 0·35		OA71 0·10	OAZ246 0·23	OC44M 0·17	OC81 0·20	OC202 0·80	ZT21 0·25
2G301 0·20	2N2926 0·10	AC188 0·25	BCY34 0·30	BY127 0·17	GET102 0·30	MPF104 0·37		OA79 0·10	OC16 0·50	OC45 0·12	OC81D 0·20	OC203 0·40	ZTX107 0·15
2G302 0·22	2N3702 0·10	ACY17 0·30	BD121 0·65	BYZ88C series 0·15	GET103 0·22			OA81 0·08	OC16T 0·38	OC45M 0·18	OC81M 0·20	OC204 0·40	ZTX108 0·12
2N696 0·15	2N3703 0·10	AD140 0·50	BD123 0·80	CRS1/05 0·25	GET116 0·50			OA85 0·12	OC19 0·37	OC46 0·27	OC81DM 0·18	OC205 0·75	ZTX300 0·12
2N697 0·15	2N3704 0·12	AD149 0·50	BF115 0·25	CRS1/40 0·47	GET875 0·25			OA86 0·15	OC20 0·85	OC57 0·60	OC81Z 0·40	OC206 0·90	ZTX304 0·25
2N706 0·10	2N3705 0·10	AD161 0·37	BF173 0·25		GEX66 1·25			OA90 0·08	OC22 0·50	OC58 0·60	OC82 0·25	OC207 0·90	ZTX500 0·16
2N706A 0·12	2N3707 0·12	AD162 0·37	BF180 0·35		GEX541 0·75			OA91 0·07	OC23 0·60	OC59 0·65	OC82D 0·20	OCP70 0·42	ZTX503 0·17
		AF114 0·25	BF181 0·35						OC24 0·60	OC66 0·50	OC83 0·25	OCP71 0·97	ZTX531 0·25
		AF115 0·25	BF194 0·17						OC25 0·37	OC70 0·12		ORP12 0·50	

VALVES

1B3GT	3B28	5Z3	12E1	815	5726/6AL5W	6923	CV28	CV404	CV2325	CV4043	E180F	GXU2	ME1403	QS108/45
1B24	3B29	5Z4G	12E14	828	5727/2D21W	6939	CV31	CV415	CV2361	CV4044	E181CC	GXU3	ME1404	QS150/15
1B35A	3C22	6AF4A	13D1	829B	5749	7193	CV45	CV416	CV2466	CV4046	E182CC	GXU4	ME1500	QS150/30
1B63A	3C23	6AK5	13E1	830B	5750	7203	CV53	CV417	CV2516	CV4048	E186F	GXU50	ME1501	QS150/36
1N21	3C24/24G	6AM5	28D7	860	5751	7360	CV73	CV428	CV2519	CV4053	E188CC	KT66	OA2	QS150/40
1N21B	3C45	6AM6	29C1	866	5802	7586	CV74	CV434	CV2520	CV4056	EA50	KT67	OA3	QS150/45
1N23B	3CX100A5	6AN5	53KU	866A	5814	8013	CV85	CV447	CV2522	CV4059	EA52	KT88	OA4G	QS150/80
1N23CR	3E29	6AN8	75B1	866E	5823	8025A	CV118	CV449	CV2721	CV4060	EA76	M8079	OB2	QS1200
1X2A	3J/121E	6AR5	75C1	827A	5840	9001	CV124	CV466	CV2901	CV4062	ECC35	M8080	OB3	QS1202
1X2B	3J/160E	6AS6	83A1	881R	5963	9002	CV128	CV469	CV3523	CV4063	ECF804	M8081	OD3	QS1203
2A3	3J/170E	6AU4GTA	85A1	891R	5965	9003	CV131	CV488	CV3929	CV4064	EF50	M8082	OG3	QS1205
2AS15	3Q/150E	6AU5GT	85A2	954	6005/6AQ5W	9004	CV132	CV491	CV3986	CV4079	EF54	M8083	OZ4	QU37
2C26A	3Q/195E	6AU6	90AG	955	6021	9005	CV133	CV492	CV3988	CV4501	EF55	M8091	OZ4A	QV03-12
2C34	3S4	6AV5GTA	90AV	956	6057	9006	CV135	CV493	CV3991	CV4502	EF804	M8096	OT15	QV04-7
2C39A	3V/340B	6AW8A	90C1	957	6058	13201A	CV136	CV717	CV3998	CV4503	EFP60	M8097	QA2400	QV05-25
2C43	3V/390A	6AX5GT	90CG	1625	6059	A1834	CV137	CV808	CV4001	CV4504	EL91	M8098	QA2403	QV06-20
2D21	3V/390B	6B4G	90CV	2050	6060	A2087	CV138	CV1072	CV4002	CV4507	EN30	M8100	QA2404	QY3-125A
2D21W	4-125A	6BA8A	95A1	2050W	6061	A2134	CV140	CV1076	CV4003	CV4508	EN31	M8136	QA2406	QY4-250A
2E26	4-250A	6BK4	100TH	2051	6062	A2293	CV144	CV1092	CV4004	CV5060	EN32	M8137	QA2407	QY4-400A
2J31	4-400A	6BK7A	150B2	4003A	6063	A2426	CV160	CV1219	CV4005	CV6004	EN91	M8140	QB3/300	R10
2J33	4B32	6BL7GTA	150B3	4212D or E	6064	A2521	CV173	CV1343	CV4006	CV6008	ESU74	M8141	QB3-5-750	R17
2J50	4C35	6BN6	150C1	4242A	6065	A2900	CV187	CV1475	CV4007	CV6045	ESU76	M8142	QB4-1100	R18
2J54	4CX250B	6BR7	150C2	4313C	6067	ACT6	CV188	CV1476	CV4008	DA30	ESU77	M8144	QF41	S11E12
2J56A	4E27	6BS7	150C3	4328A	6072	ACT9	CV190	CV1477	CV4009	DA41	F6057	M8149	QF45	S130
2K25	4J50	6BX7GT	150C4	4687	6073	B1C 1E	CV220	CV1478	CV4010	DA42	F6060	M8157	QQV02-6	S130P
2K26	4J52	6BZ6	250TH	5544	6074	BS90	CV261	CV1794	CV4011	DA100	F6061	M8161	QQV03-10	STV280/40
2K28	4J52A	6CB6	328	5545	6080	BS156	CV273	CV1480	CV4012	DET22	F6063	M8162	QQV03-20	STV280/80
2K45	4J53	6CH6	329	5642	6097C	BT5	CV284	CV1481	CV4013	E55L	FX219	M8163	QQV03-20	SU41
2X2A	4X150A	6CL6	631-P1	5644	6130	BT35	CV286	CV1482	CV4014	E80CC	FX225	M8167	QQV03-20A	SU42
3A/107A	4X150D	6CW4	705A	5651	6136	BT45	CV287	CV1787	CV4015	E80FC	FX227	M8179	QQV04-15	TD03-10
3A/108A	4X250B	6DK6	715A	5670	6189	BT79	CV315	CV1832	CV4016	E80F	G1/371K	M8190	QQV06-40	TT15
3A/108B	5B/251M	6DQ6B	715B	5672	6197	BT83	CV329	CV1833	CV4017	E80L	G120/1B	M8196	QQV06-40A	TT21
3A/109B	5B/252M	6EA8	723A/B	5676	6201	C1C	CV337	CV1835	CV4018	E80T	G150/2B	M8204	QS70/20	TTR31MR
3A/110A	5B/254M	6F33	725A	5687	6202	C1K	CV345	CV1994	CV4019	E81CC	G180/2M	M8212	QS75/20	TZ40
3A/110B	5B/255M	6H6(metal)	801	5696	6203	CAA322	CV354	CV2000	CV4020	E81L	G240/2D	M8214	QS75/40	U17
3A/146J	5B/256M	6K7GT	803	5702	6205	CV5	CV359	CV2131	CV4022	E82CC	G400/1K	M8223	QS75/60	U19
3A/167M	5B/257M	6U8A	805	5718	6360	CV25	CV360	CV2154	CV4023	E83CC	GN4	M8224	QS83/3	U27
3A5	5C22	6V6GT	807	5719	6442	CV26	CV371	CV2155	CV4024	E83F	GT1C	M8225	QS92/10	VLS631
3B/240M	5D21	11E3	808	5725/6AS6W	6463		CV372	CV2160	CV4025	E88CC	GTR120W	M8232	QS95/10	Z300T
3B/241M	5R4GY	11E13	811		6550		CV378	CV2179	CV4028	E90CC	GTR150MS	M8237	QS105/45	Z759
3B24	5U4GB	12AY7	811A		6807		CV391	CV2235	CV4033	E90L	GU18	M8245		Z803U
		12B4A	812A				CV395	CV2237	CV4035	E91H	GU20/21	ME1400		
		12BY7A	813				CV397	CV2238	CV4038	E92CC	GU50	ME1401		
								CV2253	CV4039	E180CC	GXU1			
								CV2289	CV4040					

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7400 .. .. 0·20	7410 .. .. 0·20	7437 .. .. 0·65	7476 .. .. 0·45	74107 .. 0·50	74157 .. 1·80
7401 .. .. 0·20	7411 .. .. 0·23	7438 .. .. 0·65	7480 .. .. 0·80	74110 .. 0·80	74170 .. 4·10
7402 .. .. 0·20	7412 .. .. 0·42	7440 .. .. 0·20	7482 .. .. 0·87	74111 .. 1·95	74174 .. 2·00
7403 .. .. 0·20	7413 .. .. 0·30	7441AN .. 0·75	7483 .. .. 1·00	74118 .. 1·00	74175 .. 1·35
7404 .. .. 0·20	7416 .. .. 0·30	7442 .. .. 0·75	7484 .. .. 0·90	74119 .. 1·90	74176 .. 1·60
7405 .. .. 0·20	7417 .. .. 0·30	7450 .. .. 0·20	7486 .. .. 0·45	74121 .. 0·60	74190 .. 1·95
7406 .. .. 0·30	7420 .. .. 0·20	7451 .. .. 0·20	7490 .. .. 0·75	74122 .. 1·35	74191 .. 1·95
7407 .. .. 0·30	7422 .. .. 0·48	7453 .. .. 0·20	7491AN .. 1·00	74123 .. 2·70	74192 .. 2·00
7408 .. .. 0·20	7423 .. .. 0·48	7454 .. .. 0·20	7492 .. .. 0·75	74141 .. 1·00	74193 .. 2·00
7409 .. .. 0·45	7425 .. .. 0·48	7460 .. .. 0·20	7493 .. .. 0·75	74145 .. 1·50	74194 .. 2·50
	7427 .. .. 0·42	7470 .. .. 0·30	7494 .. .. 0·80	74150 .. 3·35	74195 .. 1·85
	7428 .. .. 0·50	7472 .. .. 0·30	7495 .. .. 0·80	74151 .. 1·10	74196 .. 1·50
	7430 .. .. 0·20	7473 .. .. 0·40	7496 .. .. 1·00	74154 .. 2·00	74197 .. 1·50
	7432 .. .. 0·42	7474 .. .. 0·40	7497 .. .. 6·25	74155 .. 1·55	74198 .. 4·60
	7433 .. .. 0·70	7475 .. .. 0·55	74100 .. 2·50	74156 .. 1·55	74199 .. 4·60

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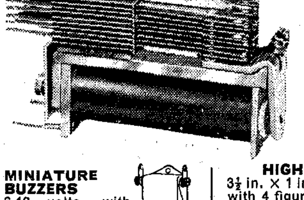

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H30	20	1 Watt Zener Diodes. Mixed Voltages 6.8–43V.	55p
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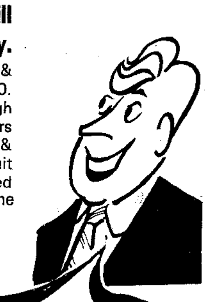

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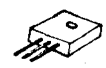

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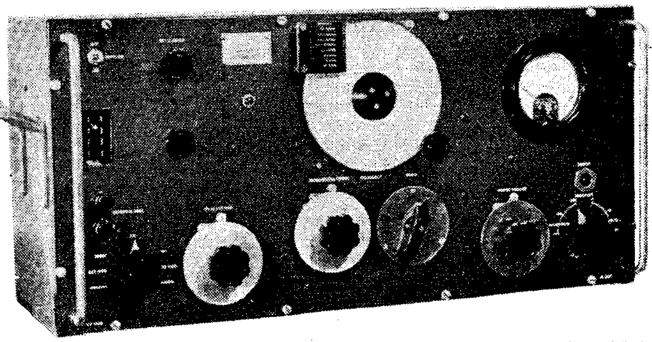

MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: ±1% at 1 Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52·5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements 29 × 12½ × 10 in. Secondhand condition. **£27·50** each, Carr. £1·50.

T.1509 TRANSMITTERS (FOR EXPORT ONLY): General-purpose HF communications transmitter for use in fixed or mobile ground stations. Hand or high-speed keying. Crystal or MO control, with temperature compensated MO circuit.CW, MCW and R/T. Frequency: 1.5 to 20 Mc/s. Modulation: 100% O/put impedance: 50 ohms. Audio input: 600 ohms. Valves: Power Amplifier 2 × 813 and Modulator 2 × 813. Power requirements 200-250 volts a.c., 50 cycles. Power out put 300 watts. Dimensions 2ft. 6in. W. × 2ft. D. × 5ft. H. Weight: 800 lbs. Excellent condition, price **£225.00** each.

AN/ARC-27 TRANSMITTER/RECEIVER (FOR EXPORT ONLY): Frequency 225-400 mc. 1750 channels 100 Kc apart with 18 preset channels. Modulation: am. Power output 9 watts. Receiver is superheterodyne. Max. output 2 watts. Antenna: 50 ohm impedance. Power requirements 24v d.c. Complete transmitter with operating cables, control box, headphones, microphone. Price **£250.00** each secondhand, excellent condition.

POWER SUPPLY suitable for AN/ARC-27: 100 volts to 250 volts a.c. input. 24v d.c. output @ 41 amps fully smoothed. **£45.00** each.

TEST SET TS-147C: Combined signal generator, frequency meter and power meter for 8500-9600 Mc/s. CW or FM signals of known freq. and power or measurement of same. *Signal Generator:* O/put −7 to −85 dbm. Transmission—FM, PM, CW. Sweep Rate—0-6 Mc/s per microsec. Deviation—0-40 Mc/s per sec. Phase Range—3-50 microsec. Pulse Repetition Rate—to 4000 pulses per sec. RF Trigger for Sawtooth Sweep—5-500 watts peak. 0.2-6 microsec. duration, 0.5 microsec pulse rise time. Video Trigger for Sawtooth Sweep—Positive polarity, 10-50V peak. 0.5-20 microsec duration at 10% max. amplitude, less than 0.5 microsec rise time between 90% and 10% max. amplitude points. *Frequency Meter:* Freq. 8470-9360 Mc/s. Accuracy—+2.5 Mc/s per sec. absolute, +1.0 Mc/s per sec. for freq. increments of less than 60 Mc/s relative, ±1.0 Mc/s per sec. a 9310 Mc/s per sec. calibration point. Accuracy measured at 25° C and 60 humidity. *Power Meter:* Input: +7 to +30 dbm. Output −7 to −85 dbm. Price: **£75** each + £1 carr.

SIGNAL GENERATOR TS-403B/U (or URM-61A): (Hewlett Packard). A portable, self-contained, general-purpose test equipment designed for use with radio and radar receivers and for other applications requiring small amounts of RF power such as measuring standing-wave ratios, antenna and transmission line characteristics, conversion gain, etc. Both the output freq. and power are indicated on direct-reading dials. 115V, AC, 50 c/s. Freq.—1800-4000 Mc/s. CW, FM, Modulated Pulse—40-4000 pulses per sec. Pulse Width—0.5-10 microsecs. Timing—Undelayed or delayed from 3-300 microsecs from external or internal pulse. O/put—1 milliwatt max., 0 to −127 db variable. O/put Impedance—50Ω. Price **£120** used, excellent condition. Unused as new condition **£150** + carr. £2.

TS-382/U AUDIO OSCILLATOR: 20 to 200,000 c/s. in four ranges. Freq. meter check 60 c/s. and 400 c/s. Emission CW. O/put voltage: 1 uv to 10V ±3% in seven ranges. Power req. 115V AC single phase. Price **£20** each, used good condition. Unused condition **£30** + carr. £1.50.

FREQUENCY METER BC-221: 125-20,000 Kc/s, complete with original calibration charts. Checked out, working order. **£18·50** + £1·00 carr. BC-221 Unused as new condition complete with headset, spare valves, charts. **£35·00** + £2·00 carr.

TS-452 F.M. SWEEP GENERATOR: Power supply 115V, 50c/s, 5-100MHz in 6 bands (rf o/put); 5-102MHz in 4 bands (freq. meter). Emission: F.M. R.F. Voltage o/put ·25V. Input impedance 470 ohms. O/put impedance 73 ohms. Displays band pass characteristics on 3in. C.R.T. S/hand good condition **£95·00** + £2·00 carr.

TS-419/URM 64 SIGNAL GENERATOR: Freq. 900-2100MHz. CW or pulse emission. Power o/put Zero dbm-120dbm continuously adjustable to ·2uv into 50. O/put impedance 50 ohms with VSWR of 2:1. 115V a.c. 50 c/s. As new condition **£150·00** + £2·00 carr.

TS-622/URM 44 SIGNAL GENERATOR: Freq. range —7 to 11 GHz Power o/put —10 to 127 dbm; Emission CW, FM, Pulse. Direct reading dials for both frequency and power. Operates on 115 volts, 50-1000Hz. As new condition **£175·00** + £2·00 carr.

CT.52 MINIATURE OSCILLOSCOPE: Portable. Operates from 115V or 250V 50-60c/s; or 180V 500c/s. A small compact tropicalised instrument designed to meet requirements of radar and communication engineers and general electronic service. Measures 9 in. × 8 in. × 6½in. Time base 10c/s-40Kc/s. Y plate sensitivity 40V per cm. Tube 2¾in. Frequency compensated amplifier up to 38dB gain. Bandwidth up to 1 Mc/s. Single sweep facilities. Complete with test leads, metal transit case. As new **£27·50** each. Carr. £1.

TRANSFORMER HV: 228V input 19,500–0–19,500 4.5KVA, Wt. 220 lbs. **£30** each. Carr. £4.

TS-683 CRYSTAL IMPEDANCE METER: 10-140MHz secondhand good condition. **£75·00** each + £1·00 carr.

TUNING UNIT: 24V geared motor driving double 25pf double spaced variable capacitor. One m/c relay and 2 other relays. **£2·50** each 30p post, good condition.

UHF ASSEMBLY: (suitable for 1,000MHz conversion) including UHF valves: 2C42, 2C46, 1B40 (complete with associated capacitors and screening), 3 manual counters 0-999. Valves 6AL5 and 8 × 6AK5. **£10·00** plus 60p post, good condition.

MODULATOR UNIT: complete with transformer and 2 × 807 valves mounted in 19 in. chassis × 8 in. high × 8 in. deep. **£4·50** secondhand cond., or **£6·50** new cond. Carriage £1.

RF UNIT: suitable for use with the above unit. Complete with 2 × 3E29 valves. Ideal for conversion to 4 metres. **£5** secondhand cond., or **£7·50** new cond. Carriage £1.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 120 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 × 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19"Wx11"Hx14"D. (All connections at the rear.) Excellent condition **£6·50** each, carr. £1.

AUTO TRANSFORMER: 230-115V, 50-60c/s, 1000 watts, mounted in a strong steel case 5" × 6½" × 7". Bitumen impregnated. **£7** each, Carr. 75p. 230-115V, 50-60c/s, 500 watts. 7" × 5" × 5". Mounted in steel ventilated case. **£4·00** each, Carr. 75p.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7·50** each, 75p carr.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3·50** each, post 50p.

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. **£1·25**, post 30p.

AIRCRAFT SOLENOID UNIT S.P.S.T.: 24V, 200 Amps, **£2** each, 30p post.

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each, 0·9 ohms. Tolerance ± 1% **£3** each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ± 1% **£3·50** each, post 30p.

TF-1041B VALVE VOLTMETER: Measures 25mV to 300V, 20 c/s to 1500 Mc/s a.c. Also 10mV to 1000V d.c. Resistance 0.02 ohms to 500 Meg. ohms. Power requirements 200-250 volts a.c. Secondhand, excellent con. **£35·00**. Carr. £1.

VARIAC TRANSFORMERS: Input 115V, output 0-135V at 2 Amps. **£3** each 75p post. Input 115V, output 135V at 5 Amps. **£5** each, 75p post.

RACK CABINETS: (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high × 21 in. wide × 16 in. deep, with rear door. **£12** each, £2·50 Carr. OR 4 ft. high × 23 in. wide × 19 in. deep, with rear door. **£8·50**, each, £2 Carr.

INSTRUMENT CABINETS: 19"W. × 16"H. × 16"D. **£5·00** + £1·25 carr. 19"W. × 10"D. × 5"H. **£2·50** + £1·00 carr.

FUEL INDICATOR Type 113R: 24V complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in 3in. diameter case. Price **£2** each, 30p post.

TS-418/URM49 SIGNAL GENERATOR: Covers 400-1000MHz range. CW Pulse or AM emission. Power Range 0-120 dbm. **£125** each. Carr. £1·50.

TN/130/APR.9 UHF TUNING UNIT: Freq. 4300-7350MHz. IF Output 160MHz with bandwidth of 20MHz and is electrically tuned by a d.c. reversible motor. **£27·50** each. Carr. £1.

APR-4 AM RADIO RECEIVER: 90-1000MHz. This receiver is suitable for monitoring and measuring frequencies as well as relative signal strength. Power Supply 115V 50c/s. **£100** each. Carr. £2.

SIGNAL GENERATOR TS-497B/URR: (Boonton). Freq. 2-400 Mc/s in 6 bands. Internal Mod. 400 or 1000 c/s per sec. External Mod. 50 to 10,000 c/s per sec. External PM. Percent Mod. 0-30 for sine wave. Am or Pulse Carrier. O/put Voltage 0·1-100,000 microvolts cont. variable. Impedance 50Ω. Price: **£85** each + £1·50 carr.

CLASS "D" WAVEMETER NO. 2: Crystal controlled heterodyne frequency meter covering 2-8MHz. Power supply 6V d.c. Good secondhand cond. **£7·50** each. Post 60p.

RCA TE-149 HETERODYNE WAVEMETER: V-cut, 1MHz crystal (0·005%). Accuracy better than 0·02%. Dial directly calibrated every 1KHz from 2·5-5MHz. Useful harmonics up to 20MHz. Provision for fitting internal dry batteries. "As new" complete with Manual and Spares. **£14** each. Carr. 75p.

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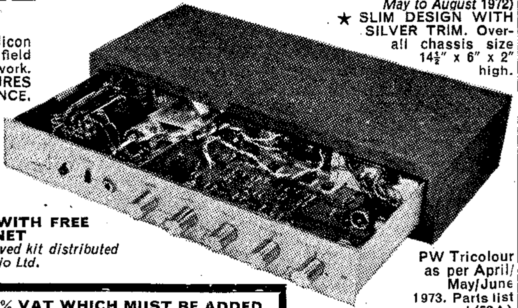

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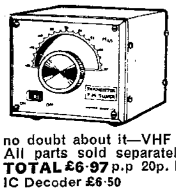

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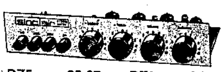

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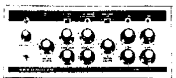

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H8/8A	16µf	16v	4p	H7/13A	200µf	25v	8p
H8/9	20µf	6v	2p	H7/14	220µf	50v	10p
H8/9A	20µf	70v	4p	H7/14A	220µf	16v	6p
H8/10	22µf	50v	4p	H7/15	220µf	25v	5p
H8/10A	22µf	100v	4p	H7/15A	220µf	35v	10p
H8/11	25µf	12v	4p	H6/1A	250µf	4v	3p
H8/11A	24µf	275v	4p	H6/2	250µf	25v	3p
H8/12	32µf	15v	4p	H6/3A	320µf	2·5v	3p
H8/12A	30µf	10v	4p	H6/4	320µf	10v	4p
H8/13A	32µf	50v	4p	H6/4A	330µf	16v	5p
H8/14	40µf	25v	5p	H6/5	330µf	25v	10p
H8/14A	40µf	16v	4p	H6/5A	330µf	35v	15p
H8/15	47µf	50v	4p	H6/7	400µf	15v	5p
H8/15A	40µf	35v	4p	H6/8	470µf	25v	10p
H7/1	50µf	6v	3p	H6/8A	470µf	35v	20p
H7/1A	50µf	10v	4p	H6/9	500µf	15v	4p
H7/2	50µf	50v	4p	H6/9A	400µf	40v	20p
H7/2A	64µf	2·5v	2p	H6/10	750µf	12v	5p
H7/3A	64µf	25v	4p	H6/13A	1000µf	25v	16p
H7/4	64µf	15v	4p	H5/2A	2200µf	16v	15p

MULLARD ELECTROLYTIC CAPACITATORS

071 and 072 Series

Type No.	Working Voltage Vdc.	Capacitance µF	Max. Ripple Current at 50°C	Weight	Price
071 15332	16	3300	2·4 amps	1oz	15p
071 15472	16	4700	3·9 amps	1oz	17p
071 15682	16	6800	5·8 amps	1½oz	22p
071 15103	16	10000	7·9 amps	2½oz	27p
071 18222	63	2200	5·8 amps	3oz	30p
072 15752	16	7500 + 7500	10·5 amps	3oz	37p
072 15113	16	11000 + 11000	13·8 amps	4½oz	49p
071 16222	25	2200	2·2 amps	1oz	15p
071 16472	25	4700	5·4 amps	1½oz	22p
072 16502	25	5000 + 5000	9·6 amps	3½oz	37p
072 16752	25	7500 + 7500	12·6 amps	4½oz	49p
072 17342	40	3400 + 3400	9·1 amps	3½oz	37p
072 17502	40	5000 + 5000	12·0 amps	4½oz	49p
071 18681	63	680	2·1 amps	1oz	15p
072 18172	63	1650 + 1650	7·8 amps	3oz	37p

106 and 107 Series

Type No.	Working Voltage Vdc.	Capacitance µF	Max. Ripple Current at 50°C	Weight	Price
106 15103	16	10000	7 amps	2½oz	65p
106 16223	25	22000	17 amps	10oz	£1·12
106 17103	40	10000	12 amps	7½oz	94p
106 18153	63	15000	28 amps	18oz	£1·79
107 10222	100	2200	10 amps	5½oz	74p

Type No.	Voltage	Capacitance	Weight	Price
102 15163	16	16000	8oz	20p
104 90003	20	39000	16oz	30p
102 16802	25	8000	7oz	25p
104 17562	40	5600	5oz	25p
104 90001	45	20000	16oz	50p
104 18332	63	3300	5oz	25p

A further 10% discount on lots of 100 of any one type.

Please calculate the weight of your order and include appropriate postage.

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2lb	21p	6lb	29p	14lb	47p	22lb	67p

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Output Transistors
- BD 112 .. 25p
- OC 36 .. 50p
- BD 145 .. 25p

Small Signal N.P.N.
- BC 108 .. 10p
- BC 109 .. 10p
- BF 194 .. 10p

Transmitting Types
- BFR 64 .. £1
- BLY 89A .. £5
- BLY 93A .. £9

Microwave Varactor Diodes
- BXY 27/28/32/35/36/37/38/39/40/41 .. £1

Microwave Detector
- CAY 10 .. £5

Microwave Mixer
- CL 7331 .. £20

Microwave Gunn Effect Oscillator
- CL 8370 .. £10
- CL 8380 .. £10
- CL 8390 .. £10
- CL 8470 .. £40

Microwave Tunnel Diodes
- AEY 13 .. £5
- AEY 16 .. £10

R.F. Transistors
- BF 180 .. 20p
- BF 194 .. 10p
- AF 124 .. 20p

Field Effect Transistors
- BFW 12/13/14 .. 25p

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- BFS 18R .. 10p
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- OCP 70 .. 20p

Complementary Drivers, 2 watt (per matched pair)

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- TBA 510 Chrominance I.C. .. £1
- FEQ 101 64bit Memory .. £1
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- 7401 .. 12p
- 7410 .. 12p
- 7420 .. 12p
- 7440 .. 12p
- 7453 .. 12p
- 7470 .. 24p
- 7472 .. 24p
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- 7474 .. 32p
- 7482 .. 88p
- 7483 .. 95p
- 7490 .. 58p
- 7491 .. 78p
- 7492 .. 58p
- 7493 .. 58p
- 7495 .. 68p
- 5400 .. 10p
- 6404 .. 10p

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Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

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Developer and Etchant .. **50p** postage

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- 3¾in × 3¾in × 0·1in .. 25p
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Terminal Pins (0·1 or 0·15) 36 for **22p.**

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500,000 in STOCK!!!

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20p dozen; **75p**-100; **£5**-1,000; **£40**-10,000

·15µf ·18µf ·22µf ·39µf ·68µf

20p dozen; **£1**-100; **£6·50**-1,000; **£50**-10,000

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3p each; **24p** dozen; **£1·75** per 100

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22pf	150pf	680pf
33pf	220pf	1,000pf
39pf	330pf	
47pf	470pf	

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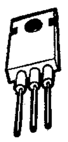
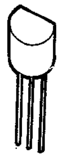
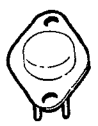
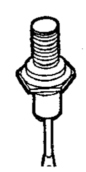

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AC125	25p	BC239	12p	MJE340	50p	OC35	50p	TIP31C	85p	2N2222	20p
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AD149	65p	BD156	75p	MPF104		OC82	25p	ZTX531	27p	2N3055	50p
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AF114	25p	BF195	15p	MPSA06	35p	OC140	30p	1N4001	8p	2N3704	10p
AF115	25p	BFX29	30p	MPSA16	30p	OC170	25p	1N4002	9p	2N3705	10p
AF116	25p	BFX84	25p	MPSA56	35p	OC171	30p	1N4003	9p	2N3706	10p
AF117	25p	BFX85	30p	MPSU06	75p	OC200	50p	1N4004	10p	2N3707	10p
AF118	50p	BFX86	25p	MPSU56	70p	OC201	60p	1N4005	12p	2N3708	10p
AF172	25p	BFX88	25p	NKT135	35p	OC202	65p	1N4006	15p	2N3709	10p
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BC108	10p	BSW68	75p	OA47	10p	TIP36A	£3·35	2N708	15p	2N4058	12p
BC109	10p	BSY95A	12p	OA70	12p	TIP41A	75p	2N930	20p	2N4059	12p
BC147	12p	C111	40p	OA79	12p	TIP42A	90p	2N1132	25p	2N4060	12p
BC148	12p	C426	30p	OA81	10p	TIP29B	58p	2N1302	16p	2N4061	12p
BC149	12p	BY100	15p	OA90	10p	TIP30B	66p	2N1303	16p	2N4062	12p
BC157	13p	BY122	65p	OA91	10p	TIP31B	70p	2N1304	20p	2N4286	15p
BC158	13p	BY126	20p	OA200	10p	TIP32B	82p	2N1305	20p	2N4287	15p
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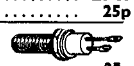

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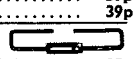

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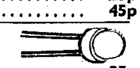

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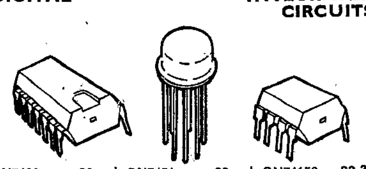

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Price £80.00 per unit
Full Technical and operating data available. Prices and details on request. Mains Power Pack for the above **£12.00 each.**

1 + 1 CARRIER EQUIPMENTS. Cossor Type CC M2A.
Solid state multiplex installations designed for U.H.F. radio systems enabling 2 speech channels each with out of band signalling, if required or the equivalent in telemetry information, to be transmitted simultaneously over a radio system.
Prices and details on request.

V.H.F. RADIOTELEPHONE BASE STATION. Cossor Type CC 603 Transmitter. Simplex or duplex operation, local or remote control with talk through facilities, using double sideband a.m. modulation.
Low-band 71.5-104MHz. or High-band 156-174MHz. versions available.
RF. Output power 25W. into 50 Ohms.
24V. dc. operation. **Prices and details on request**
OPTIONAL POWER SUPPLY Type CC 101 for type CC603 base station P.O.A.

SELECTIVE CALL SYSTEM. Codar Type CC 505/50 (50 way) or CC 505/100 (100 way). The Cossor selective call system may be used with any communication system where a base station is required to call any one or all of a number of sub-stations. Both versions available, all new and in original packing.
Price: 50 way £65 + **v.a.t.**
100 way £80 + **v.a.t.**

DEAC RECHARGEABLE BATTERY CASSETTES 13.4V (nom.) type B/SA 80351/108 Heavy duty encapsulated DEAC supply.
Size 3¼×2¼×1½in. **Price £5** + **v.a.t.**

8-WAY BATTERY CHARGER Type CC 999 Charges up to 8 of the above battery cassettes. **Price £25** + **v.a.t.**

12-WAY BATTERY CHARGER Type CC 999 Charges up to 12 of 13.4V DEAC batteries. Metered battery condition check. **Price £35** + **v.a.t.**

MICROPHONES
S. G. Brown Stick Microphone and Stand. Push-to-talk button. 300Ω. **£5** complete.
S. G. Brown Hand-held with push-to-talk button. **£8** each.

OSCILLOSCOPES

CAWKELL
Revscope S.O.1 Storage Scopes .... from **£100**

COSSOR
CDU.110. Double beam DC—20MHz. Brand new with manual **£300**
CDU.120. Double beam DC—60MHz. Brand new with manual **£450**
CDU.150. Double beam DC—35MHz. Brand new with manual **£400**

SOLARTRON
CD1220. With Wide-Band Plug-in. DC—40MHz. . **£190**
CD1220. With Differential High-gain Plug-in. . . . **£220**

TEKTRONIX
536 X-Y Oscilloscope. DC—11MHz **£300**
545 DC—30MHz **£310**
545A DC—30MHz **£385**
551 Dual Beam. 27MHz **£300**
661 Sampling Scope. 1GHZ 2m V/cm. Dual beam . **£475**
661 Sampling Scope. 3.9 GHz. 2m V/cm. Dual beam **£700**

ELECTRONIC COMPONENTS BARGAIN COMPONENT PACKS

Pack No.

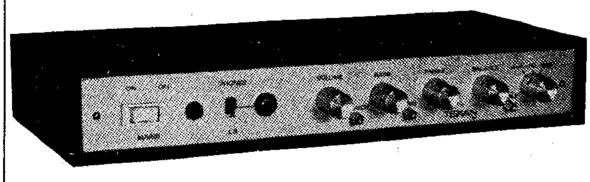
1 500 Carbon resistors, ¼, ½, 1, 2 watt.
2 100 Electrolytic Condensers.
3 250 Ceramic, Polystyrene, Silver Mica, etc., Condensers.
4 250 Polyester, Polycarbonate, Paper, etc., Condensers.
5 25 Potentiometers, assorted.
6 250 High-stab. 1%, 2%, 5% resistors.
7 50 Assorted Tagstrips.
8 1lb Assorted nuts, bolts, washers, spacers, etc.
9 25 Assorted switches, rotary, lever, micro, toggle, etc.
10 50 Preset Potentiometers.
11 Trial mixed component pack **£1.**
12 Jumbo mixed pack **£5.**

ALL COMPONENTS NEW AND UNUSED
£1 + 25p p.p. per pack, **£5** for 5 packs p/free.

COMPONENTS FOR W.W. AMPLIFIER DESIGNS

100W AMPLIFIER (FEB. 1972)	
Designer approved kit.	
Semiconductor set	15·60
Resistors, capacitors, pots	2·50
F/Glass PCB	1·30
POWER SUPPLY (For 100W Amp.)	
Designer approved kit.	
Semiconductors, Resistors, capacitors, pots, transformers, F/Glass PCB	14·70
30W BLOMLEY (New approach to class B)	
Semiconductor set	5·60
Resistors, capacitors, pots	1·85
F/Glass PCB	0·70
30W BAILEY (Single power rail)	
Transistor set	4·60
Resistors, capacitors, pots	1·45
F/Glass PCB	0·65
LINSLEY-HOOD CLASS A (Dec., 1970, circuit)	
Designer approved kit.	
2N3055 pair, BC212L, 2N1711	1·20
Resistors, capacitors, pot	1·80
F/Glass PCB	0·60
LINSLEY-HOOD 20W CLASS AB	
Designer approved kit.	
MJ481/491, MJE521, BC182L, BC212L, zener	3·35
Resistors, capacitors, pots	2·20
F/Glass PCB	0·70
Please state 8Ω or 15Ω	
REGULATED 60V POWER SUPPLY	
A 5 transistor series stabiliser, suitable for a pair of Bailey or Blomley amplifiers, featuring very effective S/C protection. All Semi/C's, R's, C's, F/Glass PCB	4·85
Power supplies for other amplifiers also available	
BAILEY/BURROWS PRE-AMP (Aug., 1971)	
Component Set: Mono	2·75
Component set: Stereo	6·35
Each component set comprises of all specified resistors, capacitors, transistors, pots, including special balance control for stereo sets.	
Stereo F/Glass PCB	1·60
STUART TAPE RECORDER	
Set of stereo f/glass PCBs	2·70
Components sets on price !ist.	

'TEXAN' TEXAS INSTRUMENTS DESIGNED & APPROVED FULL KIT



£28·50 INCLUDES TEAK CASE

20 Watt per channel stereo amplifier designed by Richard Mann of Texas Instruments and published in Practical Wireless May-July 1972.

This low distortion (0.09% at 20W into 8 ohm), wide bandwidth (—3dB 5Hz-35KHz) design is offered as a Texas Instruments approved full kit (including all metalwork and Teak case for a total of **£28.50** post paid. Full details in price list.

METALWORK SYSTEM

Designed to house Bailey, Blomley or Linsley Hood Class AB amplifiers with simple or regulated power supplies and Bailey Burrows pre-amp. Options of standard or hum reducing toroidal mains transformer.

TOROIDAL TRANSFORMER 60 volt 2 amp.

Max. height 2in. Suitable for our regulated power supply	£7.40
Simple clamp	£0.20
Magnetically screening clamp	£0.75

SEMICONDUCTORS

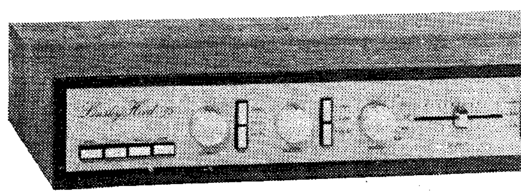
2N699	0·25	BC184L	0·11
2N1613	0·20	BC212L	0·12
2N1711	0·25	BC214L	0·14
2N2926G	0·10	BCY72	0.13
2N3053	0·15	BF257	0·40
2N3055	0·45	BF259	0·47
2N3442	1·20	BFR39	0.25
2N3702	0.11	BFR79	0.25
2N3703	0.10	BFY50	0·20
2N3704	0.10	BFY51	0.20
2N3705	0.10	BFY52	0.20
2N3706	0.09	MJ481	1·20
2N3707	0.10	MJ491	1·30
2N3708	0.07	MJE521	0·60
2N3709	0.09	MPSA05	0·30
2N3710	0.09	MPSA12	0·55
2N3711	0.09	MPSA14	0·35
2N3819	0·23	MPSA55	0·35
2N3904	0·17	MPSA65	0·35
2N3906	0·20	MPSA66	0·40
2N4058	0·12	MPSU05	0·60
2N4062	0·11	MPSU55	0·70
2N4302	0·60	SN72741P	0·58
2N5087	0.42	SN72748P	0·58
2N5210	0.54	THB11	1·10
2N5457	0·30	TIP29A	0·50
2N5830	0·30	TIP30A	0·60
40361	0·40	TIP31A	0·60
40362	0·45	TIP32A	0·70
BC107	0·08	TIP33A	1·00
BC108	0·08	TIP34A	1·50
BC109	0·08	TIP41A	0·74
BC125	0·15	TIP42A	0·90
BC126	0·15	TIP3055	0·60
BC182K	0·10	1B08T20	0·50
BC212K	0·12	1B40K20	1·40
BC182L	0·10	1N914	0·07
		1N916	0·07
		1S44	0·05
		1S920	0·10
		1S3062	0·25
		5B05	1·20

HI-FI NEWS 75 WATT AMPLIFIER

BY J. L. LINSLEY-HOOD

Published Nov. 1972 to Feb. 1973

DESIGNER APPROVED KIT



SLIMLINE STYLE CHASSIS DIMENSIONS: 17.0in. x 2.0in. x 12.0in. *This slimline unit has been made practical by the use of a specially designed TOROIDAL TRANSFORMER and highly compact printed circuit boards which have been fully tested and approved by Mr. Linsley-Hood.*

★ **75 WATTS PER CHANNEL**
★ **BANDWIDTH (3dB) 3HZ-40KHZ**
★ **DISTORTION LESS THAN 0.01%**
★ **UNCONDITIONAL STABILITY**

COMPONENT PACKS

Pack		
1	Fibre glass printed circuit board for power amp.	£0.75
2	Set of resistors, capacitors, pre-sets for power amp.	£1.50
3	Set of semi-conductors for power amp. (highest voltage version)	£5.50
4	Pair of 2 drilled, finned heat sinks	£0.80
5	Fibre glass printed circuit board for pre-amp	£1.10
6	Set of low noise resistors, capacitors, pre-sets for pre-amp	£2.70
7	Set of low noise, high gain semi-conductors for pre-amp	£2.10
8	Set of potentiometers (including mains switch)	£1.55
9	Set of 4 push button switches, rotary mode switch	£3.10
10	Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V. secondaries: 33-0-33 V. 24-0-24 V., electrostatic screen	£9.15
11	Fibre glass printed circuit board for power supply	£0.55
12	Set of resistors, capacitors, secondary fuses, semi-conductors for power supply	£3.50
13	Set of miscellaneous parts including DIN skts., mains input skt. fuse holder, interconnecting cable, control knobs	£3.25
14	Set of metal workparts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£6.30
15	Handbook, based on Hi-Fi News articles	£0.30
16	Teak cabinet	£7.35

2 each of packs 1-7 inclusive are required for complete stereo system.

FREE
TEAK CASE
WITH 75 WATT PER CHANNEL COMPLETE AMPLIFIER KITS

Total cost of individually purchased packs:
£63.95

Cost of complete kit:
£56.60

TRADE ENQUIRIES WELCOME

P.S. Full circuit description in handbook **30p**

FOR FURTHER DETAILS PLEASE WRITE TO:

POWERTRAN ELECTRONICS

PORTWAY INDUSTRIAL ESTATE, ANDOVER : HANTS

MAIL ORDER ONLY POST FREE TO U.K. OVERSEAS AT COST

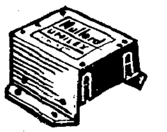
U.K. Orders Subject to 10% V.A.T. Surcharge

Basic Component Set

Set of semi-conductors, resistors, capacitors, printed circuit boards for stereo power amp, pre-amp. and power supply.

£31.35

Handbook Included



MULLARD AMP

Sensational 'Once in a Life-time Offer' Unrepeatable once stocks are cleared. The amplifier is made by Mullard. Carries maker's Guarantee. In neat case. May be used for Mono or Stereo. Music or speech. Works off dry battery, car batt. or mains power pack. FREE—all who purchase we send copy of Mullard booklet DIY stereo. **£1·60**

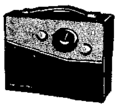
DRILL CONTROLLER

New 1kW model.
Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions **£1·65**, plus 13p post and insurance. Made up model also available **£2·48** plus 13p p. & p

MIGHTY MIDGET

Probably the finest possible radio, as described in Practical Wireless, January 73. All electronic parts **£2·20** post paid.

GOOD COMPANION I.C. VERSION



We can now offer these again in I.C. version using Ferranti ZN414 and Mullard AF Module 1172. Cabinet size approx. 11in. wide × 8in. high × 3in. deep. Complete assembly instructions, **£6·33** plus 25p post and ins. Excellent tone wood cabinet.

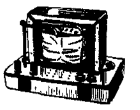
I CHIP RADIO

Ferranti's latest device ZN414—gives results better than superhet. Supplied complete with technical notes and circuits **£1·38** each. 10 for **£11·11**.

HI-Q TUNER COMPONENTS

For experimenting with the ZN414

- Kit No. 1 Plessey Miniature Tuning Condenser with built in LW switch and 3in. Ferrit slab and litz wound MW coil **72p**.
- Kit No. 2 Air spaced tuning condenser 6in. ferrit rod litz wound MW and LW coils **94p**.
- Kit No. 3 Air spaced TC with slow motion drive 8in. ferrit rod with litz wound LW and MW coils **£1·10**.
- Kit No. 4 Permeability tuner with fast and slow motion drive and LW loading coils. **50p**.

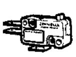


12 VOLT 1½ AMP POWER PACK

This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000 m/f/d smoothing. Price **£2·20**, plus 20p post & packing.

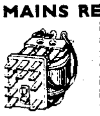
Heavy Duty Mains Power Pack. Output voltage adjustable from 15-40V in steps—maximum load 250W—that is from 6 amp at 40V to 15 amp at 15V. This really is a high power heavy duty unit with dozens of workshop uses. Output voltage adjustment is very quick—simply interchange push on leads. Silicon rectifiers and smoothing by 3,000mF. Price **£6·33** plus 65p post.

MICRO SWITCH



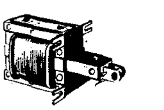
5 amp changeover contacts, **11p** each. 10 for **99p**. 15 amp. S.P Model **15p**, changeover **17p**. each

MAINS RELAY BARGAIN



Special this month are some single, double and treble pole changeover relays. Contacts rated at 15 amps. Operating coil would for 240V. A.C. Good British Make. Unused Size approx. 1½ × 1in. Open construction.
Single pole **28p** each 10 for **£2·48**
Treble pole **39p** each 10 for **£3·47**

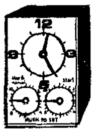
MAINS OPERATED SOLENOIDS



Model 772—small but powerful 1in. pull—approx. size 1½ × 1½ × 1¾in., **66p**.
Model 4001/—⅜in. pull. Size 2¾ × 2 × 1¼in. **83p**.
Model TT1—1½in. pull. Size 3 × 2½ × 2in. **£1·98** plus 20p. post and insurance.

MAINS TRANSISTOR POWER PACK

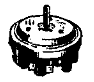
Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only **£1·10** plus 20p postage.



TIME SWITCH

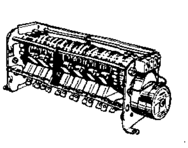
Smith's mains driven clock with 15 amp switch, also notes showing how you can wake up with music playing, kettle boiling or come home to a warm house, warn off burglars, keep pets warm, halve your heating bill, etc. **£2·25**.

PRESSURE SWITCH



Containing a 15 amp. change over switch operated by a diaphragm which in turn is operated by air pressure through a small metal tube. The operating pressure is adjustable but is set to operate in approx. 10in. of water. These are quite low pressure devices and can in fact be operated simply by blowing into the inlet tube. Original use was for washing machines to turn off water when tub has reached correct level but no doubt has many other applications. **£1·38**.

HONEYWELL PROGRAMMER



This is a drum type timing device, the drum being calibrated in equal divisions for switch setting purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 change-over micro switches each of 10 amp type operated by the trips thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs per min. Some of the many uses of this timer are Machinery control, Boiler firing, Dispensing and Vending machines. Display lighting animated and signs, Signalling, etc. Price from makers probably over £10 each. Special snip price **£6·33** plus 25p post and insurance. Don't miss this terrific bargain.

THYRISTOR LIGHT DIMMER

For any lamp up to 250 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price **£3·35**. Industrial model 5A **£3.30**

10 AMP DIMMER CONTROL

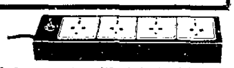
For the control of lighting on stage or in a studio or for control of portable equipment in workshops, etc. This has two 13 amp socket outlets each is controlled by a 5 amp solid state regulator. The overall length is 17in., width 3½in. and depth 1½in. In the end is fitted a master On/Off switch indicator, lamp and fuse. Price **£8·25**.

STANDARD WAFER SWITCHES

Standard size 1½in. wafer—silver-plated 5 amp. contact, standard ¼in. spindle 2in. long—with locking washer and nut.

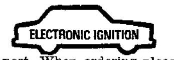
No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	44p	44p	44p	44p	44p	44p	44p	44p	44p
2 poles	44p	44p	44p	44p	44p	44p	44p	77p	77p
3 poles	44p	44p	44p	44p	77p	77p	77p	£1·04	£1·04
4 poles	44p	44p	44p	77p	77p	77p	77p	£1·32	£1·32
5 poles	44p	44p	77p	77p	£1·04	£1·04	£1·04	£1·60	£1·60
6 poles	44p	77p	77p	77p	£1·04	£1·04	£1·04	£1·87	£1·87
7 poles	77p	77p	77p	£1·04	£1·32	£1·32	£1·32	£2·15	£2·15
8 poles	77p	77p	77p	£1·04	£1·32	£1·32	£1·32	£2·42	£2·42
9 poles	77p	77p	£1·04	£1·04	£1·60	£1·60	£1·60	£2·70	£2·70
10 poles	77p	77p	£1·04	£1·32	£1·60	£1·60	£1·60	£3·00	£3·00
11 poles	77p	£1·04	£1·04	£1·32	£1·87	£1·87	£1·87	£3·25	£3·25
12 poles	77p	£1·04	£1·04	£1·32	£1·87	£1·87	£1·87	£3·52	£3·52

DISTRIBUTION PANELS



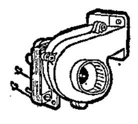
Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of heavy cable. Wired up ready to work, **£2·48** plus 25p P. & P.

CAPACITOR DISCHARGE CAR IGNITION



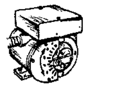
This system which has proved to be amazingly efficient and reliable was first described in the *Wireless World* about a year ago We can supply kit of parts for an improved and even more efficient version (*Practical Wireless*, June). Price **£5·55** plus 30p post. When ordering please state whether for positive or negative systems. Also available, ready made ignition systems for 6v. vehicles. **£5·78** plus 20p.

CENTRIFUGAL BLOWER



Miniature mains driven blower centrifugal type blower unit by Woods, powerful but specially built for quiet running—driven by cushioned induction motor with specially built low noise bearings. Overall size of blower is approx. 4½" × 4½" × 4". When mounted by its flange air is blown into the equipment but to suck air out mount it from the centre using a clamp, ideal for cooling electrical equipment, or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering etc., etc. A real bargain at **£2·04**.

ZPM MODULATION MOTOR



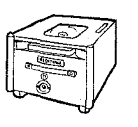
Could also be used to open ventilators, doors, valve, damper, etc. particularly suitable for remote control. Made by Satchwell. Essentially a reversible geared motor fitted with internal limit switches to stop it at the end of its travel. Size approx. 6in. × 6in. × 5½in. and weighing approx. 10 lb. This is extremely powerful and would lift a heavy door or open a long line of ventilators. To operate this motor you put the 50 cycle supply through a changeover switch. For instance a thermostat with changeover contacts could automatically regulate the temperature in a growing house, chicken hatchery, etc. An indicator on the motor graduated 0–10 shows the state of open or close. Also internally fitted is a variable resistor, wires from this to a volt meter would give a remote indication of the open or close position. A very expensive motor if both direct from Satchwell, our price complete with step down Transformer is **£15·15**.

MULLARD UNILEX

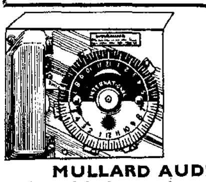
This D.I.Y. Stereo Amplifier is still available complete at **£7** for the four Mullard Modules, or Modules can be bought separately as follows:— 4 watt amplifier module (2 required) Mullard Ref. No. E.P.9000. **£1·60**.
Pre-amp module Mullard Ref. No. E.P.9001, **£1·98** each.
Power Module—Mullard Ref. No. E.P.9002, **£2·53** each.
In addition and made to Mullard specification we offer:—
Standard Control Unit with escutcheon and knobs, **£3·30**. Knobs, Set of 4, **50p**.
Special offer the complete Unilex with control pane at Pre V.A.T. price, **£10** post paid.

THIS MONTH'S SNIP

TAPE PLAYBACK UNITS



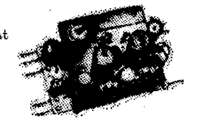
Mains operated. Made by Reditune the famous "music in background people." These are complete units ready to work and we understand that they are in good going order. We have not tested them but would exchange any that do not work properly. These have a superior motor driven flywheel to control the tape through the capstan and also an even equally useful valve amplifier with EL84 output. In a steel case with carrying handle. Two models offered, good as new **£6·50** and somewhat used at **£3·50**. 75p carriage up to 200 miles then 50p per 100 miles extra.



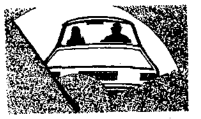
ELECTRIC TIME SWITCH

Made by Smiths these are A.C. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods. **£2·75** post and ins., 23p. Additional time contacts **55p** pair.

MULLARD AUDIO AMPLIFIERS

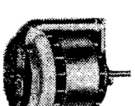


All in module form, each ready built complete with heat sinks and connection tags, data supplied.
Model 1153 500mW power output **72p**.
Model 1172 750mW power output **94p**.
Model EP9000 4 watt power output **£1·60**.
EP9001 twin channel or stereo pre amp. **£1·99**.
10% discount if 10 or more ordered.



WINDSCREEN WIPER CONTROL

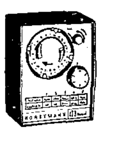
Vary speed of your wiper to suit conditions. All parts and instructions to make. **£2·48**.



PAPST MOTORS

Est. 1/40th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. **£1·65** each. Postage one 23p, two 33p. 230v. model **£3·30**.

HORSTMANN 24-HOUR TIME SWITCH



With 6 position programmer. When fitted to hot water systems this could programme as follows:—

Programme	Hot Water	Central Heating
0	Off	Off
1	Twice Daily	Off
2	All Day	Off
3	Twice Daily	Twice Daily
4	All Day	All Day
5	Continuously	Continuously

Suitable of course, to programme other than central heating and hot water, for instance, programme upstairs and downstairs electric heating or heating and cooling or taped music and radio. In fact there is no limit to the versatility of this Programmer. Mains operated. Size 3in. × 3in. × 2in. deep. Price **£3·85** as illustrated but less case.

NEW ITEMS THIS MONTH

AUTO-TRANSFORMER

Upright mounting, fully shrouded with terminal blocks for input and output. Made by a famous company for imported fridges. 150w. continuous loading or 250w. intermittent. Very nice transformer and probably cost £2 to make. Our Price **£1·65** plus 30p post and service.

3 CORE MAINS FLEX

Metric size .5 mm. which is approx. equivalent to the old 14/36 rating. Suitable therefore for mower or similar portable tools. Cores are colour coded to the new European standard. Brown—live . . . Blue—neutral . . . Yellow/Green—earth. Grey P.V.C. covered overall. 100m. coils **£5**, 50m. coils **£3** and 25m. coils **£1·75**. Post 40p on 100m. 25p for 50m. coils and 20p for 25m. coils.

PUSH ON/PUSH OFF PANIC SWITCHES

Tough enough to be foot switches and elegant enough to be panel switches. Bakelite construction with white push rod. Price **40p** less quantity discounts. Switch is rated 250 v.—2 amp.

20 WATT CAMPING LIGHT

Also makes good car emergency light. This uses a standard 2 foot 20 watt tube and operates from a 12v. car battery drawing approx. 1A. This gives illumination per amp./hour of battery life far in excess to filament lamps and in fact to the miniature 8-13 watt camping lights often offered. Complete unit ready to operate, in strong white enamelled metal frame. These would normally sell at £6, are unused but slightly soiled and we offer these at **£3·50** plus 40p post and packing.

6 MAINS TRANSFORMERS

Our Ref. MTM1. 27 volt at 8 amp. Upright mounting fully shrouded—flying leads—fully tapped primary. Price **£3·30**.

Our Ref. MTM2. 12v. at 1 amp. Upright mounting with fixing lugs, tag connection. 240v. primary—12v. 1 amp. secondary. Price **82p**.

Our Ref. MTM3. 6.3v. 2 amp. upright mounting with fixing lugs, tag connections. 240v. primary 6.3v. 2 amp. secondary. Price **77p**.

Our Ref. MTM4. 18v.-½ amp. with thermal cut-out, upright mounting with fixing lugs—tag connections. Primary 240v.—secondary 18v. at ½ amp. Price **88p**.

Mains Isolation MTM5. 350 watts earth shielded—flex leads—upright mounting lugs for fixing. Price **£4·40** each.

Mains Transformer Bargain. Standard mains 240v. input Secondary 2.4v. 9 amp. intermittent 5 amp. continuous. Price **55p**.

6 VOLT RELAYS

Our Ref. REL M1. Removable clear plastic enclosed two screw fixing. Have a 6 volt D.C. operated coil but two change-over contacts, each rated to make and break 240v. A.C. at 15 amps. Price **66p**. each.

P.O. TYPE 3000 RELAY

Our Ref. REL M2. 100 ohms coil and 2 pair normally open heavy duty contacts. Price **75p** each.

3 INTERNATIONAL TRANSISTOR BOOKS

Printed in several languages including English. Carefully compiled and each contains a wealth of information.

PHOTO-MULTIPLIER TUBE

American R.C.A. type No. 4555. These tubes have a gain of a million or more. Regular Price—over £15. We have a limited quantity and offer these at **£4·50**. Brand New. Not tested, but any not perfect would be exchanged.

6 DIGIT COUNTER

Resettable. 440 ohm coil up to 25 impulses per second. Ex-equipment but guaranteed perfect. **£2·20** each.

TANGENTIAL AIR MOVING UNITS

Work as extractors or blowers especially quiet running, perfectly balanced, plastic impeller—self oiling bearings, induction motor—outlet size 12in. × 2in. approx. Ideal to fit in cooker hood. **£2·20** plus 30p post and ins.

DESK TELEPHONES

Ex G.P.O. Black standard model with dialing dial but no internal bell. Supplied with connection diagram **94p** each. post etc. 40p for single then 65p per pair. Ditto, with bell but without dialing dial **98p** each plus 40p post for single then 65p per pair.

PUSH BUTTON SWITCH

Type 14 D.M.G. A very fine switch made by Honeywell. The switch is intended for mounting on panel through oblong hole. No screws required for fixing, its sprung clips secure it quite firmly. The operating button is approx. 1in. dia. round and dished for ease of operation. Has 2 sets of 10 amp. change-over contacts. Spring loaded, returns to normal when pressure is released. Ideal for instrument or quality gear. Price **50p** each. 10 for **£4·50**. 100 for **£40**.

MINIATURE SEALED RELAY

American made. Our Ref.: REL A1. Measures only ⅜in. wide × ⅛in. thick and ⅞in. high and it's a double change over, we don't know the contact rating but estimate this at 3/5 amps. The coil resistance is 600 ohms and 9-12 volt will close it. Ideal for models and miniaturised equipment. It's a plug in relay but we supply complete with base. Price **28p** including base.

COMBINATION SWITCH

This comprises of 12 miniature change-over micro switches. Joined in banks of 3 and mounted on frame with four digital numbered thumb wheels and a removable lever for locking the thumb wheel—the thumb wheel operates 3 banks. Over 4,000 combinations are possible but by re-wiring the switch connections underneath then thousands more variations are possible. If you are making equipment which you don't want switched on accidentally or without authority then this is a switch to consider—this can also be used as a coding switch for many other operations. Very neat and compact and measuring approx. 4in. × 1¼in. × 1¼in. deep. Priced at **£3·03**.

MAGNETIC CLUTCH

XEROX 1215494-J/N 10-1110 PN866-10. We have no information on this but it appears that the main section with coil fits to the spindle of the machine and there is a contact plate to fit on a stationary part. It appears also that the clutch can be used as a partial brake by putting reduced voltage into it, as a normal brake with normal voltage or as emergency stop by putting increased voltage into it. American made and very well made at that. Price **£1·65**.

SUB. MINIATURE MICROSWITCH

Made by Burgess, their ref. V4T6—our ref. MS.A1. These measure only ⅝in. × ⅜in. × ⅛in. thick—have change over contacts and tag connection. Price **16p** each or 10 for **£1·44**.

Where postage is not stated then orders over £5 are post free. Below £5 add 20p. S.A.E. with enquiries please.

J. BULL (ELECTRICAL) LTD.

(Dept. W.W.) 7, Park Street, Croydon, CR0 1YD
Callers to 102/3, Tamworth Road, Croydon

SERVICE TRADING CO

ALL PRICES INCLUDE V.A.T. POSTAGE AND PACKING. Overseas, please ask for quotation.

MATSUNAGA VARIABLE VOLTAGE TRANSFORMERS

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.

Carriage Paid
BRAND NEW. All types.

50 AMP

0-260 v. at 1 amp	..	£7·70
0-260 v. at 2·5 amps	..	£8·80
0-260 v. at 5 amps	..	£12·98
0-260 v. at 10 amps	..	£24·75
0-260 v. at 15 amps	..	£27·50
0-260 v. at 20 amps	..	£53·90
0-260 v. at 25 amps	..	£63·80
0-260 v. at 37·5 amps	..	£90·20
0-260 v. at 50 amps	..	£107·80

1 AMP

Special discount for quantity

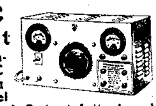
OPEN TYPE (Panel Mounting)
½ amp £5·23 1 amp £7·70 2½ amp £8·86

L.T. TRANSFORMERS

All primaries 220-240 volts.

Type No.	Sec. Taps	Price
1	30, 32, 34, 36 v. at 5 amps	£5·50
2	30, 40, 50 v. at 5 amps	£7·92
3	10, 17, 18 v. at 10 amps	£5·83
4	6, 12 v. at 20 amps	£7·70
5	17, 18, 20 v. at 20 amps	£8·58
6	6, 12, 20 v. at 20 amps	£8·14
7	24 v. at 10 amps	£6·16
8	4, 6, 24, 32 v. at 12 amps	£8·47
9	6 and 12 v. at 10 amps	£4·51

36 volt 30 amp. A.C. or D.C Variable L.T. Supply Unit

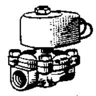


Input 220/240 v. A.C. Output Continuously variable 0-36 v. A.C./D.C Fully isolated. Fitted in robust meta case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused Ideally suited for Lab. or Industrial use. £77

MOTOROLA MAC11/6 PLASTIC TRIAC 400 PIV 10 AMP

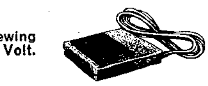
Now available EX STOCK supplied complete with full data and applications sheet. Price £1·21. Suitable Diac 22p.

240 V A.C. SOLENOID OPERATED FLUID VALVE



Will handle liquids or gases up to 7 p.s.i. Forged brass body, stainless steel core and spring. ½ in. b.s.p. inlet/outlet. Precision made. British mfg. PRICE: £2·09. Special quotation for quantity. NEW in original packing.

FOOT SWITCH

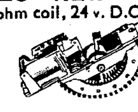


Suitable for Motors, Drills, Sewing Machines, etc., etc. 5 amp. 250 Volt. Price 99p.

POWER RHEOSTATS

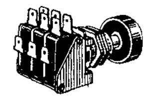
New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10/25/50/100/250/500/1k/1·5k ohm £1·10.
50 WATT 1/5/10/25/50/100/250/500/1k/1·5k/2·5k/5k ohm £1·54.
100 WATT 1/5/10/25/50/100/250/500/1k/1·5k/2·5k/3·5k ohm £2·20.
Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia brass bush. Ideal for above Rheostats. 28p ea.

UNISELECTOR SWITCHES—NEW



4 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C operation £6·71
6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. £7·48,
8 BANK 25 WAY FULL WIPER 24 v. D.C. operation £8·69.

'HONEYWELL' PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY

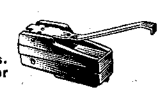


Each bank comprises of a change-over rated at 10 amps 240 volt A.C. Black knob 1 in. dia. Fixing hole ⅜ in. Prices: 1-bank 33p, 2-bank 44p, 3-bank 55p. (Illustrated) inc. P. & P. Special quotes for quantities.

VERY SPECIAL OFFER
MICRO SWITCH

5 amp. c/o contacts. Fitted with removable metal plate Ex P.O. 20 for £1·10 (min. order 20).

'HONEYWELL' LEVER OPERATED MICRO SWITCH



15 amps 250 volt A.C. c/o contacts. NEW in maker's carton. Price 10 for £2·09

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 £7·26

NEW INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. Adjustable 1-80 f.p.s., approx. ¼ output of Hy-Lyght. Price £12·10.

HY-LIGHT STROBE
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 £13·75.

'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.

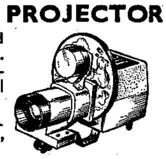
ONLY £22·88, incl. P. & P. ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE for the Super Hy-Lyght Kit including reflector, £8·25.

FOR HY-LYGHT STROBE incl. reflector, £4·95

7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 66p.

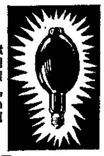
RAINBOW STROBE FOUR LIGHT CONTROL MODULE
Will operate four of our Hy-Lyght or Super Hy-Lyght Strobes in either 1, 2, 3, 4 sequence; 2 + ; or all together. Thoroughly tested and reliable. Complete with full connection instructions. Price: £20·80. Send S.A.E. for details.

COLOUR WHEEL PROJECTOR



Complete with oil filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. £20·57,
6 INCH COLOURWHEEL As used for Disco lighting effects, etc. Price £5·72

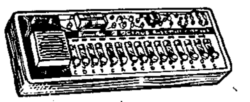
BIG BLACK LIGHT



400 Watt. Mercury vapour ultra violet lamp. Extremely compact and powerful source of u.v. Innumerable industrial applications also ideal for stage, display, discos etc. P.F. ballast is essential with these bulbs. Price of matched ballast and bulb £18·15. Spare bulb £8·03.

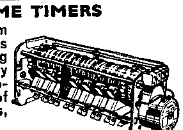
BLACK LIGHT FLUORESCENT U.V. TUBES
4ft. 40 watt. Price £6·38. (For use in standard bi-pin fluorescent fittings). MINI 9 inch 6 watt black light U.V. tube. £1·65. Complete ballast unit and holder for 9 in. tube £2·09.

ELECTRONIC ORGAN KIT



Easy to build, solid state Two full octaves (less sharps and flats). Fitted hardwood case, powered by two penlite 1½v. batteries. Complete set of parts including speaker, etc., together with full instructions and 10 tunes. £3·52.

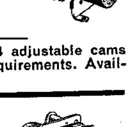
HONEYWELL PROGRAMME TIMERS



240V. A.C. 5 r.p.m. motor. Each cam operating a c/o micro switch. Cams are individually variable, allowing inumerable combinations. Ideally suited for machinery control, automation etc. Also in the field of entertainment, for chaser lights, animated displays, etc.
15 cam model £6·60
10 cam model £5·50

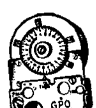
SIMPLE 12 CAM PROGRAMMER with 4 adjustable cams and 8 that may be profiled to individual requirements. Available with 15 or 13 r.p.m. motor £4·18

24 HOUR TIMER



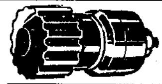
Can be adjusted to give a switching delay of between ½ hr. to 24 hrs. Driven by 200/250v. A.C. synchronous motor. 15 amp. c/o contacts. Mfg. Crater Controls Ltd. Supplied with scale calibrated 0-10 (2 hours per division) Brand new. £2·20

VENNER ELECTRIC TIME SWITCH



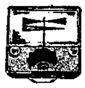
200/250 volt. Ex-GPO. Tested, perfect condition. Two ON, two OFF, every 24 hrs. at any manually pre-set time. Price: 15 amp, £3·85, 20 amp, £4·39. Also available with Solar Dial ON at dusk, OFF at dawn. Prices as above.

INSULATED TERMINALS



Available in black, red, white, yellow, blue and green. New 11p each. Incl. P. & P. Minimum order 6.

METER BARGAIN
BALANCE/LEVEL METERS



100-0-100 Micro Amp. Size 1½in. × 1½in. × ⅞in. Price only 83p

AMMETERS NEW! 2½in. FLUSH ROUND

available as D.C. Amps 1, 5, 15, 20 or A.C. Amps 1, 5, 10, 15, 20. Both types £1·98 incl. P. & P. 0-300V. A.C. £2·09

RELAYS
SIEMENS PLESSEY, etc. MINIATURE RELAYS

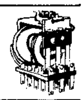
1	2	3	4	1	2	3	4
				700	12-24	2 c/o	66p*
52	4-6	6M	66p*	700	15-35	2c/oHD	77p*
52	4-6	4 c/o	88p*	700	6-12	1c/oHD	55p*
150	6-12	4 c/o	88p*	700	16-24	6 M	66p*
185	8-12	6 M	66p*	700	20-30	6 c/o	88p*
280	9-12	2 c/o	77p*	1250	24-36	4 c/o	66p*
410	10-18	4 c/o	77p*	2500	36-45	6 M	66p*
600	9-18	2 c/o	66p*	2400	30-48	4 c/o	55p
700	16-24	4M2B	66p*	9000	40-70	2 c/o	55p*
700	16-24	4 c/o	88p*	15k	85-110	6 M	55p*

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*including Base)

12 VOLT D.C. RELAY
Type 1: Three sets c/o contacts 5 amp. 88p (Similar to illustration below).
Type 2: One set c/o contacts 66p
Type 3: 4-8 volt 3 c/o HD, 67 ohm coil. 88p.

SPECIAL OFFER.
700 ohm. 4 c/o Ex. new equipment. £55·00 per 100 incl. bases (minimum 100).

230 VOLT A.C. 'DIAMOND H' RELAYS (Unused)



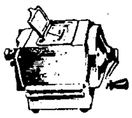
Three sets c/o contacts rated at 5 amps. Price 66p. incl. P. & P. (100 lots £44·00)
24 volt A.C. 3 c/o 66p.

230 VOLT A.C. RELAYS
One set c/o contacts rated at 7·5 amps. Boxed. Price 55p.

MINIATURE RELAYS
9-12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1 in.×⅞×½ in. Price 66p.
30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1×⅞×1½ in. 44p.

MINIATURE LATCHING RELAY
Mfg. by Clare-Elliott Ltd. (Type F) 2 c/o permanent latching in either direction. Coil 1150 ohm. 15-30 v. D.C. New 77p.

INSULATION TESTERS (NEW)



Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8 in., W. 4 in., H. 6 in. weight 6 lb.,
500 VOLTS, 500 megohms £30·80
1,000 VOLTS, 1,000 megohms £37·40

230V/240V COMPACT SYNCHRONOUS GEARED MOTORS

Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.
5 RPM A/cw 3 RPH A/cw 20 RPH cw
2 RPH cw 6 RPH cw 12 RPH cw All at 83p
cw=Clockwise. A/cw=Anti-clockwise

REVERSIBLE SPLIT PHASE MOTOR
250 r.p.m. 100-115/210-240V AC. 2 in. × 1 in. Ideal for rim-drive models, display etc. Extremely powerful for size 83p. (including small capacitor.)

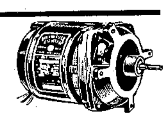
4 BANK 3 c/o PUSH BUTTON ASSEMBLY

Complete with black rectangular bottoms. 5 units £1·10 (5 units min.)

BLOWER UNIT

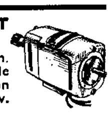
200-240 Volt A.C. BLOWER UNIT Precision German built. Dynamically balanced, quiet, continuously rated, reversible motor. Consumption 60mA. Size 120mm. dia. x 60mm. deep. Price £3·52.

BODINE TYPE N.C.I. GEARED MOTOR



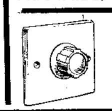
(Type J) 71 r.p.m. torque 10 lb. in. Reversible 1/70th h.p. cycle ·38 amp. (Type 2) 28 r.p.m. torque 20 lb. in Reversible 1/80th h.p. 50 cycle ·28 amp.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for 230/240v A.C. input.
Price, either type £4·84 or less transformer £2·75.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines, etc, etc.

PARVALUX TYPE SD2. 200/250 VOLT A.C. D.C. HIGH SPEED MOTOR



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: £2·20

600 WATT DIMMER SWITCH



Easily fitted. Fully guaranteed by makers Will control up to 600 watts of all lights except fluorescent at mains voltage. Complete with simple instructions £3·30

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57 BRIDGMAN ROAD, CHISWICK, LONDON, W4 5BB. Phone: 01-995 1560
Closed Saturdays.

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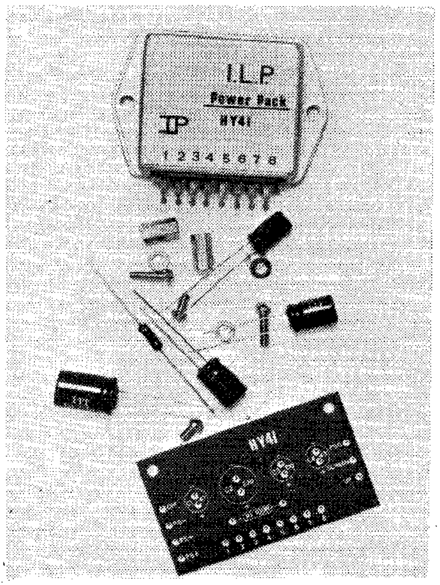
Tel.: 01-437 0576

I.L.P. (Electronics) Ltd



THE HY41

The HY41 supersedes the popular HY40 introduced by ILP last year. This highly improved module achieves true High Fidelity with a dramatic reduction in distortion (typically 0.05% at 1KHz into 8 ohms!) and is electronically and mechanically compatible with the HY40.

With this important improvement the HY41 retains all of the quality characteristics found in the earlier version and P.C. board, Resistor, Capacitors, Hardware Mountings and comprehensive manual are included in the basic kit. No further components are required to construct a complete power amplifier of extremely high performance sufficiently versatile to provide power not merely for Hi-Fi but also for public address systems and industry.

The free manual gives a full circuit diagram of the HY41 and its various applications including a complete stereo amplifier.

Like its predecessor the HY41 is based on conventional and proven circuit techniques developed over recent years.

OUTPUT POWER: British Rating 40 WATTS PEAK, 20 watts R.M.S. continuous.
LOAD IMPEDANCE: 4–16 ohms.
INPUT IMPEDANCE: 30K ohms at 1KHz.
VOLTAGE GAIN: 30db at 1KHz

TOTAL HARMONIC DISTORTION: less than 0.15% (typical 0.05%) at 1KHz.
FREQUENCY RESPONSE: 5Hz–50KHz ± 1db.
SUPPLY VOLTAGE: ± 22.5volts D.C.
SUPPLY CURRENT: 0.8 amps maximum.

PRICE: inc. comprehensive manual, P.C. board, five extra components and P. & P.:—
MONO: £5.39 **STEREO: £10.78** This is inclusive of V.A.T. plus P. & P.

UNIQUE HYBRID PRE-AMPLIFIER

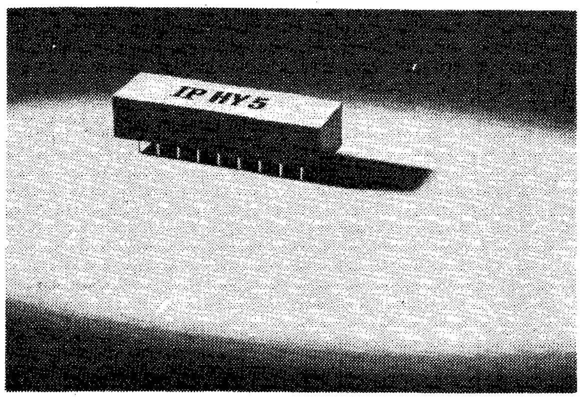
The HY5 has rapidly established a position in the WORLD as the sole hybrid pre-amplifier to contain all feedback and equalization networks within an integrated pre-amplifier circuit.

Supplied with the HY5 are two stabilizing capacitors and by the addition of volume, treble and bass potentiometers it is ready for use.

Internally the HY5 provides equalization for almost every conceivable input, the desired function is achieved by use of a multi-way switch or by direct interconnection.

Two distinctive features of the HY5 are its inbuilt stabilization circuit, allowing it to be run off any unregulated power supply from 16–25 Volts and a balance circuit which, when linked by a balance control to a second HY5, forms a complete stereo pre-amplifier.

Specifically and critically designed to meet exacting Hi-Fi standards, the HY5 combines extremely low noise with a high overload capability. When used in conjunction with the HY41 and PSU45 forms a completely intergrated system.

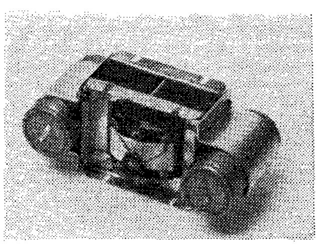


INPUTS
Magnetic Pick-up (within ±1db RIAA curve) 2mV. 47K Ω
Tape Replay (external components to suit head). 4mV. 47KΩ
Microphone (flat) 10mV. 47K Ω
Ceramic Pick-up (equalized and compensatable) 20–2000mV. variable.
Tuner (flat) 250mV. 100K Ω
Auxiliary 1 250mV. 47K Ω
Auxiliary 2 2–20mV. 100K Ω

ACTIVE TONE CONTROLS (Baxendall)
Treble ± 12db.
Bass ± 12db.
INTERNAL STABILIZATION
Enables the HY5 to share an unregulated supply with the Power Amplifier.
SUPPLY VOLTAGE
16–25 volts

SUPPLY CURRENT
6mA approx.
OVERLOAD CAPABILITY
better than 26db on most sensitive input infinite on tuner and auxl.
OUTPUT NOISE VOLTAGE: 0.5mV.

PRICE: **MONO: £3.96** **STEREO: £7.92** This is inclusive of V.A.T. plus P. & P.



POWER SUPPLY PSU45

The versatile P.S.U.45 is designed to supply your HY41's +HY5's in stereo or mono format.

Specification

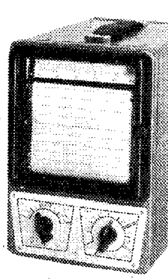
Input: 200–240 Volts.
Output: ± 22.5 Volts at 2 amps.
Overall Dimensions: L. 7"; D. 3.8"; H. 3.1"
PRICE: **£4.95** This is inclusive of V.A.T. plus P. & P.

Please note we reserve the right to substitute at our discretion updated versions of advertised designs where applicable

CROSSLAND HOUSE · NACKINGTON · CANTERBURY · KENT

CANTERBURY 63218

Electronic Brokers Ltd.



PORTABLE AC/DC RECORDING VOLTAMMETER

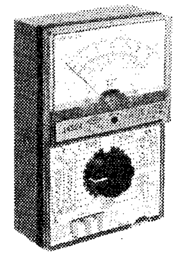
Fitted with separate zero-marking pen. Accuracy 1.5% DC, 2.5% AC. Measurements ranges — AC and DC: 5-15-150-250-500mA 1.5-5 Amps 5-15-50-150-250-500V. DC only 150mV. Frequency range 45 to 1000 c/s. Chart width 100mm. Chart speeds 20-60-180-600-1800-5400 mm/hour. Weight 22 lbs. Price complete with accessories

£78.00

WHEATSTONE BRIDGE AND CABLE FAULT LOCATOR

Measurement of resistance in the range of 0.005 to 1 megohm. Location of cable faults using Varley loop method. Location of cable faults using Murray loop method. Measurement of asymmetry of wires. Use of four-decade section as a resistance box. The bridge consists of four decade switches giving a range from 1 to 9999 ohms in 1-ohm steps. Accuracy: from 1 to 99,990 ohms 0.5%, from 0.1 to —.9999 ohms 1.5%, from 100k to 1 megohm 5.0%, from 0.005 to 0.0999 ohms 5.0%. Dimensions: 300x230x150 mm. Weight: Approx. 12 lbs. Price complete with connecting leads

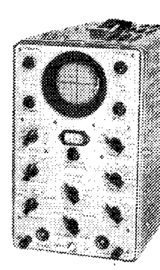
£41.00



AC/DC MULTIMETER

With taut band suspension movement. Sensitivity 20,000 ohms per volt on DC and 4,000 ohms per volt on AC.
Technical Data:
0.06-0.6-6-60-600mA-3 Amps DC. 0.3-3-30-300mA-3 Amps AC. 0.6-1.2-3-12-30-60-120-600 DC. 1200 Volts. 3-6-15-60-150-1300-600-900 Volts AC. 45 to 20,000 Hz.
500Ω, 5-50-500kΩ resistance. Decibel range −10 to +12dB. Accuracy (% of F.S.D.):—DC and resistance measurements ±2.5. Price with test leads, and storage case

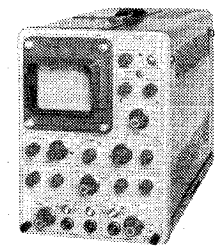
£8.00



3" SINGLE BEAM PULSE OSCILLOSCOPE

For display of pulsed and periodic waveforms in electronic circuits. Vertical amplifier: Bandwidth 10 MHz. Sensitivity at 100 KHz V RMS/mm..1-25. Horizontal Amplifier: Bandwidth 500 KHz. Sensitivity at 100 KHz V RMS/mm. sec. Free running 20-200,000 Hz in .3-25. Preset triggered sweep 1-3000μ nine ranges. Calibrator pips. Dimensions 220x360x430 mm. Weight 40 lbs. 115-230V AC operation.

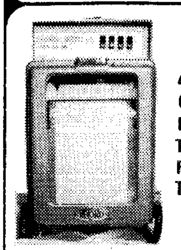
£39.00



DOUBLE BEAM OSCILLOSCOPE

Designed for investigation and measurement of pulsed and periodic waveforms. The use of two independent vertical deflection amplifiers permits the display and analysis of two different waveforms simultaneously. Display area 35x90 mm. Repetition rates of investigated waveforms 50 Hz to 1 MHz. Range of pulse length 0.35μs to 1 sec. Range of amplitudes 0.04 to 400V. Maximum amplitude without external attenuator 100V. Characteristics of vertical amplifiers: Amplifier passband at 1db DC to 1 mHz Amplifier passband at 3db DC to 5 mHz. Sensitivity at medium frequencies at broad passband 500mm/V. Size of undistorted pulse display 40mm. Input Impedance 0.5 ± .015 Megohms shunted by 45pF. Input Impedance with external attenuator 5 Megohms shunted by 13pF. Voltage attenuation ratios of the built-in attenuator 1:1; 1:10; 1:100; 1:1000. Time Base: Preset calibrated sweep durations:—microseconds per cm 0.2; 0.5; 1; 2; 5; 10; 20; 50; 100. Milliseconds per cm 0.2; 0.5; 1; 2; 5; 10; 20; 50; 100. Free-running time base frequency range 50 Hz to 1 mHz. Sweep sync. voltage and trigger voltage 0.5V. Maximum trigger pulse repetition rate 10 kHz. Built-in amplitude calibrator: Amplitude of test pulses with duration of 0.35μsec or longer 0.04-100V. Fundamental error of the calibrator +10%. Frequency of quartz crystal calibrator 100 kHz. Overshoot of pulse top for pulses with rise time not below 0.1μsec 10%. Instrument warm-up time 30 min. Power inputs 220/250 ± 50 Hz. Overall dimensions 260x550x376 mm. Weight 55 lbs.

£87.00

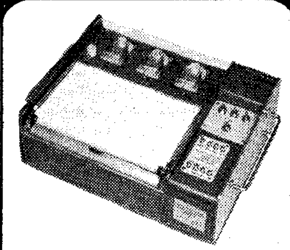


4-RANGE GENERAL PURPOSE TEMPERATURE RECORDER Type 01

Specially designed compact self-contained instrument for recording temperatures up to 500°C. The main design objectives were for an easy-to-use, robust instrument suitable for use in the laboratory and in the field. The four ranges are 10°C, 50°C, 100°C and 500°C. These are selected by push buttons allowing full use of the 3" wide chart. Two chart speeds 1" and 6" per hour are provided by the 240V 50Hz synchronous chart drive.

The 3% basic accuracy of the instrument, which is adequate for most applications, has been achieved without introducing stability problems in the d.c. amplifier, making the recorder ideal for use in schools, colleges and universities and by unskilled personnel. The recorder is complete with N1Ch/NiA1 thermo-couple and mains lead. This product is brand new and manufactured in our own laboratories with three month guarantee.

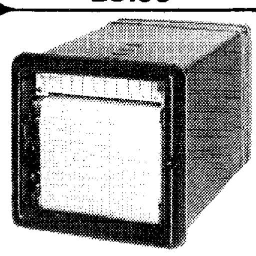
£95.00
plus £5.00 packing and carriage.



THREE CHANNEL HIGH SPEED RECORDER

Strip Chart Recorder. Chart length 175ft. Footage indicator. Width of recording channel 80mm. Chart speeds (selected by pushbuttons) 1.2-12-30-60-120-300-600-3000 mm. per minute. Full deflection current 8mA. Internal impedance 210 ohms. External impedance 800 ohms. Dimensions 510x345x175 mm. Weight 44 lbs. Price complete with accessories

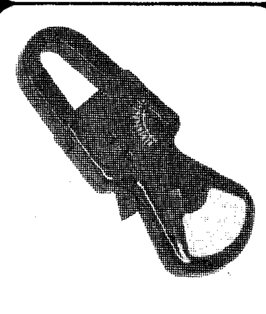
£90.00



10 CHANNEL EVENT RECORDER

Designed for recording sequences of up to ten different operations, e.g. sequence of machine tool operation, switching sequences, etc. Record is presented in the form of square "pulses". When energised, pen moves by approximately 4mm. to the right of zero line. Response time 100 milliseconds. Chart width 110mm. Chart length 50ft. Inv. capacity 72 hours. Chart speeds 20-60-180-600-1800-5400 mm/hour. Size 160x160x255mm. Weight 9 lbs. Price complete with accessories

£52.00

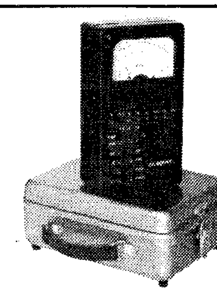


AC CLAMP VOLTAMMETER

Clamp-on Voltammeter is used for measurements of AC voltages and currents without breaking circuits.

Specification
Measurement ranges:—Current 10-25-100-250-500 Amps. Voltage 300, 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283x94x36mm. Weight 1.5 lbs.

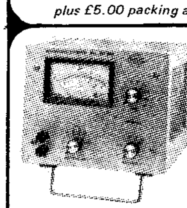
£10.50



MULTIMETER

0.1-1-10-100-1000mA, 2.5-10-20-250-500-1000V AC/DC. Sensitivity AC and DC all ranges except 10V-10,000 Ohm/V. Dimensions 212x118x75 mm. Weight 2.9 lbs. Price complete with steel carrying case and test leads

£4.95



OUTPUT POWER METER TYPE MU 964.

This instrument basically consists of a transistorized amplifier voltmeter which measures the voltage across a specified load. It is provided with 40 load values ranging from 2.5ohm to 20KOhm As the loads are purely resistive, their value keeps constant with varying frequency. A special negative feedback loop allows a nearly linear scale to be obtained. No damages to the instrument result from errors in presetting the load values or the power ranges.

Power measuring range (in 4 ranges)	from 1mW to 10 W
Level measuring range Ref. 1mW	from −3 dB to +40 dB
Frequency range	from 20 Hz to 50KHz
Accuracy	Within 0.5 dB
Load input resistances	40 Values
Resistances accuracy	better than 5%
Instrument Calibration	R.M.S.

£89

NEW AMPERTEST 690 — *A NEW CLAMP TYPE AMMETER*

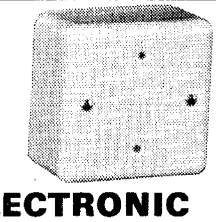
Electronic Brokers Limited announce the introduction of a new clamp type ammeter having 6 current ranges plus 2 voltage ranges for use on 50 to 60 alternating current supplies. Known as the AMPERTEST 690, the new instrument is manufactured in Italy by Industria Construzioni Electromeccaniche, one of Europe's largest manufacturers of electrical measuring instruments.

The Ampertest 690 uses the familiar clamp or 'pincer' system to measure the current flowing in a conductor without breaking the circuit. The meter, which is designed to be used with one hand, has 6 current ranges from 3 to 600 amps f.s.d. with the first division at 100 mA. The current ranges may be extended by use of a 10 to 1 current transformer which is supplied with the instrument providing ranges from 300 mA to 60 amps f.s.d. with the first division at 10 mA. In addition there are two a.c. voltage ranges, 250V and 600V f.s.d. The connections for voltage measurements are made by two leads and probes which plug into the base of the instrument.

The range to be used is selected by rotating a small serrated thumbwheel on the side of the instrument. This action brings the appropriate scale under the meter needle removing the possibility of reading the wrong scale. When not in use the meter movement is clamped by the ON-OFF switch to prevent damage during transit.

The Ampertest 690 is supplied complete with voltage measuring leads and probes and combined twin wire adaptor/current transformer in a solid leather carrying case. A belt fitting pouch is available as an extra.

£37.50



ELECTRONIC TIME DELAY SWITCH.

Specification:
Delay period 1-25 minutes adjustable, load 1000 watts maximum. Operating Voltage 180-250V a.c. 50Hz. Size 3¾ x 3¾ x 1¾ Standard Ivory Surface mounting Box. **Trade Price £5.80**

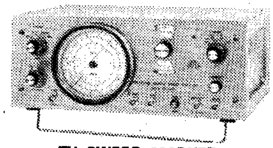
Fantastic value in Test Equipment

MODEL 300 LOGIC PROBE

A compact easy-to-operate logic probe. As a light-emitting diode is used the unit actuates with low power. It does not affect the circuit under test because of high input impedance. Up to as high a frequency as 12 MHz.

£5.50

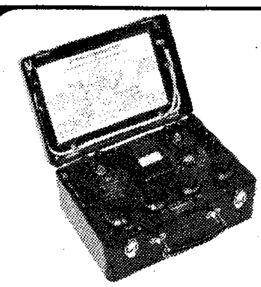
plus 75p. packing and carriage.



TV SWEEP MARKER GENERATOR Type VU 167

Suitable for alignment of tuned circuits in television sets. Incorporates a sweep generator, a market generator and a crystal-controlled oscillator operating at 5.5 MHz. Sweep frequency range 1-30 MHz, 170-260 MHz Fund, 470-780 MHz Harmonic. Marker frequency range 2-266 MHz, 480-800 MHz.

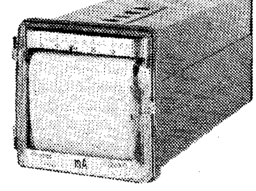
£195.00



PORTABLE WHEATSTONE BRIDGE

Designed for measurements of DC resistances in the range of 10^{-5} to 10^{6} Megohms. Basic accuracy 0.01 ohms to 10^{5} ohms is 0.2%. Dimensions 300x230x 150 mm. Weight approx. 13 lbs.

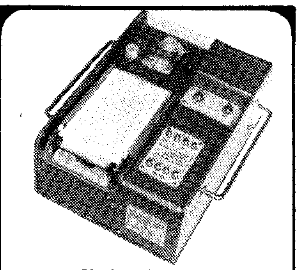
£59.00



MINIATURE PEN RECORDER

Provides permanent record of DC currents up to 1mA. Eminently suitable for use where space is limited. Separate time marker pen provided. Chart width 80mm. Chart length 40ft. Chart speeds: Slow 20-60-180 mm/hour. Fast 600-1800-5400 mm/hour. Dimensions 120x 120x285mm. Weight 7.7 lbs. (3.5 Kg). Price complete with accessories

£39.00



SINGLE CHANNEL HIGH SPEED RECORDER

Chart length 175ft. Footage indicator. Width of recording channel 80mm. Chart speeds (selected by push buttons) 1.2-6-12-30-60-120-300-600-3000 mm per minute. Full deflection current 8mA. Internal impedance 210 ohms. External impedance 800 ohms. Dimensions 320x340x175mm. Weight 35 lbs. Price complete with accessories

£55.00

Supertester 680R.

Buy it for what it is. Or buy it for what it can be.

The Supertester 680R is a completely new concept in measuring instruments. In itself a high quality test meter with eighty ranges on a 128mm mirror backed scale. It is also the basis of a complete measurement system. With the addition of the appropriate accessories it can measure a wide range of values including light, temperature, gauss and phase sequence. And there are other accessories to greatly extend the 680R's range. The 680R System offers many advantages over conventional test meters including tremendous versatility and economy.

ACCESSORIES TO CONVERT THE SUPERTESTER 680R TO THE FOLLOWING:

Amperclamp For measuring a.c. currents from 250mA to 500 amps. **£11.95**

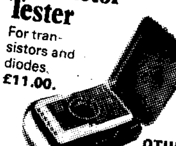
Signal Injector Producing 1KHz and 500 KHz signals for circuit testing. **£5.95**

Temperature Probe Covering the range −30 to +200°C. **£11.95**

Gauss Meter For measuring magnetic field strengths. **£11.95**

Phase Sequence Indicator To indicate the phase sequence of a 3 phase supply. **£5.95.**

Electronic Voltmeter Input resistance of 11Mohms for d.c. and 1.6Mohms shunted by 10pF for a.c. **£18.00**



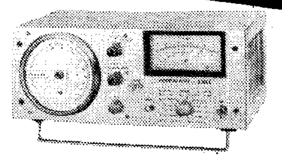
Transistor Tester For transistors and diodes. **£11.00.**

£18.50
Complete with case & probes

SUPER TESTER 680R SPECIFICATION

13 D.C. ranges from 0.1 to 2000V. 12 ranges from 50μA to 5A. 20,000 Ω/A Accuracy 1% 11 A.C. ranges from 2 to 2500V. 10 ranges from 250μA to 4,000Ω/V. Accuracy 2%. **Resistance:** 6 ranges from 0.5Ω to 100MΩ **Reactance:** 1 range of 0-10M. **Frequency:** 2 ranges of 0-50 and 0-5000 Hz. **Output Volts:** 9 ranges from 10 to 2000V. **Decibels:** 10 ranges from −24 to +70dB. **Capacitance:** 6 ranges, 4 ranges from 20 to 20,000 mfd from internal battery and 2 ranges from 50,000 to 500,000pF using mains.

OTHER ACCESSORIES AVAILABLE SHUNTS D.C. 25, 50 and 100 amps, **£4.50** each. **CURRENT TRANSFORMERS** A.C. 25 and 100 amps, **£7.00** each. **E.H.T. PROBE** Extends d.c. voltage to 25,000v **£5.95.**



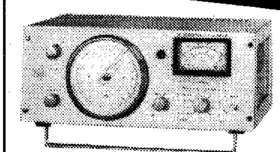
DISTORTION METER Type D 566 B

Fully transistorised for measurement of overall distortion of signals with frequencies between 10 Hz and 1 MHz. Built-in electronic voltmeter can also be used separately for measuring AC voltage, basic noise, gain or attenuation over a wide frequency range.

Distortion meter:—
Frequency range (in 5 ranges): from 10 Hz to 1 MHz. Distortion factor (in 7 ranges): from 0.03% to 100. Minimum testing voltage: 300 mV approx. Input impedance: 100 KOhm; 40 pF approx.

Millivoltmeter:
Voltage range (in 12 ranges): from 1 mV to 300 V f.s.d. Level range (rel. to 0.776 V): from + 52 dB to − 75 dB. Frequency range: from 10 Hz to 2 MHz. Bandwidth (within 3 dB): up to 8 MHz. Accuracy: better than 5%. Input impedance: 2 MOhm; 50 pF approx.

£249.00



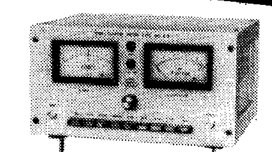
LF SIGNAL GENERATOR Type G 1165 B

Transistorised generator providing wide range of squarewave and sinewave signals. Suitable for measuring distortion, gain or attenuation when testing the frequency response of low-frequency equipment.

Sinusoidal output:—
Frequency range (in 4 ranges): from 10 Hz to 100 KHz. Output voltage: from 1 mV to 10 V. Output impedance: 600 Ohm constant. Frequency accuracy: better than 2%. Harmonic distortion: less than 0.3% (50 Hz . . . 30 KHz).

Squarewave output:—
Frequency range (in 4 ranges): from 10 Hz to 100 KHz. Output voltage: from 100 mV to 10 Vp. Output impedance: 75 Ohm constant. Risetime: less than 10nS.

£165.00

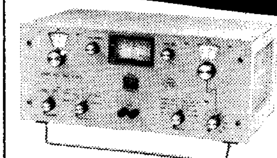


WOW AND FLUTTER METER Type WF 971

Solid state, high stability unit. Can be preset for either the European standard at 3150 Hz or the American standard at 3000 Hz. Provided with built-in oscillator.

Specifications: DIN and CCIR. Input Signal: 20 mV rms to 20 V rms approx. Frequencies (switchable): 3150 Hz and 3000 Hz. Ranges (flutter): +/− 0.1% +/− 0.3% +/− 1% f.s.d. Drift indication: +/− 2% max. Input impedance: 10mOhm max. Built-in oscillator: 3000 Hz or 3150 Hz switchable. Stability: better than 0.1%. Shifts for calibration: +/− 0.1% dynamic, 50 Hz + 2% static.

£225.00

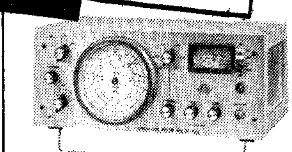


RCL BRIDGE Type P 966

For measurement of RCL and capacitor dissipation factor and inductors figure of merit Q. Consists of a system of switchable bridges, a 1 KHz generator, and a sensitive tuned detector. Particularly suitable for testing of small production batches and selection of component parameters.

Measurement ranges:
Resistance: from 0.1 Ohm to 11 MOhm. Capacitance: from 1 pF to 1100 μF. Inductance: from 10 μH to 1100 H. Accuracy: +/− 1%. Dissipation factor D: from 1.10^{-3} to 50. Quality factor Q: from 0.02 to 1000. Internal oscillator: 1 KHz.

£170.00



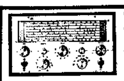
AM-FM GENERATOR Type AF 1065

Permits fast and accurate calibration of modern radio receivers. Suitable for calibration and testing in the laboratory. AM frequency range: from 140 KHz to 46 MHz in 6 ranges expanded range 430-530 KHz. FM frequency range: 9.5-12 MHz; 85-110 MHz. Frequency accuracy: better than 1%. RF output voltage: adjustable from 0.1 μV to 0.1V. Output impedance: 75 Ohm constant. Modulation: AM; FM; AM + FM. Amplitude modulation: 400 Hz; from 0-50% adjust. Frequency modulation: 1000 Hz adjust. Deviation from 0 − +/− 50 KHz. External modulation: AM; FM; from 30 Hz to 15 KHz.

£225.00

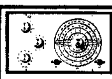
WIDE RANGE TRANSISTOR AUDIO GENERATOR

High stability low frequency generator. Basic circuit is a Wien-Bridge controlled sine wave oscillator and square wave is produced by means of a Schmitt trigger circuit. FREQUENCY RANGES: 4 from 10Hz to 100kHz. OUTPUT VOLTAGE: 1 millivolt p-p to 1 volt p-p ± 3% for sine and square wave. IMPEDANCE: 1K ohm. DISTORTION FACTOR: 0.2% for the sine wave output for the lower frequency range. < 1.0% for the upper frequency range. RISE TIME: < 0.1 microseconds for the square wave and 0.3 microseconds in the upper frequency range. WORKING VOLTAGE: 9 volt, 240mm x 140mmH x 100mmD. 2¼lbs. £27.



WIDE RANGE TRANSISTORISED R.F. SIGNAL GENERATOR

RF carrier can be internally and externally modulated from 0.5% — internal modulation frequency is variable between approximately 800 and 1200 Hz — AF output adjustable for level and frequency FREQUENCY RANGES: 8 from 147kHz to 220.0 MHz. SCALE ACCURACY: 2% or ± 0.1% when set against internal crystal calibrator. RF OUTPUT VOLTAGE: 50 millivolts minimum on all ranges. AM MODULATION: Internal and external from 0 to 50%. AF OUTPUT: Variable for frequency and level. WORKING VOLTAGE: 9 Volt. 240mmL x 140mmH x 100mmD. 3½lbs. £36.



WIDE RANGE TRANSISTORISED R.F. SIGNAL GENERATOR

A low priced R.F. Generator, 8 ranges, covers from 150kHz to 300MHz. The output can be unmodulated by means of an internal 400Hz oscillator. The A.F. signal is available from a separate output socket. Both output sockets are provided with an isolating capacitor (500 D.C. max.) FREQUENCY RANGES: 8 from 150kHz to 300.0MHz. ACCURACY: ± 2% R.F. OUTPUT VOLTAGE: 50 millivolts minimum. A.F. OUTPUT VOLTAGE: Approximately 1 Volt at 800Hz. WORKING VOLTAGE: 9 Volt. 240mmL x 140mmH x 100mmdD. 2¼lbs. £19.50

TRANSISTORISED CAPACITY/RESISTANCE BRIDGE

The measuring ranges of this Capacity Resistance Bridge are 10pF to 100mfd capacity and 10ohms to 10 megohms. Bridge balance is shown by means of a luminescent balance indicator tube. A further switch position permits measurement of capacity leakage current. RESISTANCE RANGES: 3 from 10 ohms to 10 megohms. CAPACITY RANGES: 3 from 10pF to 10mfd. WORKING VOLTAGE: 9 volt. 240mmL x 140mmH x 100mmD. 2¼lbs. **£18.50**

OSCILLOSCOPE—TYPE 46

A compact general purpose single beam, solid state, DC

Y Amplifier — 5mHz. 3 db bandwidth D.C. coupled — dc — 5mHz. 100mV — 50V. 9 steps. Maximum input (a.c. coupled) 300Vp. Input impedance approx 1MΩ & 47pf. Sweep speeds ±5%. 4 ranges 10mSec/cm to 10Sec/cm

Trigger/Sync. Automatic operation.

X Amplifier 3db bandwidth D.C. — 1mHz Input impedance approx. 2.5 kΩ 220-240v 50-60Hz. Width 24cm. Depth 19cm. 7lbs £59.65.

Also available: Function Gen. 0.1Hz ÷ 1mHz, frequency counter 5Hz ÷ 9.999mHz. Ask for more details.

ALL EQUIPMENT BRAND NEW AND GUARANTEED FOR 6 MONTHS

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Add £2 towards the cost of packing and carriage on all items for U.K. delivery (except where packing and carriage are already indicated).

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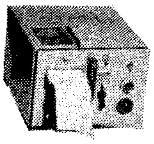
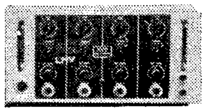
UNIQUE OPPORTUNITIES

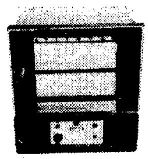
PEN RECORDERS



Portable 1, 2 and 4 channel pen recorders by Kelvin Hughes. General purpose recorders providing clear instantaneous and permanent records of phenomena with comparatively high rates of change. The torsion-strip suspension of the moving coil renders the instrument immune to the effects of vibration and acceleration.
Six possible chart speeds, chart width 55mm., length 150 ft., linearity 8 v. at 3 mA. response D.C. to 100 c/s.
Single pen with amplifier **£49**
4 pen with amplifier **£85**

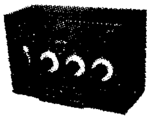


SERVORITER Model FWS



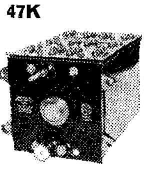
By well-known American manufacturer. Power supply 120 v. 50 Hz. Response time 24 secs. Resistance source 10 K ohms max. Chart width 11 in. This is a slow-speed recorder that can be used for measuring any quantity with a comparatively slow rate of change such as temperature, humidity etc. Supplied with electrovolt controller that enables the sensitivity, reset, proportional band and rate to be adjusted. This unit enables the demanded temperature to be controlled and the actual temperature recorded. Size: 16½ in. wide, 17½ in. high, 13½ in. deep. Price **£95.** Carriage extra.

MUTUAL INDUCTANCE BOX TYPE R.7005



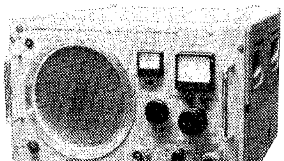
Specification Range: 0-11.100 mH. in 0.002 mH. divisions. Accuracy: ±(0.3 × 0.012M/ where M=value of mutual inductance in mH. set on the box. Frequency range: 0-2.5 Kc/s for all decades except X1=0-15 Kc/s. Maximum current: 0.5A for decades 1A for variometer (both primary and secondary wingings). Case: Polished teak. List price £65. Our price **£26·50.**

SINE COSINE POTENTIOMETER 47K



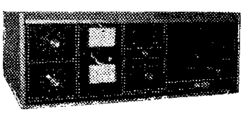
Precision component by Pye. Model 2002. Manufactured to rigid Ministry specification. The assembly consists of three units mounted in one frame. Each unit contains two sine and two coside potentiometer sections, the sliders being ganged together. Electrical connections, 2 end taps, slider and centre tap. Mechanical I/P: 30 r.p.m. Max. torque: 3½ oz./in. Dimensions: W. 6½ in. H. 5 in. D. 7½ in. Wt. 7½ lbs. Ex equipment. Good condition. Price **£5.** Carriage extra.

ROHDE & SCHWARZ Zg DIAGRAPHS HF IMPEDANCE PLOTTER



These instruments will rapidly plot the loci of the impedance or admittance of any item such as antennas, transformers, absorbers, filters and other networks. Impedance measurements are possible from 0·02Z, to 50Z, where Z°=50, 60 or 75 ohm.
Type ZDD 300—2400MHz. Price **£390.**

INFRA-RED SPECTROPHOTOMETER



Beckman Type IR-102

A single beam instrument designed primarily to analyse the effluent from a gas chromatograph, however the fast response and fast scan capabilities make it suitable for fast reaction studies involving conventional gas, liquid, or solid samples. The wave length range is 2·5 to 14·5 microns. In excellent condition. **Price £345·00**

EX COMPUTER POWER SUPPLIES

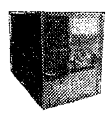
Input 220/250 Volts Output 22 Volt 10 Amp Overload Protect Lamp. **£6·50**

EX COMPUTER HIGH GRADE FULLY STABILISED POWER SUPPLIES

Input 200/250V.	Output
ADVANCE TYPE DC 207	20 Volts 9 Amps. 10 Volts 5 Amps. 10 Volts 3 Amps. 20 Volts 2 Amps.
ADVANCE TYPE DC 200	—20 Volts 13 Amps. 10 Volts 5 Amps. 20 Volts 2·5 Amps.
ADVANCE TYPE DC 202	35 Volts 9 Amps. 24 Volts 4 Amps. 10 Volts 8 Amps.
ADVANCE TYPE DC 197	6 Volts 7·5 Amps. —6 Volts 11 Amps. —28 Volts 9 Amps.
WESTINGHOUSE Fully Fused Input 200/220/240/10	14 Volts 0·75 Amps. 20 Volts 4 Amps. 25 Volts 2·5 Amps. 30 Volts 0·75 Amps.
WESTINGHOUSE	6 Volts 7·5 Amps. 6 Volts 11 Amps. 28 Volts 9 Amps.

£18 EACH. P. & P. £2.

KENT CHROMALOG 1 DIGITAL INTEGRATOR



For use with gas chromatography apparatus or anything with an output expressed as a varying direct voltage. Automatic print out and 0-10mA O/P to drive recorder. Offered in excellent condition. 3 months warranty and copy of handbook. Price **£150.** Carriage extra.

MINITRON

K.G.M. Type 3015F 7 Segment display showing figures 0-9 plus decimal point. Character of 9mm height. In 16 DIL case.

NEW LOW PRICE £1·85

SN7447N BCD Decoder Driver **£1·05**

COMPUTER PARTS

TELETYPE PUNCH

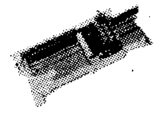
BRPE High-speed punch. Self-contained, consists of punch unit, base, motor unit. For use in many data communication systems. Operating speeds up to 100 characters per second. (1100 words per minute). Available for punching 5, 6, 7, or 8, level codes, into 11/16", ⅞" and 1" tape. Synchronous, parallel-wire input. **£195.**

WELMEC 7 & 8 HOLE ELECTRO-MECHANICAL PUNCHES & READER

Models S110 and R82C, 17 char. per sec. Rebuilt, available from stock. **£75.**

Magnetic Tape Transporters AMPEX TM4, TM2, TM7, FR300, IBM 7330, POTTER, ICL Magnetic Drums. From **£75.**

HAND PUNCHES—80 COLUMN



THE PUNCH

Is a table-mounted Model Punch. For the Serial Punching or alphanumeric Data, Alpha or Multi-Hole Punching. From **£59·50.**
103 Verifiers available **£89·50.**

ICT KEYBOARDS

in original packing—Numerical from **£4·50**

ICT KEYBOARDS

in original packing — Alphanumeric **Prices From** from **£12·50**

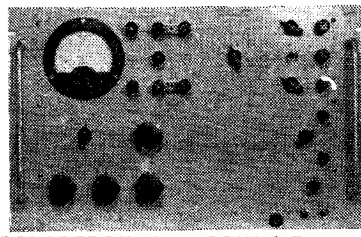
IBM PUNCH CARD EQUIPMENT FULLY GUARANTEED

Prices from

024 Automatic alphanumeric keypunch........................**£340·00**
026 Automatic alphanumeric printing keypunch...............**£820·00**
056 Verifier features and operation same as 024, 026..........**£380·00**
082 Sorter 500 cards per minute are sorted.....................**£740·00**
Carriage extra.

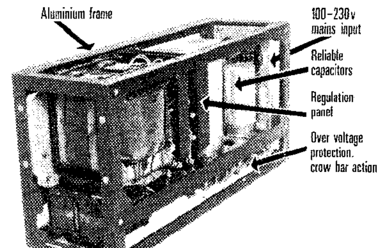
MARCONI A.M. SIGNAL GENERATOR TYPE TF801D

10-485Mc/s in five ranges. Output 0·1µV-1 Volt E.M.F. External Sine A.D. Frequency 30c/s-50Kc/s. **PRICE £195**



SOLARTRON Type OS103 L.F. DECADE OSCILLATOR

Frequency range: 0·01Hz to 11·1KHz. Sine and square wave accuracy ±2% O/P 0-10V r.m.s. 100mW into 1KΩ
PRICE: £99·00



A BARGAIN IN NEW POWER SUPPLIES. AT LESS THAN HALF MANUFACTURERS PRICES.

O/P Voltage 7·5V-9V. Max. load current 10 Amps. Max. ripple on full load approx. 60mV. p.p. Threshold current 10·5A. Overvolt protection. **OUR PRICE £12·50**

SIGNAL GENERATOR "X" BAND

Sanders model CT480 (SG480) and CT478 (SG478). Specifications: CT480 8-11·5KMHz; CT478 1·3-4·2 KMHz. O/P of 1mW from 8·0-11·0KMHZ (CT480) and 1·4-4·0 KMHZ (CT478). These high grade generators comprise a klystron oscillator in a co-axial cavity fed from a stable power source. Provision for application of square wave or pulse modulation, internal or external sources. Attenuator calibrated from 0-100 db below 1mW. I/P 110-250V 50-500Hz 200W. Rack mounting. W. 19in. H. 14in. D. 15in. Wt. 74 lbs. Price. **£125.**

AUTOMATIC RECORDING WAVE ANALYSER

Muirhead Type K100. The K100 Automatic Recording Wave Analyser can analyse and record graphicallt complex waveforms in the range 10c/s to 19Kc/s. The speed of analysis makes it possible to reduce testing times to a minimum, resulting in increased utilisation of personnel and reduced running costs of equipment.
Specification:

Frequency Range	10c/s-19Kc/s in four ranges.
Frequency Accuracy	±1% on recorder paper (1·5% bandwidth, steady frequency signal).
Selectivity	1·5% bandwidth, 3dB down to approx. 0·8% off-tune. Octave discrimination better than 70 db, *5% bandwidth 3 db down to approx. 2·5% off-tune. Flat-topped with 1 db over 3% frequency range. Octave discrimination 54 db*. 1/3 octave bandwidth 3 db down to approx. 12% off-tune. Octave discrimination 30 db*.

* Final scope of response curve is 6 db/Octave above and below tune frequency.
Further information available on request.
PRICE £450

AIRMEX 853 H.F. WAVE ANALYSER

Frequency range: 30KHz-30MHz in 7 bands. A very popular instrument which has been refurbished. Price **£45.**

AVOMETERS

Model	Price	Model	Price
D	£14	40	£16
7	£19·50	47A	£16
8	£29·50	48A	£16
8X	£35		

NB. 47A and 48A are Admiralty versions of Model 40, the only difference being that the resistance ranges 0-1·2, 0-12 ohms, which are available on the Model 40 with the use of an external power supply, are not available on the 47A and 48A. CASES AND LEADS EXTRA

PHILIPS VALVE VOLTMETER MODEL GM6014

Max. 300mV, 1000Hz-30MHz. **PRICE £30·00**

ADD 10% VAT TO ALL PRICES

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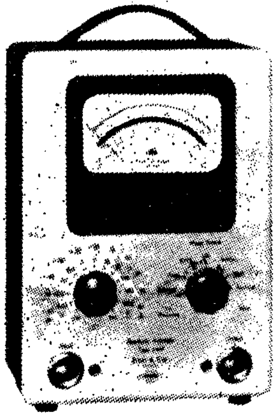


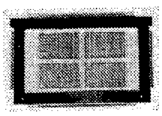
BRUEL & KJAER ELECTRONIC VOLTMETER MODEL 2409

An instrument for the measurement of peak average absolute and true R.M.S. values of AC voltages in the frequency range 2 Hz - 200 KHz. 11 voltage ranges from 10 mV - 1000 volts. Full scale deflection. Built-in ref. voltage. Input impedance 10 Meg. The high input impedance, low output impedance and accurate attenuator also make this an ideal calibrated amplifier. Brand new in manufacturer's original cartons.
Last Pre-VAT List Price £98·50 **OUR PRICE, BRAND NEW, COMPLETE WITH ACCESSORES £59·50**

7-TRACK DIGITAL MAGNETIC TAPE STORAGE 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. Frequency response approximately 0 Kc/s to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools, 230 V to 380 V. Capstan motor speed 1,500 r.p.m. 48 V DC rewind motors complete with vacuum assembly. Finished in brush aluminium and matt black. Size 27 in. x 26 in. x 8 in. Weight 90 lbs. Price **£72·50.**

MEMORY PLANES



Ferrite core memory planes with wired Ferrite cores. Used for building your own computer or as an interesting exhibit in the demonstration of a computer. Mounted on plastic material frame 5 x 8 in. Consisting of **matrices** 40 x 25 x 4 cores, each one individually addressable, and divided into 2 halves with independent sense and inhibit wires. **Price £2·50.**

EAC DIGIVISOR Mk. II DIGITAL READ-OUT DISPLAY

Ideally suitable for use in conjunction with transistorised decade counting devices. No need for amplifiers or relays as only a few milliwatts of power are required to charge the digits. The DIGI-VISOR incorporates a moving coil movement which moves a translucent scale through an optical system and the resultant single plane image is projected on a screen. The translucent scale is made to represent digits 0-9. Specification: 6·3 Volt, 250 Microamp. Image height 7/8 in. Size 4 1/16 x 2 7/64 x 1 5/8 in. List price £8·90. **Our Price £2.**

LOW FREQUENCY RESOLVED COMPONENT INDICATOR BY SOLARTRON

Type VP 253.2A. This instrument will indicate by means of two centre zero 6 in. scale meters the resolved components of a signal voltage with respect to the applied reference energisation. Frequency range 0·5 c/s-1 Kc/s. Signal voltage ranges: 50 MV, 150 MV, 500 MV, 1·5V, 5V, 50V, 15V, and 150V, with either balanced or unbalanced input. Signal Input Resistance: 10 MΩ unbalanced, 20 MΩ balanced. Reference Input Voltage 90/130 or 230/240V. Standard Rack Panel 19 in. x 12½ in. New condition complete with manual. **Price £45·00.**

VHF ADMITTANCE BRIDGE

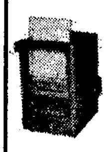
Wayne Kerr B801A 1-100 MHz. Conductance 0-100 milliohms. Capacitance 0-230 pF and 0-230 pF **£25·00.**
Also B901. Indicates parallel components of conductance and positive or negative capacitance for lines, antennas and feeders 0-100 milliohms, 0 to +/– 75 pF and –75 pF. Accuracy 2% up to 250 MHz. **Price £75·00.**

FENLOW LOW FREQUENCY ANALYSER

0·3 Hz to 1 KHz. Power density 0-10. Bandwidth switching range 06: 0·3: 1·5: 7·5: 37·5 Hz. **Price £95.**

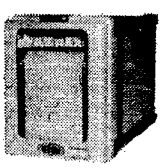
HONEYWELL ELECTRONIC POTENTIOMETRIC RECORDER

The following types are available:
1. Model Y15301115-01-01-0-(150)-01-002-202. Range 600-1300°C.R. **PRICE £95·00.**
2. Model Y153X18-/VAH/-11-111-118-/P8/DN2 Range 0-20 MV. **PRICE £95·00**



BRAND NEW MINIATURISED STRIP CHART RECORDER BY RUSTRAK

of America. This Recorder indicates the magnitude of applied currents or voltages by a continuous distortion-free line on pressure sensitive paper. Moving coil movement, scale calibrated 0-1 milliamp d.c. internal resistance 100 ohms. Chart drive motor 240 V 50 Hz. Chart speed 1" per hour. Complete with handbook. Price **£35.00** plus **£5.00** packing and carriage.



SINGLE PEN RECORDER

by Record Electrical. 3" chart, sensitivity 1 milliamp, chart speed 1" and 6" per hour. Size 8" x 11" × 6". Offered complete with pen assembly and spare chart. Listed at over £100 — this month's special price due to bulk purchase . . . **£39.50** plus **£5.00** packing and carriage.

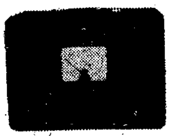
TRANSITROL TEMPERATURE CONTROLLER TYPE 990

Completely transistorised self-contained direct deflecting units for indicating and controlling temperature accurately over a wide range. Suitable where a signal can be converted into d.c. Sensitivity 10 ohms per MV. Minimum F.S.D. 8 MV. Cold junction compensation. Calibrated scale length 6.5", 0-800°C. Accuracy +/–1%. Front panel size 10" × 8¼", weight 11 lbs. Mains supply 100-260 V. Control switching and thermocouple connections all at back of case. Price **£18.50** plus **£2.00** packing and carriage.

POWER SUPPLIES, IBM EX-COMPUTER HIGHLY STABILISED, TRANSISTORISED LOW VOLTAGE POWER SUPPLIES.

These modular units incorporate overload protection on both INPUT and OUTPUT. Load regulation of 1% or better. Low ripple and fast response time. Input voltage 120-130 50 Hz. Available in the following types:

6 volt 8 Amp **£21.00**
6 Volt 12 Amp **£17·00**
6 Volt 16 Amp **£20·00**
12 Volt 4 Amp **£20·00**
12 Volt 12 Amp **£22·00**
12 Volt 20 Amp **£24·00**
30 Volt 7 Amp **£19·00**

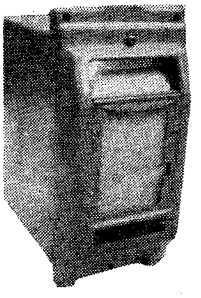


VIBRON ELECTROMETER MODEL 33B

An exceptionally stable laboratory instrument for the measurement of very small d.c. voltages and currents derived from a high impedance. The Vibron Electrometer has input ranges of 10 MV, 30 MV, 100 MV, 300 MV, and 1 V and the output is 1 mA. Full scale on all ranges. The drift does not exceed 100 microvolts in 12 hours and the input resistance is 10 to the power of 13 ohms. Price **£45·00** plus **£5·00** packing and carriage.

SPECIAL OFFER

ELLIOTT SINGLE PEN RECORDER



TYPE 230

A most versatile pen recorder producing a trace on a curvilinear 3 in. strip chart. Two synchronous speeds: 1 in. and 6 in. per hour.
Fitted with high and low alarm contacts operated by the moving coil. Basic movement 0·1mA DC coil resistance 400 ohms. Fitted with rectifier to allow operation on AC effective coil impedance at 50Hz 1800 ohms.
Power supply required: 230V 50Hz.
Applications: ideal for recording relatively slow changing phenomena such as:
Temperature: Gas or liquid Flow Rates, Sound Levels, Speed variations. Power Demand, Rainfall, humidity, etc.
PRICE £25·00
Clockwork version also available
PRICE £29·50

ASCOP DIGITAL ENCODERS

Type 504A-8-001 **Price £20.** Type EDD8G **Price £20.**

SYNCHROVERTER SWITCH TYPE G1280 BY ELLIOTT

PRICE £3.

FREQUENCY CONVERTER MODEL B.40

50 KVA to 60 Hz power frequency converter. Fully overhauled.
Specification:
Prime Mover: Electric Motor
Input: 220/380V 50Hz 3ph
Output: 220V 60Hz 3ph
at 50 KVA with PF of 0·8. **PRICE £450·00**

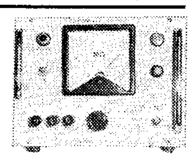
HEWLETT PACKARD DIGITAL RECORDER MODEL 565A

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

HEWLETT PACKARD SAMPLING OSCILLOSCOPE MODEL 185B

Including 187C. DC—100 Meg Hz. **PRICE £395·00**

PYE HIGH RESISTANCE OHMMETER MODEL 10B



Range from 0·3-20,000 Megohms in 4 ranges at 500V. Used for the measurement of components or circuits having high parallel capacitance.
PRICE £20·00

MULLARD VALVE VOLTMETER MODEL E7555/2 **PRICE £20·00**

PHILIPS SQUARE WAVE GENERATOR MODEL GM2314

Range 15 c/s-200 Kc/s. Duration of square wave pulses between 0·75 μ/sec and 40 m/sec. Square wave voltage 10V **PRICE £75·00**

A.E.I. POTENTIOMETRIC RECORDER

0-2·5 MV, 5, 7·5, 10, 15 MV. Chart speed 1 rpm-3 rpm OR 1 rph-3 rph. **PRICE £45·00**

FOSTER CHART RECORDER TYPE 3671 RY-6

Sensitivity 0-20 MV, –50 MV, 100 MV. Chart speed 1·5 cm/hr-6 cm/hr. **PRICE £35·00**

DUPLEX RECORD 2 PEN RECORDER

30 day clockwork —50/0/50 m/A **PRICE £55·00**

DUPLEX RECORD 3 CHANNEL PEN RECORDER

0-10 M/A. Speed 1" per hour. **PRICE £95·00**

COLVERN DIGITAL CODERS (Shaft Digitisers)

Digital Coders are electromechniacal devices, which give a unique parallel digital code output representing the angular position of the shaft. The current handling capacity is sufficient to operate relay decodes and indicators direct without intermediate stage of amplication.3 size magslip, 256 divisions, max. torque for reflected binary code 4·5 oz. ins. **PRICE £10·00.**

LEEDS & NORTHRUP STRIP CHART RECORDER

This well-known instrument is fitted with a Series 60 control unit servo amplifier 101041 BR EQ. Range: 5·571 to 18·855. Ref. junction 320F. Primary element: P1. P1. 13% RH JMC. Response time: 5 secs. for f.s.d. Chart width: 7 in. Chart speed: 1 in. per hour. Power supply: 120V 50 Hz (auto-transformer available). Dimensions: Ht. 18", width 11", depth 12½". Weight 51 lbs. **PRICE £120·00**

WIDE RANGE OSCILLATOR TYPE 400C by DAWE

1 c/s-1,000 c/s. **PRICE £35·00**

FANS BY PLANNAIR

115V-3 Phase 400 c/s-11,000 rpm. Type 1PL41-234 **PRICE £4·00**

DOUBLE PULSE GENERATOR TYPE TF 1400/S

10 c/s-100 Kc/s. Complete with TM 6600. Pulse adjustable between 1·5 μsec. before and up to 3,000 μsec. **PRICE £145·00**

R.C. OSCILLATOR TYPE G432 by FURZEHILL

Square and sinewave. 250 Kc/s. **PRICE £25·0**

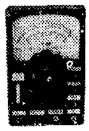
MARCONI TF867 STANDARD SIGNAL GENERATOR

Carrier Frequency. Range: 15Kc/s-30Mc/s in 11 bands. Calibration Accuracy: ± 1%. Stability: After warm up the drift in a 10-minute period is, typically, less than 0·005% for carrier frequencies up to 3·2Mc/s and less than 0·01% from 3·2-2·30Mc/s. Output Voltage: 0·4μV-4V. Impedance: 75 ohms nominal for outputs from 2-4 v. 75 ohms for outputs from 4μV-2V. 13 ohms for outputs from 0·4μV-0·4V.
Accuracy: below 3Mc/s ±0·25dB of ±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 × 21 in. wide × 14½ in. deep. **Price £165·00**

ELECTRONIC BROKERS LIMITED
49/53 PANCRAS ROAD : LONDON NW1 2QB. Tel: 01-837 7781
ADD 10% VAT TO ALL PRICES

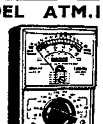
GWS G.W.SMITH & CO (RADIO) LTD

TS60 POCKET MULTIMETER



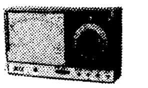
High-precision at low-cost. Ranges: D.C. 15V., 150V., 1,000V. (10,000 opv). A.C. 15V, 150V., 100V. (1,000 opv).
D.C. Current 150mA. Resistance 100k/ohms. **£1·85.** Post 15p.

AUDIOTRONIC MODEL ATM.I



Top value 1000 p.p.v. pocket multimeter.
Ranges: 0/10/50/250/1000v. AC and DC. DC Current 0-1mA/100mA. Resistance 0/150k ohms. Decibels —10 to +22dB. Size 90 × 60 × 28mm. Complete with test leads.
£2·50. Post 15p.

LT601 MULTIMETER

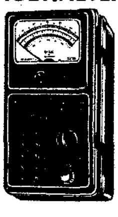


New style 20,000 o.p.v. pocket multimeter.
5 / 25 / 50 / 250 / 2500V. D.C.
10/50/100/500/1000V. A.C.
50μA/250mA. 6K/6 meg ohms. −20 to +22db.
£3·75. Post 20p.

MODEL TH-12

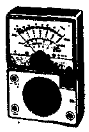
20,000 o.p.v. Overload protection. Slide switch selector.
0/·25/2·5/10/50/250/1000V. D.C.
0/10/50/250/1000V. A.C.
0/50μA/25/250mA D.C.
0/3K/30K/300K/3 meg. −20 to +50db.
£4·97. Post 15p.

RUSSIAN 22 RANGE MULTIMETER



Model U437 10,000 o.p.v.
A first class versatile instrument manufactured in U.S.S.R. to the highest standards. Ranges: 2·5/10/50/250/500/1000v D.C. 2·5/10/50/250/500/1000v A.C. D.C. Current 100 wA/1/10/100 mA/1A. Resistance 300 ohms/3/30/300K/3MΩ Complete with batteries, test leads, instructions and sturdy steel carrying case.
Our Price **£5·97.** Post 25p.

HIOKI MODEL 730X

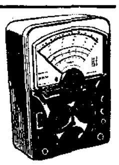


30,000 O.P.V. Overload protection. 6/30/60/300/600/1200 VDC. 12/60/120/600/1200 VAC. 60 μA/30 mA/300 mA. 2K/200K/2 megohm. −10 to +63 db. **£6·50.** Post 15p.

MODEL PL436

20kΩ/Volt D.C. 8kΩ/Volt A.C. Mirror scale. ·6/3/12/30/120/600V D.C. 3/30/120/600V A.C. 50/600μA/60/600 mA. 10/100K/1 Meg/10 meg Ω.—20 to +46db. **£6·97.** Post 12p

MODEL 500



30,000 O.P.V. with overload protection, mirror scale. 0/·5/2·5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50μA/5/50/500mA. 12 amp. D.C. 0/60/K/6 meg/60 meg Ω.
£8·87. Post paid.

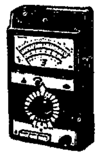
"JOSTY KIT" HIGH QUALITY CONSTRUCTION KITS

Appointed stockists at all branches

AF20	Mono Transistor Amplifier	£4·80
AF30	Mono Transistor Pre-Amplifier	£2·61
AF310	Mono Amplifier (for Stereo use two)	£5·91
AT5	Automatic Light Control	£2·58
AT30	Photo Cell Switching Unit	£5·70
AT50	400 Watt Triac Light Dimmer Speed Control	£4·80
AT55	1,300 Watt Triac Light Dimmer Speed Control	£5·70
AT56	2,200 Watt Triac Light Dimmer Speed Control	£6·90
AT60	Psychedelic Light Control, Single Channel	£7·80
AT65	Psychedelic Light Control, 3 Channel	£14·55
HF61	Medium Wave Transistor Radio	£3·33
HF65	F.M. Transistor Transmitter	£2·70
HF75	F.M. Transistor Receiver	£2·88
HF310	F.M. Tuner Unit	£15·81
HF325	De-Luxe F.M. Tuner Unit	£24·12
HF330	Stereo Decoder for use with HF310 or HF325	£9·96
HF395	Aerial Amplifier for AM/FM Bands I, II and III	£1·77
GP310	Stereo Pre-Amp to use with 2, AF310	£21·27
GU330	Tremolo Unit for guitars, etc.	£7·50
NT10	Power Supply 100 m/a 9V Stab, 12V Unstab	£6·15

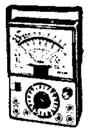
Postland Packing 15p per kit
Complete with comprehensive, easy to follow instructions and covered by full guarantee.

U4312 MULTIMETER



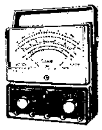
Extremely sturdy instrument for general electrical use. 667 o.p.v. 0/·3/1·5/7·5/30/60/150/300/600/900 VDC and 75mV. 0/·3/1·5/7·5/30/60/150/300/600/900 VAC. 0/300μA/1·5/6/15/60/150 600MA/1·5/6 AMP. D.C. 0/1·5/6/15/60/150/600MA/1·5/6 AMP. A.C. 0/200 Ω/3K/30K Ω. Accuracy DC 1%. AC 1·5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, eads and instructions. **£9·50.** Post 25p.

HIOKI MODEL 700X



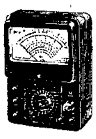
100,000 O.P.V. Overload protection. Mirror scale. ·3/·6/1·2/1·5/3/6/12/30/60/120/300/600/1200 VDC. 1·5/3/6/12/30/60/150/300/600/1200 VAC. 15/30vA/3/6/30/60/150/300 mA. 6/12 AMP DC. 2K/200 K/2 Meg/20 megohm. −20 to +63db. **£13·50.** Post 20p.

MODEL C-7080 EN



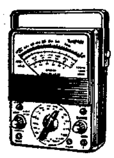
Giant 6in. mirror scale. 20,000 o.p.v.
0/·25/1/2·5/10/50/250/1000/5000V. D.C.
0/2·5/10/50/250/1000/5000V. A.C.
0/50μA/1/10/100/500mA/10 amp. D.C.
0/2K/200K/20 meg. −20 to +50 db.
£13·95. Post 35p.

370 WTR MULTIMETER



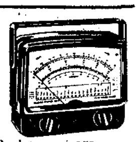
Features A.C. current ranges. 20,000 o.p.v.
0/·5/2·5/10/50/250/500/1000 V DC
0/2·5/10/50/250/500/1000 V AC
0/50μA/1/10/100MA/1/10 Amp DC.
0/100MA/1/10 Amp AC.
0/5K/50K/500K/5MEG/50MEG.
— 20 + 62 db.
£15. Post 25p.

KAMODEN 72.200 MULTITESTER



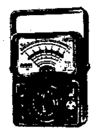
High sensitivity tester. 200,000 o.p.v. Overload protection. Mirror scale. Range 0/·06/·3/3/30/120/600/1200\ D.C.
0/3/12/60/300/11,200V A.C.
0/6μA/1·2mA/120mA/600m/12A. D.C.
0/12A. A.C.
−20 to +63dB.
0/2K/200K/2 meg/200 meg ohms.
£16·95. Post 30p.

TMK LAB TESTER



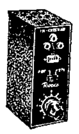
100,000 O.P.V: 6½ in. Scale Buzzer Short Circuit Check. Sensitivity: 100,000 OPV D.C. 5K/Volt A.C. D.C. Volts: .5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 3, 10, 50, 250, 500, 1,000V. D.C. Current: 10, 100μA, 10, 100, 500mA, 2.5, 10 amp. Resistance: 1K, 10K, 100K, 10MEG, 100MEG. Decibels: −10 to +49 db. Plastic Case with carrying handle. Size 7½ × 6⅜ × 3⅛. **£18·95.** P.& P. 25p.

MODEL S-100TR MULTIMETER/TRANSISTOR TESTER



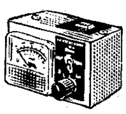
100,000 o.p.v. MIRROR SCALE/OVERLOAD PROTECTION.
0/·12—·6/3/12/30/120/600 V DC.
0/6/30/120/600 V. AC.
0/12/600uA/12/300MA/12 Amp. DC.
0/10K/1 MEG/100 MEG.
−20 to + 50 db. 0·01 —·2 mfd.
Transistor tester measures Alpha, beta and Ico. Complete with batteries, instructions and leads. **£13·50.** Post 25p.

LB4 TRANSISTOR TESTER



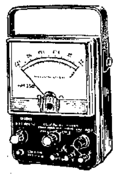
Tests PNP or NPN transistors. Audio indication. Operates on two 1.5v batteries. Complete with all instructions etc. **£4·50.** Post 20p.

LB3 TRANSISTOR TESTER



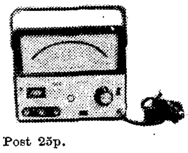
Tests ICO and B. PNP/NPN. Operates from 9v. battery. Complete with all instructions etc. **£3·95.** Post 20p.

KAMODEN HM.350 TRANSISTOR TESTER



High quality instrument to test Reverse Leak current and DC current Amplification factor of NPN, PNP, transistors, diodes, SCR's etc. 4in. × 4⅞in. clear scale meter. Operates from internal batteries. Complete with instructions leads and carrying handle. **£12·50** Post 30p.

MODEL 449A IN CIRCUIT TRANSISTOR TESTER

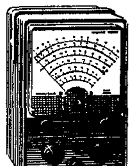


Checks true A.C. beta in/out.
Checks Icbo.
Checks diodes in/out.
Checks SCR etc.
Beta HI 10–500.
LO2–50.
Icbo 0–5000μA.
220/240V. A.C. operation. **£17·50.** Post 25p.

MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER

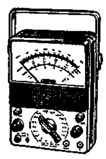
Sensitivity 330 ohms/Volt A.C. and D.C. Accuracy ·5% D.C. 1% A.C. Scale length 165mm.
0/300/750μA/1·5/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 Amp. D.C. 0/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 Amp. A.C.
0/75/150/300/750mV/1·5/3/7·5/15/30/75/150/300 750V. D.C.
0/750mV/1·5/3/7·5/15/30/75/150/300/650V. A.C.
Automatic cut out. Supplied complete with test leads, manual and test certificates. **£49.** Post 50p

TE-65 VALVE VOLTMETER



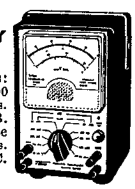
High quality instrument with 28 ranges.
D.C. volts 1.5-1,500 v.
A.C. volts 1.5-1,500 v.
Resistance up to 1,000 megohms.
220/240v. A.C. operation Complete with probe and instructions. **£17·50.** Post 30p.
Additional Probes available: R.F. **£2·12** H.V **£2·50.**

KAMODEN HM.720B F.E.T. V.O.M.



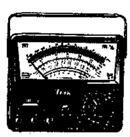
Input impedance 10 meg. ohms.
Ranges:
0/·25/1/2·5/10/50/250/1000V, D.C.
0/2·5/10/50/250/1000V. A.C.
0/25μA/2·5/25/250 MA D.C.
−20 to +62dB
0/5K/50K/500K/5 meg/500 meg ohms.
£14·95. Post 30p.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER



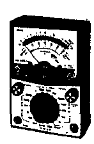
10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels −40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. **£17·50** Carr. 25p.

TMK MODEL 117 ELECTRONIC VOLTMETER



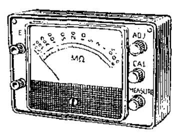
Battery operated, 11 meg input. 26 ranges. Large 4½in. mirror scale. Size 5⅞ × 4⅞ × 2⅛in. DC Volts 0·3-1200V. AC Volts 3-300V RMS. 8·0-800V. P-P. DC Current ·12-12MA. Resistance up to 2000M ohm. Decibels −20 to +51 db. Complete with leads/instructions. **£17·50.** P. & P. 20p.

MODEL L-55 FET V.O.M.



Input impedance 10 meg. ohms.
0/3/1·2/6/30/120/600V. D.C.
0/3/12/60/120/600V. A.C.
0/120μA/120mA. D.C.
0/1K/100K/10 meg/100 meg ohms. **£15·97.** Post 25p.

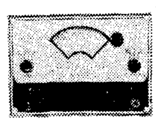
KAMODEN HMG-500 INSULATION RESISTANCE TESTER



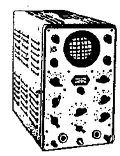
Range 0-1000 Megohms, 500 Volt. Battery operated. Wide range clear meter 4⅞in. × 4in. Complete with de luxe carrying case, batteries, instructions. **£19·95.** Post 30p.

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR

Sine 18-200,000 Hz; Square 18-50,000 Hz
Output max. + 10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case 7½in. × 5in. × 2in.
Price **£17.50**
Carr. 17p.



CI-5 PULSE OSCILLOSCOPE

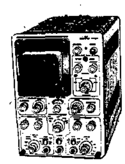


For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth 10MHz. Sensitivity at 100KHz VRMS/mm. .1-25; HOR. AMP. Bandwidth 500KHz. Sensitivity at 100KHz, V RMS/mm. .3-25; Preset triggered sweep 1–3,000μsec.; free running 20–200,000Hz in nine ranges. Calibrator pips. 220 × 360 × 430mm. 115-230V. A.C. operation. **£39·00.** Carr. paid.

TO-3 PORTABLE OSCILLOSCOPE 3in. TUBE

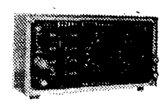
Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps –1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook **£47·50.** Carr. 50p.

RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE



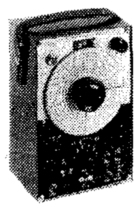
5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. × 4in. C.R.T. Calibrated triggered sweep from ·2 μ/sec. to 100 milli-sec. per cm. Free running time base 50 c/s–1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. **£87** Carr. paid.

MODEL AT201 DECADE ATTENUATOR



Frequency range: 0–200KHz.
Attenuator: 0-111db., 0·1db. step.
Impedance 600 ohms.
Max. input power 30dbm.
Size 180 × 90 × 55mm. **£12·50.** Post 37p.

ARF-300 AF/RF SIGNAL GENERATOR



All transistorised, compact, fully portable. AF sine wave 18Hz. to 220KHz.
AF square wave 18Hz. to 100KHz.
Output sine/square 10v. P-P. RF 100KHz. to 200 MHz. Output 1v. maximum. Operation 220/240v. A.C.
Complete with instructions and leads. **£29·95.** Post 50p.

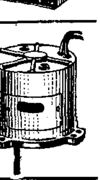
TE-20 D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 Kc/s–500 Mc/s on 6 bands. Directly calibrated Variable R.F. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. **£15.** Carr. 37p. Size 140 × 215 × 170 mm.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

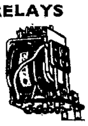
Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s.
Output impedance 5,000 ohms, 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads, **£17·50.**
Carr. 37p.

230v/240v SMITHS SYNCHRONOUS GEARED MOTORS



Built-in gearbox. All brand new and boxed. 30 RPH CW; 2 RPH CW; 20 RPH CW; 2 RPH ACW; 30 RRH CW.
50p each. Post 12p.

230 VOLT A.C. 50 c/s RELAYS

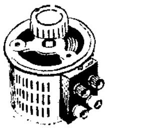


Brand new. 3 sets of changeover contacts at 5 amp rating. **50p** each. Post 10p (100 lots **£40**). Quantities available.

ALL PRICES ARE EXCLUSIVE OF 10% V.A.T.

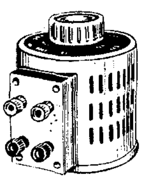
"YAMABISHI" VARIABLE VOLTAGE TRANSFORMERS

Excellent quality at low cost. All models—Input 230v. 50/60 c/s. Variable output 0-260v.



MODEL S-260 GENERAL PURPOSE BENCH MOUNTING

1 Amp ..	£7·00
2·5 Amp ..	£8·05
5 Amp ..	£11·75
8 Amp ..	£15·90
10 Amp ..	£22·50
12 Amp ..	£23·60
20 Amp ..	£49·00
25 Amp ..	£58·00
40 Amp ..	£82·50



MODEL S-260B

Panel Mounting.

1 Amp ..	£7·00
2·5 Amp ..	£8·05

Carriage and Packing Extra

AUTO TRANSFORMERS

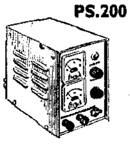
0/115/230V. Step up or step down. Fully shrouded.

80 W	£2·10	P. & P. 18p
150 W	£2·70	P. & P. 18p
300 W	£3·60	P. & P. 23p
500 W	£5·25	P. & P. 33p
1000 W	£7·50	P. & P. 38p
1500 W	£10·20	P. & P. 43p
2250 W	£17·25	P. & P. 50p
5000 W	£35·00	P. & P. £1

MCA. 220 AUTOMATIC VOLTAGE STABILISER

Input 88-125 VAC or 176-250VAC. Output 120VAC or 240VAC. 200VA rating. **£11.97.** Carr. 50p.

PS.200 REGULATED P.S.U.

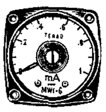


Solid state. Variable output 5-20 volt D.C. up to 2 amp. Independent meters to monitor voltage and current. Output 220/240 V. A.C. Size 7½" × 5¾" × 3⅞". **£19·95.** Post 25p.

PS.1000B REGULATED P.S.U.

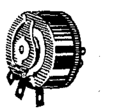
Solid state. Output 6-9 or 12 V. D.C. up to 3 amps. Meter to monitor current. Input 220/240 V. A.C. Size 4" × 3¼" × 6¼". **£11·97.** Post 25p.

240° WIDE ANGLE 1mA METERS



MW1·6 60mm. square **£3·97**
MW1·8 80mm. square **£4·97**
Post extra.

POWER RHEOSTATS



High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ¼in. dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. **95p.** P. & P. 10p.
50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. **£1·35.** P. & P. 10p.
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. **£1·95.** P. & P. 15p.

HOMER INTERCOMS

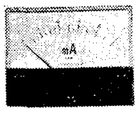
Ideal for home, office, stores, factories, etc. Supplied complete with batteries, cable and free instructions.
2 Station **£2·97.** P. & P. 15p.
3 Station **£5·25.** P. & P. 15p.
4 Station **£6·62.** P. & P. 17p.

SEW CLEAR PLASTIC PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVT. DEPTS., EDUCATIONAL AUTHORITIES, etc.

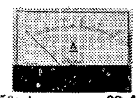
Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

TYPE SW.100 100 × 80mm



		100µA	£3·95
		100–0–100µA	£3·90
		500µA	£3·70
		1mA	£3·60
		20V. D.C. ...	£3·60
		50V. D.C. ...	£3·60
		300V. D.C. ..	£3·60
		1 amp. D.C..	£3·60
		5 amp. D.C..	£3·60
50µA	£4·15	300V. A.C. ..	£3·70
50–0–50µA ..	£3·95	VU Meter....	£4·30

TYPE SD.830 82·5mm × 110mm Fronts



		10mA	£3·10
		50mA	£3·10
		100mA	£3·10
		500mA	£3·10
		1 amp.	£3·10
		5 amp.	£3·10
		10 amp.	£3·10
50µA	£3·40	5V. D.C......	£3·10
50–0–50µA ..	£3·40	10V. D.C.....	£3·10
100µA	£3·35	20V. D.C.....	£3·10
100–0–100µA	£3·35	50V. D.C.....	£3·10
200µA	£3·30	300V. D.C...	£3·10
500µA	£3·15	15V. A.C.....	£3·30
1mA	£3·10	300V. A.C....	£3·30
5mA	£3·10	VU Meter....	£3·50

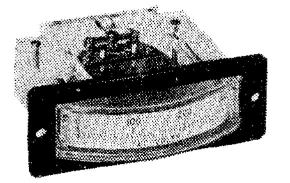
TYPE SD.640 63·5mm × 85mm Fronts

50µA	£3·05	500mA	£2·90
50–0–50µA ..	£3·05	1 amp.	£2·90
100µA	£3·00	5 amp.	£2·90
100–0–100µA	£3·00	10 amp.	£2·90
200µA	£3·00	5V. D.C.	£2·90
500µA	£2·95	20V. D.C.	£2·90
1mA	£2·90	50V. D.C.....	£2·90
5mA	£2·90	300V. D.C....	£2·90
10mA	£2·90	15V. A.C.....	£3·00
50mA	£2·90	300V. A.C....	£3·00
100mA	£2·90	VU Meter....	£3·15

TYPE SD.460 46mm × 59.5mm Fronts

50µA	£2·80	500mA	£2·60
50–0–50µA ..	£2·80	1 amp.	£2·60
100µA	£2·75	5 amp.	£2·60
100–0–100µA	£2·75	10 amp.	£2·60
200µA	£2·70	5V. D.C.	£2·60
500µA	£2·55	10V. D.C.....	£2·60
1mA	£2·60	20V. D.C.....	£2·60
5mA	£2·60	50V. D.C.....	£2·60
10mA	£2·60	300V. D.C....	£2·60
50mA	£2·60	15V. A.C.....	£2·70
100mA	£2·60	300V. A.C....	£2·70
		VU Meter ...	£2·90

"SEW" EDGWISE METERS TYPE P.E.70



3 17/32in. × 1 15/32in. × 2¾ in. deep.

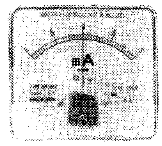
50µA	£3·75	500µA	£3·20
50–0–50µA ..	£3·60	1mA	£3·20
100µA	£3·60	300V. A.C....	£3·25
100–0–100µA	£3·50	VU Meter ...	£3·85
200µA	£3·40		

✻ MOVING IRON—

ALL OTHERS MOVING COIL

Please add postage

TYPE MR.85P 4¼in. × 4¾in. fronts.



		10mA	£3·90
		50mA	£3·90
		100mA	£3·90
		500mA	£3·90
		1 amp.	£3·90
		5 amp.	£3·90
		15 amp.	£3·90
		30 amp.	£3·95
		20V. D.C.....	£3·90
		50V. D.C......	£3·90
		150V. D.C. ..	£3·90
50µA	£4 40	300V. D.C. ..	£3·90
50–0–50µA ..	£4 25	15V. A.C.	£3·90
100µA	£4 25	300V. A.C. ..	£3 90
100–0–100µA	£4·05	S Meter 1mA	£3·90
200µA	£4·05	VU Meter	£4·55
500µA	£3·90	1 amp. A.C.*..	£3·90
5000–500µA..	£3·90	5 amp. A.C.*..	£3·90
1mA	£3·90	10 amp. A.C.*	£3·90
1–0–1mA....	£3·90	20 amp. A.C.*	£3·90
5mA	£3·90	30 amp. A.C.*	£3·90

TYPE MR.52P 2⅜in. square fronts.

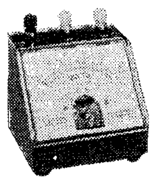
50µA	£3·50	10V. D.C.....	£2·50
50–0–50µA ..	£3·05	20V. D.C.....	£2·50
100µA	£3·00	50V. D.C. ...	£2·50
100–0–100µA	£2·95	300V. D.C. ..	£2·50
500µA	£2·65	15V. A.C.	£2·60
1mA	£2·50	300V. A.C. ..	£2·60
5mA	£2·50	S Meter 1mA .	£2·60
10mA	£2·50	VU Meter ...	£3·60
50mA	£2·50	1 amp. A.C.*	£2·50
100mA	£2·50	5 amp. A.C.*	£2·50
500mA	£2·50	10 amp. A.C.*	£2·50
1 amp.	£2·50	20 amp. A.C.*	£2·50
5 amp.	£2·50	30 amp. A.C.*	£2·50

TYPE MR.65P 3½in. × 3¼in. fronts

50µA	£3·70	10V. D.C.....	£2·60
50–0–50µA ..	£3·15	20V. D.C.....	£2·60
100µA	£3·15	50V. D.C.....	£2·60
100–0–100µA	£3·10	150V. D.C. ..	£2·60
200µA	£3·05	300V. D.C....	£2·60
500µA	£2·75	15V. A.C.	£2·80
500–0–500µA	£2·60	50V. A.C.	£2·80
1mA	£2·60	150V. A.C....	£2·80
5mA	£2·60	300V. A.C. ..	£2·80
10mA	£2·60	500V. A.C. ..	£2·80
50mA	£2·60	S Meter 1mA	£2·85
100mA	£2·60	VU Meter ...	£3·70
500mA	£2·60	50mA A.C.*..	£2·60
1 amp.	£2·60	100mA A.C.*	£2·60
5 amp.	£2·60	200mA A.C.*	£2·60
10 amp.	£2·60	500mA A.C.*	£2·60
15 amp.	£2·60	1 amp. A.C.*	£2·60
20 amp.	£2·60	5 amp. A.C.*	£2·60
30 amp.	£2·80	10 amp. A.C.*	£2·60
50 amp.	£2·90	20 amp. A.C.*	£2·60
5V. D.C.	£2·60	30 amp. A.C.*	£2·60

"SEW" EDUCATIONAL METERS

TYPE ED.107



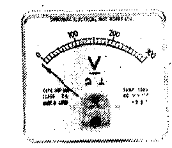
Size overall 100mm × 90mm × 108mm.

A new range of high quality moving coil instruments ideal for school experiments and other bench applications. 3in. mirror scale. The meter movement is easily accessible to demonstrate internal working.

Available in the following ranges:—

50µA	£6·90	10V D.C.	£9·95
100µA	£6·40	20V D.C.	£5·95
1mA	£5·95	50V D.C.	£5·95
50–0–50µA ..	£6·40	300V D.C. ..	£5·95
1–0–1mA	£5·95	Dual range	
1A D.C.	£5·95	500mA/5AD.C.	£7·00
5A D.C.	£5·95	5V/50V. D.C.	£7·00

TYPE MR. 38P 1 21/32in. square fronts.



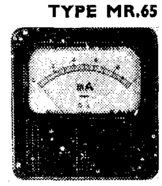
		150mA	£2·25
		200mA	£2·25
		300mA	£2·25
		500mA	£2·25
		750mA	£2·25
		1 amp.	£2·25
		2 amp.	£2·25
		5 amp.	£2·25
		10 amp.	£2·25
		3V. D.C.	£2·25
		10V. D.C.....	£2·25
50µA	£2·55	15V. D.C.	£2·25
50–0–50µA ..	£2·50	20V. D.C.....	£2·25
100µA	£2·45	50V. D.C. ...	£2·25
100–0–100µA	£2·40	100V. D.C. ..	£2·25
200µA	£2·25	150V. D.C. ..	£2·25
500µA	£2·25	300V. D.C. ..	£2·25
500–0–500µA	£2·25	500V. D.C. ..	£2·25
1mA	£2·25	750V. D.C. ..	£2·25
1–0–1mA	£2·25	15V. A.C.....	£2·30
mA	£2·25	50V. D.C.....	£2·30
5mA	£2·25	150V. A.C. ..	£2·30
10mA	£2·25	300V. A.C. ..	£2·30
20mA	£2·25	500V. A.C. ..	£2·30
50mA	£2·25	S Meter 1mA	£2·30
100mA	£2·25	VU Meter ...	£2·65

TYPE MR.45P 2in. square fronts.

50µA	£2·70	5 amp.	£2·40
50–0–50µA ..	£2·65	10V. D.C.....	£2·40
100µA	£2·60	20V. D.C. ...	£2·40
100–0–100µA	£2·50	50V. D.C. ...	£2·40
200µA	£2·50	300V. D.C. ..	£2·40
500µA	£2·45	15V. D.C. ..	£2·40
500–0–500µA	£2·40	300V. D.C. ..	£2·40
1mA	£2·40	S Meter 1mA	£2·50
5mA	£2·40	VU Meter ...	£2·70
10mA	£2·40	1 amp. A.C.*..	£2·40
50mA	£2·40	5 amp. A.C.*	£2·40
100mA	£2·40	10 amp. A.C.*	£2·40
500mA	£2·40	20 amp. A.C.*	£2·40
1 amp.	£2·40	30 amp. A.C.*	£2·40

"SEW" BAKELITE PANEL METERS

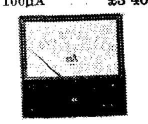
TYPE MR.65 3½in. square fronts.



		1 amp.	£2·60
		5 amp.	£2·60
		15 amp.	£2·60
		30 amp.	£2·60
		50 amp.	£2·60
		5V. D.C.	£2·60
		10V. D.C.....	£2·60
		20V. D.C. ..	£2·60
		50V. D.C. ..	£2·60
		150V. D.C. ..	£2·60
		300V. D.C. ..	£2·00
25µA	£4·60	30V. A.C.* ..	£2·65
50µA	£3·55	50V. A.C.* ..	£2·35
50–0–50µA ..	£3·35	150V. A.C.*..	£2·65
100µA	£3·00	300V. A.C.*..	£2·65
100–0–100µA	£3·00	500mA A.C.*	£2·60
500µA	£2·70	1 amp. A.C.*	£2·60
500–0–500µA	£2·70	5 amp. A.C.*	£2·60
1mA	£2·60	10 amp. A.C.*	£2·60
1–0–1m A....	£2·60	20 amp. A.C.*	£2·60
5mA	£2·60	30 amp. A.C.*	£2·60
10mA	£2·60	50 amp. A.C.*	£2·60
50mA	£2·60	VU Meter	£3·65
100mA	£2·60	50 mV D.C. ..	£2·90
500mA	£2·60	100mV D.C...	£2·90

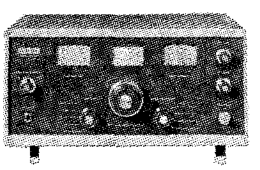
TYPE S.80 80mm Square Fronts

50µA	£3·50	100–0–100µA	£3·30
50–0–50µA ..	£3·40	500µA	£3·05
100µA	£3·40	1mA	£3·00
		20V. D.C.....	£3·00
		50V. D.C.....	£3·00
		300V. D.C. ..	£3·00
		1 amp. D.C...	£3·00
		5 amp. D.C...	£3·00
		300V. A.C. ..	£3·00
		VU Meter	£3·70



Send SAE for list of Semi Conductors and Valves

TRIO 9R59DS RECEIVER

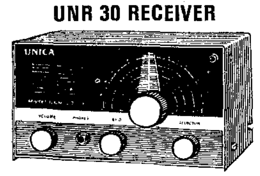


4 bands covering 550 kc/s to 30 mc/s continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW. ANL. Variable BFO. S meter. Sep. bandspread dial. IF frequency 445 kc/s. audio output 1.5w. Variable RF and AF gain controls 115/250 v. A.C. Size: 7in. × 13in. × 10in. with instruction manual.

OUR PRICE £49·50 Carr. Paid.

FULL TRIO RANGE STOCKED.

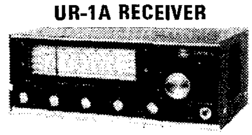
UNR 30 RECEIVER



4 Bands covering 550 kc/s-30 mc/s. B.F.O. Built-in Speaker 220/240 v. A.C. Brand new with instructions.

OUR PRICE £15·75 Carr. 37p

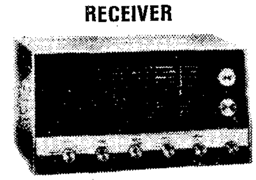
UR-1A RECEIVER



4 Bands covering 550 kc/s-30 mc/s. FET, S Meter. Variable BFO for SSB. Built-in Speaker, Bandspread, Sensitivity Control. 220/240 v. A.C. or 12 v. D.C. 12¾in. × 4¾in. × 7in. Brand new with instructions.

OUR PRICE £25·00 Carr. 37p

LAFAYETTE HA-600 RECEIVER



General coverage 150-400 kc/s. 550 kc/s-30 mc/s. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, S Meter Bandspread. RF Gain. 15in. × 9¼in. × 8¼in. 18 lb. 220/240 v. A.C. or 12 v. D.C. Brand new with instructions.

OUR PRICE £50·00 Carr. 50p

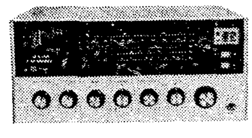
HAND HELD 2-WAY WALKIE TALKIES

Industrial quality in robust metal cases. Battery operation. Volume and squelch controls. Call button and press to talk button. Telescopic aerial. Complete with carrying cases.

2 channel 300 mW. **£52·50** Pair. Post 50p.
3 channel 2 watt. **£79·50** Pair. Post 50p.

Note: Licence required in U.K.

SKYWOOD CX203 RECEIVER



Solid state. 5 bands covering 200-420 KHz and ·55 to 30 MHz. Illuminated slide rule dial. Bandspread. Aerial tuning. BFO, AVC, ANL, "S" meter. AM/CW/SS B. Integrated speaker and phone socket. 220/240 v. A.C. or 12 v. D.C. Size 325 × 266 × 150 mm. Complete with instructions and circuit.

OUR PRICE £32·50 Carr. 50p

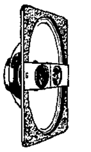
ALL PRICES ARE EXCLUSIVE OF 10% VAT

GWS

ALSO SEE FOLLOWING PAGES

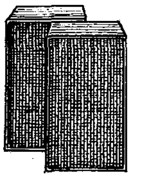
GWS G.W.SMITH & CO (RADIO) LTD

EMI LOUDSPEAKERS



Model 350. 13in. × 8in. with single tweeter/crossover. 20-20,000 Hz. 15 watt RMS. Available 8 or 15 ohms. £7·25 each. P. & P. 37p. Model 450. 13in. × 8in. with twin tweeters/crossover. 55-13,000 Hz. 8 watts RMS. Available 8 or 15 ohms. £3·62 each. P. & P. 25p.

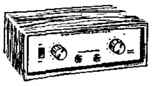
SPECIAL OFFER!
STEREO SPEAKERS



Matched pair of bookshelf speakers. De luxe teak veneered finish. Size 14½in. × 9in. × 7¼in. 8 ohms. 8 watts RMS. 16 watts peak. Complete with DIN lead.

OUR PRICE **£12·95** Carr. 50p

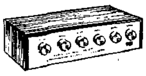
HA-10 STEREO HEADPHONE AMPLIFIER



All silicon transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9 v. battery. Inputs 5MU/100MU. Output 50MW.

OUR PRICE **£5·97** P. & P. 20p

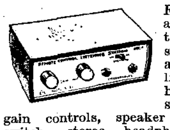
MP7 MIXER PREAMPLIFIER



5 microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. 9¼" × 5" × 3". Inputs Mics: 3 × 3mV 50K; 2 × 3mV 600 ohm. Phono mag. 4 mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K.

OUR PRICE **£8·97** P. & P. 20p

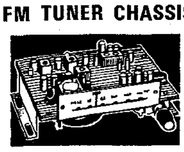
1021 STEREO LISTENING STATION



For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets. 6in. × 4in. × 2¼in.

OUR PRICE **£2·25** P. & P. 20p

FM TUNER CHASSIS



6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6in. × 4in. × 2¼in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money.

OUR PRICE **£5·95** P. & P. 20p

Stereo Multiplex Adaptor £4·97.

ALL PRICES ARE EXCLUSIVE OF 10% V.A.T.

GWS

ALSO SEE PREVIOUS PAGES

SH628 STEREO HEADPHONES

Outstanding value. Soft earpads, adjustable headband. 8-16 ohms. 20-20,000 Hz. Complete with lead and stereo plug.

OUR PRICE **£1·87** P. & P. 30p

TE1018 DE-LUXE MONO HIGH IMPEDANCE HEADSET

Sensitive magnetic headset with soft earpads. Impedance 2,600 ohms (d.c. 600 ohms). Frequency response 200-4000 Hz.

OUR PRICE **£1·97** P. & P. 30p

LIGER LH02S STEREO HEADPHONES

Lightweight headphones with padded earpieces. 4-16 ohms. 20-20,000 Hz. Complete with 6ft cord and plug.

OUR PRICE **£1·95** P. & P. 30p

SDH8V MONO/STEREO HEADPHONES

Two way stereo/mono with volume controls. Padded headband. 4-16 ohms. 20-18,000 Hz. Complete with lead and stereo plug.

OUR PRICE **£4·97** P. & P. 30p

BH001 HEADSET AND BOOM MICROPHONE

Moving coil. Headphone imp. 16 ohms. Mike imp. 200 ohms. Ideal for language teaching, communications etc. Complete with leads and plugs.

OUR PRICE **£4·95** P. & P. 30p

DH.08S Stereo Headphones

De luxe model with unique 2 way mechanical units and volume controls. 8 ohms. 20-20,000 Hz. Complete with coil lead and stereo jack plug.

OUR PRICE **£7·97** P. & P. 30p

ROTEL BARGAIN!
RH700 STEREO PHONES

Soft leather ear cushions. Impedance 8-16 ohms. 20-20,000 Hz. 15ft. coiled lead. Brand New and boxed. (List £9.95).

OUR PRICE **£6·75** P. & P. 30p

4-CHANNEL STEREO HEADPHONES

TTC G3600—Soft vinyl covered head cushion and earphones. Each earpiece incorporates two 2" speaker units. Fitted 2/4 channel changeover switch. Impedance 4-16 ohm. Frequency response 20-20,000 Hz. Complete with 15ft. coiled lead fitted two stereo plugs.

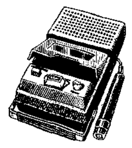
OUR PRICE **£9·95** P. & P. 30p

AUDIOTRONIC

Audiotronic Products are manufactured exclusively for the Audiotronic Group of Companies and as a member of the group we are pleased to offer you this fabulous range of high quality equipment. Made to our own specifications each item provides outstanding performance and reliability at a value for money price!

ACR.14 BATTERY/ MAINS CASSETTE RECORDER

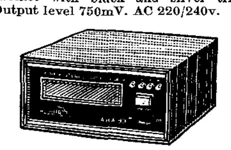
Portable twin track mono recorder with automatic recording level control. Built-in speaker. Earpiece socket. Input for radio or record player. Fast forward and rewind. Output 500mW. AC 220/240v. or 6v. DC operation. Complete with remote control microphone, mains lead, earpiece and batteries.



OUR PRICE **£10·50** P. & P 50p

AHP-8D 8 TRACK STEREO TAPE DECK

Can be used with most hi-fi amplifiers. Push button track selector and illustrated track indicators. Attractive cabinet with black and silver trim. Output level 750mV. AC 220/240v.



OUR PRICE **£11·95** P. & P. 50p

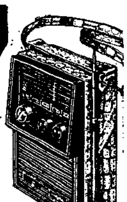
LOW NOISE TAPE CASSETTES

Top quality in library cases.

	5	10	25
C60	£1·29	£2·53	£5·99
C90	£1·85	£3·62	£8·59
C120	£2·29	£4·48	£10·63
	P. & P. 15p	Post Free	Post Free

Tape Head Cleaner 30p each.

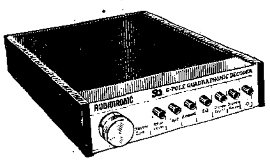
MULTIBAND RADIO



5 wavebandscovering MW 535-1605KHz and FM 88-175MHz. All-transistor. Battery or mains operation. Built in aerial and 8 section telescopic aerial. Complete with batteries, shoulder strap and earpiece.

ONLY **£7·50** P & P 35p

SQ. QUADRAPHONIC DECODER

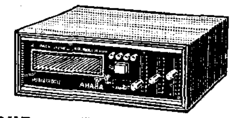


Fully transistorised containing all input, output and control facilities to reproduce 4 channel sound from SQ records and 4 channel discrete sources. Also provides conventional stereo reproduction, 2-channel and 4-channel tape recording and playback and enhancement of conventional 2-channel material. AC 220-240v. Frequency response ± 1dBm. 5Hz to 100KHz. Size: 180mm × 55mm × 220mm deep.

OUR PRICE **£22·50** P. & P. 25p

AHP-8A 8 TRACK STEREO TAPE PLAYER

Incorporates built-in amplifiers giving 4½+4½ watts rms output. Push button track selector, illuminated track indicators, slider controls for volume, balance and tone. Attractive cabinet with black and silver trim. Output impedance 8 ohms. AC 220/240v.



OUR PRICE **£17·25** P. & P. 50p

AUDIOTRONIC DOLBY 'B' NOISE REDUCTION UNITS

Reduce tape hiss by 3dB at 600Hz, 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. Size 16¾" × 8" × 3¼". AC 200/250v.

PROCESS TWO

For use with cassette and tape recorders. Freq. res. 30Hz—20KHz±2dB. Off tape monitoring. Switchable multiplex filter. Two Dolby calibration meters. S/N better than 70dB. Supplied with test cassette or tape as required.

OUR PRICE **£34·50** P. & P. 50p

PROCESS FOUR

For use with semi professional tape recorders. Freq. res. 30Hz—20KHz±2dB. S/N better than 70dB. Full source tape monitoring. Record/Replay metering. Switchable multiplex filter. Supplied with test tape.

OUR PRICE **£50·00** P. & P. 50p

STEREO HEADPHONES

LSH.20 Individual volume controls. Stereo mono switch. 8 ohms. 40-19,000 Hz. **£3·50.** P & P 30p.

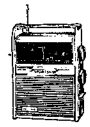
LSH.40 Two way speaker system. Individual volume controls. 8 ohms. 20-20,000 Hz. **£6·95.** P & P 30p.

LSH.60 3in speaker units. 8 ohms. 20-20,000 Hz. Complete with zipped carrying case. **£8·50.** P & P 30p.

LQH.400 4-channel dynamic headphones. Each earpiece has 4 drive units. Two stereo jack plugs fitted to leads. 4-32 ohms. 20-20,000 Hz. **£9·95.** P & P 30p.

LSH.50 Professional Quality Electrostatic. Complete with self powered energiser and control unit with headphone/speaker selector. 4-32 ohms. 20-24,000 Hz. **£15·95.** P & P 30p.

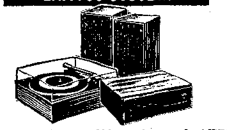
SPORTSMAN AM/FM PORTABLE RADIO MODEL AR.1000



5 wavebands covering AM 535-1065KHz. FM 88-107MHz. AIR 108-135MHz. PB 147-174MHz. WB 162.5MHz. Large horizontal slide dial with logging scale. Slider volume and squelch controls. 7 section telescopic aerial for FM and built-in ferrite bar for AM. AFC. 3in. speaker. Earpiece socket. Green leatherette covered cabinet with metal side panels. Size 152 × 79 × 219mm. Battery/mains operation.

OUR PRICE **£11·50** P. & P. 35p

AUDIOTRONIC LA.1700 SYSTEM



17+17 watt amplifier, Garrard AP76, plinth and cover, G800 cartridge, pair of Wharfdale Linton 2 speakers and all leads.

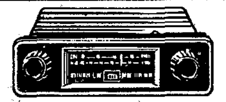
OUR PRICE **£86·95** £1·50 Carr. & Ins.

Matching LT1700 AM/FM Stereo Tuner £37·50.

ACP-8 8 TRACK CAR PLAYER

12v neg. earth. Slider controls for Volume, Tone and Balance. Channel selector button with red pilot lamp. Complete with speakers, mounting brackets and instructions.

ONLY **£12·50** P&P 40p



ACR 3500 CAR RADIO

Manual tuning of Medium and Long waves. 12v pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

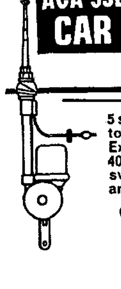
OUR PRICE **£6·50** P&P 50 p

ACR1 PUSH BUTTON CAR RADIO

Push button tuning of one LW and five MW stations of your choice. 12v pos. or neg. earth. Complete with speaker, mounting brackets and instructions.

OUR PRICE **£8·95** P&P 50p

ACA 5SE ELECTRIC CAR AERIAL



5 section. Fully automatic. 12v DC. Extends to approx. 40". Complete with switch, all leads and instructions.

OUR PRICE **£5·95** P & P 50p

SAVE UP TO 33⅓% OR MORE! GWS

AKAI BARGAINS!

AA6300 AM/FM STEREO TUNER AMPLIFIER

20+20 watts rms. Magnetic, ceramic and tape inputs. FM 88-108 MHz. AM 535-1605 kHz. Dual stereo speaker outputs. Headphone socket. (Rec. List Price £117.46).

OUR PRICE **£61·95** P. & P. 75p

CASSETTE (P. & P. 50p)	
CS35D Deck	£44·45
CS35 Recorder	£57·30
CS35/CSS8 Speakers	£67·95
GXC40D Deck	£57·20
GXC40 Recorder	£67·20
GXC40T Deck/Receiver	£99·05
GXC45 Deck	£78·25
GXC46D Dolby Deck	£83·55
GXC46 Recorder	£89·95
GXC60D Deck	£87·65
GXC65D Dolby Deck	£92·65
CARTRIDGE (P. & P. 50p)	
CR81 Deck with amps.	£65·40
CR81D Deck	£53·60
CR81T Recorder/Receiver	£92·75
CR80SS 4 channel Recorder	£114·25
CR80DSS 4 channel Recorder	£93·65
TAPE (P. & P. 75p)	
4000DS Deck	£59·95
4000DS Dust Cover	£3·95
1721L Recorder	£60·35
X5000 Recorder	£82·50
X201D Deck	£108·20
GX220D Deck	£123·95
GX221D	£138·40
GX280D Deck	£196·50
GX370 Deck	£211·50
TAPE/CASSETTE (P. & P. 75p)	
GX1900D Deck	£144·50
TAPE/CARTRIDGE (P. & P. 75p)	
X1810D Deck	£138·40
TAPE/CASSETTE/CARTRIDGE (P. & P. 75p)	
X2000SD Recorder	£180·75
MICROPHONES (P. & P. 50p)	
ADM.11 Dynamic (pair)	£7·50
STEREO RECEIVERS (P. & P. 75p)	
AA6300 20+20 watt	£61·95
AA8030 25+25 watt	£92·50
AA8080 40+40 watt	£117·50
AA8100S 2×36 or 4×18 watt	£175·00
AA8500 65+65 watt	£150·50
STEREO AMPLIFIERS (P. & P. 50p)	
AA5200 20+20 watt	£61·75
AA5500 30+30 watt	£78·50
AA5800 45+45 watt	£117·50
STEREO TUNERS (P. & P. 50p)	
AT550 AM/FM	£60·50
AT580 AM/FM	£94·50
4-CHANNEL UNIT (P. & P. 50p)	
SS1 Synthesiser	£39·95
SPEAKERS (P. & P. 50p)	
CSS8 (Pair)	£10·20
SW155 (each)	£51·00
STEREO HEADPHONES (P. & P. 30p)	
ASE 11	£4·75
ASE 20	£7·30
ASE 22	£8·25

FANTASTIC OFFER!

AKAI CS35D STEREO CASSETTE DECK

High quality 4 track record/playback deck. Accepts chrome/regular tape cassettes. Two VU meters and slider controls for recording level. Photo/Din output/input sockets. Headphone socket for monitoring.

OUR PRICE **£44·45** P. & P. 50p

HANIMEX HRC3061 CASSETTE RADIO

Record/Playback facilities plus slide rule tuning of AM 535-1620 KHz and FM 88-108 MHz. Slider volume controls. Built in condenser microphone plus separate hand/desk microphone. Telescopic aerial. Complete with earpiece, batteries and instructions. (Tape not supplied.) (Rec. List price £55·56).

OUR PRICE **£22·75** P. & P. 50p

RECORD DECKS

Carriage & Packing 50p

B.S.R. McDONALD	
C114 Mini	£3·95
C129 Mono	£5·50
C137	£7·00
510/TPD1	£13·95
610	£9·90
610/TPD1	£14·85
710	£19·20
810	£24·50
710/810 Plinth and Cover	£8·35
MP60	£7·65
MP60/G800	£10·25
MP60/TPD1	£12·60
MP60/TPD2	£11·25
HT70	£10·97
HT70/G800	£13·60
HT70/TPD1	£15·95
CONNOISSEUR	
BD1 Kit	£9·10
BD1 Chassis	£11·35
BD1/SAU2/Plinth/Cover	£27·60
BD2/SAU2/Chassis	£22·70
BD2/SAU2/Plinth/Cover	£28·50
GARRARD	
1025 T Stereo	£4·95
2025 T/C Stereo	£6·40
SP25 III	£8·50
SP25 III/Acos GP104 Ceramic	£8·50
SP25/M75–6	£13·90
AP76	£15·40
SL65B	£11·15
SL72B	£17·75
SL95B	£25·25
401	£23·50
ZERO 100A	£30·30
ZERO 100S	£27·95
GOLDRING	
G99	£18·99
G101P/C	£18·99
GL69/2	£15·75
GL72	£20·97
GL72/P	£27·80
Plinth 69/72	£6·80
LID 72	£2·80
GL75	£26·60
GL75P	£34·40
Plinth 75	£7·80
LID 75	£3·20
GL78P/C	£46·55
GL85P/C	£59·55
THORENS	
TD125/II	£52·15
TD125AB/II	£78·55
TX25	£5·60
TD150A/II	£29·25
TD160C	£43·95

PLINTHS AND COVERS

Carriage and Packing 50p

Budget SP25 etc.	£2·95
Budget 401/Arm	£11·95
Budget AP76/Zero 100S	£3·95
Budget B.S.R.	£2·95
Garrard WB1	£2·20
Garrard SPC1	£2·20
Garrard WB4	£3·25
Garrard SPC4	£2·55
SME2000 System	£26·40

SPECIAL GARRARD OFFERS!

STEREO 1025T

1025T. 4 speed autochanger unit fitted with stereo ceramic cartridge.

OUR PRICE **£4·45** Carr & Ins. 50p

SP25 III WITH ACOS GP 104

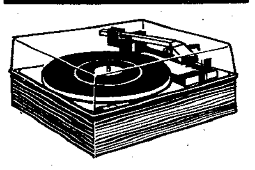
SP25 MKII. 4 speed single record player fitted with Acos GP104 stereo ceramic cartridge.

OUR PRICE **£8·50** Carr & Ins. 50p

SPECIAL OFFER OF NEAT EQUIPMENT (Buy now while stocks last)

Neat G30B Arm	£8·40
	P. & P. 25p
Neat V70 Cartridge (Original pack)	£2·15
Neat V70 Cartridge (Bulk Pack)	£1·50
Neat V70E Cartridge	£3·35
Neat V60 MH Cartridge	£3·15
	P. & P. 12p extra

RECORD DECK PACKAGES



Carriage and Packing 75p

Complete units with Stereo cartridge ready wired in plinth cover.

GARRARD	
2025 TC/9TAHCD	£10·65
SP25 111/G800	£15·00
SP25 111/M44E	£16·45
SP25 111/M44–7	£16·10
SP25 111/M55E	£16·90
SP25 111 Module/M75–6	£18·99
AP76/G800	£23·50
AP76/G800E	£25·95
AP76/M44E	£24·95
AP76/M55E	£25·65
AP76/M75ED	£31·70
AP76/M75EJ	£27·85
AP76 Module M75–6	£26·95
AP96 Module M75–6	£30·40
ZERO 100S Module/M93E	£41·85
B.S.R. McDONALD	
210/SC7M	£6·85
MP60/G800	£15·00
MP60/TPD1/G800	£15·20
MP60/M44–7	£16·60
HT70/TPD1/G800	£18·60
GOLDRING	
GL72/G800	£30·90
GL75/G800	£33·60
GL75/G800E	£36·75
GOODMANS	
TD100/G800 Teak	£46·85
TD100/G800 White	£48·60
LEAK	
Delta/M75–6	£43·95
PHILIPS	
GA105/GP200	£13·80
GA160/GP200 Teak	£19·50
GA308/GP400	£32·75
GA308 (less cartridge)	£23·95
GA212/GP400	£45·25
PIONEER	
PL12D (Less cartridge)	£31·75
PL15C (Less cartridge)	£44·25
PL41D (Less cartridge)	£104·75
PL50 (Less cartridge)	£98·90
PL61	£110·30
PLA35	£61·55
THORENS	
TD160C/Ortofon M15E Super	£62·50
TD125 AB/11/Ortofon M15E Super	£96·95
WHARFEDALE	
Linton/M44–7	£23·70

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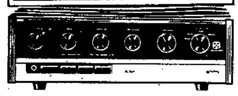

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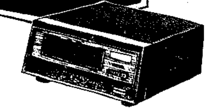

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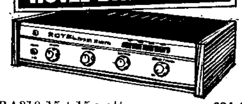

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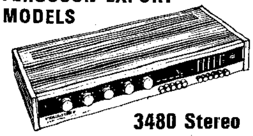

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2. New office opening Bristol. Watch this space.
3. New catalogue available. Price **15p**
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AA119	7p	BA145	17p	BYZ12	30p	OA90	7p
AA129	15p	BA154	12p	OA9	10p	OA91	7p
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10V	1,500	470	12·5 × 31·5	**4·5p**
	41,000	1,000	12·5 × 31·5	**5·5p**
	21,000	2,200	18·0 × 40·0	**10·0p**
	20,460	3,300	22·4 × 40·0	**13·0p**
16V	18,000	220	10·0 × 31·5	**3·3p**
	27,500	330	12·5 × 31·5	**5·0p**
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Voltage	Quantity	Capacitance µF	Dimensions D × L (mm)	Price
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	12,500	220	12·5 × 31·5	**5·0p**
	50,000	330	12·5 × 31·5	**5·6p**
	35,200	470	18·0 × 31·5	**6·0p**
	23,650	1,000	18·0 × 40·0	**10·0p**
35V	37,500	100	12·5 × 31·5	**3·3p**
	15,000	220	12·5 × 31·5	**6·0p**
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	15,000	470	18·0 × 40·0	**9·3p**
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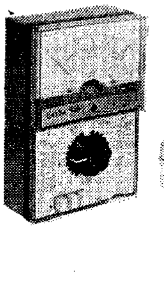
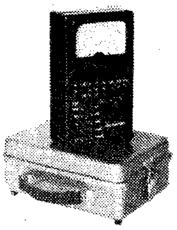
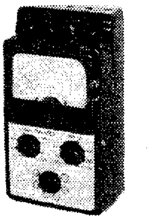
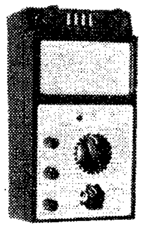
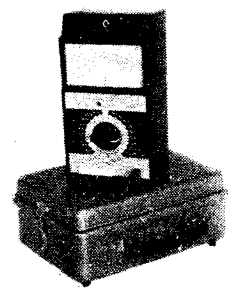

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1B3GT	0·45
1C5GT	0·45
1G4GT	0·60
1G6GT	0·60
1H5GT	0·55
1L4	0·25
1N5GT	0·55
1Q5GT	0·60
1R4	0·50
1R5	0·45
1S4	0·30
1S5	0·30
1T4	0·30
1T5GT	0·50
1U4	0·40
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1V2	0·55
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2C51	0·50
2CW4	0·75
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3A4	0·45
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3Q4	0·60
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5X8	0·70
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6/30L2	0·90
6AS6	0·45
6AB4	0·45
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6AF4A	0·60
6AG5	0·25
6AG7	0·45
6AH6	0·60
6AJ8	0·30
6AK5	0·40
6AK6	0·60
6AL3	0·43
6AL5	0·22
6AM6	0·37
6AN8	0·60
6AQ5	0·42
6AQ6	0·70
6AR5	0·55
6AR6	0·65
6AR11	1·25
6AS5	0·50
6AS6	0·45
6AS7G	0·85
6AT6	0·38
6AU5GTA	1·25
6AU6	0·30
6AV5GTA	0·90
6AV6	0·40
6AW8A	0·65
6AX4GTB	0·70
6AX5GT	0·75
6B4G	1·00
6B7	0·60
6B8G	0·30
6BA6	0·28
6BE6	0·32
6BF5	1·00
6BF6	0·55
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6BJ6	0·55
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6BR7	0·90
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6BS7	1·35
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6BX6	0·25
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6BZ6	0·45
6C4	0·35
6CB5A	1·50
6CB6	0·40
6CD6GA	1·30
6CG7	0·60
6CH6	0·60
6CL6	0·60
6CL8	0·80
6CU6	0·80
6CW4	0·70
6CY5	0·50
6CY7	0·75
6D3	0·55
6DC6	0·80
6DE7	0·70
6DK6	0·60
6DQ6B	0·75
6DS4	1·25
6E5	0·70
6EA8	0·65
6EH7	0·30
6EJ7	0·35
6EW6	0·70
6F5	0·75
6F6G	0·45
6F11	0·50
6F13	0·50
6F14	0·70
6F15	0·65
6F17	0·75
6F18	0·50
6F22	0·30
6F23	0·90
6F24	0·80
6F25	1·00
6F28	0·70
6GK5	0·60
6GK6	0·60
6J4	0·60
6J5GT	0·40
6J6	0·30
6J7	0·45
6K6GT	0·75
6K7	0·43
6K8G	0·45
6K8GT	0·50
6K23	0·75
6K25	0·75
6L7	0·45
6L18	0·50
6LD20	0·50
6N7GT	0·55
6P28	0·65
6Q7	0·50
6R7G	0·55
6S2	0·40
6S4A	0·70

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6SA7	0·45
6SC7	0·80
6SG7	0·45
6SH7	0·45
6SJ7	0·50
6SK7	0·50
6SL7GT	0·45
6SN7GT	0·45
6SQ7	0·50
6SR7	0·50
6SS7	0·40
6T8	0·38
6U4GT	0·70
6U5	0·75
6U8A	0·48
6V6GT	0·45
6X4	0·40
6X5GT	0·45
6X8	0·65
6Y6G	0·80
6Z4	0·50
7B5	0·75
7B6	0·75
7B7	0·70
7F8W	1·00
7F7	1·00
7Z4	0·75
10C2	0·60
10D1	0·65
10D2	0·55
10F1	0·75
10F9	0·65
10F18	0·60
10L1	0 60
10LD11	0·70
10P13	0·75
11D3	0·60
11D5	0·60
11E2	4·00
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12AB5	0·70
12AC6	0·60
12AD6	0·60
12AH7GT	0·40
12AL5	0 55
12AQ5	0·50
12AT6	0·40
12AT7	0·40
12AU6	0·45
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12AV6	0·45
12AV7	0·70
12AX4GTB	0·70
12AX7	0·33
12AY7	0·75
12B4A	0·65
12BA6	0·45
12BA7	0·50
12BE6	0·50
12BH7	0·50
12BY7	0·65
12C8	0·40
12E1	3·00
12E14	4·30
12H6	0·35
12J5GT	0·35
12J7GT	0·60
12K5	1·00
12K7GT	0·50
12Q7GT	0·45
12SC7	0·45
12SG7	0·45
12SH7	0·45
12SJ7	0·50
12SL7GT	0·55
12SN7GT	0·55
12SQ7	0·50
12SR7	0·50
12X4	0·50
20D1	0·60
20F2	0·70
20L1	1·10
20P1	0·50
20P3	0·60
20P4	1·10
20P5	1·20
25L6GT	0·50
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25Z6GT	0·70
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30PL13	1·10
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35B5	0·65
35C5	0·60
35D5	0·75
35W4	0·40
35Z3	0·75
35Z4G	0·40
35Z5GT	0·70
42	0·60
50A5	0·80
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50C5	0·60
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50EH5	0·65
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52KU	0·45
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85A2	0·55
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108C1	0·40
150B2	0·70
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305	0·75
310A	1·75
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805	11·00
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812A	3·50
813	4·00
829B	4·00
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837	1·00
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884	0·75
927	4·00
931A	5·00
955	0·40
991	0·50
4378	2·00
4687	2·90
5551A	18·00
5544	22·00
5545	22·00
5557	5.60
5559	9·00
5670	0·60
5751	0·70
5763	0·80
5796	12·00
5814A	0·70
5842	3·00
6072	0·90
6080	1·75
6146	1·60
6146A	2·00
6146B	2·50
6360	1·25
6883	3·00
6922	0·70
6939	2·25
7025	0·50
7044	0·75
7199	0·85
7360	3·00
7551	2·00
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7895	1·50
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DC90	0·60
DF91	0·30
DF92	0·25
DF96	0·50
DH76	0·50
DH81	0·70
DH101	0·70
DK40	0·65
DK91	0·45
DK92	0·70
DK96	0·60
DL66	1·25
DL68	0·70
DL91	0·30
DL92	0·40
DL93	0·45
DL95	0·60
DL96	0·55
DM70	0·60
DM71	0·60
DY51	0·55
DY86	0·35
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EB34	0·25
EB91	0·22
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EBC41	0·65
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EC93	0·60
EC8010	2·25
ECC34	0·50
ECC40	0·70
ECC70	1·25
ECC81	0·40
ECC82	0·33
ECC83	0·33
ECC84	0·30
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ECF86	0·70
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ECL81	0·50
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ECL84	0·55
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ECLL800	3·20
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EF41	0·65
EF42	0·70
EF80	0·25
EF83	0·60
EF85	0·35
EF86	0·30
EF89	0·28
EF91	0·37
EF92	0·35
EF93	0·28
EF94	0·30
EF95	0·40
EF96	0·25
EF97	0·65
EF98	0·75
EF183	0·30
EF184	0·35
EF804	1·25
EF811	1·00
EF812	0·90
EF814	0·80
EH90	0·50
EK32	0·60
EK90	0·32
EL5	0·60
EL12	1·00
EL34	0·50
EL35	0·50
EL36	0·50
EL37	1·70
EL41	0·75
EL81	0·55
EL83	0·50
EL84	0·25
EL85	0·43
EL86	0·40
EL90	0·42
EL91	0·40

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EL95	0·35
EL360	1·15
EL822	1·50
ELL80	0·85
EM71	0·80
EM80	0 45
EM84	0·35
EM85	1·00
EM87	0·70
EN10	6·00
EN11	5·00
EN32	1·50
EN91	0·40
EY51	0·40
EY80	0·75
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EY83	0·55
EY84	0·60
EY86	0·40
EY87	0·43
EY88	0·43
EZ35	0·45
EZ40	0·50
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HBC91	0·45
HF93	0·45
HF94	0·45

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HK90	0·50
HL23	0·50
HL23DD	0·55
HL42DD	0·70
HL92	0·60
HL94	0·60
KT8	2·50
KT36	1·20
KT44	0·70
KT45	2·00
KT66	2·35
KT71	0·60
KT76	0·60
KT77	1·00
KT88	2·25
ME91	0·65
ME1400	1·30
MH4	0·75
ML6	0·60
MSPEN/7	0·70
MT17	5·50
MU12/14	0·75
N78	1·60
NSP1	5·00
NSP2	6·00
PABC80	0·40
PC86	0·60
PC88	0·60
PC92	0·50
PC96	0·45
PC97	0·50
PC900	0·48
PCC84	0·40
PCC85	0·40
PCC88	0·55
PCC89	0·50
PCC189	0·60
PCC805	0·95
PCC806	0·95
PCE800	0·80
PCF80	0·30
PCF82	0·35
PCF84	0·60
PCF86	0·60
PCF87	1·10
PCF200	0·75

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PCF201	0·75
PCF800	1·00
PCF801	0·50
PCF802	0·50
PCF805	0·90
PCF806	0·75
PCF808	0·90
PCH2000	0·70
PCL81	0·50
PCL82	0·35
PCL83	0·65
PCL84	0·45
PCL85	0·50
PCL86	0·45
PCL88	1·25
PCL2000	0·75
PCL800	1·10
PCL801	0·95
PCL805	0·50
PD500	1·30
PEN4DD	0·70
PEN36C	0·75
PEN45	0·75
PEN45DD	0·75
PEN46	0·50
PEN383	0·75
PEN384	0·75
PEN453DD	0·75
PF86	0·70
PF818	1·00
PFL200	0·65
PL33	0·40
PL36	0·55
PL38	0·65
PL81	0·50
PL82	0·45
PL83	0·45
PL84	0·40
PL302	0·95
PL504	0·75
PL508	0·90
PL509	1·10
PL802	0·95
PLL80	0·70
PM84	0·65
PY31	0·35
PY33	0·63
PY80	0·40
PY81	0·30
PY82	0·35
PY83	0·38
PY88	0 40
PY500	1·00
PY800	0·47
PY801	0·50

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QQV03-20A	6·00
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QY3-125	9·00
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QY4-400A	16·50
R18	0·60
RG3-250A	0·85
RL18	0·50
S130	1·75
S130P	1·75
SP2	0·85
SP4	0·70
SP61	0·75
TP22	0·80
TP25	0·60
TT21	3·80
TT22	4·00
TY2-125	11·00
U18/20	0·75
U19	4·50
U20	0·75
U25	0·85
U26	0·85
U31	0·70
U37	6·50
U50	0·45
U52	0·40
U76	0·40
U78	0·40
U191	0·75
U201	0·50
U281	0·55
U282	0·55
U301	0·55
U403	0·70
U404	0·70
U801	0·80
UABC80	0·40
UAF41	0·70
UAF42	0·60
UB41	0·65
UBC41	0·55
UBC81	0·45
UBF80	0·40
UBF89	0·40
UBL1	0·70

	£
UBL21	0·70
UC92	0·45
UCC85	0·45
UCF80	0·70
UCH21	0·60
UCH42	0·70
UCH81	0·40
UCL81	0·60
UCL82	0·35
UCL83	0·65
UF9	0·65
UF11	0·60
UF41	0·65
UF42	0·65
UF43	0·65
UF80	0·35
UF85	0·40
UF89	0·40
UL41	0·65
UL84	0·43
UM4	0·60
UM84	0·30
UU5	0·75
UY1N	0·50
UY11	1·00
UY41	0·48
UY82	0·50
UY85	0·40
VLS631	2·80
VP41	0·75
VP133	1·00
VR75/30	0·48
VR105/30	0·40
VR150/30	0·40
VU33	0·75
VU39A	0·75
VU111	0·75
VU120	1·00
VU133	0·75
W729	0·75
X65	0·60
X66	0·60
X76M	0·80
XC11	1·00
XC12	0·60
XC15T	0·50
XC23	0·90
XC25	0·40
XR1-1600	12·00
Z329	1·00
Z504S	4·50
Z505S	7·00
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Z719	0·25
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Capital Radio

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The following posts are open:

1. ASSISTANT CHIEF ENGINEER — Applicants should be fully conversant with modern broadcasting technology and capable of giving a lead to a team of first class maintenance and development engineers.
2. SOUND SUPERVISOR — This is a key position in the operation of Capital Radio. The man we seek should have had a wide experience of operational sound working, either in radio, television or the recording industry. He should be capable of multi-channel operations in stereo and will be responsible to the Chief Engineer for all operational duties.

   Salary and conditions for both these appointments will reflect the importance we place on them.
3. ENGINEERS — We also require first class engineers for operations, maintenance and development work on our modern and sophisticated studio equipment. Experience in a broadcasting environment is necessary.

   Salary range: £1,992 — £2,944
4. SOUND TECHNICIANS — Capable of operation duties in a highly demanding area. A youthful outlook and enthusiastic interest in developing programme techniques is essential. Operational experience will be necessary.

   Salary range: £1,992 — £2,833

Applicants for all these posts should submit full details of their education, experience and present salary to:—

**The Chief Engineer,
Capital Radio Limited,
96 Piccadilly,
London W.1.**

2809

Telecommunications & Electronics Engineer

With the expansion of the company's offshore oil and gas production complex within the UK and Arabian Gulf areas, a telecommunications engineer is required to work in our London Office on the design, development and implementation of microwave and ultra high frequency radio systems including tropospheric scatter and digital remote control and supervisory systems. This includes interfacing with measurement and controlling instruments, pipeline valves and pumps, etc., for remote offshore oil and gas field production systems and pipelines and telecommunications systems for normal correspondence and date.

Duties will include initial site surveys and supervising final stage installation and commissioning involving overseas travel. Planning and engagement of local engineering staff for new systems and liaison with these engineers thereafter will be an important part of the duties.

Candidates aged 30 to 40 must be qualified C.Eng. or B.Sc Electronic Engineering. Experience of at least four years' in a senior capacity in installation testing or site maintenance of electronic equipment and four years' design and development experience in systems using this equipment is essential. At least one year's experience in the oil or allied industries is desirable.

■ Please write, quoting reference ZH341, giving age and brief details of background and previous experience to: The Manager, Central Recruitment, The British Petroleum Company Limited, Britannic House, Moor Lane, London, EC2Y 9BU.

HER MAJESTY'S GOVERNMENT COMMUNICATIONS CENTRE

HANSLOPE PARK, MILTON KEYNES, MK19 7BH

has vacancies in the following fields of work

(a) Microwaves.
(b) HF Communications.
(c) VHF/UHF Communications.
(d) Acoustics.
(e) General Electronic Circuit Design.
(f) Operational Analysis. For these posts applicants should be experienced scientists/engineers who have moved into Operational Analysis rather than the inverse.

Most of the posts are at Hanslope Park but some will be in the London Area.

Appointments will be made within the grades of Scientific Officer, Higher Scientific Officer and Senior Scientific Officer in accordance with the following definitions:

SCIENTIFIC OFFICER

Applicants should be not more than 27 years of age and should have one of the following qualifications:

(a) A degree in a scientific or engineering subject.
(b) Degree-standard membership of a Professional Institution.
(c) A higher National Certificate or Higher National Diploma in a scientific or engineering subject.
(d) A qualification equivalent to (c) above.

Salary Scales: £1206-£2043 with the entry point determined by qualifications and experience.

HIGHER SCIENTIFIC OFFICER

Applicants should be under 30 years of age but this requirement may be waived if special qualifications or experience can be offered. Formal qualifications are the same as for Scientific Officer above but in addition the following experience is required:

(a) Applicants with 1st or 2nd class honours degrees—at least 2 years post-graduate experience.
(b) Applicants with other qualifications—at least 5 years post qualification experience.

Salary Scale: £1946-£2515 with entry point dependent upon experience.

SENIOR SCIENTIFIC OFFICER

Applicants should be at least 25 and under 32 years of age, although the upper age limit may be waived if experience of special value can be offered.

A 1st or 2nd class honours degree with at least 4 years post-graduate experience is the normal requirement for this grade although applicants with the other qualifications given above may be considered if they have had at least 7 years appropriate experience.

Salary Scale: £2464-£3483. Entry will normally be at the minimum of the scale but applicants with experience of special value may be entered above the minimum.

Applications stating the field of work and grade required should be made to:

ADMINISTRATION OFFICER,
H.M. GOVERNMENT COMMUNICATIONS CENTRE,
HANSLOPE PARK, HANSLOPE, MILTON KEYNES, MK19 7BH

2617

RADIO OFFICERS would you come ashore for £2,300 a year?

As a Radio Operator with the Post Office Maritime Service you can continue your career ashore in an interesting and expanding service. And earn over £2,000 a year, including compulsory pension contributions, at 25 years of age working only a 41-hour week of shift duties—with overtime this could rise to £2,300 and possibly more.

Post Office Radio Operators benefit from a shorter pay scale than sea-going officers. You have good opportunities for promotion to positions earning basic salaries of up to £3,290, and prospects of further advancement into Post Office Senior Management.

To apply you need to be 21 or over and to hold a 1st class or General Certificate issued by the MPT or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

If you would like to know more, please write to the Inspector of Wireless Telegraphy, Post Office, IMTR/WTS1.1.3, Union House, St. Martin's-le-Grand, London EC1A 1AR. L49

Post Office
Telecommunications

91

SPANISH COMMUNICATIONS EQUIPMENT MANUFACTURER

Applications are invited from qualified design engineers specialized on:

a) Ground/Air Communications
b) TV Colour Transmitters
c) Side Band Transmitters

At least 5 years experience desirable. Company located in Madrid. Salary open.

Send resumé to:
NORTRON
Fernando el Católico, 63
Madrid 15
SPAIN

[2539

Granada Television

Electronic Engineers for Operational Television

Expansion has created further vacancies at the TV Centre in Manchester for electronic engineers to work in all aspects of Granada's broadcasting operations, covering studio vision, videotape, telecine, transmission switching and maintenance of sound and vision equipment.

Vacancies exist at all levels from 1st year Engineer to Substantive Grade (6th year) Engineer at salaries between £1992 and £2944 per annum. Entry point will depend on experience. Candidates who lack experience in broadcast engineering will need a minimum of two years experience in communications engineering and preferably an ONC or equivalent. Shift work, including weekends. Generous Granada Group pension and life assurance benefits. Four weeks holiday.

Applications, stating full details of education and experience to:

Robert Connell Granada Television MANCHESTER M60 9EA

GRANADA

Audio Frequency Circuit Designer

Advanced design work now being undertaken at STL has world-wide implications, both in the more conventional areas of subscriber telephones and in new electro-acoustic devices and display systems. Activity is concentrated on analogue and digital, bipolar and MOS integrated circuits at audio frequencies.

We need a designer to join our telephone subset component division, working on audio frequency circuits. He will be a graduate with at least three years' experience in circuit design. Phases of design vary according to individual problems, but in general he will work, after on-the-job training, in feasibility studies, preparation of design and procurement specifications, breadboarding and circuit optimisation constructing prototypes, liaising with the drawing office to final engineering drawings, and following jobs through to production.

Salary and career prospects, both in the UK and with associate companies in Europe, are excellent.

Location is a modern, well-equipped laboratory complex in pleasant rural surroundings. Help will be given with relocation expenses.

This is one of a number of key appointments we are making because of the expansion of our activities. A team of our engineers and managers is touring the country for informal interviews with engineers and managers of many disciplines. They will be pleased to meet you and talk about your prospects with STL, in the UK and Europe.

Come and see us, between 4pm and 10pm (or the morning after between 8.30am and 10am) at:

JUNE 14th St. Albans – The Great Red Lion Hotel
JUNE 19th Chelmsford – County Hotel
JUNE 21st Birmingham – Albany Hotel, Smallbrook
JUNE 22nd Bournemouth – Pavilion Hotel, Bath Road
JUNE 27th London – Waldorf Hotel, Aldwych, WC2

If you can't make these dates, please telephone or write to: Martin Jenner,
Standard Telecommunication Laboratories Limited,
London Road, Harlow, Essex.
Tel: Harlow 29531.

Standard Telecommunication Laboratories ITT
A British Research Centre of ITT

In-Car Entertainment
SALES DEVELOPMENT MANAGER

A major distributive company growing nationally and diversifying the range of manufacturers products and own company services supplied to the retail and commercial trades is developing through its many wholesale distribution outlets the sales of a complete range of IN-CAR ENTERTAINMENT equipment. An installation service is also to be provided.

This is a new venture in a company which has previously had only minor involvement in this field.

We want to recruit a man with some technical knowledge of the ICE products range, relevant sales and marketing skills and the ability to lift this project off the ground and establish our ICE activities as a profitable and viable proposition.

This post will be of interest to men now earning around £2,500 p.a. Company car and other benefits associated with a big company apply.

Write in strict confidence, giving full career history and personal details to date.

Please advise in a separate letter, any company to whom you do not wish your application to be forwarded.

pr

Pike Russell and Associates,
Ref 166,
St. Vedast House,
150 Cheapside, London EC2

SUMLOCK COMPTOMETER LTD.

ANITA

ELECTRONIC DESK CALCULATORS
PROGRAMMABLE CALCULATORS
VISIBLE RECORD COMPUTORS
PERIPHERALS

There are vacancies in our Field Service Organisation for Engineers to service the above range of equipment installed in London and the Home Counties.

Applications are invited from:–

- **Electronic Engineers qualified to Intermediate City & Guilds Certificate or equivalent standard and**
- **Electro/Mechanical Engineers experienced in Triumph/Adler and/or IBM input/output typewriters, readers and punches.**

Excellent training facilities and first class conditions of employment.
For further information please contact:–

Administration Manager,
Sumlock Comptometer Ltd.,
Anita House,
Rockingham Road,
Uxbridge,
Middlesex.
Tel: 89-51522

Lamson Industries Group

Audio, Digital & Telephone Engineers...

3-way potential at Cambridge

Several rare, possibly unique, positions concerning design of audio distribution systems and control logic, with involvement in digital, audio and telephone engineering all at the same time. In the compact, highly professional Advanced Systems Department, the unit which has contributed heavily to the Company's firmly-established international leadership in radio communications.

Your experience should preferably span all three fields involved, though it may currently be much deeper in one than the others. Practical ability, together with a commercially-minded attitude are more important than qualifications, although these would naturally be advantageous. You must be strong in logic as well as innovation, with the ability not simply to conceive preliminary design ideas but to visualise the end result at the same time.

For more information, including salaries, your potential career within this extensive Group, and Company benefits such as relocation assistance, please give a summary of your background in your letter addressed to M. W. Timmins, Senior Personnel Officer,

Pye Telecommunications Ltd
Newmarket Road, Cambridge, CB5 8PD.
Tel: Cambridge 61222

UNIVERSITY OF SURREY
TELEVISION SERVICE

SENIOR ENGINEER

(Technician Grade 5 £1,881—£2,241)

The Television Service is an integral part of the Audio Visual Aids Unit which provides services for teaching and research illustration throughout the University. The television equipment includes a most versatile mobile control room handling three Plumbicon studio cameras and five others.

The Senior Engineer will be responsible to the Chief Engineer/Operations Manager and will assist with the operation and maintenance of all CCTV equipment including IVC video-tape recorders and Philips Plumbicon cameras.

The minimum qualification is HNC in electronics or electrical engineering or an appropriate training in the BBC or a programme company. Experience in educational television is desirable.

Applications are invited immediately on forms which may be obtained from the Assistant Secretary (Personnel), University of Surrey, Guildford, Surrey. Previous applicants need not apply.
Tel: Guildford 71281 Ext. 452.
Closing date: 6 July 1973.

[2787

ANTARCTIC EXPEDITION

Vacancies exist for Ionospherics Technicians to work for about 30 months in the Antarctic under expedition conditions. Candidates, preferably single and aged 21-30, must be physically fit, qualified in electronics and possessing a good groundwork in valves techniques. They should be capable of working without supervision and able to improvise in adverse situations.

Successful applicants will be given a training course prior to departure in October and will be expected to commence this immediately.

Salary from £1,442 with annual increments and low income tax. Clothing provided and free messing aboard ship and in Antarctica.

Applications to:
**BRITISH ANTARCTIC SURVEY,
30 Gillingham Street, London, S.W.1
Tel: (01)-834 3687**

[2810

ROBERT GORDON'S INSTITUTE OF TECHNOLOGY, ABERDEEN
SCHOOL OF ELECTRONIC AND ELECTRICAL ENGINEERING

ELECTRONICS WORKSHOP TECHNICIAN

Applicants for the above post should have appropriate qualifications and several years of experience in the field of linear and digital electronic circuits and systems.

Salary on the scale £1,728 to £2,241 per annum with placing determined by qualifications and experience.

Further particulars and forms of application may be obtained from:-

**The Secretary and Treasurer
Robert Gordon's Institute of Technology
ABERDEEN, AB9 1FR**

[2794

Project and Commissioning Engineer

Should have good theoretical training in electronics plus actual experience of professional audio equipment in broadcasting, recording, or with a specialist manufacturer.

Electronics Draughtsman

To work mainly on console structures, chassis and panel layouts, (small electro-mechanical details), and some printed circuit work. At least two years similar experience.
Apply in writing to:
**Mr. Swettenham,
HELIOS ELECTRONICS LIMITED,
161 High Street, Teddington,
Middlesex, TW11 8HT**

[2702

CHELSEA COLLEGE
University of London

Electronics Technician Grade V

required in Applied Acoustics Laboratories for the design, development and maintenance of electronic systems for post-graduate teaching and research.

Salary Scale £2,056-£2,416 per annum (including London Allowance).

Further details and application forms from

The Departmental Superintendent (5AA), Chelsea College, (WW) Pulton Place, London, SW6 5PR.

[2803

UNIVERSITY OF SOUTHAMPTON

Department of Physics

A

TECHNICIAN

is required to assist with the construction and assembly of instrumentation to be flown in small sounding rockets for upper atmosphere research.

Applicants should have served an apprenticeship or hold an equivalent qualification in electrical engineering with relevant workshop experience. Additional experience in electronics would be an advantage.

The appointment will be for one year in the first instance. Salary scale £1,539—£1,794 per annum. Applications giving details of age, qualifications and experience and the names and addresses of two referees should be sent to the Deputy Secretary's Section (Ext. 2400), The University, Southampton SO9 5NH, as soon as possible. Please quote reference number: WW 259/73/T.

[2703

FOREMOST IN THE UNITED KINGDOM

IN CONSTANT TOUCH WITH EVERY EMPLOYER OF EXPERIENCED ELECTRONICS ENGINEERS

Our professional placement service is specialised, confidential and completely free

Phone us at any time or write quoting WW105

ELECTRONICS APPOINTMENTS LTD
4 DRYDEN CHAMBERS,
119 OXFORD STREET,
LONDON, W1R 1PA.
TEL: 01-434 1861

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MARCONI INSTRUMENTS LIMITED

ELECTRONIC TECHNICIANS

are required to work on calibration, fault-finding and testing of telecommunications measuring instruments. The work is varied and will enable technicians with experience of r.f. circuits to broaden their knowledge of the latest techniques employed in the electronics and telecommunications industries by bringing them into contact with a wide range of the most advanced measuring instruments embracing all frequencies up to u.h.f.

Entrants may be graded as Test Technicians, Senior Test Technicians or Technician Engineers according to experience and qualifications. Our servicing and production programme, geared to our recognised export achievement, provides employment combined with prospects of advancement, not only within these grades, but into other technical and supervisory posts within the Company at Luton and St. Albans.

Salaries are attractive and conditions excellent. A Pension Scheme includes substantial life assurance cover provided by the Company. Assistance with removal may also be given in appropriate cases. Please write or telephone, quoting reference WW178 , for application form to:

mi

Mr. M. Leavens, Works Manager
Telephone: Luton 33866, or
Mr P Elsip, Personnel Officer
Marconi Instruments Ltd
Longacres, St. Albans, Herts
Telephone: St. Albans 59292

Member of GEC-Marconi Electronics

1971 THE QUEEN'S AWARD TO INDUSTRY

LOUDSPEAKER DESIGN ENGINEER

An outstanding opportunity exists for an enthusiastic engineer to set up a new division of Loudspeaker Manufacturing within the SNS Electronics Group.

Experience in design and production management techniques in the Audio Electronics Industry is required, together with a determination to succeed.

The successful applicant, who will be responsible to the Technical Director, will join a young and expanding organisation with a reputation for equipment of the highest quality, in which prospects for advancement are excellent.

Salary will be commensurate with ability, experience and qualifications.

Telephone or write for an appointment to:—

Mr. R. Jones, Technical Director,
SNS ELECTRONICS GROUP
851 Ringwood Road, Bournemouth, BH11 8LN
Tel: Northbourne (02016) 5331/4.

SNS

Careers with EMI in

Quality Assurance

A rapid expansion programme throughout our location at Hayes, Middlesex, has created vacancies for Test and Quality Staff.

Senior Test Engineers
Test Engineers
Assistant Test Engineers

If you are interested in working in any of the areas outlined below, please contact us. We are one of the world's leading companies in electronics and we can offer you a wide range of opportunities and excellent prospects for a satisfying career in engineering.

Radar and Equipment Division

This division designs and manufactures sophisticated airborn and surface radar equipment. We have a number of large contracts for the development and supply of radar devices to the armed forces.

Sound and Vision Equipment Ltd.

This company designs and manufactures audio-visual equipment including closed-circuit television systems, television cameras and video devices. It won the Queens Award to Industry for its celebrated 2000 range of light-weight television cameras.

Medical Electronics Division

This division designs and produces the celebrated EMI-Scanner. The computerised X-ray system for the diagnosis of brain diseases, invented by one of our research scientists who won the £25,000 MacRobert Award for outstanding technological innovation in British Industry in 1971. This equipment obtained the 1973 Queen's Award to Industry for technological achievement.

Microelectronics Division

The work of this division is the development and manufacture of thick and thin film circuits and a wide range of microelectronic devices.

Central Quality Assurance

We have the following vacancies in our Central Quality Assurance Department which provides technical support to all divisions in the electronics operations.

Test Gear Engineer

To design and build special-to-type test equipment and to construct the calibration and maintenance schedules of test gear at the commissioning stage.

Technical Liaison Engineer

To liaise with development teams to provide transfer of expertise to the production units, advising on test methods and equipment and solving problems at all stages of development and production.

Metrologist

To carry out precision measurements in our standards laboratory using measuring devices, sensitive comparators and optical instruments.

Salaries: £1400-£2400

dependent upon the position and the experience and ability of the person

Please write or telephone for an application form:

EMI

R. N. L. BLACK, Personnel Department,
EMI Electronics Ltd., 135 Blyth Road, Hayes, Middlesex.
Tel: 01-573 3888 Ext. 2887

International leaders in Electronics, Records and Entertainment.

DUBLIN INSTITUTE FOR ADVANCED STUDIES

School of Cosmic Physics

Applications are invited for the post of

SENIOR TECHNICIAN

in the Geophysical Section of the School located in Dublin. The necessary qualifications are the Science Laboratory Technicians Advanced Certificate, a University Degree in science or equivalents. The appointee will be required to maintain and operate laboratory and field geophysical equipment. Experience in maintenance, use and construction of

ELECTRONIC EQUIPMENT

is essential. The post is permanent and pensionable (non-contributory) with salary scale £1,675 x £73 (5) x £46—£2,086 (under review) plus Marriage and Family Allowances. Applications should reach the Registrar, Dublin Institute for Advanced Studies, 10 Burlington Road, Dublin 4, Ireland, not later than 31 July, 1973.

[2806

LINCOLN No. 1 HOSPITAL MANAGEMENT COMMITTEE

LINCOLNSHIRE MEDICAL PHYSICS DEPT.

MEDICAL PHYSICS TECHNICIAN

(GRADE III)

A technician is required to work primarily in the new Audiological Measurement section of the Lincolnshire Medical Physics Department at St. George's Hospital, Lincoln. The successful applicant will be required to assist in all the scientific audiological tests carried out by the section.

The work involves technical problems together with personal contact with patients of all ages.

Applicants should be qualified to HNC standard in Electronics or be trained to an equivalent standard. Comprehensive training will be given on technical and clinical practice. Further information from the Physicist-in-Charge.
Salary Scale £1,602—£2,076.

Applications giving full details of education, qualifications and experience together with the names of two referees to the Hospital Secretary, St. George's Hospital, Lincoln.

[2785

HARROW COLLEGE OF TECHNOLOGY AND ART

TECHNICIAN:

SCHOOL OF PHOTOGRAPHY

Up to £1,980

A Technician/Engineer in television and sound is required for a new post in the Film and Television Department. Duties will include the technical operation and routine maintenance of a C.C.T.V. Studio requiring electronic and mechanical skills and knowledge in the television field. Relevant City and Guilds or H.N.C. qualifications are desirable and further in-service training will be considered.

Unless otherwise stated **all the above positions** involve a 35-hour week (Monday to Friday).

Application forms from The Registrar, Harrow College of Technology and Art, Northwick Park, Harrow, Middx. HA1 3TP (864 4411 Ext. 31). Returnable by **8th June**, 1973.

[2788

UNIVERSITY OF SURREY

Laboratory Superintendent

Department of Physics

Applications are invited for a newly established post in the Department of Physics. The person appointed must possess extensive experience of high level experimental work in scientific or engineering laboratories and will take an active part in experimental work in the Department.

The qualification required is a degree in a relevant subject, but an experienced candidate with H.N.C. and corporate membership of an appropriate institution or learned society could be considered. The appointment will be that of a Senior Experimental Officer in the University for which the salary scale is £3,192-£4,299.

Further particulars can be obtained from the Assistant Secretary (Personnel), University of Surrey, Guildford, Surrey GU2 5XH, and to whom applications in the form of a curriculum vitae should be returned to by 6th July, 1973.

[2696

UNIVERSITY OF KENT AT CANTERBURY

Research Studentships in Electronics

A few studentships are available for first and top second degree candidates for research in the following fields.

Digital Communications.
Computer Systems and Cybernetics.
Solid State Devices.
Microwaves.
Radio Astronomy.
Space Research.
Experimental Relativity.
Medical Electronics.

Further details and application forms from: Professor R. C. Jennison, The Electronics Laboratories, The University of Kent at Canterbury, Canterbury, Kent.

[2792

ELECTRONICS TECHNICIAN

The Electronics Department of Brompton Hospital has a vacancy for an additional Electronics Technician (Grade 3) to undertake the construction and maintenance of electronic equipment used in the Hospital, e.g. instrumentation, amplifiers, transducers, oscilloscopes, optical recorders, mass-spectrometer, analogue computers and TV systems. Applicants should have a good working knowledge of electronics and be qualified to O.N.C. standard or equivalent. Day release facilities for further approved education.

Salary £1,714-£1,969 per annum including London Allowance. Further details and application form:

Departmental Superintendent, B.H., Chelsea College, Pulton Place, London SW6 5PR.

[2692

Senior Electronics Engineer

Noise Measurement

We are seeking a man with a minimum qualification of an Electronics HNC to lead the Instrumentation Section of our Noise Research Department.

Based in Derby, this section provides a measurement service to a department of twenty-five qualified staff conducting research and development into methods of reducing aero-engine noise. Noise measurements are made on a variety of static rigs, engine test beds and on field exercises. The department is well equipped with modern instrumentation and excellent supporting facilities are available.

Candidates should be aged between 28 and 35 and be prepared to work away from base for short periods during field trials.

At least four years experience of electronic instrumentation and test work is required, together with a sound knowledge of analogue tape recording. Some experience of acoustic measurements and Bruel and Kjaer equipment would be advantageous.

The Company operates an excellent Life Assurance and Staff Pension Scheme, and we shall be pleased to discuss relocation assistance with applicants who are invited for interview.

Please write for an application form, giving brief details of qualifications and career to-date, to: Head of Employment Office, Rolls-Royce (1971) Ltd, Derby Engine Division, P.O. Box 31, Derby DE2 8BJ

ROLLS ROYCE

Derby Engine Division

BOTSWANA

ASSISTANT ENGINEER

Grade II

- ★ Gratuity 25% of basic salary.
- ★ Subsidised accommodation.
- ★ 24-36-month tour.
- ★ Appointment Grant £100-£200 normally payable.
- ★ Low taxation.
- ★ Holiday visit passages.
- ★ Education Allowances.
- ★ Free family passages.

Required by the Posts and Telecommunications Department to establish a new radio workshop repairing a wide range of HF/VHF radio communications equipment.

Candidates, 30-45 years, must possess the City and Guilds Intermediate Certificate in Telecommunications, have had five years' relevant experience, excluding training, and must be capable of undertaking minor radio equipment modification, installation and aerial work. Experience with Plessey, Racal and Pye equipment and some knowledge of radio stores would be an advantage.

Salary will be in the range £1780 to £2700 according to experience.

Because of lower rates of Income Tax in Botswana the gross emoluments, including gratuity, are roughly equivalent to a UK salary of £2600 to £3700 for a single man and £2650 to £3900 for a married man with two children.

This post is partly financed by Britain's programme of aid to the developing countries administered by the Overseas Development Administration of the Foreign and Commonwealth Office.

For further particulars you should apply, giving brief details of experience to:

crown agents M Division, 4 Millbank, London, SW1P 3JD, quoting reference number M2K/730429/WF.

[2796

Electronics Test Engineers

Pye Telecommunications of Cambridge and Haverhill have immediate vacancies for Production Test Engineers. The work entails checking to an exacting specification VHF/UHF radio-telephone equipment before customer delivery; applicants must therefore have experience of fault finding and testing electronic equipment, preferably communications equipment. Formal qualifications while desirable, are not as important as practical proficiency. Armed service experience of such work would be perfectly acceptable. Pye Telecommunications is the world's largest exporter of radio-telephone equipment and is engaged in a major expansion programme designed to double present turnover during the next five years. There are, therefore, excellent opportunities for promotion within the company. Pye also encourages its staff to take higher technical and professional qualifications.

These are genuine career opportunities in an expansionist company, so write or telephone without delay for an application form to:

Mrs A E Darkin at
Cambridge Works, Elizabeth Way, Cambridge CB4 1DW.
Telephone: Cambridge 51351.
or Mrs C Dawe at
Colne Valley Road, Haverhill, Suffolk.
Telephone: Haverhill 4422.

Pye Telecommunications Ltd

A member of the Pye of Cambridge Group

.2802

RADIO/AUDIO ENGINEER
(CONSUMER ELECTRONICS)

THORN

FOR NEW ZEALAND

A versatile man is required with some experience in all or most of the following aspects; Component approval, development of mechanical chassis and presentation items as well as circuit development, a commercial appreciation of cost methods, industrial processes such as surface finishing of various materials and plastic moulding.

Appropriate formal qualification would be an advantage but broad and proven experience is considered most important.

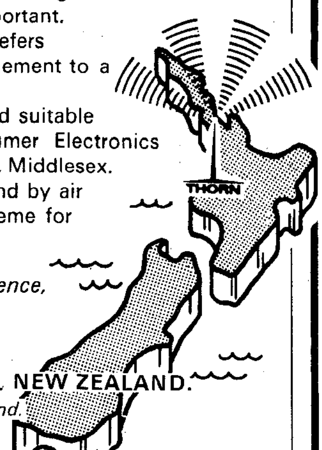
This position should appeal to a man who prefers responsibility over a wide field rather than confinement to a narrow section of development engineering.

All applications will be carefully considered and suitable applicants will be interviewed by Thorn Consumer Electronics Ltd., formerly British Radio Corporation Ltd., Enfield, Middlesex.

The man finally chosen will travel to New Zealand by air under the New Zealand assisted immigration scheme for which all arrangements will be made by us.

Applicants should write giving full details of experience, marital status etc., to:

THORN RADIO INDUSTRIES N.Z. LTD.,
36/38 HASTIE AVE., MANGERS, AUCKLAND, NEW ZEALAND.
a subsidiary of Thorn Consumer Electronics Ltd., England.



BRUNEL UNIVERSITY

COMPUTER SCIENCE

An

ELECTRONICS TECHNICIAN

is required from 1 August 1973 for construction, modification, maintenance and minor development of Digital and Analogue equipment.

This is a new post; experience of Digital or Analogue apparatus is desirable but not essential but a good grounding in electronics with some experience of service work is essential.

Applicants preferably over 30, should possess a minimum of ONC or equivalent and/or substantial relevant experience.

Salary in the grade 4 scale, £1,728—£2,028 plus £90 London Weighting.

Postcard for application form and further details to Establishment Secretary, Brunel University, Uxbridge, Middlesex or telephone UXBRIDGE 37188, extension 40 (quoting reference CS/7). Closing date: 2nd July 1973.

[2698

Workshop Service Engineers

to repair calculator printed circuit boards. Good basic electronic knowledge required and experience in a Service Department. Salary £1,750 plus and L.V.'s.

Apply to:- **Mr. V. Knight,**
Automatic Business Machines Ltd.,
Wyfold Road, Fulham, S.W.6.
Tel: 385 3311 [2695

THE CITY UNIVERSITY

ELECTRONICS TECHNICIAN I

(Grade 3)

required immediately in the Educational Services Unit. It is expected he will have had experience in all forms of audio visual, audio recording, sound amplification and CCTV equipment, including video tape recording. Duties will include:

(a) Construction and modification of electronic equipment.
(b) Testing of equipment.
(c) Maintenance and adjustment of audio visual and CCTV equipment.
(d) Assist in maintaining a comprehensive audio visual service within the University.
(e) Ability to project film up to professional standard.

Salary within the range £1,539-£1,794 plus £175 London Allowance.
Closing date: 29th June 1973.
Further details and application form can be obtained from The Personnel Officer, The City University, St. John Street, London, EC1V 4PB.

[2821

THE HATFIELD POLYTECHNIC

TECHNICIAN

for Psychological Laboratory

for maintenance and construction of a variety of electronic and other equipment.

Applicants should preferably hold an appropriate Intermediate or National Certificate or City and Guilds qualification.

Salary scale: £597—£1,143 per annum.

Application form and further details from The Staffing Officer, The Hatfield Polytechnic, PO Box 109, Hatfield, Herts AL10 9AB.

Please quote ref: 266/WW.

[2789

digital

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ELECTRONIC ENGINEERS OR TECHNICAL INSTRUCTORS WHO HAVE

(a) A wide knowledge of electronics and computer techniques.
(b) Experience in, and a flair for, trouble-shooting modern Digital hardware.
(c) An interest in the education of young technicians and enthusiasm for transferring to them a significant amount of (a) and (b) above.

The positions will entail both formal instruction and convincing operational demonstrations before perceptive and conscientious students. An inventive and flexible approach will be required.

These advanced positions, which include some responsibility for the career development of students, will carry an attractive salary.

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DIGITAL EQUIPMENT INTERNATIONAL LTD.,
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Senior Technician

up to £2,109

to be responsible for the general management of a large new well equipped Television Studio and Control Room.
He will be assisted by a Technician and will be responsible to the Vice-Principal.
The Senior Technician will be required to become fully conversant with all the equipment and to assist users to operate it. Post Ref. 1ST.

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up to £1,788

Salary:
Senior Technician—on a scale within the range £1,629 - £2,019 with starting point and maximum dependant on qualifications and experience (plus £90 London Allowance).
Technician—on a scale within the range £1,248 - £1,698 with starting point and maximum dependant on age, qualifications and experience (plus £90 London Allowance).
Conditions include a basic 36½ hours per week with possibly some evening and overtime work.
Further details and application form from the Senior Administrative Officer; completed forms to be returned within 2 weeks of publication of this advertisement. Post Ref. 2T. [2659

NORTHWICK PARK HOSPITAL AND CLINICAL RESEARCH CENTRE
Watford Road, Harrow, Middlesex, HA1 3UJ. Tel: 01-864 5311

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2. A Technician with duties similar to those described above who will be working under some supervision.

Salary—Grade IV: £1,548-£1,953, under review.

The hospital is new and closely allied with the Clinical Research Centre. In 1974/75 there will be over 900 beds. Good staff facilities and a pleasant working atmosphere. Active social club. Temporary accommodation may be available.

Further particulars and application forms, returnable by July 23rd, from Mrs. J. Moore, Ext. 2202. [2811

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DO YOU HAVE	PMG 1. PMG 11. 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 af a 7 month specialist training course, successful applicants are paid on a scale rising to £2,527 pa; commencing salary according to age — 25 years and over £1807 pa. During training salary also by age, 25 and over £1350 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

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If you have experience in the electronics industry, radio or T.V. maintenance or in the Services, we can offer you a progressive career in a Production Test Department here at Marconi Communication Systems in Chelmsford.

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Please write with full personal and career details to R.S. Ransom, Marconi Communication Systems Limited, New Street, Chelmsford, Essex, CM1 1PL, quoting ref WW or telephone Chelmsford 53221, extension 498.

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Marconi Communication Systems

A GEC-Marconi Electronics Company

SENIOR ELECTRONIC ENGINEER

required for circuit development. Experience of nanosecond pulse circuitry, design and familiarity with image converter devices would be an advantage. Several years' continuous experience in electronic circuit design is essential.

Qualifications of HND or HNC or equivalent required. Salary negotiable according to experience and qualifications.

We are a small specialist company manufacturing advanced scientific instruments. Very good working conditions in a pleasant rural area 25 minutes from Central London. Contributory pension and free-life insurance scheme. Excellent canteen facilities.

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VOCATIONAL TRAINING INSTRUCTORS

(Civilian Instructional Officer, Grade III)

All applicants should have served a full apprenticeship or have had equivalent recognised training followed by at least five years industrial experience in the Radio and Television and/or Electronics servicing industry. City and Guilds Certificate (or equivalent) is desirable. Teaching or instructing experience are added advantages.

RADIO AND TELEVISION SERVICING posts at:

H.M. PRISON, AYLESBURY, Bucks. H.M. PRISON, LEWES, Sussex. H.M. PRISON, THE VERNE, Portland, Dorset.

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Hours: A 40-hour, 5-day week is worked with 4 weeks and 2 days annual leave in addition to the usual 9 public and privilege holidays.

Write for Application Form to: The Establishment Officer, Home Office, Personnel and Administration Department, Portland House, R.10/10 (7TI), Stag Place, London, SW1E 5BX, stating for which post you apply. Closing date for the receipt of completed application forms: 29 June 1973.

[2804

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20-30 year old General Electronic Design Engineer with some experience in Antenna design required for small expanding Company.

Must be capable of working by himself.

He should be willing to assist on test supervision and occasional visits to customers.

Please apply to:

Mr. D. A. R. Wallace — Managing Director, Antenna Specialists UK Limited, Thame Industrial Estate, Bandet Way, Thame, Oxfordshire. Tel: Thame 3621/2

INSTITUTE OF GEOLOGICAL SCIENCES

GEOPHYSICAL INSTRUMENT TECHNICIAN

(P & TO IV)

required to assist in the maintenance, field trials, operation and development of complex geophysical instruments for use on land, at sea and in boreholes. Although based at Acton, field operations range over the British Isles and UK Continental Shelf and duties may also include short visits abroad.

Candidates must have ONC or equivalent in Electrical or Mechanical Engineering and have served a recognised apprenticeship.

Present salary £1,555 (at 21)—£1,940 (at 28 or over on entry)—£2,180. Subsistence is paid for field operations. Non-contributory pension scheme and prospects of promotion.

Application forms available from Establishment Section, Exhibition Road, London SW7 2DE. Telephone 01-589 3444. Please quote Ref. P & TO/AGU/73.

[2697

BRITISH ANTARCTIC SURVEY

RADIO TECHNICIAN

required, three-year contract in Stanley, Falkland Islands. Qualified to ONC Telecommunications standard, experience of teleprinters advantageous. A knowledge of medium and high-powered HF transmitters and good general workshop ability with HF equipment. Officer will be required to carry out aerial farm maintenance as part of his duties. Salary at the rate of £1,379 per annum in the scale of £1,379, £1,443, £1,487, £1,570, £1,634, £1,745, £1,798. This scale is currently under revision.

Apply to:

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SAMUELSON FILM SERVICE LTD., LONDON, N.W.2 require an

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TO MAINTAIN PORTABLE RADIO TELEPHONE EQUIPMENT

Applicant must have a wide experience of fault finding and testing in this field.

Qualifications, while desirable, are not as important as practical proficiency.

PENSION SCHEME

SALARY NEGOTIABLE

Telephone General Manager, 01-452 8090, Ext. 248

[2790

UNIVERSITY OF EDINBURGH
Department of Mechanical Engineering
Applications are invited for the post of

ELECTRONICS TECHNICIAN (TG5)

tenable from 1st August, 1973. The appointee will be expected to service the electronic equipment already in the Department, and to design and construct, using modern techniques, specialised equipment needed for research and teaching purposes. The possession of a H.N.C. may be an advantage.

Salary scale: £1,881-£2,241 per annum.

Applications in writing, giving full details of experience and qualifications together with the names of two referees, should be sent, as soon as possible, to the Secretary to the University, Old College, South Bridge, Edinburgh, EH8 9YL. Please quote reference 2034.

[2805

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are urgently required for our expanding UHF/VHF Television Distribution Laboratory. Write or phone for an immediate interview (which can be arranged outside normal working hours if necessary) to:

Mrs. V. NELSON,
Personnel and Training Officer,
ARISDALE AVENUE, SOUTH OCKENDON, ESSEX. Tel: South Ockendon 3477

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(WW7)

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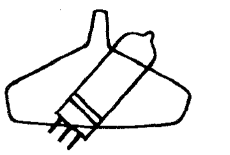

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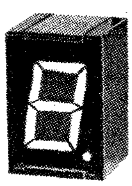

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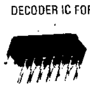

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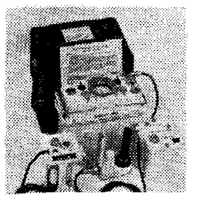

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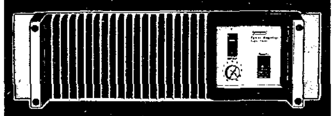

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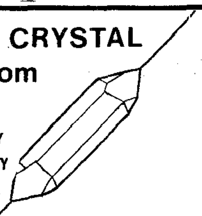

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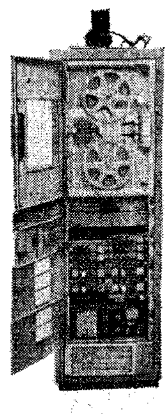

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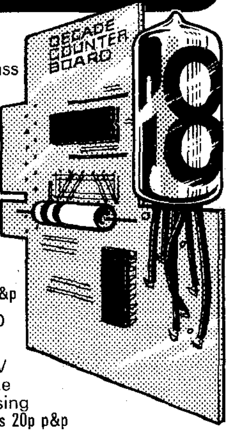

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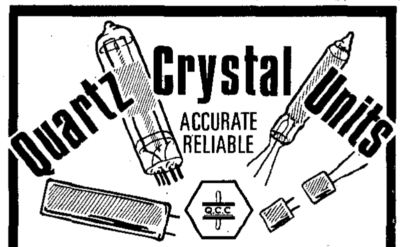

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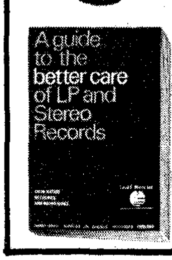

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