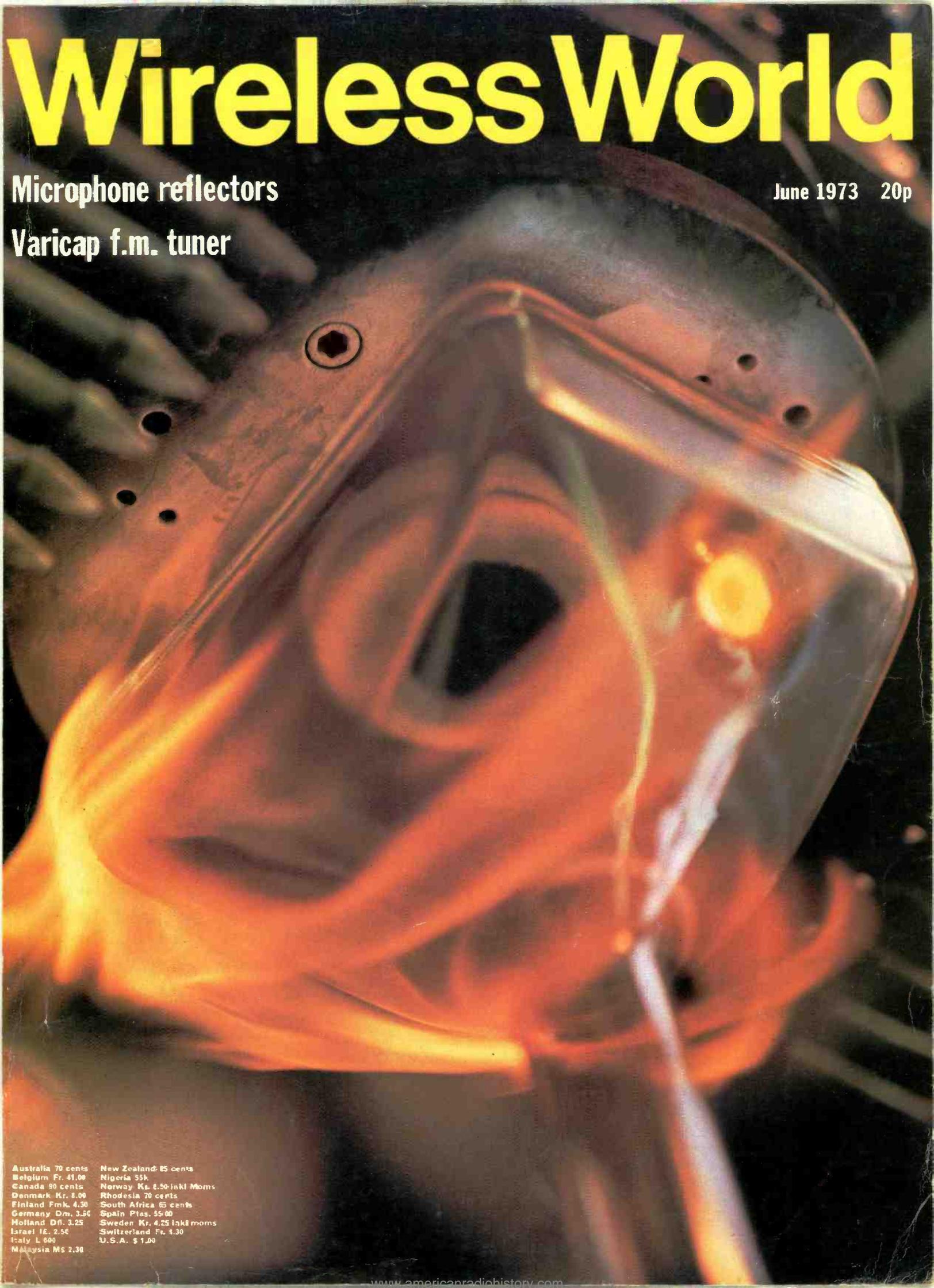


Wireless World



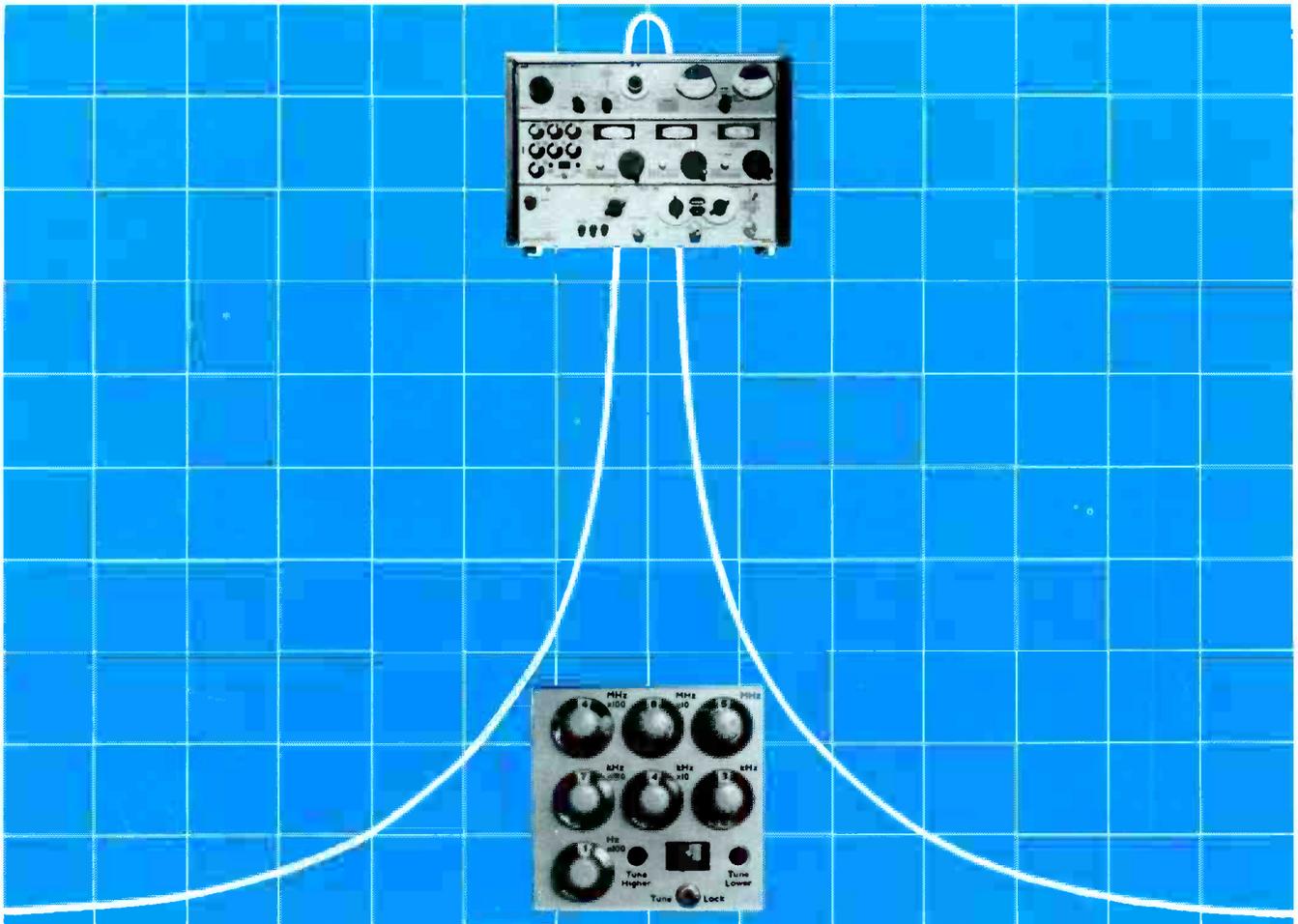
Microphone reflectors

June 1973 20p

Varicap f.m. tuner

Australia 70 cents
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Denmark Kr. 8.00
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Germany Dm. 3.50
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Sweden Kr. 4.25 inkl moms
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U.S.A. \$ 1.00

The TF2006 Signal Generator goes one better...



**With a new built-in synchronizer
for precise bandwidth measurements
at high speed!**

The M.I. TF 2006/1

The M.I. TF2006/1 – a brand-new variant of the established TF2006 – is fitted with a synchronizer in place of one of the oscillator units. Result: the incorporation of outstanding new facilities for working with narrow band equipment . . . at speed!

The synchronizer is crystal controlled to an accuracy of 2 parts in 10^7 . Generator frequency can be locked in 100Hz steps over the whole range of the instrument (10-500MHz). Seven switches pre-set the frequency. A system of two flashing lights indicates whether the generator is tuned too high, too low – or within locking range.

For bandwidth measurements on narrow band equipment there is no need to reset the generator tuning controls at each measurement point. For variations close to the frequency to which the generator is tuned the required new frequency is

simply set with the synchronizer digital controls. Working is considerably speeded up.

An external counter with its risk of spurious radiations is completely unnecessary.

More good news . . . it costs no more than the TF2006 which will continue to be available for those who require the full 4 to 1000 MHz coverage



MARCONI INSTRUMENTS LIMITED

Longacres, St. Albans, Herts. England

A GEC-Marconi Electronics Company

Telephone: St. Albans 59292 Telex: 23350

WW-001 FOR FURTHER DETAILS

LOW COST VOLTMETERS

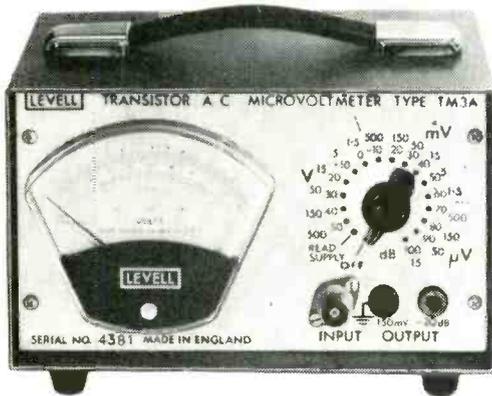


LEVELL
PORTABLE INSTRUMENTS

VISIT US ON STAND 621 AT L. E. C. S. 73
OLYMPIA, LONDON, 22-25 MAY

NOTE: All prices subject to V.A.T.

These highly accurate instruments incorporate many useful features, including long battery life. All A type models have 3 1/4" scale meters, and case sizes 5" x 7" x 5". B types have 5" mirror scale meters and case sizes 7" x 10" x 6".



A.C. MICROVOLTMETERS

VOLTAGE & dB RANGES: 15µV, 50µV, 150µV... 500V f.s.d. Acc. ± 1% ± 1% f.s.d. ± 1µV at 1 kHz. - 100, - 90... + 50dB, scale - 20dB/+ 6dB rel. to 1mW/600Ω.
RESPONSE: ± 3dB from 1 Hz to 3MHz, ± 0.3dB from 4Hz to 1MHz above 500µV. Type TM3B can be set to a restricted B.W. of 10Hz to 10 kHz or 100 kHz.
INPUT IMPEDANCE: Above 50mV : > 4.3MΩ < 20pf. On 50µV to 50mV : > 5MΩ < 50pf.
AMPLIFIER OUTPUT: 150mV at f.s.d.

£49 type TM3A **£63** type TM3B

D.C. MICROVOLTMETERS

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

£55 type TM10 (appearance similar to type TM9B)

D.C. MULTIMETERS

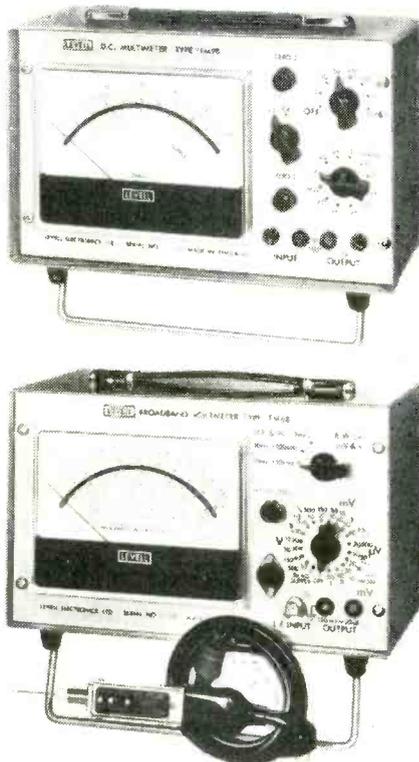
VOLTAGE RANGES: 3µV, 10µV, 30µV... 1kV. Acc. ± 1% ± 1% f.s.d. ± 0.1µV. LZ & CZ scales.
CURRENT RANGES: 3pA, 10pA, 30pA... 1mA (1A for TM9BP) Acc. ± 2% ± 1% f.s.d. ± 0.3pA. LZ & CZ scales.
RESISTANCE RANGES: 3 Ω, 10 Ω, 30 Ω... 1kM Ω linear. Acc. ± 1%, ± 1% f.s.d. up to 100M Ω.
RECORDER OUTPUT: 1V at f.s.d. into > 1k Ω on LZ ranges.

£75 type TM9A **£89** type TM9B **£93** type TM9BP

BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV... 3V f.s.d. Acc. ± 4% ± 1% off f.s.d. at 30MHz. - 50dB, - 40dB, - 30dB to + 20dB. Scale - 10dB/+ 3dB rel. to 1mW/50 Ω. ± 0.7dB from 1MHz to 50MHz. ± 3dB from 300kHz to 400MHz.
L.F. RANGES: As TM3 except for the omission of 15µV and 150µV.
AMPLIFIER OUTPUT: Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

£85 type TM6A **£99** type TM6B



Send for literature covering our full range of portable instruments.

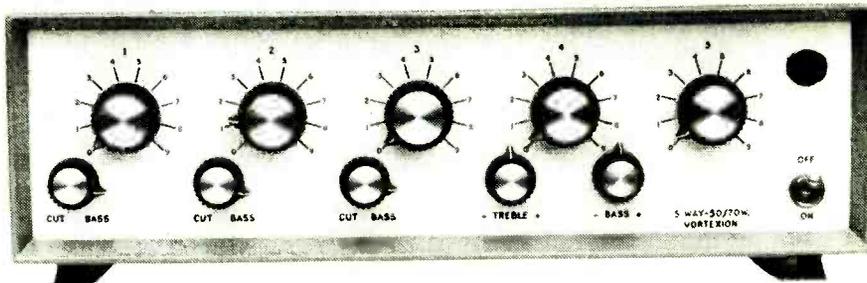
LEVELL ELECTRONICS LTD. Moxon Street, High Barnet, Herts. EN5 5SD
Tel: 01-449 5028/440 8686

WW-004 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 with bass cut controls on each of the three low impedance balanced line microphone stages and a high impedance (1.5 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 another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8-16 ohms output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected. The mixer section has an additional emitter follower output for driving a slave amplifier, phones or tape recorder, output .3V out on 600 ohms upwards. Price £92.40 subject to V.A.T.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER (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 2-30/60Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15Ω and 100 volt line. Price £84.70 subject to V.A.T.

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. Price £88.00 subject to V.A.T.

THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4 channel F.E.T. mixer, 2-30/60Ω 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. Price £126.50 subject to V.A.T.

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.

20/30 WATT MIXER AMPLIFIER. High fidelity all silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. The response is level 20 to 20,000 cps within 2dB and over 30 times damping factor. At 20 watts output there is less than 0.2% intermodulation even over the microphone stage at full gain with the treble and bass controls set level. Standard model 1-low mic. balanced input and HiZ gram. Outputs available 8/15 ohms OR 100 volt line.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s-20 Kc/s \pm 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. Price £148.50 subject to V.A.T.

F.E.T. MIXERS and PPMs. Various types of mixers available. 3, 4, 6 and 8 channel with Peak Programme Meter. 4, 6, 8 and 10 Way Mixers. Twin 3, 4, and 5 channel Stereo, also twin 4 and 5 channel Stereo with 2 PPMs.

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WW-005 FOR FURTHER DETAILS

The X25

Why two shafts?



"elementary"

220-240 Volts or 100-120 Volts.

Model X25

The leakage current of the X25 is only a few microamps and cannot harm the most delicate equipment even when soldered "live". Tested at 1500v A.C. 25 watt. Fitted long-life iron-coated bit 1/8".

2 other bits available 3/32" and 3/16"

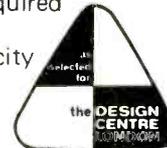
Price: **£1.75** (rec. retail) P & P 8p



One ceramic shaft to give you near-perfect insulation and negligible leakage current (only 3-5 microamps) so that you can safely solder delicate and expensive integrated circuits and transistors, even when "live".

Another shaft, of stainless steel, to give you the strength required of an everyday robust general purpose iron.

Plus large volume long-life bits to store the enormous heat-capacity of the 25 watt element. Bits that do not stick (no screws or pins) and bits that slide over the element shaft to give you efficient heat transfer and a capacity equivalent to irons of 2-3 times the wattage.



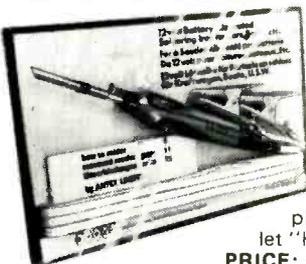
MODEL CCN

220 volts or 240 volts. The 15 watt miniature model CCN also has negligible leakage.

Test voltage 400v. A.C. Totally enclosed element in ceramic shaft.

Fitted long-life iron-coated bit 3/32". 4 other bits available 1/8", 3/16", 1/4" and 3/64".

PRICE: **£1.80** (rec. retail) OR Fitted with triple-coated, iron nickel and Chromium bit 1/8". PRICE: **£1.95** (rec. retail). P&P5p



MODEL MES.KIT

Battery-operated 12v. 25 watt iron fitted with 15' lead and 2 heavy clips for connection to car battery. Packed in strong plastic wallet with booklet "How to Solder"

PRICE: **£1.95** (rec. retail). P&P12p

MODEL G

18 watt miniature iron, fitted with long life iron-coated bit 3/32". Voltages 240, 220 or 110.

PRICE: **£1.83** (rec. retail). P&P5p



All prices mentioned are exclusive of V.A.T.



MODEL CN

Miniature 15 watt soldering iron fitted 3/32" iron-coated bit. Many other bits available from 3/64", to 3/16". Voltages 240, 220, 110, 50 or 24.

PRICE: **£1.70** (rec. retail). P&P5p

MODEL CN2

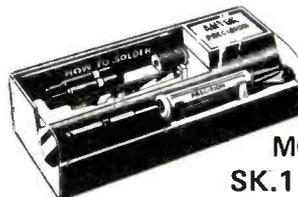
Miniature 15 watt soldering iron fitted with nickel plated bit 3/32". Voltages 240 or 220.

PRICE: **£1.70** (rec. retail). P&P5p

MODEL SK.2 KIT

Contains 15 watt miniature iron fitted with 3/16" bit, 2 spare bits 5/32" and 3/32"

heat sink, solder, and "How to Solder" booklet. PRICE: **£2.40** (rec. retail). P&P8p



MODEL SK.1 KIT

Contains 15 watt miniature iron fitted with 3/16" bit, 2 spare bits 5/32" and 3/32", heat sink, solder, stand and "How to Solder" booklet. PRICE: **£2.75** (rec. retail). P&P12p



From radio or electrical dealers, car accessory shops or in case of difficulty direct from:—
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Please send the ANTEX colour catalogue.

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ANDERS MEANS METERS...

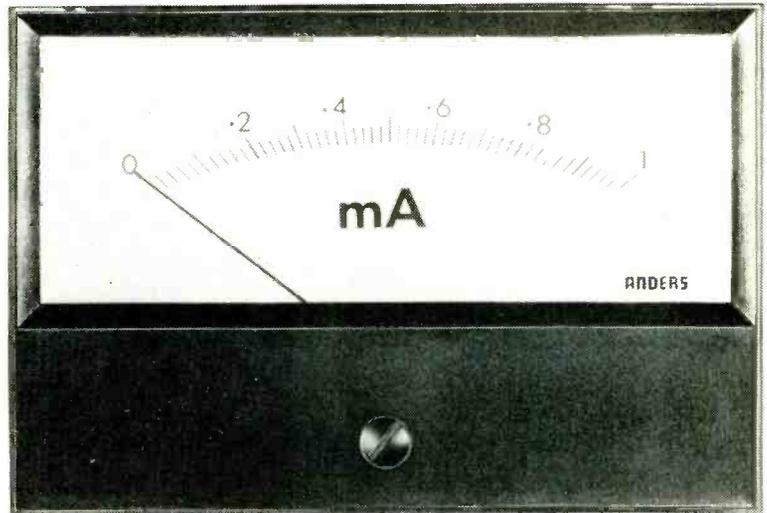
REGAL RANGE

- New 100° arc high quality meters at low prices.
- Rugged taut band construction
— pivot and jewel available to order
- Sensitivities to 10 μ A
- Very competitively priced for OEM quantities
- Modern styled meters in matt black plastic cases with flattened arc giving long scale.

TWO MODELS

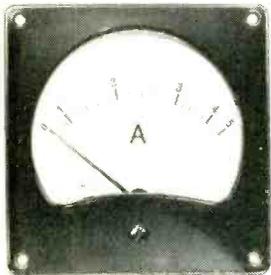
R55 2.5in (63.5mm) Scale length

R65 3.2in (81.3mm) Scale length

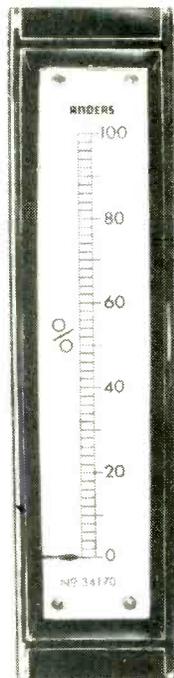


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

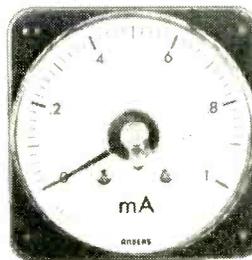
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



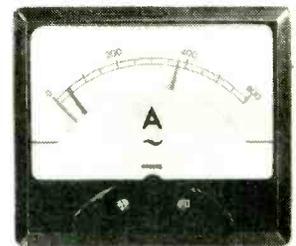
Vulcan Moving Iron. 4 models, 1.5", 1.8", 2.7", 3.7" scales. Voltmeters, ammeters and motor starting meters.



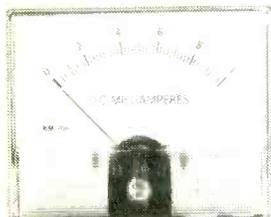
Profile 350 edgewise 4.3" scale. DC moving coil and AC moving coil rectified. Horizontal or vertical mounting.



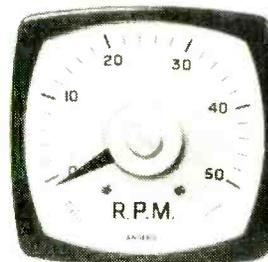
Oxford Long Scale 240°. 2 models, 5.5", 8" scales. DC moving coil and AC moving coil rectified.



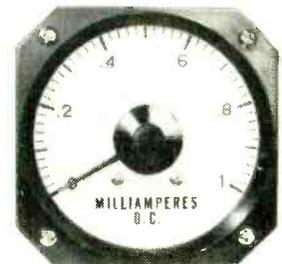
Solicontroller Moving Coil Relay. DC moving coil and AC moving coil rectified. 1 or 2 adjustable alarm controls.



Kestrel Clear Front. 7 models, 1.3"—5.25" scales. DC moving coil, AC moving coil rectified, AC moving iron.



Stafford Long Scale 240 6 models, 3.5"—11.5" scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98 scale.



Lancaster Long Scale 240. 2 models, 4", 5.5" scales. DC moving coil and AC moving coil rectified.

Send for fully illustrated catalogue.

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

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

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www.americanradiohistory.com

Westinghouse TV colour tubes guarantee purity in both colour and black & white

Today's Westinghouse Electric colour tubes, in addition to offering recognised excellence of colour definition, have white field purity... vitally important to reception of black and white transmission.

Two 67 cm diagonal versions
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.

Expanded European facilities
Pacing the growing demand in Europe for Westinghouse tubes, we have made a permanent commitment to fully support our customer. ■ With trained technical sales personnel in major European cities. ■ With

warehousing and testing facilities in Kassel, W. Germany and Le Mans, France. ■ With a sustaining European oriented R&D programme.

Customer oriented

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.

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1 Curfew Yard, Thames Street
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GENEVA FRANKFURT LONDON
MILAN PARIS STOCKHOLM



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

WW—008 FOR FURTHER DETAILS

What is improved?

This question is put to us frequently these days so a few words of explanation as to why and how we 'improved' our Model 3009 Series II precision pick-up arms may be helpful.

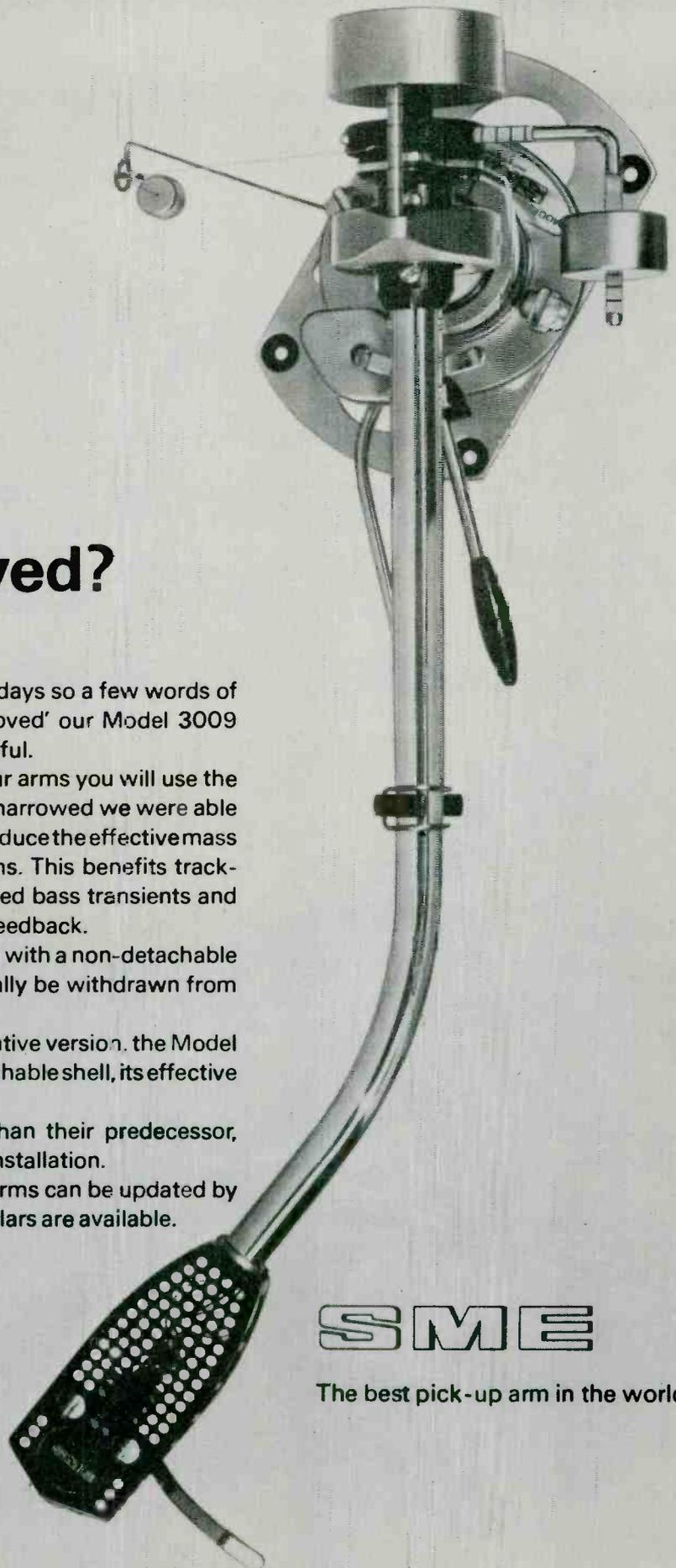
We assumed that if you choose one of our arms you will use the sort of cartridge it deserves. The field thus narrowed we were able to make them more compact and above all reduce the effective mass of the standard model to a mere 5.5 grams. This benefits trackability and all round definition with improved bass transients and still lower sensitivity to external shock and feedback.

Cleaning the stylus is not really a problem with a non-detachable shell as the stylus assembly itself can usually be withdrawn from the cartridge for this purpose.

Where the facility is demanded an alternative version, the Model 3009/S2 Improved is similar but has a detachable shell, its effective mass is consequently 4 grams higher.

Both models require a lot less space than their predecessor, widening their application and simplifying installation.

Following our established policy earlier arms can be updated by our Service Department from whom particulars are available.



SME

The best pick-up arm in the world

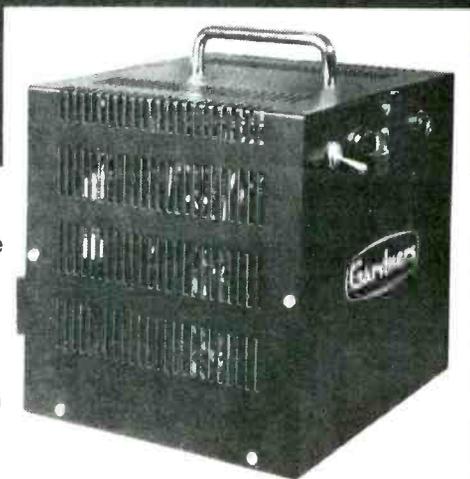
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LTD/S17

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BIG BOOST FOR THE GARDNERS RANGE

50Hz 300VA Square Wave Inverters



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

Both models offer unusually high output ratings enabling the user to operate many conventional loads such as lighting and small power tools in situations where main power supplies are not available.

Gardners inverters are designed to drive any mains operated equipment which is not unduly sensitive to the difference between sine and square waveforms. Incandescent lamps, TV sets, electric drills are typical of a wide field of possible applications . . .

Both the 107A and B models are rated at 300VA (300W U.P.F.) and will accommodate reasonable short term overloads. Price £61 plus VAT. Brochure GT 26 gladly sent on request.

Gardners

Specialists in Electronic Transformers

GARDNERS

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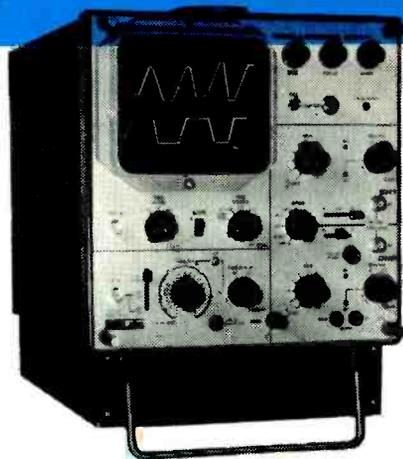
SE portable



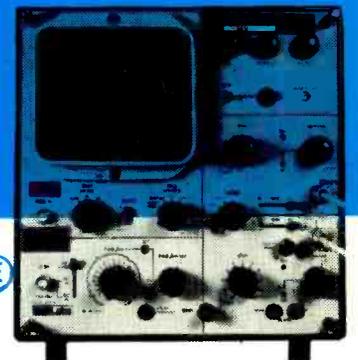
A



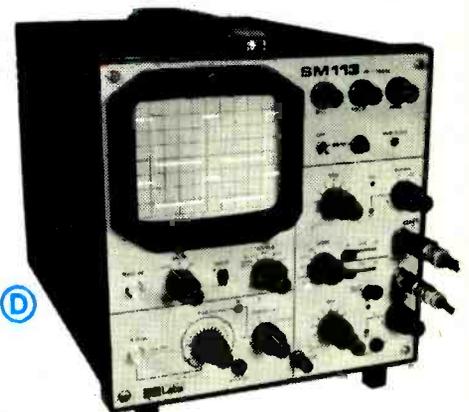
B



C



E



D

A HM207

8MHz Single Beam Service Scope, ideal for T.V. maintenance, teaching and field service, all at a price you can afford.
£79

B HM312

10MHz Single Beam, portable, ideal for production line testing, teaching establishments and servicing.
£138

C SM111

20MHz Dual Trace, battery powered, portable, ideal for both the laboratory and field servicing.
£270

D SM113

35MHz Dual Trace, battery powered, portable, high brightness version of the very successful SM111.
Only £295.00

E CT570/3 (NATO SM111)

20MHz Dual Trace, rugged & portable, chosen as first line test equipment by the British Armed Services.
From £320

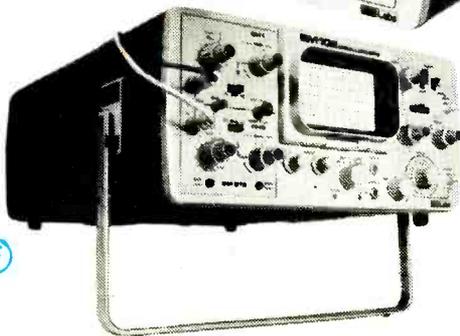
F EM102

30MHz True Dual Beam, battery powered, with plug-ins including High Gain Differential and Wide Band.
From £320

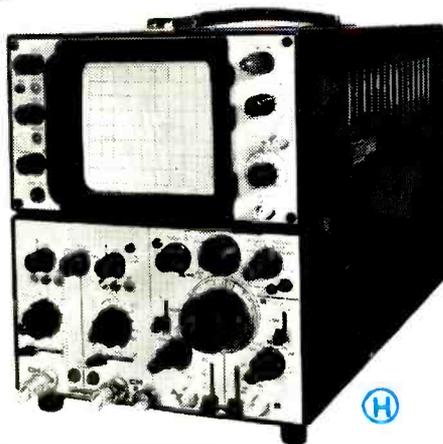
oscilloscopes



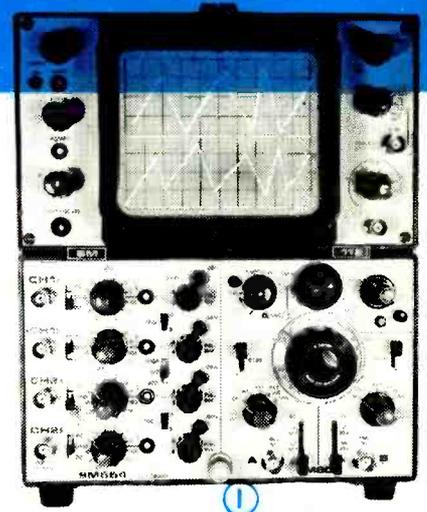
Ⓒ



Ⓕ



Ⓖ



Ⓖ

Ⓒ EM102D

True Dual Beam, with delayed sweep, battery powered, plug-ins with triggering to > 60 MHz. From £360

Ⓕ SM112/SM599

100MHz Dual Trace plug-in, portable, lowest cost instrument of this performance on the market.

Only £850

Ⓖ SM112/SM554

50MHz Four Beam, plug-in, very comprehensive, ideal for time correlation and data analysis. Complete £920

Prices quoted exclude V.A.T.

HIRE OR BUY

For a small charge you can hire any of the instruments shown here, singly or as part of a system which we can design for you.

If you decide later to purchase the equipment, we can refund part of the hire fee to you.

You save your capital and space. You beat obsolescence.

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WW-011 FOR FURTHER DETAILS

The world's
most universal
audio bridges

Wayne Kerr's B224 and B642



The B224 is a manually operated bridge, the resistive and reactive terms being independently set to a null indicated on the meter. A rechargeable battery is fitted in order to make the instrument portable.



The B642 balances itself automatically. The meters read real and quadrature terms and highly stable analogue outputs are provided which are directly proportional to capacitance and conductance above 10Ω impedance and also to inductance and resistance below 10Ω. One or two decades can be set to provide the first significant figures of the measurement, thereby increasing the meter sensitivity by 10 or 100 times. If a chart recorder is connected to the output of either term, drifts in component values to at least four significant figures can be observed.

For more information, either call Bognor (02433) 4501 or write to the address below:

WAYNE KERR

Durban Road, Bognor Regis, Sussex PO22 9RL
A member of the Wilmot Breedon group.

SPECIFICATION

Frequency	B224 (Manual balance)		B642 (Autobalance)	
	1592Hz (internal) 200Hz - 50kHz (external)		1592Hz (internal) 200Hz - 20kHz* (external)	
Ranges for specified accuracy				
	0.1%	0.3%	0.1%	0.3%
C	100fF - 10μF	10μF - 10mF	1pF - 10μF	10μF - 10mF
G	1nS - 100mS	100mS - 1kS	10nS - 100mS	100mS - 100S
L	1mH - 10kH	100nH - 1mH	1mH - 10kH	1μH - 1mH
R	10Ω - 1GΩ	1mΩ - 10Ω	10Ω - 100MΩ	10mΩ - 10Ω

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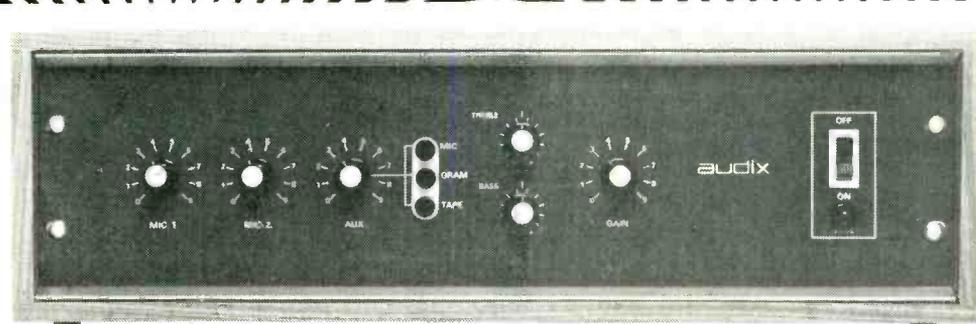
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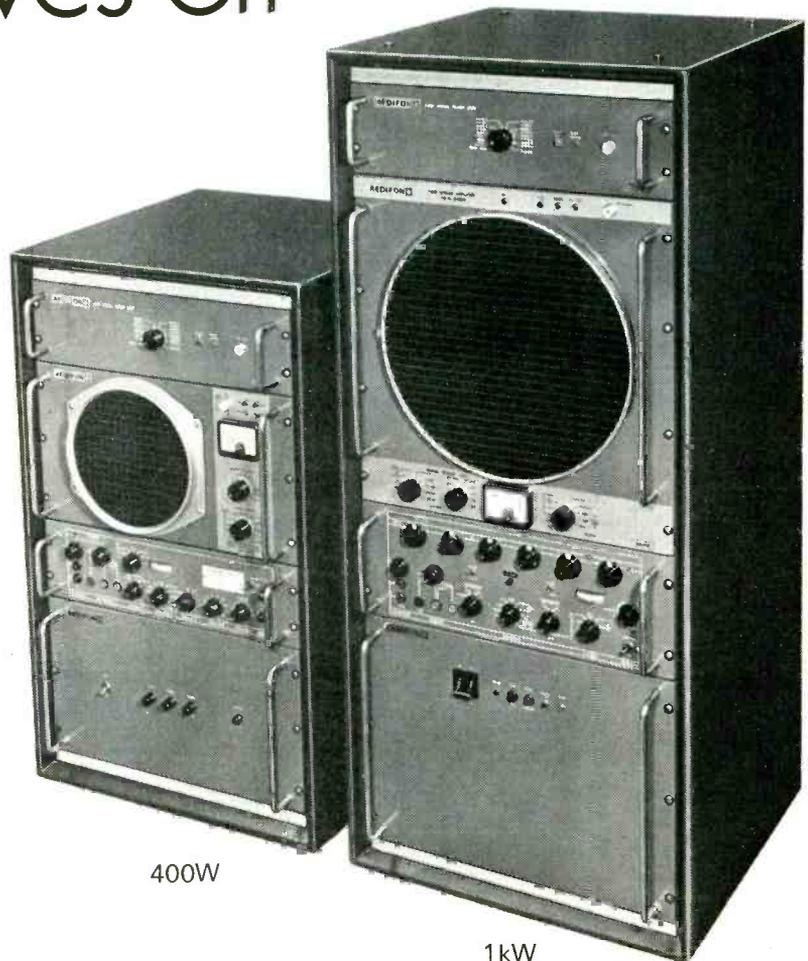
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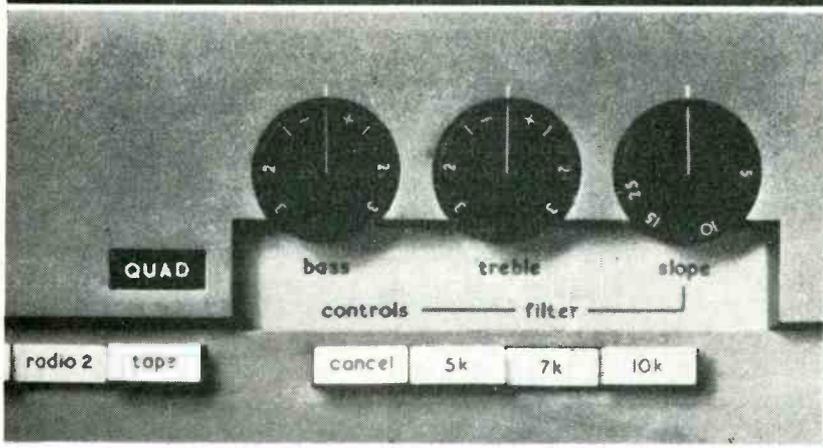
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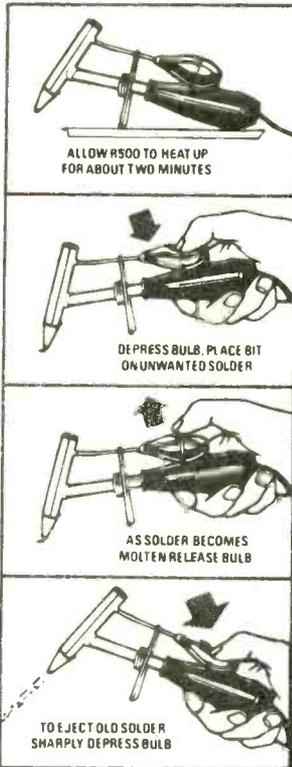
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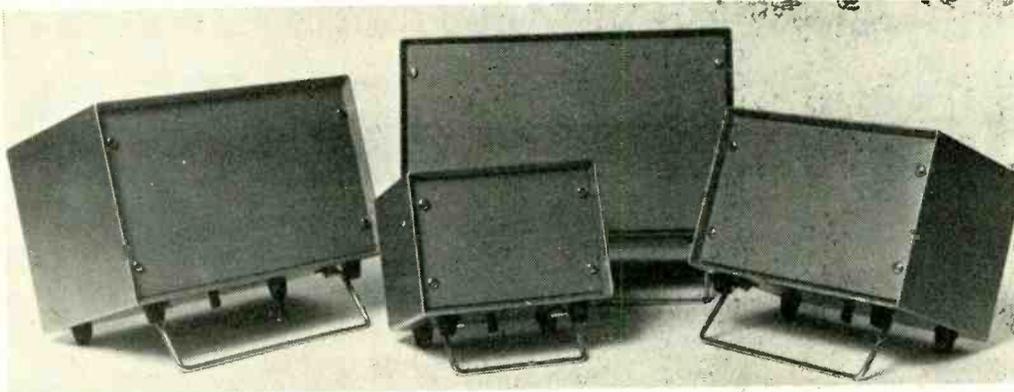
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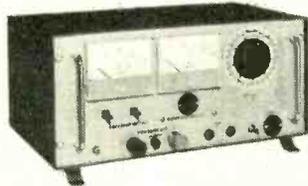
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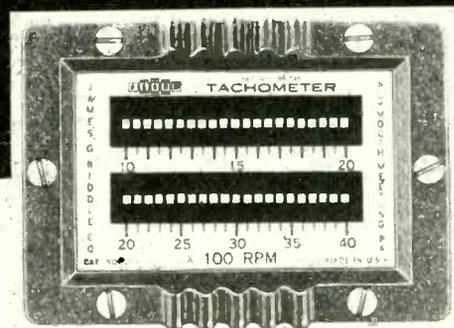
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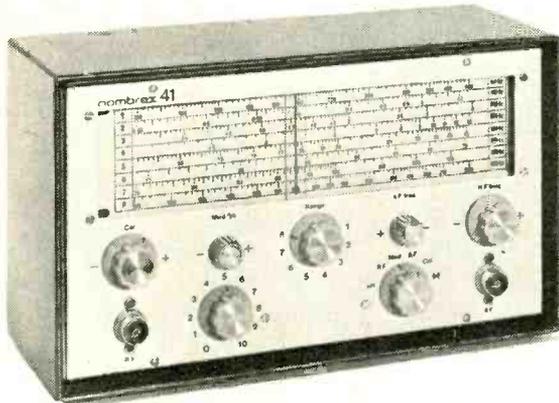
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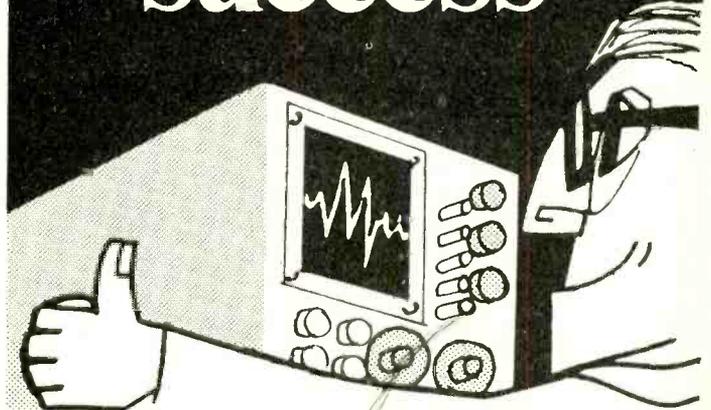
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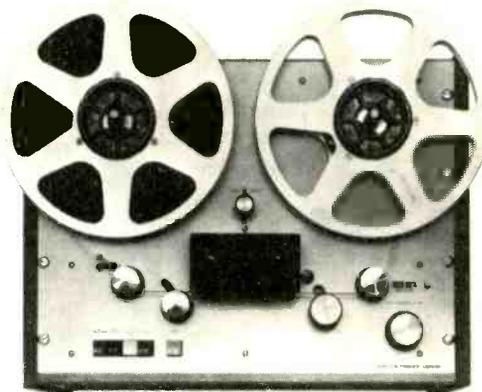
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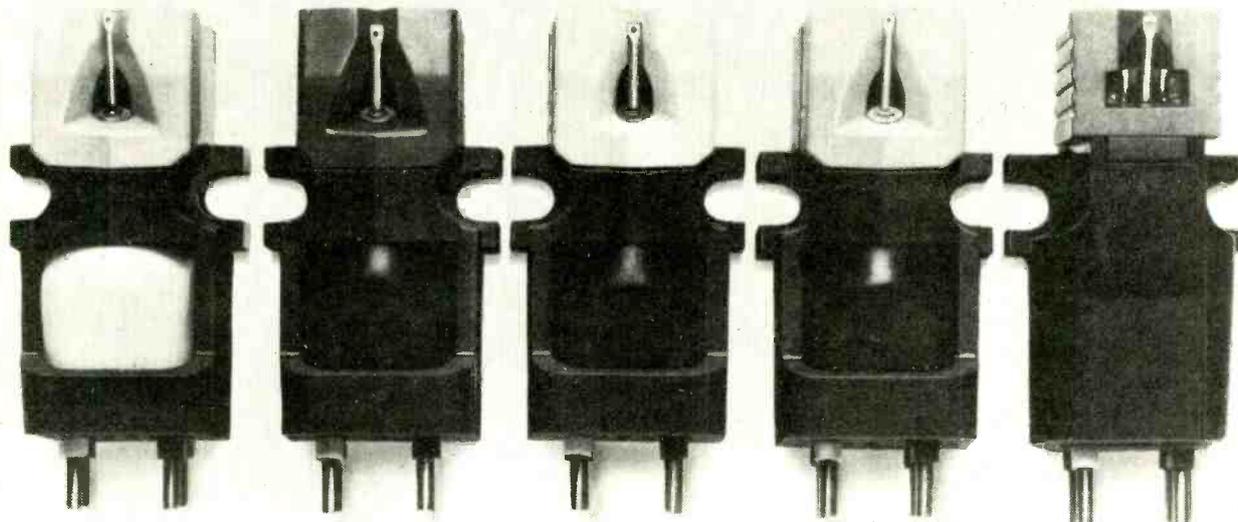
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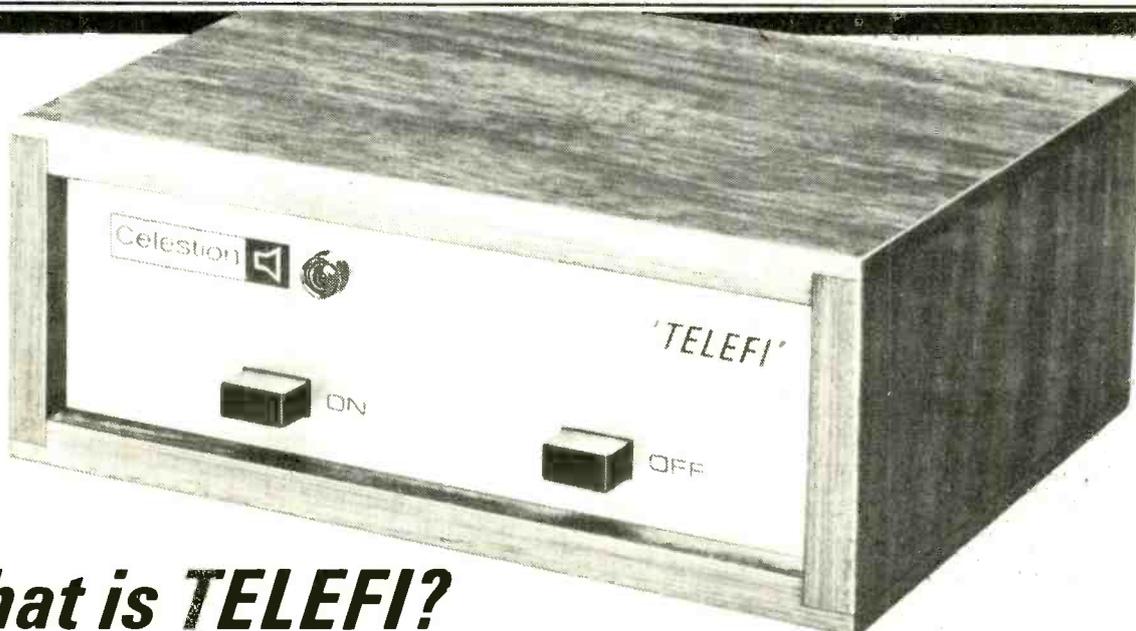
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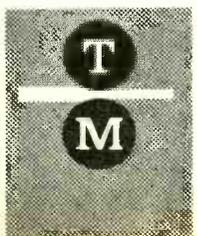
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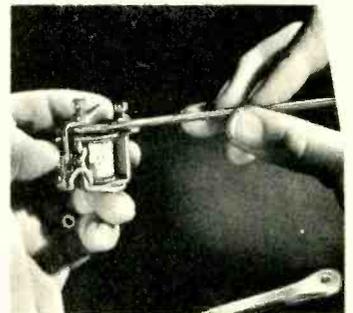
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1.0 to
18.0 GHz

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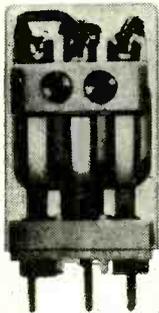
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MODEL
U-50DX

SANWA MULTI TESTERS

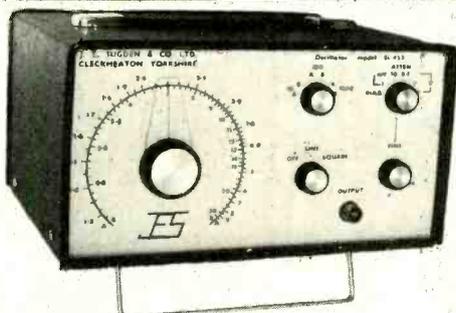
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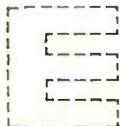
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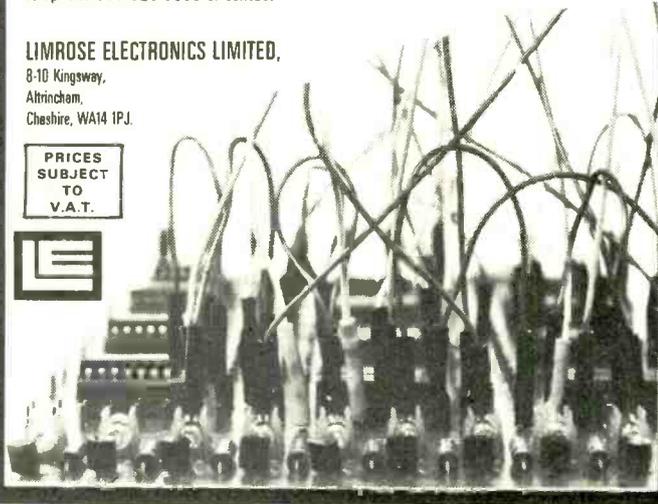
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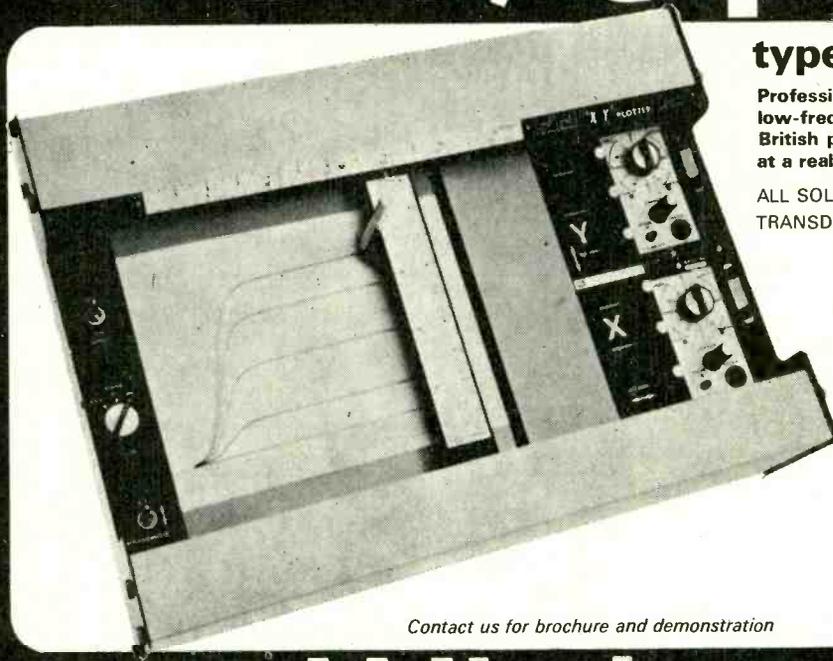
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Specification

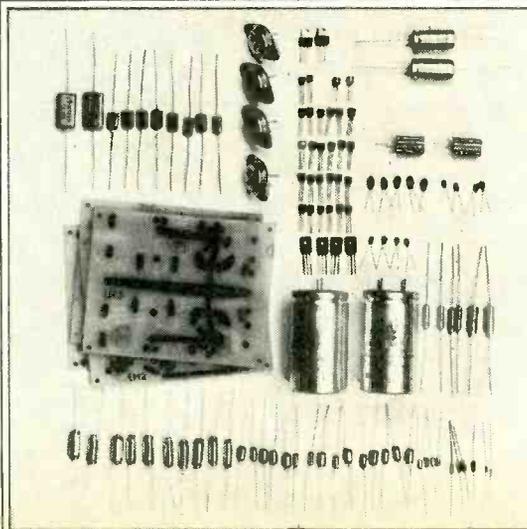
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Input selector:
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100K Ω 470K Ω
Mode selector:
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Stereo. Mono LH only.
Mono RH only. Mono
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Filter 'slope' control
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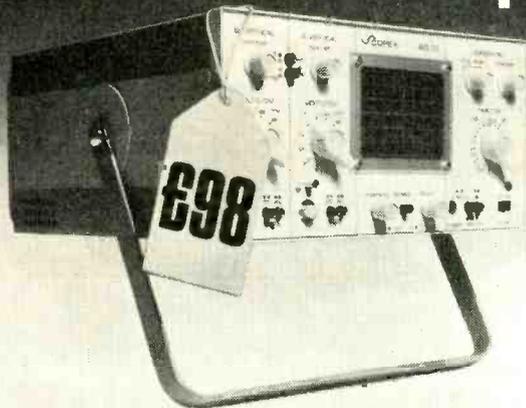
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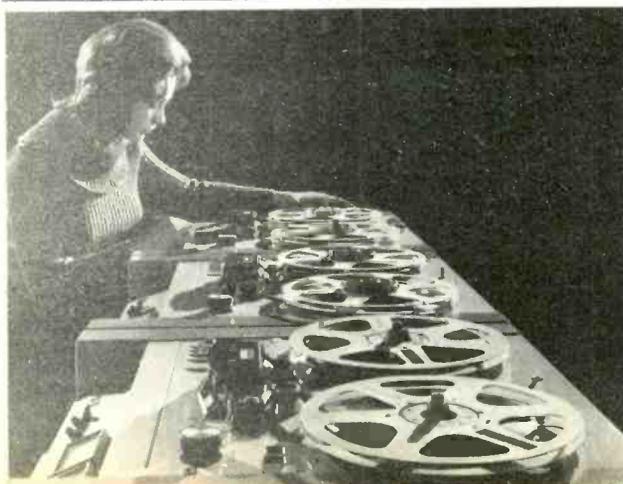


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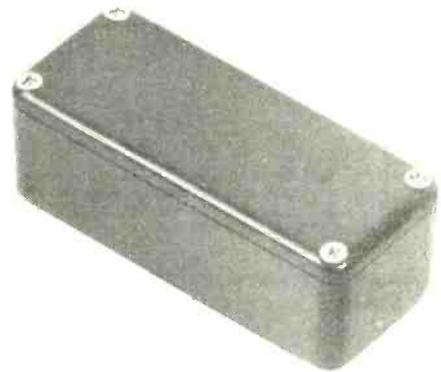
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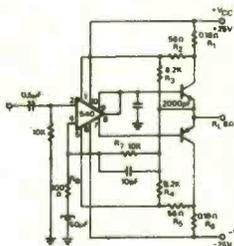
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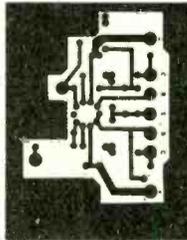


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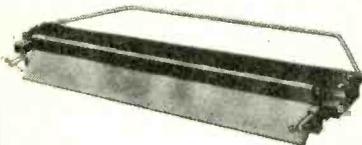
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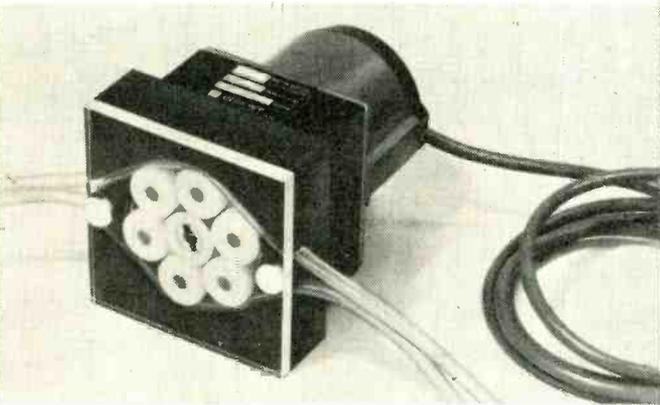
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CONTROL SYSTEMS & COMPONENTS,

DIGITIZED SYRINGES

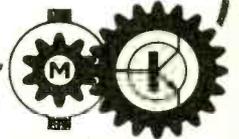


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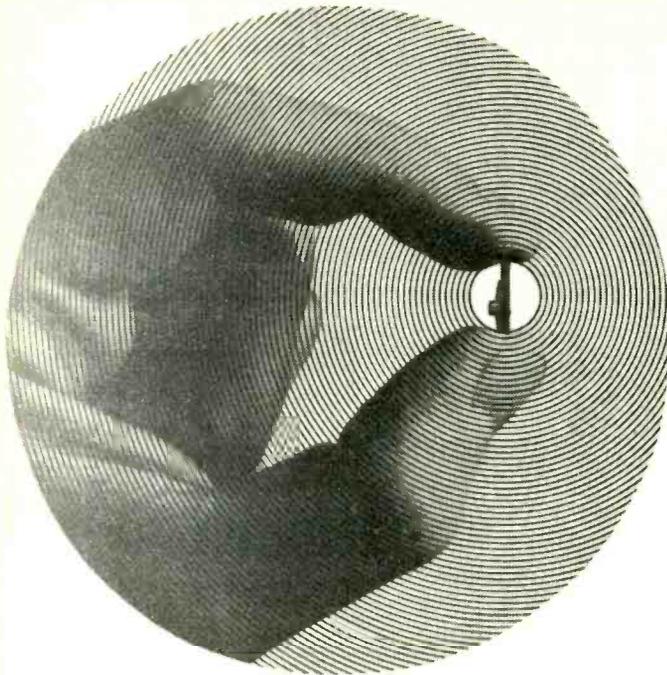
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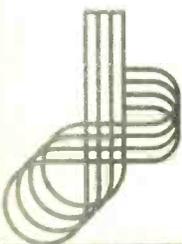


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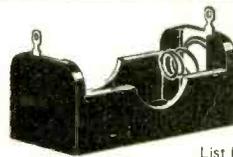
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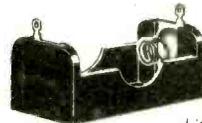
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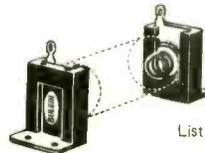
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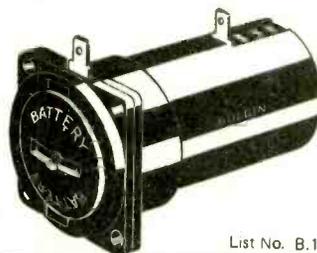
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OMRON brand Synchronous Motor driven timer with single instantaneous and two timed change-over contacts. **MINIMUM** guaranteed electrical and mechanical 10,000,000 operations.

*Stocked in 110VAC 240VAC up to twenty eight hours time range; 1/2% repeat accuracy. **£14.90** "one off" **£10** in quantity.

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Screw terminals, with clips to hold the timer or switch firmly in place where mounted. Type 8PF for STPNH, TDS, DTS. Type 8PFI for 61FGP & TDA.

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Stock range 110/240 VAC up to 28 hrs **£12.50** "one off" to **£8** in quantity

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Single Pole Changeover 15amp switch O.F. 400gm R.F. 114gm M.D.O. 4mm. **£19** per 100; **£150** per 1000; **£700** per 5000.



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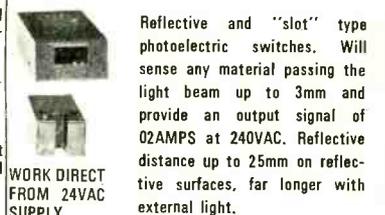
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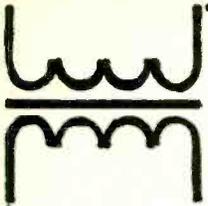
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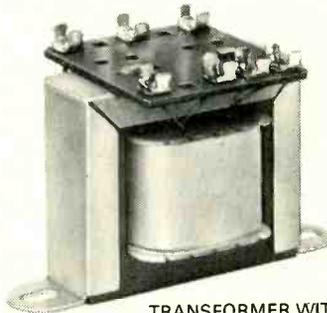
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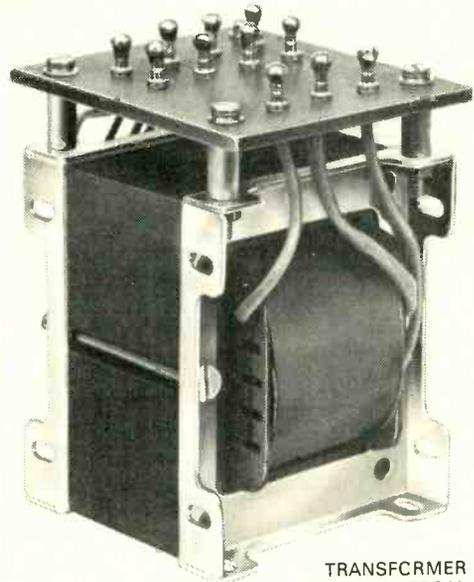
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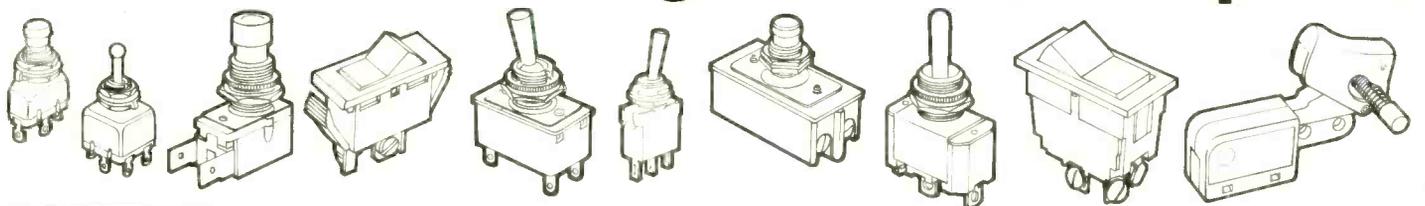
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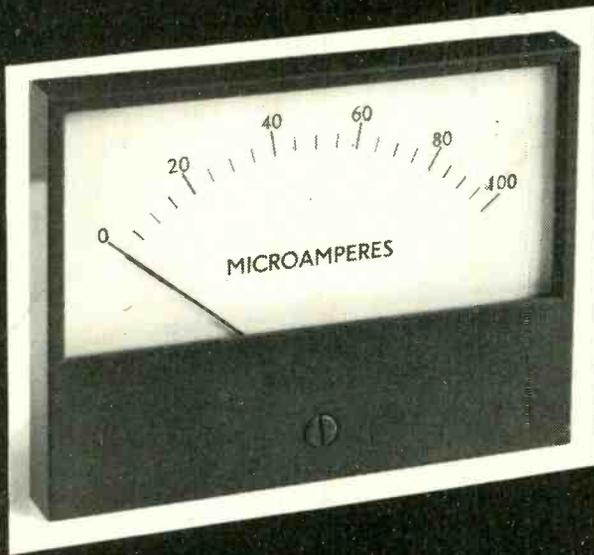
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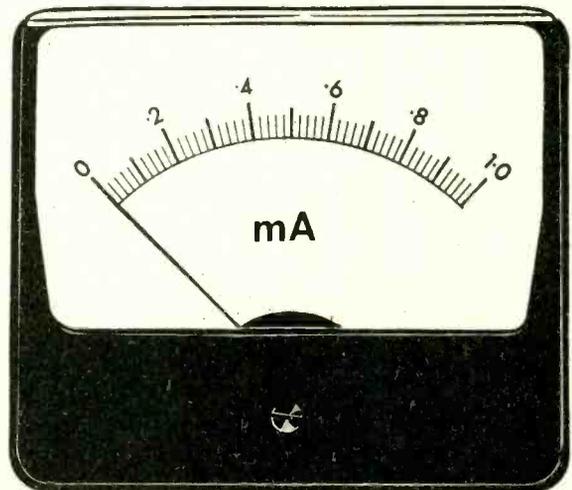
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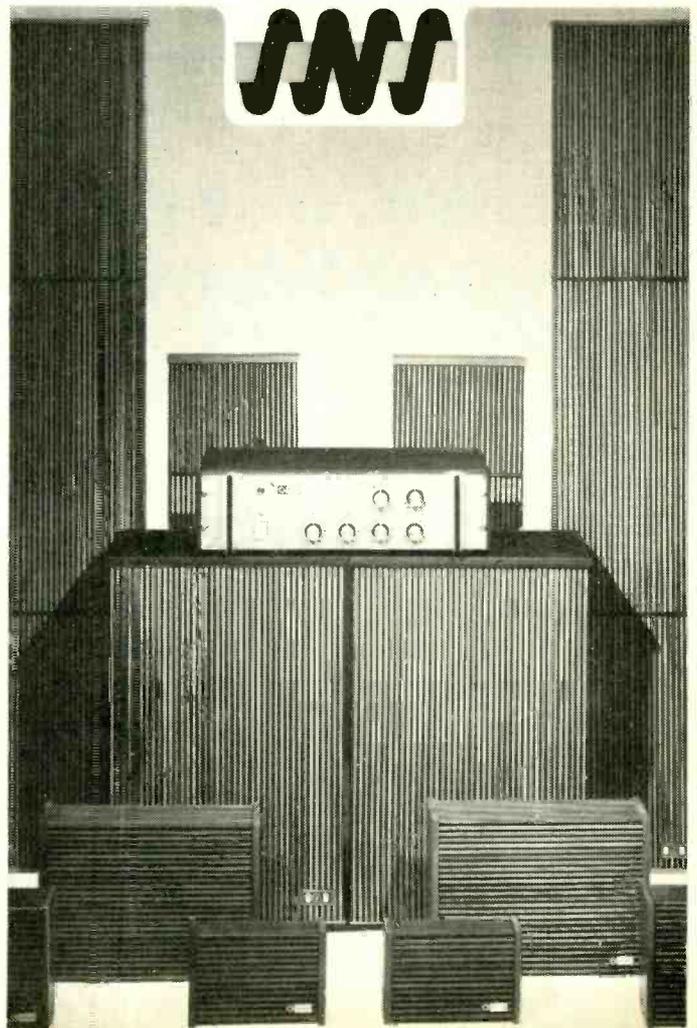
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NELSON-JONES

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Ceramic I.F. strip. Triple gang tuning, 3V r.m.s. output level, suitable for phase locked decoder, as below. Designer's own P.C.B.

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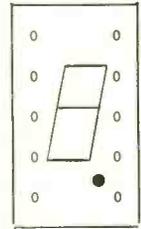
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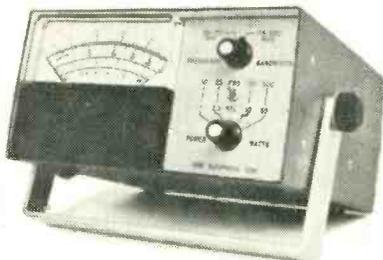
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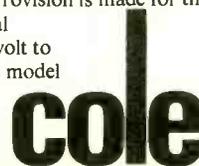
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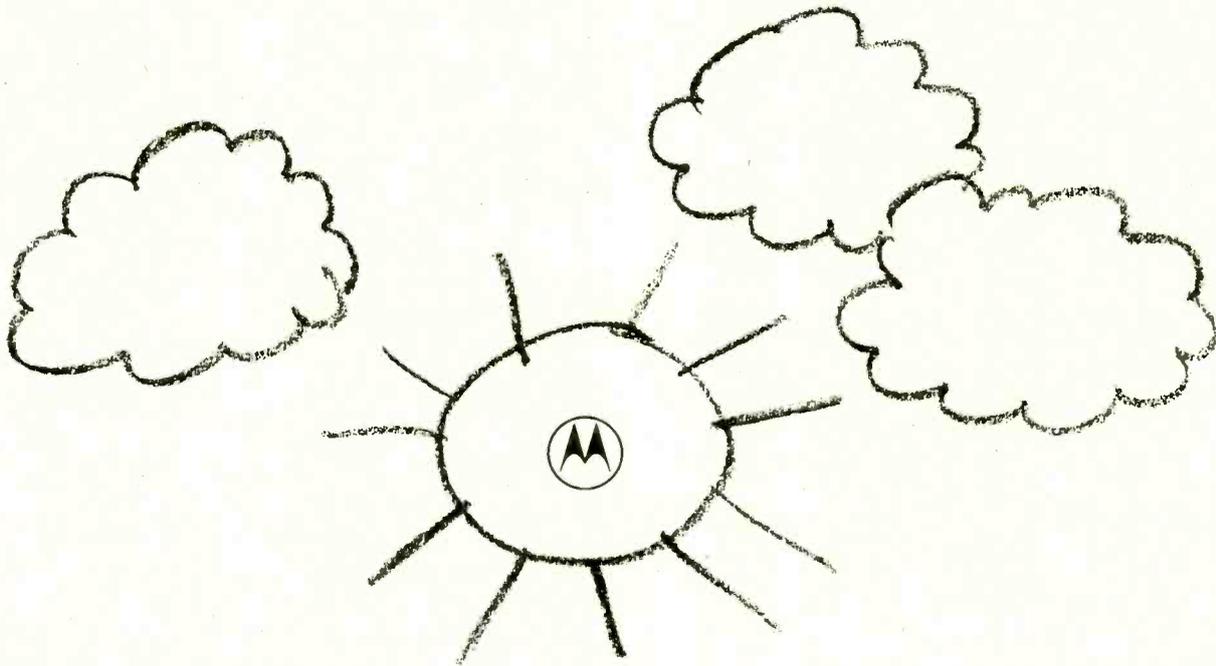
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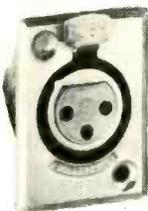
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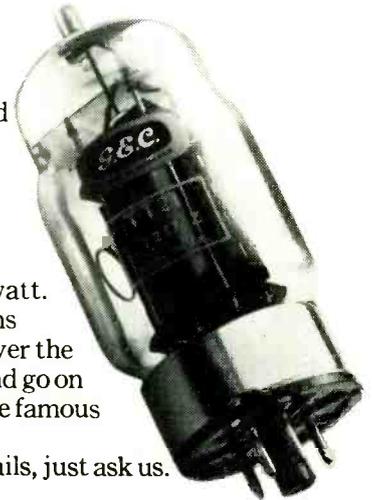
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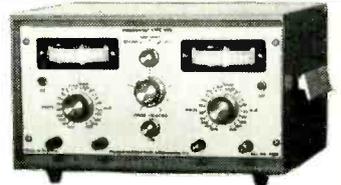
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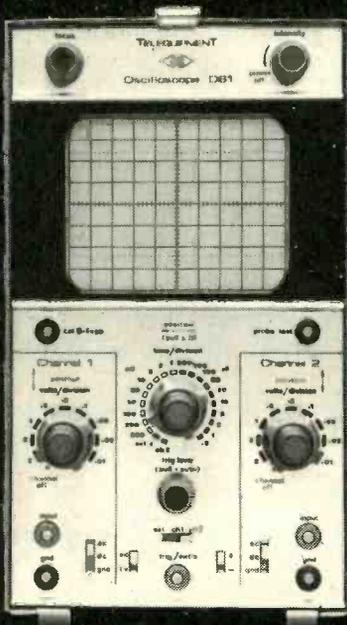
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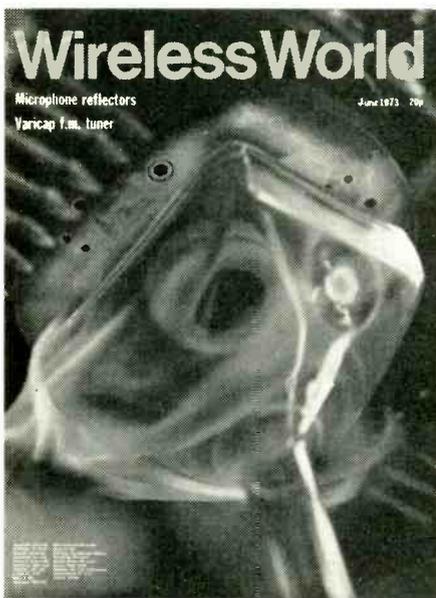
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Sixty-third year of publication

June 1973

Volume 79 Number 1452



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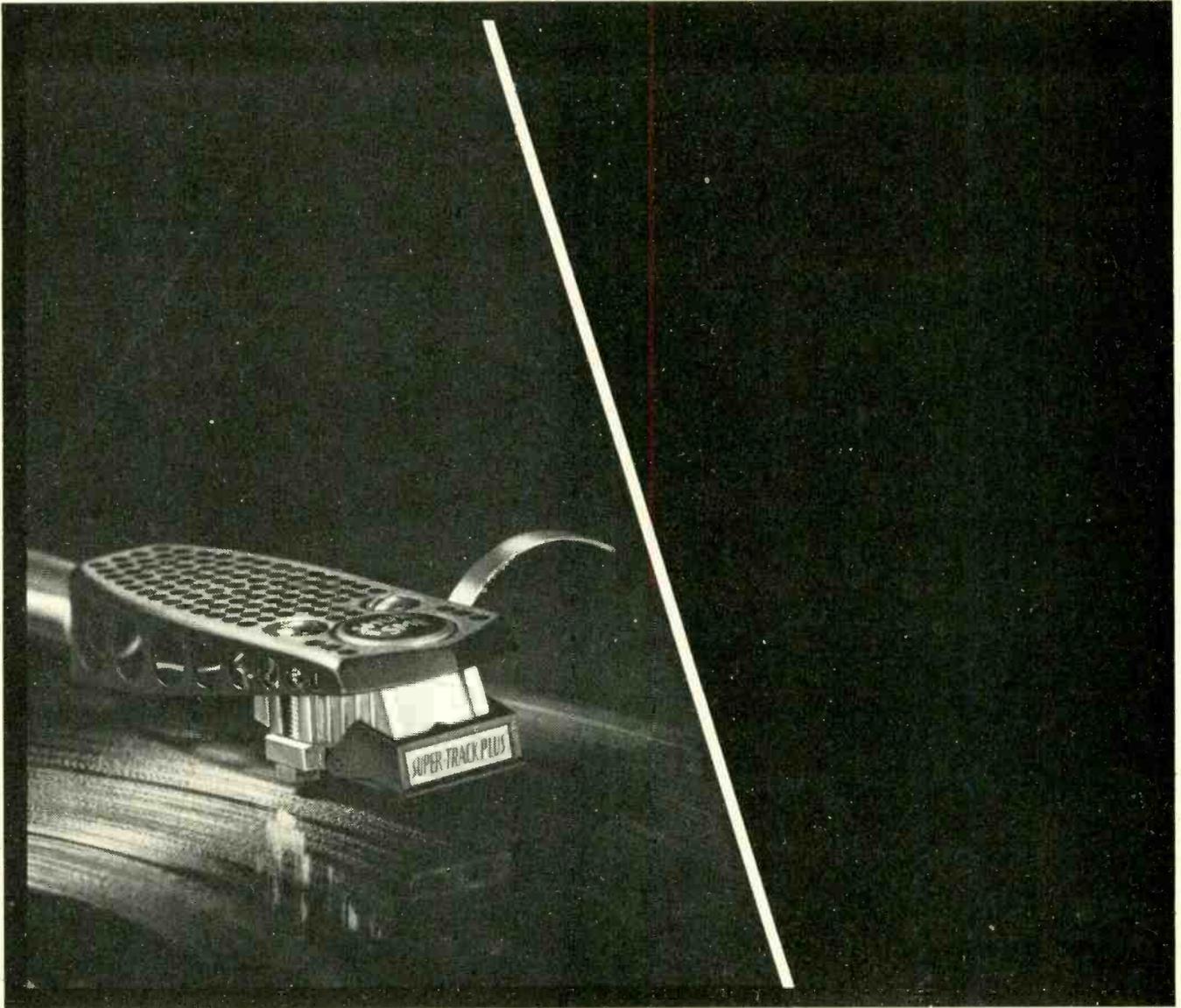
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Pity the poor teacher! Ever since electronic engineering became a recognizable subject for instruction its teachers have had the task of not only handing on the existing knowledge acquired by man over, say, a century but imparting new knowledge which is accumulating at a staggering rate with every day that passes. At the end of his three-year course a university student finds in the outside world a technology which is markedly different from what it was at the beginning. Integrated circuits are just one of the sub-technologies — like valves, transistors and computers in their day — which have hit the course planners very hard. One cannot treat them solely as functional blocks but must explain their anatomy — the active and passive devices and the circuit techniques of which they are composed. Unquestionably the student must learn about integrated circuits, but should he be taught? Should he be taught about them *as* integrated circuits, or should the aim of the educationalists be to ensure that his fundamental knowledge of physics, chemistry, maths, circuit elements and network theory is so secure that he can cope with i.cs — and any other sub-technology which may come along (e.g. opto-electronics) — as a matter of course?

What raises this question is a combination of two facts: (a) there is a serious shortage of circuit designers in the electronics industry, and (b) electronic engineering courses in universities and polytechnics are no longer predominantly based on circuit techniques and device fundamentals but are including more and more material on systems — communication, control, computing and so on. Of course, the universities in particular can rightly claim that it is not their function to provide vocational training for circuit designers but to educate — to develop the intellectual powers of the student rather than specific mental and/or manual skills. Even so, the requirements for electronic engineering education do often coincide with the requirements for vocational training, and in fact many students want it this way because they see a degree as a meal ticket. But the main point in question is whether the shortage of circuit designers is in any way the result of the changes taking place in electronic engineering courses. To be a good circuit designer one needs the mental flexibility which can only be obtained from a fundamental knowledge of elemental devices and circuits and their possibilities in various configurations. To acquire this knowledge takes time and there is only a limited time available in a course.

It was evident from a recent conference at Hull University on teaching electronic engineering in degree courses that some educationalists, at least, consider this time well lost for the sake of integrated circuits. In one first degree course, for example, integrated circuits have largely replaced their discrete circuit predecessors and about two-thirds of the final year is spent on digital i.cs. In another, students are given the opportunity to design and evaluate their own i.cs and obtain some experience of fabrication.

Admirable as these efforts are to tackle this sub-technology, there is perhaps a danger of throwing out the baby with the bath-water. Concentration on circuits and discrete circuit elements may be thought old-fashioned in a world of systems and building blocks, but may it not in fact serve better the long-term interests of both electronic engineering and education?

Microphone Reflectors

Effects of reflector material, size, focal length and microphone size and position on amplitude and polar response

by G. N. Patchett,* Ph.D., B.Sc., F.I.E.E., F.I.E.R.E., M.I.E.E.E.

A parabolic microphone reflector is often dismissed as a device which reflects the sound waves on to the microphone and hence increases its sensitivity and makes it highly directional. Unfortunately, this is a very simplified picture of a very complex problem bringing in the effects of reflection, diffraction and interference. The normal arrangement of a parabolic reflector and microphone is shown in Fig. 1, the microphone being situated at the focal point of the reflector and facing into it. The parabola has the property that the distance $AB + BC$ is a constant whatever the angle BC makes to the axis. Thus all sound waves travelling as a plane wave will arrive after reflection at the microphone at the same instant, i.e. in phase.

The difficulties of the reflector arise because of the large range of frequencies over which the reflector should operate e.g. 100 to 20,000Hz, a range of 200:1, and because the size of the reflector is comparable in size to the wavelength at some frequencies. Parabolic reflectors are, of course, commonly used for light and microwaves but these problems do not arise. Considering visible light, the wavelength is from, say, 400 to 700nm, a corresponding frequency range of less than 2 to 1. The wavelength of the light is, of course, extremely small compared with any normal reflector. Similarly, when dealing with parabolic aerials the range of frequencies is small and the wavelength of the radiation is small compared with the dimensions of the aerial.

There are many possible variations when dealing with the performance of reflectors, some being size of reflector, focal length, material, size of microphone and type of microphone, e.g. omnidirectional or unidirectional. Many statements have been made about the effect of some of these but I felt that scientific measurement of the effects of some of the variables would be valuable.

Unfortunately, acoustic measurements are difficult to make because there is no perfect sound source and one is troubled by reflections. Most of the tests have been done in an anechoic chamber but such

chambers have their limitations, and the one used was small for this purpose. Some measurements were made in the open but then difficulties arise due to wind, noise and reflections. Some errors occurred due to difficulties of aligning the reflector accurately on to the sound source.

Before reading details of the tests and results, consider what is an ideal reflector. It should have a uniform frequency response over the range concerned, a narrow polar diagram that does not change with frequency, a good forward to backward ratio and also be as small and light as possible. These factors are largely covered by considering the frequency response and polar diagram of various reflector-microphone combinations.

Frequency response

The overall frequency response does, of course, depend on the microphone, and to eliminate the frequency response of the microphone, the results given are those obtained by subtracting the response of the open microphone from the response of the same microphone in a reflector. Thus the response curves show the *change* in frequency response of the microphone when used with a reflector. There are a number of difficulties in making these measurements and most were made in an anechoic chamber. Unfortunately, there is no perfect sound source giving a uniform response over the whole audio range.

The normal method of overcoming this difficulty, when determining the frequency response of microphones, is to use a standard microphone to control the output of the loudspeaker, so that the sound level at the standard microphone is constant. By placing the standard microphone near to the microphone on test, it can be assumed that the sound level on the test microphone is also constant. This technique cannot be used with a microphone in a reflector because the standard microphone cannot be placed near to the test microphone, as it would be upset by the reflector.

Accordingly, a standard microphone was used, with feedback to maintain a constant level at the standard microphone, but this was placed well away from the reflector. The sound level at the test microphone could not be assumed

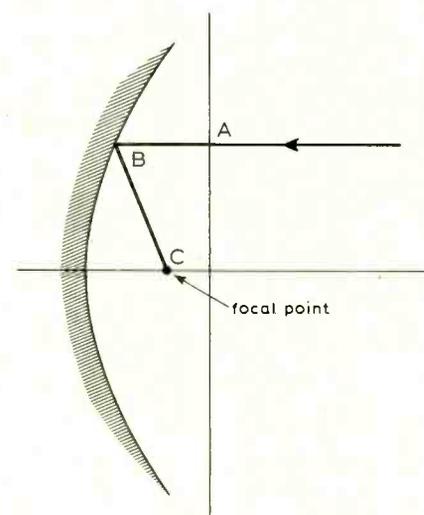


Fig. 1 The difficulty with a parabolic reflector arises because reflector size is comparable to wavelength at some frequencies.

constant, but provided changes were not made in the positions of the microphones, the sound radiated in the direction of the test microphone would remain the same, with or without reflector. Hence the *change* in frequency response by adding a reflector would be correct.

It is common practice to use a number of speakers with crossover networks to cover the whole frequency range. It was soon realized that such a sound source would not be satisfactory, as the sound at different frequencies comes from different places and when dealing with the microphone and reflector which is highly directional this would lead to errors. Hence, eventually a Tannoy speaker was used where the tweeter is situated behind the cone and the cone is used as the horn of the high frequency unit.

The first consideration was the effect of the material of the reflector. Response curves were taken on a 24-in aluminium reflector and a 24-in fibreglass reflector, both having a 7-in focal length. These gave identical responses and it was concluded that changing the material from metal to fibreglass had no appreciable effect.

The effect of such a reflector, using a Grampian DP6 omnidirectional micro-

* University of Bradford.

phone, is given in Fig. 2, and varies greatly with frequency. The gain is poor at low frequencies because the wavelength of the sound wave is comparable to or greater than the dimensions of the reflector. At 200Hz the wavelength is about 5.6 feet and hence diffraction rather than reflection takes place. The large dip of about 7dB at 600-700Hz is thought to be due to cancellation of the reflected wave by the direct wave. As the microphone is omnidirectional, it will pick up the direct wave and the reflected wave, after travelling to the reflector and back. The difference in distance is twice the focal length, 14in, corresponding to half a wavelength at a frequency of approximately 500Hz, which does not agree exactly, probably because the microphone is not a point source.

One might expect that the gain would continue to increase at high frequencies whereas, in practice, the response drops rapidly above about 10kHz. This is assumed to be due to interference effects when the wavelength is comparable with the size of microphone. Wavelength at 10kHz is 1.3in which is of the same order as the size of the microphone. Maximum gain is about 20dB which is well worth while and occurs at about 5kHz. If the drop in response at high frequencies is due to the size of microphone, then it can be reduced by using a smaller microphone. This was confirmed by the use of a Sony ECM50 which is only about $\frac{3}{8}$ in diameter and $\frac{3}{4}$ in long. In this case the peak was at about 10kHz and the maximum gain was about 22dB.

The next factor to be considered was the size of reflector, and two other fibreglass reflectors were constructed exactly similar to the 24in reflector (i.e. 7in focal length) but of diameter 18 and 12in. Fig. 3 shows the change in response, using the same microphone and two reflectors. Considering first the 18in one, the gain is now less at low frequencies as would be expected but the maximum gain is not changed much. The dip occurs at the same frequency and the magnitude of the dip is approximately the same. However, due to the low gain at low frequencies, the bottom of the dip gives a response which is less than that of the open microphone. The 12in reflector results in still less low-frequency response and a response at 700Hz which is much less than that of the open microphone. The maximum response is now reduced appreciably.

The next variable to be considered was the focal length and a fibreglass reflector was made of 24in diameter and 4in focal length. This results in a much deeper reflector which is heavier and more difficult to carry. The response, using the same DP6 microphone, is given in Fig. 4. This is similar to the 7in focal length as regards low-frequency response and maximum gain but there is no appreciable dip. If the dip is caused by interference between direct and reflected waves, then it would now occur at 900Hz. There is some reduction at this frequency but nothing like the reduction which occurs with the reflectors of greater focal length.

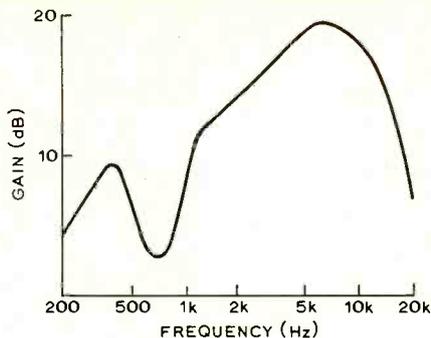


Fig. 2 Frequency response of omnidirectional DP6 microphone in 24in diameter reflector of 7in focal length.

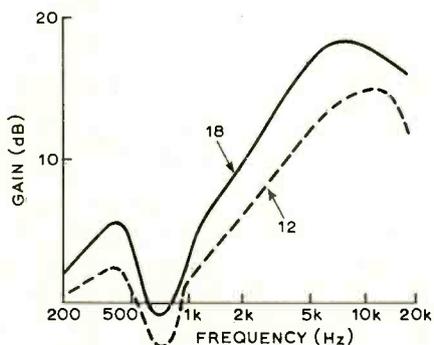


Fig. 3 Frequency response of DP6 microphone in 18 and 12in diameter reflectors of 7in focal length.

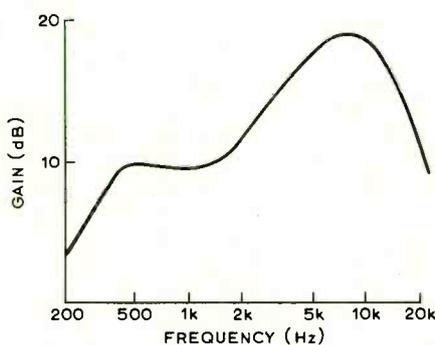


Fig. 4 Frequency response of DP6 microphone in 24in diameter reflector of 4in focal length.

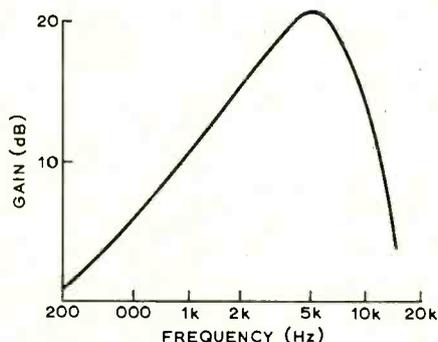


Fig. 5 Frequency response of M69 cardioid microphone in 24in diameter reflector of 7in focal length.

I do not know why. The deeper reflector therefore has the advantage of a more uniform response and it also has the advantage of protecting the microphone from the wind to a greater extent than the shallower reflector.

If the dip is due to interference between direct and reflected waves, then it should be largely removed by using a directional microphone such as one with a cardioid polar diagram. The effect of using a Beyer M69 microphone which has a cardioid polar diagram is given in Fig. 5 when used in the 24in diameter, 7in focal length reflector. The response at low frequencies is now very poor. In the case of the omnidirectional microphone, even if there are no reflected waves, the response at low frequencies will be the same as without a reflector because of the use of the direct sound waves. With the cardioid microphone the pick up of direct waves will be negligible (say -20 to -30dB) and hence the only output is that due to the reflected wave which is small. There is now no dip as there is no appreciable interference between direct and reflected waves, owing to its low response to direct waves.

The peak occurs at about the same frequency, namely 5kHz, and the maximum gain is about the same as the DP6. However, the response drops off very rapidly at high frequencies for reasons not known. The same microphone was tried in the 24in diameter, 4in focal length reflector and very similar results obtained, but with slightly greater gain at low frequencies (1 to 2dB). A Sony ECM21 (Electret) microphone, which also has a cardioid response, was tried with similar results but better at high frequencies, presumably due to its smaller size.

In all the above cases the microphone was placed at the focus of the reflector. Changing the position along the axis does not alter the frequency response appreciably but, as shown later, does alter the polar diagram. In all the above cases the sound source was on the axis of the reflector and the response changes rapidly for sources off-axis. The response of the DP6 microphone in a 24in diameter 7in focal length reflector is shown in Fig. 6 when the sound source is only

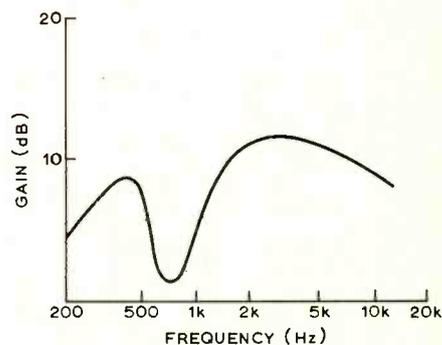


Fig. 6 Frequency response of DP6 microphone in 24in diameter reflector of 7in focal length with sound source 10° off axis.

10° off the axis. This should be compared with Fig. 2 taken on the axis under the same conditions. The response is approximately uniform apart from the dip at 700Hz. Maximum response is now less than that on the axis by some 10dB. Thus the frequency response and sensitivity obtained depend greatly on the accuracy of aiming. If the reflector is used for bird recording and there are a number of birds spaced apart, then the frequency response will be different for the different birds.

Response curves were also taken in the open air and they had the same general characteristics. However, I found it impossible to obtain steady readings at the high frequencies where the reflector is very directional. This was due to the slight wind which tilts the wavefront so that, as far as the reflector is concerned, the sound appears to be coming off-axis. In practice, if there is any wind, the frequency response will change continuously and often rapidly.

Polar diagrams

Polar diagrams were obtained using the anechoic chamber and rotating the microphone-reflector assembly. The shape of polar diagram depends very much on the frequency at which it is taken. Diagrams at a number of frequencies are given in Fig. 7 for a DP6 microphone in a 24-in diameter 7-in focal length reflector. These have been drawn with the response on axis the same at all frequencies but, of course, they will be of different amplitude according to the frequency response of the microphone. These curves are actual polar diagrams and include the effect of the microphone polar response.

With the DP6 the polar response of the microphone itself is substantially omnidirectional. At low frequencies the reflector has little effect and the response is almost omnidirectional. It is not until a frequency of, say, 2kHz is reached that the reflector-microphone combination becomes directional. At a frequency of 6kHz the response becomes highly directional and the output drops approximately 15dB when 10° off axis. There is generally an increase in response in the backward direction, relative to the sides, due to diffraction round the reflector.

A 24-in diameter reflector with a focal length of 4-in gave similar polar responses although the response in the backward direction was reduced as might be expected, the deeper reflector shielding the microphone more. The sharpness of the response in the forward direction was rather less, in general, than that of the 7-in focal length reflector. In these diagrams all the minor lobes have not been shown but have been smoothed out, as these are likely to change with small changes of frequency and, in some cases, are too numerous to draw on small diagrams.

As the size of the reflector is reduced the polar diagrams become more omnidirectional, particularly at low frequencies, and diagrams are given for the 12-in reflector of 7-in focal length in

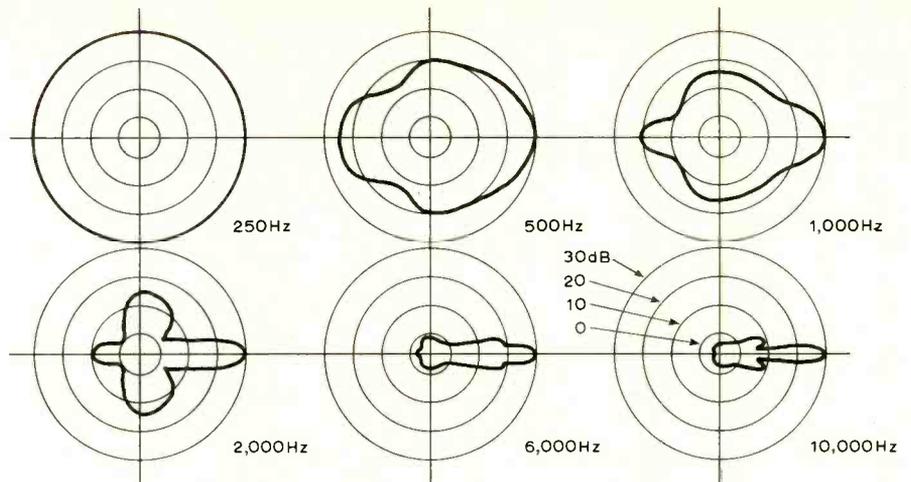


Fig. 7 Polar diagrams of DP6 microphone in 24in diameter reflector of 7in focal length.

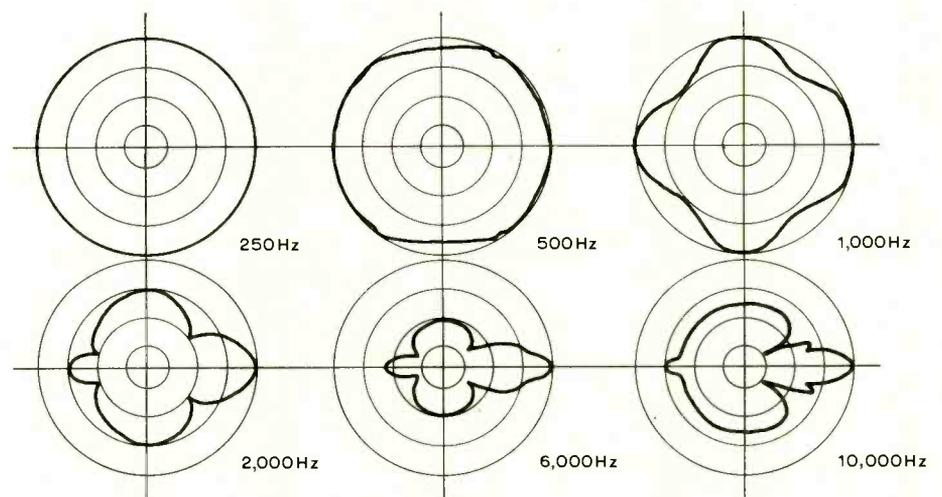


Fig. 8 Polar diagrams of DP6 microphone in 12in diameter reflector of 7in focal length.

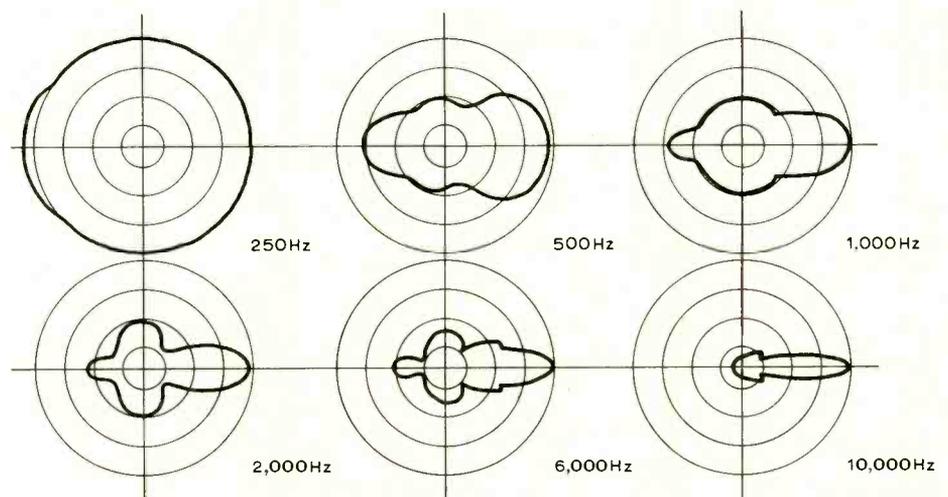


Fig. 9 Polar diagrams of M69 cardioid microphone in 24in diameter reflector of 7in focal length.

Fig. 8, using the DP6 microphone. At high frequencies the differences are not as great, but the smaller reflector does not give as great a suppression in other than the forward direction or, looking at the other way, does not give as great a gain in the forward direction. This is to be expected from the frequency response curves.

In Fig. 9 are shown the polar diagrams of a cardioid microphone (M69) in a 24-in diameter reflector of 7-in focal length. This combination gives sharper polar diagrams, particularly at low frequencies. However, at 250Hz and lower frequencies the response is greater in the backward direction than the forward. It must be remembered that the

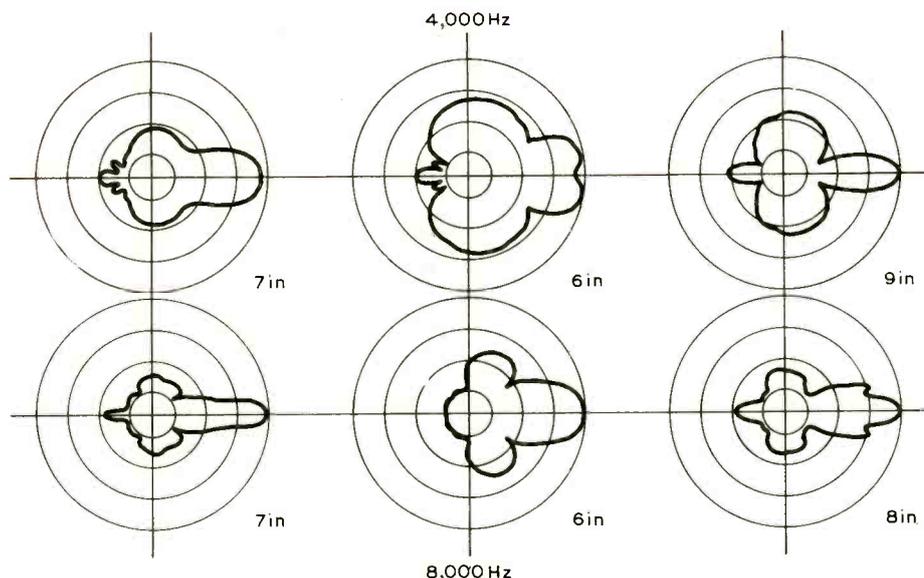


Fig. 10 Polar responses of a DP6 microphone in a 24in diameter reflector of 7in focal length with the microphone at different distances from the reflector.

microphone is pointing in the backward direction i.e. it has its maximum response in that direction. Thus at low frequencies, where the reflector has little effect, the response tends towards that of the microphone itself. This is an obvious disadvantage if there are low frequency interfering sounds at the back of the reflector. The responses of this microphone in a 24-in diameter, 4-in focal-length reflector were similar but with suppression of the response at the sides and back being rather better.

The effect of moving the microphone on the axis away from the focal point is large and is shown in Fig. 10. These are taken at 4 and 8kHz for the DP6 microphone in a 24-in diameter, 7-in focal-length reflector. If the microphone is not placed at the focal point, the sharp polar diagram is destroyed with the introduction of side lobes.

It is obvious that some distortion of the sound will occur when using a reflector, the amount depending very much on what is being recorded. Frequency distortion will be greatest when a large range of frequencies is involved, there being considerable loss of low and very high frequencies. How important this is depends on the application.

Reflectors are commonly used for wild life recording, particularly of birds. Many birds have a song at high frequencies and hence the loss at low frequencies is not so important but some harmonics may be lost due to the reduced response at very high frequencies. I did some tests to determine if the distortion was audible.

Recordings of birds were obtained using an open microphone. These were then played in an anechoic chamber, using a high-quality loudspeaker, and the resultant sounds were picked up by various microphones and microphone-reflector combinations. The difference is only slight for birds with a high-frequency song but is very noticeable in the case of birds with a relatively low-frequency

song. One recording was made of a chaffinch and Canada geese. When a reflector is used, the relative levels change, the chaffinch song being increased relative to that of the geese, and the sound of the geese is appreciably changed and becomes much thinner.

It should be possible to correct for this response, say after recording, by re-recording through a filter with a response the opposite to that of the microphone-reflector combination. I tried this and an improved result is obtained, the bird sounding more natural. However, the difficulty is that any low-frequency unwanted background noise is greatly increased and unless an original recording with very low background can be obtained, the method is not very practical. Another difficulty is that the response varies greatly if the source is off axis and hence the filter used can only be correct if the sound source was accurately on the axis. Any other sounds off axis would, of course, be distorted due to the correction filter.

It is difficult to know just how much distortion is acceptable and again this depends on the application. If the recording is of a rare bird, then a recording with some frequency distortion is presumably better than nothing or one with large background noise due to the use of an open microphone.

An alternative to the microphone and reflector, and used by broadcast authorities, is the gun microphone. This has a more uniform frequency response if designed correctly. It does not have a sharp polar diagram, although the polar diagram does not change much with frequency. The microphone does not have the inherent gain of a reflector and is very expensive.

In practice, the polar response of any directional microphone will be changed by the reflection from local objects, from the ground and by the effect of the wind.

Jobs for the Grads

When looking for jobs electronic engineering graduates are increasingly coming to regard industry as a "relatively insecure second best" according to Roland G. Hirst, Careers Adviser of Hull University. Speaking at a recent conference at Hull on electronic engineering teaching* (see Leader), Mr Hirst said that until 1970-71 few graduates had had serious difficulty in obtaining jobs, and a very high proportion of students had sought employment in the electronic engineering industry. The severe recession in graduate recruitment to the industry which took place in 1970-71 and continued into 1971-72 seemed to be largely over. Large numbers of vacancies had been notified for 1972-73 graduates but a strange change seemed to have taken place. The publicity given to "rationalization", redundancies, "adjustments to research budgets" and the like seemed to have penetrated the undergraduate consciousness. The result this year was that industry was rarely mentioned as a primary career aim.

Adverse publicity and the sharply reduced number of vacancies had had a considerably greater effect on student attitudes than most employers seemed to realize, went on Mr Hirst. With a virtually static output and a steadily rising demand for electronic engineers which the present economic expansion seemed to indicate, the industry would need to positively market its career opportunities if it were to achieve its recruitment targets.

An industrialist and part-time academic, Dr P. L. Kirby of Welwyn Electric Ltd, admitted that the industry tended to take a short-term view over employment. "When things get difficult down come the shutters" he said, and sandwich courses etc. were cut. The difficulty was that industrial cycles were short-term events relative to the universities' time scales. There had in fact been an electronics manufacturing boom since Christmas, particularly in the components sector, and although there was a general atmosphere of confidence prevailing the employers were not willing to commit themselves. Employment would not go up *pro rata* with production: it was greater productivity that they wanted.

Mr Hirst maintained that the massive publicity to "graduate unemployment" was based in part on a misconception. Graduates were the only specialist group entering employment for whom figures were available. Whether graduates suffered more or less than school leavers, holders of H.N.Ds and other groups was simply not known.

*Copies of the Proceedings can be obtained from Dr F. W. Stephenson, Department of Electronic Engineering, University of Hull, price £2.50 including postage.

News of the Month

TV data service

Engineers of the Independent Broadcasting Authority have recently developed and demonstrated a new television data system, "Oracle", capable of providing a continuous public information service on conventional TV transmitting networks. With this system, the public would receive up to 50 different "pages" of information "written" on their television screens, each page containing up to 880 characters, or roughly 120 words. These messages can be displayed or superimposed on the screen of a domestic TV receiver without in any way affecting the reception of normal television programmes.

The system is similar to the B.B.C.'s proposed "Ceefax" system (see May issue "TV Information Service") with information transmitted within the normal TV signal. The two systems are, however, not compatible and before a nationwide service could be considered it seems desirable that a standard for the transmission of such a service should be decided upon. Experimental "Oracle" transmissions have been made on the IBA's London television broadcasting station to test the experimental receiving unit which has been assembled at the Authority's London headquarters. Any kind of written information could be sent, one page at a time, with the individual pages up-dated at regular intervals. Since it takes 1.8 seconds for the transmission of one page of this material, it is possible for the 50 pages — each perhaps representing an entirely different information service — to be up-dated or re-written in a period of less than two minutes. The viewer would also have the facility to "hold" indefinitely any page of this information.

Two television line periods, during field blanking, have been set aside internationally for data transmission, although not specifically for public data transmission. Two 64-microsecond line periods repeating at the rate of 25 per second, are more than sufficient to allow the amount of data envisaged in an "Oracle" service to be transmitted. During each brief "Oracle" transmission period — that is 64 microseconds 50 times a second — one "segment" of display information representing up to ten characters, is transmitted together with its "address code". This address indicates to

the receiving unit the exact position on the screen and to which page the information relates. This signal is in the form of a run-in code (5 binary digits or bits), a start code (8 bits), a line number (5 bits) and the field or page number (6 bits), and the address (8 bits).

Collision prevention for cars

RCA have developed an experimental radar designed to prevent car collisions by responding to the distance of the car ahead and sounding a warning when the separation distance becomes unsafe. The radar, mounted on the front of a car, transmits a continuous signal which is received by a "passive reflector" on the rear of the vehicle ahead. The reflector doubles the frequency of the transmitted signal and sends it back to the radar. By measuring the time required for the signal's round trip, distance to the car in front can be calculated. A warning light and buzzer indicate when the separation distance decreases below one car length for each 10 m.p.h. of speed of the car carrying the radar. Range of the radar is 100 yards.

The radar still requires testing and refinement but RCA believe that an opera-

tional system, including both the transmitting/receiving radar and the special reflector, can be mass produced within five years. Besides safety applications, the radar could also permit a smoother traffic flow and significantly decrease travel time in congested areas.

An important feature of the radar system is its rejection of false responses created by signals returned from roadside objects. This is achieved by making the radar receiver responsive only to those signals produced by the reflector at double the transmitted frequency. Since the signals reflected by the road and roadside objects are not at this second harmonic, they are ignored by the radar. The experimental radar transmitter/receiver measures $17 \times 8 \times 2\frac{1}{2}$ in. It is mounted on the front bumper of the car, but an operational version could be smaller and concealed in the grillework or behind a non-metallic front licence plate. The radar beam is narrow, so that when a car moves out to pass a car ahead, the signal is not reflected and the car can pass without a warning being sounded.

Fast data link

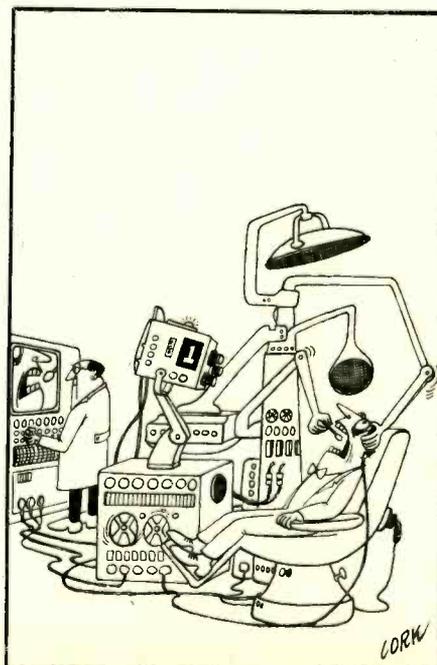
The Harwell Electronics and Applied Physics Division of the U.K. Atomic Energy Authority have developed a novel system for interconnecting computers over inexpensive lines without the aid of repeaters. The system permits a rapid exchange of serial data at a low error rate over distances up to $1\frac{1}{2}$ miles. For example, the data transfer rate over $1\frac{1}{2}$ miles and with an error rate of 1 in 10^{10} is 880 kilobits/sec. Shorter distances allow higher bit rates and vice versa.

A data-link system consists of a pair of couplers, each inter-facing a computer to line, software inter-facing with the customer's programme, and the line itself. Each coupler is connected to its computer as a typical autonomous peripheral device, i.e. it can receive command words and have its status tested under programme control, and it exchanges data with the computer in autonomous mode. The transmit channel of a coupler accepts words in parallel from the computer and converts them to a serial bit-stream for transmission. The receive channel accepts a serial bit-stream and presents data as parallel words to the computer.

The software package operates in real-time, and data links time share with the customer's other programmes. Error detection and rapid recovery facilities are included. Each data link operates over two twisted-pair wires in multi-pair telephone cables.

BSI asks for industry's view

Many people have suggested that some kind of standard code for product reference numbers is desirable and investigations are being carried out in this country and abroad. Three years ago, when the British Standards Institution circulated a draft for comment, the replies



showed interest in the idea of a standard but little agreement on the form of numbering to be used.

In order to find out what system of numbering will be the most suitable BSI is now circulating a second draft, with a questionnaire. This draft describes three different systems of numbering and the advantages and disadvantages of each. People responsible for the allocation and use of product reference numbers are asked to obtain copies of the draft and send BSI their views in the questionnaire. The information thus collected should show what kind of standard format is likely to be the most useful.

Queen's Award to Industry

Among companies receiving the Queen's Award to Industry are EMI, Racal-Milgo, B & W Electronics and the English Electric Valve Company.

EMI received two awards, one to the Central Research Laboratories at Hayes, Middlesex for technological innovations in the EMI-Scanner, a computerized X-ray technique for the investigation and diagnosis of brain disease. The second is to Anglo-EMI Film Distributors Ltd, the Group's film production and overseas distribution company, for export achievement. Racal-Milgo and B & W also receive their awards for export achievements in the respective fields of data communications and loudspeakers.

The award to the English Electric Valve Company is in recognition of achievement for technical innovation in ceramic hydrogen thyatrons. These are gas-filled electron tubes used as very accurate, high voltage, high current, fast operating switches which can switch powers of many millions of watts with accuracies measured in nanoseconds.

IBC '74

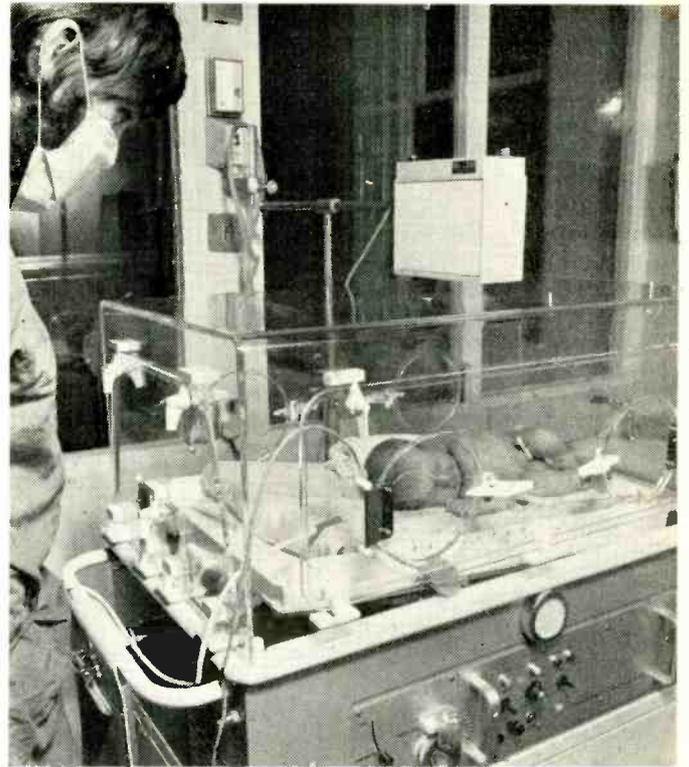
The fifth International Broadcasting Convention — IBC '74 — will be held in London at the Grosvenor House, Park Lane, from 23rd to 27th September 1974.

Advances in all aspects of broadcasting will be highlighted both in the technical sessions and in the exhibition of broadcasting equipment, both radio and television. Among the items to be covered in the technical sessions are: automation in broadcasting; training and management; future maintenance philosophy; propagation and service planning; receivers; recording, storage and replay; satellites in broadcasting; signal distribution systems: signal sources; sound systems — stereophonic and quadraphonic; technical aspects of international programme exchange; and transmitters, transposers and aerials.

New communications satellite

A new synchronous satellite, Intelsat IV-A, will have nearly twice the capacity of the Intelsat IVs now in global service. The International Telecommunications

Based on a radar principal applied to intruder detection devices, the unit suspended above this baby provides monitoring of the life condition without any physical contact. Should movement cease, an alarm is triggered and immediate action can be taken by the nursing staff. The detector, supplied by S. E. Laboratories, is installed at the new Nottingham City Hospital baby care unit.



Satellite Organization (Intelsat) has approved a \$72 million contract with Hughes Aircraft Company to build three of these high-capacity satellites for handling increasing international telecommunications traffic. Launch from Cape Kennedy of the first satellite in the new Intelsat IV-A series is scheduled for mid-1975.

An estimated 40 million overseas telephone calls will be made to and from the United States this year. The number is expected to rise to 200 million by 1980. To fulfil this accelerating growth, the larger and more powerful Intelsat IV-A will carry a new type of aerial able to re-use the same frequency aimed at different points on the globe. Use of the new aerial system will require no major changes or modifications in existing Intelsat ground stations. The spacecraft will provide capacity for 11,000 telephone circuits or 20 simultaneous colour TV channels, nearly double that of the present Intelsat IVs.

Tape news

Philips, the originators of the Compact Cassette tape system, celebrate the tenth anniversary of their invention this year. The cassette recorder was first introduced as a small battery portable machine at the Berlin Radio Fair in 1963 and since then the combined total sales of cassette machines have topped the ten million mark.

This year also marks their entry into the DIN "hi-fi" standard range with new cassette recorders. A particularly interesting feature of these machines is a clever hysteresis clutch fitted to the feed and take-up spools in place of the more conventional felt pad clutch. Philips claim

that this clutch, unlike the felt pad version, requires no maintenance and will give the correct torque in braking and take-up modes under all conditions. If the claim proves to be well founded this one idea could go a long way towards reducing the common jamming problems experienced with many cassette machines.

Further to our March issue report on modern tape recorder heads, an increasing number of research and development papers have been reaching us on the topic of Sendust heads. This material first appeared in some experimental video heads made in Japan. It is an alloy of 85% iron, 5.5% aluminium and 9.5% silicon, the permeability falling midway between that of Mumetal and the ferrites currently employed for many audio heads. Sendust was first discovered in Japan over 20 years ago as a substitute for the nickel alloys but since it could only be made in powder form its use has been, until recently, confined to resin-bonded powder cores for r.f. coils and transformers. New techniques are being developed to produce a suitable form for the laminations of a head core. Its advantage over Mumetal is that it is considerably harder and suffers less from loss of magnetic properties when the usual finishing operations are undertaken. From the amount of interest being shown in this material it is felt that tape recorders with heads of this new material are likely to appear on the market this year. Its value is obvious in cassette recorder applications where chromium dioxide tape, now readily available, creates two unique problems. First, increased head wear, though some brands claim equal wear with the ferric oxide types and second, a higher coercivity which some ferrite heads cannot overcome without driving into saturation.

Seen at the Physics Exhibition

Display techniques ● c.a.d. ● function generation ● node logic

Voltage-variable colour filter

The "twisted" nematic display, a liquid crystal* cell relying for its operation on polarized light, has the attractions of negligible current consumption, low threshold voltage, high contrast ratio, and dual absorption or transmission modes (black on white or white on black displays). In this kind of display a thin film of a nematic liquid crystal, or a mixture of such materials, is sandwiched between two glass plates on which conducting but transparent electrodes have been deposited, around 10 to 50 μ m apart.

This type of display uses the surface of the electrodes to orient the nematic molecules (in a nematic, the ellipsoidal molecules have their long axes in the same direction) parallel to the electrodes. In a "twisted" nematic cell, *WW* May 1972 page 230, the alignments on the two electrodes are at 90° to one another, the result being that the molecular alignment is twisted and follows a quarter turn of a helix. As the helix pitch is made much larger than the wavelength of light used, the helix acts as a guide for plane-polarized light, rotating it through 90°.

Application of an electric field over a certain threshold value causes the induced electric dipole, and hence the molecule, to be parallel with the field. Being parallel to the optic axis, polarized light now passes unrotated. Thus, with the addition of a polarizer either side of the cell, the display can be switched from transmitting to reflecting or vice versa by making the alignment of the two polarizers 90° or 0°.

Work on this kind of device is going on at many laboratories and devices of this kind were shown by the Royal Radar Establishment, last year. A related device was shown by Standard Telephone Laboratories this year, that produces a voltage-variable colour display. In this one, molecules are again aligned parallel to the electrode surfaces, but the surfaces are arranged to be parallel, rather than twisted

by 90°. So all the molecules are constrained by the surface forces to have their long axes parallel to, and in the plane of, the electrodes. The material resembles a uniaxial crystal with its optic axis perpendicular to the light direction.

The cell is placed between "crossed" (90-degree) polarizers, with the long molecule axis at 45° to the polarization axis of each polarizer, this giving maximum light transmission. The material is birefringent (for light not incident along the optic axis) and there is a phase difference between the ordinary and extraordinary refracted rays. Plane-polarized light is thus rotated by the crystal, the amount depending on wavelength. When the molecules are normal to the incident light, the birefringence is maximum, decreasing to zero as the applied electric field rotates the molecules to be parallel to the field, and light direction.

White plane-polarized light, transmitted by a polarizer, is rotated by the cell and only a narrow bandwidth of light, i.e. one colour, passes the second polarizer, effectively giving a voltage-controlled colour filter. The material is so birefringent that the plane of polarization is rotated by more than the 90° required for transmission through the second polarizer at low voltages. Several wavelengths are transmitted corresponding to 90, 270, 450° etc., producing mixed colours. At about 10 to 20V pure colours are obtained and at around 30 to 40V all molecules are aligned with the field, resulting in no birefringence and no transmission (polarizers crossed).

Response to voltage changes is fast and the display can be operated up to around 100kHz. High-purity material can be used because no conduction is required, which apparently greatly increases operating life. Operating temperature of such devices is -15 to +70°C.

Computer-aided graphic circuit design

A system using existing circuit analysis programmes allows circuit designers to specify circuit connections graphically and maintain a record of the circuit for any subsequent changes which may be made. Called Circuit, this interactive graphical

system was developed by the Applied Physical Sciences department of the University of Reading, and generates the data stream required by Racal's REDAP31 programme.

In the display mode, the designer is shown a rectangular matrix of dots and a library of component symbols on a visual display unit. The circuit is assembled by using a light pen to move components to suitable pairs of dots. Component values are entered by teleprinter. When the circuit has been completely built up in this way, a programme is called up which numbers the nodes and lists the components with their values and mode numbers. Obvious errors are detected and appropriate error messages printed. Once this and any other data, for instance source and load impedances and frequencies of interest, has been filed, the designer telephones the system providing the circuit analysis programme and results of the analysis appear on the teleprinter. Hardware required by the system is a PDP 8 computer with a 20,000 word drum backing store, a simple terminal and, of course, a Datel link.

Non-volatile storage with m.n.o.s. transistors

Semiconductor memories based on bistable circuits are characterized by volatility of the stored information, i.e. if the supply fails the stored information is lost. The non-volatile property of the m.n.o.s. (metal-nitride-oxide-silicon) transistor enables information retention over several months, typically. The m.n.o.s.t. is an insulated-gate f.e.t., similar to a conventional m.o.s. transistor, whose threshold voltage may be varied between wide limits by the application to the gate of a voltage greater than a certain critical value. As the device can be switched between two distinct threshold voltages, it has the basic requirement of a memory device.

Charge is stored in deep traps within the gate dielectric so that no power is required to maintain either state. The information may be read out by sampling with a gate voltage between the two threshold voltages and detecting if the device is on or off. As long as this gate voltage is less than the critical voltage, there is no tendency to alter the storage state.

*The liquid crystal state, shown in a small percentage of organic compounds, is intermediate between the melting point of a solid crystal and the isotropic liquid, with the optical and electrical anisotropy of a solid crystal but the flow properties of a liquid.

(The m.n.o.s. transistor differs from the conventional m.o.s. transistor only in the structure of its gate dielectric. In the m.o.s.t. this is a 150nm layer of thermally grown silicon dioxide, in the m.n.o.s.t. it is a two-layer structure of silicon nitride on silicon dioxide.) Retention time depends on write time; a write time of 1μs results in storage for a day, and a 10ms write time will produce storage for over a century!

The Plessey Company were showing how m.n.o.s. devices were useful in measuring electron or hole mobility in inversion layers because a charge introduced between silicon and metal electrodes remains stored indefinitely, being undisturbed by a measuring potential applied to the gate. Equipment exhibited measured effective mobility over a range of gate potentials, effected by superimposing an a.c. signal on the d.c. gate supply and monitoring the transconductance. The mobility-gate potential curve is displayed directly on an x-y recorder.

Waveform synthesis — 1

Analogue techniques to produce simple waveforms such as sinusoidal, rectangular, triangular and ramp shapes while being straightforward, do not lend themselves easily to generating any waveshape. A new instrument by Prosser Scientific Instruments enables the synthesis of any waveform using digital methods and with a keyboard data input, while at the same time allowing analogue control over the signal outputs.

The instrument is addressed from a keyboard, (alternatively from punched tape, resistive probe or an electrical analogue signal via an a-to-d converter) and is coded by providing rectangular cartesian co-ordinates of the designed waveform. In practice, the waveform is fed into the keyboard from a tabulation of co-ordinates derived either by calculation or by reading from a previously plotted graph. Only the y co-ordinate is fed in, the instrument



Prosser Scientific Instruments digital waveform synthesizer with keyboard data input.

automatically advancing to the next x space. An m.o.s. random access memory is clocked at one step intervals, a numerical display showing the current x position. Correction of wrong entries is facilitated by the register being made to clock backwards. When the entry is complete each pair of co-ordinates can be checked on the display. The generator is then ready to recall the programme waveform by emptying the store through a d-to-a converter.

In capturing natural events, the transducer would feed the a-to-d converter and the event would then be stored in the memory, to be played back at any chosen repetition rate. As the literature on the PSI3000 instrument says of this mode, it's a bit like a tape recorder with continuous tapes that can be played back at any speed. The effect of modifying the event in some way can then be investigated using the keyboard.

The waveform can be repetitively displayed at any desired rate, amplitude or phase. An additional output is available with variable delay useful for auto-correlation and possibly in other applications. One suggestion is in simulation of road surface profiles in testing vehicles — the synthesized output representing the

displacement to the vehicle's front wheels and the delayed waveform representing the back wheel displacement. The two signals would then serve as inputs to a vibration simulator.

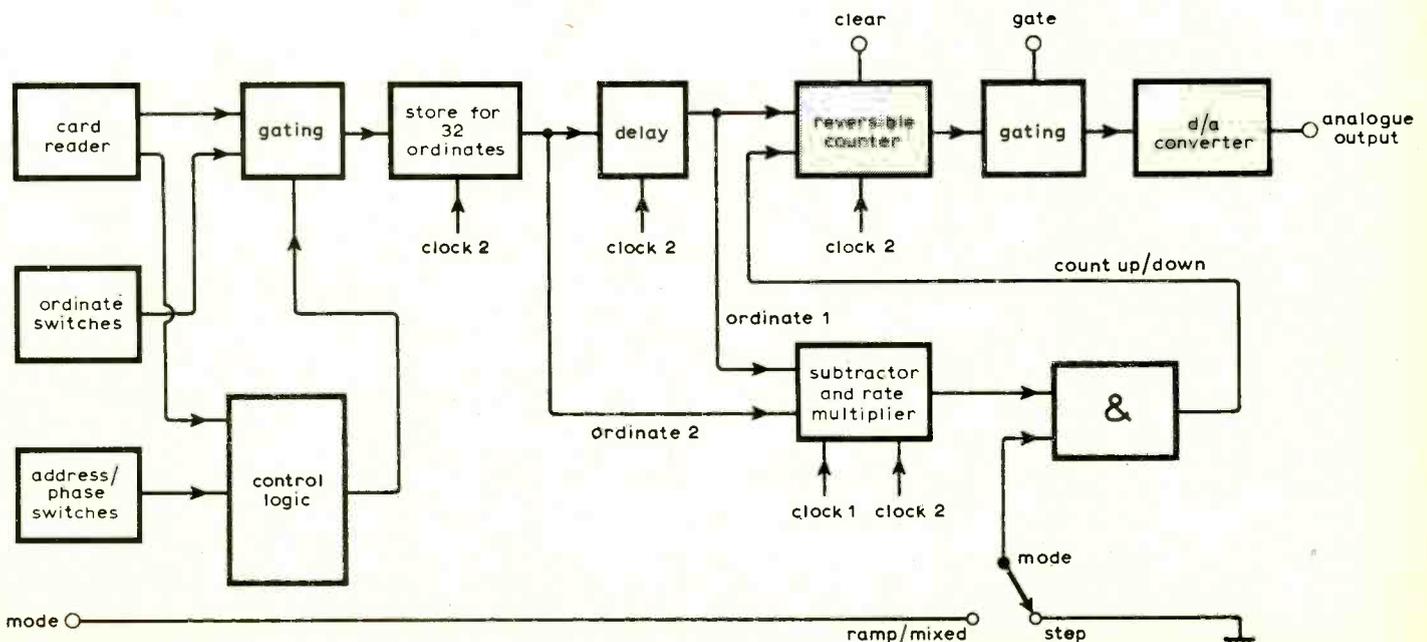
Waveform synthesis — 2

In another digital function generator, developed at the City of Leicester Polytechnic, the input ordinate information can be fed in by an inexpensive card reader or by specifying the address or number of the ordinate and its binary/octal value on two sets of switches. The operation is different in that output waveform is constructed in a ramp mode (in control engineering parlance, a first-order hold process) in which successive ordinates, taken from a 32 × 8 bit m.o.s. store, are connected by a staircase approximation to a straight line (see block diagram). The difference between two successive ordinates is fed to a rate multiplier whose output operates a reversible register counting up or down at a rate proportional to the difference between the two ordinates. When the second ordinate of a pair is reached, the difference is then taken between the next two. Information is stored in 8-bit form, the output range of ±5V being quantized into 256 levels, spaced by about 40mV.

In another mode, the pulse (or zero-order hold mode), the output is held constant at the last ordinate value between any pair of ordinates. This is specially suited to generating pulse sequences with differing, well-defined amplitudes.

External mode control and clear inputs are provided and a phase-locked trigger can be used to move the starting point along the waveform.

As there is no lower frequency limit of the instrument it can be used for precision v.l.f. measurement and control applications. Upper frequency limit is 1kHz. As the 8-bit precision chosen corre-



One way of generating waveforms digitally, proposed at Leicester Polytechnic, which can be used with an inexpensive pencilled-card reader.

sponds to a maximum of 256 steps between ordinates, the clock drive frequency is 32×256 times the output frequency, or about 8MHz in this case.

New technique in driving solid-state displays

New drive circuitry for solid-state displays that needs only one character generator for any number of characters, while at the same time being static, requiring only two signal leads to the display and eliminating current-limiting resistors, has been developed by ITT Central Applications Laboratory. The function of so-called drive circuits is to provide signals at the right voltage and current levels to operate the display, to route input information to the required output device, to convert binary-coded input data to the appropriate form, store the input, and to synchronize the system with a clock. These functions are currently implemented either in a static or in a dynamic, multiplexed way.

With the traditional static technique, all the functions are duplicated for each character, and with alphanumeric displays this can be costly. Further, the decode/drive i.c. would be specific to a display and different circuits would be needed for different kinds of display.

Time sharing methods need only one decoder, the character generator and drive functions being shared among characters by multiplexing, but suffer from a lack of "modularity" or flexibility and because the displays are switched there are brightness and peak current problems, making integration complex. (With liquid crystal devices there may also be operating speed limitations.)

The new concept is to mount an m.o.s. serial-in parallel-out shift register on a substrate together with, say, the gallium arsenide phosphide elements, each output of the register being connected to one of the display. The system has the advantage of requiring only one character generator for producing coded signals for the shift registers, which are connected in series. The output resistance of the m.o.s. circuit can be designed to provide current limiting for the i.e.d.s, and outputs can be paralleled if more current is needed. Liquid crystal displays can be driven from the same i.c.

The system operates as follows. Coded data of the first digit is fed to the character generator where it is decoded and passed to the first shift register by a train of clock pulses applied to both units.

Data for the second digit are then fed into the generator and the next sequence of clock pulses shifts the information from the first register into the second and the new data into the first. With each sequence of pulses information is shifted to the left as new information is fed in from the right. When all the information has been fed into the shift registers a static display is given requiring no external memory.

By suitable choice of the number of bits, a shift register i.c. can be developed so that two chips can drive a 7x5 dot matrix and one chip with its output paralleled in pairs can drive a seven- or nine-segment numeric display.

In use each character is completely modular and, apart from supplies, the only connections required are a single input and output and a clock input. Any number of characters can be strung in series and both liquid crystal and diode displays can be mixed. There are also other applications, for instance the solid-state analogue display, described elsewhere. Seven-segment numeric displays are in production and 35-dot alphanumeric displays are expected to be available in September from ITT Components Group, (STC) Brixham Road, Paignton, Devon TQ4 7BE.

Solid-state analogue readout

Although the solid-state digital readout using light-emitting diodes has undoubted advantages in many situations that demand high accuracy, and high reliability in the presence of vibration, it is not the answer to everybody's display problem. Where accuracy is not of prime importance, analogue readouts enable information to be read off instruments much more quickly. This is especially so in automotive and aeronautical situations, and where a large number of variables are being displayed simultaneously, as in process control plant. In these situations the robustness of solid-state systems would be beneficial.

A solution to this was presented on the Standard Telephone Laboratories' stand, where a solid-state analogue display is achieved by arranging i.e.d.s in a column or row, say 50 for 2% resolution. The measured variable in the form of an analogue voltage is first converted into digital form. Then a serial-in parallel-out shift register is used to feed each dot or diode on the array. The control circuits are arranged to feed this shift register with an appropriate pulse and clock sequence to

produce the right indication. In one example seen, "writing" takes 3ms followed by 30ms of display, the input voltage being sampled and displayed 30 times a second. The m.o.s. shift register chip is that used in the display modules, described elsewhere (see "Driving solid-state displays"). The circuit arrangement permits only two signal wires to the display unit ("data" and "clock" lines), apart from power lines. The unit lends itself to low-profile fabrication, which should attract the motor manufacturers' interest, as the cost of panel cut-outs would be avoided.

Node logic

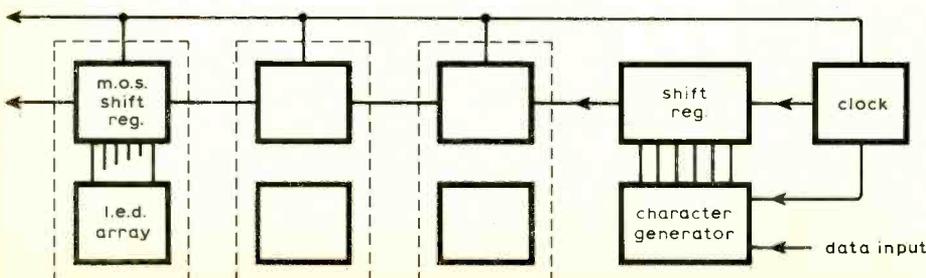
Node logic elements have been developed at the University of Reading, which are suitable for directly implementing the logic on a state diagram. The state diagram provides a method of describing the behaviour of a sequential logic system. On the state diagram, each state that the system can or must assume is represented by a node. Each transition from state to state is signified with an arrow from node to node which is labelled with the signal that causes this particular transition. Using the available range of logic elements, it is often difficult to design a reliable electronic implementation of a system although it may be quite easily defined by a state graph.

To simplify this process, a logic element has been designed which directly simulates the node on a state graph. The wiring between elements is in one-to-one correspondence with the "connections" on the state diagram, which is itself the logic diagram of the circuit implementation. In the development stage, the logic elements have been built on conventional printed circuit plug-in boards.

The state graph simulator is arranged so that the node element terminals are brought out onto patch panels allowing the direct "plug-up" of a state graph. On the patch panel, each node has a set of input sockets, a set of stimulus sockets and appropriate output sockets. To represent a state graph arrow, a jumper lead is plugged between a node output and the following node input. The stimuli which cause a state change from a node are plugged into its stimulus input sockets. The machine can then be operated by switching the stimuli as logic levels or pulses.

Should a fault occur due to the disconnection between nodes or a node malfunction then the "present state" node cannot execute its state transition procedure on receipt of a stimulus. It therefore puts a signal to a fault bus-line causing an indication. Acknowledgement of this indication by operation of a switch causes the last operative node indicator light to come up, indicating the last state the machine was in. This is helpful to an operator plugging up a system but in addition gives the challenging possibility of a system which detects its own faults and bridges them out with a spare element or circuit, a kind of "self-healing" logic system.

Serial-in parallel-out shift registers enable display modules to be connected with only data wires.



F.M. Tuner Design — Two Years Later

Varicap diode tuning and lower gain modifications

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

Many readers have asked the author for details of a modification to the f.m. tuner published in April and May 1971 (and April 1972) which will enable it to be voltage tuned. The variable-capacitance diode design subsequently produced and described in this article covers the same tuning band of 87.5 to 108MHz. Also described is a simple modification to reduce the gain of the original tuner.

In recent years a number of types of silicon variable-capacitance diodes have appeared on the market, some having very high ratios of minimum to maximum capacitance. These diodes make use of the capacitance of the depletion layer in a reverse biased diode. All semiconductor diodes exhibit a voltage dependence of reverse biased capacitance, but the degree of variation and loss factor depend on the construction of the diode. Normal signal diodes, although exhibiting the effect, do not have a sufficient variation for tuning the f.m. band. The 87.5-108MHz band needs a minimum capacitance change of the order of 3:1. This apparently large ratio is necessary because of the relatively high stray capacitances in the circuit. In a tuner designed solely for varicap tuning these strays can be reduced somewhat, but here we are concerned with replacing a normal tuning capacitor without altering the layout.

For the design described below the BB103 diode has been chosen and the capacitance/voltage relationship for these diodes is shown in Fig 1. A wide capacitance range can be covered by the diodes (almost 5:1) if the bias can be allowed to drop to a value of some -0.3 volts. However, the range required can be obtained between approximately -2 and $-27V$. A low reverse bias has to be avoided in a tuner using f.e.t.s since the oscillator voltage injected is high compared with a bipolar design. The diodes must not be allowed to conduct or the law will be spoilt in the oscillator tuning section by the resultant build up of charge at the low frequency end of the band where the diode bias is lowest. To assist in the application of the bias and to obtain a suitable value of capacitance, two diodes are used in each tuning section (see Fig. 2) The diodes are "back-to-back" and the bias is applied to the centre point. In the case of

the oscillator and aerial input tuned circuits, the whole circuit is at ground potential and therefore only a high value feed resistor is needed to supply the centre point of the diodes with the necessary reverse bias. The value of the resistor must be high enough to avoid unnecessary reduction of the Q of the tuned circuits. A value of from $100k$ to $1M\Omega$ is suitable. The tuned circuit coil in the drain circuit of Tr_1 is at the drain potential and a blocking capacitor has therefore to be added in this circuit. This in turn means the addition of a second high value resistor to ensure that the bias is applied to both diodes.

The varicap diodes and associated components are assembled on a small p.c.b. which takes the place of the tuning capacitor. The components are all mounted on one side of the board in the usual manner together with connection leads of 22s.w.g. tinned copper wire and the p.c.b. is then mounted on spacers. Components on the underside use the original mounting holes provided for the tuning capacitor. An external lead from this sub-board is then taken to the tuning control unit,

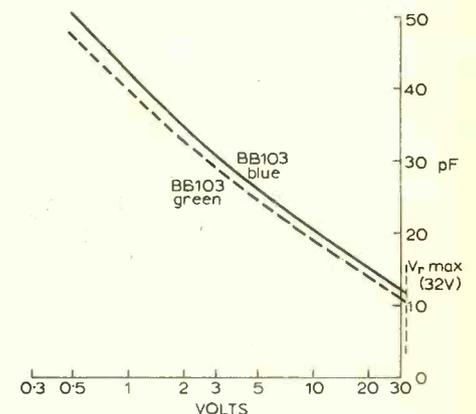
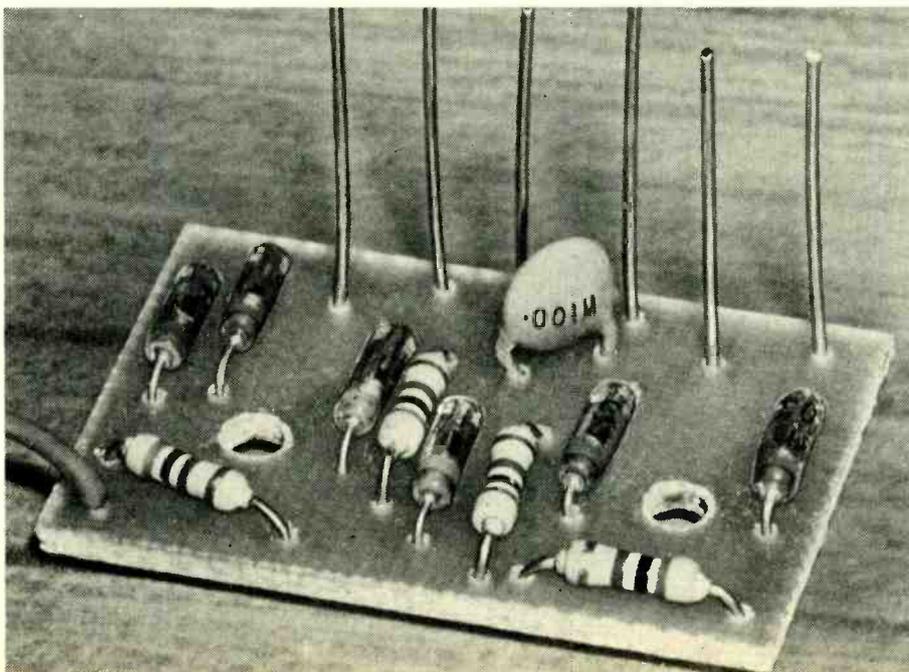
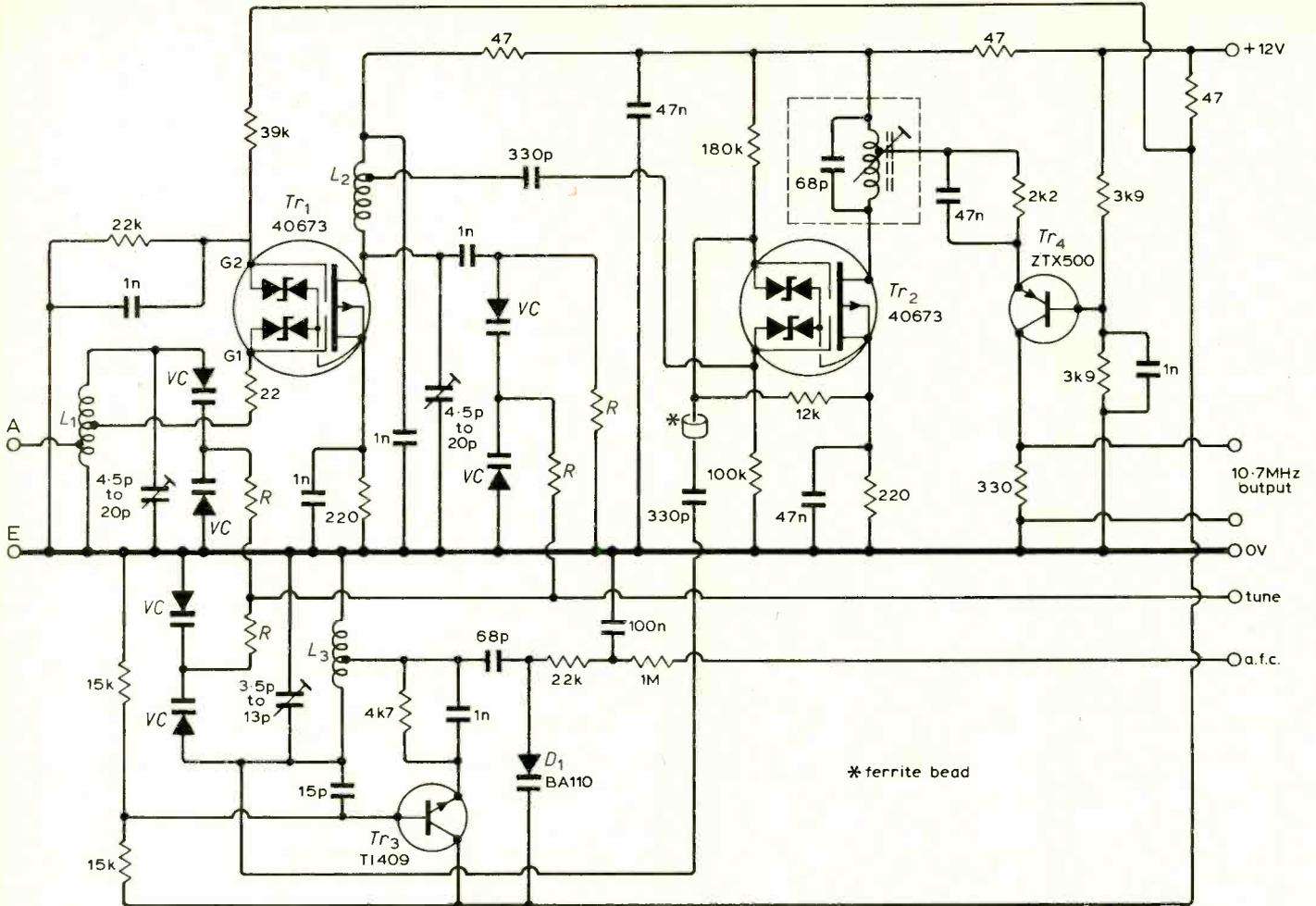


Fig. 1. Capacitance versus voltage relationship for the variable-capacitance diode alternatives.

Varicap board showing the diodes, resistors and capacitor, together with the connecting wires. The diode cathodes face away from the six connecting wires.

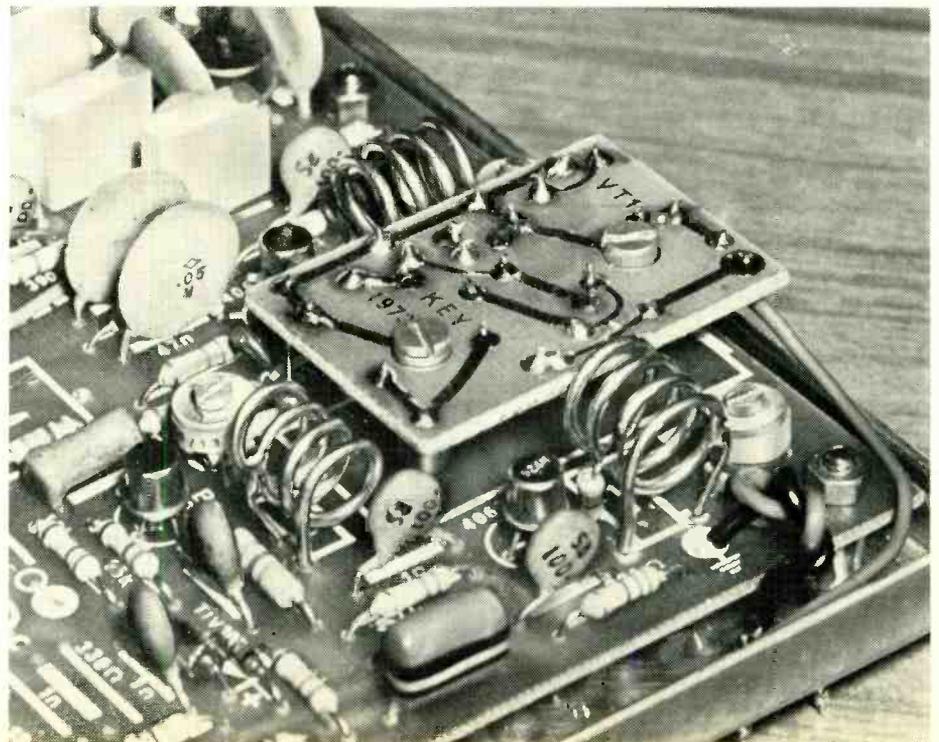


which is described below. This new p.c.b. is shown mounted on a tuner. A photograph shows the underside of the board before mounting on the tuner.

The only other changes needed to the tuner for varicap diode tuning is that the coils need to be replaced with slightly modified versions (shown in the photograph). The coils are all made from 18 s.w.g. tinned copper wire, but L_1 and L_2 are of a different diameter to the original coils. These two coils are now wound on a $\frac{5}{16}$ in former. Inductor L_1 is otherwise as the original design, but on L_2 the tap has been moved to the end turn nearest the supply, and physically adjacent to the 100k Ω resistor. This change reduces the interaction between the tuning of the mixer and oscillator tuned circuits when trying to "track" the tuner, and although not great this reduction in interaction does make tracking much easier. Gain is not affected to any noticeable degree. The oscillator coil L_3 remains at $\frac{1}{4}$ in internal diameter, but differs in construction. The direction of winding has been reversed, giving approximately an extra half turn. A 22 Ω anti-parasitic resistor prevents the front-end "taking-off" at u.h.f. This "vertical" resistor replaces the tap connecting L_1 to $G1$ of Tr_1 , and is shown in the photograph just behind the 0.001 μ F capacitor in the foreground. Coils are 0.1in from the surface of the board as in the

Fig.2. Revised front end of the tuner showing the replacement of tuning capacitors by varicap diodes which provide voltage tuning.

General view of the varicap board fitted to the tuner.



original design. It must be emphasized that these new coil designs only apply to the varicap design.

Tuning control units

A tuner control unit is used with the varicap tuner which is similar to those now being fitted to most single standard u.h.f. television sets.

This particular unit has six selector buttons. Pressing any button releases the previously selected button, and turning the selected button adjusts the tuning. In these units six potentiometers with graded tracks are wired with all tracks in parallel, but with the sliders selected by the action of pushing a button. The grading of the track is such that an approximately linear relationship between potentiometer movement and frequency is achieved when used with a varicap tuner. Various manufacturers fit other extra facilities; for instance the tuning control unit has a switch made when any button is held fully in, so that when tuning a station by rotation of the control knob, and pressing it at the same time, the a.f.c. control can be shorted out. The method of connection of this switch to the tuner is shown in Fig. 3. Many of these tuning control units have such a switch, though not necessarily ganged to the selector mechanism. It is often an additional button at one end. Various values of total resistance are available but a common value is 100kΩ per track, giving a six-button unit a resistance of around 16kΩ with the six tracks in parallel.

Power supplies

The varicap tuner needs a highly stable noise free supply of around 30V to supply the tuning control unit, and the author has therefore devised a suitable circuit, Fig. 4, giving regulated supplies of 30V (nominal), and 12V. An optional 6V supply (stabilized) is also included for use with

the Portus and Haywood decoder². The Motorola MC1310 integrated circuit decoder also works well with the tuner and may be run off the stabilized 12V rail. The circuit of the 30V stabilizer uses the SGS TBA271 regulator, which is itself an integrated circuit, but is equivalent to a low temperature coefficient high voltage zener diode. For as good a regulation as possible the device is fed by a constant-current circuit, consisting of a transistor with emitter resistor and the base-emitter voltage stabilized by a zener diode. The temperature coefficients of the forward bias of the transistor and the zener diode are approximately equal and therefore

cancel. The use of this constant current feed together with the low slope resistance of the TBA271 gives the main smoothing action of the supply, but this is augmented by the addition of a capacitor to reduce still further the ripple and noise. This capacitor is used together with the series impedance of one of the two pre-set potentiometers (used to set the span of the tuning control voltage) as a simple RC filter. The result is a supply with less than 100μV pk-to-pk noise. The 12V supply uses an SGS TBA625B integrated circuit series regulator. This gives a very simple circuit and is current overload protected above 100mA load.

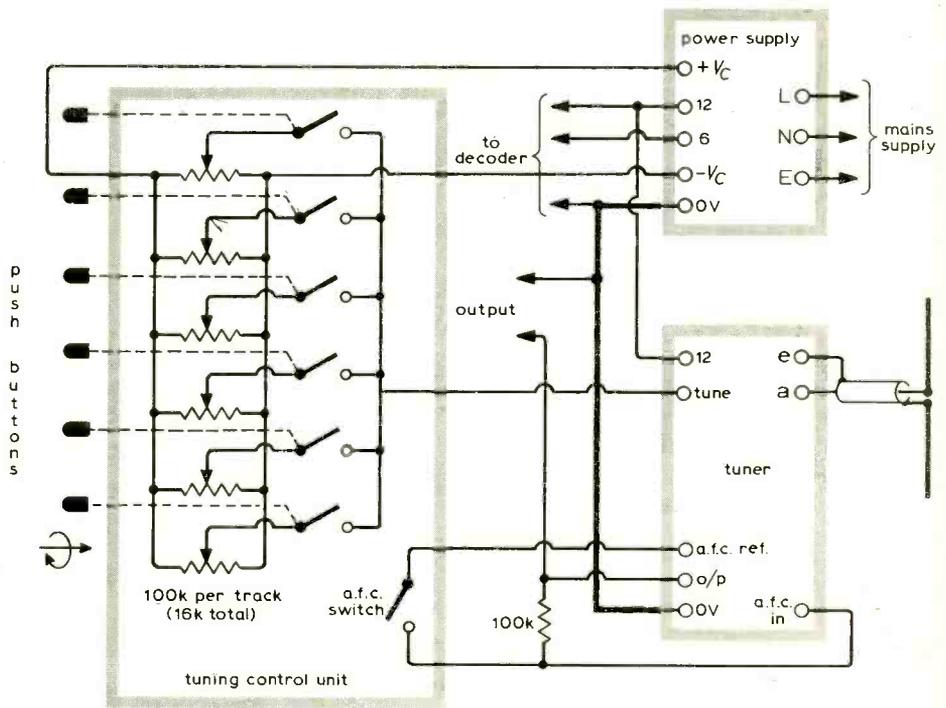
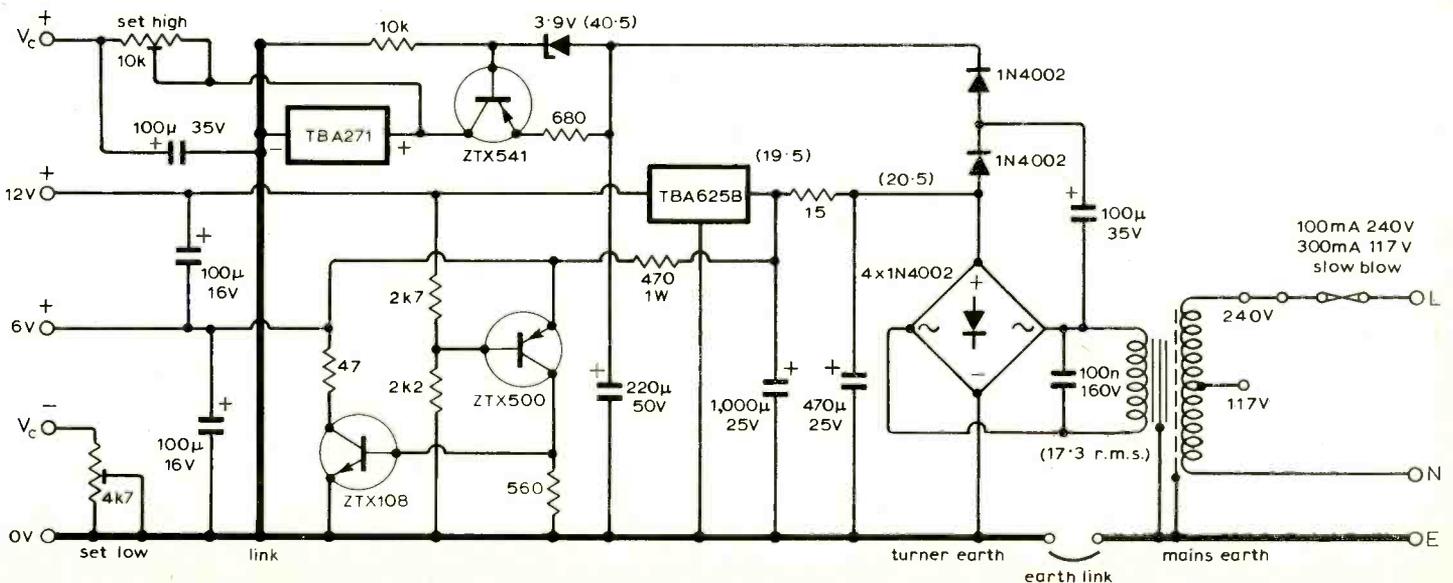


Fig.3. Method of connecting the switches of the tuner control unit to the tuner.

Fig.4. Stable noise free power supply giving regulated 30V and 12V and an optional stabilized 6V supply. Voltage levels in volts are shown in brackets at appropriate points on the diagram.



The rectification circuit for the 30V supply may seem a little odd at first until it is realized that it is a simple voltage doubler but "hung" on top of the rectified supply for the 12V regulator. The voltage doubler only gets half-wave pulses from the side of the bridge rectifier to which it is connected, but the output of the doubler (when added to the main supply) results in a supply approximately twice that of the main supply, without the added complexity of an additional winding on the transformer.

If the 6V supply is omitted then the capacitor between the 6V output and the 0V line should be omitted and replaced by a wire link so that the upper 100µF capacitor is connected to the 0V line.

Varicap setting-up procedure

The first stage in this procedure is to reduce the number of variables by setting the voltage limits of the tuner unit. The limits are set using the two variable resistors of the power supply circuit "set low" and "set high". The two controls interact to some extent and the adjustment must be repeated several times until both are correct. The "set low" control is set for a potential of +2.2V with respect to the 0V line at the bottom extreme of the tuner, and the "set high" control is set for +27.0V at the upper extreme of the tuner control unit. (If BB103-Blue diodes are used in the tuner then the "set low" should be set to +2.7V and the "set high" to +29.0V.)

Following this step the normal alignment procedure is followed, and this is easiest if the first two buttons of the tuning

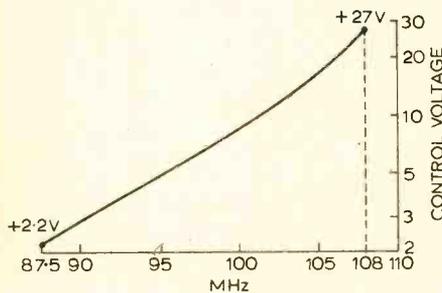


Fig.5. Voltage available from the tuning control unit as a function of frequency.

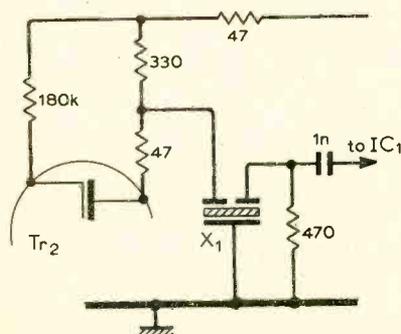


Fig.6. Arrangement after removal of the first stage of the i.f. amplifier for the lower gain version.

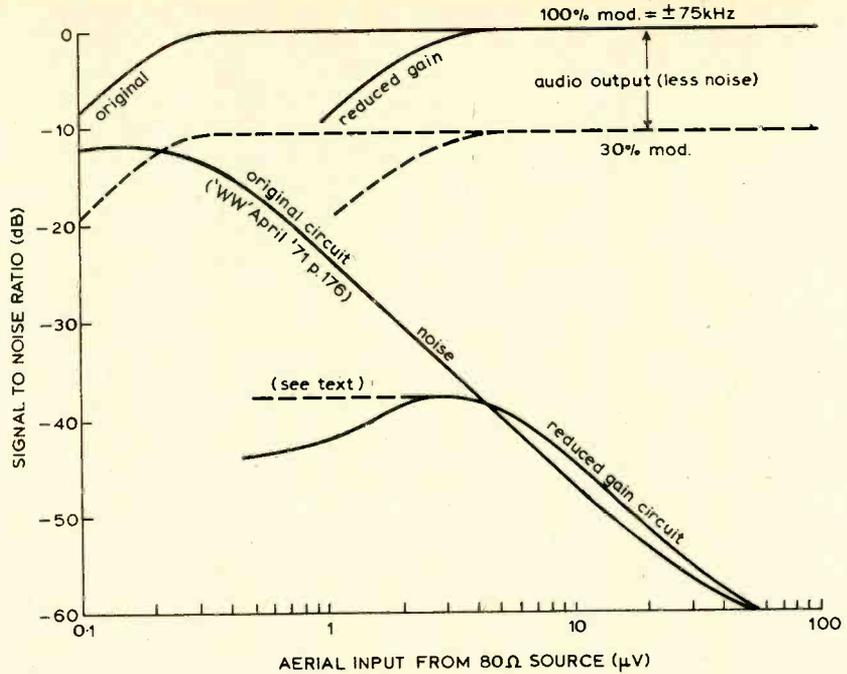


Fig.7. Noise performance of the modified receiver compared with the original curves of the April 1971 article.

control unit are set to the two extremes of voltage. With the lowest voltage selected the inductors are set, and with the highest voltage selected the trimmer capacitors are set. Initially, it is easier to set the oscillator range in this way and then concentrate on the aerial and r.f. tuning, followed by a final check of all three tuned circuits.

It is important to state that in some tuning control units on the market there is a fixed resistor in series with the low voltage end of the potentiometers. It is therefore important to check the voltage actually available from the tuning control unit at the actual extremes of travel.

The relationship between voltage and frequency is shown in Fig.5, the voltage being plotted on a logarithmic basis.

Performance

Measurements on the prototype tuner indicate that the change to varicap tuning has had no effect on sensitivity or signal to noise ratio, though since the alterations were not made to the original prototype, it is not possible to be absolutely firm on this point. Certainly the performance is well up to the expected level and differs little from the original.

Components

- Varicap diodes Siemens type BB103 Green or Blue (all six diodes must be of the same colour selection. With this proviso matching should not be necessary).
- Resistors (R) any value between 100k and 1MΩ 1/8 or 1/4W carbon film.
- Capacitor 0.001µF ceramic disc, preferably 500V low leakage type.

Mounting 3/16in 6 BA spacers (2) and 1/4in x 6 BA cheese head screws (2) plus washers and nuts (2 each).

All components for tuning board, control unit and power supplies, are available from Integrex Ltd, P.O. Box 45, Derby, DE1 1TW. S.A.E. for details.

Lower gain version

The author has had a number of enquiries regarding the sometimes very high noise level on some tuners when tuning between stations. The optimum level of overall gain practical in a tuner with a given noise factor has been investigated. The conclusion has been that, although helpful to the long distance listener, the full gain of the original tuner does not add greatly to the practical usefulness of the receiver for listening to normal broadcast programmes at reasonable signal strength. Removing the first i.f. stage and coupling the mixer directly to the first i.f. filter provides the necessary simple modifications.

The actual noise level of a receiver is related not only to the noise factor of the receiver, but also to its gain, as even the quietest receiver will be noisy if it has sufficient gain. This is because the "noise factor" is merely a measure of the ratio of the noise output of the actual receiver, compared to that of an ideal receiver. This ratio is expressed usually in decibels. The source in both cases is resistive, and equal to the normal source impedance (in the case of this receiver an 80Ω source).

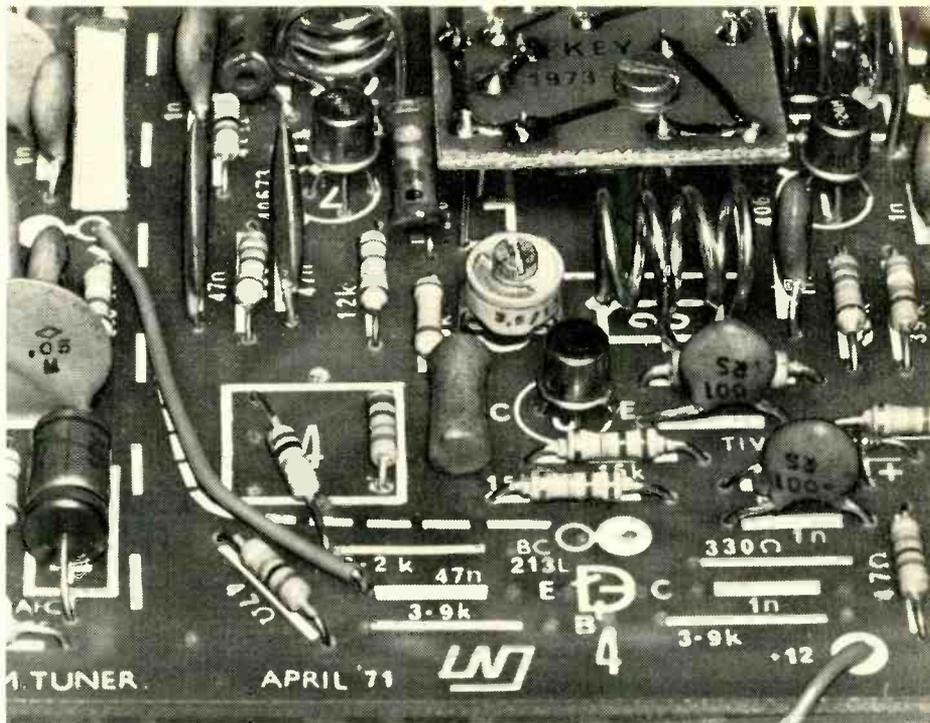
Since the tuner has a number of stages all subject to normal tolerances, it has been found (not unexpectedly) that some receivers are relatively quiet and others almost reach limiting on their own noise. Only ±1dB variation per stage means a variation of overall gain between receivers of 4 : 1, and ±2dB (roughly) ±20%

will give about 16 : 1 so the apparent differences in noise are hardly surprising.

A "noisy" receiver (but with a noise factor of approximately 3dB), was therefore taken and the first stage of the i.f. amplifier (Tr_4) was removed leaving the arrangement shown in Fig.6. The actual modification is shown (see photograph) where the blank component locations are clearly seen together with the two added resistors and the new link between r.f. and i.f. sections (now only a single wire). The 47 Ω resistor lies diagonally across the location of the previously fitted L_4 and the 330 Ω resistor is on the right of the outline of L_4 .

The noise performance of the modified receiver is shown in Fig.7 which also shows the original curves of the April 1971 article. The curves should merge, but it must be remembered that the figures were measured on two different receivers, and the 2dB difference in the noise levels between 5 and 50 μ V is therefore quite a good agreement between measurements taken nearly two years apart. The noise level below 3 μ V should flatten off, not drop as shown. The reason for this is that a slight offset in the i.f. amplifier demodulator stages can result in one sided clipping of low noise levels and this is evident in the output waveform without any injected signal. The effect disappears as soon as the signal level rises appreciably above the basic noise level.

It has been found in this reduced gain version that the interaction between the tuning of the mixer and oscillator tuned circuits is greater though the reason is not immediately obvious. The effect is reduced to normal proportions by moving the tap on L_2 by one turn to the end turn nearest the 100k Ω resistor and Tr_2 , as recom-



View of the area where the missing and additional components are located in the lower gain version.

mended in the varicap tuned version of the receiver. The curves of Fig.7 were taken with this change to L_2 .

The actual 30dB quieting level of the modified receiver is lower than that of the original receiver according to the curves of Fig.7 (about 1.1 μ V against 1.9 μ V), which only proves that anything taken out of context can prove almost anything. The performance should be more than adequate for all normal listening, and the author

has received RAD10 Bristol in Bourne-mouth fairly regularly on a simple loft mounted dipole.

References

1. Letters to the Editor, *Wireless World*, July 1972, p.318.
2. Portus, R. T. and Haywood, A. J. "Phase-locked Stereo Decoder", *Wireless World*, Sept. 1970, pp.418-422.

Experiments with Operational Amplifiers

10. Precise rectification with an op-amp and diode combination

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

Semiconductor diodes show pronounced non linearity at low forward voltages; in the case of a silicon diode no appreciable conduction takes place through the diode until the forward voltage across it exceeds about 0.5V. As a result of this non linearity diodes give rise to appreciable errors when used to rectify small signals in a conventional rectification circuit. The point is illustrated by the input and output waveforms for a simple diode half-wave rectifier shown in Fig. 10.1.

A circuit which can be used to demonstrate the way in which an operational amplifier diode combination overcomes the effect of diode non linearities is illustrated in Fig. 10.2.

Typical waveforms for the circuit are shown in Fig. 10.3 in which the upper trace is a sinusoidal input voltage, the middle trace is the amplifier output voltage and the lower trace is the rectified output signal.

The offset voltage potentiometer is adjusted so as to obtain the symmetrical amplifier output waveform shown when a small amplitude input signal is applied. The input amplitude is less than 0.2V in Fig. 10.3; a

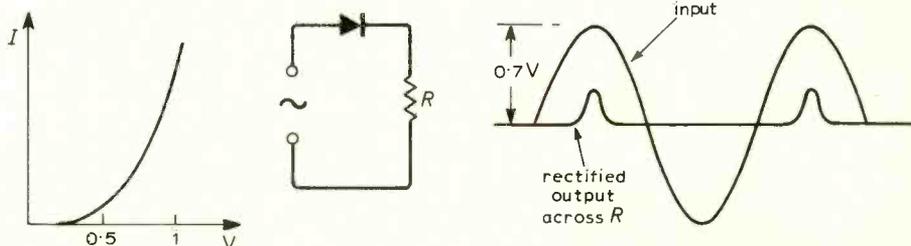


Fig. 10.1. Simple diode rectifier.

simple diode rectifier would give no measurable output with such a small amplitude input signal. In the circuit of Fig. 10.2 the diode D_1 is connected in the feedback path of the amplifier so that the initial forward voltage drop required to make the diode conduct is supplied by the amplifier output voltage. Before diode conduction starts the amplifier acts virtually open loop so that the signal required at the input to cause diode conduction is very small, $\frac{0.5}{A_{VOL}} V$.

Once the diode D_1 is conducting the effect of its non linearities on the rectified output is effectively divided by the loop gain.

The second feedback path through diode D_2 is included in the circuit to prevent amplifier output saturation on the input half cycles for which D_1 is reverse biased. Note that the circuit can be used to produce gain as well as rectification, dependent upon the ratio R_2/R_1 .

Precise rectifier as a.c. millivoltmeter

An operational amplifier, a diode bridge and a d.c. microammeter can be used as the basis for a precise a.c. millivoltmeter. A circuit which can be used to investigate the action and limitations of such an arrangement is given in Fig. 10.4.

The a.c. input signal is applied to the non phase-inverting input terminal of the amplifier. Feedback through the diode bridge forces the voltage across the resistor R to follow the input voltage. A current e_i/R must pass through the bridge, and this current, rectified by the bridge, passes through the d.c. meter. The reading of the meter indicates the average value of the full-wave rectified current. If e_i is the r.m.s. value of the sinusoidal input signal the rectified current through the d.c. meter is

$$\frac{2\sqrt{2}}{\pi} \cdot \frac{e_i}{R}$$

In investigating the action of the circuit it is convenient to measure the d.c. current with a multirange current meter. The meter is initially set to one of its less sensitive ranges, the input to capacitor C is earthed and the offset balance potentiometer is adjusted for minimum current through the meter. The sensitivity of the meter is increased while making this adjustment.

An a.c. signal, of frequency say 120Hz, is now applied. Its value is increased in steps and the reading of the d.c. meter is recorded for each value of the a.c. input signal. Suitable values for the input signal are 2mV, 4mV, 6mV, 8mV, 10mV, (r.m.s. values) and so on through increasing decades.

The linearity of the system can now be assessed. In making this assessment don't forget possible errors or non linearities in the test instruments. Pronounced non linearity, of course, occurs when the amplifier output saturates. The signal at the output of the amplifier should be monitored with an oscilloscope in order to detect the onset of such saturation.

The frequency response of the system may be investigated by applying an input signal of fixed amplitude, say 50mV, and increasing the frequency until the reading of the d.c. meter falls. The reason for this fall

in response at the higher frequencies will be obvious if the output waveform of the amplifier is monitored. Amplifier output waveforms for frequencies of 50Hz and 5 kHz are shown in Fig 10.5.

The steps in the upper, 50Hz waveform occur as the amplifier output voltage takes up the diode forward voltage drops. When

the frequency is increased to 5kHz (lower trace) the time taken by the amplifier output to overcome the diode forward voltage drops is an appreciable fraction of the period of the waveform and so the average value of the rectified current falls. The system response at the higher frequencies is thus limited by amplifier slewing rate.

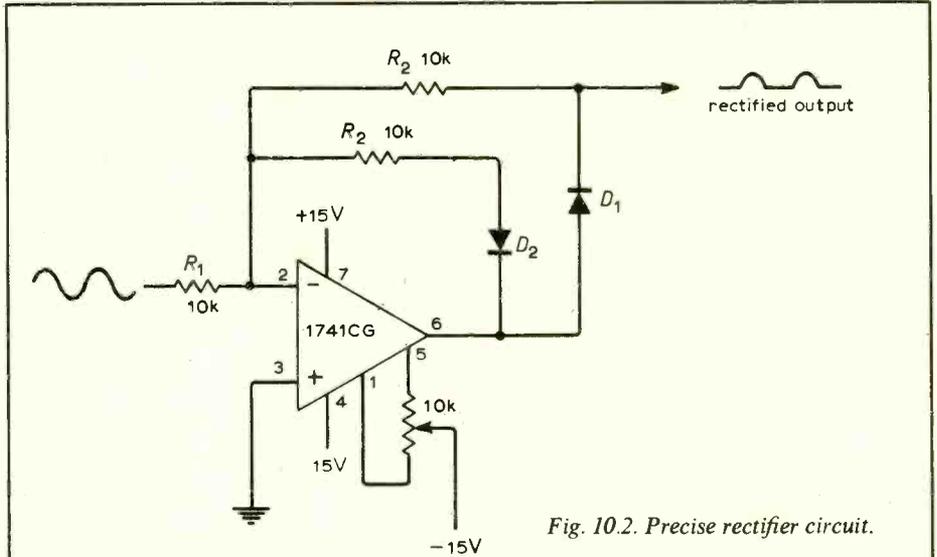


Fig. 10.2. Precise rectifier circuit.

Fig. 10.3. Waveforms for precise rectifier in Fig. 10.2. Horizontal time scale, 1ms/div; vertical scale, 0.2V/div.

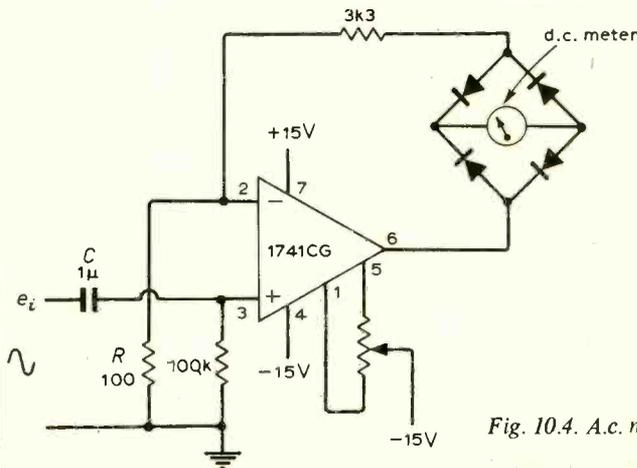
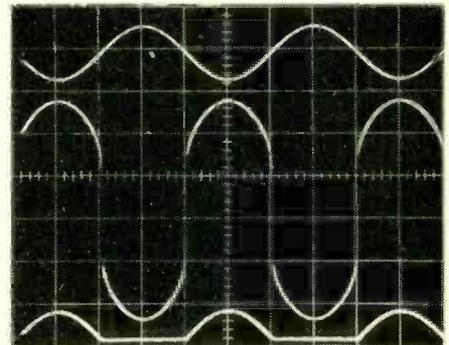
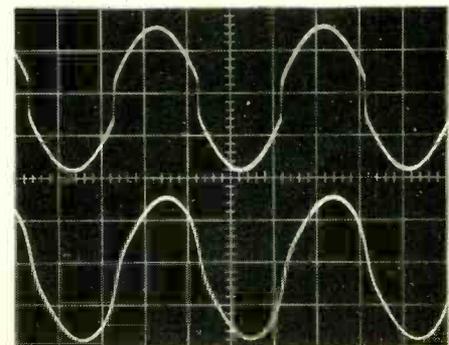


Fig. 10.4. A.c. millivoltmeter.

Fig. 10.5. Amplifier output waveforms. Upper trace time scale, 5ms/div; lower trace time scale, 50μs/div. Vertical scale, 2V/div.



25-watt Transistor Transmitter for 20 metres

by S. A. Money, G3FZX

The circuit, forming a basic transmitter, contains three stages operating respectively as crystal controlled oscillator, frequency doubler and power amplifier, and is designed primarily for c.w. transmission.

For many amateurs a major interest of the hobby is that of working stations in distant countries. This can be more readily achieved by using the h.f. bands such as 14 or 21MHz. In order to make one's signal heard above the general din on the bands in their present crowded state, it is highly desirable that the transmitter used should have a power input to the final r.f. amplifier of at least some 20-30W. With an efficient aerial system such a transmitter can provide contacts with stations in all parts of the world.

Choice of p.a. transistor

R.f. power transistors capable of operating at powers of up to 100W have become available in the past few years. These devices are expensive, at prices varying from £30 to £60 each, and are primarily intended for use in military and commercial equipment. Transistors of this type are not readily available to the amateur so the design of this

transmitter was based on the use of cheaper and more easily obtainable types.

Many power transistors have a maximum collector voltage rating V_{ceo} of 60 to 80V. When class B or C operation is used, the collector voltage can rise to twice the supply voltage due to the flywheel action of the collector tuned circuit. To allow an adequate margin of safety the supply rail should not be more than 24 to 28V.

If we assume a power input of 25W, the mean d.c. collector current will need to be about 1A with a 25V supply. In class B, the peak collector current will be roughly three times the mean d.c. value. For class C, the peak current may be as high as four times the mean value. Under these conditions therefore the p.a. transistor used must be capable of handling peak values of collector current up to 3 or 4A.

Assuming that the efficiency of the p.a. stage will be about 60%, the transistor must

be capable of dissipating about 10W. This requirement rules out transistors in TO5 cans and implies the use of TO3, TO66 or other high power dissipation types.

In order to have reasonable power gain and to maintain stable operation, the transition frequency (f_T) should be at least five times the frequency at which the amplifier operates. For 14MHz operation this requires an f_T of at least 70MHz.

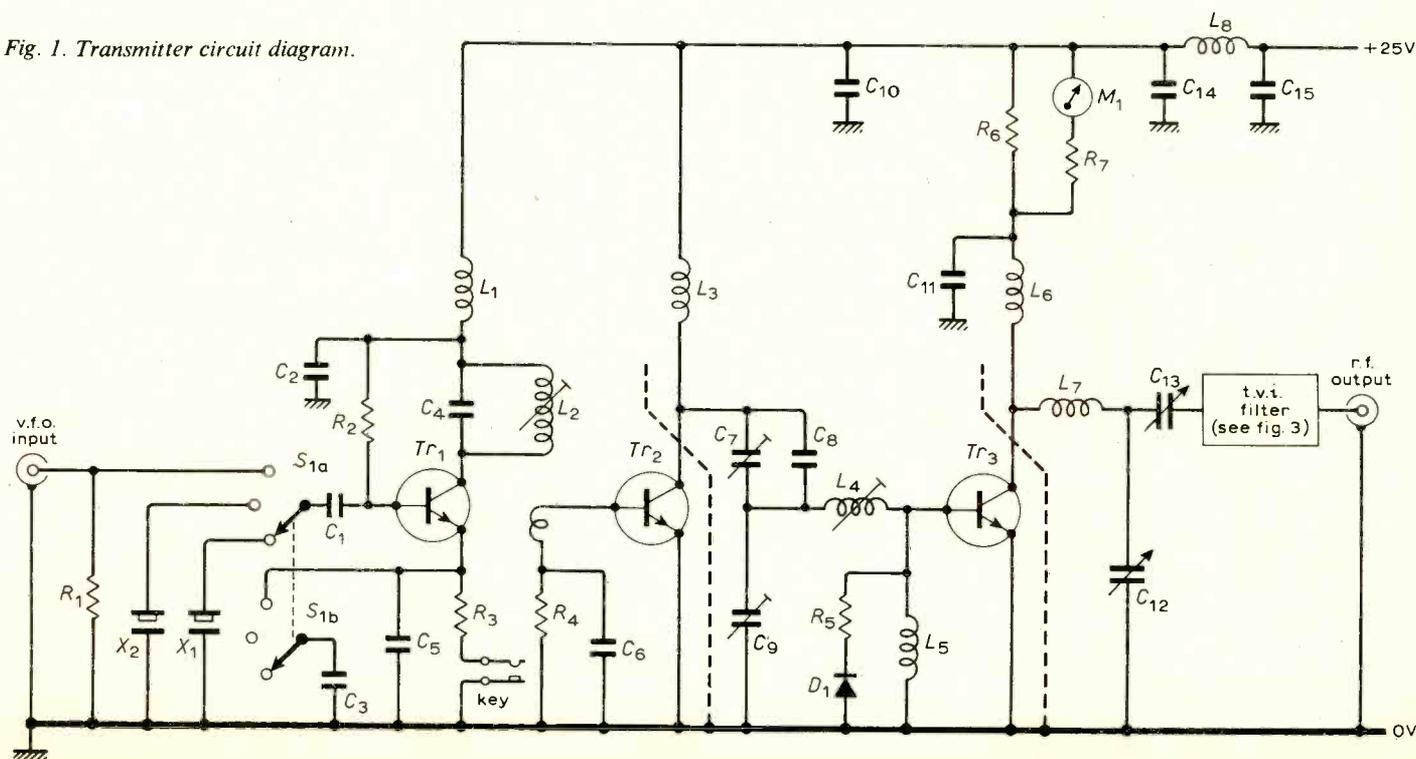
The transistor chosen for this stage of the transmitter was the Mullard type BD123, which has a V_{ceo} of 80V. Its maximum peak collector current is 5A and the f_T is 85MHz. The BD123 is mounted in a TO3 can and will dissipate up to 35W safely if it is mounted on a sufficiently large heat sink.

Power amplifier design

The final stage of the transmitter Tr_3 , Fig. 1, runs at 25W input with a BD123 transistor operating in the class B mode. Class B operation was chosen because, although it is less efficient, it produces lower harmonic output and needs less drive power than an equivalent class C stage.

To obtain optimum power transfer, this

Fig. 1. Transmitter circuit diagram.



stage must be correctly matched to the load. The output impedance of this transistor is made up of a resistive component R_p in parallel with a capacitive component X_p representing the collector capacitance and circuit strays.

The value of R_p can be calculated from the formula,

$$R_p = \frac{V_s^2}{2P_o}$$

where V_s is the d.c. supply voltage and P_o is the power output from the stage. The value for the power output is assumed to be about 60% of the power input since this is a reasonable value for the efficiency of a class B stage. With V_s at 25V and P_o at 15W this gives a value of roughly 20Ω for R_p . The capacitance of the transistor and circuit strays is about 100pF which, at a frequency of 14MHz, represents a reactance of approximately 125Ω.

The matching network used to couple this amplifier stage to the load must not only match the two impedances but also provide sufficient selectivity to reduce the output of harmonics to an acceptable level. A good compromise can be obtained between power transfer and harmonic output by designing the matching circuit to have a loaded Q value somewhere between 10 and 15. In this transmitter it was decided to aim for a Q value of 12.

In many transmitters using valves for the output stage, the matching to the load is achieved by using a low-pass Pi section network. Unfortunately this type of network is only effective if the ratio between the source and load impedances is fairly high. If the two impedances to be matched are similar in value it becomes impracticable to design a Pi network which will have the required value of working Q . In the output stage of this transmitter, the impedance ratio is only about 3:1 if we assume that the load is a normal 70Ω aerial feeder cable properly terminated.

It would be possible to match this ratio of impedances by using two Pi networks in cascade with one network having a very low Q value. However, a more attractive solution is to use the T type network shown in Fig. 2. This particular type of circuit is most suitable for transistor transmitters because it easily matches two similar impedances.

The equivalent circuit of the transistor is shown as an impedance represented by series resistance R_s and capacitive reactance X_s . As a first step in the design of the network the parallel impedance values R_p and X_p must be converted into their equivalent series form by using the two equations

$$R_s = \frac{R_p}{1 + (R_p/X_p)^2}$$

$$\text{and } X_s = \frac{R_s R_p}{X_p}$$

For the BD123 stage the value for R_s will be about 20Ω and the value for X_s will be around 4Ω. At this point the value of the series inductance L_1 can be calculated from:

$$XL_1 = QR_s + X_s$$

If we are designing for a Q of 12 then XL_1

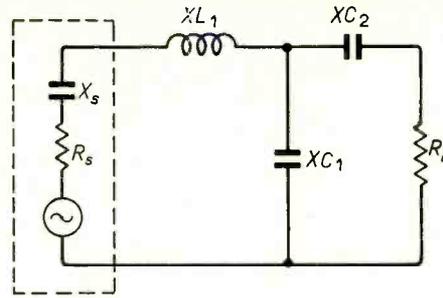


Fig. 2. A "T" matching network.

will be 240Ω which at 14MHz represents an inductance of 2.7μH. A coil to give this inductance consists of 16 turns of 16 s.w.g. enamelled wire close wound with a diameter of $\frac{3}{8}$ in. The coil length will be about $\frac{1}{4}$ in and the coil should be completely self supporting.

In order to find the values for the tuning and loading capacitors C_1 and C_2 two constants A and B must be calculated from

$$A = R_s(1 + Q^2)$$

$$\text{and } B = \sqrt{(A/R_L) - 1}$$

where R_L is the load impedance which is assumed to be a pure resistance. If R_L is taken as 70Ω then the value of A will be 2900 and B will be 6.4.

At this point the reactance values for the tuning and loading capacitors can be found from:

$$XC_1 = \frac{A}{Q - B}$$

$$\text{and } XC_2 = BR_L$$

which give values of $XC_1 = 480Ω$ and $XC_2 = 448Ω$. The corresponding capacitors will have values of 24pF and 25pF respectively at a frequency of 14MHz. In the actual transmitter these capacitors C_{12} and C_{13} are 50pF air-spaced variable types. In the prototype transmitter 100pF variable capacitors were used with 100pF fixed capacitors in series to reduce the maximum value and to make the tuning adjustment easier. It should be noted that both the stator and the rotor of capacitor C_{13} are live and this capacitor must therefore be insulated from the panel which is grounded. These two capacitors may be of the preset type since the tuning adjustment will remain correct over most of the 14MHz band.

Since the output is taken off in parallel from the collector of the power amplifier stage an r.f. choke L_6 is required to feed the d.c. supply voltage to the collector. This choke has an inductance of about 15μH and consists of 100 turns of 28 s.w.g. enamelled wire close wound in one layer on a 2in length of $\frac{3}{8}$ in diameter s.r.b.p. rod. A similar choke L_5 is used from base to ground but in this case the winding consists of 120 turns of 30 s.w.g. wire wound in one layer on a $\frac{1}{2}$ in diameter rod.

Diode D_1 and resistor R_5 are included in the base circuit of the transistor to protect it during the half cycle when the base is reverse biased. For a BD123 the reverse base to emitter breakdown voltage is only 5V whereas the unloaded base drive signal may exceed 10V peak unless a diode limiter

circuit is used. It was found that the addition of a diode limiter actually tended to increase the base drive current to the p.a.

It is essential that the inductance of the emitter to ground lead from the p.a. transistor should be kept as low as possible to prevent instability. The actual wire should be as short as practicable and of heavy gauge. All other earth returns for this stage should be connected to the chassis at the same point as the lead from the emitter.

Frequency doubler and oscillator

For the frequency doubler stage Tr_2 a second BD123 transistor is used. This stage is operated in class C to obtain maximum harmonic output.

The p.a. stage has an effective power gain at 14MHz of about 10dB. This means that it requires an input drive signal of some 1.5W from the doubler stage. Since the efficiency of the doubler stage is not likely to be better than 25%, its d.c. collector input power will need to be 6 to 8W in order to produce the required drive power. The mean d.c. collector current drawn by this transistor is between 250 and 300mA.

Matching between Tr_2 and Tr_3 is via a T network similar to that used at the p.a. collector. The inductance of L_4 needs to be 3μH which is obtained by winding 20 turns of 26 s.w.g. wire in a single layer on a $\frac{3}{8}$ in diameter former. This former is of the type used for television i.f. coils and is tuned by a 6mm dust core. This dust core is adjusted in conjunction with variation of C_7 and C_9 to give correct tuning and matching. The r.f. choke L_3 is made in the same way as L_6 in the p.a. stage.

The 7MHz drive signal from the oscillator stage Tr_1 is link coupled to the base of Tr_2 . Resistor R_4 and capacitor C_6 give the reverse bias needed for class C operation.

In the interests of simplicity a crystal controlled oscillator is used for frequency control. The value of the emitter bypass capacitor C_5 is chosen so that a large phase shift is produced in the emitter circuit. Positive feedback then occurs, the quartz crystal ensuring stable oscillation.

A switch S_1 has been included to enable one of two alternative crystals to be selected, allowing transmitter frequency to be easily changed. Since the average amateur tends to have a collection of crystals in different types of holders, it is convenient to make sockets available for two different types.

Unless a wide selection of crystal frequencies is available, operation of the transmitter would normally be limited to one or two frequencies. To allow greater flexibility of operation, therefore, provision has been made to drive the transmitter from an external v.f.o. With S_1 set in its third position, the v.f.o. input is applied to Tr_1 which acts as a straightforward amplifier.

To ensure stable operation of Tr_1 as an amplifier, the base circuit is shunted by a low resistance R_1 and the emitter bypass capacitor is increased to 0.047μF.

Keying of the transmitter is carried out by simply breaking the d.c. feed to the emitter of Tr_1 . When the stage is operating as a crystal oscillator, keying is quite clean with no "chirp" or key clicks. When the oscillator is keyed-off, no drive signal is

applied to the doubler and p.a. stages so that they both remain cut-off.

Harmonic filter

In common with other amateur band transmitters this unit can cause quite severe harmonic interference on nearby television receivers unless some form of low pass filter is included in the output circuit. Details of a t.v.i. filter used in this transmitter are given in Fig. 3 which is a five section filter with constant *k* middle sections and *m* derived half sections at the ends to give better impedance matching. Nominal roll-off frequency of this filter is 20MHz and its characteristic impedance is 70Ω.

Without a filter the transmitter harmonic radiation caused complete wipe out of Band 1 signals on a television receiver 15ft from the aerial. With the filter in the circuit, interference was reduced to a slight pattern.

Construction

Layout of the transmitter does not seem to be very critical, provided that normal r.f. construction techniques are used such as keeping leads short and making use of single point earth returns for each stage.

The transistors used in the p.a. and doubler stages are required to dissipate a few watts of power when the transmitter is radiating, and to avoid overheating they must be mounted on some form of heat sink.

To avoid unwanted feedback and possible instability, it is a good idea to mount a screen between the base and collector circuits of each of the stages. It is convenient to make these screens perform a dual function as both screen and heat sink for the transistors. Mica washers are used to insulate the transistors from the screen whilst allowing conduction of heat.

To obtain good heat conduction the screens must be made of aluminium at least 1/16in thick. In the prototype transmitter the screens used were 4 x 2 inches of 16 s.w.g. aluminium and were solidly connected to the chassis and case of the transmitter to improve heat transfer. Under normal keyed operation, the p.a. transistor heat sink will run slightly warm after a long period of transmission.

If it is desired to run the transmitter with continuous carrier output, such as for n.b.f.m. working, the heat sink used for the p.a. stage must be made larger. A standard finned type heat sink giving about 4° C/W should however be large enough for use under these conditions.

The t.v.i. filter must be mounted in the same case as the transmitter. Individual sections of the filter must be screened from one another to prevent direct coupling of harmonics. This is indicated in Fig. 3. To avoid mutual coupling coils in adjacent sections of the filter are mounted at right angles to one another.

Power supply

An external 24 to 28V power supply is used for the transmitter. This supply must be either stabilized or regulated to handle the large variations in current drawn by the transmitter. With the key down the current drawn from the supply will be about 1.5A,

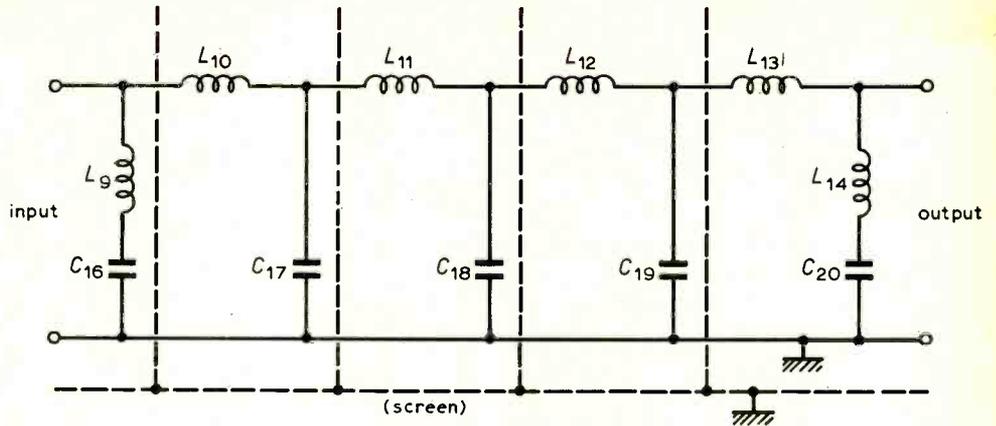


Fig. 3. Harmonic suppression filter to prevent television interference.

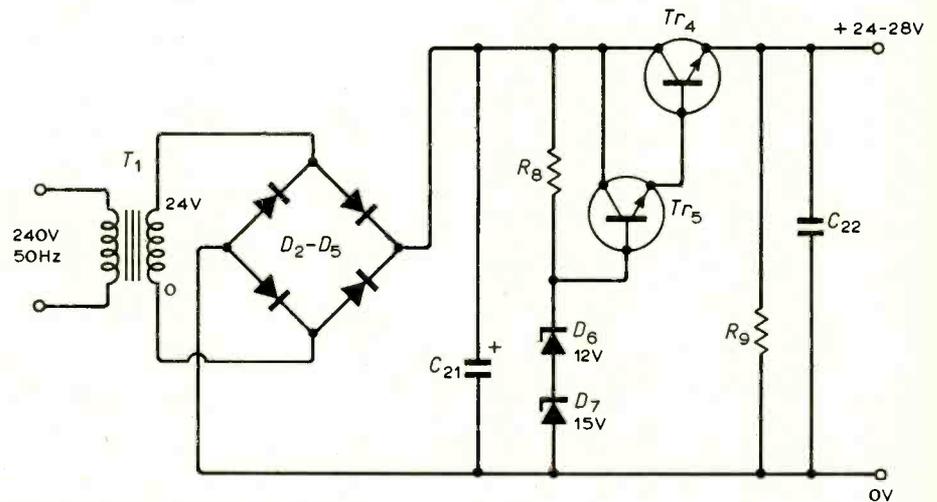


Fig. 4. Power supply circuit diagram.

whereas with the key up the current will be virtually zero.

An r.f. filter comprising L_8 , C_{14} and C_{15} (Fig. 1) is included at the point where the power supply lead enters the case of the transmitter. This filter is intended to prevent leakage of r.f. signals into the power supply leads which could cause unwanted radiation.

A circuit of a suitable power supply for use with the transmitter is given in Fig. 4. A 2N3055 transistor Tr_4 is used as a series regulator. The output voltage is set by the two zener diodes D_6 and D_7 which drive the base of the series transistor via the emitter follower Tr_5 . The 2N3055 transistor will need to be mounted on a heat sink since it will have to dissipate about 4 to 6W when the transmitter is radiating.

While carrying out initial tests with the transmitter it is useful to be able to supply only 12V, which reduces the possibility of destruction of transistors due to mistuning or overloading. By tapping the base of Tr_5 at the junction of the two zener diodes, an output of about 12 to 15V is obtained.

Testing and tuning

Monitoring of the collector current to the p.a. stage is provided by measuring the voltage drop across the 1Ω resistor R_6 using a 1mA meter in series with a 1kΩ resistor R_7 .

A 70Ω dummy load will be needed when setting up. This can easily be made up from

four 68Ω carbon, or other non-inductive type, resistors which are wired in series/parallel to give a total value of 68Ω. Each of these resistors must be rated at 2 or 3W.

To give a visible indication of the power output a 2.5V, 0.3A torch bulb is connected in series with the dummy load. At full power output from the transmitter the current in the dummy load will be about 0.5A. Since this level of current will overload and possibly burn out the lamp it is advisable to connect a low value resistor across the lamp during the later stages of testing.

Before starting any tests the transmitter wiring should be checked for any possible errors. Capacitors C_7 , C_9 , C_{12} and C_{13} should all be set at roughly half their maximum value. At this point the supply, set to 12V, may be applied. With the key circuit open no current should flow.

To check the oscillator stage connect a voltmeter across R_4 with the positive lead connected to ground. A 7MHz band crystal is now plugged in the circuit and the key closed. Adjust L_2 until a voltage is obtained across R_4 which indicates that the oscillator is running and drive is being applied to the doubler stage.

There should at this point be some current flowing in the output stage. Adjust L_4 to produce the maximum current on the meter M_1 . The capacitors C_{12} and C_{13} may now be adjusted to obtain maximum current into the dummy load.

With power being delivered to the load

and the p.a. and doubler stages roughly tuned to resonance, the full supply voltage can be applied. The network L_4 , C_7 and C_9 are adjusted together to produce maximum p.a. collector current which should be about 0.9 to 1.0A. Adjust C_{12} and C_{13} again to produce maximum brilliance on the dummy load indicator lamp. These adjustments will be found to be interdependent, but as a rough guide C_{13} adjusts the load coupling and C_{12} is used to tune the circuit to resonance. It will be found that if C_{13} is made too large or too small there will be a fall off in the maximum achievable output. The capacitors should be adjusted to give an optimum between these states. The settings will be fairly broad and, once set up, they should hold over a large part of the 14MHz band.

Performance

Over the past two years two versions of this solid state transmitter have been used on the 14MHz band. One transmitter was only run at 12W input whilst the later unit was run at the full 25W. In both cases the aerial used was a rather inefficient indoor dipole running NE to SW.

Contacts with all parts of Europe were found to be easily made and consistent reports of signal strengths from S-7 to S-9 were obtained. Working stations in Asia, Africa and North America is naturally a little harder but reports averaging S-5 to S-8 are regularly received during contacts with the U.S.A. and Canada. So far it has not been possible to contact Australia but this is probably due to the orientation of the aerial which does not favour Australia and the Pacific area.

Components list

Resistors

R_1	100 Ω	R_6	1 Ω 3W
R_2	33k Ω	R_7	1k Ω
R_3	100 Ω	R_8	330 Ω
R_4	330 Ω	R_9	4.7k Ω
R_5	10 Ω		

All resistors $\frac{1}{2}$ W unless otherwise stated

Capacitors

C_1	0.002 μ F	paper
C_2	4700pF	ceramic
C_3	0.047 μ F	polyester or paper
C_4	330pF	mica
C_5	330pF	mica
C_6	1000pF	ceramic
C_7	3-40pF	tubular trimmer
C_8	22pF	mica
C_9	3-40pF	tubular trimmer
C_{10}	0.047 μ F	polyester or paper
C_{11}	0.047 μ F	polyester or paper
C_{12}	50pF	air spaced variable
C_{13}	50pF	air spaced variable
C_{14}	0.047 μ F	polyester or paper
C_{15}	0.047 μ F	polyester or paper
C_{16}	68pF	mica
C_{17}	220pF	mica
C_{18}	220pF	mica
C_{19}	220pF	mica
C_{20}	68pF	mica
C_{21}	10,000 μ F	36V
C_{22}	0.47 μ F	polyester or paper

Semiconductors

Tr_1	BFY51	D_1	1N4001
Tr_2	BD123	D_2-D_5	3A, 100-1000 p.i.v. silicon diodes
Tr_3	BD123		
Tr_4	2N3055	D_6	12V, 400mW zener diode
Tr_5	2N2219	D_7	15V, 400mW zener diode

Inductors

L_1	2.5 mH r.f. choke
L_2	Primary—14 turns 26 s.w.g. enamelled Secondary—4 turns 26 s.w.g. enamelled, wound at d.c. supply end of primary Former—Neosid 8mm diameter with dust core
L_3	100 turns 26 s.w.g. enamelled, close wound on $\frac{3}{8}$ in diameter s.r.b.p. rod
L_4	20 turns 26 s.w.g. enamelled Former—Neosid 8mm diameter with dust core
L_5	120 turns 30 s.w.g. enamelled, close wound Former— $\frac{1}{4}$ in diameter s.r.b.p. rod
L_6	Same as L_3
L_7	16 turns 16 s.w.g. enamelled, close wound $\frac{3}{4}$ in diameter, self supporting $1\frac{1}{4}$ in long
L_8	20 turns 18 s.w.g. enamelled, close wound $\frac{1}{2}$ in diameter self supporting
L_9	12 turns 18 s.w.g. enamelled, close wound $\frac{1}{4}$ in diameter self supporting
L_{10}	18 turns 18 s.w.g. enamelled, close wound $\frac{1}{4}$ in diameter self supporting
L_{11}	Same as L_{10}
L_{12}	Same as L_{10}
L_{13}	Same as L_{10}
L_{14}	Same as L_9
T_1	50Hz mains isolation transformer with secondary winding of 0-24V, 2-3A

Microwaves at the Physics Exhibition

Impatt diode applications

The Impatt diode is challenging the travelling-wave-tube in many respects. An amplifier shown by S.T.L. provides an output of 1W c.w. at 8GHz, and requires 120V d.c. supply, a great advantage over currently available t.w.ts. The amplifier comprises four cascaded stages, circulator coupled, and each stage is provided with its own constant-current and transient protection circuits allowing the simplest of external d.c. supplies to be used. A novel design for each amplifier circuit is used so that each of the four stages can use the same type of matching circuit to provide the optimum gain and bandwidth characteristics with reduced manufacturing problems. Overall, it provides a bandwidth of 250MHz at 8GHz — prototype centre frequency — with 40dB of gain but this can be increased to 400MHz by overdriving to a reduced gain of 30dB. Silicon Impatt diodes used in the prototype yield better than 70% operating efficiency but work is now going

on to replace these with the more efficient gallium arsenide devices, around 15%. (Overdriven Impatt diode amplifiers are necessarily non-linear and obviously not suitable for a.m. systems.)

Phase switching, usually performed by p-i-n diodes at a loss in microwave phase modulation systems, can be achieved with Impatt diodes with the advantage of power gain, as demonstrated by the Services Electronics Research laboratory. An Impatt diode, forming the termination of a transmission line, reflects signals that are incident with magnitude and phase depending on the values of the real and imaginary parts of the diode terminal admittance. Under conditions of reverse bias, where avalanche current is flowing, the diode conductance can appear negative over a wide range of frequencies and therefore can provide signal gain where the reflected wave is greater than that of the incident wave. The magnitude of the reflected wave basically depends on the real or conductive components of the diode equivalent circuit whereas the phase is associated with the imaginary or shunt reactance part of the model.

A situation can arise where at or near the avalanche transit-time frequency, the conductance component can be equal at two different levels of diode current, but because the series inductance element is a function of this current the phase delay at these two currents is different. In the demonstration, the diode current was switched alternatively between two values, chosen to give the same amplifier gain, providing phase switching of up to 180° with small-signal gains of about 10dB with very little amplitude modulation. For further details, see *Electronics Letters*, vol.8 no. 19.

Q-band communications

A lightweight Q-band communications link capable of handling data rates of up to 1Mbit/sec has been developed by Decca Radar Ltd. Designed for short-distance communications of up to 5km, the link can be tuned to any frequency in the 26.5 to 40GHz band. The demonstration link was operated with a Gunn device transmission source providing a c.w. power output of around 7 to 10mW at approximately 34GHz, pulse modulated at 1MHz with a p-i-n diode circuit. The Gunn devices are apparently operating in the $n \lambda/2$ mode in full-height waveguide and it is claimed that little trouble has been found with moding or hysteresis. Aerial gain is greater than 30dB with parabolic reflectors of around 25-cm diameter and the hardware is mounted in the case space behind the box-shaped aerial mounting.

The receiver uses a similar Gunn oscillator, suitably attenuated, to drive the Q-band mixer which, it is said, maintains its sensitivity figure over at least a 6dB variation in local oscillator power — very useful for long-term gain stability. The overall noise factor, with 50MHz i.f. bandwidth, of <12.5dB allows good link range, easy tuning and a minimal drift problem.

Unusual forms of Analogue Modulation

A discussion of the importance of a.g.c.

by R. C. V. Macario*, B.Sc., Ph.D., M.I.E.E.

Some time ago the writer questioned the merits of simple diode detection and suggested that more complicated detector circuits could have advantages in the design of radio receivers.¹ Many such designs have been appearing, especially in broadcast receiver technology^{2,3} and in mobile radio communication equipment.^{4,5,6}

There is no doubt that these more complex circuits can perform some remarkable signal recovery, but one soon discovers an interesting feature in that automatic gain control (a.g.c.) prior to signal detection takes on a new importance. It is interesting to note that hardly any of the above references discuss the a.g.c. problem, yet it is an unfortunate fact that many of the detection circuits described do not operate in a practical environment unless well controlled automatic gain control is available. The great merit (or one of them at least) of the diode detector is that it provides its own a.g.c., at least on full carrier a.m. modulation.

The great merit of frequency modulation is likewise, that it provides its own form of a.g.c. by limiting, and system equipment designers are much more tempted to stay with systems where some of the circuit problems are automatically eliminated.

Other forms of modulation

If, however, a restriction is placed on channel bandwidth, or the maximum range for a given primary power is a priority, other forms of modulation become of interest. In particular the transmission of speech is considered since this, in the main, possesses the large amplitude fluctuations which are so difficult for the automatic gain control circuits to cope with in a completely satisfactory manner. The speech bandwidth can take two values, (a) broadcast quality, say 40Hz to 4000Hz, and (b) communication quality, say 300Hz to 3000Hz, and this can be a restriction which may have to be noted.

The modulations to be described fall into three categories:

1. The speech signal to be transmitted is completely amplitude suppressed so that it no longer possesses any amplitude fluctuation and so a.g.c. is hardly necessary.

2. The speech signal is amplitude suppressed as in (1), but an additional coded signal is transmitted so that some of the speech amplitude fluctuations can be recovered and reinstated.

3. The speech signal is not suppressed (more than usual) but a variable carrier is transmitted so that the total signal has more or less a constant amplitude — rather like f.m.

All of these systems need a more complicated transmitter processor and a more complicated receiver detector circuit, but in all cases the a.g.c. can act on the average signal and retain the old envelope detector simplicity.

Category 1. Completely amplitude suppressed speech is identified with the infinitely clipped speech experiments of Licklider and Pollack⁷ who showed that the speech intelligence is maintained under

these conditions. A direct and efficient method of achieving this form of speech is shown⁸ in Fig. 1. The speech signal, category (b), is converted to a single sideband signal and then infinitely clipped by a limiter. The residual carrier is adjusted so that during speech pauses the remaining carrier constitutes the output and suppresses the noise.⁹ A simple filter, following the limiter, suppresses the harmonics of the clipped r.f. waveform.

If one listens directly (via a converter back to audio of course) the speech "quality" is surprisingly good, and one finds the improvement in talk power is at least ± 10 dB. However, if one listens to the system after transmission through a radio system with some attendant distortion, the "quality" is degraded very rapidly. This appears to be a fundamental disability of infinitely clipped speech, but improvements have been reported. For in-

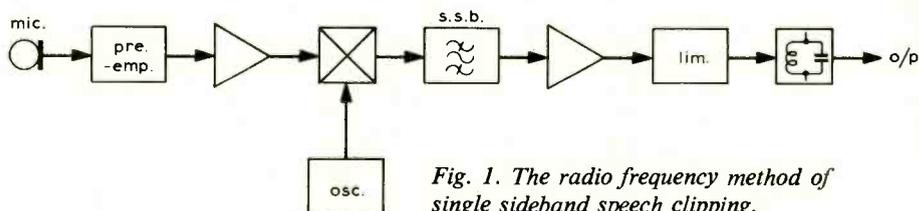
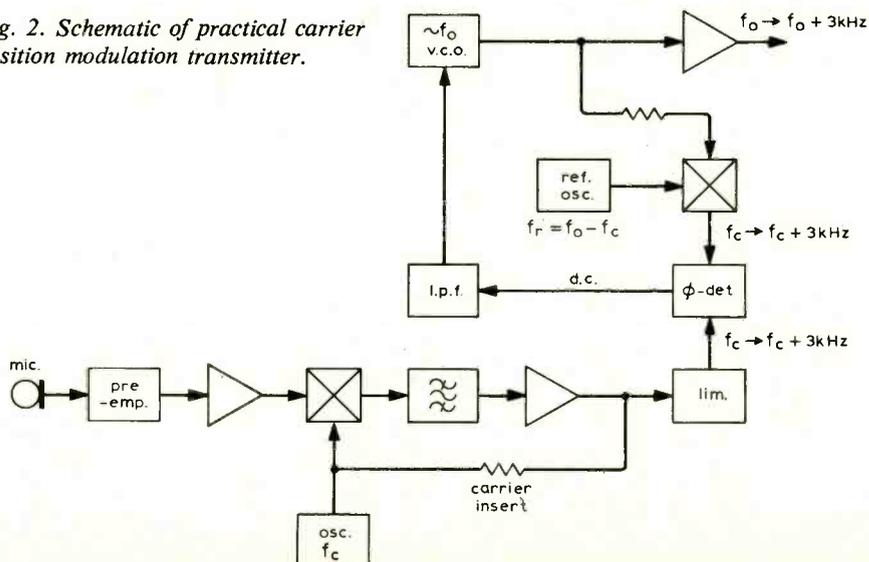


Fig. 1. The radio frequency method of single sideband speech clipping.

Fig. 2. Schematic of practical carrier position modulation transmitter.



stance James and Daley¹⁰ report a significant improvement if the speech band is split up into a number of smaller channels, clipped individually and then reconstituted then the quality is indeed quite remarkable.

Applied to a radio communication system this form of modulation seems to appear under two names. Thus in amateur radio circles¹¹ it is known as infinitely-clipped phase-locked s.s.b. (p.l.s.s.b.), which is, as far as one can ascertain, identical to a General Electric mobile radio system known as carrier position modulation — c.p.m.¹². The transmitter arrangement for both methods may be shown as Fig. 2. It will be seen in this diagram that the speech processor of Fig. 1 precedes the carrier phase lock circuits, which in turn can be followed by class C r.f. amplifiers. During periods of speech a constant-amplitude suppressed-carrier signal is transmitted, during speech pauses a full carrier is transmitted; whence the name carrier position modulation, since a change only in frequency occurs, not in amplitude.

Now the main advantage from the point of view of the present discussion of carrier position modulation, or phase-locked single sideband, is that a.g.c. in the receiver is now a simple matter, if indeed necessary at all, since there is no amplitude information to be recovered from the received signal. However the "quality" of the signal under practical conditions would need careful study.

The efficiency of this form of modulation with regard to transmission range, bearing in mind class C operation of stages can be employed and it also only occupies approximately a 3kHz signal bandwidth, is noted in Fig. 3.

This graph¹² plots measured word intelligibility against received signal level in receivers having the same front end noise figure and optimum bandwidth for the modulation concerned — which is noted. Bearing in mind that +6dB would also be equivalent to raising a transmitter power from 25W to 100W, the advantage of c.p.m. is noteworthy. The curve for the narrow band f.m. signal is actually some 3dB above the theoretical¹³ achieved by pre-emphasis and slight bandwidth clipping.

Category 2. As mentioned, infinitely-clipped speech works well until there is some attendant distortion in the transmitter-receiver link. Therefore a number of modulation systems have been "invented" which overcome this fact by restoring amplitude information to the received signal from information received in a pilot signal transmitted alongside the main signal.

The best known system in this class of modulation is of course "Lincompex"¹⁴, and since this has been very well described no more will be said about it here.

An earlier family of similar systems are the "Frena" and "Frenac" systems¹⁵ of speech transmissions. The primary purpose of these systems is to improve performance under adverse signal-to-noise conditions, and an estimate of this fact is attempted in Fig. 4. In this diagram, which has the same ordinate as Fig. 3, are

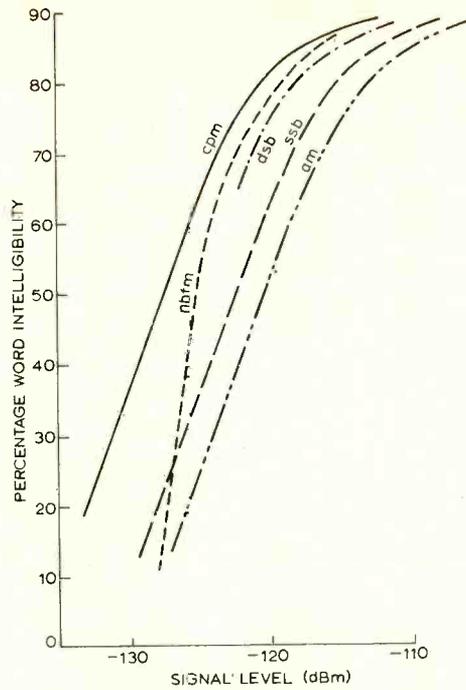


Fig. 3. Threshold intelligibility performance of amplitude modulation, single sideband, double sideband suppressed carrier, narrow band frequency modulation and carrier position modulation.

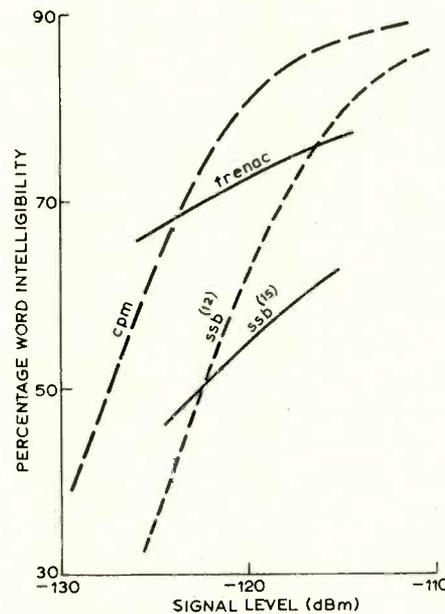
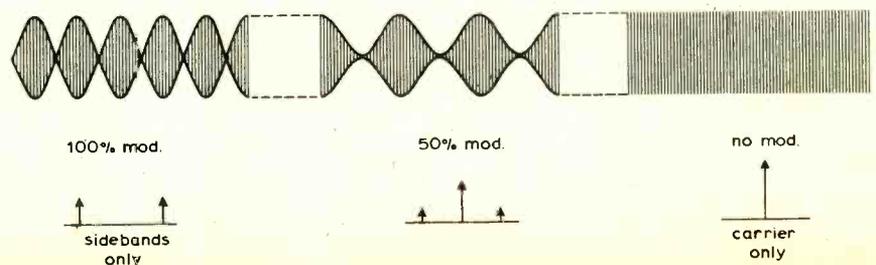


Fig. 4. Estimated threshold intelligibility performance of "Frena" compared to single sideband and carrier position modulation.

Fig. 5. The waveform and spectrum of double sideband controlled carrier.



superimposed the intelligibility results given by Jagger and Greefkes for their "Frena" system. Their method of assessing intelligibility employed recognizable sounds, whereas the more recent tests (scale of Fig. 3) employ words, so one would expect a difference between the two methods especially with regard to the fall-off in intelligibility. But this does not hide the significant feature that the "Frena" system does demonstrate the wanted improvement.

The feature of main interest to the discussion, however, is the question does the system assist the a.g.c. problem? The answer is yes, if the control tone (amplitude information) is an f.m. signal and the main speech channel has a constant amplitude. The total signal transmitted is then of constant amplitude. Of even greater interest is to note the nature of the "Frenac" system. Here the control tone is pulse modulated, and it is arranged that "the pilot signal has a certain constant value when speech is absent, and is zero when it is present. This amounts to saying that the frequency signal and the amplitude signal are transmitted in turn, and the obvious course is to transmit them at the same amplitude. The carrier of the single-sideband signal in the frequency channel can profitably be made to act as pilot signal."

It would therefore appear that "Frenac" p.l.s.s.b. and c.p.m. are in reality the same form of modulation, possibly constructed in different ways, but providing the same meritorious features.

Category 3. In the final category, the speech waveform is less severely processed and the systems lie between the previous systems and straightforward single sideband and double sideband suppressed carrier. Now it is common practice to provide voice operated a.g.c., especially for s.s.b. (A3J telephony) which works very well in the main if the a.g.c. circuit is sufficiently sophisticated, i.e. Plessey device SL621, but if the detector has to establish synchronization before an audio waveform is generated, as in the case of double sideband suppressed carrier^{4,13}, this form of a.g.c. is unworkable. An a.g.c. voltage can be derived by envelope detecting the incoming signal (out of the i.f. stages), but here again the correct choice of time constant is difficult if this detector is to distinguish between, say, rapid fading and a speech waveform. Therefore systems have

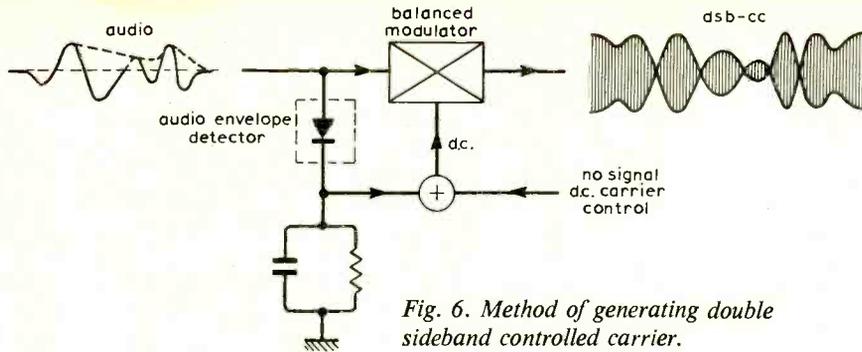


Fig. 6. Method of generating double sideband controlled carrier.

been proposed in which the carrier amplitude is made to vary inversely as the sideband amplitude¹⁶.

Fig. 5 illustrates the action of the controlled carrier on a double sideband controlled carrier signal. It will be seen that there is a gradual take over of the signal energy by either the carrier or the sidebands, depending on the amplitude of the sidebands. The waveform would be similar for two tone single sideband controlled carrier. In either example this contrasts to the almost snap change-over action of the carrier position modulation, phase locked single sideband or "Frenac" system.

A means of generating d.s.b.-c.c. is shown in Fig. 6. In effect the quick acting envelope detector of the receiver has been removed to the transmitter, allowing a slow acting envelope derived a.g.c. to be placed in the receiver. Note also that the waveform envelope of the signal is now completely constant as in modulation categories 1 and 2, as is to be expected since, as explained, this category is an intermediate system. Also, because the carrier is amplitude modulated it will have instantaneous sidebands on either side of it at a frequency spacing dependent on the time constant chosen for the carrier control. This will necessitate restricting the audio signal bandwidth to commercial quality, as indeed needs to be the case for the previous modulation systems.

Finally, it is of interest to note a form of modulation which so intermingles the audio waveform sidebands and a carrier that a constant amplitude phase shift keyed waveform results, which of course can be transmitted with constant amplitude. In this system¹⁷ the conditioned speech waveform (the amplitude variation is restricted using pre-emphasis and compression) is converted to a suppressed clock pulse duration modulation (s.c.p.d.m.) which in turn is fairly easily converted to phase shift keying at the required r.f. frequency. Without going into details of the transmitter modulator and the receiver demodulator, the latter needing two phase lock loop detectors, the point of interest is again the avoidance of a.g.c. problems by placing more complication in the transmitter, and thereby radiating a constant amplitude signal. The only penalty paid by this particular system, however, for being able to not have to use infinitely clipped speech, is

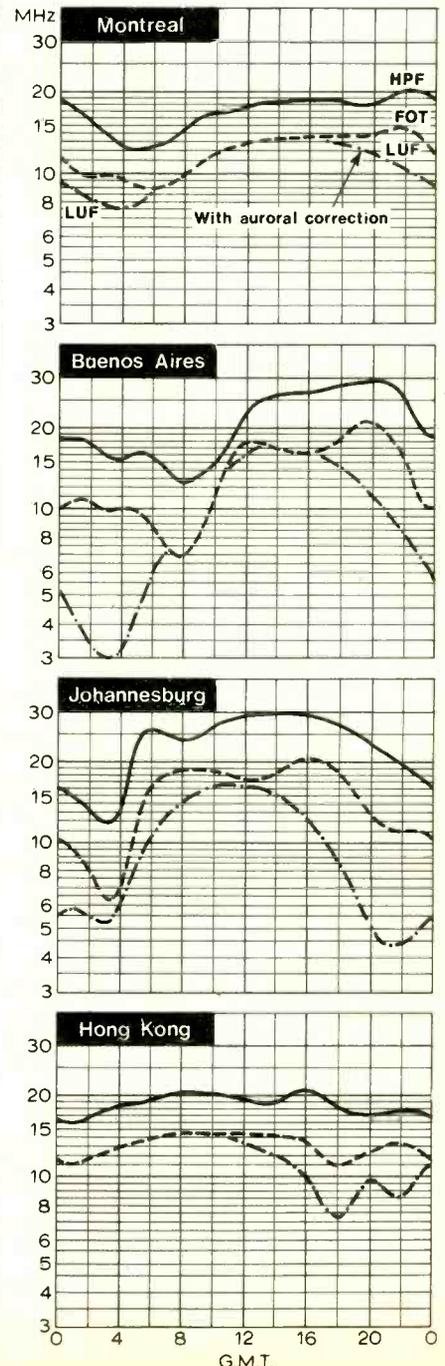
that the bandwidth of the signal has to be between four and eight times the audio baseband width.

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H.F. Predictions for June

Conditions have been generally poor in recent months and there is no prospect of rapid improvement. In fact the lower daytime MUFs of summer season coupled with present magnetic and solar activity levels look like producing the worst month so far this year. The most favourable periods are the first and last five days of the month. LUF calculations assume that ionospheric reflections will occur at all frequencies, thus the contradiction of LUF exceeding FOT (LUF curves discontinued for this condition) often arises. This does not mean that communication is impossible: the value of MUF minus LUF is an indication of ease of communication at frequencies around FOT.

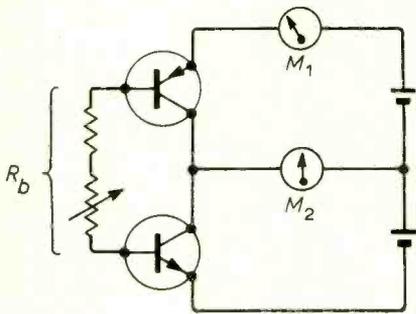


Circuit Ideas

Concise descriptions of new circuits are invited for *Circuit Ideas*, for which £5 is paid on publication. Contributors should say how their circuit is an improvement over existing circuits, preferably in the first sentence.

D.C. matching of complementary pairs

The emitter current at which matching is required is set up by adjusting R_b . Current meter M_1 indicates this. Centre-zero meter M_2 now displays the difference between the collector currents of the two transistors. The direction of deflection of M_2 shows which transistor



has the higher h_{FE} . If the base-emitter drops can be allowed for R_b may be calibrated in base current: this is useful information when the matched pair is transferred to a working circuit.

G. W. Short,
South Croydon,
Surrey.

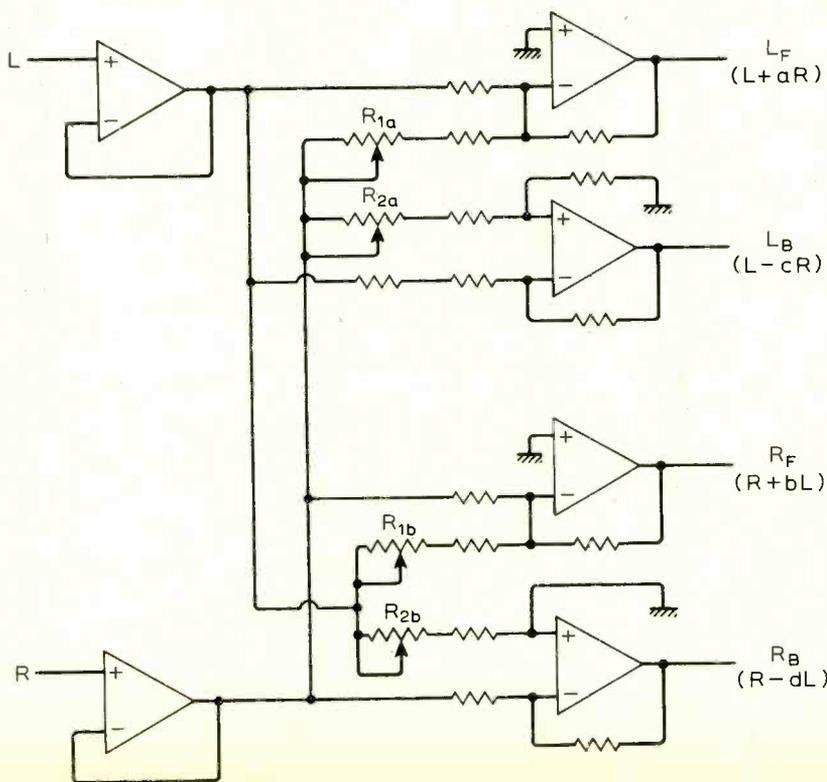
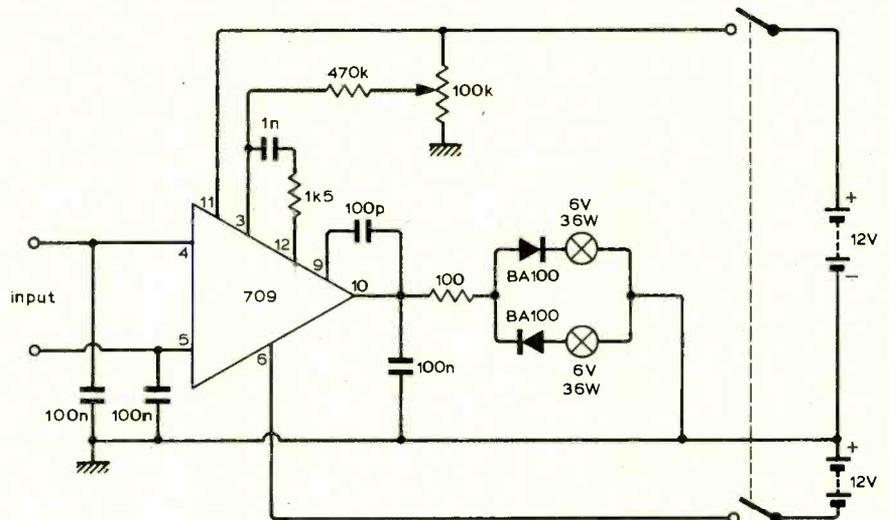
Miniature null indicator

This circuit provides good sensitivity, while having the advantages of small size and ruggedness (as compared with a moving-coil indicator). The amplifier, a 709 type, is driven open loop. This means that a small change in the input voltage — about one mV — will cause the output to switch from one rail to the other. This output state is indicated by one of the

bulbs. The null is indicated by both bulbs being extinguished, the initial null having been set by shorting the input and adjusting the potentiometer.

If desired, the diodes can be LEDs and the bulbs dispensed with. In this case the series resistance may need altering.

Brian P. Cowan,
University of Sussex,
Brighton.



Surround sound with 741s and variable crosstalk

An alternative to the TA7117P matrix i.c. mentioned by Geoffrey Shorter in the March issue (page 116) uses 741 i.c.s and differs from the circuit on page 3 of the January 1972 issue in that crosstalk is variable.

In the circuit shown left fixed resistors are $1k\Omega$ and ganged variable resistors $250k\Omega$. As in the TA7117P the two inputs are added and subtracted in varying proportions depending on the setting of the two variable resistors. The added signals $L + aR$ and $R + bL$ feed the front channels and the subtracted pair feed $L - cR$ and $R - dL$ feed the rear channels.

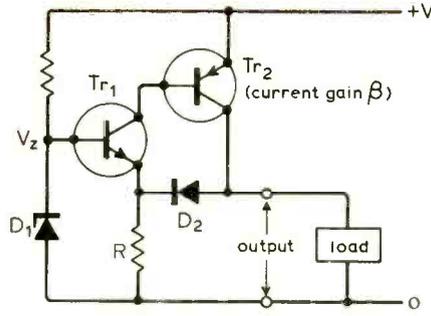
With the values as shown above, $a = b$ and $c = d$, and the crosstalk ratio will be $1/(1 + \text{wiper resistance})$ and therefore can be varied between 1 and 0.0004.

M. D. Bamforth,
Oldham,
Lancs.

Simple current-limited stabiliser

This simple circuit fits in the gap between the simplest emitter follower stabilizer and the more expensive series stabilizers with current limit protection.

Emitter followers with zener diode stabilized input voltage are often used to provide simple stabilization and ripple reduction on transistor equipment power supplies. A simple modification can be made to provide a current-limit action, using the circuit shown. Diode D_2 is added to the complementary transistor emitter follower and at low currents does



not affect the circuit other than to provide some temperature compensation for V_{be} changes in Tr_1 . The maximum Tr_1 collec-

tor current is $\approx V_z/R$ giving a maximum Tr_2 collector current of $I_{max} \approx \beta V_z/R$, where β is the d.c. current gain of Tr_2 . If the load impedance becomes too low diode D_2 becomes reverse biased and the current is limited to I_{max} . No component values are given as the circuit will work with a wide range of components to suit the particular application. Transistor Tr_2 should preferably be a silicon transistor, both from the point of view of heat sink requirements and of improved current-limit characteristic.

A. E. T. Nye,
Cranleigh,
Surrey.

Voltage-controlled two-phase sawtooth oscillator

The oscillator described is a design I am working on to investigate its possibilities for providing a waveform of any desired frequency and phase as soon as these quantities are specified. The interest of the problem lies in specifying phase, for which one voltage line is perhaps not enough while two are perhaps too many. The oscillator is a sawtooth type but at a fixed amplitude outputs can be shaped to give a sinewave. (See for example New techniques in function generation under "Notes from the Physics Exhibition", *W.W.* May 1972 p. 236). It is based on the fact that the sine and cosine functions of an angle each cross the zero line whenever the other reaches a peak or trough. For sine and cosine the sum of their squares is constant but for the two-phase sawtooth oscillator the arithmetical sum of the outputs is constant.

Assume a direct voltage V_{in} ; this is amplified as $\pm \frac{1}{2}V_{in}$ by each of the two amplifiers at the left of the diagram, depending on whether the f.e.t. is off or on in each case. Each output is integrated to give a rising or falling ramp by the two following inte-

grators. The polarity of the two resulting outputs is monitored by the last two operational amplifiers, which switch rapidly between the limits of their outputs. The top one has positive gain, the lower one negative gain. Each controls the switching f.e.t. at the beginning of the other channel. The generator has similarities in each channel with R. J. Tidey's version of G. B. Clayton's generator (*W.W.* May 1972 p. 239), but instead of discrimination at two definite voltage levels to trigger a bistable circuit, leading to reversal of the polarity of the input to the integrator, this reversal is caused by the zero crossings of the other channel.

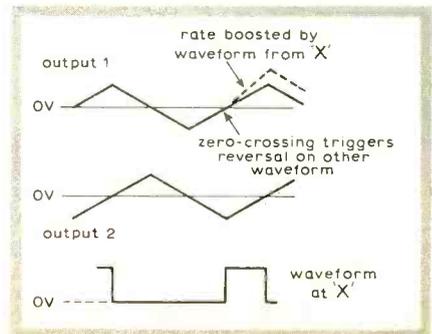
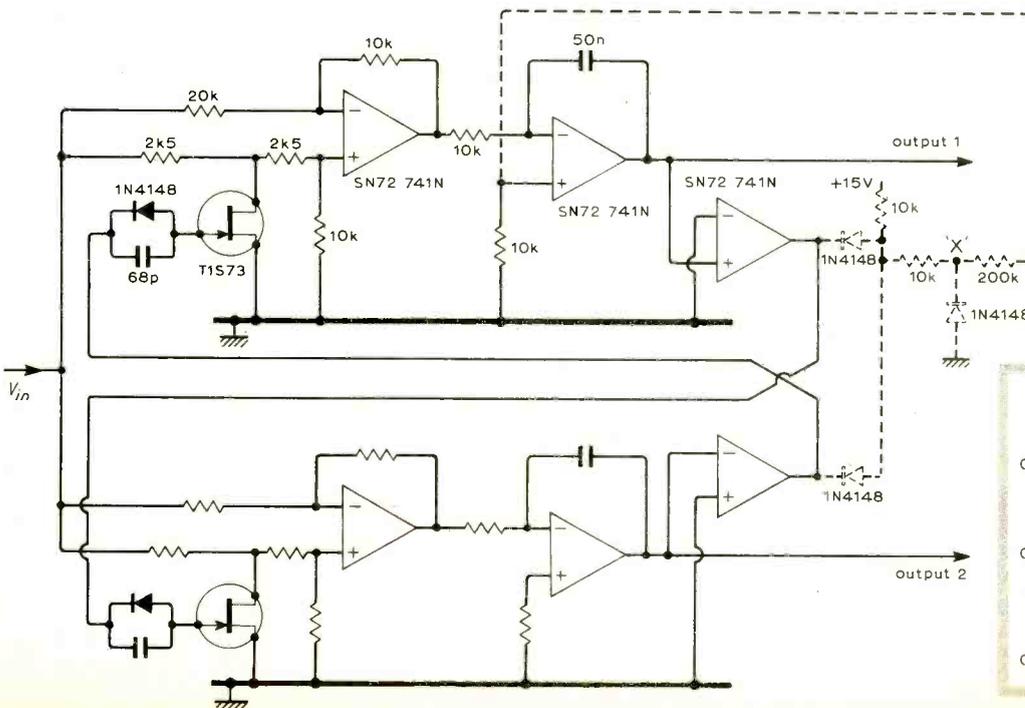
Once oscillation is established, the output of one integrator is travelling toward zero, and the output of the other is travelling away from zero, with the same or opposite polarity. When the first output crosses zero the discriminator switches the f.e.t. in the input amplifier of the other channel. This reverses the polarity of the voltage to the integrator so that its output now travels toward zero. But the first output, having passed through zero, is now travelling away

from it. Each channel is now in the situation the other channel started off in, so the second channel passes through zero output from its integrator, whereupon its discriminator switches the f.e.t. in the first channel, and the action is self-perpetuating.

The Q of the system is nominally infinite, i.e. oscillations once started continue at the same level for some time, not that there is any provision for starting them. Provisionally, I would add some gating from the outputs of the two discriminator 741s to boost the slope of one sawtooth in one quadrant, using the components shown in broken lines.

All this is happening on a time scale determined by V_{in} , assumed constant. If V_{in} is reversed in polarity the oscillator repeats its past performance backwards, like a film projector switched from forward to reverse; this is "negative frequency". If V_{in} becomes zero the output voltages freeze at constant values. Modulating V_{in} modulates the output frequency. This may be more useful if the outputs are shaped into sinewaves.

F. B. Jones,
Crosfield Electronics Ltd,
London.



Realm of Microwaves

3. Modern circuitry

by M. W. Hosking* M.Sc.

The general summaries in the preceding article of the various types of transmission line treated them simply as carriers of electromagnetic waves. No attention was given to the ways in which a transmission line can be locally modified to influence the field. As part remedy, this article commences with a description, not of the many and varied components such as frequency, power and attenuation measuring devices, but of the basic reactive elements from which they are constructed. Progress can then be made towards a description of distributed-element, microwave integrated circuits using the microstrip form of transmission line. Finally, a worked example is given of the design of a microwave receiver.

Transmission-line distributed elements

A distributed element is an inductance, capacitance, or resistance, the exact value of which is a function of frequency, and where the L , C or R is formed by a discrete length of the transmission line itself. To appreciate the significance of this, consider a few further transmission line properties. Derivation and proof of these statements is elementary, and are not given space in this text.

Firstly on the periodic nature of the line: an impedance or admittance occurring at a particular point will be repeated in value all the way down the line at half line-wavelength, $\lambda_g/2$ intervals. For example, if a shunt inductance is formed across the line at A and, say, five half-wavelengths further along at B, a shunt capacitance is placed, then the input admittance sees B superposed on A or, equivalently, A superimposed on B. The input is thus susceptive, having a value equal to the normal sum of the inductive and capacitive susceptances of the two elements.

The second important property is that a quarter line-wavelength interval acts as an impedance inverter. That is, an impedance $a + jb$ looks like an admittance $1/(a + jb)$ at all points which are odd multiples of a quarter line-wavelength away.

Strictly speaking, these two statements are true only if the transmission line has zero loss, but in most practical cases, the loss per wavelength is small enough to give negligible error. One use of these periodic relationships might be a requirement to introduce some reactance, say, at a point in a system which is not directly accessible. By choosing a part of the transmission line some distance from the required point and inserting the appropriate component value, the required effect can be produced. Again, this is strictly true at only one frequency and approximations or trade-offs have to be made if a wider bandwidth is required.

To achieve any particular value of reactance, capacitive or inductive, use is often made of the properties of an open-circuited or short-circuited length of line. No matter what form of transmission line is used, be it waveguide, coaxial or other, the following properties apply. Suppose a length of transmission line is to be short circuited at one end and the input impedance to be noted at different distances from the short. Then, at the short circuit itself, the impedance is zero but, on moving away down the line, the input impedance will appear as an inductive reactance, increasing in value until it reaches infinity at a quarter wavelength from the short. At this point the reactance reverses sign and becomes capacitive, decreasing in value from infinity to zero and then repeating. (This is also true for

a purely open-circuited line, but with a quarter wavelength phase difference; that is the first quarter wavelength is capacitive instead of inductive.)

Thus, any value of reactance can be produced from a suitably terminated length of transmission line, that is, a distributed element. Such elements can then be placed in series or parallel with the main line to influence the flow of power and can be dealt with, computationally, in the same way as for normal a.c. theory. To those brought up on dielectric capacitors, it is interesting to point out that a capacitance produced in the above fashion is not necessarily a d.c. open circuit. An example of a series T-junction in microstrip is shown in Fig. 1 and here it is possible to influence the e.m. field travelling down the main line by the impedance of the series arm; by the length of the series arm; and by the way in which the series arm is terminated.

There are really two effects at a junction like this. By the definition of "distributed" the line dimensions are comparable in size to the wavelength, the junction actually appears as a physical discontinuity to the field in the main line and will disturb it. This disturbance is equivalent to the effect of a reactance across the main line. Impedance of microstrip is a function of linewidth; the narrower the strip, the higher the impedance. This governs the value of X_c . On top of the basic junction reactance is superposed the impedance of the series arm itself and its termination and herein

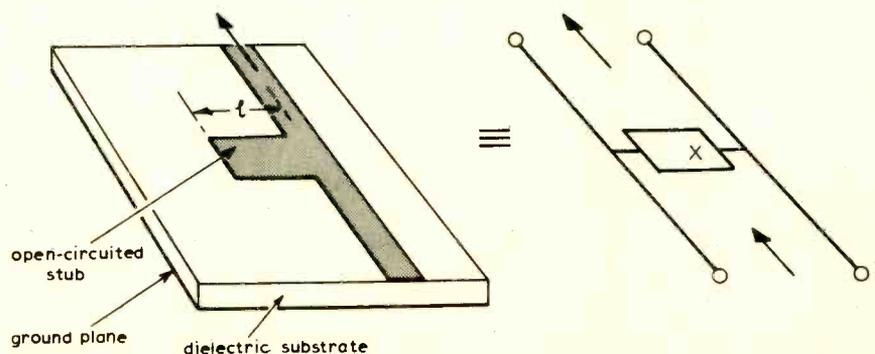


Fig. 1. Illustrating a T-junction in microstrip transmission line. Reactance X is a function of the stub length and can be made to vary between zero ohms and infinity.

* British Aircraft Corporation.

lies great scope for influencing and controlling the transmission properties of the main line.

By way of illustration, suppose the length of the series arm was made a half microstrip-wavelength long and formed as in Fig. 1. Leaving radiation effects from the end to the dedicated reader, this is an open-circuited strip and the terminating impedance (in this case infinity) will be repeated in value at half-wavelength intervals. Thus, there will be an infinite impedance (open circuit) across the junction and the main power flow will be uninterrupted. If now the open-circuited stub is gradually shortened, the impedance presented at the junction appears as a gradually decreasing inductive reactance. At the point when the line length becomes a quarter wavelength long, the impedance-inverting property applies and the open circuit is transformed into a short circuit, effectively blocking the transmission line.

A simple application of such a quarter-wave open-circuited stub is as a band-stop filter such as is often used in a superhet circuit adjacent to the mixer diode. Here, the requirement is to let the intermediate frequency (say tens of MHz) through to the rest of the circuit and suppress the signal frequency (say thousands of MHz). If the stub is made a quarter-wave long at the signal frequency, then it goes virtually unnoticed at i.f. but appears as a short circuit to the signal.

As an additional example, use can be made of this transmission line principle to construct a simple switch or modulator. The half-wave stub can be terminated in a semiconductor diode which, depending on whether forward or reverse bias is applied to it, can have a high (open circuit) or low (short circuit) impedance. The periodic nature of the half-wavelength stub then transforms the impedance across the main line and one has a simple

on/off switch. In practice, the stub length can be made slightly greater or less than a half wavelength and the reactance due to this deviation can be used to compensate for the electrical discontinuity introduced by the diode itself.

The foregoing illustrates one of the basic differences between the design of microwave circuits and those at lower frequencies and is worthwhile reiterating; a simple inductance or capacitance can be produced by using a physical length of the transmission line itself. Whether an element is termed inductive or capacitive depends on the way it affects the phase relationship between the electric and magnetic fields (or voltage and current); such elements can be produced by a variety of other means. In fact, any abrupt change in the dimensions of any of the transmission line forms, or any external object brought close enough to perturb the fields, will act as a reactive device.

Coupled transmission lines

If instead of using some localized element to perturb the fields a second transmission line itself were brought into close proximity with the first, so that the fringing fields could overlap, then a portion of the power could be coupled from one line into the other. Used mainly in stripline and microstrip form, coupled lines comprise a major feature of microwave integrated circuit design. Although this effect has been known ever since these circuit forms have been used, it has not been until very recently that, particularly for microstrip, the mathematical analysis has overtaken the empirical approach in the design of circuits. Even now, there is no comprehensive set of equations giving explicit values of circuit parameters, and design problems must either be left in synthesis form for computer studies or worked out using graphical solutions for the coupled lines.

To determine the properties of a section of coupled line, the overall field configuration can be resolved into two separate patterns. Each of these represents a travelling wave and are called the even and odd modes of the coupled junction. The electric field patterns are as shown in Fig. 2 with the even mode having the same field polarity on each conductor and the odd mode having opposite polarities. There is much stronger field coupling between the conductors for the odd mode.

Having thus split up the overall field, it is possible to define a separate impedance for each mode, the even mode always having a higher value than the odd. The overall impedance of the coupled section is equal to the geometric mean value of the even and odd mode impedances. In similar fashion to the single microstrip line, the mode impedance is a function of w/h increasing as w gets narrower. But, now, it is also dependent on the line spacing, s/h and the impedance of the even mode increases as the spacing becomes closer, while that of the odd

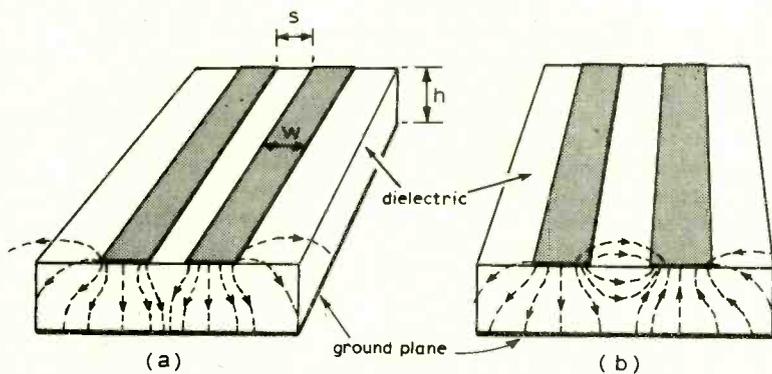


Fig. 2. Coupled microstrip lines showing the electric field distributions for the two analytical modes. Coupling is a function of the spacing and is much stronger for the odd-mode, making the characteristic impedance less than that of the even-mode case.

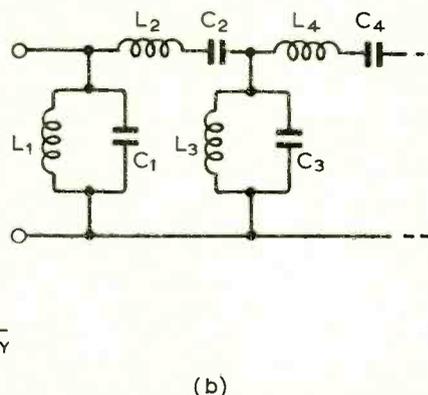
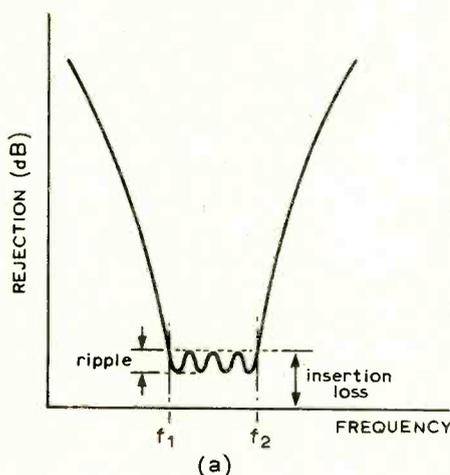
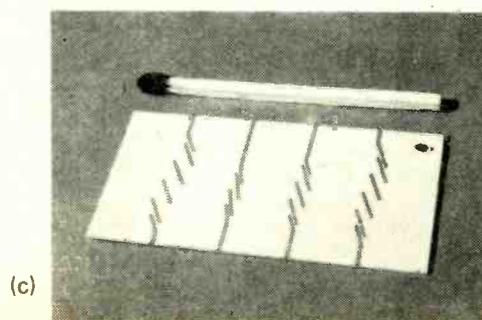


Fig. 3. Trade-offs can be made between the width of the pass-band, ripple amplitude and stop-band rejection for the characteristic of (a). Shown in the photograph are four microstrip bandpass filters, each having the same centre frequency but different pass-band shapes. Each filter consists of a number of half-wavelength resonators with mutual electromagnetic coupling as shown idealistically in (b).



mode decreases. Also, as the spacing between lines changes, so too does the amount of power that is coupled from one to the other.

Making use of the properties of coupled transmission line sections are two very important and widely used types of component: filters and directional couplers. Virtually any microwave integrated circuit will use one or both of these. The most common filter type to be based on the coupled line is the bandpass filter having the general characteristic of Fig. 3 (a) and an equivalent circuit shown in Fig. 3 (b). Basically, such a filter consists of a number of parallel resonant sections, coupled together with series resonant sections. Modifications are usually made to this simple circuit to improve the response, but that is another story. The width and shape of the passband, together with the stopband rejection and rate of cut-off are all functions of the number and type of resonators and of the inter-resonator coupling.

In microstrip or stripline form, the resonators are produced with open-circuited sections of transmission line. Such a section of line will resonate at the frequency for which it is a half-wavelength long. For instance, if the example used in part 2 is continued and we require a 50-ohm impedance microstrip line on 0.025-in thick alumina, for which $\epsilon_r = 9.7$, to be resonant at 3GHz; then the free space wavelength is 10 cm and the microstrip wavelength is 4 cm. So the strip will resonate at 3GHz if it is 2 cm long.

In practice, slight corrections would have to be made to this length to compensate for fringing capacitances from the open ends. For practical convenience, open-circuited strips are used, but the foregoing would apply just the same to a half-wavelength short-circuited strip. As such, this example may also serve to illustrate the difference in size between microstrip and waveguide. To propagate 3GHz standard waveguide has internal cross-sectional dimensions of 7.2 cm \times 3.4 cm and the guide wavelength will be 13.85 cm giving a resonant length of just under 7 cm. The ratio in volume of just the resonators is, thus, about 2,000 : 1.

Having chosen the resonator length, the filter itself can be constructed as in Fig. 3 (c). Each resonator has input and output coupling to it from adjacent resonators, the coupling length being a quarter wavelength. The amount of overlap of the fringing fields between strips governs the bandwidth and rate of cut-off. This is a photograph of a range of filters, designed for operation at 9GHz and having various passband characteristics.

In similar fashion to the filter, it is possible to tap-off power from the main transmission line into a secondary line. Such a device is called a directional coupler and is one of the most commonly used microwave components. There are many possible designs suitable for stripline

and microstrip, the simplest being that of Fig. 4. Here, the main transmission line includes the section 1-2 with the secondary line 3-4 brought into close proximity. The length of the coupling section is a quarter wavelength and the amount of power tapped-off depends on the spacing between the two lines. With the input at 1, say, the main output will be at 4 with the coupled output at 2 and a 90° phase difference between both of them. Ideally, no power should appear at 3.

Directional couplers are classified in terms of their coupling factor: defined as the ratio of the power in arm 2 to that in arm 4 and this is usually expressed in decibels. Thus, coupling is $10 \log_{10} (P_2/P_4)$ and is a negative number. The sign is usually ignored and one talks of a 3dB, 10dB, 20dB coupler, meaning that $\frac{1}{2}$, $\frac{1}{10}$, $\frac{1}{100}$ of the mainline power is coupled into arm 3. The particular type of coupler shown is most suitable for what is termed the "loose" coupling of power: generally 1/10th or less. For "tighter" coupling, the gap must be narrower and becomes impractically small. As an example, still using the 0.025-in standard alumina and 50-ohm microstrip transmission line, an equal power split of 3dB would require a line spacing of about one tenth of a thousandth of an inch; a 10dB coupler would require a spacing of 0.007in and a 20dB coupler, one of 0.033in. The gap required for the 3dB coupler is not achievable using the conventional microstrip etching or deposition techniques and in any case the surface finishes available on alumina would preclude such fine definition. The current practical limit on linewidth and spacing is about 0.001in.

There are many occasions when an equal power split is required and the 3dB directional coupler is probably the most widely used of all. It is possible to use coupled lines, but not in the form shown and not by methods which are particularly convenient in the microstrip type of circuit. Instead, the design shown in Fig. 5 is almost invariably used. The first is the hybrid ring coupler, sometimes called a "rat-race", and can also be built in waveguide or coaxial form. For an input at one arm, there is an equal power split between the two adjacent arms and ideally no output from the fourth. Suppose for instance that power enters arm 1; it will divide equally at the junction with the ring and the two halves will flow in opposite directions. Power arriving at arm 2 will have travelled a distance $3\lambda_g/4$ in each direction and will be in phase and combine to give an output. Similarly, power at arm 4 will have travelled $\lambda_g/4$ one way and $5\lambda_g/4$ (which is equivalent to $\lambda_g/4$) the other and will combine in phase. At arm 3, however, there will be a $\lambda_g/2$ phase difference and no combination will take place. In practice, this decoupled arm is typically isolated by about 20dB from the output arms in microstrip. One further point of design is that, to provide a good match, the impedance of the line forming the ring is made $1/\sqrt{2}$ of that of the arms.

The branch-line coupler of Fig. 5 (b)

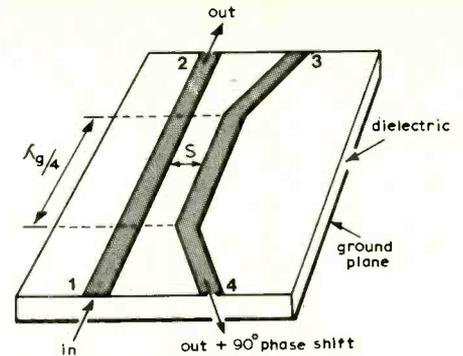


Fig. 4. Coupled-line microstrip directional coupler. An input at 1 produces a main-line output at 2 with a coupled output at 4. The output at 4 is a function of the spacing.

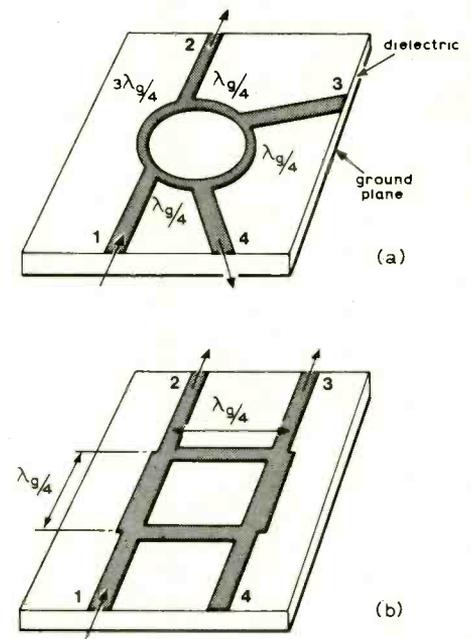


Fig. 5. Two examples of microstrip directional coupler, invariably used to produce an equal power split. There is always a 90° phase difference between the two outputs due to the different path lengths involved.

works in similar fashion to the hybrid ring, an input at arm 1 producing outputs at 2 and 3. By adjusting the impedances of the branch arms it is possible to produce unequal outputs. Also, this coupler can be made to operate over a wider frequency band than the hybrid ring by increasing the number of branch arms.

Both of these couplers are readily produced in stripline or microstrip form and are used extensively. A common application is a balanced mixer circuit where, if the branch line coupler was used, the two mixer diodes would be attached to the output arms 2 and 3 and the signal and local oscillator to arms 1 and 4. In this way each diode receives an equal amount of signal and oscillator power and the signal source and oscillator are well isolated from each other.

An example of microstrip coupler

circuits appeared in the Doppler radar article by K. Holford in the November 1972 issue of *WW* (Fig. 1, page 535). A coupled-line type can be seen at the upper left — probably 10dB from the text — and two hybrid ring couplers appear at the centre.

To complete this article and to demonstrate how the various components can be used a worked example follows on the design of a microwave receiver. This is one of the basic units common to all radar and communication systems and its presentation here should enable useful comparisons to be made by those readers acquainted with receiver design at more “do-like” frequencies.

Microwave receiver design

The type of receiver will be a super-heterodyne one for increased sensitivity, using a balanced mixer and we will arbitrarily choose a signal frequency at the centre of X-band of 10GHz. The microwave circuitry will be in the microstrip form of transmission line and the complete circuit, as it would appear in practice, is shown in Fig. 6. The signal input would be coupled to the receiver by an external aerial and there might be the need for an impedance-matching section. Not detailed is the intermediate frequency amplifier which would be fed directly from the r.f. filter output and might need a matching section.

In detail then: the first parameter to be settled for the receiver is the i.f., as this influences the design of the local oscillator, input filter, output filter and i.f. amplifier. Most of all, it concerns the input filter, the main purpose of which is to cut out spurious signals at the image frequency. If a low i.f., say 1MHz, was chosen, one would be asking the filter to provide an attenuation of perhaps 30-50dB at a frequency 2MHz from 10GHz and implying *Q*-factors of several thousand. Such a design is not really practicable, especially in microstrip and would also pose stability problems. Therefore a high i.f. is preferable — another benefit being that

fewer filter sections will be needed, as the cut-off rate is reduced and so the losses in the filter itself will be smaller. At the other end of the scale, the higher the frequency, the higher the amplifier noise figure; although with small-signal transistors currently giving only 3.5dB or less noise figure at 4GHz, this is not the problem it once was. It is almost always the i.f. amplifier which defines the noise bandwidth of the receiver by either an input filter or preferably by using tuned stages. Thus, an i.f. very large compared with the bandwidth presents tuning and stability problems.

So having a free hand let us choose an i.f. of 500MHz and a 3dB amplifier bandwidth of 50MHz, necessitating *Q*-factors of up to 10 and put the image frequency at $(10,000 - 2 \times 500) = 9.5\text{GHz}$ with the oscillator frequency at 9.5GHz. Finally, assume that an extensive survey of the r.f. environment has indicated that 30dB of image rejection is required. The parallel-coupled bandpass filter at the input to the receiver can now be designed. Its characteristic will be that of Fig. 3 (a) and it is only necessary to define the bandwidth for the number of sections to be determined. The bandwidth cannot be lower than 50MHz and the maximum width will depend on the variation of the signal frequency; let us choose it as 100MHz.

When several tuned circuits are coupled together, as is the case in the filter, it is possible to vary the coupling to produce a passband response which is either a smooth curve or is rippled. In particular, the ripple amplitude can be made to vary as some mathematical function and a “trade-off” made between ripple and rate of cut-off. Our requirement for cut-off rate is not particularly stringent, so we shall specify a very small allowable ripple of 0.1dB. In this case, the 100MHz bandwidth is measured to the 0.1dB points at the band edges. Graphs and tables exist for determining the filter design details and from these two resonant sections will provide the 30dB image rejection. Using

high-purity alumina substrate with a 10 microinch surface finish and gold metalization, the passband insertion loss of this filter will be less than 1dB.

The last article showed that the microstrip line impedance was a function of the strip width *w* to substrate thickness *h* ratio. If we adopt the usual 50-ohm impedance then Fig. 5 of that article shows that a *w/h* value of unity is required. We will use standard 0.025-in thick alumina and so the input and output lines to the filter will be this width. Because not all of the microwave field is confined to the alumina, there is an effective dielectric constant, ϵ_{eff} which is lower than the material value ϵ_r . From Fig. 4 of Part 2: ϵ_{eff} in our case is 6.7, for $\epsilon_r = 9.7$ and each half-wavelength resonator is $0.228\text{-in long } (\lambda/2\sqrt{\epsilon_{eff}})$.

Fringing fields from the ends of these resonators make them seem electrically longer and to compensate for this effect they must be shortened. In this case, the correction would be about 0.019in from each end, making the lengths 0.190in. If this were not done, then the filter passband would be at a lower frequency than required.

The signal, after passing through the filter, reaches one input of a 3dB directional coupler where it divides equally and arrives at the two mixer diodes. Each section of the coupler is made $\lambda_g/4 = 0.114\text{in long}$, only two shunt arms being required as the operating bandwidth is fairly narrow. The impedance of the series arms in the coupler is made $1/\sqrt{2}$ times that of the input and shunt arms which means a value of 35.4 ohms and Fig. 5 of part 2 requires *w/h* = 1.85, giving a linewidth of 0.046in. The other input to the coupler, which would be isolated from the signal input by typically 15dB to 20dB, carries the local oscillator signal which divides equally to the mixer diodes.

The oscillator will be a Gunn effect device, with an output power of perhaps 50mW. Such a device is typically 2% efficient, requiring a d.c. input of 9V, 280 mA for full output. With 2.5W being dissipated, good heat-sinking is essential and for this reason the Gunn device will be shunt-mounted across the microstrip line as in Fig. 7 (a). Many oscillator designs are possible in microstrip, the one chosen here being the Gunn device terminating a half-wavelength section of line which, as explained for the filter, will be resonant at the oscillator frequency. In this case adjustments to the line-length must take into account the equivalent circuit of the Gunn device and in particular the parasitic reactions of the package. The simple equivalent circuit will be as in Fig. 3(b) of Part 1.

In this example the resonant line is split into two nominal $\lambda_g/4$ sections and a varactor diode inserted between them. The capacitance of this diode is a function of bias voltage and so the apparent electrical length of the gap between the two sections can be varied. Under reverse bias, the diode capacitance decreases as the reverse voltage increases, thereby shorten-

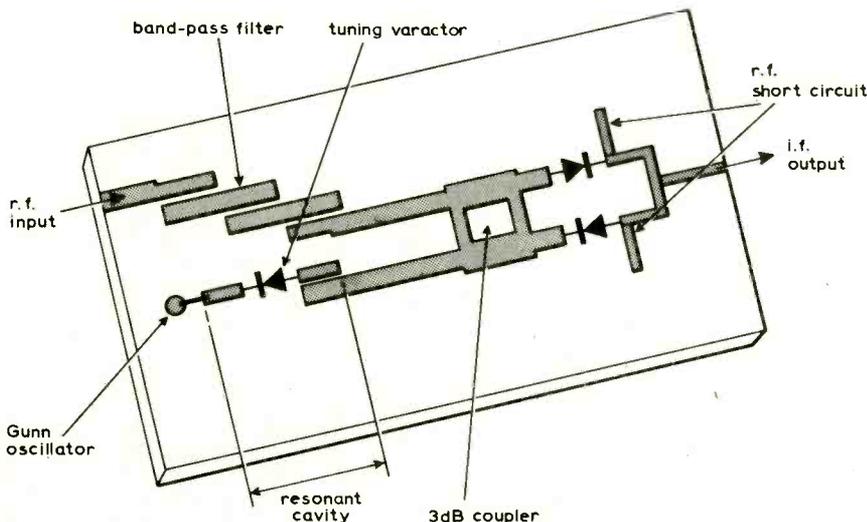


Fig. 6. Microstrip receiver with integrated local oscillator, approximately four times full size. Even when packaged, size and weight are many times smaller than waveguide circuitry.

ing the electrical length of the line and increasing the resonant frequency. The diode could be mounted in similar fashion to the oscillator diode but as no heat sinking is required it is preferable to do away with the complicating package and use a chip diode. Series mounting also gives a slightly greater tuning range than shunt. The output from an a.f.c. loop would be connected to the varactor which, with careful design, could provide $\pm 3\%$ frequency tuning.

Output from this complete oscillator section is conveniently taken by means of a parallel-coupled length of line and might tap-off about 10mW of power. There are inherent power losses in the system, some power being radiated from the Gunn end of the cavity, some lost in the bias circuitry, some dissipated in the varactor and more lost in the coupling section and 3dB Coupler.

On arrival at the two mixer diodes, the signals combine to produce the i.f., image frequency and an infinite series of intermodulation products. Most of the output power is split between the i.f. and image and the efficiency of the mixer system is considerably influenced by the way in which the image power is dealt with. If nothing were done to prevent it, the image would be reflected back from the diodes and would be lost through the oscillator and signal input lines. By reflecting this power back again into the mixer with the correct phase, the conversion efficiency can be improved. This job is done in part by the signal input filter, which looks like a short circuit to the out-of-band image. By adjusting the distance between the filter and the coupler, this short circuit can be transformed to the diodes themselves by the periodic property of the line described previously.

The type of diode most commonly used now at these frequencies is the Schottky barrier or hot carrier diode. This is a metal/semiconductor junction device which is essentially free of charge-storage

restrictions, resulting in more efficient rectification and lower noise. For microstrip applications, the diode is conveniently packaged in the beam-lead style of mount shown in Fig. 7 and thermo-compression-bonded into place. In common with other types of mixer, there is an optimum oscillator power level for lowest conversion loss, in this case about 1 to 3mW per diode. The i.f. impedance is also a function of oscillator power, decreasing as the power increases and at the optimum level is around 180ohm. On combining the mixer outputs, though, the diodes appear in parallel to the i.f. and so the impedance presented to the amplifier is 90ohm, which is compatible with typical low-noise input stages.

One main advantage of the balanced mixer is the suppression it provides of the a.m. components of oscillator noise. These appear in phase at each diode while the two i.f.s are out of phase; therefore the diodes are inserted with opposite polarities so that on summing the outputs the noise cancels. Finally, the $\lambda_g/4$ open-circuited stubs mentioned previously are placed after the mixers to appear as short-circuits to the input r.f. signal at these points.

In practice, the complete circuit would be packaged in a metal box, the final problem being to ensure that the sides and top of this enclosure do not interfere with the microstrip fringing fields.

Having established the design and determined the components, an estimate can be made of the sensitivity of the receiver. The minimum signal that can be detected is limited by the electronic thermal noise background, given by $S = kTB$, where k is Boltzmann's constant = 1.38×10^{-23} joule/K, T the receiver temperature (Kelvin) and B_n the noise bandwidth (not the 3dB bandwidth B). Taking $T = 290K$ and $B_n = 1.16B$ (this assumes a three-stage amplifier), $S = 2.32 \times 10^{-13}W$ for the ideal case.

Practically, this figure is degraded by losses in the system which we can estimate as: 2dB circuit losses in filter and coupler, 4dB mixer noise figure and 2dB mismatch and i.f. amplifier loss; giving a total of 8dB. This means that the sensitivity is decreased by 6.3 times the above thermal noise power to a value of about 1.5×10^{-12} .

A receiver such as this employs a large number of individual microwave components, both active and passive and provides a good example of microwave circuit design. Although quite commonly constructed in waveguide, the modern type of circuitry is hybrid microstrip as illustrated here and is particularly suited to compact light-weight installations in aircraft and missiles.

Announcements

"Components and Small Devices" is one of a series of three-day courses dealing with production in the electronics industry. The course is to be held at Twickenham College of Technology, Egerton Road, Twickenham, Middlesex TW2 7SJ from the 5th to 7th June.

MSL Calibration Centre of Hunting Gate, Hitchin, Hertfordshire announce a new **calibration service**. This covers a range of instrumentation including oscilloscopes, pulse generators, frequency counters, digital voltmeters and a comprehensive range of multimeters and associated prime standards.

Henri Picard & Frere Ltd have moved to 357/359 Kennington Lane, London SE11 5HY. The company supplies precision hand and special-purpose tools for electronics production and servicing, micro-assembly, and laboratory use.

The Ministry of Defence has approved the **Muirhead-Vactic Test House** at Garth Road, Morden, Surrey for Part III Approval. The main facilities cover conditions simulating altitudes up to 100,000ft, temperature variations between $-80^\circ C$ to $350^\circ C$ and humidity to 95%. Other conditions available are salt spray, water percolation, dust, vibration and bump tests.

The Broadband Marketing Department of Pye Telecommunications has extended its broadband u.h.f. and microwave activities by the recent award of a number of contracts, from the Post Office, for **multi-channel telephony and colour television** systems. These are to expand a communication system between Plymouth and the Goonhilly Satellite Earth Station.

The **Midlands Electricity Board**, Northern Area, has placed an order worth £125,000 with Pye Telecommunications Ltd, Newmarket Road, Cambridge, for a radio communications network which will cover North Shropshire and North Staffordshire. The order includes five of the Pye Telecommunications L300 point to point radio links in the 1.5GHz band.

Emihus Microcomponents Ltd, Clive House, 12/18 Queens Road, Weybridge, Surrey, have acquired the connector business of the Belgian company Sabca who have been manufacturing connectors under licence from Hughes Aircraft Co.

Light Soldering Developments Ltd, 28 Sydenham Road, Croydon CR9 2LL, manufacturers of the Litesold range of soldering irons have appointed Lugton & Co. Ltd, of London, as their distributor for London and the South East.

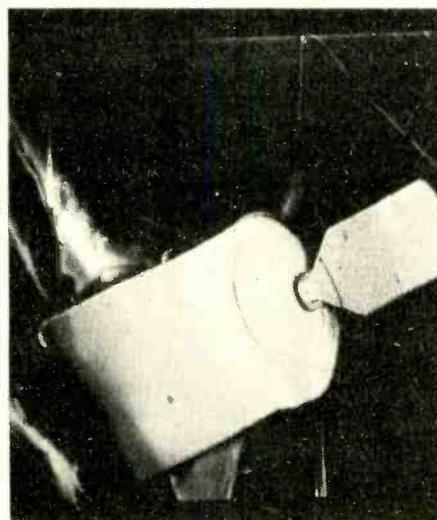
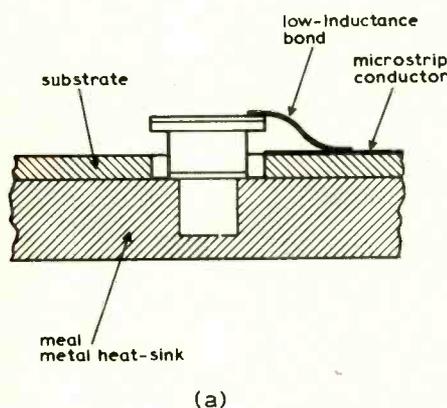


Fig. 7(a). Shunt-mounted Gunn diode in microstrip. Series mounting cannot be used at even moderate power levels because of the heat-dissipation problem. Photograph shows beam-lead Schottky barrier mixer diode 77 times full size. Smaller tap is about 0.005in wide by 0.002in thick.

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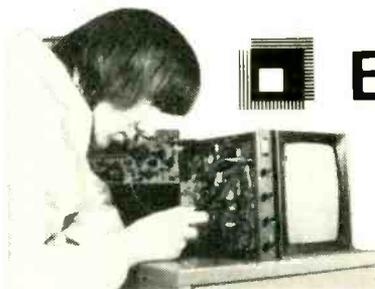
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Circards — 7

Power amplifiers

Efficiencies ● matching ● “rms” power

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

All amplifiers are power amplifiers in that the power delivered to the load is greater than that drawn from the source. Few are power amplifiers in the same sense that an operational amplifier with feedback may be said to be a voltage amplifier or a current amplifier. Thus in Fig. 1 the load voltage is defined for a given input signal and the load power is proportional to the conductance of R_L . For Fig. 2 feedback defines the load current while the corresponding power developed in the load is proportional to the resistance of R_L .

This suggests that as many power amplifiers use shunt-derived feedback to define their output characteristics, they could properly be regarded as voltage amplifiers which just happen to be capable of delivering large powers to a load of sufficiently low resistance. Operating these amplifiers from a constant supply voltage in the usual way fixes an upper limit on the load voltage. Practical imperfections in the transistors together with current limiting resistors or other protective circuitry reduce this upper limit but still leave the peak output voltage broadly proportional to the supply.

Output power depends equally on the maximum current that can be supplied to the load. The mean value of this power over a complete cycle for a sinusoidal output voltage and resistance load is $\hat{V}\hat{I}/2$, where \hat{V} and \hat{I} are the peak instantaneous values of voltage and current, and as $\hat{V} = \hat{I}R_L$ and $V_{rms} = \hat{V}/\sqrt{2}$, alternative expressions are $V_{rms} \cdot I_{rms} = \hat{V}^2/2R_L = I^2R_L/2 = V_{rms}^2/R_L = I_{rms}^2R_L$.

At this point, you might be asking: “what about r.m.s. power?”. This, unfortunately, is on a level with the equivalent enquiry after the well-being of the workers. It can be answered in various ways none of which are useful. To interpret it properly it must be realized that, while the power developed in the load varies from instant to instant, it is the mean or average value of that power that determines, for example, the loudness of the sound produced by a given loudspeaker. The r.m.s. value of the power can be defined mathematically in the same manner as the r.m.s. value of the voltage, but it has no comparable physical significance, i.e. it would require the instantaneous power to be squared, integrated to obtain the mean value of the “power squared”, and then the

square root taken of the result. The confusion arose because mean power happens to equal the product of r.m.s. voltage and r.m.s. current for certain specified conditions which commonly occur. Hence the “r.m.s.” term has become firmly attached to the power measurement itself particularly in the advertising for audio equipment. It should be detached.

While the voltage term in the output power is fixed by the supply voltage, the current term is a property of the amplifier. Consider first the amplifiers based on a single transistor as shown in Fig. 3. In each case the transistor is assumed to be dealing with an a.c. signal which has equal positive and negative magnitudes, e.g. a sine wave. Thus the transistor must be biased to some quiescent voltage/current setting which will allow positive and negative-going output swings. If distortion is to be avoided the transistor must remain conducting throughout the cycle, i.e. neither the current nor the p.d. across the transistor shall fall to zero. This mode of operation, class A, may be

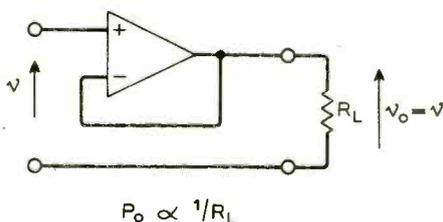
defined in terms of the “angle of conduction”, being the full 360° of the cycle. In class B each device conducts for precisely 180° or half the cycle and in class C conduction is for $<180^\circ$.

In Fig. 3 (a) if the direct current is permitted to flow in the load, equal positive and negative excursions occur for a voltage across the transistor equal to half the supply voltage (assuming an ideal transistor). Thus the peak of the a.c. component of load voltage is $\hat{V} = V/2$. Hence the a.c. power in the load is $(V/2)^2/2R_L = V^2/8R_L$. In the absence of signal the current drawn from the supply is $V/2R_L$ giving a supply power $V^2/2R_L$. This shows an efficiency of 0.25. The quiescent power splits 50/50 between transistor and load resistance.

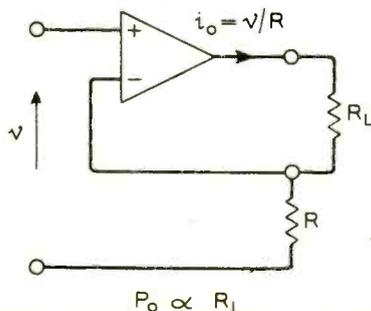
It is possible to do still worse. In Fig. 3 (b) the load is capacitively coupled to the amplifier to eliminate the direct current in the load. A collector resistor is still required to allow the flow of current in the transistor, establishing the quiescent conditions for class A operation. Now the total a.c. power is split between R and R_L and the maximum efficiency is reduced to 0.125.

The situation can be retrieved if the collector resistor can be replaced by some constant-current stage as in Fig. 3 (c). The positive peak current in the load can then equal the quiescent current even when the collector approaches the supply voltage (assuming a constant-current stage that can function with a p.d. falling towards zero). Hence the load can have a maximum current swing simultaneously with a maximum voltage swing. In Fig. 3 (b) when the transistor current falls to zero, R and R_L are effectively in series and the p.d. across R limits that across R_L .

The constant-current stage may consist of an inductor whose reactance is high compared to the resistance of the load at all frequencies of interest; an ideal transformer that also allows the use of arbitrary load resistance by proper choice of turns ratio; a transistor biased to deliver a constant current. The disadvantage of (d) and (e) is that the amplitude-frequency response is limited unless bulky and expensive inductor/transformers are available. They do offer the possibility of higher efficiency than any of the other circuits. For example, Fig. 3 (f) allows the peak current in the load to equal the quiescent current, and the peak voltage to equal the transistor quiescent voltage,



Figs. 1 and 2. In a voltage amplifier and a current amplifier, load voltage or current is defined for a given input signal and load power is proportional to the conductance of R_L (Fig. 1 above) or the resistance of R_L (Fig. 2 below), suggesting that power amplifiers using shunt-derived feedback could be looked on as voltage amplifiers, but capable of handling large powers.



*All at Paisley College of Technology

i.e. half the supply voltage for the best operating conditions. Thus load power is $(I_{dc} V/2)/2$ while supply power is $V I_{dc}$, giving an efficiency of 0.25 bringing the efficiency back to the level of Fig. 3 (a) but with the d.c. component removed from the load. In Fig. 3 (d), the peak current in the load is still equal to the quiescent current, but the inductance allows the collector voltage to swing positive with respect to the supply line as the transistor current falls—a load peak voltage equal to the supply voltage being available. The a.c. power in the load then becomes $V I_{dc}/2$ for the same supply power $V I_{dc}$, and maximum efficiency is 0.5. This is the highest efficiency possible in class A and the transformer-coupled circuit of Fig. 3 (e) has the same capabilities. It is common for practical circuits using small transformers to have efficiencies in the region of 0.25 to 0.4.

The low efficiencies attained by these single-device circuits lead to the investigation of multiple transistor circuits. Simply operating transistors in parallel may increase the quiescent power they can dissipate and hence the available output power, but the method offers only second-order improvements in efficiency by reduction of saturation voltage etc. Before turning to other classes of amplifier, consider the natural extensions that are possible of the circuit of Fig. 3 (f). Replace the transistor used as a current source by one receiving a signal as in Figs 4 (a) to (d). The signals to the two transistors depend on the configuration used, but the aim in each case is to cause one transistor to decrease its current by the same amount as the other increases it, still assuring class A operation for each transistor individually. In this way the peak current in the load may equal twice the

circuit quiescent current: at the point when the current in one transistor reaches zero the other has doubled. The peak load voltage remains at half the supply voltage when the output is biased to the supply mid-point for maximum undistorted output.

So far the term "matching" has been avoided. For low-level amplifiers, input impedance is frequently matched to that of the source; this is the condition for minimum noise. To maximize the power gains of following stages the output and input impedances may be matched, i.e. made equal. This remains the practice in r.f. amplifiers, but at lower frequencies deliberate mismatch is more common as it allows for better control over the gain.

A fallacy that is based on the experience with these low-level stages, and derives from the maximum power-transfer theorem is often extended to power amplifiers. For each of the class A stages described earlier there is a value of load resistance that maximizes the output power without clipping the waveform peaks. As shown for each individual case there are separate limits for both peak voltage and peak current, and the optimum load will have a resistance given by the ratio of these peaks. This load resistance has nothing to do with the output resistance of the transistor.

Consider Fig. 5 which represents the operation of Fig. 3 (d). Draw the load line representing the load resistance through the quiescent point; the maximum output power without distortion is achieved for the slope giving symmetrical voltage and current swings in the positive and negative directions. Such a line intersects the V_c, I_c axes at $2V_c$ and $2I_c$ respectively and the slope of the line is the same as that joining the V_c, I_c points on the axes. This optimum load is thus confirmed as depending on the quiescent conditions with the slope of the transistor characteristics (the true output resistance) playing no part. Life is rarely that simple in practice, and the results are modified by saturation effects as well as by the various non-linearities, but not sufficiently to disturb the principle, which applies equally to the circuits of Fig. 4.

Hence for Fig. 4 (c) when used as a class A amplifier the quiescent current (I_s) may be calculated from the supply voltage (V_s) and the intended load resistance. Peak voltage in load is $V_s/2$; peak current in load is $2I_s$; therefore optimum load resistance is $V_s/4I_s$. Resulting mean load power is $(V_s/2)2I_s/2 = V_s I_s/2$, corresponding to an efficiency of 0.5 for ideal transistors.

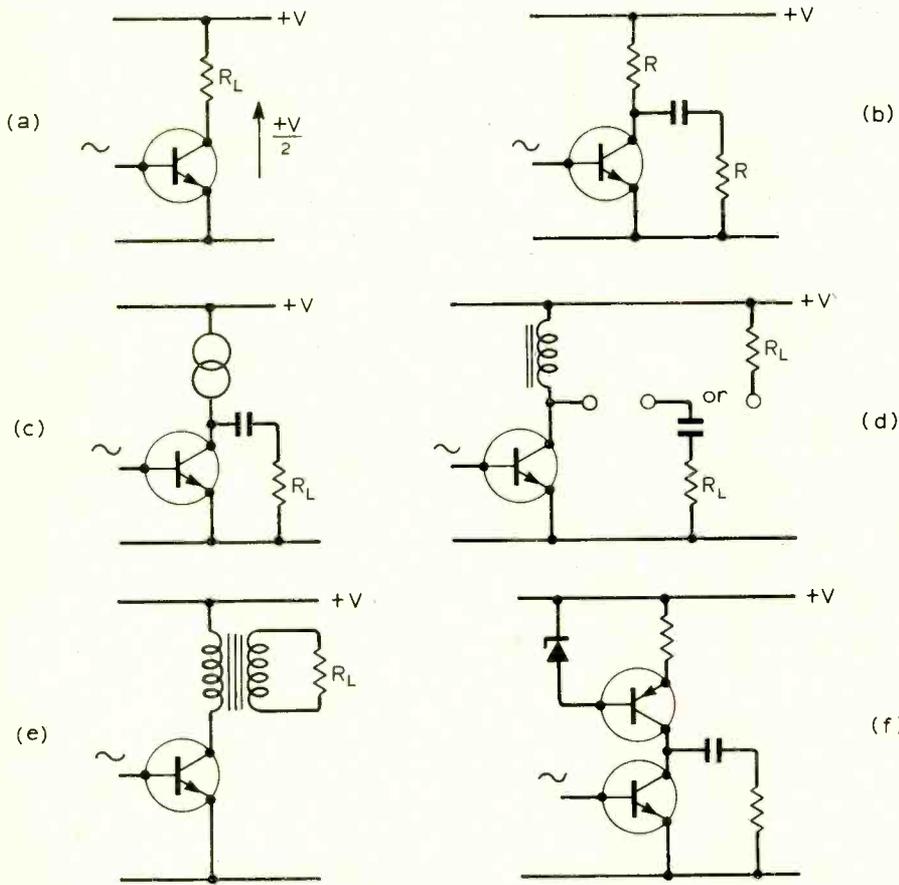


Fig. 3. In a resistive-load class A amplifier (a) efficiency is only 25%; with a capacitively-coupled load efficiency could be 12½% for equal values of resistor shown (b). Replacing collector resistor by a constant-current circuit (c) means the peak load current can equal the quiescent current. Examples of constant-current circuits are a simple inductor (d) or transformer (e) both giving maximum possible efficiencies of 50%, or at (f) using an additional transistor, efficiency 25%.

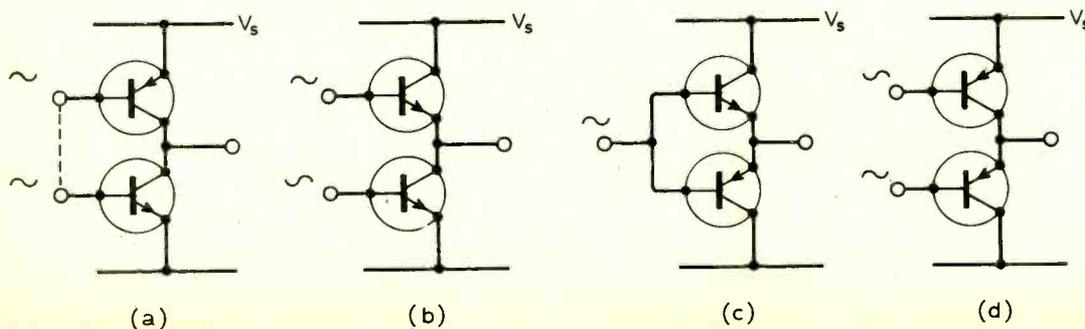


Fig. 4. Using a second for signal handling enables the peak load current to equal twice the quiescent current, with efficiencies of up to 50%.

These circuits are not restricted to class A operation. Indeed they are more commonly used as push-pull class-B amplifiers in which the bias network (not shown) is adjusted to bring both transistors to the edge of conduction. Each transistor then conducts during one half-cycle, there being no quiescent current. There is no comparable limit to the peak current that may be provided; class B simply demands that conduction takes place in a device for 180° in the cycle. A limit will be imposed in any particular design by the current/power limitations of the transistors/power supply. In principle any basic design for a class B power amplifier using configurations such as those of Fig. 3 (c) and (d) may be extended to higher current levels by replacing the output transistors with Darlington pairs, complementary pairs etc. Thus 100W and 100mW amplifiers may be surprisingly similar in configuration. At high power levels the importance of protection and of maintaining stable bias leads to the addition of circuits monitoring and/or controlling the current in the output stage.

To minimize the distortion due to device non-linearity at low currents (cross-over distortion) the bias networks are set to provide some quiescent current, setting the operation intermediate between true class B and class A—often called class AB and further subdivided into AB₁, AB₂ according to the fraction of the cycle for which each device is non-conducting. The design of low-distortion power amplifiers is a highly specialized subject that will warrant separate treatment in a later series though outline design procedures and practical examples of simple and economical circuits are given in this series of Circards.

Quiescent power in class B is zero. Maximum output power with ideal transistors (Fig. 6) is $\hat{V}^2/2R_L$ where \hat{V} is $V_s/2$. Therefore $P_{L,max}$ is $V_s^2/8R_L$.

Under these conditions, the mean current drawn from the supply is $V_s/2\pi R_L$. This is because the current is drawn from the supply only during the positive half-cycle; the negative half-cycle results in charge being withdrawn from the large coupling capacitor, which charge is restored during the next positive half-cycle. The mean power drawn from the supply is $V_s I_{dc} = V_s^2/2\pi R_L$ and the corresponding efficiency is

$$\frac{P_L}{P_s} = \frac{V_s^2}{8R_L} \cdot \frac{2\pi R_L}{V_s^2} = \frac{\pi}{4}$$

or 78.5%.

As the load power is proportional to the square of the output voltage while the supply power is proportional to the voltage it follows that efficiency is proportional to output voltage. It is also true that at some intermediate level of output, the load power having fallen faster than the supply power, the power in the transistors passes through a maximum. For sine wave drive the maximum dissipation in each transistor is at an output voltage where \hat{V} is V_s/π , and the dissipation is then about one fifth of the maximum output power derived above, i.e. a 10W amplifier could theoretically be constructed using a pair of transistors with power ratings of only 2W each.

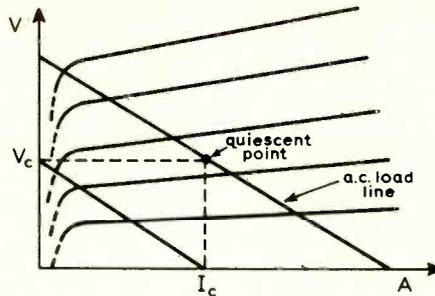


Fig. 5. Optimum load for maximum signal handling is represented by load line cutting axes at $2V_c, 2I_c$, for Fig. 3 (d) or (e) and depends on the quiescent condition and not transistor output resistance. In general optimum load can be calculated from peak voltage/peak current.

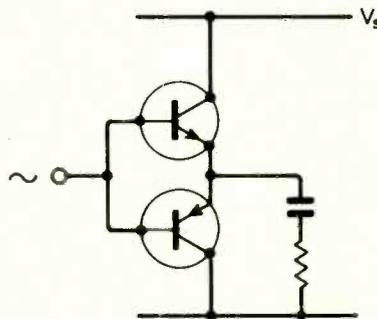


Fig. 6. In this typical class B stage, text shows maximum efficiency to be 78.5%.

Class C amplifiers are normally restricted to tuned amplifier systems, conduction taking place for only a small part of a cycle, and the recovery of a sinusoidal waveform then demands a high-Q circuit. The exception is the power-control circuits such as controlled rectifier and triac circuits in which only the mean value of voltage/current/power is of interest and waveform shape is non-critical. These differ from conventional class C circuits in that the conduction has a controlled starting angle but always finishes near the end of a half-cycle; class C r.f. amplifiers are biased such that the conduction angle is symmetrical about the peak of the drive waveform.

A further difference is that the power control devices are operated as nearly as possible as perfect switches, while at the high frequencies normally associated with class C stages, a very detailed design procedure is required to cope with transistor parameters. This will normally include complex conjugate matching to source and load, to optimise performance. Efficiency can exceed that for class B, though power losses in the passive components involved in the tuning/matching processes are inevitable. A further application of class C power amplifiers is in frequency multiplication where the output circuit is tuned to a harmonic of the input frequency. These aspects are germane to more detailed later studies of r.f. circuits.

Class D is the generic term for switching circuits in which the active devices are switched multiply in and out of conduction during a single cycle of the input signal. They

are also power realizations of pulse modulation systems, the theory for which can be used to determine the spectral components of the output. As one example, circuits such as those of Fig. 4 may have their signal drive replaced by high-speed pulse waveforms whose widths are modulated by the received signal. If the load is fed via an LC filter, the pulse frequency terms can be removed and the output transferred to the load is proportional to the signal.

For ideal transistors the switching process allows for zero power dissipation; at all times either the transistor p.d. or its current tend to zero. If the unwanted terms are to be well outside the band of frequencies that it is required to amplify, then the pulse frequency may have to be so high that serious power losses occur during the instants of switching, while charge storage in either of the transistor base-emitter junctions can lead to excessive current spikes through the series path then provided by the two transistors. The principle is more readily applicable to small servo-motor systems than to audio amplifiers as the electro-mechanical properties of the load do not require very high switching frequencies. In some cases efficiencies may exceed 90% with 100% as the theoretical upper limit.

In all the above circuits an ever-present problem is that of protecting both the circuit and its load from excessive current flow. Much time and energy is expended on systems for protection against faults, but inevitably accidents happen, so often after some improvement or embellishment has been added. One can only wonder if such thoughts may have been in the mind of William Wordsworth when he wrote

I have submitted to a new control;

A power is gone which nothing can restore;

A deep distress hath humanized my soul.

A cry from the heart that will speak to all designers of power amplifiers.

How to get Circards

Order a subscription by sending £9 (U.K. price; £10.50 elsewhere) for a series of ten sets to Circards, J. Rider, IPC Business Press Ltd (Sundry Sales), 33 Bowling Green Lane, London EC1R 0NE. Specify which set your order should start with, if not the current one. Per set (12 cards), price is £1 U.K. and £1.15 elsewhere.

Topics covered in Circards are active filters 1, switching circuits (comparators and Schmitts) 2, waveform generators 3, a.c. measurement 4, audio circuits (low level) 5, constant-current circuits 6, and power amplifiers 7 (current issue). Subsequent Circard issues should include: use of optoelectronic devices, astable circuits, logic gate circuits, wideband amplifiers, alarm circuits, digital counters, pulse modulators, micropower circuits.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Transmitting aerial design

I would like to suggest the possibility of another method of reducing interference in addition, or alternative, to frequency allocation or use of suppressed carrier systems on the medium waves. This is associated with aerial design.

Many wavelengths from an aerial, all that is left of the composite field is a transverse one, in which the electric and magnetic vectors are perpendicular to the line of propagation, and the inverse square law applies to this radiation. However, closer to the aerial we find radial components of radiation which die away more rapidly than as r^2 . Would it not be possible to design an aerial with strong radial components and small transverse component, so that the fields which die away inversely as r^4 and above are used for local communication; while the field which dies away inversely with r^2 is of sufficiently small amplitude not to cause interference over long distances at night?

Guy S. M. Moore,
University of London King's College,
London W.C.2.

Current flow symbology

Over the years your journal, through its articles and correspondence columns, has played an important part in tidying-up thinking, terminology and conventions in our industry. I wonder if a really basic convention could be discussed and possibly one of the alternatives chosen as *Wireless World* policy?

I refer to the direction of current flow. Some people, I am one of them, regard electron flow as current and indicate on circuit diagrams the direction of electron flow by arrows. Other people prefer to refer to "conventional current" and indicate its direction by arrows pointing +ve to -ve.

A brief survey of educational books showed other variations. One showed steady current flowing +ve to -ve but signal currents flowing -ve to +ve. In another, the "two" currents are called electric current and electron current. In another, electron current is called "negative current". So long as it is made clear in the text of articles which convention is used I suppose it does not matter very

much to experienced engineers, but it does seem rather a waste of effort and it must cause confusion, particularly to students.

Pneumatic and hydraulic engineers manage without a theory which needs the belief in a "conventional" air or water current flowing in the opposite direction to the flow of air or water particles.

Is there any serious objection to dropping "conventional" current and dealing only with electron flow, calling the flow "current" or "electron current" and indicating its direction on circuit diagrams by arrows pointing -ve to +ve?

C. H. Banthorpe,
Northwood,
Middlesex.

Measuring displacement

I was interested to read the article on "Displacement and position" in Richard Graham's series on Industrial Electronics, and in particular his comments on the susceptibility of the incremental moiré fringe counting system to miscounted pulses and mains transients (April issue).

Modern chrome-on-glass or stainless steel gratings, housed in a sealed channel to prevent contamination, will provide signals of good amplitude and waveform which virtually preclude errors due to miscounting, provided that the maximum permissible speed of counting is not exceeded. Unfortunately, the effects of vibration, a fairly common hazard with machine tools in particular, can give rise to instantaneous very high counting rates and hence to counting errors.

The problem of mains transients is more serious than is commonly imagined; operation of arc welding equipment, overhead cranes, and even nearby machine tools, can cause momentary "spikes" in the mains supply and hence counting errors. Furthermore, complete failure of the mains supply, although only for a second's duration, can result in the scrapping of complex and expensive components.

One method of eliminating this problem is to power the reading heads, interpolation circuitry and counters from a "floating" battery supply: a Ni-Cd or other storage battery, with voltage stabilizer, continuously trickle-charged from the

mains. This solution not only caters for gross breaks in the mains supply, but also smooths out even the most extreme mains transients.

An additional point, regarding radial gratings, is that any eccentricity in the rotation of the grating will frequency-modulate the output pulse train, giving rise to angular reading errors. The conventional way of avoiding this "eccentricity error" is to employ two diametrically opposed reading heads (or occasionally four heads at 90° spacing) and to combine the in-phase and quadrature signals from these heads in operational amplifiers. However, this technique is of use only when the grating eccentricity is less than one-eighth of a line spacing. For very fine gratings (64,800 or 72,000 radial lines) this means that the bearing must have an eccentricity of only a few micro-inches, and that the grating must be mounted to a similar accuracy — both requirements possible only on equipment of the very highest accuracy.

A recent development by the Cranfield Unit for Precision Engineering is a form of digital eccentricity-reducing circuit, acting in combination with a phase-division circuit giving typically 20 equispaced pulses for each prime fringe. The Cranfield circuit accepts signals from two diametrically opposed reading heads, and reduces the effects of any eccentricity present by the same factor as the phase-division circuit, e.g. 20 times. The circuit will accept signals from gratings with any amount of eccentricity, and in particular a small modification enables a continuous display of the eccentricity present to be made *even while the grating is stationary*. This feature has reduced the time required to centralize gratings and bearings to a few minutes.

Finally, position servo systems have been developed at Cranfield using moiré fringe measurement, with positioning resolutions of 0.5µm (linear) and 0.9 arc-seconds (rotary).

J. Dinsdale,
Cranfield Unit for Precision Engineering,
Bedford.

"Biamplifier" loudspeakers

I notice in Mr Peter Hiscocks' letter on "Loudspeaker parameters" (March) he mentions the Biamplifier approach.

Some fifteen years ago at Philco we marketed such a system. The amplifiers were quite modest with the ratio of their respective power capabilities arranged to coincide with their section of the audio spectrum. Additionally, the loudspeakers were designed into the filter characteristics. The overall aural effect certainly demonstrated a low level of intermodulation and even a direct comparison with the standard high fidelity equipment of the day failed to prove any marked inferiority, even though the price differential was very considerable.

The disastrous sounds associated with overdrive of the high feedback amplifier was of course absent and the impression was of almost unlimited power from the

system. The low-pass filter action of the bass/mid-range loudspeaker contributes to the low aural distress. Also, unlike the passive cross-over, no distortion products of mid-frequency overload are diverted into the treble loudspeaker; this remains clean until treble components of the programme material themselves overload the treble amplifier.

H. D. Garland,
Romford,
Essex.

Distortion reducer

The article "Distortion Reducer" by D. Bollen (*W.W.* Feb. 1973, pp. 54-57) describes a useful method of reducing distortion in power amplifiers. Since the article gives no references to earlier work in this field, it is worth pointing out that exactly the approach used by Bollen for distortion reduction has been described in detail much earlier (J. R. Macdonald, *Proc. I.R. E.* 43, 808, 1955). This scheme, termed active-error feedback, preferentially makes use of a feedback, amplified error signal. Bollen shows in his Fig. 1 a realization with unity gain in the feedback path (amplifier *C* has unity gain), but his actual experimental circuit (Fig. 4) and text involve an error signal path with greater than unity gain, as described in 1955 and perhaps even earlier. The current availability of inexpensive i.c. operational amplifiers now makes the active error approach extremely easy to implement, but the usual precautions appropriate for negative feedback amplifiers must be observed.

J. Ross Macdonald,
Dallas,
Texas, U.S.A.

Old headphones needed

I hope you will be kind enough to allow space for this begging-letter. I need a few old headphones for children's Science lessons. The 'phones need not even be good enough to emit readable speech, so long as they "crackle" when a faint voltage is passed through their leads and diaphragms.

If headbands are present, they will be a marvellous bonus, but we do want some earpieces and leads that respond to a voltage of about 0.5V.

My problem is that we have no money to pay for these. Your readers already know that teachers in primary schools these days ungrudgingly spend quite a bit of their own pay in supplementing their fellow ratepayers' contribution. In the present case I am saving for a secondhand 4-channel mixer so that some less-articulate children may be encouraged to help make a "radio play" on my (1958 model) tape-recorder; we are therefore stumped for cash for headphones for Science.

John R. Gibson,
Sudbury Junior Mixed Primary School,
Watford Road,
Sudbury,
Middlesex.

Mechanical television

I am trying to revive interest in mechanical television for recording and line-transmission, using the most modern electronic devices that have appeared since the demise of the mechanical system, circa 1934.

I feel sure that many *W.W.* readers with a knowledge of mechanics and optics would be interested in taking part in such work as an unusual inter-disciplinary project, particularly those of a younger generation to whom the ideas are virtually unknown. I have already felt considerable warmth of enthusiasm from the older workers in this field to whom this subject has a naturally nostalgic appeal.

Having received most courteous help from the I.T.A. and the B.B.C., not to mention the local radio station, I am moved to make a wider appeal, and the use of your pages would be a great help.

D. B. Pitt,
Wollaton,
Nottingham.

Magnetic pickup loading

The origin of the myth that the 47k Ω load resistor specified for most magnetic cartridges results in a h.f. cutoff is one that has always mystified me, and to see it perpetuated in the latter part of Mr Fison's letter (*Wireless World* March issue) puzzles me even more. It is perfectly true that if we consider a typical magnetic cartridge to be almost a pure inductive source, then a termination with the usual 47k Ω load would create a simple 1st-order low pass filter, with the -3dB point obtaining when $R_L = X_L$ and thereafter increasing to the anticipated 6dB/octave slope (Fig. 1).

But, of course, in a real circuit, this would be an incorrect assumption. The inductive component in, for example, the pickup referred to is heavily damped and a quick measurement in my lab suggests that Fig. 2 would be much nearer to the equivalent circuit. I am sure that it will be agreed that now the h.f. fall-off will be very small within the audio passband and, indeed, hardly worth working out. Let's now take the example a stage farther. It is a fact that there will certainly be a shunt *C* component in our equivalent circuit (Fig. 3) and, if one assumes that the amount of coupling lead is not less than 1 metre of low capacitance screened cable, then the value of the shunt *C* will not be less than 100pF and may be as much as 250pF (although this is far from desirable).

Without R_L the equivalent circuit now looks like an unterminated basic $\frac{1}{2}$ -section low pass filter and, as one might expect, there will now be a rise at the h.f. end, reaching a well damped peak somewhere between 10kHz and 20kHz and dependent, naturally, upon the source inductance and the shunt capacitance. This is where the optimum load comes in, and, as we know already, the cartridge parameters

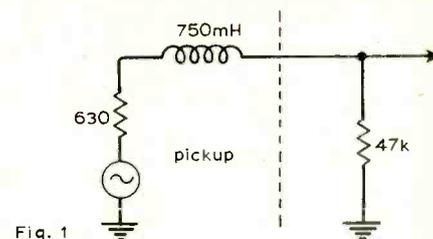


Fig. 1

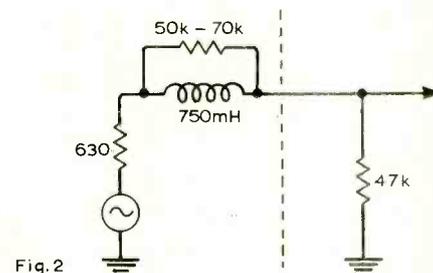


Fig. 2

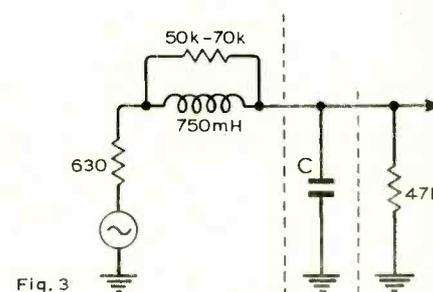


Fig. 3

are normally tailored by the cartridge designer for an optimum load of 47k Ω . Please note, I have not taken into account at all the inevitable mechanical resonances in the pickup such as that which arises from the stylus mass and the compliance of the record material. These will almost certainly contribute to an additional rise in amplitude at the h.f. end of the passband.

Incidentally, if I might be permitted a little aside? It might be rather interesting to discover how many of my colleagues, entrusted with the task of evaluating commercial amplifiers for the popular hi-fi press, take the precaution of inserting a simulated cartridge into the signal path when checking the characteristics of the "magnetic pickup" input stage? The results can often be quite revealing, since one must not overlook the fact that this reactive signal source is usually in the n.f.b. path of the input stage as well.

Reg Williamson,
Norwich.

Loudspeaker loading

As a student of electroacoustics I have taken interest in your articles and letters on loudspeakers. It is my opinion that instead of trying to eliminate all resonances to produce systems working on one single loading principle, one should make deliberate use of as many as possible (suitably damped of course) to extend and improve bass response. After having tried out most of the available methods in my own systems, I have finally arrived at a very satisfactory design based on t.l.s., reflex and tuned pipe principles at the

same time, the effects occurring at different frequencies below about 100Hz. This has enabled me to get a good, clean and strong response to about 30Hz from a modest elliptical unit costing about £4 in this country mounted in a 2 cu.ft cabinet.

I would also like to add to Telfer's and Greenbank's letters on horns that I feel the ability to produce reasonably plane waves at low frequencies (also mentioned by "Toneburst" if my memory serves me right) is essential in the correct reproduction of spatial information, especially when illusions of distance are necessary. This accounts for the obvious superiority of a good horn in reproducing large orchestral works etc. Listening to chamber music or music where direct sound plays a minor role, e.g. an organ, or sitting at a distance from the speaker in a large room, all tend to reduce this difference. The only real disadvantage of the hornloaded speaker seems to be bulk, which should not be much greater than conventional systems of comparable quality in both extended response and handling capability, though the latter is hard to achieve in direct radiators.

Peik Borud,
Trondheim,
Norway.

Electronics in psycho-kinesis

An apparatus used in a psycho-kinesis experiment performed in the U.S.A. is shown in the accompanying diagram (a). It consists of a solenoid, a conventional magnetic compass, a battery and a current-limiting resistor *R*. The combination of the solenoid and the compass provides a sensitive galvanometer. The experiment was performed by Professor E. M. Monahan, a parapsychology teacher at Georgia State University, Atlanta, Georgia. Professor Monahan is a well-known "psychic" or "sensitive", with many remarkable accomplishments to her credit, discussed in current magazine articles (*Newsweek* August 28th 1972, *Atlanta Magazine* August 1972).

In the author's design of the psycho-kinesis (p.k.) apparatus, the following four aims were pertinent. To prove that the "sensitive", in this case Professor Monahan, could (1) deviate a magnetic needle by p.k. energy, (2) similarly rotate a magnetic needle, thus for a short time providing a "mind-driven motor", (3) symbolically, at least, employ p.k. energy to inject "stimulance" (negative resistance or negative conductance) in an electric circuit, and (4) establish "energy conversion" — the fact that in this experiment mind energy can be converted to mechanical energy, electrical energy, and heat.

The circuit diagram of the complete apparatus is shown in (b), where *r* is the resistance of the solenoid. With the switch in position "a", the circuit is open. When the switch is in position "b", the situation shown in (a) is established, the current *i_α* being just sufficient to cause a small deflection *α°*. When the switch is in position

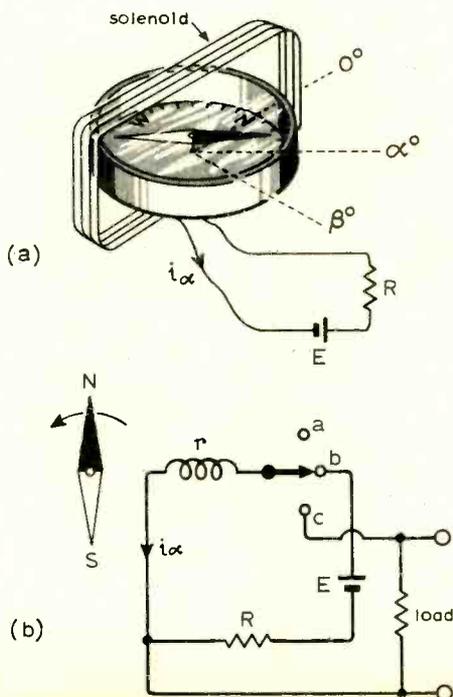
"c", the solenoid is connected to a load resistor, provided with output terminals for the connection of a sensitive d.c. voltmeter. Experiments (1) and (2) have been performed before, and today it is a fact that "sensitives" can employ p.k. energy to deviate and rotate a magnetic needle. During October 1972, Professor Monahan successfully performed experiments (1), (2) and (3). The research model used by her did not have the particular switch arrangement with a load resistor, and experiment (4) was therefore never performed, but there is no need to perform it since Maxwell's equations assure us that rotation of the magnetic needle results in an alternating current in the load resistor.

In experiment (3) the needle moves because the p.k. force combines vectorially with the earth's magnetic field force in agreement with Newton's laws. While the "sensitive" did not change anything in the electrical circuit, the fact remains that a deflection *β* obtains, with a current *i_β* in excess of the current *i_α*, determined by Ohm's law. Mathematically, therefore, we may satisfy the equations by introducing a negative resistance *R_N*, writing

$$i_{\alpha} = \frac{E}{r+R}; \quad i_{\beta} = \frac{E}{r+R+R_N};$$

$$R_N = \frac{E}{i_{\beta}} - (r+R) = (r+R) \left(\frac{i_{\alpha}}{i_{\beta}} - 1 \right)$$

We are now measuring the mind action in the international unit ohm, and, as an example, *R_N* = -100 ohm. For an experiment of this nature to actually contribute "stimulance", the p.k. action must be extended to the current carriers in the proper electrical circuit rather than being applied to a magnetic needle. Whenever a carrier is deviated from its trajectory in an electric or magnetic field, as described by Maxwell's equations, the potentiality for an increased or decreased loss exists, contributing possibilities for the design of new kinds of amplifiers, oscillators, s/n ratio



enhancers and similar devices, and it is hoped that such experiments will attract the interest by research workers in the communications field. The most valuable contribution that can ever come out of such research is an apparatus for storing of p.k. energy.

Among future research apparatus contemplated is a p.k. power meter, in which a wheel of known mass and weight is rolled up a slope by p.k. energy. The mind energy is then measured directly in the unit joule, and the mind power in watt. Professor Monahan has already succeeded to rotate a wheel by p.k. power, and to make a paper clip move on a table top. It moves in little jumps. There is a great need for refined test equipment in this new field. Of special interest is a recently developed research apparatus in which p.k. energy is applied to material or living tissues inside the capacitor of an oscillator, so that the mind action can be measured in the international unit hertz. Harry E. Stockman,
Arlington,
Mass., U.S.A.

Audio amplifier design

With reference to the letter from Messrs Vereker and Mornington-West in your May issue, I would like to point out that the amplifier unit of my design to which Mr Vereker refers, and on which he made his published measurements, was one which I had lent to him for experimental purposes and in which the harmonic distortion performance was below specification. Moreover, I had informed Mr Vereker on this point at the time.

This circumstance arose because of the unsatisfactory characteristics of the output transistor pair with which it had been fitted (these were the only pair I had spare at the time). This particular phenomenon, worsening of the t.h.d. at higher frequencies, will inevitably occur in any power amplifier design in which the h.f. and l.f. negative feedback loops are divided (which is necessary to meet the Otala transient intermodulation criterion¹) if the output transistors are badly matched or if their h.f. parameters are poor, since the t.h.d. characteristics at frequencies above that of the operating range of the main l.f. feedback loop depend on the effectiveness of output stage emitter follower action. If this phenomenon is found, this cause should be suspected.

For the record, when the output devices were changed (a reasonably well matched, ± 20%, pair of Sescosem BDY56s was used) the harmonic distortion of the same unit was lower than that of my reference standard signal generator at frequencies up to 20 kHz, i.e., better than 0.05% at 10 kHz and better than 0.1% at 20 kHz. I take the point that a shunt feedback design might be better still, but common mode failure was not the cause of the phenomenon observed

J. L. Linsley Hood.
Taunton,
Somerset.

1. Otala, M., *Trans. I.E.E.E.*, Sept. 1970.

Paris Components Exhibition

New semiconductors seen at the Sixteenth International Salon

The romantic picture of Paris in the Spring fell some way short of accuracy this year, at least during the exhibition. Rain and wind were present in full measure, although the exhibition attendance did not seem to suffer as a result.

Exhibitors were about 11% down in number on last year's figure, but the effect on the leg muscles was hardly noticeable. To report on 910 stands is impossible and we have concentrated on the subject which we thought would provide the most innovation — semiconductor devices and circuits. If we are right in this assumption, we can only say that new components in the other categories must have been very thin on the ground indeed. In the opinion of many people we spoke to, manufacturers have been caught unprepared by the welcome resurgence in the electronics industry and are having a hard time supplying the demand for established components without developing new ones. This can only be a very short-lived situation and one would expect future shows to be as fruitful in novelty as previous ones have been.

Integrated circuitry continues to develop at a remarkable rate. Equipment that was "mini" even a few months ago can now be "micro" and an equipment manufacturer who rushes into hardware with his new calculator, for instance, confident in the knowledge that his latest integrated circuit is the ultimate in l.s.i., is likely to be informed otherwise rather rapidly.

Fairchild Semiconductor, for example, have brought one stage nearer the ideal of the "computer on a chip" with the PPS25 system. They have taken the low-cost m.o.s. l.s.i. technology, which has revolutionized the design of calculators and, with an expected upsurge of interest in mind, have applied it to the realization of minicomputers and data-processors. A family of integrated processing units has been designed to form the nucleus of programmable digital processing systems, removing the cost barrier and making possible the development of computing equipment for use with small systems. Fairchild say that the PPS25 (programmed processor system) fills the gap between calculators and minicomputers. A basic system would consist

of an arithmetic/logic unit to provide timing and supervision in addition to arithmetic functions, a memory, consisting of three 25-digit shift registers, a read-only memory for programme storage and input/output units — all on six chips, costing less than £25. The PPS25 uses single-polarity silicon-gate m.o.s. techniques and is compatible with t.t.l. circuitry at all interfaces.

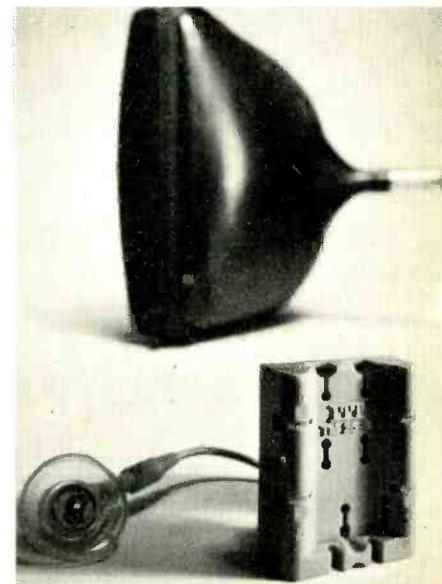
A particularly elegant application of integrated m.o.s. circuits is the Bizerba price-computing counter weighing machine, using a pair of Siemens integrated circuits specially designed for this purpose. The arithmetical process is the reverse of that used in the count-by-weight machine used in industry to count large numbers of small items, and performs the multiplication of two quantities. The weight of the goods for sale is transduced into electrical form by means of a coded, transparent disc mounted on the spindle of the mechanical weighing machine. Lamps and phototransistors continuously record the weight information, which is passed to the electronics. The price per unit weight is entered by means of a ten-digit keyboard, and the two m.o.s. packages multiply the weight

by the unit price to give selling price, which is displayed digitally. Siemens point out that one of the more significant benefits of l.s.i. is the reduction in soldered joints and ensuing increase in reliability. The use of these two packages has reduced the number of joints from about 4000, using t.t.l. and r.t.l., to 48.

The improved C-550 calculator chip produced by General Instrument SpA offers the facilities required to make an 8-digit, 4-function, display calculator dissipating only 150mW at 14V. No under or overflow indication is provided, the lack of a decimal point in the calculated result implying that the whole number consists of more than eight digits. The exponent (up to the 79th) is obtained by dividing the result by powers of 10 until the decimal point appears.

The same company were also showing their read-only memory ic — the RO-5-5184 — which is an m.o.s. character generator for needle mosaic printers. It contains a $64 \times 9 \times 9$ matrix and an internal counter with forward/reverse control. The outputs are tri-state.

Large-scale integration is primarily for large-scale application, or, at least, it has been until now. The high cost of



E.h.t. rectifiers and multipliers for solid-state colour television in silicon by General Instrument Europe (left) and in selenium by ITT.

development of these ics has limited the use of purpose-designed units to long-run manufacture. In an effort to overcome this limitation, several firms are now making life easier for the small user by the introduction of circuits which contain a large number of finished, but unconnected, active and passive devices. The French firm of Sintra have given the name Monochip to their design, which comes in three versions, and which contains from 197 to 352 components (14 to 24 outputs). Bipolar transistors of p-n-p and n-p-n types are provided, with a maximum current capability of 200mA, and resistors are between 200 Ω and 90k Ω in value. In addition, Schottky diodes are provided with the n-p-n transistors and a Hall-effect device is included to enable an external magnetic field to initiate operation. The user specifies the interconnection pattern which the manufacturer applies.

Ferranti have called their approach to this problem of cost reduction the uncommitted logic array (u.l.a.). Using their recently developed collector diffusion isolation process which produces a component density in the bipolar technology comparable to that of m.o.s. techniques, they have developed an array of 187 three-input gate cells which are complete except for the fifth mask, which is the pattern for the aluminium interconnection layer, specified by the customer. Each cell can be connected to operate as either a logic element or as part of a linear circuit such as an operational amplifier or oscillator. Gate delays are typically 35ns and power dissipation is 2.5mW per cell.

Motorola introduced their 1024-bit read-only memory, which is claimed to be the largest production memory in this technique. This is a complementary m.o.s. memory which is programmed by the user with the aid of punched cards or a truth table. The use of c.m.o.s. confers the benefit of extreme tolerance to power supply variations, the range 3 to 18V being usable. The MCM14524 can therefore, be used not only in all c.m.o.s. systems but will interface with bipolar elements. Access time is 70ns.

Also using c.m.o.s., National Semiconductor have introduced their 54C/64C/74C series of logic circuits performing the same functions as the well-established 54/74 series of t.t.l. units. The two series are compatible, and low-power t.t.l. and d.t.l. can also be interfaced with the "C" series. The advantages of c.m.o.s. are low power dissipation (dependent on supply voltage and clocking frequency), high noise immunity (45% of supply voltage), reasonably short transition times (50ns) and a propagation delay of about 25 to 50ns.

A clearly evident trend is the recognition by a number of firms of the need for electronics in motoring. AEG-Telefunken, for instance, showed an ic, the SAJ150, which can be used to control direction indicators and hazard warning lights, as well as providing a timing function for other on-car equipment with

independently variable on and off periods. ITT presented their power pulse generator ic which serves as a central timer for direction and hazard indicators and timed wipers, and will provide an excess-speed warning signal. Both these devices indicate the presence of a lamp failure by increasing flashing speed. Thomson-CSF also had a device on show which provides the timing and warning functions, and have developed the ESM16 transistor for use in electronic ignition systems.

Industrially, special-purpose integrated circuits are now being presented, the technique of integration enabling sensors and controls to be made which, while exceeding the reliability of electro-mechanical devices, are lower in cost. Siemens presented a series of three units, the TCA105, TCA345 and 5059 which are inductive, light-operated and magnetic switches. The TCA105 consists of a flexible input stage, operating as



The C609 inverter thyristor from General Electric, rated at 1kHz and 1200A. The involuted cathode structure permits a rating of 850A at 5kHz, long-term di/dt of 500A/microsecond and minimum dv/dt of 400V/microsecond.

either oscillator or Schmitt and includes a voltage regulator. Applications include phototransistor output level detection and proximity detectors using inductively coupled oscillators. Anti-phase outputs are provided, giving currents of up to 50mA. The TCA345 is also a level detector and is notable for its low power consumption (1.8V at 800 μ A quiescent). It is primarily intended for use in photographic camera control circuitry. The SO59 is a Hall-effect circuit with Hall generators on the chip. An output is obtained in a field of 600 gauss which is t.t.l.-compatible. Application in typewriter keyboards and calculators is envisaged.

The National Semiconductor LX1600 absolute pressure transducer is capable of measuring pressure in the range 0.3 atmospheres at temperatures of -40°C to $+105^{\circ}\text{C}$, is temperature-compensated and is chiefly contained in one thick-film integrated circuit. A piezo-resistive bridge with a vacuum reference, and a diaphragm are integrated on thick film, while the amplifiers are on a separate chip in the same package. The unit is, in effect, a simple potentiometer which

is free from the loading problems imposed by an ordinary resistive type. Loading impedance is in the order of megohms, while the output is from a few kilohms. The input is over-voltage protected and the output is not damaged by shorts to earth. Applications include medical investigations, meteorological work and process control.

SGS Ates SpA mounted a working demonstration of their new voltage-and-temperature-protected amplifiers TBA810S and TC940. The former, in a 12-lead quad-in-line package with heat-sink tabs, will deliver 6W at 14.4V into 4 Ω , at which point it is completely immune to short circuits and overloads. A rise in junction temperature automatically limits output power.

The highlight of the Plessey display was their collection of Process III Bipolar circuits including the remarkable SP600 high-speed frequency divider series which is t.t.l.- or e.c.l.-compatible. This is capable of dividing a frequency of 1GHz by four and 100MHz by 32, while using only 10mA. Process III linear products include the SL360 matched transistor pair and the SL3145 array, exhibiting an f_T of 2.5GHz. The low-noise SL362 has a noise figure of 4dB between 30 and 200MHz at 50 ohms, while SL645 is a square-law device for communications use. The devices in this series exhibit f_T of more than 2GHz due to the extreme thinness of the epitaxial layer (4 microns) and the emitter/base and base/collector junctions (0.25 and 0.5 microns). Plessey claim them to be the fastest monolithic integrated circuits in the world.

ITT's new v.h.f. transistors include the BFT13A, which is a low-noise beam-lead type useful up to 5.5GHz, while the BFT16 will deliver 200mW at 3.5GHz. Their Schottky diode rectifier is capable of putting out 30A of rectified current with a repetitive p.i.v. of 20V, while dropping only 400mV.

AEG-Telefunken introduced four new i.i.d. silicon diodes for use in microwave integrated circuits. One of these is intended for use in up-converters up to 12GHz, while the other three are frequency multiplication types at 2GHz, 7GHz and 11GHz, exhibiting rise times of 0.2ns, reverse voltage of 36V and junction capacitances of 0.4pF to 2pF.

Twelve complementary pairs of TO220 power transistors were shown by Sescosem, ranging from 36 to 75W at up to 90V, and intended for medium power switching with inductive loads and servo motor applications. They also had four complementary Darlington pairs, giving between 50 and 75W at 80V.

ITT claim a major breakthrough with their new thermistor (HT103/750) which is in probe form and which can be used up to 1000 $^{\circ}\text{C}$. It is a negative temperature coefficient type, offering a resolution better than 100 ohms and a cooling time constant of three seconds. The device is much simpler to use than other high-temperature devices, such as gas and liquid-in-metal thermometers and thermocouples.

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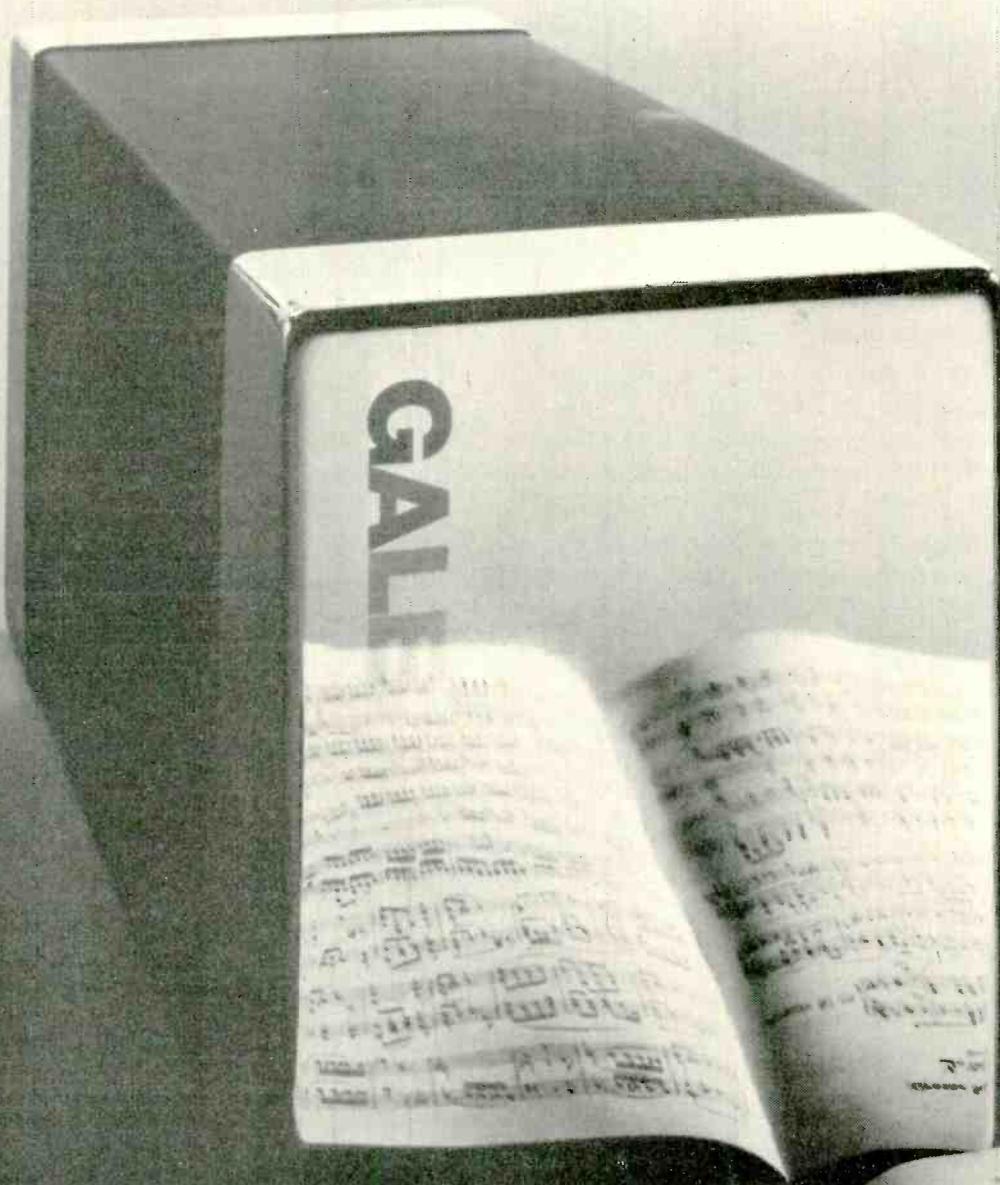
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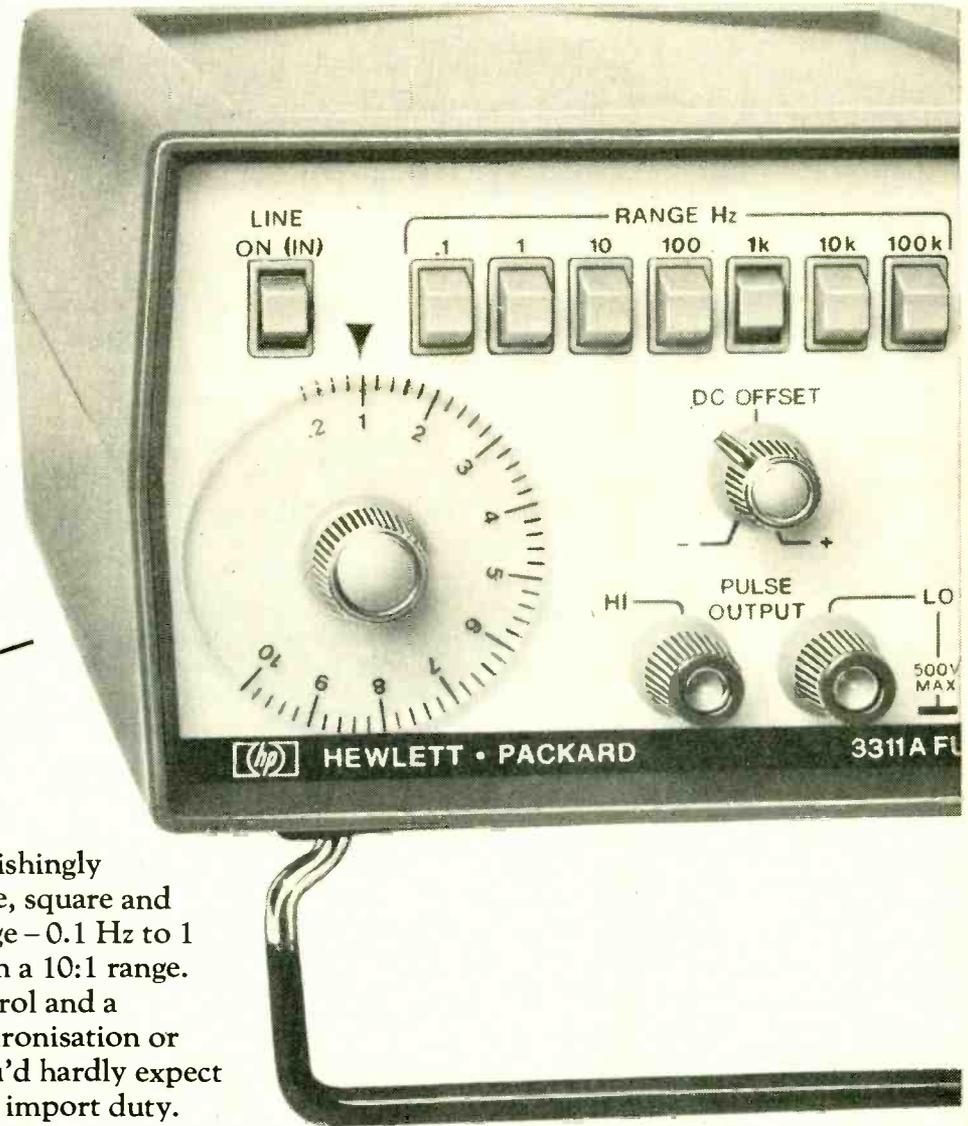
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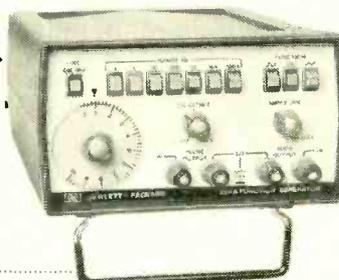
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Magnetism and Magnetic Units

The measurement of the intensity of magnetization and its units

by M. McCaig, Ph.D., F.Inst.P.

In the January issue of *Wireless World*, "Cathode Ray" accused the Sheffield manufacturers of permanent magnets of blocking the introduction of SI (formerly known as m.k.s.) units. Actually the Permanent Magnet Association, comprising all the important Sheffield magnet manufacturers, published nearly twenty years ago a booklet listing permanent magnet properties in m.k.s. as well as c.g.s. units. Since then this practice has been continued in the majority of P.M.A. publications. Until recently, however, very few others have copied their example. The majority of papers on magnetism, published throughout the world, have used c.g.s. units. In 1968 I wrote a paper for a journal of international repute in the field of magnetism and electronics. The only important comment by the referee was "What does SI mean?"

I think one of the reasons for the neglect of SI units by those working in magnetism has been the tardiness of those working out the system to provide a unit and symbol for one of the most fundamental magnetic quantities. I refer to what in c.g.s. units is called the intensity of magnetization, and is usually represented by the symbol J , although some writers have used I or M . "Cathode Ray" still ignores the need for this unit. In his terms it is a measure of the number of aligned electrons circulating in orbit or spinning within the material. Practically, this quantity can be defined by the torque that unit volume of the material experiences in an external field, and it is most important not to confuse this quantity with the flux density B . If a magnetization curve J versus H is plotted, J eventually reaches a constant maximum value, the saturation magnetization; B on the other hand, continues to increase indefinitely, because it includes a component due to the applied field H . The difference between B and J is even more striking in permanent magnets. In an ideal permanent magnet it is possible to reverse the direction of B , while the magnet remains fully magnetized with J unchanged in the original direction. Many modern permanent magnet materials come surprisingly close to this ideal behaviour. The first extensive exploitation of this property was for field measuring devices using Silmanal. This is an alloy of silver, manganese and aluminium, which is only slightly magnetic, but requires a very high field to change its magnetization.

Its intrinsic coercivity, the field necessary to reverse J , is at least ten times its ordinary coercivity, the field that just reverses B . Platinum cobalt, some grades of ferrite and the new rare-earth cobalt alloys can also exist with their magnetization and flux density opposed.

Even in the c.g.s. system, workers in permanent magnetism did not find the unit provided for intensity of magnetization very convenient. They usually plotted $4\pi J$ rather than J itself, and were in this way able to use the same scale as for B . Perhaps unwittingly, they were forestalling rationalization, which is a feature of SI units discussed by "Cathode Ray".

Publishers of textbooks as distinct from scientific journals often urged authors to use m.k.s. or later SI units. As no unit had been recommended for intensity of magnetization, the authors had to invent one. Not surprisingly, they invented two different units; some authors expressed intensity of magnetization in tesla, others in Am^{-1} . Furthermore, some authors used the symbol J others M , and all four permutations of these units and symbols have been used.

My colleagues and myself in the Permanent Magnet Association were unanimous in preferring tesla, but had an open mind on the symbol. For some years we used J and then believing we were following the consensus decided to change to M . Shortly afterwards the various international committees that consider units made a pronouncement. Both units were to be recognized with different names and symbols: thus we may speak of the polarization with symbol J and unit tesla or the intensity of magnetization with symbol M and unit Am^{-1} . In the circumstances, this was a sensible compromise, but inevitably there are many books in circulation in which these conventions are not observed.

Some misconceptions about magnetic quantities have arisen from a false belief that measuring a physical quantity in a different unit with different dimensions made it into a different physical quantity. The dimensions of a physical quantity give us very little information about the nature of that quantity. Rather they often tell us which of several alternative methods we have chosen to measure that quantity. Specific gravity is dimensionless, density has the dimensions of mass per unit volume and its numerical value depends on the units

we use for mass and volume. Whether we speak of specific gravity or density and whatever units we use, the value we assign to copper is a little over three times that of aluminium. Specific gravity and density are different ways of measuring the same physical quantity.

On the other hand, the height of a mountain or building can obviously be varied independently of its horizontal dimensions, but we are quite happy to measure both in the same unit, say metres or feet. We do this in spite of the fact that when we climb a mountain we realize that altitude does have a different physical significance from horizontal distance. If the same principle that some people think should apply to electrical and magnetic units had been applied to architecture and cartography, we should probably measure heights in joules per kg, the work required to raise unit mass.

SI units provide two units for what we may in general terms call magnetic fields. A distinction is made between the flux density B measured in tesla and the magnetizing force H measured in Am^{-1} . In free space, one of these quantities is redundant, because we always find that $B \equiv \mu_0 H$, where μ_0 the magnetic constant or permeability of free space = $4\pi \times 10^{-7}$ henry per metre (Hm^{-1}). In free space it does not matter whether we work with B or H , provided we are quite clear which we are using. Actually, all calculations from the current flowing in a coil lead directly to H in Am^{-1} and all measurements for example by means of a coil and fluxmeter lead naturally to B in tesla.

When we deal with magnetic materials we require not two but three independently variable quantities. Actually, no less than five quantities can be distinguished, but relations between them mean that only three can be varied independently. In the above statement, I should make it quite clear that I am counting the polarization J and intensity of magnetization M as only one quantity because $J \equiv \mu_0 M$.

Perhaps it will be clearer if I enumerate these quantities. There are:

- (i) B the flux density in the material which can be measured in tesla by means of a coil and fluxmeter.
- (ii) The polarization J or intrinsic magnetization M of which we have already spoken.
- (iii) The externally applied field that can

exert a torque on the sample. If we use the polarization J this external field should be H_e in Am^{-1} and if we use M the external field should be B_e in tesla. In other words a torque must be a product of one quantity in tesla and one in Am^{-1} , but we can choose which is which.

(iv) The self demagnetizing field H_d ; this depends on J and the shape of the sample. For the moment we will assume that it is expressed in Am^{-1} , but sometimes we have to multiply it by μ_0 to convert it to tesla.

(v) The magnetizing force H in Am^{-1} which determines the state of magnetization of the material and which we require for the X axis of a hysteresis loop.

The relations between these quantities to which I have referred are:

$$H = H_d + H_e$$

and

$$B = J + \mu_0 H = J + \mu_0 (H_d + H_e)$$

or if we use M

$$B = \mu_0 (M + H)$$

It should be noted that all the quantities in these equations are vectors and some of them will often need to be treated as negative.

Now I realize this may seem rather complicated, and to some extent the complications are unavoidable. Some of the complications are, however, due to trying to press the subject into a straight jacket of units that just does not fit. The idea that every quantity ought obviously to be measured in tesla or Am^{-1} just as a mass is measured in kg and a length in metres does not work. In some cases the decision is arbitrary and often we have to treat the same quantity sometimes in one unit and sometimes the other.

As I am sceptical about the deep philosophical significance of some of the schisms within the adherents of SI units (there is a battle of almost religious fervour between those who wish to use J/tesla and those who believe in M/Am^{-1}) I prefer to be guided by convenience. People will only change over to SI units if they are flexible enough not to entail a large amount of extra work.

If one is measuring the hysteresis loop of an anchor ring of soft magnetic material, there is no problem. H is naturally calculated in Am^{-1} and B is naturally measured in tesla. The area of the hysteresis loop obtained gives the energy loss per cycle in joule m^{-3} .

With permanent magnets the situation is less simple; H is nowadays unlikely to be calculated; more probably it will be equated to measurement of B made just outside the magnet and the manufacturer will have calibrated the instrument in tesla or possibly gauss, but certainly not in Am^{-1} . It is also likely that the polarization J (or magnetization M) as well as B will be required; J may be deduced from B and H by calculation or by remeasurement with certain modifications to the apparatus. An inconvenient choice of units can be very expensive in time and money.

To illustrate the advantages and disadvantages of the various possibilities, Fig. 1 shows the curves for a typical rare-

earth cobalt magnet plotted (a) with B in tesla, M in Am^{-1} against H in Am^{-1} (b) with B in tesla and J in tesla against H in Am^{-1} and (c) with B in tesla J in tesla plotted against $\mu_0 H$ also in tesla.

Method (a) is extremely inconvenient. In many cases today, the final output is an XY recorder, using standard graph paper. To record B in tesla and M in Am^{-1} directly would involve an expensive modification to standard equipment. Alternatively it can be done by laborious calculations. Method (b) is certainly an improvement although there are still difficulties if one has to use existing equipment calibrated in tesla or gauss to measure H and to calculate B from J or vice versa still involves multiplying each value of H by $4\pi \times 10^{-7}$. Method (c) was used by several contributors to the seventeenth Conference on Magnetism and Magnetic Materials and published by the American Institute of Physics in March 1972.

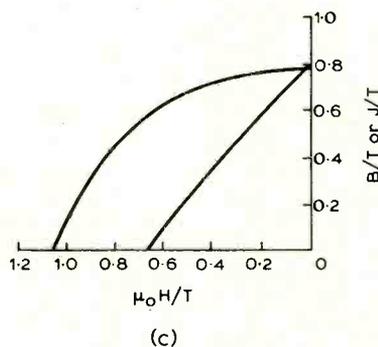
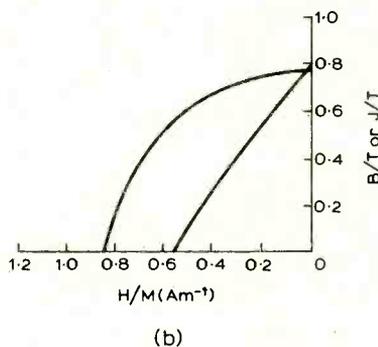
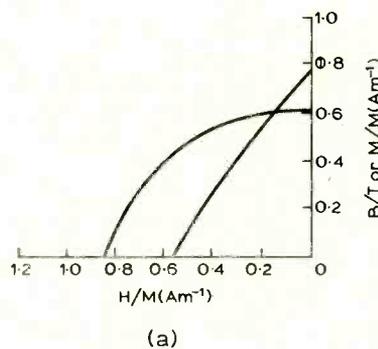


Fig. 1. (a) Demagnetization curve with B in tesla and M and Am^{-1} against H in Am^{-1} . (b) With B in tesla and J in tesla against H in Am^{-1} . (c) With B in tesla, J in tesla against $\mu_0 H$ in tesla. The left curve in each case is that of $B - \mu_0 H$.

Using a product of two quantities rather than a single quantity as the unit for one of the co-ordinate axes of a graph is a practice accepted in many branches of science and technology. There should, therefore, be no objection to using $\mu_0 H$ for the X axis in this case, and since both μ_0 and H are in SI units it in no way conflicts with the spirit of SI units. I believe that this method should be used when it is found to be convenient. It is more convenient in the following circumstances—

(i) If it is necessary to use equipment already calibrated in tesla or gauss to measure H . The factor 10^4 gauss = 1 tesla being a simple power of 10 causes little difficulty.

(ii) If it is desired to calculate B knowing J or J knowing B , only a simple addition or subtraction of the X co-ordinate value $\mu_0 H$ is involved.

(iii) It is easy to see whether the value of $\mu_0 H$ which brings J to zero is greater or less than B_r . If it is greater the magnet can be treated as a "hard" permanent magnet. It is suitable for applications such as repulsion devices and certain types of motors and generators, in which other materials with μ_0 times the intrinsic coercivity less than B_r , would be demagnetized. It is also possible to make design calculations with the assumption that the permanent magnet is uniformly magnetized.

The objection to plotting B against $\mu_0 H$ is that it may be necessary to divide by μ_0 to obtain the $(BH)_{\text{max}}$ product in Jm^{-3} . This division has only to be performed once for each curve. In any case, I advocate this course only as an optional procedure when it is clearly more convenient. The decision concerning J/tesla or M/Am^{-1} is much more important. Obviously agreement is desirable, but I am convinced that those working with permanent magnets would find J much more convenient.

Paul Dirac, O.M.

Professor Paul Dirac has been awarded the Order of Merit for intellectual achievement. When he was 31, Professor Dirac gained the Nobel Prize for his work on what was then the new planetary theory of atomic structure. He devised a set of equations which required the existence of negative energy for all possible results to be true; accordingly, he predicted a new sub-atomic particle, the short-lived positron or anti-electron, which is a positively-charged electron. A few years later, the positron was experimentally discovered by Dr Carl Anderson in America, Professor Dirac's theory thereby being substantiated. In 1930, he published his book "Quantum Mechanics", in which he asserted that nature can never be completely defined in terms of space-time happenings, as the observation required to specify natural events imposes artificial constraints upon them. This philosophy became known as the uncertainty principle of Heisenberg and Dirac.

Audio Power Amplifier

by P. L. Taylor*, M.A.

In this article the author puts forward a proposal for a transistor power output stage which does not claim the best possible performance but provides an economic configuration to achieve acceptable results. A circuit diagram for a 30W main amplifier with 0.1% distortion and a hum level of -50dBW is presented together with a description of the design philosophy.

The current-voltage relationship of a semiconductor junction is basically an exponential form. This curve has the property that moving it horizontally along the voltage axis is equivalent to a simple change of the scale of the vertical or current axis. There is an unfortunate consequence when it comes to trying to adjust two exponential curves back-to-back to make a class B output stage, Fig. 1. No matter how one juggles the two curves relative to each other the resultant, shown dotted, always has the same shape; it merely changes in scale. It is a hyperbolic sine and is far from linear. Semiconductor junctions are evidently bad starting material for a class B design.

Matters are somewhat better if a fixed resistance R is included in series with each junction. A few moments' work with pencil and paper shows that, for the nearest approach to a linear resultant characteristic, the resistance should have a value equal to the slope resistance of the junction at the standing or quiescent current. What happens when it does not have this value has been graphically illustrated by Gibbs¹.

There is an important practical consequence. If I_0 is the standing current and V_0 the corresponding voltage drop across the base-emitter junction, then the general equation relating current I and voltage V is,

$$I = I_0 \exp\{K(V - V_0)\}.$$

The slope resistance is dV/dI , and when $I = I_0$, takes on the value $1/KI_0$. If the series resistance has this value we get the particularly simple result that the standing voltage drop across it must be $I_0 \times 1/KI_0 = 1/K$. So if I_0 is firstly chosen, the value of resistance follows and the circuit must be designed to maintain $1/K$ volts across the resistance under quiescent conditions.

Now $K = q/kT_j$ where q is the charge on an electron, k is Boltzmann's constant and T_j is junction temperature. It is the same for all transistors n-p-n or p-n-p, germanium or silicon, and has the value $40V^{-1}$ at room temperature. Hence there is a universal rule

which defines that, for class B operation of any transistor, the standing voltage drop across each series resistor should be 25mV at room temperature†. Here lies the practical difficulty. The 25mV is in series with the much larger, and variable, 550mV, or so, voltage drop V_0 across the junction. It is small wonder that temperature compensating diodes and preset adjustments are required in class B designs. Added to this are the difficulties that the adjustment is critical², K is temperature-dependent (so that strictly the series resistance should

†By a similar argument one obtains another universal rule which defines the transfer conductance of all transistors to be 40mA/V per mA of emitter current at room temperature. It is strange that not many textbooks mention this valuable and easily-remembered fact.

vary with junction temperature) and the series resistance must include the internal emitter resistance of the transistor—about $\frac{1}{2}\Omega$ for type BD121. Therefore, only part of the 25mV is available outside the transistor for monitoring the standing current. All in all, it is surprising how well class B stages have been made to perform.

Class AB is a little better. Typical values are $R = 1\Omega$ and $I_0 = 100mA$, so that the standing voltage drop is 100mV. This voltage is still rather small compared with 550mV but unfortunately it cannot be increased much above this figure because, as I_0 is increased, there are problems of power dissipation in the transistors. On the other hand R is in series with the load so that if this resistance is increased, the peak voltage drop across it reduces the peak power available in the load. That is, R ideally should be small compared with the resistance of the load.

The new circuit to be described attempts to overcome these difficulties by putting the current monitoring resistor outside the main feedback loop.

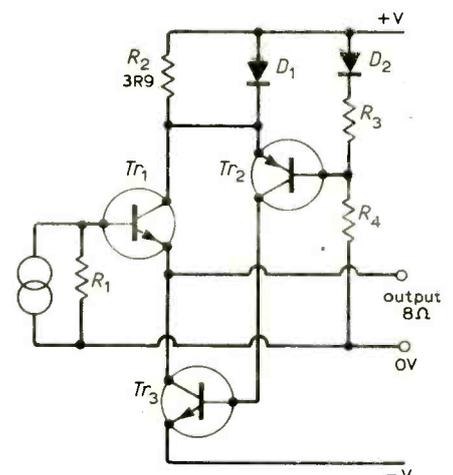
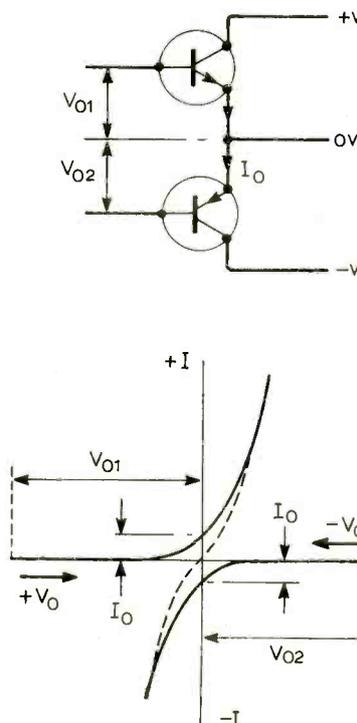


Fig. 2. Basic configuration of power output stage.

Fig. 1 (left). Class B cross-over characteristics constructed from two curves of exponential form.

*University of Salford.

Multiphonic Organ

Switching system permits use of a small number of generators (six) with a four-octave keyboard

by J. H. Asbery, B.Sc., M.I.E.R.E.

The first electronic organs to be built consisted of a single generator in which the value of one of the components was controlled by the keyboard. Fig. 1 is a block diagram of part of the usual system. If key C is pressed RV_1 is connected to the generator. RV_1 is adjusted during tuning so that the generator frequency is that of note C. If key B^b for example is pressed RV_3 is connected to the generator and RV_3 is adjusted during tuning so that the generator pitch is that of B^b . If two notes are pressed at the same time only the highest note is operative. These organs are very simple and are still sold and in use today. They are called "monophonic".

In order to overcome the limitation of the monophonic organ the "polyphonic" organ was developed. Fig. 2 is a block diagram of part of a typical polyphonic organ. For each note there is an oscillator that is tuned to the pitch of that note. When any key is pressed the output of the oscillator is connected to a "busbar". The busbar is connected via filters, which shape the wave and control the tone to the amplifier. In a typical organ there may be, for example, 49 generators. This system is not only expensive but wasteful, as many organists do not use more than about four or six notes at any one time.

The "multimonophonic" organ, which is abbreviated to "multiphonic", is a compromise between the simple and cheap but very limited monophonic organ and the versatile but expensive and complicated polyphonic organ. The principle is that of the monophonic organ, but repeated with more than one generator. In circuit diagrams of multiphonic organs change over switches are not shown as in Fig. 3(a) with the contacts at the corners of a triangle but as in Fig. 3(b) with the contacts at three of the four corners of a square. This makes the diagrams easier to follow and tidier. The principle of the multiphonic organ is shown in Fig. 4 which is part of an organ shown with keys B and A^b pressed. Variable resistor RV_2 is connected to generator number 1 which therefore oscillates at the pitch of B and RV_5 is connected to generator 2 which therefore oscillates at the pitch of A^b . Generator 3

is not connected to any resistor and therefore does not oscillate. A thickened line is used to show the connection path to each generator.

The keyboard switches must be of the break-before-make type to avoid connecting a generator to two resistors at the

same time during changeover. Two types of switches are available: (1) Discrete 3-pole changeover switches. With these it is necessary to connect fixed contacts of the poles together and to wire between switches as shown on the Fig. 5 circuit diagram. (2) Integrated switching systems

Fig. 1. Principle of monophonic organ. The pitch of the single generator is changed by switching in different resistors.

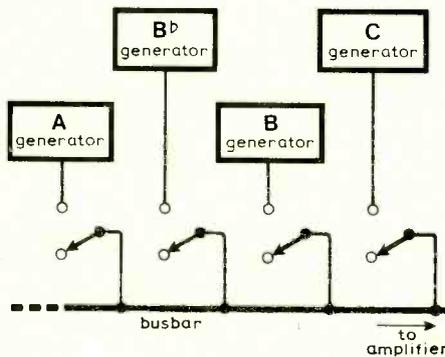
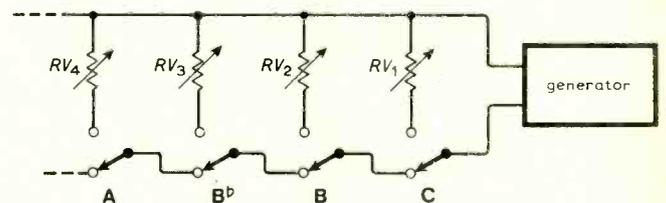


Fig. 2 (left). The polyphonic organ has a generator, individually tuned and switched, for each note.

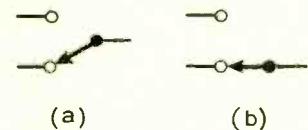


Fig. 3. Conventions for change-over switch symbols: (a) conventional switch; (b) multiphonic organ switch.

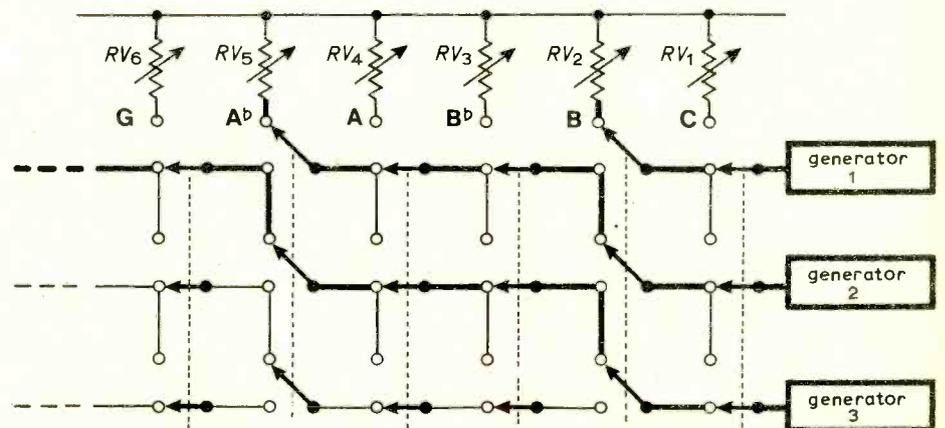


Fig. 4. Part of a multiphonic organ with two keys, A^b and B, pressed simultaneously. The connection paths between the variable resistors and the generators are shown by the thickened lines.

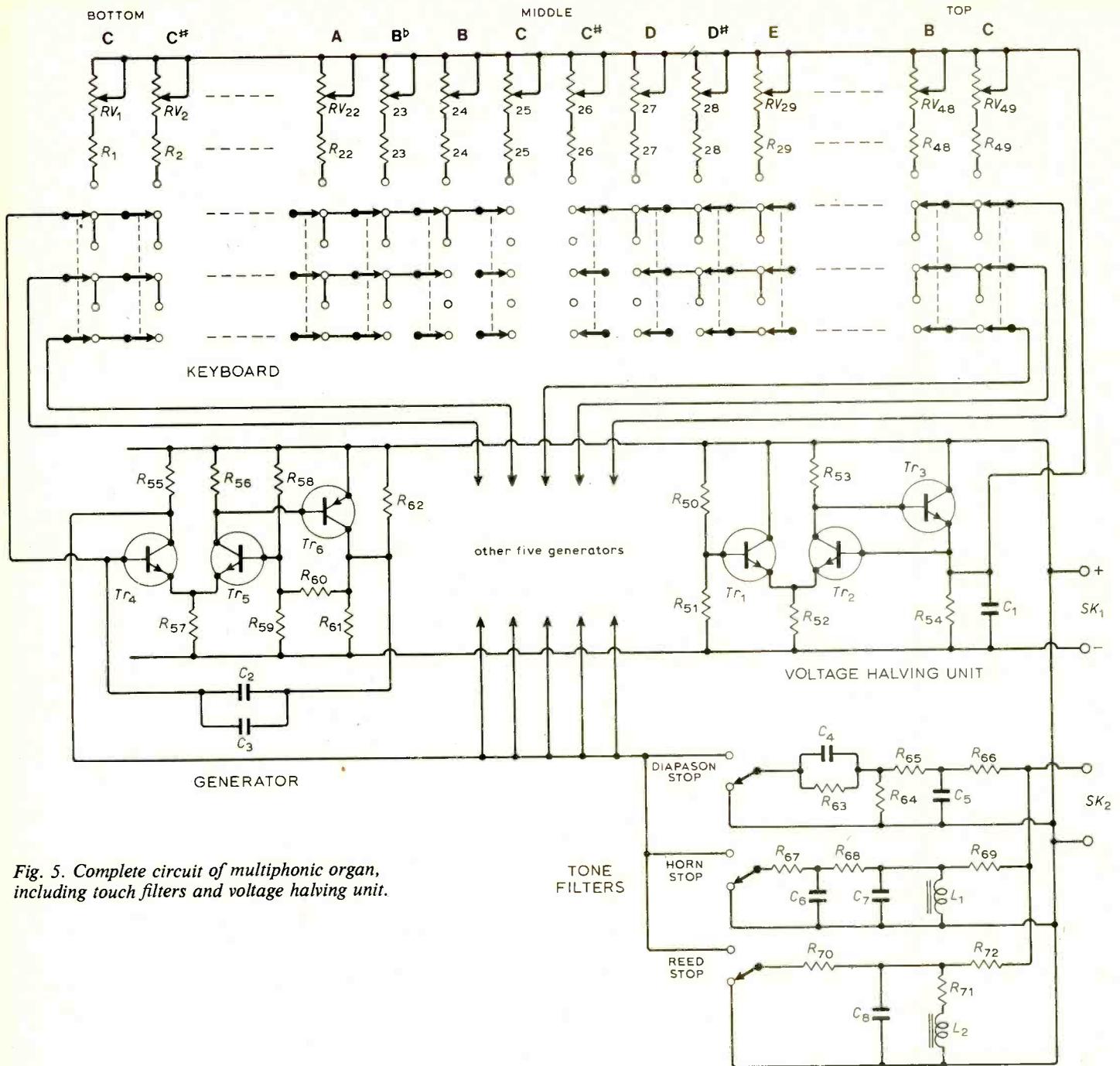


Fig. 5. Complete circuit of multiphonic organ, including touch filters and voltage halving unit.

in which the normally open contact of one pole, the normally made contact of the next pole of the same switch and the changeover contact of same pole of the next switch is one piece of gold plated wire. This eliminates all wiring between poles of each switch and between switches.

If desired, better long term stability and finer tuning can be achieved by replacing each tuning variable resistor by a fixed resistor of about 90% of the required value and a variable resistor of about 20% of the required value.

In the organ circuit of Fig. 5 the three highest keys pressed in the right-hand half of the keyboard "speak" and the three lowest keys pressed in the left-hand half of the keyboard also "speak". If more than six keys are pressed at the same

time the extra ones simply do not "speak". There are no undesirable side effects.

The generators have been designed for long term stability and for accuracy of tracking; that is, a given value of resistor will cause different generators to oscillate at very nearly the same frequency. No separate output buffer is required for each generator as the output is derived from a resistor in the collector of one of the transistors, this point not being part of the feedback loop.

The ends of the keyboard resistors remote from the generators are connected to half the supply voltage. It is not sufficient to provide this supply merely with a potential divider of two resistors, as current drawn by one generator would alter the voltage of the main supply rail,

thereby affecting the other generators. A conventional series stabilizing circuit provides a supply at half the main supply voltage and one that remains at half this voltage when current is drawn. The 470-ohm load resistor (R_{54} in Fig. 5) is required as, during a half of each cycle, current is fed onto the half voltage supply rail. Occasionally all the generators will be in this same half cycle so that the 470-ohm bleed resistor has to be adequate to carry the current from all the generators.

In the tone filters in Fig. 5, the inductors L_1 and L_2 , which are both 650 mH, are provided by Eagle transformers, type LT-700. The secondary (black and white leads) is left open circuit and the centre-tap of the primary (white lead) is left

unconnected. The inductor connections are made to the ends of the primary winding (red and green leads).

When building this organ it is advisable to keep the units as small and as close together as possible and to leave as much space spare as possible, as multiphonic organs are particularly amenable to the adding of extra facilities at later dates.

Components list

Variable resistors (RV)

- 1 to 13 — 3k wire wound
- 14 to 25 — 1k wire wound
- 26 to 37 — 3k wire wound
- 38 to 49 — 1k wire wound

Fixed resistors (R)

- 1 — 22k
- 2 and 26 — 21k
- 3 and 27 — 20k
- 4 and 28 — 19k
- 5 and 29 — 18k
- 6 and 30 — 17k
- 7 and 31 — 16k
- 8 and 32 — 15k
- 9 and 33 — 14k
- 10 and 34 — 13k
- 11 and 35 — 12.5k
- 12 and 36 — 12k
- 13 and 37 — 11k
- 14 and 38 — 10.5k
- 15 and 39 — 10k
- 16 and 40 — 9.5k
- 17 and 41 — 9.1k
- 18 and 42 — 8.6k
- 19 and 43 — 8.2k
- 20 and 44 — 7.8k
- 21 and 45 — 7.5k
- 22 and 46 — 6.8k
- 23 and 47 — 6.5k
- 24 and 48 — 6.2k
- 25 and 49 — 5.9k

All above fixed resistors, metal film 2%.

- 50 — 7.2k
- 51 — 7.2k } metal film 1%
- 52 — 7.2k
- 53 — 10k carbon 20%
- 54 — 470 carbon 20%
- 55 — 2.2k carbon 5%
- 56 — 2.2k carbon 20%
- 57 — 7.2k metal film 2%
- 58 — 15k
- 59 — 4.3k } metal film 1%
- 60 — 2.0k
- 61 — 1.0k
- 62 — 2.0k
- 63 to 66 — 100k carbon 20%
- 67 — 22k
- 68 — 15k
- 69 — 22k } carbon 20%
- 70 — 22k
- 71 — 2.2k
- 72 — 47k

Capacitors

- 1 — 8 μ 8V
- 2 — generators 1 to 3, 400n
generators 4 to 6, 100n
- 2% but matched in sets to 0.5%, polycarbonate or polyester
- 3 — as required to match generators
- 4 — 1n
- 5 — 5n
- 6 — 20n
- 7 — 100n
- 8 — 20n

Inductors

- L_1 and L_2 — both 650mH, see text.

All parts and components can be obtained from: J. H. Asbery, 87 Oakington Manor Drive, Wembley, Middlesex.

Books Received

Telecommunication by Speech: the transmission performance of telephone networks by D. L. Richards presents a co-ordinated account of the principles and practice of telephone communication system design from the viewpoint of transmission performance. It presents a classification of knowledge in each branch of the subject and provides a method for translating the basic requirements for speech communication into performance standards and rules for system design that not only takes account of the variety of transmission and switching systems, but also the important economic factors involved. Price £12.00 Pp. 589. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

World Radio and TV Handbook 1973; 27th edition edited by J. M. Frost contains in the first section instructive articles relating to broadcasting, and information on broadcasting and television organizations. The main section of the book contains detailed information, country by country, of the radio stations and broadcasting organizations of every country in the world. Included are names and addresses of broadcasting companies, names and titles of leading officials, lists of broadcasting stations in each country including frequencies, wavelengths, transmitter power, call signs and station names. Programme schedule information is also listed, including times, frequencies, and beam areas of the broadcasts. Price £3.00 Pp. 400. Billboard Publications Inc., 7 Carnaby Street, London W1V 1PG.

Electronic Display and Data Systems: Constructional Practice by C. J. Richards. Both main elements of display and data systems — generation (and refinement) and display — must be mounted, housed and connected, and the operators' working conditions must be such that they will be able to concentrate on making the best use of the display. There must be mechanical engineering in support of the electronic engineering, and in value it can amount to 40% of the total cost of a system; there must therefore be co-operation between the engineers. To improve co-operation is the purpose of this book. It gives the electronic engineer an understanding of the mechanical aspects of an installation, and the non-electronic engineer an appreciation of the problems of the circuit designer. Price £9.00. Pp. 459. McGraw-Hill Book Company (U.K.) Ltd, Maidenhead, Berkshire.

Electronics: A Course Book for Students by G. H. Olson is a shortened and revised version of "Electronics: A General Introduction for the Non-Specialist". It is written specifically as a qualitative introduction with a minimum of mathematics and circuit analysis. The opening chapters introduce resistors, capacitors, inductors, transistors, diodes and their response to voltage and current changes. Subsequent chapters discuss indicating instruments, power supplies, amplifiers and oscillators. The book will be of value to all non-specialists and in addition should provide a useful text for the undergraduate in electrical or electronic engineering or to supplement more analytical books. Price £2.60. Pp. 351. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

M.O.S. Integrated Circuit Design edited by E. Wolfendale describes the metal oxide silicon transistor with the basic design equations

derived, physical effects explained and typical values given. The basic logic elements used by the m.o.s. designer are taken in turn and translated into the dimensions necessary to create the mask for their fabrication. The layout of a fully integrated chip and the achievement of maximum density of devices are described. Checking and correction using logic simulation and an interactive graphics console form the final stage. The last chapter is an example of the design of a small chip, showing how all the techniques described are brought together to solve a practical design problem. Electronic equipment designers who are increasingly involved in the use of custom designed m.o.s. circuits will find this book a useful practical guide. It will also enable students to familiarize themselves with the techniques involved. Price £4.00 Pp. 120. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

Pattern Recognition Techniques by J. R. Ullmann provides a broad introduction to a subject which is becoming increasingly important in the processing of data where the use of human effort may be precluded by the number of patterns to be recognized, the speed of recognition required or simply by economic considerations. Examples range from recognition of fingerprints to faces and from cars to cardiograms, but it is the recognition of written and printed characters which has been most widely investigated and applied. Many different disciplines have to be considered: optics, statistics, switching theory, graph theory and Fourier analysis — these are introduced in simple terms so that specialist knowledge is not required. The book has been written for engineers, computer scientists and biologists and all those whose work is presenting them with the problems of automation of pattern recognition. Price £10.00 Pp. 412. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

Elements of Linear Microcircuits by T. D. Towers is based on a series of articles written by the author for *Wireless World* and gives practical guidance on the selection of commercially available devices. It shows how to use the wealth of circuit functions available and gives considerable attention to the practical aspects of handling these sensitive circuits in practical assemblies. The emphasis throughout is on applications and the every-day problems of designing electronic equipment rather than production technology. Chapter subjects include packaging, selection, handling, op-amps, audio, i.f. and wideband amplifiers, voltage regulators, radio and TV receivers. The book should be of great value to engineers in research and development laboratories and students at ONC/HNC level upwards. Price £2.80 Pp. 108. Butterworth & Co. Ltd, 88 Kingsway, London, WC2B 6AB.

Satellite Broadcasting by Chayes, Fawcett, Ito and Kiss sets out the questions and answers to a questionnaire initiated by the International Broadcast Institute concerned with the social, economic and legal problems that satellite broadcasting brings. Price £5.00 Pp. 159. Oxford University Press, 37 Dover Street, London W1X 4AH.

Making and using Electronic Oscillators by W. Oliver is a practical guide to the use of oscillators in radio, TV, telecommunications and other electronic applications. Price £2.00. Pp. 120. W. Foulsham & Co. Ltd., Yeovil Road, Slough, Bucks SL1 4JH.

World of Amateur Radio

Power plus?

American journals from time to time take a cold look at the state of amateur radio in their country — and do not always like what they see. A recent outspoken editorial by Richard Ross, K2MGA, editor of *CQ*, comments severely on the apparent decline in the ethical standards of a small but growing number of amateurs; he claims that not a single day passes without examples on the amateur bands of "broadcasting, music transmissions, obscenity, false signals, unidentified communications and malicious interference" but considers that the most flagrant abuse of the regulations is in the area of excessive power.

Richard Ross recalls that only a few years ago a full 1kW (the legal limit for amateurs in the United States) was the dream of amateurs, and for most an unattainable dream. "Technological advances and greater affluence have made a joke of that dream . . . the kilowatt amplifier is as much a part of the amateur scene as the transceiver . . . the kilowatt linear serves all too often as an exciter . . . several firms make no secret of the availability of 4, 6 or even 10kW amplifiers . . . but the galling thing is the growing number of 'amateurs' on the air with 50 or more kilowatts at their finger tips for use when the going gets tough."

"How do you begin to return to sane attitudes towards transmitter power?" he asks, adding "The strongest weapon against known violators of the legal limit is the contempt of his peers . . . treat him as an outlaw and watch him react . . . that's what our self-policing tradition is all about".

Even allowing for an element of journalistic licence, the idea of 50kW transmitters being used with high-gain aerials on the amateur bands is something to make amateurs stop and think. The expression "Californian kilowatt" to cover the use of power a little above a kilowatt is almost traditional — but now it seems we could really be approaching the days of amateur operation with a *megawatt* of effective radiated power!

Satellites and special tests

Oscar 6 is now usually active for five instead of four days each week, being switched off for battery re-charging only on Tuesdays and Wednesdays. The first British amateur to gain the new A.R.R.L. Oscar 6 "1000" Award (*WoAR*, March) is P. J. A. Gowen, G3IOR of Hellesdon near Norwich; his 144MHz has 12 watts output

to a "six-over-six" stacked slot-fed Yagi 33ft high. Among his best long-distance contacts through Oscar 6 have been K7BBO (4780 miles) and W5ORH (4556 miles). The French amateur Marc Tonna, F9FT at Reims has already made over 2500 contacts in more than 40 countries through Oscar 6.

The next Oscar satellite is being planned to carry three transposers: one for 432 to 144MHz and two for 144 to 29MHz which are being designed for an active life of the order of three years.

French amateurs are planning further balloon-carried transposer launchings this year, including the "Mirabel" which is scheduled for May 20; the transposer accepts 432.1 to 432.4 MHz and retransmits on 145.6 to 145.9MHz. Launchings of the "Anjou" series are planned for May 31, July 4 (or June 24), July 29, August 26 and September 23 (or October 21), although it is not certain that all these launchings will prove possible.

During the total eclipse of the sun on June 30, an h.f. propagation experiment will be conducted by A. Duffau, 5T5AD who will be in Akjoujt operating the special station 5T5SOL between 1000 and 1100 UT with KWM-2 transceiver and omnidirectional aerial (it is possible the station may function as an automatically keyed beacon).

The IARU Region 1 has asked the R.S.G.B. to re-plan frequencies of the entire European network of v.h.f./u.h.f. beacon stations.

Narrow-band f.m. on 144MHz

Karl Kanalz, G5AGX (6 Wood End, Hayes, Middx) of the U.K. FM Group (London) feels the item last month "a question of deviation" described the compatibility question of f.m. operation from the viewpoint of a.m. operators and notes that some a.m. and s.s.b. signals are equally wideband. He believes that most a.m. operators on 144MHz in the London region are misinformed about what constitutes a specified bandwidth for a signal — be it a.m., f.m. or s.s.b. — and do not have equipment capable of measuring transmitted or received bandwidths.

He says that the U.K. FM Group has set itself the task of showing newcomers to f.m. how to ensure that equipment is set up for true n.b.f.m. with deviation not greater than ± 3 kHz by making available suitable test equipment for the alignment of equipment. They are also hoping to establish similar groups in other parts of

the country. He believes that it is possible to clean up any "wideband" problems since almost all transmitters can be adjusted for narrow-band operation. He admits that some present receivers will not provide optimum signal-to-noise ratio on narrow signals although the FM Group is supplying narrowband filters for receivers. He agrees that problems can arise (on all modes) from the use of wide tolerance crystals.

Certainly our earlier comments were not intended to discourage the use of true n.b.f.m. but rather to draw attention to the problems that can arise when f.m. equipment is used without understanding the implications of deviation adjustment.

In brief

The British Amateur Radio Teleprinter Group is holding its second annual convention on Saturday, June 30 at Meopham Village Hall, Meopham, near Gravesend, Kent (11 a.m. to 6 p.m.). During the afternoon lectures will be given on r.t.t.y. operation, G4ATG will operate r.t.t.y. on 14090kHz and there will be a "teleprinter art competition" (tapes to D. Goacher G3LLZ). Further information from G. Shirville, G3VZV, 2 Orchard Close, Toddington, Dunstable (Toddington 2470) A recent World Radio Club interview with the former Irene Marcuse, widow of Gerald Marcuse, G2NM, described how "Empire" broadcasting was launched informally from G2NM at Caterham in the autumn of 1927. A special licence was granted by the Post Office and the broadcasts covered a period of about two years. Apart from many musical and other "live" broadcasts there were also re-broadcasts of B.B.C. medium-wave programmes; the transmissions were the first to broadcast the chimes of Big Ben to a world audience. The station operated on 32 metres with $1\frac{1}{2}$ kW from an excellent site with a 100ft mast and was heard all over the world DK0IEC is a special station being set up at Munich during the meetings of the International Electrotechnical Committee from June 15 to 29 Mobile rallies during June include: May 30 to June 2, Bath & West Show (Shepton Mallet, Somerset); June 10 Elvaston Castle Countryside Park, near Derby; June 17 Amateur Radio Mobile Society (RAF Cosford, 8 miles north-west of Wolverhampton); June 24 Bristol R.S.G.B. Group, Longleat, Wiltshire Hull & District Amateur Radio Society have a mobile rally on May 27 at the East Riding College of Agriculture, Bishop Burton, near Beverley (A1079 road) the R.S.G.B. is raising its Corporate membership subscriptions from July 1 American amateurs WA2LTM and W9WCD have raised the 23cm distance record from 551 to 770 miles Irish amateurs can now use an extended 70MHz band (70125 to 70450kHz) and consideration is being given to a telephony-only licence for v.h.f. operation The Irish Radio Transmitters Society celebrates its Diamond Jubilee in June — it was formed as the Dublin Wireless Group in June 1913.

PAT HAWKER, G3VA



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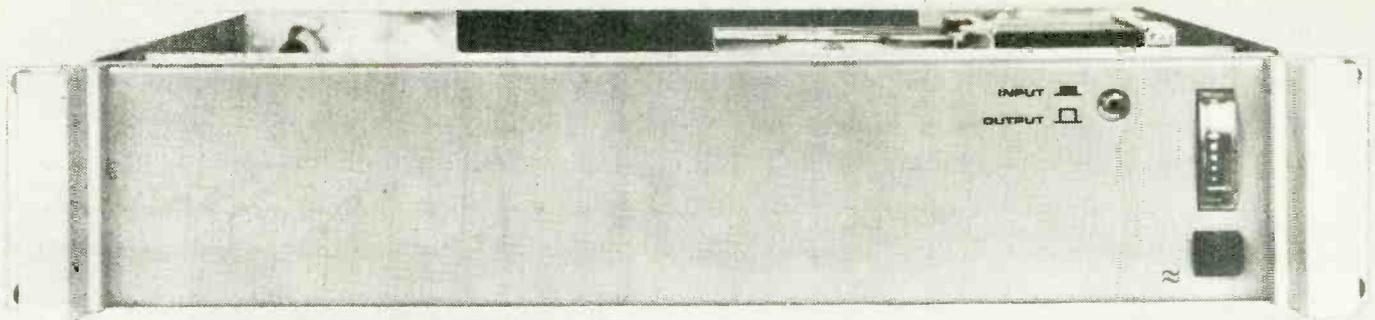
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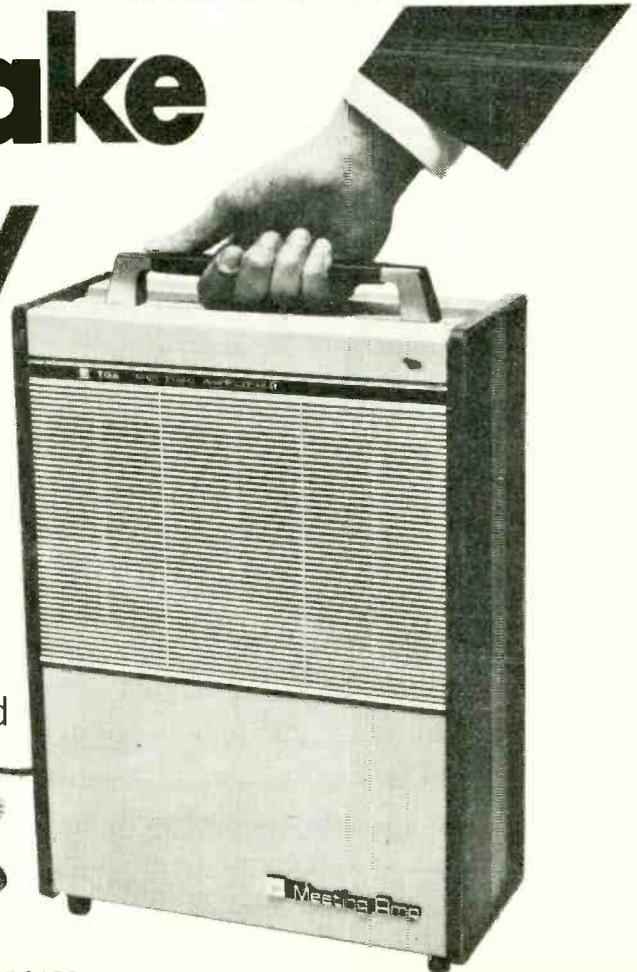
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WW-096 FOR FURTHER DETAILS

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WW-097 FOR FURTHER DETAILS

New Products

Modular display system

The Series 1400 is a mounting and driving system for the Sperry SP750 information displays and is made by Spectra-Tek U.K. The displays are mounted in an extruded aluminium bezel, complete with decoders, panel fixing arrangement and a red or orange polarizing filter which carries a title strip area below the characters. Arrays of any length from two digits upwards may be ordered and they are delivered fully assembled and tested.

The life expectancy is 100,000 hours and at full brightness the 14mm high characters are said to be easily readable in direct sunlight at a distance of 40ft over a viewing angle of 130 degrees.

Connections to the t.t.l. decoders are via gold-plated edge-connectors and, in addition to full numerical display, the decoders are also capable of providing six alphabetical characters. Decimal points are fitted and a ± 1 unit is available.

With a bezel height of 35mm, character spacing of 13.5mm and a depth of only 32mm, the 1400 Series offers an alternative solution to display problems at £6 per decade complete.

Spectra-Tek U.K. Ltd, Kirkby Moorside, York YO6 6DW.

WW315 for further details

Instruments knobs

West Hyde Developments are now entering the knob market. The ranges to be sold by them will all be under their existing trade name Contil. Insulation is by means of a bush between the body of the knob and the shaft, to comply with German V.D.E. standards

These knobs also have interchangeable dials of various colours and a dial lock. This provides a positive lock so that the knob cannot move by vibration but allows the setting to be easily changed. It also provides a scale line if required. Fixing is by grub screw and the shaft size is 4mm or 6mm.

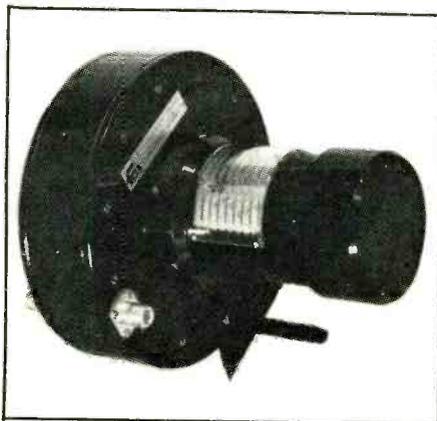
The knobs cost from 22p for 100 off for the small knob to 43p for the largest knob with a coloured skirt and a line. The dial locks cost between 15p and 23p,

depending upon quantity and line. West Hyde Developments Ltd, Ryefield Crescent, Northwood Hills, Northwood, Middlesex HA6 1NN.

WW305 for further details

Coaxial frequency meter

The model FMC 1 coaxial hybrid frequency meter, operating from 0.3 to 1GHz, is the low frequency version of a family of three such instruments designed for the 0.3 to 12GHz band of frequencies by Flann Microwave Instruments. Each instrument is of the absorption type and utilizes a mode change from coaxial to circular operation, thus providing extra



wide frequency coverage without spurious resonance. The multi-turn helical dial/drive mechanism is directly calibrated in GHz and gives high resolution throughout. The FMC 1 calibration accuracy is ± 1 MHz, and Type N connectors are fitted as standard. Flann Microwave Instruments Ltd, Dunmere Road, Bodmin, Cornwall.

WW304 for further details

Pocket pulser

Semra-Benney announce the introduction of the pocket pulser type 2113. This device is a miniature, self-powered source of pulses intended for quick checks on instruments and systems. Designed in the European Organization for Nuclear Research (CERN), Geneva, the pocket pulser is primarily intended for checking systems which monitor signals from photo-

multipliers, although it has many other obvious applications. The output is very similar to that obtained from a photomultiplier, having a 2.5ns rise and 5ns fall time.

Powered by a small mercury cell, it will deliver pulses continuously for over 300 hours into 50Ω before a battery change is necessary, and this, together with the long shelf-life of the battery, means infrequent battery changes. No power is used until the pulser is terminated by a load and there are no switches or moving parts.



Specification:

Output amplitude	— 1V $\pm 10\%$ neg. going into 50Ω via a miniature coaxial socket (Lemo type 00250)
Risetime	— 2.5ns
Pulse width	— 5ns
Repetition rate	— 12kHz $\pm 30\%$ (fixed)
Load	— 50Ω direct-coupled (Note: load must always be direct-coupled)
Output impedance	— Low impedance in series with 47pF capacitor
Power source	— Mallory Duracell TR152R (mercury)
Dimensions	— 60.325 \times 44.45 \times 19.05mm
Weight	— 56.7g
Case material	— A.B.S.
Price	— 1-9. £29.50 including battery and miniature mating coaxial output connector, plus v.a.t.

Semra-Benney (Electronics) Ltd, Chandler's Ford, Hampshire SO5 3ZU.

WW 309 for further details

Square wave inverter

A square wave inverter marketed by Gardners Transformers is of high power rating and will operate a wide range of 240, 50Hz equipment. Two versions are available — Type 107A for use from 12V batteries and Type 107B for 24V d.c. systems.

The 300W rating is claimed to be conservative and obtainable even when used with a single 12V car battery. This continuous rating is coupled with an

adequate short-term overload capability, permitting the use of the inverter not only for resistive loads but now also for small electric motor-driven tools such as drills, polishers, and sanders which take substantially more current for starting than when running.

The frequency is almost independent of input voltage and load, and thus the unit can be used to drive tape-recorders and similar instruments employing synchronous motors. The inverters are supplied at a price of £61 ex works. Gardners Transformers Ltd, Christchurch, Hants.

WW322 for further details

Double-balanced mixer

Watkins-Johnson has introduced Model M1K double-balanced mixer, a high-intercept, wideband unit in a hermetically sealed package. It is said to provide superior two-tone performance over the frequency range from d.c. to 4GHz. With only +23dBm local oscillator drive level, this mixer has a +28dBm (typical) input third-order intercept point. With two input tones at 0dBm, the third order products will be typically suppressed 56dB relative to the desired output.

The M1K is also designed for a low noise figure — typically 6dB. In addition, +10dBm of output power can be obtained. This is important in up-converting applications where low-frequency amplification can be substituted for expensive microwave amplification.

Best isolation (typically greater than 30dB) is achieved by feeding the high-level i.o. signal to the L-port. Both L- and R-ports are a.c.-coupled and have a 1 to 4GHz frequency response. The I-port is d.c.-coupled and has d.c. to 1GHz frequency response.

Minimum conversion loss is achieved by providing an i.o. level of +20dBm. At this level, conversion loss is typically 6dB. For minimum intermodulation products, the input signal level is recommended to be as low as possible. Watkins-Johnson International, Shirley Avenue, Windsor, Berks.

WW324 for further details

L.S.I. socket with retaining cover

Jermyn Manufacturing have announced an addition to their range of specialized i.c. sockets. The main features of this socket, which is for 36-lead l.s.i. devices, are said to be very low insertion force and extremely low contact resistance. Normally, low contact resistance means high insertion force, and vice versa, but these two conflicting requirements have been optimized by employing a hinged cover which clamps over the i.c. after it has been placed in position. The cover when fitted, applies side pressure to the contacts, forcing them against the legs of the i.c., thus achieving a contact resistance on only 10mΩ.

A secondary benefit which is claimed to result from this arrangement is that i.c.s. can be inserted in, and withdrawn from, the socket at high speed without fear of damage to the fragile i.c. legs. The socket, which is moulded in glass-filled polycarbonate, is fitted with gold-plated phosphor bronze contacts, to give long term reliability and resistance to environmental extremes. Jermyn Manufacturing, Vestry Estate, Sevenoaks, Kent.

WW318 for further details

L.F. charge amplifier

B & K Laboratories have announced a low frequency charge amplifier for use with piezoelectric force and vibration transducers. Known as the Type 2628, it is said to be particularly suitable for handling very low frequency and quasi-static signals, and, depending on its gain setting, it has time constants of up to 100,000 seconds. This corresponds to a low frequency limit of 2μHz, the upper frequency limit being 100kHz. These

frequency limits are adjustable by step controls of high pass and low pass filters, the active low pass filter being incorporated so that unwanted higher frequency signals can be suppressed. A 3 digit variable "sensitivity conditioner" is provided in dial form and can be used to adjust the charge amplifier to the exact sensitivity of the transducer being used. The adjustment range is between 1 and 110pC/unit, and the position of the decimal point is automatically indicated by signal lights. The input of the 2628 itself automatically eliminates errors due to long connecting cables. Stage gain is step controlled and allows the signal output to be varied from 0.0001V/unit to 10V/unit. Two signal level indicators are provided. The first indicates overload at the input or output stage and the second lights when the signal is within 20dB of the full output, thus indicating the best output signal level for minimum noise. B & K Laboratories Ltd, Cross Lances Road, Houslow, Middx.

WW306 for further details

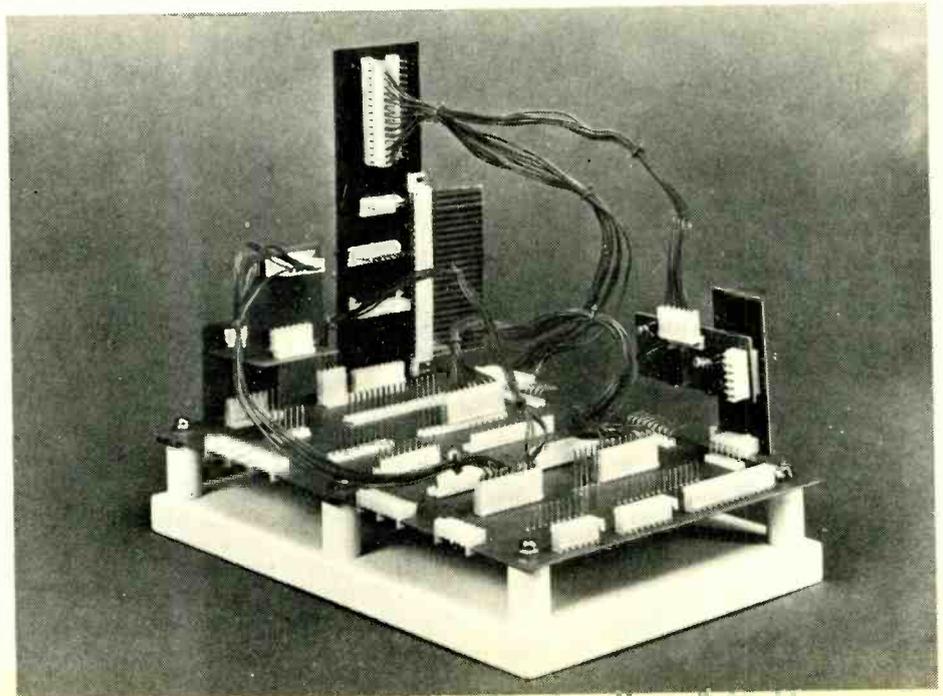
P.C.B. connection system

A new technique in printed-circuit board interconnections is now available from Molex International. Called Konekton, the system utilizes rigid wire terminal points and claims to solve design, electrical and mechanical problems commonly associated with use of copper pads as contacts on p.c. boards. The connectors in the Konekton series are injection moulded and can be supplied in a variety of materials centre spaced on 3.962mm and 5.08mm with a straight-forward design. Internally, each connector terminal has the same basic spring configuration, a double cantilever. By restricting the opening in the connector and by allowing no pin larger than

2.032mm diameter to enter, the terminal cannot be overstressed.

In addition, by restricting the connector's end wall thickness, several connectors can be placed next to each other without sacrificing a circuit. With various combinations of 3-, 4-, 5- or 6 — circuit connector housings, for example, any number of circuits from 3 to 24 can be terminated with no more than four connectors. Maximum wire size the terminal will accept is 20 gauge. Rigid, square or round wire 1.143mm diameter is recommended as the male terminal, but other wire sections can be used. Molex International, 14 Yeading Lane, Hayes, Middlesex.

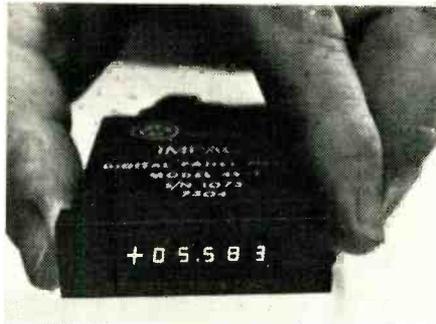
WW308 for further details



Digital panel meters

Varian's Velonex Division introduces a range of digital panel meters of small size. These are named Impac (Instrument Meters Packaged as Components). The meters are available in models displaying 3, 3½, 4 or 4½ digits. Dimensions of all models are identical: front panel area is less than 1.7 sq.in. and the volume is less than 3 cubic inches. Other major features of the meters are:

- Low power consumption; less than 0.3W on standby and less than 1W with all characters illuminated.
- Automatic zeroing. Before each internal measurement cycle an automatic zeroing circuit calibrates the meter against any offset or drift errors that may have occurred. There is no need for manual zeroing. In fact, the meter needs only one kind of manual adjustment, a normal, full-scale calibration, and this can be done as infrequently as twice a year.
- L.e.d. display with a \pm sign and decimal point give long life and easy, unambiguous readings.
- Inputs and outputs necessary for the system user are standard with the Impac meters, including b.c.d., strobe, end-of-conversion, sign and overload outputs. Inputs include convert and



hold, display and sign blanking. All signals are compatible with d.t.l./t.t.l. logic. Decimal point can be placed before any digit or omitted altogether. Some salient specifications of this range of digital panel meters are:

Warmup time less than 10 seconds to stated accuracy.

Accuracy 0.1% of reading for 3 and 3½-digit units; 0.05% of reading for 4 and 4½-digit units.

Temperature coefficient, 0.01%/°C, 10°C to 40°C.

Operating temperature range, 0°C to 50°C.

Sample rate: 10 per second for 3 and 4-digit meters; 7 per second for 3½ and 4½-digit models.

Weight, less than 3.5 oz.

F.O.B. prices — single quantity: series 30, 3-digit, \$112; series 35, 3½-digit, \$125; series 40, 4-digit, \$169; and series 45, 4½-digit, \$225.

Varian Benelux B.V., Postbus 9158, Maassluisstraat, 100, Amsterdam.
WW 313 for further details.

TV masthead amplifier

The new Star u.h.f. masthead amplifier from Belling-Lee increases signal levels by approximately 4 times, helping to give good quality television picture reception in fringe and secondary service areas. Three versions of the amplifier cater for reception on channels 21-34, 39-51 and 49-68. The power supply unit, moulded in flame retarding plastic, provides 15V d.c. for the masthead amplifier via the coaxial down lead. Belling and Lee Ltd, Great Cambridge Road, Enfield, Middx. EN1 3RY.

WW303 for further details

Multipurpose test instrument

The Versatester 1 from Systron-Donner provides, in a single instrument, signal sources, power sources, a digital multimeter and a counter. Improved serviceability is claimed as the basic instrument can, in large part, be used for self-test and calibration. The major features are:

Supplies d.c. power, +5V, +15V, -15V, \pm 30V

Generates 20Hz to 20MHz: pulses; sine waves; and square waves

Digitally measures and displays to four digits: frequency, auto ranging 20Hz to 20MHz; d.c. volts, 0-500V in 4 ranges; a.c. volts, 0-500V in 4 ranges, and d.c. ohms, 0-5M in 5 ranges.

Systron-Donner Corporation, Data-pulse Division, 10150 West Jefferson Blvd., Culver City, California 90230.

WW302 for further details

Educational logic kit

A set of educational equipment announced by Opto Electronic Displays Ltd consists of a power supply unit, a logic tutor and an analogue/control kit.

These three pieces of equipment were developed for the Open University Technology courses and the set is now to be made available to educationalists, electronics and computer-science-based industries. The power supply gives +5 volts, and has a meter and switched ranges, also variable outputs and current limiting circuits.

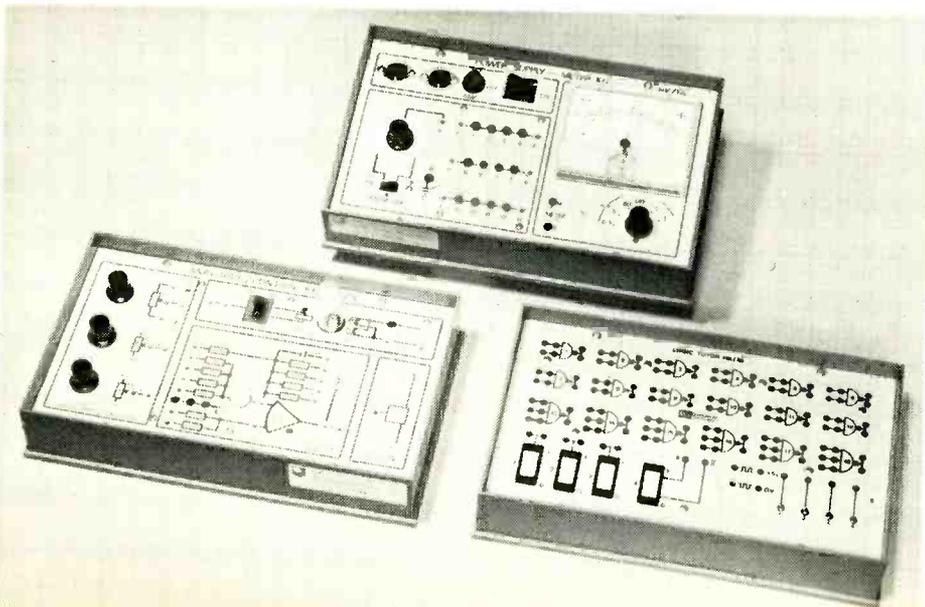
The logic tutor has 18 NAND gates,

4 switches and 4 output lamps which can be wired together with plug-in leads to investigate simple or complex circuits.

The analogue/control kit was designed specifically to teach simple analogue computing and control systems. It is based on the universally accepted 741C operational amplifier.

These units are marketed by the Open University and are available with text and course material in the form of books. Opto Electronic Displays Ltd, 269a Haydons Road, Wimbledon, London S.W.19.

WW312 for further details



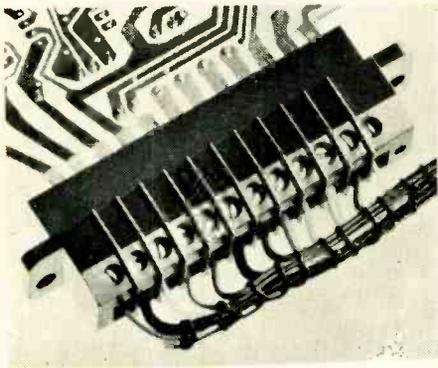
Digital multiplex clock

Designed for use in recording studios and by those engaged in the production of audio visual presentations, the Electrosonic ES1857 digital multiplex clock records on to tape the time elapsed in minutes, seconds, and half-seconds. Each time signal is recorded as a complete piece of information so that on replay it becomes possible to see the exact time information wherever you are on the tape. It is not a counting system, so there is no need to start from a specific point on the tape and any tape recorder with reasonable bandwidth can be used. The U.K. price of the ES1857 is £330.00. Electrosonic Ltd, 815 Woolwich Road, London SE7 8LT.

WW325 for further details

Edgeblock connector

Pye Connectors announce the availability of a component they believe to be unique. Called the Edgeblock, it combines in one moulding a printed circuit board edge



connector and a screw terminal block. The Edgeblock has a single row of 12 contact positions on 5.08mm pitch and is designed to accept p.c.b. thicknesses from 1.37mm to 1.88mm. The gold-plated phosphor bronze screw terminal contacts are rated at 5A and can accommodate wire sizes ranging from 7/0.22mm to 19/0.3mm. The dielectric moulding is grey self-extinguishing a.b.s. having a working temperature range of minus 20°C to plus 80°C. Pye Connectors Ltd, Hitchin Street, Biggleswade, Beds.

WW301 for further details

Studio Recorder

Scully Recording Instruments, a division of Dictaphone Corporation, have announced a new professional recorder/reproducer called the 280B. The new unit combines completely redesigned electronics and a new tape motion sensing system.

Specifications for the 280B include signal to noise ratio of 72dB at mastering speeds. Bandwidth is essentially flat, displaying ± 2 dB 30Hz to 18kHz. Mother-daughter board architecture results in a "clean" electronic cabinet and all test and adjustment points are readily accessible from a comfortable working position. The electronics slide out on roller arms and the individual channel modules are easily removed.

A new motion sensing system, called OPTAC, and internal logic enable the engineer to select a new mode and activate it without touching the stop button first. It also allows the engineer to enter and leave the record mode while the transport is in play.

Selective synchronization is standard on all multi-channel machines, thus there is the inherent ability to sequentially record programming material synchronous with previously recorded tracks.

The 280B series is available in either rack or console configurations, with 1, 2 and 4 channel models using most of the popular head configurations. Dictaphone Company Ltd., 14 Broadway, London S.W.1.

WW 326 for further information.

Counter timer

Racal Instruments have introduced the Model 9523 VLF Counter Timer. A reciprocal computing capability is utilized at low frequencies to improve frequency measurement resolution up to 1000 times, in four ranges covering 0.1Hz to 1kHz. An example of the claimed improvement in resolution is that a 50Hz signal would be displayed as 50.00Hz in little more than a second, or as 50.000Hz in about ten seconds.

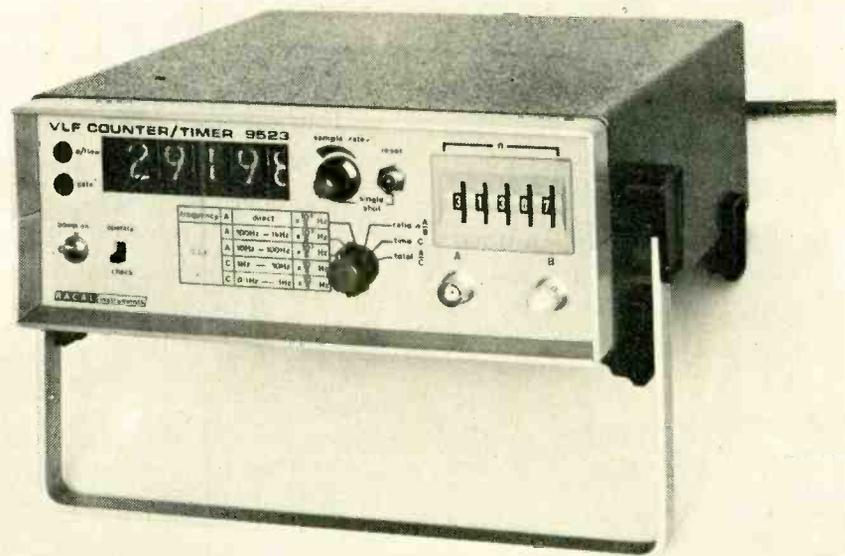
The instrument measures frequency, frequency ratio, time interval and totalized counts in the 0.1Hz to 10MHz range. The variable digital timebase enables the instrument to be used in a variety of industrial applications where the presentation of measurements in "engineering units" is often essential, and

direct readings in terms of r.p.m., litres per minute, miles per hour etc. can be obtained by selection of the correct gate time.

Three input channels are provided, two for direct frequency and frequency ratio readings and the third for v.l.f. measurement and as a gating channel for time interval measurements. In timer applications the start/stop signals may be electrical or contact closures with incorporated circuitry, to avoid false operation due to contact bounce.

The counter timer is of half-rack dimensions, 100mm in height, and weighs 2.7kg. Optional additions include b.c.d. data outputs and rear mounting inputs sockets. Racal Instruments Ltd., Duke Street, Windsor, Berks. SL4 1SB.

WW323 for further details



Solid State Devices

S.D.S. Components, the distributors for a number of semiconductor manufacturers, have announced the availability of the Signetics 82S90 Schottky decade counter which features typical clock rates of up to 100MHz. The device can be made to function as a decade counter with a b.c.d. output, as a decade counter in the bi-quinary code or as separate divide-by-two or divide-by-five counters.

A second Signetics device also from S.D.S. is the 2533V, a 1024-bit static shift register. This utilizes silicon gate p-channel m.o.s. construction, is t.t.l. compatible and is available in an 8 pin d.i.l. package that is exactly one half the length of a standard 16 pin d.i.l. A guaranteed 1.5MHz operating rate is offered for a power consumption of only 250W per bit.

Included in this month's announcements are details of the Plessey SL440, a power control circuit consisting of a triac firing circuit, a zero crossing detector, a servo amplifier and a timing circuit in a single package. The servo amplifier can be connected as an integrator to provide for a wide range in the rate of change of power in the load. The SL440 produces a 50 μ s, 60mA pulse to fire the triac and

provides a stabilized 11.3V power supply for external circuitry. SDS Components Ltd, Hilsea Trading Estate, Portsmouth, Hants PO3 5JW.

WW330 decade counter

WW331 static shift register

WW332 power control circuit

New from R.C.A. is a range of devices for consumer applications. The CA2111A integrated circuits contain f.m.-i.f. amplifier limiters driving a quadrature f.m. detector. They feature low a.f.c. voltage drift over the full operating-temperature range, an input limiting voltage (knee) of typically 400 μ V at 10.7MHz and 2.5 μ V at 4.5MHz and 5.5MHz. The a.m. rejection is typically 45dB at 10.7MHz and finally the device represents a direct replacement for the Sprague ULN2111A and the Motorola MC1357. Suitable for use in colour or monochrome receivers is the RCA CA3120E, a signal processor incorporating a sync separator, noise inverter, a.g.c. comparator and an r.f.-a.g.c. delay amplifier.

The CA3096E and CA3096AE are n-p-n/p-n-p transistor arrays for general purpose use. They consist of five independ-

dent transistors, two p-n-p and three n-p-n types on a common monolithic substrate with separate connections for each transistor. The CA3096AE differs in that it has a matched n-p-n transistor pair. The devices are packaged in a d.i.l. 16-pin case.

Designed for u.h.f. power applications, the RCA 40970 is a silicon n-p-n epitaxial planar r.f. power transistor with internally mounted capacitors which provide an individual T matching network for each base cell. This design is said to provide a high input resistance and a low input Q to increase its broadband performance.

Three new liquid crystal display drivers that provide level shifting functions are also available on a limited sampling basis only, in 16 lead d.i.l. ceramic packages. They have preliminary designations CD 4054A, CD 4055A and CD 4056A.

The last device announced from RCA this month is a programmable power switch/amplifier integrated circuit family, types CA3094T, CA3094AT and CA3094BT. These differ only in supply voltage ratings, — up to 24V, 36V and 44V respectively. They have a power switching capability of over 10W peak or 3W average and can be programmed to idle at microwatt power levels. R.C.A. Ltd., Solid State Europe, Sunbury-on-Thames, Middlesex.

WW333 f.m.-i.f. amplifier-limiter

WW334 signal processor i.c.

WW335 transistor arrays

WW336 u.h.f. power transistor

WW337 liquid crystal drivers

**WW338 programmable power switch/
amplifier**

Celdis, distributors for General Electric, General Instruments, Transitron and Mullard, announce new devices from these manufacturers.

First, from Transitron comes the 745 series high speed Schottky t.t.l. These devices offer fast switching at low power levels, the range featuring typical propagation delays of 3ns with a power dissipation of 20mW per gate and 100MHz typical flip-flop clock input frequencies. Typical 100 up prices are 75p each for gates and £1.74 for flip-flops.

General Instruments have produced a new range of diodes given the generic name of Glass-amp II among which Celdis feature the 1N5059-1N5062 series. These have voltage ratings from 200 to 800V, and an average forward current rating of 1A at 75°C or 750mA at 100°C. Prices for the 200V version, 1N5059, are 7.5p each and for the 800V version 1N5062 are 10.3p each (both prices at 100 up rate).

A new range of 15W zeners from Mullard are also stocked by Celdis, these being designated the BZV15 family. The devices will withstand a 600W surge rating and provide reference voltages from 10 to 75V with 5% tolerance on individual device ratings. Typical price is £0.284 + 2% each at 100 up rate.

Designed for the suppression of surge voltages and the protection of instrumenta-

tion and circuits, the metal oxide varistor (m.o.v.) is a new product from General Electric. These components are similar in size to a T05 transistor and are characterized by a response speed of 50ns. Variations are available for use on 130, 150 and 250V a.c. applications, capable of absorbing energy surges of 1, 2 or 4 joules, and, depending on type, of withstanding peak currents of 75A or 150A (7 μ s pulse width). Also from G.E. is a complete new family of photon coupled isolators capable of withstanding a surge voltage (input to output isolation) of 4000V. Known as the H15 series the devices are enclosed in a new 4-pin plastic package with pin spacing compatible with the normal d.i.l. centres. A range of variations is available from a simple photo-transistor and solid state lamp, to types which have their output in the form of a photo-Darlington array. General Electric have also announced the introduction of the H13 series of photon coupled interruptor modules designed to accept the edge of a computer card, tape or shaft encoder between the two components of the device to interrupt the signal. Celdis Ltd., 37/39 Loverock Rd., Reading, Berks RG3 1ED.

WW339 Schottky t.t.l.

WW340 rectifier diodes

WW341 zener diodes

WW342 metal oxide varistor

WW343 photo coupled isolators

WW344 photon coupled interruptors

New products added to the catalogue of G.D.S. (Sales) include an operational amplifier from Teledyne, several devices by Harris and some new digital devices from Motorola. The Teledyne 2740 is a hybrid operational amplifier with output short circuit protection, input overvoltage and latch-up immunity, internal 6dB/octave frequency compensation and an external offset voltage null capability. Limit parameters are quoted for a temperature range of 0°C to + 100°C and are as follows. Open loop gain 86dB, offset current 5nA, bias current 10nA, and offset voltage drift 10mV. Two new dual transistors with a 3 μ V/°C maximum base-emitter differential voltage drift have now been produced by Harris. Designated types 2N5117 (p-n-p) and 2N4044 (n-p-n) these are available in the standard 6-pin TO-78 package. Where the high performance of these devices are not required, the 2N4100 (n-p-n) and 2N5118 (p-n-p) with a 5 μ V/°C drift, or the 2N4045 and 2N5119, with a 10 μ V/°C drift are offered as alternatives. Also from Harris are the so-called fourth generation operational amplifiers which employ dielectric isolation and vertical p-n-p transistors which provide closed loop bandwidths up to a claimed 100 times better than conventional 741 devices operated at the same gain. These new amplifiers, the HA2605 and HA2625, have typical d.c. characteristics of 5nA offset current, 300M Ω input resistance and 80,000 minimum large signal open loop gain. The HA2605 is internally compensated and has a 12MHz gain-bandwidth product, full power band-

width of 75KHz, and a 7V/ μ s slew rate. The HA2625 is the uncompensated version of the HA2605 with 100MHz gain bandwidth product, 600kHz full power bandwidth and a 35V/ μ s slew rate. A bandwidth control pin is available on both amplifiers so that bandwidth can be specified where necessary.

A further two Harris operational amplifiers are characterized by fast slew rates. The HA2525 has a 120V/ μ s slew rate, 1.6MHz full power bandwidth and a 0.1 μ s settling time to 0.1%. An internally compensated version, the HA2515 has a 60V/ μ s slew rate, 1MHz full power bandwidth and 0.25 μ s settling time.

Finally three Motorola digital devices are introduced by G.D.S. The MC14527 is a b.c.d. rate multiplier (m.o.s. type) that provides an output pulse rate based upon the b.c.d. input number. A seven-segment latch/decoder/driver, type MC14511, represents a new addition to the Motorola c.m.o.s. family and provides the functions of a 4-bit storage latch, an 8421 b.c.d.-to-seven-segment decoder and an output drive capability. Also from the c.m.o.s. range of devices is the MC14528CL, a dual monostable multivibrator which may be triggered from either edge of the input pulse and will produce an output pulse with a width from 0.3 to 100 μ s. The device is packaged in a 16-pin d.i.l. case and costs £1.302 in 100 plus quantities.

G.D.S. (Sales) Ltd., Michaelmas House, Salt Hill, Bath Rd., Slough, Bucks.

WW 345 hybrid op-amp

WW 346 dual transistors

WW 347 fourth generation op-amps

WW 348 fast slew op-amps

WW 349 c.m.o.s. devices

S.G.S. Ates have introduced a new range of complementary m.o.s. devices some of which are to be made available later this year. Initially, it is intended to second source the CD4000A range manufactured by R.C.A. and from whom S.G.S. Ates have purchased the technology licence. The new range is to be identically numbered with the originals.

Four new complementary pairs of silicon power transistors designated BD433/34; BD281/82; BD283/84 and BD285/86 have also been introduced. Principally intended for audio applications, they can be used for audio output stages delivering, in the case of the last two pairs of devices, up to 20 watts of power into the load.

Finally a new protected audio power amplifier, type TBA810S Ω which will deliver 6W into a 4 Ω load. Complete thermal protection is provided for by automatic limiting of output power. The device is available in a 12-lead quad-in-line plastic package with either flat, pierced tabs for the attachment of an external heat sink (TBA810AS) or bent metal tabs to solder direct to a printed circuit board. S.G.S. Ates Componenti Eletronici SpA, Via C. Olivetti, 1, 20041 - Agrate Br., Milan, Italy.

WW 350 m.o.s. range

WW 351 complementary power transistors

WW 352 audio power amplifier

Real and Imaginary

by "Vector"

Whatever Happened to the Likely Lads?

For what follows you can blame the recent Letters to the Editor on the subject of Marconi's 1907 patent for producing c.w. from a spark source. It seemed such an odd-ball invention that I wanted to know more about it, so I did what I always do on such occasions; I called on a friend of mine who is an ardent collector of old books on radio and kindred matters.

I didn't call in vain. He dug out a volume "Telephony Without Wires" (P. R. Coursey, Wireless Press Ltd, 1919) which is a mine of information on the subject. It seems that right from the start of wireless telegraphy lots of people had had a go at telephoning via spark-generated waves, the general approach being to connect a microphone in place of the morse key. Seeing that the original spark gaps produced heavily damped wave-trains with large chunks of nothing in between them (relatively speaking) the lack of success was predictable.

A little later some experimenters transferred allegiance to the arc system or the h.f. alternator, but others concentrated on trying to produce undamped wave-trains at faster sparking rates. The book traces the development of quenched spark, as it was termed, and devotes two chapters to methods of producing continuous waves from spark. I mustn't encroach upon the sacred ground of the correspondence columns, but there is no doubt that spark-begotten c.w. was no myth. Incidentally, you might be interested to know of two familiar names who made important contributions to the state of the art; one was W. Dubilier and the other — wait for it! — was H. Yagi.

Why, I wondered, seeing that input/output efficiencies of up to 75% were claimed, did such methods of producing c.w. die the death? Coursey gives part of the answer in connection with the smooth-disc approach; it was apparently only suitable for low powers (and output power was particularly important then because there were no amplifiers at the receiving end). Furthermore, the disc had to run at very high speeds even to achieve radiations of the order of 30kHz, while frequent gap-cleaning operations were necessary. Nevertheless, Marconi developed the 1907 device extensively and a highly sophisticated version (the timed disc c.w. generator)

emerged which continued as the standard Marconi transmission system until the early 1920s when thermionic valves took over. P. R. Coursey's book has pictures of a 300kW installation and it's quite a piece of ironmongery.

Marconi, of course, was primarily concerned with telegraphy for trans-world communication and so introduced an audible note by means of studs on the discs to break up the pure c.w. (if pure is the right word, which it probably wasn't!). It certainly wouldn't have approached the regularity of valve-generated waves.

So that's what happened to one likely lad. I sometimes wonder, though, whether we aren't mistaken in assuming that nothing of value remains in the field of spark research. Consider, for a moment, a few unrelated facts. Spark techniques had developed into a highly efficient means of producing electromagnetic waves of all frequencies from centimetric to v.h.f. Even by 1907, rudimentary means had been found whereby c.w. could be obtained from it. And what of the oscillating crystal of 1911 in which a microscopic spark seems to have been a key feature? Remember, too, that Tesla suggested that spark-generated waves might be used for what we now call radar and, indeed, a primitive form of it was patented in 1904. Given the accumulated know-how of the past seventy years, isn't it just possible that somewhere lies the germ of, let's say, a simple, cheap sub-miniature radar transmitter for use on road vehicles in fog? Or something?

I've just mentioned Tesla. Now, there's a colourful character, if ever there was one. What was he? Charlatan? Showman? Mystic? Eccentric? Genius? Certainly he was continually bursting into the headlines with extraordinary inventions, a large proportion of which never got beyond print: automatons, communication from Mars, death-rays — you name it, Tesla had had a go at it. Yet over and beyond this, Tesla was a visionary-genius with a great number of solid patents to his credit, a pioneer of polyphase a.c. (he designed the alternators for the first Niagara Falls hydro-electric station) and a man who was years ahead of his time in matters concerning high potential, high frequency currents. A man whose worth is recognized by the bestowal of

his name upon the unit of magnetic flux density. A complex character indeed.

In 1899 Tesla set up an impressive laboratory at Colorado Springs and before long announced that he had found it practicable to send and receive telegraphy and telephony around the world: many thousands of messages could be sent simultaneously. A cheap and simple device which could be carried in one's pocket would record the message.

But this was only the beginning; in addition, Tesla claimed that he could also distribute power in unlimited amounts without the aid of wire conductors. His "magnifying transmitter", as far as he described it, was essentially a circuit of very high induction and small resistance; the mode of operation (he said) was the diametrical opposite of conventional wireless telegraphy, the electromagnetic radiations being insignificant. With proper conditions of resonance obtained, the circuit "acts like an immense pendulum, storing indefinitely the energy of the primary exciting impulses upon the earth and its conducting atmosphere".

Eventually his transmitter was to emit a wave complex of a total maximum activity of 10 million horse power (this, added Tesla, rather unnecessarily, "is obtainable only by the use of certain artifices"). As a start he proposed to distribute 10,000 h.p. under a tension of 100 million volts "which I am now able to produce and handle with safety".

One of the chief benefits of the scheme, as Tesla saw it, would be the illumination of isolated homes, each one of which would have a power collector on its roof and with the lighting derived from vacuum tubes operated by h.f. currents. Tesla added that the driving of clocks and other such apparatus would be a feature, commenting that "the idea of impressing upon the earth American time is fascinating and very likely to become popular".

As far as one can gather, then, his idea was to set the entire earth into electrical oscillation at a frequency of 150kHz and to pump in power to be in resonance with the waves that he was sure would travel from the transmitting centre to a point diametrically opposite it on the earth's surface and then return. This travelling power could be tapped off anywhere by means of a tuned circuit, an earth connection and an elevated collecting rod. (How he proposed to stop pirating is not clear.)

Tesla built a central power plant and transmitting tower for his "World Telegraphy" at Long Island, New York. The tower was 187 ft high and topped by a hemispherical head 68 ft in diameter. The externals were completed by 1902 and some equipment installed, but by now the backers were crying off and Tesla was desperately short of money.

Tesla was forever dreaming up projects and then abandoning them, often because of lack of money. Many were undoubtedly crackpot but, on the credit side, he produced a great number of viable inventions. Isn't it possible that a careful search might reveal a few likely lads among those abandoned?

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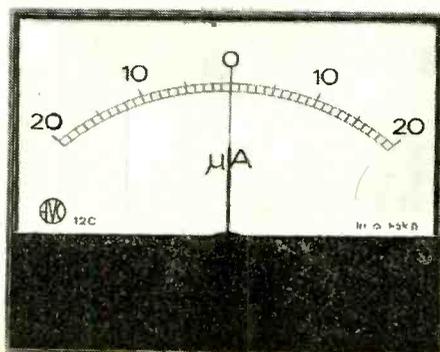
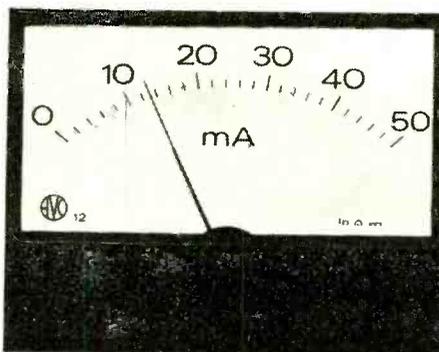
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Thorn Measurement, Control and Automation Division.

Sinclair Project 60

Now—the Z.50 Mk.2

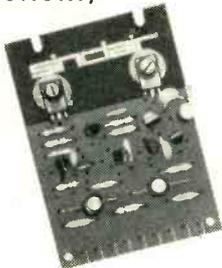
with built-in automatic transient overload protection

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 symmetrical 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

Z.30 the power amplifier for quality and economy

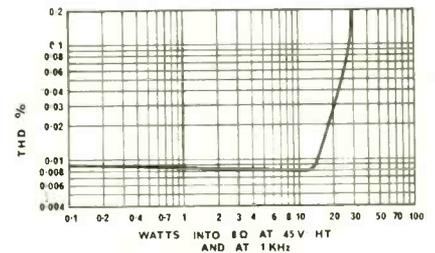


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The Z.30 provides excellent facilities for the constructor requiring a high fidelity audio system of less power than that available from Z.50's. Using a power supply of 35 volts, Z.30 will deliver 15 watts RMS into 8 ohms, or 20 watts RMS into 3 ohms 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 1/8 x 2 1/4 x 1/2) Z.30, Z.50 and Z.50 MK.2 modules are compatible and interchangeable.

Brilliant new technical specifications

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



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.

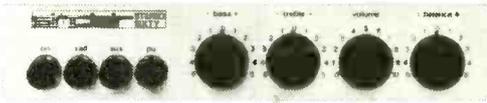
Each Project 60 module is tested before leaving our factory and is guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you, if it is returned within two years from the date of purchase. Outside this period of guarantee a small charge (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 ± 1 dB. 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

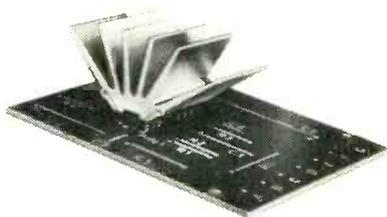


The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other advanced features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo 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:** 7 μ V for lock-in over full deviation. **Squelch level:** Typically 20 μ V. **Signal to noise ratio:** > 65dB. **Audio frequency response:** 10Hz — 15KHz (± 1 dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2 μ V. **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.

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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 tran-

sistor 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). 6–8 Ω . **Frequency Response:** 5Hz to 100KHz ± 1 dB. **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 x 45 x 28mm including pins and heat sink.

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PZ.8 Mk.3—£7.98

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(not suitable for Project 60 tuner) £4.98

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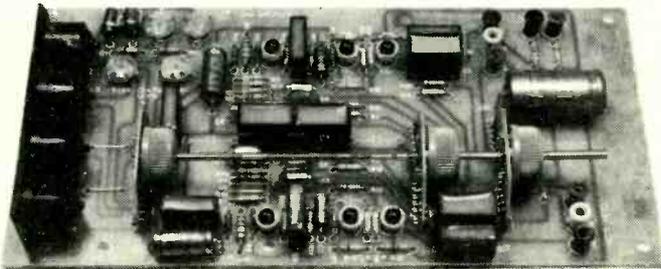
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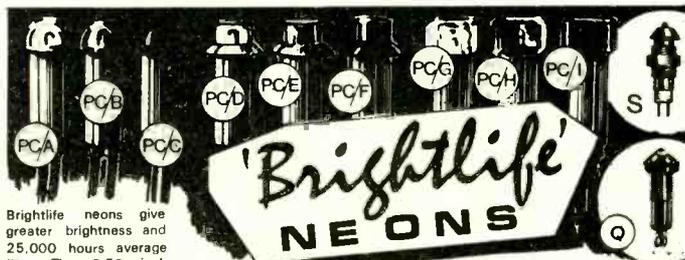
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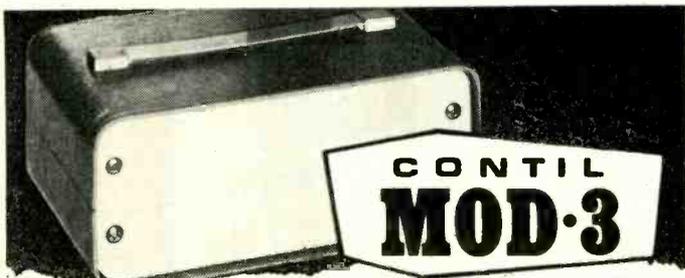
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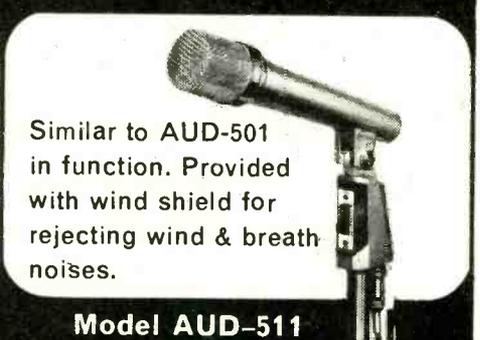
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 This kit comprises a pair of MagSlips to provide remote indication of aerial azimuth and consists of a transmitter and receiver. The transmitter is directly coupled to the remote aerial and the receiver can be mounted at the control point, to provide immediate and continuous indication of aerial position. Supply voltage required is 50v 50Hz and the price £5.75. (P.P.d.) including a pointer for the receiver. The suggested use of these items would include a mains operated, geared motor to drive the aerial, controlled from the position to which is fed back position information by the magSlip link. Transformers to provide 50v 50Hz from 240v A.C. £1.95 each. (P.P.d.)

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AN3106A-14S-2S	5	BFR-16-10P-1	2	BFR-20-27P	21	2AA 10mfd. 6v.	81	146CA 25mfd. 25v.	74	0.15mfd. 150v.	338
BFR22-14SW-1	3	BFR-36-10SW-1	6	BFR-20-21P-1	25	3AA 20mfd. 6v.	250	201CA 1.5mfd. 25v.	40	102FA	
CA3106ER-24-28PY	3	CA3106ER-16-10S	4	CA3106ER-24-28PW	2	4AA 40mfd. 6v.	233	402CA 180mfd. 6v.	63	0.25mfd. 150v.	609
CA3106ER-24-21P	6	CA3106ER-28-21SW	5	CA3106ER-28-21PY	2	6AA 200mfd. 6v.	127	403CA 30mfd. 6v.	45	103FA 0.5mfd. 150v.	91
CA3106A-40-56P	2	CA3106A-40-56S	1	CA3102A-10SL-3P	23	102AA 5mfd. 6v.	4	1DA 0.75mfd. 50v.	780	104FA 1mfd. 150v.	1118
CA3102A-40-56PZ	1	CA3106A-40-56SZ	5	CA3106A-40-56SX	5	103AA 10mfd. 6v.	97	2DA 1.5mfd. 50v.	205	106FA 5mfd. 150v.	49
CA3102A-40-56SW	20	CA3102A-40-56SW	15	CA3102A-40-56SY	15	106AA 100mfd. 6v.	236	3DA 3mfd. 50v.	75	132FA 0.2mfd. 150v.	20
CA3102A-40-56PX	15	CA3102A-40-56PX	10	CA3102A-40-56PY	21	146AA 100mfd. 6v.	6	4DA 5mfd. 50v.	273	134FA 1.0mfd. 150v.	19
DB25S C925	25	DD51216-1	20	DB25S	1000	1BA 2.5mfd. 12v.	189	5DA 10mfd. 50v.	753	400FA T.J.	
DD19678-9	9	DD19678-4	123	DB25S	210	2BA 5mfd. 12v.	775	6DA 25mfd. 50v.	833	22mfd. 15v.	30
DC19678-3	168	DM50S	256	D24661	147	3BA 10mfd. 12v.	504	4DA 25mfd. 50v.	132	401FA T.G.	
DPD-78-34P-1L	11	DP A20746	9	DC37S	3	4BA 20mfd. 12v.	533	101DA 0.375mfd. 50v.	84	33mfd. 15v.	120
GS02-10SL-3P-111	3	GS02-10SL-3P-001	213	DP JM-98-34P-B	15	5BA 40mfd. 12v.	50	102DA 0.75mfd. 50v.	71	400FA 0.2mfd. 150v.	15
GS02-10SL-3P-301	30	GS02-18-8P-001	16	DPD-A15-34P-1L	6	6BA 100mfd. 12v.	1346	103DA 1.5mfd. 50v.	87	401FA 22mfd. 15v.	83
JCA142059	36	JCS0B38503	17	GS02-14S-5P-301	15	41BA 2.5mfd. 12v.	1	106DA 1.25mfd. 50v.	88	402FA 68mfd. 15v.	400
KASE06F-22-21P	22	K08-21-3/8	3	GS02-18-8P-001	6	42BA 5.0mfd. 12v.	3	143DA 12.5mfd. 50v.	154	403FA 150mfd. 15v.	556
XO8-19-1/2	14	KPSE06F-24-61P	11	K08-16-3/8	9	44BA 20mfd. 12v.	4	144DA 2.5mfd. 50v.	46	403GA 100mfd. 20v.	100
KPT02E-22-55PY	11	KPSE06F-14-15S	16	K08-16-3/8	16	101BA 1.25mfd. 12v.	380	145DA 12.5mfd. 50v.	85	407KA 68mfd. 35v.	24
KPT06F-18-32SX	5	KPT80-8C	40	KPT81-14C	63	102BA 2.5mfd. 12v.	87	912DA 75mfd. 50v.	120	402KA 22mfd. 35v.	150
MS3102A-22-14P	84	MS3102A-18-8P	24	MS3102A-18-8P	24	103BA 5mfd. 12v.	675	913DA 1.5mfd. 50v.	379	403KA 47mfd. 35v.	141
MS3108E-18-4S	4	MS3108E-22-14S	5	MS3108E-22-14S	2	104BA 10mfd. 12v.	846	103DB 0.25mfd. 50v.	174	51E 20mfd. 3v.	225
MS3106E-14S-5S(C)	3	MS3106E-22-14S	8	MS25042-40C	60	105BA 20mfd. 12v.	85	1EA 40mfd. 100v.	83	D 24-5 C4 24mfd. 5v.	10
MS3180-240	16	MS126F-14-15S	8	MS25042-40C	60	106BA 50mfd. 12v.	342	2EA 0.75mfd. 100v.	56	E 33 50mfd. 6v.	295
WK-01-22C3/8	11	WK-26C 3/8	25	TNG PL11-17-55	17	143BA 5mfd. 12v.	212	3EA 1.5mfd. 100v.	4	3EG 10mfd. 6v.	224
				WB1114/B/16B	64	1CA 1.5mfd. 25v.	335	4EA 2.5mfd. 100v.	181	D24-10 C5	
						2CA 2.5mfd. 25v.	40	5EA 5mfd. 100v.	4	24mfd. 10v.	50
						3CA 6mfd. 25v.	660	6EA 15mfd. 100v.	63	D32-15 C6	
						4CA 10mfd. 25v.	304	41EA 0.4mfd. 100v.	42	32mfd. 15v.	6
						5CA 20mfd. 25v.	50	43EA 1.5mfd. 100v.	152	D6-20 C4 6mfd. 20v.	8
						6CA 50mfd. 25v.	607	44EA 2.5mfd. 100v.	474	6176-1 100mfd. 15v.	200
						41CA 1.5mfd. 25v.	21	45EA 0.5mfd. 100v.	69	DO25-30 CL	
						42CA 2.5mfd. 25v.	4	101EA 0.2mfd. 100v.	382	0.25mfd. 30v.	10
						43CA 6mfd. 25v.	146	102EA 0.5mfd. 100v.	38	D4-30 C4 4mfd. 30v.	10
						44CA 10mfd. 25v.	32	105EA 2.5mfd. 100v.	30	D8-30 C5 8mfd. 30v.	18
						101CA 0.75mfd. 25v.	355	106EA 7.5mfd. 100v.	713	DO2-35 CL	
						102CA 1.25mfd. 25v.	371	403AAA 220mfd. 10v.	32	0.2mfd. 35v.	88
						103CA 3mfd. 25v.	325	1FA 0.3mfd. 150v.	917	DO25-30CL	
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						105CA 10mfd. 25v.	142	3FA 1.0mfd. 150v.	523	401KC 3.3mfd. 35v.	75
						106CA 25mfd. 25v.	180	4FA 2mfd. 150v.	259	D14-35 C6	
						141CA 0.75mfd. 25v.	636	5FA 4mfd. 150v.	112	14mfd. 35v.	27
								6FA 10mfd. 150v.	524	400KB 0.68mfd. 35v.	30

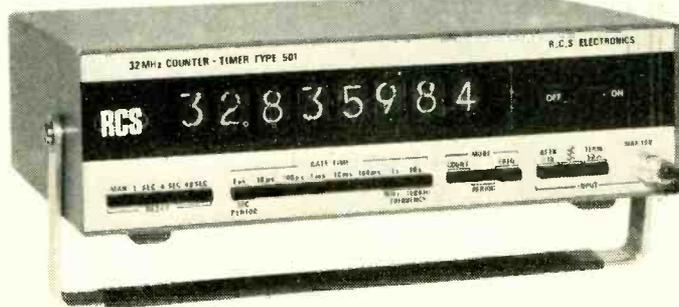
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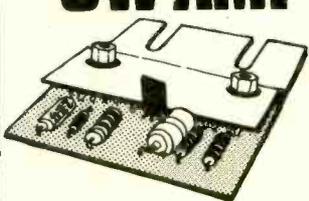
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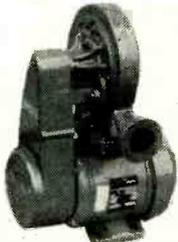
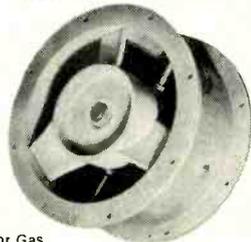
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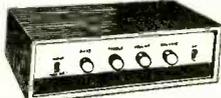


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COMPLETE KIT (less cabinet), Carr. 70p Cabinet if req. 25 extra **£27.50**

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- Power Rating R.M.S. continuous. 2 years guarantee. Carr. free
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| 12" 'POP' 50 | 15" 'POP' 60 | 18" 'POP' 100 |
| 50 Watts | 60 Watts | 100 Watts |
| 15 Ohm | 8/16 Ohm | 8/15 Ohm |
| 13,000 Gauss | 14,000 Gauss | 14,000 Gauss |
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Including 2 ind. controlled inputs

Separate Bass and Treble Controls. Valves EP85, EP86, EOC85, GZ34, EL34. Sensitivity 30mV. 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
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12" 25 WATT Dual Cone 15 ohms NOT for Bass Guitar. Or Dep. £1.25 and 9 monthly payments 89p (Total £9.26)

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- Teak veneer finish. Pleasing design. Acoustically lined. All sizes approx.
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 - ES8 for optimum results with any 8 in. HI-FI speaker. **£6.50**
 - ES10 outstanding performance with HI-FI 10-in. speaker. 25 1/2 x 16 x 9 in. Ported. **£6.75**
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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 20-15,000 Hz Imp 3 or 8/15 Ohm. (state requirement.) **£3.70**

REMARKABLE VALUE **£3.70**

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inc. 803 8" unit, 303 Pressure Tweeter, Printed circuit, inductive capacitive cross-over, acoustic filling panels, screws, etc. Post free Response ONLY **£9.96**

HIGH FIDELITY SPEAKERS

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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 803T .8" 10W	£2.98
HF 102D .10" 10W	£3.30
HF 120 .12" 15W	£4.95
HF 120H .12" 15W	£5.50
HF 125 .12" 15W	£6.35
HF 125H .12" 15W	£9.85

Please state impedance required. 3 or 8-15 ohm.

HI-FI SPEAKER SYSTEMS

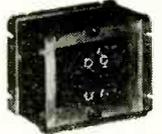
Audiotrine 121K. 12 in. 15 watt, 11,000 Gauss bass unit. Cross-over unit and Tweeter. Smooth response and wide frequency range ensure realistic sound reproduction. Carr. 35p **£6.50**

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TRANSFORMERS

MAINS ISOLATING SERIES
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
07	20	1 11	7.0 x 6.0 x 6.5	1.77 30
100	60	3 8	8.9 x 8.0 x 7.7	2.62 36
61	100	5 12	10.2 x 8.9 x 8.3	2.88 52
30	200	9 8	12.0 x 10.3 x 10.0	4.83 52
62	250	12 4	9.5 x 12.7 x 11.4	6.38 67
52	350	15 0	14.0 x 9.8 x 12.4	8.55 82
63	500	27 0	17.1 x 11.4 x 15.9	13.2 *
92	1000	40 0	17.8 x 17.1 x 21.6	22.70 *
128	2000	63 0	24.1 x 21.6 x 15.2	37.50 *
129	3000	84 0	21.6 x 21.6 x 20.3	58.67 *
190	6000	178 0	31.1 x 35.6 x 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
113	20	1 11	7.3 x 4.3 x 4.4	0-115-210-240	0.93 22
64	75	1 14	7.0 x 6.4 x 6.0	0-115-210-240	1.82 30
66	150	3 0	10.2 x 10.2 x 9.5	0-115-200-220-240	2.20 36
64	300	6 0	10.2 x 10.2 x 9.5	" "	4.28 52
67	500	12 8	14.0 x 10.2 x 11.4	" "	6.35 67
84	1000	16 0	11.4 x 14.0 x 14.0	" "	11.54 82
93	1500	28 9	13.5 x 14.9 x 16.5	" "	16.72 *
95	2000	40 0	17.8 x 16.5 x 21.6	" "	21.82 *
73	3000	45 8	17.4 x 18.1 x 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.	Weight lb oz	Size cm.	Secondary Windings	P & P
111	0.5	0.25	7.6 x 5.7 x 4.4	0-12V at 0.25A x 2	0.93 22
213	1.0	0.5	8.3 x 5.1 x 5.1	0-12V at 0.5A x 2	1.11 22
71	2	1	7.0 x 6.4 x 5.7	0-12V at 1A x 2	1.46 22
18	4	2	8.3 x 7.0 x 7.0	0-12V at 2A x 2	2.04 36
70	6	3	10.2 x 7.6 x 8.6	0-12V at 3A x 2	2.46 42
108	8	4	10.0 x 8.3 x 8.2	0-12V at 4A x 2	2.73 52
71	15	6	7.9 x 10.8 x 10.2	0-12V at 5A x 2	3.23 52
17	16	6	12.1 x 11.4 x 10.2	0-12V at 8A x 2	4.99 52
115	20	10	12.1 x 11.4 x 10.2	0-12V at 10A x 2	6.35 52
187	30	15	13.3 x 12.1 x 12.1	0-12V at 15A x 2	11.73 82
226	60	30	17.0 x 14.5 x 12.5	0-12V at 30A x 2	21.37 *

30 VOLT RANGE Secondary Taps

Ref. No.	Amps.	Weight lb oz	Size cm.	Secondary Taps	P & P
111	0.5	0.25	8.3 x 3.7 x 4.9	0-12-15-20-24-30V	1.11 22
79	1.0	0.5	7.0 x 6.4 x 6.0	" "	1.48 22
3	2.0	1	8.9 x 7.0 x 7.6	" "	2.33 36
20	3.0	1.5	10.2 x 8.9 x 8.6	" "	2.73 42
21	4.0	2	10.2 x 10.0 x 8.6	" "	3.23 52
117	5.0	2.5	12.1 x 10.0 x 8.6	" "	4.02 52
117	6.0	3	12.1 x 10.0 x 10.2	" "	4.80 52
88	8.0	4	14.0 x 11.7 x 10.0	" "	6.20 67
89	10.0	5	14.0 x 10.2 x 11.4	" "	7.85 67

50 VOLT RANGE Secondary Taps

Ref. No.	Amps.	Weight lb oz	Size cm.	Secondary Taps	P & P
102	0.5	1 11	7.0 x 7.0 x 5.7	0-19-25-33-40-50V	1.46 30
103	1.0	2 10	8.3 x 7.3 x 7.0	" "	2.13 36
104	2.0	5 0	10.2 x 8.9 x 8.6	" "	2.96 42
105	3.0	6 0	10.2 x 9.5 x 8.3	" "	4.01 52
106	4.0	9 4	12.1 x 11.4 x 10.2	" "	5.31 52
107	6.0	12 4	12.1 x 11.4 x 13.3	" "	7.85 67
118	8.0	18 9	13.3 x 13.3 x 12.1	" "	10.25 97
119	10.0	19 12	16.5 x 11.4 x 15.9	" "	12.85 97

60 VOLT RANGE Secondary Taps

Ref. No.	Amps.	Weight lb oz	Size cm.	Secondary Taps	P & P
124	0.5	2 4	8.3 x 9.5 x 6.7	0-24-30-40-48-60V	1.48 36
126	1.0	3 0	10.2 x 7.6 x 7.6	" "	2.06 36
127	2.0	5 6	10.2 x 8.9 x 8.6	" "	3.23 42
125	3.0	8 8	11.9 x 9.5 x 10.0	" "	4.92 52
123	4.0	10 6	11.4 x 9.5 x 11.4	" "	6.35 67
120	6.0	16 12	13.3 x 12.1 x 12.1	" "	9.20 82
122	10.0	23 2	16.5 x 12.7 x 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 FOR CHARGING 6 OR 12VOLT BATTERIES

Ref. No.	Amps.	Weight lb oz	Size cm.	P & P
45	1-5	1	7.0 x 6.0 x 6.0	1.47 30
5	4-0	1 11	10.2 x 7.0 x 8.3	2.23 32
86	6-0	5 12	10.2 x 8.9 x 8.3	3.37 52
146	8-0	6 4	8.9 x 10.2 x 10.2	3.84 52
50	12-5	11 14	13.3 x 10.8 x 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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| 25+ 7.5p | 25+ 55p | 25+ 55p |
| 100+ 6.5p | 100+ 45p | 100+ 50p |
| 500+ 6.0p | 500+ 40p | 500+ 45p |
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BRAND NEW FULLY GUARANTEED DEVICES

AC107	0.22	AD162	0.37	BC148	0.11	BD136	0.44	BF185	0.33	MPF105	0.41	2G344	0.20	2N2217	0.24	2N3053	0.19	2N4659	0.11
AC113	0.22	AD161	A	BC149	0.13	BD137	0.50	BF188	0.44	OC19	0.39	2G345	0.18	2N2218	0.22	2N3054	0.51	2N4660	0.13
AC115	0.26	AD162 (MP)		BC150	0.20	BD138	0.55	BF194	0.13	OC20	0.70	2G371	0.13	2N2219	0.22	2N3055	0.55	2N4661	0.13
AC117K	0.22		0.61	BC151	0.22	BD139	0.61	BF195	0.13	OC22	0.42	2G371B	0.18	2N2220	0.24	2N3059	0.16	2N4662	0.13
AC122	0.13	AD1140	0.55	BC152	0.19	BD140	0.66	BF196	0.16	OC23	0.46	2G373	0.19	2N2221	0.22	2N3091A	0.18	2N4664	0.19
AC125	0.19	AF114	0.27	BC153	0.31	BD141	0.66	BF197	0.16	OC24	0.62	2G373A	0.19	2N2222	0.22	2N3092	0.16	2N4665	0.19
AC126	0.19	AF116	0.27	BC154	0.33	BD142	0.66	BF198	0.16	OC25	0.48	2G377	0.13	2N2368	0.19	2N3093	0.16	2N4666	0.19
AC127	0.19	AF117	0.27	BC155	0.33	BD143	0.66	BF199	0.16	OC26	0.28	2G378	0.18	2N2369	0.16	2N3094	0.16	2N4667	0.19
AC128	0.19	AF118	0.27	BC156	0.33	BD144	0.66	BF200	0.50	OC28	0.55	2G381	0.18	2N2369A	0.16	2N3095	0.19	2N4668	0.19
AC132	0.16	AF118	0.39	BC157	0.20	BD176	0.66	BF202	1.05	OC29	0.55	2G382	0.18	2N2370	0.22	2N3096	0.23	2N4669	0.19
AC134	0.16	AF124	0.39	BC159	0.13	BD177	0.72	BF205	0.50	OC28	0.55	2G383	0.18	2N2371	0.22	2N3097	0.23	2N4670	0.19
AC137	0.16	AF125	0.28	BC161	0.55	BD178	0.72	BF208	0.66	OC29	0.55	2G389	0.18	2N2372	0.22	2N3098	0.23	2N4671	0.19
AC141	0.16	AF126	0.31	BC167	0.13	BD180	0.77	BF209	0.61	OC30	0.55	2G401	0.33	2N2373	0.22	2N3099	0.23	2N4672	0.19
AC141K	0.19	AF127	0.31	BC168	0.13	BD181	0.77	BF210	0.61	OC31	0.55	2G417	0.28	2N2374	0.22	2N3100	0.23	2N4673	0.19
AC142	0.16	AF139	0.33	BC169	0.13	BD182	0.77	BF211	0.61	OC34	0.17	2N388A	0.61	2N2375	0.22	2N3101	0.23	2N4674	0.19
AC142K	0.19	AF178	0.33	BC170	0.13	BD187	0.77	BF212	0.61	OC45	0.14	2N404	0.22	2M2904	0.23	2N3146	0.31	2N5457	0.35
AC131	0.17	AF179	0.55	BC171	0.16	BD189	0.99	BF213	0.39	OC70	0.11	2N404A	0.31	2N2404A	0.23	2N3497	0.31	2N5458	0.35
AC154	0.22	AF180	0.55	BC172	0.16	BD190	0.83	BF214	0.39	OC71	0.11	2N404B	0.31	2N2405	0.23	2N3498	0.31	2N5459	0.35
AC155	0.22	AF181	0.50	BC173	0.16	BD191	0.83	BF215	0.39	OC72	0.11	2N405	0.54	2N2406A	0.23	2N3499	0.31	2N5460	0.35
AC156	0.22	AF186	0.50	BC174	0.16	BD196	0.94	BF216	0.39	OC74	0.17	2N405A	0.54	2N2407	0.23	2N3500	0.31	2N5461	0.35
AC157	0.27	AF239	0.41	BC175	0.24	BD198	0.99	BF217	0.39	OC75	0.17	2N406	0.16	2N2408	0.23	2N3501	0.31	2N5462	0.35
AC165	0.22	AL102	0.72	BC177	0.21	BD199	1.05	BF218	0.39	OC76	0.17	2N406A	0.16	2N2409	0.23	2N3502	0.31	2N5463	0.35
AC166	0.22	AL105	0.72	BC178	0.21	BD199	1.05	BF219	0.39	OC77	0.17	2N407	0.16	2N2410	0.23	2N3503	0.31	2N5464	0.35
AC167	0.22	AS126	0.28	BC179	0.21	BD200	1.05	BF220	0.39	OC81	0.17	2N408	0.16	2N2411	0.23	2N3504	0.31	2N5465	0.35
AC168	0.27	AS127	0.33	BC180	0.27	BD205	0.88	BF221	0.39	OC82	0.17	2N409	0.16	2N2412	0.23	2N3505	0.31	2N5466	0.35
AC169	0.16	AS128	0.28	BC181	0.27	BD206	0.88	BF222	0.39	OC83	0.17	2N410	0.16	2N2413	0.23	2N3506	0.31	2N5467	0.35
AC176	0.22	AS129	0.28	BC182	0.11	BD207	1.05	BF223	0.39	OC84	0.17	2N411	0.16	2N2414	0.23	2N3507	0.31	2N5468	0.35
AC177	0.27	AS130	0.28	BC183	0.11	BD208	1.05	BF224	0.39	OC85	0.17	2N412	0.16	2N2415	0.23	2N3508	0.31	2N5469	0.35
AC178	0.21	AS131	0.28	BC184	0.11	BD209	1.05	BF225	0.39	OC86	0.17	2N413	0.16	2N2416	0.23	2N3509	0.31	2N5470	0.35
AC179	0.31	AS152	0.28	BC185L	0.11	BD210	1.10	BF226	0.39	OC87	0.17	2N414	0.16	2N2417	0.23	2N3510	0.31	2N5471	0.35
AC180	0.19	AS154	0.28	BC186	0.13	BD211	0.50	BF227	0.39	OC88	0.17	2N415	0.16	2N2418	0.23	2N3511	0.31	2N5472	0.35
AC180K	0.22	AS155	0.28	BC184L	0.13	BD212	0.50	BF228	0.39	OC89	0.17	2N416	0.16	2N2419	0.23	2N3512	0.31	2N5473	0.35
AC181	0.19	AS156	0.28	BC186	0.31	BD213	0.50	BF229	0.39	OC90	0.17	2N417	0.16	2N2420	0.23	2N3513	0.31	2N5474	0.35
AC181K	0.22	AS157	0.28	BC187	0.31	BD214	0.50	BF230	0.39	OC91	0.17	2N418	0.16	2N2421	0.23	2N3514	0.31	2N5475	0.35
AC187	0.24	AS158	0.28	BC189	0.12	BD215	0.50	BF231	0.39	OC92	0.17	2N419	0.16	2N2422	0.23	2N3515	0.31	2N5476	0.35
AC187K	0.22	AS221	0.44	BC208	0.12	BD216	0.50	BF232	0.39	OC93	0.17	2N420	0.16	2N2423	0.23	2N3516	0.31	2N5477	0.35
AC188	0.24	BC107	0.10	BC209	0.13	BD217	0.55	BF233	0.39	OC94	0.17	2N421	0.16	2N2424	0.23	2N3517	0.31	2N5478	0.35
AC188K	0.22	BC108	0.10	BC210L	0.12	BD218	0.55	BF234	0.39	OC95	0.17	2N422	0.16	2N2425	0.23	2N3518	0.31	2N5479	0.35
AC189	0.22	BC109	0.11	BC211L	0.12	BD219	0.55	BF235	0.39	OC96	0.17	2N423	0.16	2N2426	0.23	2N3519	0.31	2N5480	0.35
AC191	0.22	BC113	0.11	BC214L	0.16	BD220	0.55	BF236	0.39	OC97	0.17	2N424	0.16	2N2427	0.23	2N3520	0.31	2N5481	0.35
AC191K	0.22	BC114	0.17	BC215	0.28	BD221	0.55	BF237	0.39	OC98	0.17	2N425	0.16	2N2428	0.23	2N3521	0.31	2N5482	0.35
AC192	0.22	BC115	0.17	BC216	0.39	BD222	0.55	BF238	0.39	OC99	0.17	2N426	0.16	2N2429	0.23	2N3522	0.31	2N5483	0.35
AC192K	0.22	BC116	0.17	BCY30	0.27	BD223	0.55	BF239	0.39	OC100	0.17	2N427	0.16	2N2430	0.23	2N3523	0.31	2N5484	0.35
AC193	0.22	BC117	0.17	BCY31	0.29	BD224	0.55	BF240	0.39	OC101	0.17	2N428	0.16	2N2431	0.23	2N3524	0.31	2N5485	0.35
AC194	0.22	BC118	0.11	BCY32	0.33	BD225	0.55	BF241	0.39	OC102	0.17	2N429	0.16	2N2432	0.23	2N3525	0.31	2N5486	0.35
AC194K	0.22	BC119	0.11	BCY33	0.33	BD226	0.55	BF242	0.39	OC103	0.17	2N430	0.16	2N2433	0.23	2N3526	0.31	2N5487	0.35
AC195	0.22	BC120	0.11	BCY34	0.33	BD227	0.55	BF243	0.39	OC104	0.17	2N431	0.16	2N2434	0.23	2N3527	0.31	2N5488	0.35
AC195K	0.22	BC121	0.11	BCY35	0.33	BD228	0.55	BF244	0.39	OC105	0.17	2N432	0.16	2N2435	0.23	2N3528	0.31	2N5489	0.35
AC196	0.22	BC122	0.11	BCY36	0.33	BD229	0.55	BF245	0.39	OC106	0.17	2N433	0.16	2N2436	0.23	2N3529	0.31	2N5490	0.35
AC197	0.22	BC123	0.11	BCY37	0.33	BD230	0.55	BF246	0.39	OC107	0.17	2N434	0.16	2N2437	0.23	2N3530	0.31	2N5491	0.35
AC198	0.22	BC124	0.11	BCY38	0.33	BD231	0.55	BF247	0.39	OC108	0.17	2N435	0.16	2N2438	0.23	2N3531	0.31	2N5492	0.35
AC199	0.22	BC125	0.11	BCY39	0.33	BD232	0.55	BF248	0.39	OC109	0.17	2N436	0.16	2N2439	0.23	2N3532	0.31	2N5493	0.35
AD130	0.42	BC140	0.33	BCY70	0.16	BD233	0.55	BF249	0.39	OC110	0.17	2N437	0.16	2N2440	0.23	2N3533	0.31	2N5494	0.35
AD140	0.53	BC141	0.33	BCY71	0.20	BD234	0.55	BF250	0.39	OC111	0.17	2N438	0.16	2N2441	0.23	2N3534	0.31	2N5495	0.35
AD142	0.53	BC142	0.33	BCY72	0.18	BD235	0.55	BF251	0.39	OC112	0.17	2N439	0.16	2N2442	0.23	2N3535	0.31	2N5496	0.35
AD143	0.43	BC143	0.33	BCZ10	0.22	BD236	0.55	BF252	0.39	OC113	0.17	2N440	0.16	2N2443	0.23	2N3536	0.31	2N5497	0.35
AD149	0.55	BC144	0.33	BCZ11	0.28	BD237	0.55	BF253	0.39	OC114	0.17	2N441	0.16	2N2444	0.23	2N3537	0.31	2N5498	0.35
AD161	0.37	BC147	0.11	BCZ12	0.28	BD238	0.55	BF254	0.39	OC115	0.17	2N442	0.16	2N2445	0.23	2N3538	0.31	2N5499	0.35
				BD135	0.44	BF184	0.28	MPF104	0.41	2G339A	0.18	2N2194	0.39						

BF185	0.33	MPF105	0.41	2G344	0.20	2N2217	0.24	2N3053	0.19	2N4659	0.11
BF188	0.44	OC19	0.39	2G345	0.18	2N2218	0.22	2N3054	0.51	2N4660	0.13
BF194	0.13	OC20	0.70	2G371	0.13	2N2219	0.22	2N3055	0.55	2N4661	0.13
BF195	0.13	OC22	0.42	2G371B	0.18	2N2220	0.24	2N3059	0.16	2N4662	0.13
BF196	0.16	OC23	0.46	2G373	0.19	2N2221	0.22	2N3091A	0.18	2N4664	0.19
BF197	0.16	OC24	0.62	2G373A	0.19	2N2222	0.22	2N3092	0.16	2N4665	0.19
BF198	0.16	OC25	0.48	2G377	0.13	2N2368	0.19	2N3093	0.16	2N4666	0.19
BF199	0.16	OC26	0.28	2G378	0.18						

-the lowest prices!

74 Series T.T.L. I.C.'S

BI-PAK STILL LOWEST IN PRICE FULL SPECIFICATION
GUARANTEED. ALL FAMOUS MANUFACTURERS



	1	25	100+		1	25	100+		1	25	100+
SN7400	0.17	0.18	0.13	SN7450	0.17	0.16	0.13	SN74141	0.74	0.71	0.64
SN7401	0.17	0.16	0.13	SN7451	0.17	0.16	0.13	SN74145	£1.85	£1.54	£1.43
SN7402	0.17	0.16	0.13	SN7453	0.17	0.16	0.13	SN74150	£3.30	£2.97	£2.75
SN7403	0.17	0.16	0.13	SN7454	0.17	0.16	0.13	SN74151	£1.10	£1.05	0.99
SN7404	0.17	0.16	0.13	SN7460	0.17	0.16	0.13	SN74153	£1.32	£1.21	£1.05
SN7405	0.17	0.16	0.13	SN7470	0.32	0.29	0.27	SN74154	£1.98	£1.87	£1.78
SN7406	0.39	0.34	0.31	SN7472	0.32	0.29	0.27	SN74155	£1.54	£1.43	£1.32
SN7407	0.39	0.34	0.31	SN7473	0.41	0.39	0.35	SN74156	£1.54	£1.43	£1.32
SN7408	0.20	0.19	0.18	SN7474	0.41	0.39	0.35	SN74157	£2.09	£1.98	£1.87
SN7409	0.20	0.19	0.18	SN7475	0.50	0.48	0.46	SN74160	£1.98	£1.87	£1.78
SN7410	0.17	0.16	0.13	SN7476	0.44	0.43	0.42	SN74161	£1.98	£1.87	£1.78
SN7411	0.28	0.27	0.26	SN7480	0.74	0.71	0.64	SN74162	£4.40	£4.13	£3.85
SN7412	0.39	0.34	0.31	SN7481	£1.32	£1.27	£1.21	SN74163	£4.40	£4.13	£3.85
SN7413	0.32	0.29	0.27	SN7482	0.96	0.95	0.94	SN74164	£2.43	£2.37	£2.31
SN7416	0.48	0.44	0.42	SN7483	£1.21	£1.16	£1.05	SN74165	£2.48	£2.42	£2.37
SN7417	0.48	0.44	0.42	SN7484	£1.10	£1.05	0.99	SN74166	£3.85	£3.58	£3.30
SN7420	0.17	0.16	0.13	SN7485	£3.98	£3.55	£3.74	SN74174	£2.53	£2.42	£2.31
SN7422	0.55	0.53	0.50	SN7486	0.35	0.34	0.33	SN74175	£1.78	£1.65	£1.54
SN7423	0.55	0.53	0.50	SN7489	£6.05	£5.78	£5.50	SN74176	£2.75	£2.64	£2.53
SN7425	0.55	0.53	0.50	SN7490	0.74	0.71	0.64	SN74177	£2.75	£2.64	£2.53
SN7426	0.50	0.48	0.44	SN7491	£1.10	£1.05	0.99	SN74180	£2.20	£1.76	£1.54
SN7427	0.50	0.48	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	0.71	0.64	SN74182	£2.20	£1.98	£1.78
SN7430	0.17	0.16	0.13	SN7494	0.85	0.82	0.75	SN74183	£2.85	£2.85	£2.85
SN7432	0.50	0.48	0.44	SN7495	0.85	0.82	0.75	SN74190	£2.15	£2.09	£2.04
SN7433	0.88	0.83	0.77	SN7496	0.96	0.93	0.86	SN74191	£3.09	£2.94	£2.94
SN7437	0.71	0.68	0.66	SN74100	£1.82	£1.76	£1.71	SN74192	£3.15	£2.99	£2.94
SN7438	0.71	0.68	0.66	SN74104	£1.07	£1.04	0.97	SN74193	£2.20	£1.98	£1.93
SN7440	0.17	0.16	0.13	SN74105	£1.07	£1.04	0.97	SN74194	£2.97	£2.86	£2.75
SN7441	0.74	0.71	0.64	SN74107	0.44	0.42	0.40	SN74195	£2.20	£2.09	£1.98
SN7442	0.74	0.71	0.64	SN74110	0.61	0.59	0.55	SN74196	£1.98	£1.87	£1.78
SN7443	£1.43	£1.38	£1.32	SN74111	£1.38	£1.27	£1.21	SN74197	£1.98	£1.87	£1.78
SN7444	£1.43	£1.38	£1.32	SN74116	£1.10	£1.05	0.99	SN74198	£6.05	£5.50	£5.23
SN7445	£1.98	£1.95	£1.93	SN74119	£1.49	£1.38	£1.21	SN74199	£6.05	£5.50	£5.23
SN7446	£1.07	£1.04	0.97	SN74121	0.44	0.41	0.36	3 Terminal Pos Volt Reg. 70.3			
SN7447	£1.40	£1.07	£1.05	SN74122	£1.54	£1.43	£1.21	Plastic O/P 1.5 Amps. uA7805			
SN7448	£1.10	£1.07	£1.05	SN74123	£3.08	£2.97	£2.86	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 x 105 mm x 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.

BRITISH MADE. only £3.58 each



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 x 105 mm x 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 Minित्रon
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
L.C. Driver Rec.	BP41/14 141	BP41 or 141	BP47
PRICE EACH	£1.87	£1.70	£2.09

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:

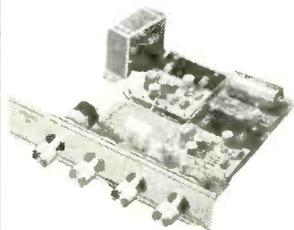
- Frequency response 20Hz—20kHz ±1dB
- Harmonic distortion better than 0.1%
- Inputs: 1. Tape head 1.25mV into 50KΩ
- 2. Radio, Tuner 35mV into 50KΩ
- 3. Magnetic P.U. 1.5mV into 50KΩ
- All input voltages are for an output of 250mV.
- Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20kHz.
- Bass control ±15dB at 20Hz
- Treble control ±15dB at 20kHz
- Filters: Rumble (high pass) 100 Hz
- Scratch (low pass) 8kHz
- Signal/noise ratio better than +65dB
- Input overload +26dB
- Supply +35 volts at 20mA
- Dimensions 292 x 82 x 35 mm

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £25.30 FREE p. & p.

only £13.15

The STEREO 20

The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm x 14 cm x 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
Freq. res. 20Hz-20kHz
Harmonic distortion typically 0.25% at 1 watt
Input 1 (Cer.) 300mV into 1M
Input 2 (Aux.) 4mV into 30K
Bass control ±12dB at 60Hz
Treble con. ±14dB at 14kHz

£13.47 free p. & p.

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 x 7400	0.55	UIC36	5 x 7446	0.55	UIC86	5 x 7486	0.55
UIC01	12 x 7401	0.55	UIC47	5 x 7447	0.55	UIC90	5 x 7490	0.55
UIC02	12 x 7402	0.55	UIC48	5 x 7448	0.55	UIC91	5 x 7491	0.55
UIC03	12 x 7403	0.55	UIC50	12 x 7450	0.55	UIC92	5 x 7492	0.55
UIC04	12 x 7404	0.55	UIC51	12 x 7451	0.55	UIC93	5 x 7493	0.55
UIC05	12 x 7405	0.55	UIC53	12 x 7453	0.55	UIC94	5 x 7494	0.55
UIC06	8 x 7406	0.55	UIC54	12 x 7454	0.55	UIC95	5 x 7495	0.55
UIC07	8 x 7407	0.55	UIC50	12 x 7400	0.55	UIC98	5 x 7498	0.55
UIC10	12 x 7410	0.55	UIC70	8 x 7470	0.55	UIC00	5 x 7400	0.55
UIC13	8 x 7413	0.55	UIC72	8 x 7472	0.55	UIC21	5 x 7421	0.55
UIC20	12 x 7420	0.55	UIC73	8 x 7473	0.55	UIC41	5 x 7441	0.55
UIC38	12 x 7438	0.55	UIC74	8 x 7474	0.55	UIC51	5 x 7451	0.55
UIC40	12 x 7440	0.55	UIC75	8 x 7475	0.55	UIC54	5 x 7454	0.55
UIC41	5 x 7441	0.55	UIC76	8 x 7476	0.55	UIC93	5 x 7493	0.55
UIC42	5 x 7442	0.55	UIC80	5 x 7480	0.55	UIC199	5 x 74199	0.55
UIC43	5 x 7443	0.55	UIC81	5 x 7481	0.55			
UIC44	5 x 7444	0.55	UIC82	5 x 7482	0.55	UICX1	25 Assorted 74's 1.55	
UIC45	5 x 7445	0.55	UIC83	5 x 7483	0.55			

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

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	1% Precision Resistors	0.55
C 4	75	1/2W 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 x 3.5mm 2 x 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 Laminates approx. 10" x 7"	0.55

Please add 10p post and packing on all component packs, plus a further 10p on pack Nos. C1, C2, C18, C20.

RTL MICROLOGIC CIRCUITS	Price each	DUAL IN-LINE IC's	TWO Ranges
Epoxy TO-5 case uL300	1-24 25-99 100 up	PROFESSIONAL & NEW PROF. TYPE No.	LOW COST.
Buffer	38p 36p 29p	T80 14 pin type	27p 33p
uL914 Dual 2 1/2p gate	38p 36p 29p	T80 16 " "	38p 35p 33p
uL923 J-K flip-flop	55p 51p 49p		

Data and Circuits Booklet for IC's Price 8p.

LINEAR I.C.'s—FULL SPEC.

Type No.	Price
RP 201C—81201C	1-24 25-99 100 up
RP 701C—81701C	69p 58p 49p
BP 702C—81702C	69p 55p 49p
BP 702—72702	58p 49p 44p
BP 709—72709	39p 37p 33p
BP 709P—uA709C	39p 37p 33p
BP 710—72710	48p 46p 44p
BP 711—uA711	49p 47p 44p
BP 741—72741	55p 50p 45p
uA703C	31p 25p 20p
TAA 263—	77p 66p 60p
TAA 293—	99p 82p 77p
TAA 350	87p 74p 65p

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ALL PRICES SHOWN INCLUDE V.A.T.

OA2	0.30	8BG6G	1.05	6L6GT	0.50	12AE6	0.48	30P12	0.69	ARP3	0.35	EC54	0.50
OB2	0.30	8BH6	0.43	6L7(M)	0.38	12AT7	0.16	30P16	0.28	ATP4	0.40	EC86	0.59
OC2	0.30	8BK6	0.39	6L12	0.32	12AU6	0.21	30P19	0.40	AZ1	0.40	EC88	0.59
OD2	0.30	8BL6	0.50	6L12	0.44	12AU7	0.19	30P4	0.65	AZ31	0.46	EC92	0.34
OE2	0.30	8BM6	0.28	6L19	1.39	12AV6	0.28	30P11	0.57	AZ41	0.53	EC93	1.50
OF2	0.30	8BN6	0.31	6L21	0.32	12AX7	0.21	30P12	0.29	B319	0.27	EC93	1.50
OG2	0.30	8BP6	0.78	6L22	0.48	12B6	0.78	30P13	0.75	BL63	0.50	EC93	1.50
OH2	0.30	8BR6	0.69	6L22	0.48	12BA6	0.30	30P14	0.75	CL33	0.90	EC93	1.50
OI2	0.30	8BS6	1.25	6L22	0.48	12BE6	0.30	30P15	0.87	CV8	0.53	EC93	1.50
OJ2	0.30	8BT6	0.72	6L25	0.21	12BH7	0.27	35A3	0.48	CV63	0.53	EC93	1.50
OK2	0.30	8BU6	0.50	6L28	0.59	12BK7	0.27	35A5	0.75	CV988	0.19	EC93	1.50
OL2	0.30	8BV6	0.21	6L31	0.28	12J5GT	0.30	35D5	0.70	CY1C	0.53	EC93	1.50
OM2	0.30	8BW6	0.50	6L31	0.28	12K7GT	0.30	35L6GT	0.42	CY31	0.29	EC93	1.50
ON2	0.30	8BX6	0.25	6L31	0.28	12K7GT	0.30	35W4	0.23	D63	0.20	EC93	1.50
OO2	0.30	8BY6	0.21	6L31	0.28	12L7GT	0.28	35Z3	0.59	DAC2C	0.33	EC93	1.50
OP2	0.30	8BZ6	0.31	6L31	0.28	12M7GT	0.28	35Z4GT	0.24	DAP98	0.33	EC93	1.50
OQ2	0.30	8C6	0.28	6L31	0.28	12NA7	0.28	35Z6GT	0.30	DC90	0.60	EC93	1.50
OR2	0.30	8C8	0.28	6L31	0.28	12NB7	0.28	35Z6GT	0.30	DD4	0.53	EC93	1.50
OS2	0.30	8C9	0.73	6L31	0.28	12NC7	0.28	50B5	0.35	DD4	0.53	EC93	1.50
OT2	0.30	8CA	0.28	6L31	0.28	12ND7	0.28	50C5	0.32	DF91	0.14	EC93	1.50
OU2	0.30	8CB	0.28	6L31	0.28	12NE7	0.28	50D2	0.32	DF96	0.34	EC93	1.50
OV2	0.30	8CC	0.28	6L31	0.28	12NF7	0.28	50E5	0.32	DF96	0.34	EC93	1.50
OW2	0.30	8CD	0.28	6L31	0.28	12NG7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
OX2	0.30	8CE	0.28	6L31	0.28	12NH7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
OY2	0.30	8CF	0.28	6L31	0.28	12NJ7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
OZ2	0.30	8CG	0.28	6L31	0.28	12NK7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PA2	0.30	8CH	0.28	6L31	0.28	12NL7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PB2	0.30	8CI	0.28	6L31	0.28	12NM7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PC2	0.30	8CJ	0.28	6L31	0.28	12NN7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PD2	0.30	8CK	0.28	6L31	0.28	12NO7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PE2	0.30	8CL	0.28	6L31	0.28	12NP7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PF2	0.30	8CM	0.28	6L31	0.28	12NQ7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PG2	0.30	8CN	0.28	6L31	0.28	12NR7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PH2	0.30	8CO	0.28	6L31	0.28	12NS7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PI2	0.30	8CP	0.28	6L31	0.28	12NT7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PJ2	0.30	8CQ	0.28	6L31	0.28	12NU7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PK2	0.30	8CR	0.28	6L31	0.28	12NV7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PL2	0.30	8CS	0.28	6L31	0.28	12NW7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PM2	0.30	8CT	0.28	6L31	0.28	12NX7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PN2	0.30	8CU	0.28	6L31	0.28	12NY7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PO2	0.30	8CV	0.28	6L31	0.28	12NZ7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PP2	0.30	8CW	0.28	6L31	0.28	12O1	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PQ2	0.30	8CX	0.28	6L31	0.28	12O2	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PR2	0.30	8CY	0.28	6L31	0.28	12O3	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PS2	0.30	8CZ	0.28	6L31	0.28	12O4	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PT2	0.30	8D6	0.28	6L31	0.28	12O5	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PV2	0.30	8D8	0.28	6L31	0.28	12O6	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PW2	0.30	8DA	0.28	6L31	0.28	12O7	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PX2	0.30	8DB	0.28	6L31	0.28	12O8	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PY2	0.30	8DC	0.28	6L31	0.28	12O9	0.28	50H5	0.32	DH76	0.28	EC93	1.50
PZ2	0.30	8DD	0.28	6L31	0.28	12O10	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QA2	0.30	8DE	0.28	6L31	0.28	12O11	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QB2	0.30	8DF	0.28	6L31	0.28	12O12	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QC2	0.30	8DG	0.28	6L31	0.28	12O13	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QD2	0.30	8DH	0.28	6L31	0.28	12O14	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QE2	0.30	8DI	0.28	6L31	0.28	12O15	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QF2	0.30	8DJ	0.28	6L31	0.28	12O16	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QG2	0.30	8DK	0.28	6L31	0.28	12O17	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QH2	0.30	8DL	0.28	6L31	0.28	12O18	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QI2	0.30	8DM	0.28	6L31	0.28	12O19	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QJ2	0.30	8DN	0.28	6L31	0.28	12O20	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QK2	0.30	8DO	0.28	6L31	0.28	12O21	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QL2	0.30	8DP	0.28	6L31	0.28	12O22	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QM2	0.30	8DQ	0.28	6L31	0.28	12O23	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QN2	0.30	8DR	0.28	6L31	0.28	12O24	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QO2	0.30	8DS	0.28	6L31	0.28	12O25	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QP2	0.30	8DT	0.28	6L31	0.28	12O26	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QQ2	0.30	8DU	0.28	6L31	0.28	12O27	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QR2	0.30	8DV	0.28	6L31	0.28	12O28	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QS2	0.30	8DW	0.28	6L31	0.28	12O29	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QT2	0.30	8DX	0.28	6L31	0.28	12O30	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QU2	0.30	8DY	0.28	6L31	0.28	12O31	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QV2	0.30	8DZ	0.28	6L31	0.28	12O32	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QW2	0.30	8E6	0.28	6L31	0.28	12O33	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QX2	0.30	8E8	0.28	6L31	0.28	12O34	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QY2	0.30	8EA	0.28	6L31	0.28	12O35	0.28	50H5	0.32	DH76	0.28	EC93	1.50
QZ2	0.30	8EB	0.28	6L31	0.28	12O36	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RA2	0.30	8EC	0.28	6L31	0.28	12O37	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RB2	0.30	8ED	0.28	6L31	0.28	12O38	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RC2	0.30	8EE	0.28	6L31	0.28	12O39	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RD2	0.30	8EF	0.28	6L31	0.28	12O40	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RE2	0.30	8EG	0.28	6L31	0.28	12O41	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RF2	0.30	8EH	0.28	6L31	0.28	12O42	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RG2	0.30	8EI	0.28	6L31	0.28	12O43	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RH2	0.30	8EJ	0.28	6L31	0.28	12O44	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RI2	0.30	8EK	0.28	6L31	0.28	12O45	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RJ2	0.30	8EL	0.28	6L31	0.28	12O46	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RK2	0.30	8EM	0.28	6L31	0.28	12O47	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RL2	0.30	8EN	0.28	6L31	0.28	12O48	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RM2	0.30	8EO	0.28	6L31	0.28	12O49	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RN2	0.30	8EP	0.28	6L31	0.28	12O50	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RO2	0.30	8EQ	0.28	6L31	0.28	12O51	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RP2	0.30	8ER	0.28	6L31	0.28	12O52	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RQ2	0.30	8ES	0.28	6L31	0.28	12O53	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RS2	0.30	8ET	0.28	6L31	0.28	12O54	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RT2	0.30	8EU	0.28	6L31	0.28	12O55	0.28	50H5	0.32	DH76	0.28	EC93	1.50
RU2	0.30	8EV	0.28	6L31	0.28	12O56</							

BRAND NEW SEMICONDUCTORS & COMPONENTS GUARANTEED

WE SUPPLY NEARLY ALL THE COMPONENTS FOR PROJECTS ADVERTISED IN THIS MAGAZINE

TRANSISTORS

2G301	0-15	2N3402	0-12	2N5459	0-33	AF211	0-55	BCY30	0-35	BFW15	0-35
2G302	0-15	2N3403	0-19	3N128	0-63	AF239	0-41	BCY31	0-40	BFX13	0-23
2G303	0-25	2N3404	0-24	3N138	1-65	AF240	0-72	BCY32	0-60	BFX29	0-25
2G306	0-30	2N3405	0-27	3N140	0-92	AF249	0-54	BCY33	0-34	BFX30	0-25
2G309	0-30	2N3414	0-10	3N141	0-81	AF280	0-54	BCY34	0-35	BFX37	0-30
2G345B	0-25	2N3415	0-10	3N142	0-58	AFY42	0-74	BCY38	0-40	BFX44	0-33
2G371	0-15	2N3416	0-15	3N143	0-75	AL102	0-75	BCY39	1-05	BFX63	2-48
2G374	0-15	2N3417	0-15	3N152	0-92	AL103	0-70	BCY40	0-50	BFX68	0-30
2N174	1-40	2N3570	1-25	3N153	0-81	ASY26	0-30	BCY42	0-15	BFX84	0-24
2N404	0-23	2N3571	1-12	3N154	0-84	ASY27	0-36	BCY43	0-15	BFX85	0-29
2N456	0-75	2N3572	0-97	3N159	1-17	ASY28	0-28	BCY58	0-21	BFX86	0-24
2N456A	0-75	2N3702	0-10	3N200	1-30	ASY29	0-30	BCY59	0-22	BFX87	0-25
2N457A	0-80	2N3703	0-10	3N201	1-05	ASY50	0-20	BCY66	0-66	BFX88	0-20
2N491	3-25	2N3704	0-14	40050	0-78	ASZ21	0-55	BCY67	0-66	BFX89	0-45
2N584	0-26	2N3705	0-10	40251	0-81	BC107	0-14	BCY70	0-17	BFY10	0-35
2N696	0-15	2N3706	0-09	40309	0-33	BC108	0-13	BCY71	0-22	BFY11	0-45
2N697	0-15	2N3707	0-10	40310	0-50	BC109	0-14	BCY72	0-13	BFY17	0-90
2N698	0-25	2N3708	0-70	40313	0-92	BC113	0-13	BCY87	3-47	BFY18	0-25
2N699	0-29	2N3709	0-09	40316	0-50	BC114	0-12	BCY88	2-40	BFY19	0-25
2N705	0-10	2N3710	0-12	40318	0-92	BC115	0-15	BCZ11	0-35	BFY20	0-50
2N706A	0-12	2N3711	0-90	40322	0-92	BC116	0-15	BD115	0-75	BFY27	0-40
2N708	0-13	2N3712	0-05	40360	0-46	BC116A	0-18	BD116	0-75	BFY41	0-43
2N709	0-40	2N3713	1-08	40361	0-48	BC117	0-21	BD121	0-75	BFY43	0-62
2N711	0-30	2N3714	1-15	40362	0-50	BC118	0-11	BD123	0-82	BFY51	0-18
2N718	0-21	2N3715	1-23	40363	0-88	BC119	0-27	BD124	0-67	BFY52	0-16
2N718A	0-30	2N3716	1-30	40389	0-46	BC121	0-23	BD130	0-57	BFY53	0-15
2N720	0-50	2N3773	2-35	40394	0-56	BC123	0-29	BD131	0-40	BFY56	0-34
2N721	0-55	2N3774	3-33	40395	0-50	BC125	0-15	BD132	0-50	BFY64	0-41
2N914	0-15	2N3775	4-19	40405	0-44	BC126	0-20	BD135	0-43	BFY75	0-40
2N916	0-17	2N3776	5-95	40407	0-33	BC132	0-50	BD136	0-49	BFY76	0-22
2N918	0-30	2N3777	4-84	40408	0-50	BC134	0-11	BD137	0-55	BFY77	0-24
2N919	0-20	2N3778	2-25	40409	0-52	BC135	0-11	BD138	0-63	BFY78	0-36
2N929	0-14	2N3779	3-15	40410	0-53	BC136	0-15	BD139	0-71	BFY90	0-60
2N930	0-14	2N3780	4-50	40411	2-25	BC137	0-15	BD140	0-83	BRY39	0-30
2N1090	0-23	2N3781	3-67	40414	3-55	BC138	0-20	BDY10	1-25	BSX19	0-13
2N1091	0-24	2N3782	3-37	40438	1-44	BC140	0-34	BDY11	1-50	BSX20	0-14
2N1131	0-20	2N3789	1-76	40467	0-69	BC141	0-39	BDY17	1-50	BSX21	0-20
2N1132	0-20	2N3790	2-20	40468A	0-44	BC142	0-24	BDY18	1-75	BSX26	0-34
2N1302	0-16	2N3791	2-06	40600	0-69	BC143	0-21	BDY19	1-97	BSX27	0-34
2N1303	0-16	2N3792	2-20	40601	0-67	BC144	0-24	BDY20	0-92	BSX28	0-25
2N1304	0-20	2N3794	0-10	40602	0-46	BC145	0-21	BDY38	0-65	BSX29	0-47
2N1305	0-20	2N3819	0-37	40603	0-58	BC147	0-11	BDY60	0-90	BSX30	0-68
2N1306	0-22	2N3820	0-47	40604	0-56	BC148	0-10	BDY61	0-85	BSX59	0-78
2N1307	0-22	2N3823	0-62	40636	0-52	BC149	0-13	BDY62	0-75	BSX60	0-54
2N1308	0-25	2N3824	0-75	40673	0-75	BC153	0-18	BF115	0-23	BSX61	0-42
2N1309	0-37	2N3826	0-23	AC107	0-30	BC154	0-18	BF117	0-43	BSX76	0-15
2N1483	0-90	2N3854	0-16	AC113	0-16	BC157	0-14	BF119	0-58	BSX77	0-20
2N1507	0-24	2N3854A	0-16	AC115	0-16	BC158	0-13	BF121	0-25	BSX78	0-25
2N1613	0-20	2N3855	0-16	AC117	0-20	BC159	0-14	BF123	0-27	BSW70	0-28
2N1631	0-35	2N3855A	0-16	AC121	0-13	BC160	0-37	BF125	0-25	BSY24	0-20
2N1637	0-30	2N3856	0-16	AC126	0-25	BC167B	0-11	BF127	0-27	BSY25	0-15
2N1638	0-27	2N3856A	0-16	AC127	0-25	BC168B	0-13	BF152	0-20	BSY26	0-20
2N1701	1-10	2N3858	0-16	AC128	0-25	BC168C	0-13	BF153	0-29	BSY27	0-15
2N1702	2-15	2N3858A	0-16	AC141K	0-30	BC169B	0-13	BF154	0-16	BSY28	0-15
2N1711	0-17	2N3859	0-16	AC142K	0-25	BC169C	0-13	BF158	0-15	BSY38	0-15
2N1893	0-34	2N3859A	0-16	AC151V	0-14	BC170	0-11	BF159	0-27	BSY39	0-15
2N2102	0-30	2N3860	0-16	AC152V	0-17	BC171	0-13	BF160	0-23	BSY51	0-25
2N2147	0-70	2N3866	0-16	AC153	0-22	BC172	0-11	BF161	0-35	BSY52	0-25
2N2148	0-60	2N3877	0-25	AC153K	0-25	BC182	0-10	BF163	0-20	BSY53	0-25
2N2192	0-40	2N3877A	0-26	AC154	0-20	BC182L	0-12	BF166	0-35	BSY54	0-30
2N2192A	0-40	2N3878	1-22	AC176	0-18	BC183	0-09	BF167	0-18	BSY56	0-79
2N2193	0-40	2N3879	1-91	AC176K	0-20	BC183L	0-09	BF173	0-19	BSY65	0-15
2N2193A	0-42	2N3900	0-20	AC187K	0-20	BC184	0-11	BF177	0-25	BSY78	0-40
2N2194	0-27	2N3900A	0-21	AC188K	0-26	BC184A	0-11	BF178	0-25	BSY79	0-45
2N2194A	0-30	2N3901	0-32	ACY17	0-25	BC186	0-25	BF179	0-30	BSY790	0-09
2N2195	0-37	2N3903	0-20	ACY18	0-15	BC187	0-25	BF180	0-35	BSY95A	0-09
2N2195A	0-18	2N3904	0-17	ACY19	0-20	BC204	0-11	BF181	0-32	BU104	1-42
2N2218A	0-30	2N3905	0-21	ACY20	0-20	BC205	0-10	BF182	0-30	BU105	2-25
2N2219	0-37	2N3906	0-20	ACY21	0-18	BC206	0-11	BF183	0-40	CI11	0-53
2N2219A	0-51	2N4036	0-63	ACY22	0-13	BC207	0-10	BF184	0-17	D40N3	0-62
2N2220	0-20	2N4037	0-42	ACY28	0-18	BC208	0-09	BF185	0-17	GET111	0-45
2N2221	0-20	2N4058	0-16	ACY30	0-42	BC209	0-10	BF194	0-14	GET113	0-20
2N2221A	0-33	2N4059	0-09	ACY39	0-55	BC211	0-30	BF195	0-15	GET114	0-20
2N2222	0-31	2N4060	0-11	ACY40	0-31	BC212K	0-10	BF196	0-15	GET115	0-50
2N2222A	0-41	2N4061	0-11	ACY41	0-17	BC212L	0-16	BF197	0-15	GET119	0-35
2N2368	0-11	2N4062	0-11	ACY44	0-31	BC214L	0-23	BF198	0-15	GET120	0-25
2N2369	0-39	2N4302	0-25	AD136V	0-96	BC236	0-16	BF199	0-18	GET535	0-20
2N2369A	0-17	2N4303	0-32	AD140	0-50	BC237	0-09	BF200	0-35	GET536	0-20
2N2646	0-50	2N4913	0-80	AD142	0-54	BC238	0-09	BF224J	0-14	GET538	0-20
2N2647	1-20	2N4914	0-87	AD143	0-45	BC239	0-09	BF225J	0-19	GET873	0-12
2N2711	0-12	2N4915	0-95	AD149V	0-66	BC251	0-20	BF237	0-22	GET880	0-30
2N2712	0-12	2N4916	0-20	AD150	0-63	BC252	0-18	BF238	0-22	GET883	0-20
2N2713	0-17	2N4917	0-17	AD161	0-37	BC253	0-23	BF244	0-16	GET887	0-20
2N2714	0-17	2N4918	0-50	AD162	0-37	BC257	0-09	BF245	0-33	GET890	0-22
2N2904	0-18	2N4919	0-53	AD161	Pr.	BC258	0-09	BF246	0-43	GET895	0-25
2N2904A	0-25	2N4920	0-60	AD162	0-69	BC259	0-13	BF247	0-49	TIP29A	0-49
2N2905	0-26	2N4921	0-50	ADZ11	1-50	BC261	0-20	BF254	0-14	TIP30A	0-53
2N2905A	0-23	2N4922	0-55	ADZ12	1-75	BC262	0-18	BF255	0-15	TIP31A	0-62
2N2906	0-18	2N4923	0-60	AF106	0-27	BC263	0-23	BF257	0-41	TIP32A	0-74
2N2906A	0-23	2N4926	0-60	AF109R	0-40	BC300	0-42	BF258	0-46	TIP33A	1-01
2N2907	0-18	2N4927	1-00	AF114	0-25	BC301	0-34	BF259	0-48	TIP34A	1-51
2N2907A	0-25	2N4928	1-80	AF115	0-24	BC302	0-27	BF261	0-23	TIP35A	2-90
2N2923	0-12	2N4929	2-23	AF116	0-25	BC303	0-54	BF264	1-45	TIP36A	3-70
2N2924	0-12	2N4930	2-25	AF117	0-20	BC304	0-43	BF270	0-25	TIP41A	0-79
2N2925	0-12	2N4931	2-70	AF118	0-50	BC307	0-10	BF271	0-21	TIP42A	0-90
2N2926	0-12	2N5172	0-58	AF121	0-22	BC307A	0-10	BF272	0-53	TIP2955	0-98
Green	0-10	2N5174	0-22	AF124	0-24	BC307V1	0-10	BF273	0-25	TIP3055	0-60
Yellow	0-10	2N5175	0-26	AF125	0-20	BC308	0-09	BF274	0-28		
Orange	0-10	2N5176	0-32	AF126	0-19	BC308A	0-09	BF457	0-53		
2N3053	0-31	2N5190	0-92	AF127	0-20	BC308B	0-09	BF458	0-65		
2N3054	0-46	2N5191	0-96	AF139	0-38	BC309	0-10	BF459	0-57		
2N3055	0-60	2N5192	1-24	AF170	0-25	BC309A	0-10	BFS21	2-10		
2N3390	0-20	2N5193	1-01	AF172	0-25	BC309B	0-10	BFS21A	2-30		
2N3391	0-20	2N5194	1-10	AF178	0-55	BC313	0-30	BF528	0-92		

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AZ31 0-55	DY802 0-35	ECP82 0-40	EP98 0-75	EZ80 0-27	OA2 0-38	PD500 1-30	P 82 0-35	UCH42 0-70	IT4 0-30	6BR7 0-60	6UG6 1-00	12BH7 0-45	80 0-65
AZ41 0-50	EABC80	ECH35 1-00	EP183 0-30	EZ81 0-29	OB2 0-35	PEN45D 30	PY83 0-38	UCH81 0-40	384 0-35	6BW6 0-85	6V6GT 0-40	30C15 0-80	807 0-50
CB131 1-00	CL33 1-30	EAF42 0-55	ECH84 0-45	EL34 0-50	GY501 0-80	PC900 0-48	PL38 0-25	UF41 0-60	5V4G 0-45	6CH6 0-60	7B7 0-50	30FL1 0-75	2A11 4-00
DAF91 0-30	EBC33 0-50	EBC41 0-65	ECL80 0-45	EL37 0-25	GZ30 0-40	PC884 0-40	PL81 0-50	UF89 0-40	5Y3GT 0-40	6E5 1-00	7C5 1-13	30PL14 0-85	3BP1 3-00
DAF96 0-45	EBC81 0-30	ECL86 0-40	EL42 0-65	GZ34 0-60	PC189 0-55	PL82 0-45	U25 0-80	UL14 0-65	6J30L2 0-80	6J5GT 0-30	7H7 0-75	30L15 0-85	3DP1 2-50
DF91 0-30	EBF80 0-40	ECL89 0-25	EL54 0-25	H63 0-90	PCF86 0-60	PL84 0-40	U26 0-80	UY41 0-48	6AL5 0-20	6V7GT 0-45	787 2-25	30P12 0-60	3FP7 1-50
DK91 0-45	EBF89 0-30	EF37A 1-20	EL85 0-35	HL41DD	PCF86 0-60	PL85 0-40	U29 0-80	VF4B 1-25	6AS7 0-85	6K7GT 0-35	12AC6 0-50	30P11 0-75	5BP1 4-00
DK92 0-50	EBL31 1-50	EF39 0-60	EL360 1-20	HN309 1-50	PCF802 0-50	PL509 0-90	U404 0-60	VR75/30	6AT6 0-35	6K8GT 0-50	12AD6 0-55	30PL13 0-93	5CP1 5-00
DK96 0-50	ECC40 1-00	EF41 0-65	EL800 1-00	KT61 1-75	PCF805 0-80	PL599 1-60	U801 1-18	VR105/30	6AU6 0-25	6P25 1-75	12AE6 0-55	30PL14 0-90	5FP7 3-00
DL92 0-35	ECC81 0-35	EF80 0-25	EM80 0-45	KT66 2-35	PCF806 0-70	PL801 0-80	U801 1-18	VR105/30	6AV6 0-30	6Q7GT 0-43	12AT6 0-30	35L6GT 0-50	8B1 10-00
DL94 0-48	ECC82 0-30	EF85 0-35	EM81 0-60	KT81 (7C5)	PCF809 0-85	PL802 0-85	U801 1-18	VR105/30	6BA6 0-25	6R87M 0-40	12AT7 0-35	35W4 0-35	CV329 17-50
DL96 0-45	ECC83 0-30	EF86 0-30	EM84 0-35	KT82	PCF812 0-85	PK4 2-85	U801 1-18	VR105/30	6BE6 0-30	6S17GT 0-30	12AU6 0-35	35Z3 0-70	CV360 5-00
DM70 0-45	ECC85 0-40	EF89 0-28	EY51 0-40	KT88 2-25	PCF813 0-85	PK25 2-50	U801 1-18	VR105/30	6BH6 0-75	6S17GT 0-35	12AU7 0-30	35Z4T 0-60	DG7-5 8-00
DY86 0-33	ECC88 0-40	EF91 0-33	EZ40 0-50	KTW611-00	PCF815 0-40	PK33 0-63	U801 1-18	VR105/30	6B16 0-50	6S17GT 0-35	12AX7 0-30	50C5 0-50	DG7-5 10-00
DY87 0-33	ECC89 0-35	EF92 0-33	EZ41 0-50	N78 1-50	PCF816 0-45	PK33 0-63	U801 1-18	VR105/30	6BQ7A 0-45	6T4GT 0-35	12BE6 0-40	50C6 0-50	VCR1387-00

TRANSISTORS

1N21 0-17	2N708 0-15	2N3711 0-10	AP117 0-25	BF196 0-15	CR83/40	GJ7M 0-37	NKT128	NKT403	OA95 0-07	OC26 0-25	OC71 0-12	OC84 0-25	ORP60 0-40
1N23 0-20	2N1302 0-18	2N3710 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT101	NKT211	NKT404	OA200 0-07	OC28 0-60	OC72 0-20	OC82 0-65	ORP61 0-40
1N4001 0-07	2N1304 0-22	2N3709 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT120	NKT212	NKT405	OA202 0-10	OC29 0-60	OC73 0-30	OC83 0-25	XX640 0-60
1N4002 0-10	2N1305 0-22	2N3708 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT121	NKT213	NKT406	OA210 0-25	OC30 0-40	OC74 0-30	OC84 0-35	XX642 0-60
1N4003 0-10	2N1306 0-25	2N3707 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT122	NKT214	NKT407	OA215 0-20	OC31 0-40	OC75 0-25	OC85 0-35	XX643 0-70
1N4004 0-15	2N1307 0-25	2N3706 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT123	NKT215	NKT408	OA220 0-20	OC32 0-40	OC76 0-25	OC86 0-35	Z821 0-15
1B11 0-13	2N2147 0-75	2N3705 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT124	NKT216	NKT409	OA225 0-20	OC33 0-40	OC77 0-25	OC87 0-35	Z822 0-15
1B13 0-13	2N2148 0-75	2N3704 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT125	NKT217	NKT410	OA230 0-20	OC34 0-40	OC78 0-20	OC88 0-35	Z823 0-15
1B132 0-13	2N2149 0-75	2N3703 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT126	NKT218	NKT411	OA235 0-20	OC35 0-40	OC79 0-20	OC89 0-35	Z824 0-15
2Q220 0-63	2N2646 0-45	2N3702 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT127	NKT219	NKT412	OA240 0-20	OC36 0-40	OC80 0-20	OC90 0-35	Z825 0-15
2Q301 0-20	2N2926 0-10	2N3701 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT128	NKT220	NKT413	OA245 0-20	OC37 0-40	OC81 0-20	OC91 0-35	Z826 0-15
2Q302 0-22	2N2927 0-10	2N3700 0-10	AP139 0-30	BF197 0-15	CR810 3-13	MAT129	NKT221	NKT414	OA250 0-20	OC38 0-40	OC82 0-20	OC92 0-35	Z827 0-15
2N696 0-15	2N3703 0-10	2N3699 0-15	AP139 0-30	BF197 0-15	CR810 3-13	MAT130	NKT222	NKT415	OA255 0-20	OC39 0-40	OC83 0-20	OC93 0-35	Z828 0-15
2N706 0-10	2N3702 0-10	2N3698 0-15	AP139 0-30	BF197 0-15	CR810 3-13	MAT131	NKT223	NKT416	OA260 0-20	OC40 0-40	OC84 0-20	OC94 0-35	Z829 0-15
2N706A 0-12	2N3701 0-10	2N3697 0-15	AP139 0-30	BF197 0-15	CR810 3-13	MAT132	NKT224	NKT417	OA265 0-20	OC41 0-40	OC85 0-20	OC95 0-35	Z830 0-15

VALVES

1B3GT	3B28	5Z4G	12E1	815	572F	6923	CV28	CV40	CV2325	CV4043	E180F	GXU9	ME1403	Q8108/45
1B4	3B29	6AF4A	12E14	828	572F	6939	CV31	CV415	CV2331	CV4044	E1810C	GXU3	ME1404	Q8109/15
1B35A	3C22	6AK5	13D1	829B	572F	7193	CV46	CV416	CV2466	CV4046	E1820C	GXU4	ME1500	Q8150/30
1B35A	3C23	6AM5	13E1	830B	572F	7193	CV45	CV417	CV2516	CV4048	E186F	GXU5	ME1501	Q8150/36
1N21	3C24/24G	6AN5	13F1	830B	572F	7193	CV73	CV418	CV2519	CV4053	E1880C			Q8150/40
1N21B	3C24/24G	6AN5	13G1	830B	572F	7193	CV74	CV419	CV2520	CV4056	EA30	KT66	OA2	Q8150/45
1N23B	3CX100A5	6AN8	13H1	830B	572F	7193	CV75	CV420	CV2521	CV4059	EA32	KT67	OA3	Q8150/80
1N23CR	3E29	6AR5	13I1	830B	572F	7193	CV76	CV421	CV2522	CV4060	EA35	KT68		Q81290
1X2A	3J/121E	6AS6	13J1	830B	572F	7193	CV77	CV422	CV2523	CV4062	ECC35		OA40	Q81202
1X2B	3J/170E	6AU40TA	13K1	830B	572F	7193	CV78	CV423	CV2524	CV4063	ECCF804	M8079		Q81205
2A3	3Q/160E	6AU50T	13L1	830B	572F	7193	CV79	CV424	CV2525	CV4064	EF50	M8080	OB2	Q81205
2A815	3Q/195E	6AV50TA	13M1	830B	572F	7193	CV80	CV425	CV2526	CV4065	EF55	M8081	OB3	Q81205
2C26A	3B4	6AW8A	13N1	830B	572F	7193	CV81	CV426	CV2527	CV4066	EF60	M8082	OB4	Q81205
2C34	3V/340B	6AX50T	13O1	830B	572F	7193	CV82	CV427	CV2528	CV4067	EF65	M8083	OB5	Q81205
2C39A	3V/390A	6B4G	13P1	830B	572F	7193	CV83	CV428	CV2529	CV4068	EF70	M8084	OB6	Q81205
2C43	3V/390B	6BA8A	13Q1	830B	572F	7193	CV84	CV429	CV2530	CV4069	EF75	M8085	OB7	Q81205
2D21	4C25	6BK7A	13R1	830B	572F	7193	CV85	CV430	CV2531	CV4070	EF80	M8086	OB8	Q81205
2E26	4-125A	6BL7GTA	13S1	830B	572F	7193	CV86	CV431	CV2532	CV4071	EF85	M8087	OB9	Q81205
2J31	4-400A	6BN6	13T1	830B	572F	7193	CV87	CV432	CV2533	CV4072	EF90	M8088	OB10	Q81205
2J33	4B32	6BR7	13U1	830B	572F	7193	CV88	CV433	CV2534	CV4073	EF95	M8089	OB11	Q81205
2J50	4C35	6C8A	13V1	830B	572F	7193	CV89	CV434	CV2535	CV4074	EF100	M8090	OB12	Q81205
2J54	4C35/250B	6C8B	13W1	830B	572F	7193	CV90	CV435	CV2536	CV4075	EF105	M8091	OB13	Q81205
2J56A	4E27	6C8C	13X1	830B	572F	7193	CV91	CV436	CV2537	CV4076	EF110	M8092	OB14	Q81205
2K25	4J50	6C8D	13Y1	830B	572F	7193	CV92	CV437	CV2538	CV4077	EF115	M8093	OB15	Q81205
2K26	4J52	6C8E	13Z1	830B	572F	7193	CV93	CV438	CV2539	CV4078	EF120	M8094	OB16	Q81205
2K28	4J52A	6C8F	14A1	830B	572F	7193	CV94	CV439	CV2540	CV4079	EF125	M8095	OB17	Q81205
2K45	4J53	6C8G	14B1	830B	572F	7193	CV95	CV440	CV2541	CV4080	EF130	M8096	OB18	Q81205
2X2A	4X150A	6D6B	14C1	830B	572F	7193	CV96	CV441	CV2542	CV4081	EF135	M8097	OB19	Q81205
3A/107A	4X150D	6DQ6B	14D1	830B	572F	7193	CV97	CV442	CV2543	CV4082	EF140	M8098	OB20	Q81205
3A/108A	4X250B	6EA8	14E1	830B	572F	7193	CV98	CV443	CV2544	CV4083	EF145	M8099	OB21	Q81205
3A/108B	5B/251M	6E83	14F1	830B	572F	7193	CV99	CV444	CV2545	CV4084	EF150	M8100	OB22	Q81205
3A/109B	5B/252M	6H6(metal)	14G1	830B	572F	7193	CV100	CV445	CV2546	CV4085	EF155	M8101	OB23	Q81205
3A/110A	5B/253M	6K7GT	14H1	830B	572F	7193	CV101	CV446	CV2547	CV4086	EF160	M8102	OB24	Q81205
3A/110B	5B/253M	6K7GT	14I1	830B	572F	7193	CV102	CV447	CV2548	CV4087	EF165	M8103	OB25	Q81205
3A/145J	5B/256M	6L6	14J1	830B	572F	7193	CV103	CV448	CV2549	CV4088	EF170	M8104	OB26	Q81205
3A/167M	5B/257M	6L6	14K1	830B	572F	7193	CV104	CV449	CV2550	CV4089	EF175	M8105	OB27	Q81205
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Wholesale/Retail: 369 Alum Rock Road, Birmingham B8 3DR. Tel. 021-327 2339

Special Offer!!!

SMALL ELECTROLYTICS

Ref. No.	Capacity	Voltage	Price	Ref. No.	Capacity	Voltage	Price
H8/1	1µf	150v	4p	H7/4A	64µf	35v	5p
H8/1A	2µf	150v	2p	H7/5	80µf	16v	4p
H8/2	2.2µf	25v	4p	H7/6	100µf	25v	5p
H8/2A	3.3µf	25v	4p	H7/6A	100µf	15v	4p
H8/3	3µf	50v	4p	H7/7	100µf	25v	4p
H8/3A	4µf	50v	4p	H7/8	125µf	16v	5p
H8/4	4.7µf	25v	4p	H7/8A	100µf	35v	6p
H8/4A	5µf	64v	4p	H7/9	100µf	63v	6p
H8/5	5µf	10v	4p	H7/9A	125µf	4v	4p
H8/5A	5µf	150v	4p	H7/10	125µf	25v	6p
H8/6A	10µf	10v	4p	H7/10A	160µf	2.5v	3p
H8/7	10µf	70v	4p	H7/11	160µf	25v	6p
H8/8	16µf	35v	4p	H7/11A	150µf	16v	5p
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	H6/13A	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.	Voltage	Capacitance	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.

Not over 1½lb	Ordinary Parcels 16p	Not over 4lb	Ordinary Parcels 25p	Not over 10lb	Ordinary Parcels 37p	Not over 18lb	Ordinary Parcels 57p
2lb	21p	6lb	29p	14lb	47p	22lb	67p

TRANSISTORS

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		
Micro-miniature N.P.N.			
BFS 18R	10p		
LDA 400/403/450/452	10p		
Infra-red Transmitters			
CQY 11A	£4		
CQY 12A	£10		
Light-sensitive Trans.			
OCF 70	20p		
Complementary Drivers, 2 watt (per matched pair)			
INTEGRATED CIRCUITS			
TBA 500 Luminance I.C.	£1		
TBA 510 Chrominance I.C.	£1		
FEQ 101 64bit Memory	£1		
7400	12p		
7401	12p		
7410	12p		
7420	12p		
7440	12p		
7453	24p		
7470	24p		
7472	24p		
7473	32p		
7474	32p		
7482	88p		
7483	88p		
7490	95p		
7491	78p		
7492	58p		
7493	58p		
7495	68p		
5400	10p		
6404	10p		

NEW! NEW! NEW! NEW!

An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.
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.
Light sensitive aerosol spray £1.00 plus postage
Developer and Etchant 50p

NEWER THAN NEW!!!

Fibre Glass Board pre-treated with light-sensitive lacquer enabling you to produce prototype printed circuits within five minutes.

75mm x 100mm	33p
150mm x 100mm	66p
150mm x 200mm	£1.32
250mm x 200mm	£2.20

Epoxy-Resin

75mm x 100mm	22p
100mm x 150mm	44p
150mm x 200mm	88p

VEROBOARD

2½in x 1in x 0.15in	6p
3½in x 2½in x 0.15in	16p
3½in x 3½in x 0.15in	25p
5in x 2½in x 0.15in	25p
5in x 3½in x 0.15in	30p
17in x 2½in x 0.15in	55p
17in x 3½in x 0.15in	79p
250mm x 2½in x 0.1in	21p
3½in x 3½in x 0.1in	25p
5in x 2½in x 0.1in	25p
5in x 3½in x 0.1in	25p

Spot Face Cutter 38p. Pin Insert Tool 57p.
Terminal Pins (0-1 or 0-15) 36 for 22p.

MULLARD POLYESTER CAPACITORS

500,000 in STOCK!!!

-001µf	-0018µf	-0056µf	-015µf
-0012µf	-0022µf	-01µf	-033µf
-0015µf	-0027µf	-012µf	-082µf

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

ERIE MONOLITHIC CERAMIC CAPACITORS

3p each; 24p dozen; £1.75 per 100
10pf 68pf 560pf
15pf 100pf 620pf
22pf 150pf 680pf
33pf 220pf 1,000pf
39pf 330pf
47pf 470pf

RECORDING TAPE BARGAIN! The very best British Made low-noise high-quality Tape 1 5in Standard 38p. Long-play 45p. 5½in Standard 45p. Long-play 60p. 7in Standard 60p. Long-play 82p. We are getting a fantastic number of repeat orders for this tape. Might we suggest that you order now whilst we still have a good stock at these low prices?
TRANSISTORISED FLUORESCENT LIGHTS, 12 volt. All with reversed polarity protection. 8 watt type with reflector suitable for tents, etc. £3. Postage/Packing 25p. 15 watt type, batten fitting for caravans £4. Postage/Packing 25p. 13 watt type, batten with switch. 22in x 2in x 1in £5. Postage/Packing 25p. THESE CAN BE SENT ON APPROVAL AGAINST FULL PAYMENT.

RECTIFIERS 1N4007 1200 peak volts, 30 amps peak current, 1 amp mean current. 100 for £7.50, 1,000 £50.

£1 100 ½ WATT RESISTORS 100 CERAMIC CAPACITORS 100 DIODES PACK No. 1	£1 1 VERO-BOARD CUTTER 5 2½ in. x 1 in. x 15 BOARDS 50 SQ. INS. "ODD PIECES" VERO PACK No. 3	£1 20 ASSORTED UNUSED MARKED, TESTED TRANSISTORS BC108 ETC. PACK No. 5	£1 6 COMPUTER PANELS CONTAINING MASSES OF DIODES, TRANSISTORS, INDUCTORS, RESISTORS & CAPACITORS PACK No. 7
£1 100 RESISTORS 100 CERAMIC CAPACITORS 100 POLYSTYRENE CAPACITORS PACK No. 2	£1 100 RESISTORS 100 CERAMIC CAPACITORS 50 MULLARD POLYESTER CAPACITORS PACK No. 4	£1 1 TRANSISTORISED SIGNAL TRACER KIT 1 TRANSISTORISED SIGNAL INJECTOR KIT PACK No. 6	£1 100 RESISTORS 100 CERAMIC CAPACITORS (ASSORTED TYPES) PACK No. 8

REMEMBER! ALL GOODS PLUS 10% V.A.T.
G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 15p.

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	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	10%	4.7Ω-10MΩ	E12	1	0.9	0.75 nett
C	1/2W	5%	4.7Ω-10MΩ	E24	1.2	1	0.7 nett
C	1W	10%	4.7Ω-10MΩ	E12	2.5	2	0.5 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, Electrofil 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.

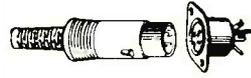
Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions on total value of resistor order.)

TRANSISTORS BY SIEMENS AND NEWMARKET

2N3055 npn silicon power	60p	BD135 npn medium power	30p
AC153K pnp germanium low power	23p	BD136 pnp medium power	33p
AC176K npn germanium low power	42p	DIODES	
AD161 npn germanium medium power	42p	OA90, OA91, OA95 each 6p	
AD162 pnp germanium medium power	40p	OA200—9p; OA202—10p	
AF139 pnp germanium UHF	33p	Other semi-conductors	
BC107—13p; BC108—12p; BC109—13p	} npn	AC128—21p AF117—24p	
BC167—10p; BC168—9p; BC169—10p		} pnp	BFY51—19p
BC177—15p; BC178—14p; BC179—15p			
BC257—9p; BC258—8p; BC259—9p			
Standard groupings available.			

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

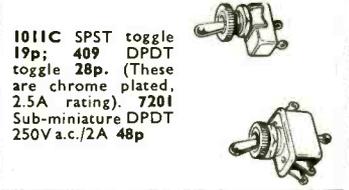
Lockable types, phono connectors, etc.

COVERS & HEATSINKS



T03 Transistor cover, clip-on 7p
HEATSINK
Type 6VVI
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

Part No.	Price
FLH101 (7400)	20p
FLH201 (7401)	20p
FLH191 (7402)	20p
FLH291 (7403)	20p
FLH211 (7404)	25p
FLH271 (7405)	25p
FLH381 (7408)	25p
FLH391 (7409)	25p
FLH111 (7410)	20p
FLH351 (7413)	35p
FLH121 (7420)	20p
FLH131 (7430)	20p
FLH141 (7440)	24p
FLH101 (74141)	(16) £1.22
FLH281 (7442)	(16) £1.16
FLH361 (7443)	(16) £1.45
FLH371 (7444)	(16) £1.45
FLH151 (7450)	20p
FLH161 (7451)	20p
FLH171 (7453)	20p
FLH181 (7454)	20p
FLY101 (7466)	20p
FLJ101 (7470)	45p
FLJ111 (7472)	32p
FLJ121 (7473)	45p
FLJ141 (7474)	45p
FLJ151 (7475)	(16) 45p
FLJ131 (7476)	(16) 45p
FLH221 (7480)	68p
FLH231 (7482)	87p
FLH241 (7483)	(16) £1.32
FLH341 (7486)	33p
FLJ161 (7490)	80p
FLJ221 (7491AN)	£1.28
FLJ171 (7492)	85p
FLJ181 (7493)	80p
FLJ231 (7494)	(16) £1.13
FLJ191 (7495)	87p
FLJ261 (7496)	(16) £1.48
FLJ301 (74100)	(24) £1.64
FLJ281 (74104)	43p
FLJ271 (74107)	52p
FLK101 (74121)	48p
FLJ201 (74190)	(16) £1.80
FLJ211 (74191)	(16) £1.80
FLJ241 (74192)	(16) £1.74
FLJ251 (74193)	(16) £1.74

POTENTIOMETER carbon type

long spindles. Double wipers for low noise.

SINGLE GANG R20 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 each. Escutcheon, light grey, 10p. Knobs, flat, grip type, in 7 colour, 5p each.

SKELTON 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.

NUTS, SCREWS, ETC. In pence per 100. Nuts 2BA—51p; 4BA—35p; 6BA—32p. Screws 1"—2BA—85p; 4BA—43p; 6BA—32p. 0.5"—2BA—62p; 4BA—29p; 6BA—24p. Screws roundedhead, cheese headed or countersunk. Other sizes available. Also tags, washers, spacers, etc.



ELECTROLYTICS

µF	Prices in pennies							
	3V	6.3V	10V	16V	25V	40V	63V	100V
0.47							7	7
1.0						7	7	7
2.2						7	7	7
4.7				7	7	7	7	7
10			7	7	7	7	7	7
22			7	7	7	7	7	7
47	7	7	7	7	7	7	8	12
100	7	7	7	7	7	8	12	18
220	7	7	7	8	9	10	17	26
470	7	8	9	9	12	17	24	41
1000	9	12	12	17	20	23	40	
2200	14	16	22	25	36	40		
4700	23	26	37	40				
10,000	37	40						

Small est size 3.7mm x 12mm. Largest size 25.5mm x 41mm. Full ranges of many other types of capacitors stocked.

ROTARY SWITCHES

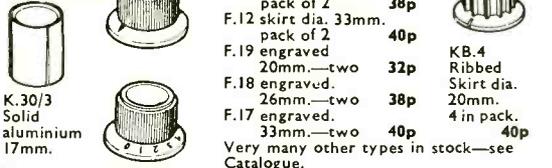
Radiospares Miniature Make-switch (in assembly kit form). Shaft 48p.

Wavechange switches IP12W, 2P6W, 3P4W, 4P3W, each 32p.

Wafers, MBB—2P5W, 1P 11W; BBMIPI2W, 2P6W, 3P4W, 4P3W, 6P2W, each 32p.



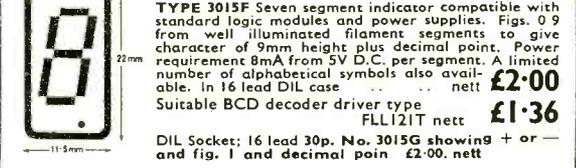
KNOBS (for 0.25 shafts)



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

Very many other types in stock—see Catalogue.

Minitron DIGITAL INDICATOR



TYPE 3015F Seven segment indicator compatible with standard logic modules and power supplies. Figs. 0-9 from well illuminated filament segments to give character of 9mm height plus decimal point. Power requirement 8mA from 5V D.C. per segment. A limited number of alphabetical symbols also available. In 16 lead DIL case ... nett £2.00

Suitable BCD decoder driver type FLL121T nett £1.36

DIL Socket; 16 lead 30p. No. 3015G showing + or — and fig. 1 and decimal point £2.00. nett

ZENER DIODES

Full range E24 values: 400mW: 2.7V to 36V, 14p each; 1W: 6.8V to 82V, 21p each; 1.5W: 4.7V to 75V, 48p each. Clip to increase 1.5W rating to 3 watts (type 266F) 4p.

SIEMENS THYRISTORS

0.8A 400V, 48p; 600V 76p. 3A 400V, 52p; 600V, 76p. DE-SOLDER BRAID 6ft. nett 50p

S-DEC

Unsurpassed for "breadboard work" can be used indefinitely without deterioration. Components just push into plug holes and connect automatically. Slot for control panel. 70 holes. £1.44.

T-DEC

For more advanced work with 208 contacts in 38 rows. Will take one 16 lead carrier. £2.88. (Carriers supplied separately.)

MAINS TRANSFORMERS

MT3 30V/2A plus 4 taps	£2.85
MT103 50V/1A plus 4 taps	£2.55
MT104 50V/2A plus 4 taps	£3.50
MT127 60V/2A plus 4 taps	£3.80
13T05 13V½A, CT	£1.25
28T05 12+12; 2-0.2V½A	£1.40

IT SAVES YOU 25p TO START WITH

That's the price of the 96 page Electro-value Catalogue (No. 6) and with it we give you a 25p refund exchange voucher on orders which come to £5 or more. The Catalogue is packed with bargains in brand new guaranteed to makers spec. items plus I.C. circuit and schematic diagrams, transistor diagrams and specs, equivalent tables etc. Send 25p (plus 2p VAT when operative) for Catalogue by return.

DISCOUNTS
Available on all items except those shown with NETT PRICES. 10% on orders from £5 to £15. 15% on orders £15 and over.

TERMS OF BUSINESS
All items are offered for sale in accordance with our standard terms of business, a copy of which is available on request. Prices subject to alteration without notice. Enquiries from quantity users invited.

PACKING & POSTAGE
FREE in U.K. For mail orders for £2 list value and under, there is an additional handling charge of 10p.

V.A.T.
Prices shown here DO NOT INCLUDE V.A.T.
Orders from U.K. customers must be accompanied by an additional 10% of nett value for V.A.T.
Overseas orders are exempt.

COMPONENTS FOR W.W. AMPLIFIER DESIGNS

100W AMPLIFIER (FEB. 1972)	
Designer approved kit.	15.60
Semiconductor set	2.50
Resistors, capacitors, pots	1.30
F/Glass PCB	1.30
POWER SUPPLY (For 100W Amp.)	
Designer approved kit.	14.70
Semiconductors, Resistors, capacitors, pots, trans-formers, 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.	1.20
2N3055 pair, BC212L, 2N1711	1.80
Resistors, capacitors, pot	0.60
F/Glass PCB	0.60
LINSLEY-HOOD 20W CLASS AB	
Designer approved kit.	3.35
MJ481/491, MJ521, BC182L, BC212L, zener	2.20
Resistors, capacitors, pots	0.70
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 list.	

'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

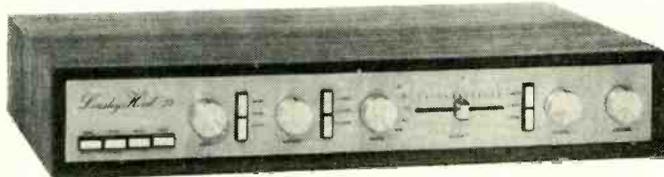
SEMICONDUCTORS

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	MPSA66	0.40
2N3906	0.20	MPSU05	0.60
2N4058	0.12	MPSU55	0.70
2N4062	0.11	SN72741P	0.58
2N4302	0.60	SN72748P	0.58
2N5087	0.42	THB11	1.10
2N5210	0.54	TIP29A	0.50
2N5457	0.30	TIP30A	0.60
2N5830	0.30	TIP31A	0.60
40361	0.40	TIP32A	0.70
40362	0.45	TIP33A	1.00
BC107	0.08	TIP34A	1.50
BC108	0.08	TIP41A	0.74
BC109	0.08	TIP42A	0.90
BC125	0.15	TIP3055	0.60
BC126	0.15	1B08T20	0.50
BC182K	0.10	1B40K20	1.40
BC212K	0.12	1N914	0.07
BC182L	0.10	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.

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

- ★ 75 WATTS PER CHANNEL
- ★ BANDWIDTH (3dB) 3HZ-40KHZ
- ★ DISTORTION LESS THAN 0.01%
- ★ UNCONDITIONAL STABILITY

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.

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

VALVES

B12H	£ 1.75	ECL80	£ 0.38
CV31	£ 0.31	ECL82	£ 0.31
DAF96	£ 0.40	ECL83	£ 0.63
DF06	£ 0.40	ECL86	£ 0.16
DK96	£ 0.43	EF36	£ 0.40
DL92	£ 0.28	EF37A	£ 1.13
DL94	£ 0.40	EF40	£ 0.40
DL96	£ 0.40	EF41	£ 0.78
DM70	£ 0.27	EF80	£ 0.22
DY86	£ 0.28	EF85	£ 0.47
DY87	£ 0.28	EF85	£ 0.31
DY802	£ 0.43	EF86	£ 0.27
E880C/1	£ 1.08	EF89	£ 0.25
E1800C	£ 0.37	EF91	£ 0.27
E1800C	£ 0.90	EF92	£ 0.31
E1800C	£ 1.08	EF95	£ 0.31
EAS0	£ 0.18	EF183	£ 0.26
EAC800	£ 0.27	EF184	£ 0.31
EAF42	£ 0.46	EF1200	£ 0.67
EB91	£ 0.18	EL34	£ 0.45
EBG33	£ 0.45	EL41	£ 0.47
EBG41	£ 0.45	EL84	£ 0.21
EC81	£ 0.31	EL85	£ 0.37
ERF80	£ 0.38	EL86	£ 0.36
EA73	£ 0.38	EL90	£ 0.31
EBF89	£ 0.27	EL95	£ 0.31
ECC81	£ 0.27	EL500	£ 0.76
ECC82	£ 0.25	EM31	£ 0.22
ECC83	£ 0.27	EM80	£ 0.36
ECC84	£ 0.27	EM84	£ 0.31
ECC85	£ 0.38	EM87	£ 0.83
ECC86	£ 0.40	EY51	£ 0.38
ECC88	£ 0.33	EY86	£ 0.40
ECC189	£ 0.47	EY81	£ 0.40
ECP80	£ 0.31	EY88	£ 0.40
ECP82	£ 0.31	EZ41	£ 0.45
ECP83	£ 0.67	EZ80	£ 0.22
ECP801	£ 0.56	EZ81	£ 0.24
ECP802	£ 0.56	EZ84	£ 0.52
ECH15	£ 0.81	EZ37	£ 0.63
ECH18	£ 0.25	K796	£ 1.88
ECH83	£ 0.30	FT88	£ 2.18
ECH84	£ 0.40	N78	£ 1.60
ECH200	£ 0.56	OA2	£ 3.10

R17	£ 0.45	UBF80	£ 0.35
R19	£ 0.35	UBF89	£ 0.30
STV	£ 0.40	UCC85	£ 0.35
280/40	£ 3.20	UCF80	£ 0.48
STV	£ 0.40	UCH42	£ 0.60
280/80	£ 8.20	UCH81	£ 0.25
TT21	£ 3.30	UCL82	£ 0.30
U25	£ 0.68	UCL83	£ 0.50
U26	£ 0.68	UV41	£ 0.50
U27	£ 0.45	UF80	£ 0.30
U191	£ 0.60	UF89	£ 0.30
U801	£ 0.70	UL41	£ 0.40
UAC80	£ 0.30	UL84	£ 0.30
UAF42	£ 0.50	UUS	£ 0.55
UBC41	£ 0.41	UY41	£ 0.32
		UY85	£ 0.30
		VR150/30	£ 0.30

5B254M	£ 2.00	6A05	£ 0.30
5B255M	£ 1.80	6A05W	£ 0.45
5K40Y	£ 0.65	6A86	£ 0.30
5U40	£ 0.20	6A87	£ 0.70
6V4G	£ 0.37	6AT6	£ 0.25
5Y4G	£ 0.35	6AUG	£ 0.20
5Y3GT	£ 0.30	6AX4GT	£ 0.50
5Z3	£ 0.48	6AX5GT	£ 0.60
5Z4	£ 0.75	6B17	£ 0.35
5Z4GT	£ 0.84	6B67	£ 0.18
6AB7	£ 0.25	6BA6	£ 0.20
6AC7	£ 0.25	6BE6	£ 0.20
6AH6	£ 0.45	6BG6G	£ 0.47
6AK5	£ 0.25	6BJ6	£ 0.35
6AK8	£ 0.30	6BQ7A	£ 0.35
6AL5	£ 0.18	6BR7	£ 0.75
6AL5W	£ 0.35	6B7M	£ 0.35
6AM6	£ 0.25	6BW6	£ 0.65
6AN6	£ 0.45	9BW7	£ 0.45

COLOMOR

THE VALVE WITH A GUARANTEE

6K7G	£ 0.17	6C4	£ 0.25	6K7G	£ 0.17
6K8GT	£ 0.32	6C5	£ 0.20	6K8GT	£ 0.32
6K85	£ 0.60	6CH6	£ 0.47	6K85	£ 0.60
6L3M	£ 0.42	6CL6	£ 0.42	6L3M	£ 0.42
68A7	£ 0.35	6D6	£ 0.15	68A7	£ 0.35
68A7GT	£ 0.25	6EA8	£ 0.50	68A7GT	£ 0.25
68C7GT	£ 0.20	6E23	£ 0.60	68C7GT	£ 0.20
68G7	£ 0.35	6F33	£ 1.35	68G7	£ 0.35
68J7	£ 0.30	6H6M	£ 0.18	68J7	£ 0.30
68J7GT	£ 0.28	6J4WA	£ 0.65	68J7GT	£ 0.28
68K7	£ 0.40	6J5	£ 0.35	68K7	£ 0.40
68L7GT	£ 0.27	6J5GT	£ 0.20	68L7GT	£ 0.27
68N7GT	£ 0.27	6J6	£ 0.18	68N7GT	£ 0.27
68Q7	£ 0.30	6J7G	£ 0.30	68Q7	£ 0.30
68Q7GT	£ 0.30	6J7M	£ 0.35	68Q7GT	£ 0.30
6V6G	£ 0.15	6K6GT	£ 0.45	6V6G	£ 0.15
6V6GT	£ 0.30	6K7	£ 0.27	6V6GT	£ 0.30
6X4	£ 0.25	30FL12	£ 0.50	6X4	£ 0.25
6X50	£ 0.25	30FL14	£ 0.50	6X50	£ 0.25
6X50GT	£ 0.30	30FL15	£ 0.50	6X50GT	£ 0.30
6Y6G	£ 0.60	30FL17	£ 0.65	6Y6G	£ 0.60
6Z0L2	£ 0.70	30FL19	£ 0.65	6Z0L2	£ 0.70
6Z4	£ 0.30	30FL1	£ 0.60	6Z4	£ 0.30
6Z7	£ 0.45	30FL13	£ 0.75	6Z7	£ 0.45
6Z8A	£ 0.60	30PL14	£ 0.73	6Z8A	£ 0.60
6Z9A	£ 0.30	30PL16	£ 0.42	6Z9A	£ 0.30
6Z9B	£ 0.30	30PL17	£ 0.45	6Z9B	£ 0.30
6Z9C	£ 0.30	30PL18	£ 0.45	6Z9C	£ 0.30
6Z9D	£ 0.30	30PL19	£ 0.45	6Z9D	£ 0.30
6Z9E	£ 0.30	30PL20	£ 0.45	6Z9E	£ 0.30
6Z9F	£ 0.30	30PL21	£ 0.45	6Z9F	£ 0.30
6Z9G	£ 0.30	30PL22	£ 0.45	6Z9G	£ 0.30
6Z9H	£ 0.30	30PL23	£ 0.45	6Z9H	£ 0.30
6Z9I	£ 0.30	30PL24	£ 0.45	6Z9I	£ 0.30
6Z9J	£ 0.30	30PL25	£ 0.45	6Z9J	£ 0.30
6Z9K	£ 0.30	30PL26	£ 0.45	6Z9K	£ 0.30
6Z9L	£ 0.30	30PL27	£ 0.45	6Z9L	£ 0.30
6Z9M	£ 0.30	30PL28	£ 0.45	6Z9M	£ 0.30
6Z9N	£ 0.30	30PL29	£ 0.45	6Z9N	£ 0.30
6Z9O	£ 0.30	30PL30	£ 0.45	6Z9O	£ 0.30

SPECIAL OFFER TRANSISTORS, ZENER DIODES

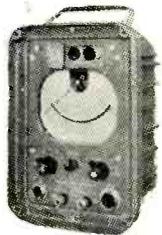
OC71	£ 0.12	1N702-7230-38	£ 0.30	3N139	£ 1.75	ASY67	£ 0.48	CRS3/40	£ 0.50
OC72	£ 0.20	1N82A	£ 1.20	3N140	£ 0.87	BAW19	£ 0.28	C82A	£ 0.65
OC73	£ 0.30	1N4785	£ 0.50	3N154	£ 0.95	BC107	£ 0.10	CV102	£ 0.25
OC75	£ 0.25	1ZMT5	£ 0.35	3N159	£ 1.45	BC108	£ 0.10	GET103	£ 0.23
OC76	£ 0.25	1ZMT10	£ 0.33	3PR5	£ 0.45	BC113	£ 0.10	GET115	£ 0.45
OC81	£ 0.20	1ZT5	£ 0.67	12F160	£ 0.73	BC118	£ 0.20	GET116	£ 0.50
OC81D	£ 0.20	1ZT10	£ 0.63	4095A	£ 1.25	BCY72	£ 0.15	GEX66	£ 1.50
OC81DM	£ 0.20	3G385	£ 0.51	4095B	£ 1.25	BP115	£ 0.25	NKT222	£ 0.20
OC82	£ 0.25	2G403	£ 0.51	4096A	£ 1.25	BP173	£ 0.20	NKT304	£ 0.50
OC82DM	£ 0.20	2N918	£ 0.37	4096B	£ 1.25	BPY51	£ 0.20	RA8310AF	
OC83	£ 0.25	2N1304	£ 0.22	40969	£ 1.40	BPY52	£ 0.20	BF8	£ 0.20
OC83B	£ 0.15	2N1306	£ 0.25	AC126	£ 0.25	BF8	£ 0.20	SD918	£ 0.33
OC84	£ 0.25	2N1307	£ 0.25	AC127	£ 0.25	B92	£ 0.47	SD928	£ 0.31
OC122	£ 0.50	2N2147	£ 0.64	AC128	£ 0.20	BSY29	£ 0.25	SD938	£ 0.32
OC200	£ 0.55	2N2411	£ 1.00	AC176	£ 0.20	BU100	£ 1.80	SD94	£ 0.21
OC140	£ 0.40	2N2904A	£ 2.05	ACY17	£ 0.25	BYZ13	£ 0.25	SD988	£ 0.48
OC170	£ 0.25	2N2989	£ 0.20	ACY28	£ 0.17	BYZ16	£ 0.63	V405A	£ 0.40
OC171	£ 0.30	2N3063	£ 0.20	AD149	£ 0.50	CR81/10	£ 0.25	Z2A51CF	£ 0.78
OC172	£ 0.37	2N3054	£ 0.50	AD161	£ 0.35	CR81/20	£ 0.38	ZR11	£ 0.33
OC200	£ 0.40	2N3055	£ 0.64	AD162	£ 0.35	CR81/30	£ 0.40	ZR21	£ 0.46
OC201	£ 0.75	2N3730	£ 0.50	AP118	£ 0.50	CR81/35	£ 0.43	ZR22	£ 0.42
OC206	£ 0.95	2N3731	£ 0.75	AP127	£ 0.20	CR81/40	£ 0.48		
IN21B	£ 0.30	2N4172	£ 0.50	AP139	£ 0.30	CR83/05	£ 0.30		
IN25	£ 0.60	82903	£ 0.50	AP178	£ 0.48	CR83/20	£ 0.38		
IN43	£ 0.10	3F100	£ 0.62	AP186	£ 0.40	CR83/30	£ 0.43		
IN70	£ 0.07	3FR5	£ 0.32	AS926	£ 0.25	CR826/025	£ 0.65		
IN677	£ 0.12	3N128	£ 0.87	AS928	£ 0.25				

MANY OTHERS IN STOCK including integrated circuits, C.R.T. and special valves. U.K. POSTAGE over £3 free, 3p for one valve plus 1p for each additional valve or transistor. C.O.D. 25p extra.

VALVES AND TRANSISTORS

Telephone enquiries for valves, transistors, etc., retail 743 4946; trade and export 743 0899.

MARCONI TEST EQUIPMENT



VALVE VOLTMETER TYPE TF 958.
Measures A.C. 100mV; 150V; D.C. 50mV up to 100V. Multiplier extends ac range to 1.5kV. Balanced input and centre-zero scale for D.C. 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 0.1uV-100mV at 50 ohms. Int. mod. freq. 1 to 10kHz, ext. mod. freq. 100Hz to 10kHz. Freq. dev. up to 300kHz. £225. Carriage £1.50.

TF 1258A VHF SPECTRUM ANALYSER for analysis and measurement of radar Equipment. Frequency range 90 to 230MHz with crystal check points. Sweep width 0.5 to 5MHz, output pulse delay (a) 85-175 uSec, (b) 0.7-1.4 mSec with x1 and x2 multiplier, and -2, -x1, x2 multiplier. Output 2uV to 20mV with x10 multiplier. £200. Carriage at cost.

MUIRHEAD PHASEMETER. Type D729/AM and P.S.U. D729 A/S. Complete with manual, leads, as new £20.

TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, scopes, counters, filters etc. SPEC. TF 1400S. Rep. freq. 10Hz to 100kHz, pulse width 0.1 to 100u sec., delay 1-1.5 to 1-3000u sec., rise time < 30N sec. SPEC. TM 6600/S. As for TF1400S except pulse width 0.5 to 25u sec, delay 0 to +300u sec. £230.

SIGNAL GENERATOR TYPE ANJ5M-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 30db), 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, AM, PM, CW (calibrated and stabilised), CW (400Hz and 1kHz) and external, FM, 400Hz and 1kHz and external 0.75kHz dev. S.F.M. -x1, x10, x100, 0-75, 750 & 7500kHz dev. resp., P.M. -50 to 5000 pps at 1 to 30u sec. 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.

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 uV-IV source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator, 502 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 1225B
TF 1225A
TM 57A
White Noise Test Set.

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 100uV 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 100 MHz SAMPLING OSCILLOSCOPE WITH 185A DUAL TRACE PLUG-IN. Full spec. and P.O.A.

5248 COUNTER FREQUENCY MEASUREMENT: 10Hz to 10,1MHz. Accuracy 1/1 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 49Hz 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.

SPECTRUM ANALYSER TYPE PAF089.

Spec. as for TF 801D/1/S except for minor circuit changes e.g. 1 and 2 MHz switched calibrator. P.O.A.

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: -50dB to +10dB. Impedance: 75, 100, 600uS. 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.

HF. ABSORPTION WATTMETER TF 957. Range: 1 to 100MHz, Power: 0.1 to 25w, Impedance 52uS on 1W range, 70uS on 25W range. £22.50. Carriage 75p.

TEKTRONIX OSCILLOSCOPES.

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.



MODEL 1092 TESTMETER

5,000 O.P.V. 0/3/15/50/300/1200 V. D.C. 0/6/30/300/800 V. A.C. 0/300µA/300 mA 0/10K/1 meg Ω Decibels -10 to +16 db £2.75 each. 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.



HIKI MODEL 720X

20,000 O.P.V. Overload protection. 5/25/100/500/1000 VDC. 10/50/250/1000 V.A.C. 50µA/250 mA. 20K/2 meg ohm. -5 to +62db. £5.97. Post 15p.



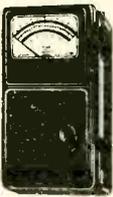
MODEL TH-12

20,000 o.p.v. Overload protection. Slide switch selector. 0/2.5/2.5/10/50/250/1000V. 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 mA/10/100 mA/1A. Resistance 300 ohms/3/30/300K/3M Ω. Complete with batteries, test leads, instructions and sturdy steel carrying case. Our Price £5.97. Post 25p.



HIKI MODEL 730X

30,000 O.P.V. Overload protection. 6/30/60/300/600/1200 VDC. 12/60/120/600/1200 V.A.C. 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. 50/100µA/60/600 mA. 10/100K/1 Meg/10 meg Ω. -20 to +46db. £8.97. Post 12p.



MODEL 500

30,000 O.P.V. with overload protection. mirror scale. 0/2.5/2.5/10/25/100/250/500/1,000 V. D.C. 0/2.5/10/25/100/250/500/1,000 V. A.C. 0/50µA/50/500mA. 12 amp. D.C. 0/60/6 meg/60 meg Ω. £8.97. Post paid.



U4312 MULTIMETER

Extremely sturdy instrument for general electrical use. 667 o.p.v. 0/3/15/75/30/60/150/300/600/900 VDC and 75mV. 0/3/15/75/30/60/150/300/600/900 V.A.C. 0/300 µA/1.5/8/15/60/150 600mA/1.5/8 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, leads and instructions. £9.50. Post 25p.



HIKI MODEL 750X

50,000 o.p.v. 43 ranges 0-0.3 to 1,200V. D.C. 0-3 to 1,200 V. A.C. 0-300µA/300mA. 0-3K/30 meg. ohms. -10 to +17 db. £8.97. Post 20p.



HIKI MODEL 700X

100,000 O.P.V. Overload protection. Mirror scale. 3/6/12/15/3/6/12/30/60/120/300/600/1200 VDC. 1.5/3/6/12/30/60/150/300/600/1200 V.A.C. 15/30V A/3/6/30/60/150/300 mA. 0/12 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. 0/2.5/12.5/10/50/250/1000/5000V. 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 D.C. 0/2.5/10/50/250/500/1000 V A.C. 0/50µA/1/10/100mA/1/10 Amp DC. 0/100mA/1/10 Amp AC. 0/5K/50K/500K/5MEG/50MEG. -20 to +62 db. £15. Post 25p.



HT100B4 MULTIMETER

Features A.C. current ranges. 100,000 o.p.v. Mirror Scale, Overload protection. 0/5/2.5/10/50/250/500/1000 V D.C. 0/2.5/10/50/250/1000 V A.C. 0/10/250µA/2.5/25/250 MA/10 Amp DC. 0/100mA/10 Amp AC. 0/20K/200K/2MEG/20MEG. -20 + 62 db. £15.00. Post 25p.



KAMODEN 72.200 MULTITESTER

High sensitivity tester. 200,000 o.p.v. Overload protection. Mirror scale. Range: 0/0.6/3/30/120/600/1200 V. D.C. 0/5/12/60/300/11,200V A.C. 0/6µA/1.2mA/120mA/600mA/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. 6 1/2 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, 1MEG, 100MEG. Decibels: -10 to +49 db. Plastic case with carrying handle. Size 7 1/4 x 6 1/2 x 3 1/8. £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 VDC. 0/6/30/120/600 V. AC. 0/12/600µA/12/300MA/12 AMP. DC. 0/10K/1 MEG/100 MEG. -20 to +50 db. 0-01. 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.



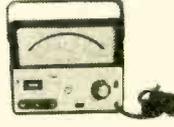
KAMODEN HM.350 TRANSISTOR TESTER

High quality instrument to test Reverse Leak current and DC current Amplification factor of NPN, PNP, transistors, diodes, SCR's etc. 4 1/4 x 4 1/4 in. clear scale meter. Operates from internal batteries. Complete with instructions leads and carrying handle. £12.50 Post 30p.



MODEL 49A IN CIRCUIT TRANSISTOR TESTER

Checks true A.C. beta in/out. Checks Ico. Checks diodes in/out. Checks SCR etc. Beta HI 10-500. L0-250. Ico 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. 0/75mV/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. £40. 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: 0/1/0.3/1.3/3/10/30/100/300 v. R.M.S. 4 cps-1.2 Mc/s. Decibels -40 to +50 db. Supplied brand new complete with leads and instructions. Operation: 250 v. A.C. £17.50 Carr. 25p.



TMK MODEL 117 ELECTRONIC VOLTMETER

Battery operated, 11 meg input. 25 ranges. Large 4 1/4 in. mirror scale. Size 6 1/4 x 4 1/4 in. DC Volts 0.3-1200V. AC Volts 3-300V R.M.S. 8-0-800V. P.P. DC Current 12-12MA. Resistance up to 20000 ohm. Decibels -20 to +51 db. Complete with leads/instructions. £17.50. P. & P. 20p.



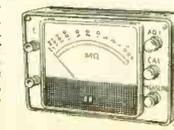
MODEL L-55 FET V.O.M.

Input impedance 10 meg. ohms. 0/3/12/60/120/600V. D.C. 0/3/12/60/120/600V. A.C. 0/120µA/120mA. D.C. 0/1K/100K/10 meg/100 meg ohms. £18.97. Post 25p.



KAMODEN HMG-500 INSULATION RESISTANCE TESTER

Range 0-1000 Meg-ohms, 500 Volt. Battery operated. Wide range clear meter 4 1/4 in. x 4 in. 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 7 1/4 in. x 5 in. x 2 in. 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; 10KHz. AMP. Bandwidth 500KHz. Sensitivity at 100KHz. V RMS/mm. 3-25; Preet triggered sweep 1-3,000µsec.; free running 20-200,000Hz in nine ranges. Calibrator pips. 220 x 360 x 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 -15 MHz. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. 0.9v p-p/CM. bandwidth 1.5 cps-800 KHz. Input imp. 2 meg Ω. 20 PF. Time base. 5 ranges 10 cps-300 KHz. Sync. Pronounced. Internal/external. Illuminated scale. 140 x 215 x 330 mm. Weight 15lbs. 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. x 4in. CRT. Calibrated triggered sweep from 2 µsec. to 100 milli-sec. per cm. Free running time base 50 cps-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 300mW. Size 180 x 90 x 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 B.F. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. £15. Carr. 37p. Size 140 x 215 x 170 mm.



TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 80 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 RPH CW. 50p each. Post 12p.



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 7 1/2" x 5 1/2" x 3 1/2". £19.95. Post 25p.

PS.1000B REGULATED P.S.U.

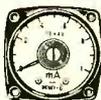


Solid state. Output 6-9 or 12 V. D.C. up to 3 amps. Meter to monitor current. Input 220/240 V. A.C. Size 8 1/2" x 3 1/2" x 6 1/2". £11.97. Post 25p.

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.



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, 1/2 in. dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. 90p. P. & P. 10p.
50 WATT. 10/25/50/100/250/500/1000/2500 or 3000 ohms. £1.15. P. & P. 10p.
100 WATT. 1.5/10/25/50/100/250/500/1000 or 2500 ohms. £1.65. P. & P. 15p.



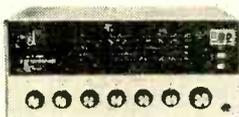
HAND HELD 2-WAY WALKIE TALKIES

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 x 208 x 150 mm. Complete with instructions and circuit.

OUR PRICE £32.50 Carr. 50p

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 x 80mm



- 100-1000µA £3.80
- 100-0-100µA £3.70
- 500µA £3.50
- 1mA £3.40
- 20V. D.C. £3.40
- 50V. D.C. £3.40
- 300V. D.C. £3.40
- 1 amp. D.C. £3.40
- 5 amp. D.C. £3.40
- 300V. A.C. £3.45
- VU Meter £4.15

TYPE SD.830 82.5mm x 110mm Fronts



- 10mA £2.50
- 50mA £2.50
- 100mA £2.50
- 500mA £2.50
- 1 amp £2.50
- 5 amp £2.50
- 10 amp £2.50
- 5V. D.C. £2.50
- 10V. D.C. £2.50
- 20V. D.C. £2.50
- 50V. D.C. £2.50
- 300V. D.C. £2.50
- 15V. A.C. £2.75
- 300V. A.C. £2.75
- VU Meter £3.00

TYPE SD.640 83.5mm x 85mm Fronts

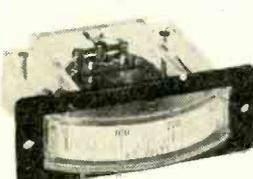
- 50µA £2.80
- 50-0-50µA £2.70
- 100µA £2.65
- 100-0-100µA £2.55
- 200µA £2.55
- 500µA £2.35
- 1mA £2.35
- 5mA £2.35
- 10mA £2.35
- 50mA £2.35
- 100mA £2.35
- 500mA £2.35
- 1 amp £2.35
- 5 amp £2.35
- 10 amp £2.35
- 5V. D.C. £2.35
- 20V. D.C. £2.35
- 50V. D.C. £2.35
- 300V. D.C. £2.35
- 15V. A.C. £2.40
- 300V. A.C. £2.40
- VU Meter £2.70

TYPE SD.460 46mm x 59.5mm Fronts

- 50µA £2.40
- 50-0-50µA £2.35
- 100µA £2.35
- 100-0-100µA £2.35
- 200µA £2.35
- 500µA £2.20
- 1mA £2.15
- 5mA £2.15
- 10mA £2.15
- 50mA £2.15
- 100mA £2.15
- 500mA £2.15
- 1 amp £2.15
- 5 amp £2.15
- 10 amp £2.15
- 5V. D.C. £2.15
- 10V. D.C. £2.15
- 20V. D.C. £2.15
- 50V. D.C. £2.15
- 300V. D.C. £2.15
- 15V. A.C. £2.30
- 300V. A.C. £2.30
- VU Meter £2.55

"SEW" EDGWISE METERS

TYPE P.E.70



3 17/32in. x 1 11/32in. x 2 1/2 in. deep.

- 50µA £3.40
- 50-0-50µA £3.30
- 100µA £3.30
- 100-0-100µA £3.20
- 200µA £3.20
- 500µA £3.05
- 1mA £2.70
- 300V. A.C. £2.70
- VU Meter £3.75

*** MOVING IRON— ALL OTHERS MOVING COIL**

Please add postage

TYPE MR.85P 4 1/4in. x 4 1/4in. fronts.



- 10mA £3.10
- 30mA £3.10
- 100mA £3.10
- 500µA £3.10
- 1 amp £3.10
- 5 amp £3.10
- 15 amp £3.10
- 30 amp £3.20
- 20V. D.C. £3.10
- 50V. D.C. £3.10
- 150V. D.C. £3.10
- 300V. D.C. £3.10
- 15V. A.C. £3.10
- 300V. A.C. £3.10
- 8 Meter 1mA £3.15
- VU Meter £3.95
- 1 amp. A.C.* £3.10
- 5 amp. A.C.* £3.10
- 10 amp. A.C.* £3.10
- 20 amp. A.C.* £3.10
- 30 amp. A.C.* £3.10
- 50µA £3.95
- 50-0-50µA £3.40
- 100µA £3.40
- 100-0-100µA £3.30
- 200µA £3.30
- 500µA £3.20
- 500µA-500µA £3.10
- 1mA £3.10
- 1-0-1mA £3.10
- 5mA £3.10

TYPE MR.52P 2 1/2in. square fronts.

- 50µA £3.40
- 50-0-50µA £2.85
- 100µA £2.85
- 100-0-100µA £2.75
- 500µA £2.55
- 1mA £2.20
- 5mA £2.20
- 10mA £2.20
- 50mA £2.20
- 100mA £2.20
- 500mA £2.20
- 1 amp £2.20
- 5 amp £2.20
- 10V. D.C. £2.20
- 20V. D.C. £2.20
- 50V. D.C. £2.20
- 300V. D.C. £2.20
- 15V. A.C. £2.20
- 300V. A.C. £2.20
- 8 Meter 1mA £2.30
- VU Meter £3.50
- 1 amp. A.C.* £2.20
- 5 amp. A.C.* £2.20
- 10 amp. A.C.* £2.20
- 20 amp. A.C.* £2.20
- 30 amp. A.C.* £2.20

TYPE MR.65P 3 1/2in. x 3 1/2in. fronts

- 50µA £3.70
- 50-0-50µA £3.00
- 100µA £3.00
- 100-0-100µA £2.90
- 200µA £2.90
- 500µA £2.65
- 500-0-500µA £2.40
- 1mA £2.40
- 5mA £2.40
- 10mA £2.40
- 50mA £2.40
- 100mA £2.40
- 500mA £2.40
- 1 amp £2.40
- 5 amp £2.40
- 10 amp £2.40
- 15 amp £2.40
- 20 amp £2.40
- 30 amp £2.40
- 50 amp £2.75
- 5V. D.C. £2.40
- 10V. D.C. £2.40
- 20V. D.C. £2.40
- 50V. D.C. £2.40
- 150V. D.C. £2.40
- 300V. D.C. £2.40
- 15V. A.C. £2.55
- 50V. A.C. £2.55
- 150V. A.C. £2.55
- 300V. A.C. £2.55
- 500V. A.C. £2.55
- 8 Meter 1mA £2.60
- VU Meter £3.70
- 100mA A.C.* £2.40
- 200mA A.C.* £2.40
- 500mA A.C.* £2.40
- 1 amp. A.C.* £2.40
- 5 amp. A.C.* £2.40
- 10 amp. A.C.* £2.40
- 20 amp. A.C.* £2.40
- 30 amp. A.C.* £2.40

"SEW" EDUCATIONAL METERS

TYPE ED.107

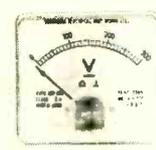


Size overall 100mm x 90mm x 108mm.

A new range of high quality moving coil instruments ideal for school experiments and other bench applications. The meter movement is easily accessible to demonstrate internal working.

- Available in the following ranges—
- 50µA £5.50
 - 100µA £5.10
 - 1mA £4.85
 - 50-0-50µA £5.10
 - 1-0-1mA £4.85
 - 1A D.C. £4.85
 - 5A D.C. £4.85
 - 10V D.C. £4.85
 - 20V D.C. £4.85
 - 50V D.C. £4.85
 - 300V D.C. £4.85
 - Dual range
 - 500mA/5A D.C. £5.10
 - 5V/50V D.C. £5.10

TYPE MR.38P 1 21/32in. square fronts.



- 150µA £1.75
- 200µA £1.75
- 300µA £1.75
- 500µA £1.75
- 750µA £1.75
- 1 amp £1.75
- 2 amp £1.75
- 5 amp £1.75
- 10 amp £1.75
- 3V. D.C. £1.75
- 10V. D.C. £1.75
- 15V. D.C. £1.75
- 20V. D.C. £1.75
- 50V. D.C. £1.75
- 100V. D.C. £1.75
- 150V. D.C. £1.75
- 300V. D.C. £1.75
- 500V. D.C. £1.75
- 750V. D.C. £1.75
- 15V. A.C. £1.85
- 50V. D.C. £1.85
- 150V. A.C. £1.85
- 300V. A.C. £1.85
- 500V. A.C. £1.85
- 8 Meter 1mA £1.85
- VU Meter £2.30

TYPE MR.45P 2in. square fronts.

- 50µA £2.50
- 50-0-50µA £2.30
- 100µA £2.30
- 100-0-100µA £2.05
- 200µA £2.05
- 500µA £2.05
- 500-0-500µA £1.85
- 1mA £1.85
- 5mA £1.85
- 10mA £1.85
- 50mA £1.85
- 100mA £1.85
- 500mA £1.85
- 1 amp £1.85
- 5 amp £1.85
- 10V. D.C. £1.85
- 20V. D.C. £1.85
- 50V. D.C. £1.85
- 300V. D.C. £1.85
- 15V. A.C. £1.85
- 300V. A.C. £1.85
- 8 Meter 1mA £2.00
- VU Meter £2.50
- 1 amp. A.C.* £1.85
- 5 amp. A.C.* £1.85
- 10 amp. A.C.* £1.85
- 20 amp. A.C.* £1.85
- 30 amp. A.C.* £1.85

"SEW" BAKELITE PANEL METERS

TYPE MR.65 3 1/2in. square fronts.



- 1 amp £2.15
- 5 amp £2.15
- 15 amp £2.15
- 30 amp £2.15
- 50 amp £2.15
- 5V. D.C. £2.15
- 10V. D.C. £2.15
- 20V. D.C. £2.15
- 50V. D.C. £2.15
- 150V. D.C. £2.15
- 300V. D.C. £2.15
- 30V. A.C.* £2.20
- 50V. A.C.* £2.20
- 150V. A.C.* £2.20
- 300V. A.C.* £2.20
- 500mA A.C.* £2.15
- 1 amp. A.C.* £2.15
- 5 amp. A.C.* £2.15
- 10 amp. A.C.* £2.15
- 20 amp. A.C.* £2.15
- 30 amp. A.C.* £2.15
- 50V. D.C. £2.15
- 150V. D.C. £2.15
- 300V. D.C. £2.15
- 30V. A.C.* £2.20
- 50V. A.C.* £2.20
- 150V. A.C.* £2.20
- 300V. A.C.* £2.20
- 500mA A.C.* £2.15
- 1 amp. A.C.* £2.15
- 5 amp. A.C.* £2.15
- 10 amp. A.C.* £2.15
- 20 amp. A.C.* £2.15
- 30 amp. A.C.* £2.15
- 50V. D.C. £2.15
- 150V. D.C. £2.15
- 300V. D.C. £2.15
- 30V. A.C.* £2.20
- 50V. A.C.* £2.20
- 150V. A.C.* £2.20
- 300V. A.C.* £2.20
- 500mA A.C.* £2.15
- 1 amp. A.C.* £2.15
- 5 amp. A.C.* £2.15
- 10 amp. A.C.* £2.15
- 20 amp. A.C.* £2.15
- 30 amp. A.C.* £2.15
- 50V. D.C. £2.15
- 150V. D.C. £2.15
- 300V. D.C. £2.15

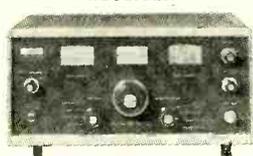
25µA £3.85
50µA £3.00
50-0-50µA £2.60
100µA £2.60
100-0-100µA £2.50
500µA £2.45
500-0-500µA £2.15
1mA £2.15
5mA £2.15
10mA £2.15
50mA £2.15
100mA £2.15
500mA £2.15

TYPE S.80 80mm Square Fronts

- 50µA £3.80
- 50-0-50µA £3.40
- 100µA £3.40
- 100-0-100µA £3.30
- 500µA £3.05
- 1mA £2.85
- 20V. D.C. £2.85
- 50V. D.C. £2.85
- 300V. D.C. £2.85
- 50V. D.C. £2.85
- 1 amp. D.C. £2.85
- 5 amp. D.C. £2.85
- 300V. A.C. £2.85
- 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. 8 meter. Sep. bandspread dial. IF frequency 445 kc/s. audio output 1.5w. Variable RF and AF gain controls. 115/230 v. A.C. Size: 7in. x 13in. x 10in. with instruction manual.

OUR PRICE £49.50 Carr. Paid. FULL TRIO RANGE STOCKED.

ALL PRICES ARE EXCLUSIVE OF 10% VAT

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

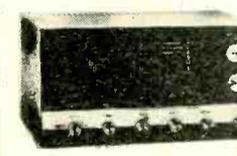
UR-1A RECEIVER



4 Bands covering 550 kc/s-30 mc/s. FET, 8 Meter. Variable BFO for SSB. Built-in Speaker, Bandspread, Sensitivity Control. 220/240 v. A.C. or 12 v. D.C. 12 1/2in. x 4 1/2in. x 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, 8 Meter Bandspread. RF Gain. 15in. x 9 1/2in. x 8 1/2in. 18 lb. 220/240 v. A.C. or 12 v. D.C. Brand new with instructions.

OUR PRICE £50.00 Carr. 50p



G.W.S. G.W. SMITH & CO (RADIO) LTD

EMI LOUDSPEAKERS

Model 350. 13in. x 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. x 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 14 1/2in. x 9in. x 7 1/2in. 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. 9 1/2" x 5" x 3". Inputs Mics: 3 x 3mV 50K; 2 x 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. x 4in. x 2 1/2in.

OUR PRICE **£2-25** P. & P. 20p

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 £3-25. P. & P. 15p. 4 Station £4-62. P. & P. 17p.

FM TUNER CHASSIS

6 TRANSISTOR HIGH QUALITY TUNER. SIZE ONLY 6in. x 4in. x 2 1/2in. 3 I.P. 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.

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 LMO2S STEREO HEADPHONES

Lightweight headphones with padded earpieces. 4-16 ohms. 20-20,000 Hz. Complete with fit 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 **£3-97** 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 **£4-62** 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

RECORD DECK PACKAGES



Carriage and Packing 75p

Complete units with Stereo cartridge ready wired in plinth cover.

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2025 TC/9TAHCD	£10-85
SP25 111/G800	£15-90
SP25 111/M44E	£18-45
SP25 111/M44-7	£18-10
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	£24-95
AP76/M75ED	£31-70
AP76/M75EJ	£27-85
AP76 Module M75-6	£28-95
AP96 Module M75-6	£30-40
ZERO 1008 Module/M93E	£41-85

B.S.R. McDONALD	
210/SC7M	£8-85
MP60/G800	£15-00
MP60/TPD1/G800	£15-20
MP60/M44-7	£16-75
HT70/TPD1/G800	£18-80

GOLDRING	
GL72/G800	£30-90
GL75/G800	£34-10
GL75/G800E	£36-75

GOODMANS	
TD100/G800 Teak	£46-85
TD100/G800 White	£48-80

LEAK	
Delta M75-6	£43-95

PHILIPS	
GA105/GP200	£13-80
GA160/GP200 Teak	£20-00
GA308/GP400	£22-75
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)	£108-90
PL51	£110-30
PLA55	£61-55

THORENS	
TD160C/Ortofon M15E Super	£62-50
TD125 AB/11/Ortofon M15E	£58-00
Super	£96-95

WEARFEDEALE	
Linton/M44-7	£23-70

AUDIOTRONIC MULTIBAND RADIO

5 waveband covering MW 535-1605KHz and FM 88-175MHz. All transistors. 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

AUDIOTRONIC SQ. QUADRAPHONIC DECODER

Fully transistorised containing all input, output and control facilities to reproduce 4 channel sound from 8Q 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 x 55mm x 220mm deep.

OUR PRICE **£22-50** P. & P. 25p



ALL PRICES ARE EXCLUSIVE OF 10% V.A.T.

RECORD DECKS



Carriage & Packing 50p

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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	£12-80
MP60/TPD2	£11-25
HT70	£10-97
HT70/G800	£13-80
HT70/TPD1	£15-95

CONNOISSEUR	
BD1 Kit	£9-10
BD1 Chassis	£11-35
BD1/SAU2/Plinth/Cover	£27-60
BD2/SAU2/Chassis	£23-35
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	£15-55
8L85B	£11-15
8L72B	£17-75
8L85B	£25-25
401	£23-50
ZERO 100A	£30-30
ZERO 1008	£27-95

GOLDRING	
G99	£18-99
G101P/C	£18-99
G109/2	£15-75
GL72	£20-97
GL72/P	£27-80
Plinth 69/72	£6-80
LD72	£2-80
GL75	£26-60
GL75P	£34-40
Plinth 75	£7-80
LD75	£3-20
GL78P/C	£46-55
GL85P/C	£59-55

MICRO-SEIKI	
MR111	£24-90
MR111 Plinth and Cover	£8-25

THORENS	
TD125/II	£52-15
TD125AB/II	£75-55
TD160	£5-60
TD150A/II	£29-25
TD160C	£43-95

PLINTHS AND COVERS

Carriage and Packing 50p	
Budget SP25 etc.	£2-95
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Budget AP76/Zero 1008	£2-95
Budget B.S.R.	£2-95
Garrard WB1	£2-20
Garrard SPC1	£2-20
Garrard WB4	£3-25
Garrard SPC4	£2-55
M/E2000 System	£26-40

SPECIAL GARRARD OFFERS!

STEREO 1025T	
1025T. 4 speed autochanger unit fitted with stereo ceramic cartridge.	
OUR PRICE £4-95 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
Neat V70 Cartridge (Original pack)	£22-15
Neat V70 Cartridge (Bulk Pack)	£1-50
Neat V70E Cartridge	£3-35
Neat V60 MH Cartridge	£3-15

3408 Stereo Tuner Amplifier

Covers FM 88-108 MHz. Five push button tuning scales. 8+9 watts rms. Inputs for stereo ceramic cartridge and tape, etc. Separate bass, treble, balance and volume controls.

OUR PRICE **£31-50** Carr. 50p

3416 Stereo Tape Deck

4 track. 7 1/2, 3 1/2, 1 1/2 i.p.s. Stereo/mono record/play. 7" reels. Inputs for dynamic mikes, radio, gram. Complete with cover.

OUR PRICE **£41-95** Carr. 75p

SAVE OVER 50%



KANIMEX NRC 3061 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/deck microphone. Telescopic aerial. Complete with earpiece, batteries and instructions. (Tape not supplied.) (Rec. List price £55-95).

OUR PRICE **£22-75** 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	£2-62	£5-59
C120	£2-29	£4-48	£10-63

P. & P. Post Post
15p Free Free

Tape Head Cleaner 30p each.



AUDIOTRONIC DOLBY 'B' NOISE REDUCTION UNITS

Reduce tape hiss by 3dB at 600Hz. 6dB at 1200Hz and 10dB for all frequencies above 3000Hz. Size 16 1/2" x 8" x 3 1/2". 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. 8/N better than 70dB. Supplied with test cassette or tape as required.

OUR PRICE **£32-50** P. & P. 50p

PROCESS FOUR

For use with semi professional tape recorders. Freq. res. 30Hz - 20KHz ± 2dB. 8/N better than 70dB. Full source tape monitoring. Record/Replay metering. Switchable multiplex filter. Supplied with test tape.

OUR PRICE **£48-00** P. & P. 50p

SPECIAL PURCHASE!

FERGUSON EXPORT MODELS



3408 Stereo Tuner Amplifier

Covers FM 88-108 MHz. Five push button tuning scales. 8+9 watts rms. Inputs for stereo ceramic cartridge and tape, etc. Separate bass, treble, balance and volume controls.

OUR PRICE **£31-50** Carr. 50p

3416 Stereo Tape Deck



4 track. 7 1/2, 3 1/2, 1 1/2 i.p.s. Stereo/mono record/play. 7" reels. Inputs for dynamic mikes, radio, gram. Complete with cover.

OUR PRICE **£41-95** Carr. 75p



SAVE UP TO 33 1/3% OR MORE! GWS



- AKAI BARGAINS**
- CASSETTE P. & P. 50p)**
- CS35D Deck £44-95
 - CS35 Recorder £57-75
 - CS35 CSSR Speakers £67-95
 - GXC40B Deck £67-95
 - GXC40 Recorder £67-95
 - GXC40T Deck/Receiver £101-25
 - GXC45 Deck £78-25
 - GXC46 Dolby Deck £84-30
 - GXC46 Recorder £90-75
 - GXC80D Deck £87-85
 - GXC80D Dolby Deck £93-40
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 - CR81D Deck £54-10
 - CR81T Recorder/Receiver £93-70
 - CR80S8 4 channel Recorder £114-25
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 - 4000D8 Dust Cover £3-95
 - 1721L Recorder £60-35
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 - X201D Deck £108-20
 - GX220D Deck £123-95
 - GX221D Deck £136-40
 - GX280D Deck £190-50
 - GX370 Deck £211-50
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- TAPE CARTRIDGE (P. & P. 75p)**
- X1810D Deck £138-40
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 - AA8030 25+25 watt £92-50
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 - AA81008 2x36 or 4x18 watt £175-00
 - AA8500 65+65 watt £150-50
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- STEREO HEADPHONES (P. & P. 30p)**
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 - ASE 20 £7-30
 - ASE 22 £8-25



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).

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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 £44-95 P. & P. 50p



UNREPEATABLE OFFER!

NIKKO TRM50 STEREO AMPLIFIER

17+17 watts rms. Inputs for magnetic and crystal phono, tuner, tape etc. Dual stereo speaker outputs. Headphone socket. Full range of controls. (Rec. List Price £59-50.)

OUR PRICE £39-95 P. & P. 50p



ROTEL BARGAINS!

TRIO KA 2000A SYSTEM

16+16 watt amplifier. BSR MP60, plinth and cover, G800 cartridge, pair of Denton 2 speakers and all leads.

OUR PRICE £70-95 Carr. & Ins. £1-25

Matching KT 1000A AM/FM Stereo Tuner £43-75.

AM/FM STEREO RECEIVERS

- RX150 7+7 watt £36-95
- RX200 10+10 watt £46-50
- RX400 20+20 watt £57-50

P. & P. 75p.

VAT 10% VAT (10p in the £)

All prices are subject to 10% VAT (10p in the £) to total value of goods including carriage/packing and send cash with order. PLEASE PRINT NAME & ADDRESS CLEARLY.

Order with confidence by post - but remember to add 10% VAT (10p in the £) to total value of goods including carriage/packing and send cash with order. PLEASE PRINT NAME & ADDRESS CLEARLY.



BSR 8 TRACK BARGAINS!

TD88 STEREO TAPE CARTRIDGE DECK

Connects to most stereo amplifiers (output 125 mV). Automatic/Manual programme selector.

OUR PRICE £12-75 P. & P. 50p

TD83V £15-25 (P. & P. 50p)



- SINCLAIR PROJECT 60 PACKAGE DEALS**
- 2 x Z30 Stereo 60/PZ5 £15-95 P. & P. 37p.
 - 2 x Z30 Stereo 60/PZ6 £18-00 P. & P. 37p.
 - 2 x Z50 Stereo 60/PZ8 £20-25 P. & P. 37p.
 - Transformer for PZ8 £3-65
 - Active Filter Unit £4-45
 - Pair of Q16 Speakers £10-70 P. & P. 50p.
 - Project 60 FM Tuner £14-95 P. & P. 50p.
 - Sinclair Project 60S £20-97 P. & P. 37p.
- All other Sinclair Products in stock.
- 3000 Amplifier £22-95 P. & P. 50p.
 - 3000 Amplifier £28-95 P. & P. 50p.
 - 2000/3000 Tuner £26-95 P. & P. 50p.
 - Q830 Speaker £14-99 P. & P. 50p.

MONATONE 6750 SYSTEM



AM/FM 4+4 watt stereo tuner amplifier. Garrard 2025 T/C, plinth and cover, stereo cartridge, pair of matching speakers and all leads.

OUR PRICE £30-50 Carr. £1-00

ALBANY HOUSE AM108 SYSTEM



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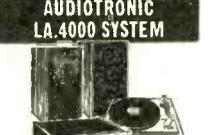


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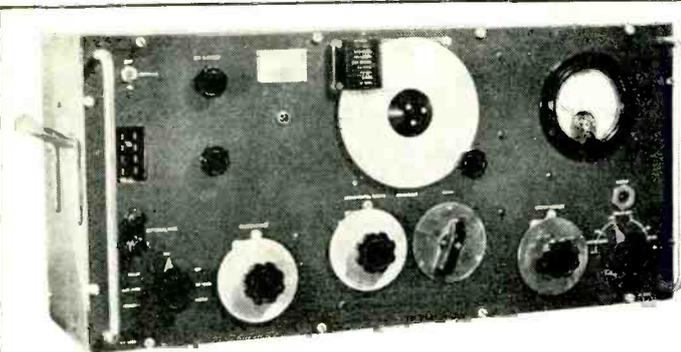
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MARCONI SIGNAL GENERATOR TYPE TF-144G: Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: $\pm 1\%$ at 1 Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52.5 ohms. Internal 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 x 12 1/2 x 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/p/ut impedance: 50 ohms. Audio input: 600 ohms. Valves: Power Amplifier 2 x 813 and Modulator 2 x 813. Power requirements 200-250 volts a.c., 50 cycles. Power out put 300 watts. Dimensions 2ft. 6in. W. x 2ft. D. x 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/p/ut -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 microseconds. Timing -Undelayed or delayed from 3-300 microseconds from external or internal pulse. O/p/ut-1 milliwatt max., 0 to -127 db variable. O/p/ut 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/p/ut voltage: 1 uv to 10V $\pm 3\%$ 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/p/ut); 5-102MHz in 4 bands (freq. meter). Emission: F.M. R.F. Voltage o/p/ut -25V. Input impedance 470 ohms. O/p/ut 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/p/ut Zero dbm-120dbm continuously adjustable to -20uv into 50. O/p/ut 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/p/ut -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. x 8 in. x 6 1/2 in. Time base 10c/s-40Kc/s. Y plate sensitivity 40V per cm. Tube 2 1/2 in. 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 x 6AK5. £10.00 plus 60p post, good condition.

MODULATOR UNIT: complete with transformer and 2 x 807 valves mounted in 19 in. chassis x 8 in. high x 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 x 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 @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V a rd 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 x 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19" W x 11" H x 14" D. (All connections at the rear.) Excellent condition £6.50 each, carr. £1.

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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.

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INSTRUMENT CABINETS: 19" W. x 16" H. x 16" D. £5.00 + £1.25 carr. 19" W. x 10" D. x 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.

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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.

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POWER UNIT TYPE 24: (for R.216 Receiver) A.C. operated 100-125V or 200-250V, 50c/s. "As new" £10 each. Carr. 75p.

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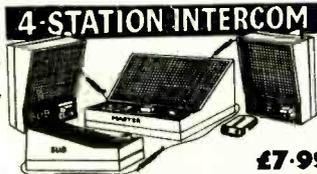
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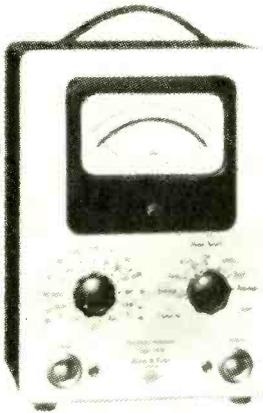
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Ferrite core memory planes with wired Ferrite cores. Used for building your own computer or as an interesting exhibit in the demonstration of a computer. Mounted on plastic material frame 5 x 8 in. Consisting of matrices 40 x 25 x 4 cores, each one individually addressable, and divided into 2 halves with independent sense and inhibit wires. Price **£2.50**.

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Ideally suitable for use in conjunction with transistorised decade counting devices. No need for amplifiers or relays as only a few milliwatts or power are required to charge the digits. The DIGIVISOR 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 $\frac{1}{2}$ in. Size 4 $\frac{1}{8}$ x 2 $\frac{1}{4}$ x 1 $\frac{1}{2}$ in. List price £8.90. Our Price **£2.20**.

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, 15V, 50V, and 150V, with either balanced or unbalanced input. Signal Input Resistance: 10 M Ω unbalanced, 20 M Ω balanced. Reference Input Voltage 90/130 or 230/240 V. Standard Rack Panel 19 in. x 12 $\frac{1}{2}$ 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 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**

MARCONI A.M. SIGNAL GENERATOR

TYPE TF 801D

10-485 Mc/s in five ranges. Output 0.1 μ V-1 Volt E.M.F. External Sine A.D. Frequency 30 c/s-50 Kc/s **PRICE £195.**

HONEYWELL ELECTRONIC POTENTIOMETRIC RECORDER

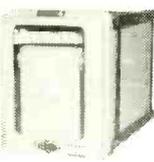
The following types are available:

- Model Y15301115-01-01-0-(150)-01-002-202. Range 800-1300°C.R. **PRICE £95.00.**
- Model Y153X18-VAH/-11-111-118-/P8/DN2 Range 0-20 MV. **PRICE £95.00.**



BRAND NEW MINIATURISED STRIP CHART RECORDER BY RUSTRAK

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" x 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" x 8 $\frac{1}{2}$ ". 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 **£12.00**
- 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.

PRECISION POTENTIOMETERS TEN TURN 3600° ROTATION

Res. Ohms	Linearity Per cent	Manufacturers	Price £
100/100/100		Beckman	7.00
100	0.5	Beckman	2.00
200	0.5	Beckman	2.00
500	0.1	Beckman	2.50
500		Colvern	1.25
500		Foxes	1.00
500		Colvern	1.50
500		Colvern	2.00
500	1.0	Relcon	1.25
1K		Relcon	1.25
2K	0.5	Beckman	2.00
2K	0.25	Beckman	2.00
2K		Reliance	1.00
2K		General Controls	1.00
5K		Relcon	1.50
5K		Colvern	2.00
10K	0.5	Beckman	2.00
10K	0.1	Beckman X	2.50
10K	0.1	Colvern	2.50
15K		Colvern	2.00
18K		Beckman	2.00
25K	0.5	Halipot	2.00
29K	0.05	Beckman	3.50
30K		Colvern	1.00
30K		Beckman	2.00
30K	0.1	Beckman	2.50
30K	0.5	Beckman	2.00
30K	0.25	Beckman	2.25
30K	1.0	Colvern	1.00
50K		Reliance	1.25
50K		Colvern	1.25
50K	X	Foxes	1.25
50K	0.5	Beckman	2.00
50K	0.1	Beckman	2.50
100K/100K		Ford	4.00
100K	0.1	Beckman	2.50
100K	0.5	Beckman	2.00
100K		Colvern	1.25
100K		Colvern	1.50
298K	0.1	Beckman	2.50
300K	0.1	Beckman	2.50
THREE TURN			
100/100	0.5	Beckman	2.00
100/100		Beckman	2.00
300		Beckman	1.25
1K		Fox	1.25
10K	0.5	Beckman	1.25
20K/20K	0.1	Beckman	2.00
10K/10K	0.1	Beckman	2.00
50K	0.5	Beckman	1.00
FIFTEEN TURN			
25K/25K		Beckman B	5.50
46K/46K		Beckman B	5.00

SPECIAL OFFER! SINGLE PEN RECORDER — ELLIOTT

TYPE 230



A most versatile pen recorder producing a trace on a curvilinear 8 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**

ADD 10% VAT TO ALL PRICES



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WW-115 FOR FURTHER DETAILS

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(ELECTRONICS) LTD.

9 & 10 CHAPEL ST., LONDON, N.W.1
01-723-7851 01-262-5125

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	£7.00	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	40p
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	£6.25	40p
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	10	£6.00	45p
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 4-8-12-18-20-24-32V.
No. 5 3-6-9-12-15-18V.

30-25-0-25-30V. 2a. with Screen £43.00, 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. 100-200-220-240V. Sec. 240V. Centre tapped 1.2kva. Conservatively rated. Size 8 1/2 x 7 1/2 ins. Wgt. 59 lbs. Open frame type, terminal connections. Fraction of maker's price. £17.00 carr. £1.00.

STEP DOWN 240/110V. AUTO TRANSFORMERS FOR AMERICAN EQUIPMENT.

Fitted with 2 or 3 pin American sockets. All sizes from 80 to 2kva. available. Send s.a.s. for list. American sockets, plugs, adaptors also available.

T.E.C. HEAVY DUTY ISOLATION TRANSFORMERS

Pri. 240V. Sec. 150V. 4kva. Size 9 x 8 1/2 x 7 ins. Wgt. 70 lbs. £22.50 carr. £2.00.

RICH AND BUNDY.

Pri. 220-230-240-250V. Sec. 265-270-275V. 1400 watts. Conservatively rated. Size 8 x 8 x 7 ins. Terminal block connections. £17.00 carr. £1.00.

440 VOLT S.P. TRANSFORMERS

No. 1 T.E.C. Pri. 330-400-415-440V. Sec. 33 60 amps. Size 9 x 9 x 8 ins. Terminal block connections. Conservatively rated. £20.00 carr. £2.00. No. 2 Davenport Pri. 415-440-525V. Sec. 220V. 2kva. Size 9 x 8 1/2 x 8 ins. £25 carr. £2.00. No. 3 Davenport. Pri. 380-400-415-440V. Sec. 110V. 6amps. Size 6 x 6 1/2 x 5 1/2 ins. £8.50 carr. £1. No. 4 Davenport. Pri. 380-400-417-437V. Sec. tapped 110-270V. 0.15kva. Size 7 x 5 1/2 x 5 ins. £6.50 carr. 75p. No. 5 Rich and Bundy. Pri. 380-400-420-440V. Sec. 240V. 40 watts. Size 4 x 4 x 4 ins. Terminal block connections. £2.50 carr. 50p. Drake. Pri. 440V. Sec. 220-240V. 100 watts. Shrouded. £3.25 postage 40p.

ISOLATION TRANSFORMERS ADMIRALTY PATTERN

Pri. 230V. Sec. 230V. Very conservatively rated at 3.5 amps. In steel case. Size 13 x 10 x 8 ins. £15.00 carr. £2.00.
WODEN. Pri. 240V. Sec. 110V. Centre tapped. 750 watts. Unshrouded. £9.90 carr. £1.00. DRAKE. Pri. 220-240V. Sec. 110V. 30 watts. Table top connections. £1.50 postage 25p.

PARMEKO ISOLATION TRANSFORMERS

Pri. tapped 100-110-220-230-240-250V. Sec. 115V. 13.5 amps. Conservatively rated, fully shrouded. Table top connections. Size 13 x 10 x 8 1/2 ins. £32.50 carr. £2.00. Pri. tapped 200-210-220-230-240-250V. Sec. tapped 90-100-110-120V. 7.5 amps. Conservatively rated. Table top connections. Size 9 x 8 x 8 ins. £22.50 carr. £1.50.

ADVANCED COMPONENTS CONSTANT VOLTAGE TRANSFORMERS

Input 160-280V. Output 230V. 150 watts. Type 140A £7.00 carr. 75p. Output 28V. 8 amps open frame type £4.90 carr. 75p. Output 4V. 3 watts 75p carr. 25p. Output 240V. 30 watts enclosed type £1.30 carr. 35p.

SODINE ELECTRIC GEARED MOTORS

HP. 1/35 A.C. 115v. 50 cycles. RPM 137. Torque 9 in lbs. Ratio 10-1. Pulley Drive. Complete with Control Box containing Capacitor, On/Off Switch, Micro switch reversing connections. Ideal for electric door systems. £10.00 carr. £1.

CRESSALL TOROVLTV VARIABLE TRANSFORMERS

Input 115V. Output 0-135V. 1.25 amp. Complete with calibrated dial and control knob. Size 2 1/2 x 3 1/2 ins. dia. £3.00 carr. 25p. Brand new.

ALL PRICES INCLUDE VAT

SMITHS 12v. D.C. VEHICLE HEATER MOTORS

3 dia. length 4 ins. Spindle 1/4 in. Very powerful 1.1 carr. 25p. With 6 1/2 in. fan £1.25 carr. 25p. As above with twin turbo fans £1.50 carr. 35p.

A.C. GEARED MOTORS BY FAMOUS MAKERS

30/250V. 50 cycles induction type. 4.2 r.p.m. Cont. rating 5 lb. in. Right angle worm drive. Overall size 7 ins. Dia. 3 ins. Spindle length 3 ins. Dia. 1/4 in. £4.75 carr. 45p. Gear motor 50V. D.C. Shunt wound. Cont. rating. 34 r.p.m. 2 lb. in. Right angle worm drive. Overall size 6 x 3 ins. Dia. Spindle 1 in. Dia. £3.75 carr. 35p.

A.C. 220-240V. SHADED POLE MOTORS

1500 r.p.m. Double spindle. Length 1 1/2 in. and 1 in. Overall size 3 x 3 1/2 x 2 ins. Similar to turbo fan heater motors. 50p. P.P. 15p.

MINIATURE 24V. D.C. GEARED MOTORS

300 r.p.m. Size 2 x 1 1/2 x 1 ins. Length of spindle 1 in., dia. 1/4 in. 75p. P.P. 15p.

RADICON WORM REDUCTION GEAR BOXES

Size 1 1/2 in. Ratio 14:5/1. Drive spindle: length 1 1/2 in., dia. 1/4 in. Reduction spindle: length 1 1/2 in., dia. 1/4 in. Overall size 5 x 4 1/2 x 5 ins. £2.00 carr. 50p.

NEWMARK SYNCHRONOUS MOTORS

220-240V. 50 cycles. 3 watts. 8 r.p.m. Overall size 2 x 2 x 2 ins. 30p. P.P. 10p.
6 revs. per hour. Size 2 1/2 x 2 x 2 ins. 50p. P.P. 10p.

GENTS 6V. D.C. ALARM BELLS

6 in. dia. gong. Overall size 4 1/2 x 6 x 6 ins. £3.00 carr. 50p.

RELAYS

Omron 24V. A.C. or 12V. D.C. 2 7A CO contacts. Size 1 1/2 x 1 1/2 x 1 in. Single hole fixing. 45p. Postage 5p.
Miniature 6-12V. D.C. 24V. A.C. 1 CO contact. Size 1 1/2 x 1 1/2 x 1 in. S. hole fixing. 35p. Postage 5p.
Keyswitch 240V. A.C. 1 7A CO contact. Size 2 x 1 x 1 ins. S. hole fixing. 45p. Postage 5p.
B and R. 240V. A.C. 3 CO 7A contacts. Size 1 1/2 x 1 1/2 x 1 1/2 ins. S. hole fixing. 80p. Postage 5p.
Robinsons. 240V. A.C. 2 5A CO contacts. Size 2 1/2 x 1 1/2 x 1 1/2 ins. S. hole fixing. 50p. Postage 5p. Special terms for qty. of 25.

G.P.O. RELAYS

3000 type. 100Ω 1 25 amp. make contact 60p. 2000 + 130Ω 1 normal CO 40p. 75Ω 3M. 1B. 1 CO normal contacts 40p. P.P. on all relays 10p.
600 type. 600Ω 12V. D.C. 2 CO contacts 30p. Postage 5p.

UNIMAX SEQUENTIAL MICRO SWITCHES

2 pole CO 15A contacts. 2nd pole actuates after 1st pole. Leaf roller action 60p. Postage 5p. Burgess type 3BR/74 S. Pole CO 10A contacts. 1/2 in. raised plunger button type. Three for 50p inc. post. Miniature telephone type S. Pole CO contact. Size 1 1/2 x 1 1/2 x 1/2 ins. Five for 50p inc. post.

SOLENOIDS

MAGNET DEVICES. A.C. 240V. Rating 50% 1 in. pull. Overall size 2 1/2 x 1 1/2 in. 85p. P.P. 15p. Pleesay A.C. 240V. rating 50%. 1 1/2 pull. Overall size 3 x 2 x 2 ins. 85p. P.P. 15p. Bordon Miniature type 1/2 pull. 12V. D.C. Size 1 in. dia. len. 1 1/2 in. 45p. P.P. 5p.

H.T. TRANSFORMERS BY FAMOUS MANUFACTURERS

PARMEKO. All primaries 220-240V. Type 1. Sec. 630-0-620V. 105mA 5v. 4A. 5v. 2A. Potted type £3.00. Carr. 50p. Type 2. Sec. 1,875V. 60mA. 4.2kv. wkg. and 500V. 31mA. Potted type £3.50. Carr. 50p. Type 3. Sec. 310-0-310V. 35mA and 200-0-200V. 20mA. 6.3V. 1A. 6.3V. 1A. Potted type £2.75. P.P. 50p. Type 4. Sec. tapped 760-700V. 50mA. 6.3V. 1.5A. £1.75. P.P. 30p.

WODEN.

All primaries 220-240V. Type 1. Sec. 890-710-0-710-890V. 120mA. unshrouded table top connections, tropicalised £2.50. P.P. 50p. Type 2. Sec. 190V. 60mA. 6.3V. 3A. £1.25. P.P. 25p. Type 3. Sec. tapped 150-150V. 4 amp. unshrouded table top connections £2.75. P.P. 75p. Type 4. Sec. 130V. 450mA. three times. "C" core, table top connections £3.50. P.P. 50p. Type 5. 6.3V. 1.6A. and 2V. 0.8A. and 6.3V. 1A. unshrouded table top connections £2.50. Carr. 50p.

GARDNERS.

All primaries 220-240V. Type 1. 350-0-350V. 60mA. 6.3V. 4A. 5V. 2.5A. shrouded £1.50. P.P. 30p. Type 2. 300-0-300V. 60mA. 6.3V. 4A. "C" core. £1.50. P.P. 30p. Type 3. 450-400-350-0-350V. 50mA. "C" core. £1.25. P.P. 25p. Type 4. 250-0-250V. 100mA. 6.3V. 3A. 6.3V. 3A. 5V. 3A. Potted type £2.50. P.P. 50p. Type 5. 350V. 44mA. 20V. 10mA. 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 6 1/2 x 6 x 6 in. £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. Carr. 50p.
REDCLIFFE "C" core types. Pri. 220-240V. Sec. 11V. 6A. £2.30 P.P. 35p. Pri. 220-240V. Sec. 30V. 350 mA. 75p. P.P. 25p. Pri. 220-240V. Sec. tapped 370-390-400V. 6 mA. 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. 69-81-85-87-89V. 10A. T block connections. Unshrouded £8.00 carr. 75p. Type 3 tapped. 66-58-80V. 3A. T block connections. £2.95. P.P. 60p. Type 4 100-0-100V. 85mA. and 81-84-87V. 150mA. and 6V. 1A. £1.75. P.P. 25p. Type 5 tapped. 11-8-13V. 14A. and 13.9V. 1.4A. twice. Unshrouded. T block connections. £4.90 carr. 75p. Type 6 10V. 2A. and 80V. 0.6A. T block connections. Unshrouded. £1.80 carr. 25p. Type 7 18V. 4A. and 13V. 6A. T block connections. Unshrouded. £3.00 carr. 50p. Type 8 1V. 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. 17.6V. 6A. £2.25. P.P. 30p.

METALISED PAPER CAPACITORS

Dubilier 40mfd. 150V. D.C. wkg. at 70°C. 40p. Postage 10p.
Hunte 15mfd 350V. D-C. wkg. 40p. Postage 10p.

HIGH CAPACITY ELECTROLYTICS

10,000mfd. 70V. D.C. wkg. 10,000mfd. 50V. D.C. wkg. 60p. 25,000mfd. 25V. D.C. wkg. 20,000mfd. 30V. D.C. wkg. 10,000mfd. 25V. D.C. wkg. 9,000mfd. 40V. D.C. wkg. 3,000mfd. 30V. D.C. wkg. 50p. P.P. all capacitors 20p.

SCOTCH MAGNETIC COMPUTER TAPE

Type 3M459 1/2 in. 3,600 feet. Supplied new in maker's cartons. At a fraction of maker's price. £2.00. Postage 35p.

HEAVY DUTY HEAT SINKS

With 2 OC 29. Size 6 x 5 x 2 1/2 ins. Weight 3 lbs. 85p. Postage 25p.

COMPONENT PANELS

Brand containing 1. Miniature Relay 58000Z 2 contacts. 1. 8mfd. 450V. Tubular cap. 1. 50mfd. 50V. cap. Three panels for £1. P.P. 15p.

TUBULAR MOTOR START CAPACITORS

HUNTS 20mfd. 275V. A.C. 75p. P.P. 25p. 15mfd. 250V. A.C. 50p. P.P. 15p. 7.5mfd. 250V. A.C. 40p. P.P. 15p. 6mfd. 440V. A.C. 60p. P.P. 15p. T.C.C. 3.5mfd. 250V. A.C. 40p. P.P. 15p. 2.2mfd. 250V. A.C. 35p. 2.5mfd. 300V. A.C. 40p. P.P. 15p. 4mfd. 250V. A.C. 40p. P.P. 15p. 8mfd. 400V. A.C. 50p. P.P. 20p. 10mfd. 250V. A.C. wkg. 50p. P.P. 15p. 48mfd. 275V. A.C. wkg. 75p. P.P. 15p. 2.6mfd. 500V. D.C. wkg. 35p. P.P. 15p.

L.T. SMOOTHING CHOKES

By famous makers "C" core types
10mh. 25a. £3.00 carr. 50p. 15mh. 3.8a. £1.75 carr. 35p. Swinging types 7.5mh. 175mh. 6a. 10.5a. £2.75 carr. 35p. 10mh./100mh. 4a. 10.5a. £3 carr. 50p. 50mh./100mh. 5a. 10.5a. £3.00 carr. 50p. Oil-filled potted types 100mh. 2a. £2.30 carr. 50p. 130mh. 1.5a. £1.50 carr. 35p. 150mh. 3a. open frame type. Tropicalised £3.00 carr. 40p. 50mh./2a. shrouded. £2.00 carr. 35p. 7mh. 5a. "C" core. 75p. carr. 25p.

H.T. SMOOTHING CHOKES

Parmeko potted types. 8h. 600mA. £3.00 carr. 50p. 10h. 300mA. £2.00 carr. 30p. 10h. 180mA. £1.50 carr. 30p. 15h. 180mA. £2.00 carr. 50p. Swinging type. 5h. 0.4a. 4h. 0.25a. £1.50 carr. 30p. 10h. 120mA. 75p carr. 25p. 18h. 75mA. 10h. 75mA. 50h. 25mA. 50p carr. 20p.

L.T. TRANSFORMERS

Famous maker. Special offer. No. 1 Pri. 240V. Sec. 17V. 2A. twice. Open frame type £1.75. Postage 30p. No. 2 Pri. 220-240V. Sec. 12V. 10A. Open frame type £2.50. Postage 40p.

CRESHAM POTTED OIL-FILLED CHOKES

9 henries 500mA. 5kv. wkg. £7.50 carr. £1.50.

AMOS L.T. CHOKES

"C" core type. 140mh. 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.

H.T. TRANSFORMERS

PARMEKO. Pri. 240V. Sec. 250-0-250V. 50mA. 6.3V. 1A. £1.25. P.P. 35p. 6.5A. £2.50. P.P. 40p. Type 3: Pri. 240V. Sec. 300-0-300V. 66 mA. 6.3V. 4A. £1.50. P.P. 35p. A.C. Pri. 240V. Sec. 250V. 60 mA. 15V. 1.2A. 6.3V. 4.5A. £1.25. P.P. 35p. open type table top connections. Size 4 x 3 1/2 x 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. 8.3V. 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. 20-7V. 5A. 23V. 500mA. 180V. 100mA. 78V. 80mA. £4.50 carr. 75p. Type 5: Pri. 200-220-240V. Sec. 140V. 195mA. P.P. 40p. Type 6: Pri. 110-220-240V. Sec. 230V. 200mA. 6.3V. 7A. £2.50 carr. 50p. Type 7: Pri. 115-230V. Sec. 9-10V. 0.42A. 6.3V. 3.8A. 6.3V. 1.2A. £1.50. P.P. 35p. Type 8: Pri. 110-220-240V. Sec. 680-800-700-720-740-760V. 50mA. 6.3V. 1.8A. £2.00. P.P. 35p. 115V. Pri. only Type 1: Sec. 3700-0-3700V. 44mA. £4.90 carr. £1. Type 2: Sec. 6.3V. 11A. 1.4kv. wkg. 4V. 13A. 7kv. wkg. £2.90 carr. 50p. Type 3: £30-0-330V. 30mA. 6.8V. 6A. £4.30 carr. £1. Type 4: 6.3V. 4A. 6.3V. 0.9A. 6.3V. 0.6A. 75p. P.P. 25p. Type 5: 6.3V. 0.9A. 6.3V. 0.6A. 75p. P.P. 25p. LINE O.P. TRANSFORMERS Input 10KΩ 80mA. d.c. Eight 000Ω outputs PJS turns ratio 11.5/1 + or - 3 DB. 20 c/s-3500 c/s. £3.30. 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.
Pri. 200-220-240V. Sec. 16.3V. 1A. twice. 10V. 1A. twice. 22.5-25-28.8V. 5A. 26.5V. 2.5A. 23.9V. 1A. 6.3V. 2A. 145-0-145V. 200 mA "C" Core. Table top connections £4.95 carr. 75p.
Pri. 200-220-240V. Sec. 20-21-22-23-24-25V. 6A. 20-21-22-23-24-25V. 3.5A. 18-19-20-21-22-23V. 2A. 11-12-13-14-15-16V. 0.5A. twice 100-0-100V. 150 mA "C" Core. T. top connections. £7.25 carr. £1.
Pri. 200-220-240V. Sec. tapped 63-68-74V. 3A. and 6V. 4A. Open frame terminal block connections £3.00 carr. 50p.
Pri. 200-220-240V. Sec. 37-40-43V. 5A. 100. 300 mA. twice. Oil-filled potted type. £6.50 carr. 50p.
Pri. 200-220-240V. Sec. 39V. 8.6A. 38V. 2.6A. Oil-filled potted type. £8.00. carr. £1.
Pri. 200-220-240V. Sec. tapped 30-57.5-115V. 0.5A. "C" Core T. top connections. £2.25 carr. 30p.
LTP Pri. 200-220-240V. Sec. 6.3V. 8A. three times. 6.3V. 3A. twice. open frame type T. top connections £4.25 carr. 75p.
Woden Pri. 220-240V. Sec. 10V. 2A. fully shrouded £1.60 carr. 30p.
Pri. 220-240V. Sec. tapped 6-12V. 2A. fully shrouded £1.95 carr. 25p.
Pri. 200-220-240V. Sec. tapped 10-13-17V. 7A. Open frame. T. top connections £2.25 carr. 30p.

Pri. 220-240V. Sec. 24.5-0-24.5V. 0.75A. "C" Core. T. top connections £1.85 carr. 25p.
Pri. 200-220-240V. Sec. 11-0-11V. 176mA. "C" core. T. top connections 75p. carr. 25p.

PARMEKO HT TRANSFORMERS NEPTUNE OIL FILLED TYPE.

Pri. Sec. 350-0-350V. 200 mA. 6.4V. 6A. 6V. 3A. Size 6 1/2 x 4 1/2 x 4 ins. £3.00 carr. 50p.

RICH AND BUNDY TRANSFORMERS

Pri. 220-380-415-440V. Sec. 250V. 80 watts conservatively rated. Open frame type. Terminal



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: 10K Ω

Input Sensitivity: 0Dbm (0.775volt RMS)

Load Impedance: 4-16 Ω

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 \pm 1Db

Supply Voltage: \pm 45volts

APPLICATIONS: P.A., Disco, Groups, Hi-Fi, Industrial.

PRICE: £14.90 inc. VAT & P & P

Trade applications welcomed

DELIVERY FROM JULY 1st

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.

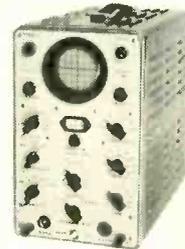
£41.00



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.

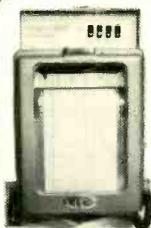
£39.00



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



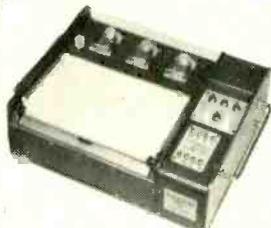
4-RANGE GENERAL PURPOSE TEMPERATURE RECORDER Type 01

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/N1A1 thermocouple and mains lead. This product is brand new and manufactured in our own laboratories with three month guarantee

£95.00

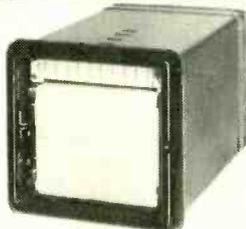
plus £5.00 packing and carriage.



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

ELECTRONIC TIME DELAY SWITCH.

Specification:

Delay period 1-25 minutes adjustable, load 1000 watts maximum. Operating Voltage 180-250V a.c. 50Hz. Size 3½ x 3½ x 1½ Standard Ivory Surface mounting Box. Trade Price £5.80

NEW AMPERTEST 690 — A NEW CLAMP TYPE AMMETER

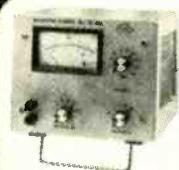
Electronic Brokers Limited announce the introduction of a new clamp type ammeter having 6 current ranges plus 2 voltage ranges for use on 50 to 60 alternating current supplies. Known as the AMPERTEST 690, the new instrument is manufactured in Italy by Industria Costruzioni Elettromeccaniche, one of Europe's 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



OUTPUT POWER METER Type MU 96A.

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 2.50hm 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

Fantastic value in Test Equipment

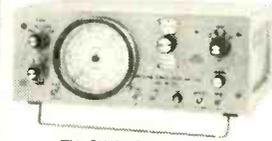


MODEL 300 LOGIC PROBE

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 marker 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.

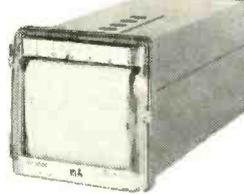
£195.00



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 300x230x150 mm. Weight approx. 13 lbs.

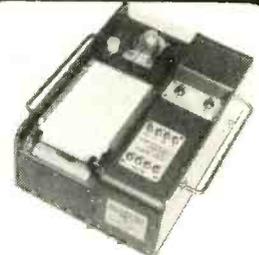
£59.00



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 120x120x285mm. 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.

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 1.8Mohms 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 µA Accuracy 1%. 11 A.C. ranges from 2 to 2500V. 10 ranges from 250µA to 4,000µV. 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 20 to 20,000 mfd from internal battery and 2 ranges from 50,000 to 500,000pF using mains.

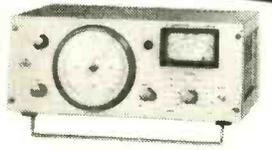
OTHER ACCESSORIES AVAILABLE: SHUNTS D.C. 25, 50 and 100 amps. £4.50 each. CURRENT TRANSFORMERS A.C. 25 and 100 amps. £7.00 each. E.H.T. PROBE Extends d.c. voltage to 25,000v. £5.95.



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.

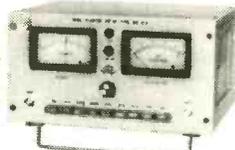
£249.00



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 to 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. Rise time: 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 0.1 V. 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

ALL EQUIPMENT BRAND NEW AND GUARANTEED FOR 6 MONTHS

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CALLERS WELCOME MON-FRI 9 A.M. to 5-30 P.M. SAT 9-30 A.M. to 2 P.M.

Add £2 towards the cost of packing and carriage on all items for U.K. delivery (except where packing and carriage is already indicated).



ELECTRONIC BROKERS LTD.

53 Pancras Rd, London NW1 2QB. Tel: 01 837 7781

Please send me

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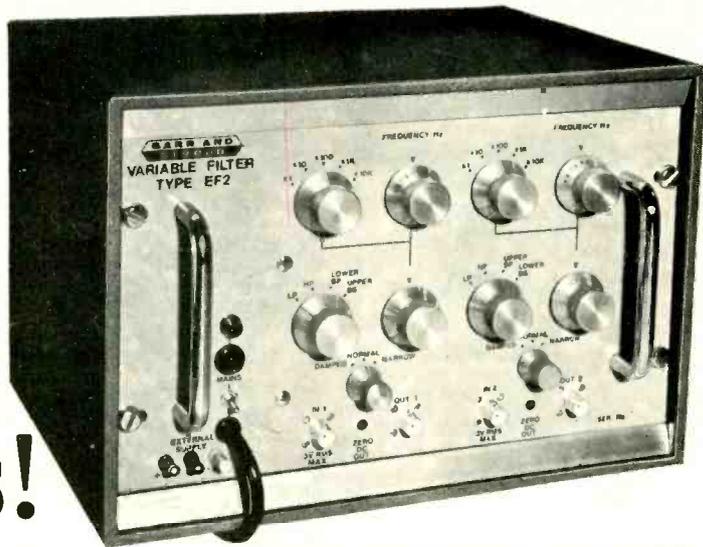
cash/cheque/P.O.

Name

Address

WW-117 FOR FURTHER DETAILS

Surely the best value in variable filters!



Look, for instance, at these three features of the Barr & Stroud solid state EF2.

- Two independent lowpass/highpass filter channels
- Attenuation slope 36 or 72 dB/octave
- 6th order response through computer-aided design

Then add all these other features and we think you will agree the EF2 is worth a closer look.

- Frequency range from 0.1 Hz to 100 kHz in five decades
- Frequency tolerance $\pm 5\%$ except at range limits
- Maximum attenuation greater than 75 dB
- Combined channels provide band pass, band stop or band separation modes

- Mode switching without use of external links
- Digital selection of cut-off frequency giving accurate repeatability
- Response switchable to 'normal', 'narrow', or 'damped' condition
- Up to 20 dB gain available in 'narrow' condition
- Operation from internal power supply or external batteries
- Output protected against short circuit

Price: £450 + VAT

Further details in pamphlet 1652/ available on request.

Barr and Stroud also design and build special filters to individual customer requirements. Extensive use of computer facilities ensures economical and accurate realisation of the desired characteristics.



BARR & STROUD LIMITED

Annie'sland, Glasgow, G13 1HZ. Telephone: 041-954 9601 Telex: 778114
Kinnaird House, 1 Pall Mall East, London, SW1P 1RT. Tel: 01-930 1541 Telex: 261877



ELECTRONIC ORGAN DIVIDER BOARDS built to high industrial/computer spec. 5 octave set £15. Complete with connection data and oscillator details.

COPPER LAMINATE P.C. BOARD
8 1/2 x 5 1/2 x 1/16 in. 12 1/2 p sheet, 5 for 50p
11 x 6 1/2 x 1/16 in. 15p sheet, 4 for 50p
11 x 8 x 1/16 in. 20p sheet, 3 for 50p
Offcut pack (smallest 4 x 2 in.) 50p 300 sq. in.
P&P single sheet 4p. Bargain packs 10p

SPEAKERS AND CABINETS

E.M.I. 13 x 8 in. (10 watt) with two tweeters and cross-over 3/8/15 ohm models. £3.75. P.P. 25p.
E.M.I. 13 x 8 in. base units (10 watt) 3/8/15 ohm models £2.25. P.P. 25p.

E.M.I. 6 1/2 in. rnd. 10 watt Woofers. 8 ohm. 1 3,000 gss £2.25. P.P. 15p.

E.M.I. 20 watt (13 x 8 in.) with single tweeter and "X-over" 20 Hz to 20,000 Hz. Ceramic magnet 11,000gss. £8. P.P. 40p. 20 watt base unit only. £6. P.P. 40p.

CABINETS for 13 x 8 in. speakers manufactured in 1/2 in. teak-finished blockboard. Size 14 x 10 1/2 x 9 in. £5 ea. P.P. 40p.

20W. CABINET. 18 x 11 x 10 in. £6. P.P. 50p.

PRECISION A.C. MILLIVOLTMETER (Solartron) 1.5m.v. to 15v; 60db to 20db. 9 ranges. Excellent condition. £22.50. P.P. £1.50.

V.H.F. POWER TRANSISTORS TYPE PT4176D (2N4128). 24 watt 175 MHz. £1.50 ea. S.A.E. for spec

MINIATURE UNISELECTORS (A.E.I. 2203A). 3 bank, 12 position, non-bridging wipers. £4.25 ea. Brand new Complete with base.

CD.1220 OSCILLOSCOPE, with dualtrace Plug-in. (CX1257) DC-24MHZ. £125.
Wide band Plug-in (CX1256) DC-40MHZ. £25.

SOLARTRON OSCILLATOR (CO546) 25Hz-500KHz £50.

OVERLOAD CUT-OUTS, Panel mounting (1 1/2 x 1 1/2 x 1 1/2 in.) 800 M/A/1.8 amp/10 amp. 35p ea. P.P. 5p.

BULK COMPONENT OFFER. Resistors/Capacitors. All types and values. All new modern components. Over 500 pieces £2. (Trial order 100pcs. 50p.) We are confident you will re-order

TWIN STABILISED POWER SUPPLIES (A.P.T.) +80v. @ 500 M/A. -80v. @ 500 M/A (9 x 6 x 5 1/2 in.) New. £8.50 with spec. & circuit.

U.K. ORDERS 10% V.A.T. SURCHARGE

HIGH-SPEED MAGNETIC COUNTERS. 4 digit (non reset) 24v. or 48v. (state which) 4 x 1 x 1 in. 40p. P.P. 5p.



5 digit (non-reset) 6-12-24-48v. (state which) 75p. P.P. 5p.

5 digit (Reset) 12v. £3. P.P. 5p.

HIGH CAPACITY ELECTROLYTICS

2,200µf. 100v. (1 1/2 x 4in.) 60p. 3,150µf. 40v. (1 1/2 x 4in.) 60p. 10,000µf. 25v. (1 1/2 x 4 1/2 in.) 60p. 10,000µf. 100v. (2 1/2 x 4 1/2 in.) £1. 12,000µf. 40v. (2 x 4in.) 75p. 16,000µf. 16v. (2 x 4in.) 60p. 21,000µf. 40v. (2 1/2 x 4in.) £1. Post and packing 5p.

"PAPST" TAPE MOTORS. (LZ 20.50). New Boxed. £2. P.P. 25p.

TRANSFORMERS

L.T. TRANSFORMER. (Shrouded) Prim. 200/250v. Sec. 20/40/60v. 2 amp. £2 ea. P.P. 40p.

L.T. TRANSFORMER (CONSTANT VOLTAGE). Prim. 200/240v. Sec. 1. 50v. at 2 amp. Sec. 2. 50v. at 100 m/a £3. P.P. 50p.

L.T. TRANSFORMER. Prim. 110/240v. Sec. 2x32v. @ 4 amp. 20v. @ 5 amp. 15v. @ 1.5 amp. 7v. @ 2.5 amp. £3. P.P. 50p.

L.T. TRANSFORMER. Prim. 220/240v. Sec. 13v. 1.5 amp. 65p. P.P. 15p.

L.T. TRANSFORMER. Prim. 115/240v. Sec. 10-5v. at 1 amp. c.t. 28-0-28v at 2 amp. shrouded type. £2. P.P. 40p

2500 watt ISOLATION TRANSFORMER (CONSTANT VOLTAGE). Prim. 190-260v. 50Hz. Sec. 230v. at 10-9 amps. £30. Carr. £2.

H.D. STEP-DOWN TRANSFORMER. Prim. 200/240v. Sec. 117v at 19-8 amps. (2,300 watt). £22.50. Carr. £2.

H.T. TRANSFORMERS. Prim. 200/240v. Sec. 300-0-300v. 80 m.a. 6.3v. c.t. 2 amp. £1.50 P.P. 40p.

350-0-350v. 60 m.a. 6.3v. c.t. 2 amp. £1. P.P. 25p.

STEP-DOWN TRANSFORMERS: Prim. 22/240v. Sec. 115v. Double wound 500w. £5. P.P. £1. 700w. Sec. (with filters) £10. P.P. £1. 500w. (metal cased with socket output) and overload protection. £6-50.

AUTO-WOUND. 75W. £1. P.P. 25p. 300W. £1-50. P.P. 50p 750W. £6. P.P. £1

L.T. TRANSFORMER. Prim. 110/240v. Sec. 0/24/40v. 1.5A. (Shrouded type). £1.50. P.P. 25p.

HT/LT TRANSFORMER Prim. 240v. (tapped) Sec. 1. 500-0-500v. 150 m/a. Sec. 2. 31v. 5 amp. £2-75 P.P. 50p.

HEAVY DUTY E.H.T. TRANSFORMER. Prim 0/110/240v. Sec. 1800v. 3-1 K.V.A. £28. Carr. £2 4K.V.A. model £33. Carr. £2.

PRECISION CAPACITANCE JIGS. Beautifully made with Moore & Wright Micrometer Gauge. Type 1. 18.5pf. to 1,220pf. £10 each Type 2. 9.5pf. to 11.5pf. £6 each.

MULTICORE CABLE (P.V.C.). 6 core (6 colours) 3 screened, 14/0048. 15p. yd. 100 yds. £12.50.

24 core (24 colours) 20p. yd. 100 yds. £17.50.

30 core (15 colours) 22p. yd. 100 yds. £18.50.

34 core (17 colours) 25p. yd. 100 yds. £20.

Minimum order 10 yds.

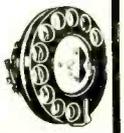
TELEPHONE DIALS (New) £1 ea.

RELAYS (G.P.O. '3000'). All types. Brand new from 37 1/2p ea. 10 up quotations only.

EXTENSION TELEPHONES (Type 706) New/Boxed. £5. 50p.

RATCHET RELAYS. (310 ohm) Various Types 85p. P.P. 5p.

UNISELECTORS (Brand new) 25-watt 75 ohm. 8 bank 1/2 wipe £3-25. 10 bank 1/2 wipe £3-75. Other types from £2-25.



BLOWER FANS (Snail type) Type 1: Housing dia. 3 1/2 in. Air outlet 1 1/2 x 1 in. £2.25. P.P. 25p. Type 2: Housing dia. 6 in. Air outlet 2 1/2 x 2 1/2 in. £4. P.P. 50p. Both types 115/240v. A.C. (brand new).

POT CORES LA1/LA2/LA3 50p each

RELAYS

SIEMENS/VARLEY PLUG-IN. Complete with transparent dust covers and bases. 2 pole c/o contacts 35p ea.; 6 make contacts 40p ea.; 4 pole c/o contacts 50p ea. 6-12-24-48v types in stock.

12 VOLT H.D. RELAYS (3x2x1 in.) with 10 amp. silver contacts 2 pole c/o 40p ea.; 2 pole 3 way 40p. P.P. 5p.

24 VOLT H.D. RELAYS (2x2x1 1/2 in.) 10 amp. contacts. 4 pole c/o. 40p ea. P.P. 5p.

240v. A.C. RELAYS. (Plug-in type). 3 change-over 10 amp contacts. 75p (with base). P.P. 5p.

SUB-MINIATURE REED RELAYS (1 in. x 1/2 in.) Wt 1/2 oz. 1 make 3/12v. 40p ea.

SILICON BRIDGES. 100 P.I.V. 1 amp. (1 1/2 x 1 1/2 in.) 30p. 200 P.I.V. 2 amp. 60p.

24 VOLT A.C. RELAYS (Plug-in). 3 Pole Change-over 80p.

2 Pole Change-over 45p.

PATTRICK & KINNIE

191 LONDON ROAD · ROMFORD · ESSEX

ROMFORD 44473

RM7 9DD



MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—2 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way, 1 pole, 12 way. All at 22p each.

TOGGLE SWITCHES

Metal, all standard types with metal dolly 240v. 3 amp: SP, ST 17p SP, DT, 22p DP, ST 22p DP, DT. 25p less 10% for ten of same type.

ROCKER SWITCH

13 amp self-living into an oblong hole. Size approximately 1 1/4 x 3/4, 9p each, 10 for 82p.



SLIDE SWITCHES

Slide Switch, 2 pole change over panel mounting by two 6 B screws, big cut max. 1" x 1" rated 250v lamp. 8p each, 10 for 72p. Ditto as above but for printed circuit 7p each, 10 for 63p.

Sub Miniature Slide Switch, DDDT 10mm (1" approx.) between fixing centres. 14p each or 10 for £1.26.

DOUBLE LEAF CONTACT

Very slight pressure closes both contacts. 8p each, 10 for 72p. Plastic push-rod suitable for operating. 6p each, 54p for 10

LIGHT CELL

Almost zero resistant in sunlight increases to 10 K. Ohms in dark or dull light, epoxy resin sealed. Size approx. 1 in. dia. by 1/4 in. thick. Rated at 500 MW. Wire ended. 61p. Suit most circuits.



PAPST MOTORS

Eat. 1/20th 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. 230 V. Model £3.30



MINIATURE SEALED RELAY

American made. Our Ref. No. REL A1. Measures only 1/2" wide x 1/4" thick and 1/2" 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 or 4 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 rewiring 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. 4" x 1 1/2" x 1 1/2" deep. Priced at £2.75.

MAGNETIC CLUTCH

XEROX 1215434-J/N 10-1110 P8866-10. 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.



DRILL CONTROLLER

New 1kW model. Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. This includes all parts, case, everything and full instructions £1.65, plus 13p post and insurance. Made up model also available £2.50 plus 13p p. & p

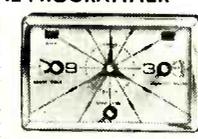


BAKELITE INSTRUMENT CASE

Size approx. 6 1/2" x 3 3/4" x 2" deep with brass inserts in four corners and bakelite panel. This is a very strong case suitable to house instruments and special rigs, etc. Price 50p each. Faxlids 11p extra.

15A ELECTRICAL PROGRAMMER

Learn in your sleep: Have radio playing and kettle boiling as you awake—switch on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an electrical programmer.



Clock by famous maker with 15 amp. on/off switch. Switch on time can be set anywhere to stay on up to 6 hours. Independent 60 min. memory jogger. A beautiful unit. Price £2.15 + 20p p. & p. or with glass front chrome bezel 83p extra.

WATERPROOF HEATING ELEMENT

24 yards length 70W. Self-regulating temperature control. 55p post free.



HIGH ACCURACY THERMOSTAT

Uses differential comparator I.C. with thermistor as probe. Designer claims temperature control to within 1/7th of a degree. Complete kit with power pack £2.15.

TREASURE TRACER

Complete Kit (except wooden batteries) to make the metal detector as the circuit in Practical Wireless August issue. £3.30 plus 20p post and insurance.

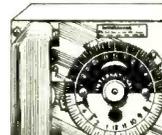
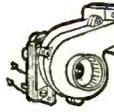


NUMICATOR TUBES

For digital instruments, counters, timers clocks, etc. Hi-vac XN.13. Price £1.65 each

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. 4 1/2" x 4 1/2" x 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 £2.05.



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 50p pair.

COMPUTER TAPE

2,400ft. of the Best Magnetic Tape money can buy. Some users claim good results with Video and sound. 1/4 in. wide. £1.10 plus 30p. post. Spare spools and cassettes 55p.



1" Scotch tape. Brand new. Suits most video recorders. £3.30 for 3,600ft.



GOOD COMPANION I.C. MODEL

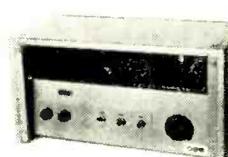
We can now offer this fine receiver but in I.C. version, using Ferranti ZN414 and Mullard AF Module 1172. Cabinet size approx. 1 1/2 in. wide x 8 in. high x 3 in. deep. Complete with excellent 2 tone cabinet with assembly instructions £5.75.

ERGOTROL UNITS

These units made by the Mullard Group are for operating and controlling d.c. Motors and equipment from A.C. mains.

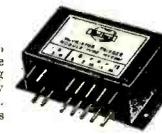
Thyristors are used and these supply a variable d.c. resulting in motor speed control and operating efficiency far superior to most other methods. The units are contained in wall mounting cabinets with front control panel on which are fuses—push buttons for on/off and the variable thyristor firing control.

4 models are available—all are brand new in makers cases: Model 2410 for up to 5 amps £19.25 Model 2411 for up to 10 amps £30.25



MULLARD THYRISTOR TRIGGER MODULE

This produces pulses for phase control triggering, it has two isolated out-puts, so one thyristor or two thyristors (in separate arms of bridge) may be controlled by one module. The timing circuit is synchronised to the mains frequency and control is by an external variable resistor or from a voltage or current source. Provision is made for feedback where automatic control is required. Price £4.95 each or 10 for £45.00.



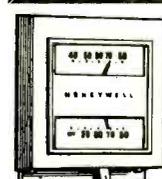
THIS MONTH'S SNIP

CAPSTAN TAPE MECHANISM

Mains operated motor with belt drive to heavy fly wheel on metal platform with tape guide and release lever. Tape speed 31. Ideal for continuous loop players and similar projects. Not new but guaranteed in first class condition and supplied with a 6 months guarantee. Limited quantity only £2.75 each plus 30p post and insurance.

THERMOSTAT WITH THERMOMETER

Made by Honeywell for normal air temperatures 40°-80°F (5-26°C). This is a precision instrument with a differential which can be adjusted to better than 1°F. A mercury switch breaks on temp. rise—the switch is operated by coiled bi-metal element and an adjustable heater is incorporated for heat anticipation. Elegantly styled and encased in an ivory plastic case with clear plastic windows, thermometer above and switch setting scale below. Size approx. 3 3/8" x 3 1/2" x 1 1/4" deep. Can be mounted on conduit box or directly on wall. Price £1.38 each or 10 for £12.52.



RADIO STETHOSCOPE

Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. £2.20—twin stethoset instead of earpiece 83p extra—post and ins. 20p.



HORSTMANN "TIME & SET" SWITCH

(A 30 Amp Switch.) Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price £1.65. Post and ins. 23p.

SUB. MINIATURE MICROSWITCH

Made by Burgess, their Ref. V176—our ref. MS. A1. These measure only 1/2" x 1/2" x 1/4" thick—have change over contacts and tag connection. Price 16p each or 10 for £1.44.

INSULATED TERMINALS

For mounting through metal panel. These are heavy duty 2 B.A. type. Good quality and made originally for government contracts. All black but it is a simple matter to paint the flat front face with any appropriate colour. This type of terminal normally sells at 15p each. Our price only 6p each or 10 for 54p.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 x 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. £2.50 plus 25p P. & P.



MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied. Model 1183 500mW power output 72p. Model 1172 750mW power output 94p. Model EP9000 4 watt power output £1.60. EP9001 twin channel or stereo per amp. £1.98. 10% discount if 10 or more ordered.

CAR PANEL SWITCH. Our Ref. No. 801. Arco made. Has long flat ended toggle black and chrome finish. Rated 2A. at 250v. and is double pole on/off. Listed at 45p. Our price 24p each.



CAR PANEL AUTO. SWITCH. Ref. No. 803. Again a flat ended toggle. Made by Arrow. A 3 position double pole change over switch control off for auto aerials, reversing motors etc. 33p each.

3 PIN PLUG AND SOCKET. Our Ref. No. P801. Flat pins. American style rated at 10A. 250v. Socket panel mounting. Plug is white and intended for flex. Useful where non standard power outlet is required. Also suitable for speaker leads, etc. etc. Price 25p per pair.

3 PIN REVERSE PLUG AND SOCKET. Our Ref. P802. For bringing live leads to equipment. All brown bakelite construction, rated 10A. 250v. Price 39p per pair.

R.P.H. MOTOR. Smiths. 240v. 50 cycle mains working. Ideal motor to drive clock mechanisms. Price £1.10 each 13 AMP JUNCTION BOXES. Made to take 7028 cables so ideal for ring mains. Price 9p each or 10 for 81p.

PORCELAIN FUSE AND CARRIER. 20A. 250v. MEM Ref. No. 151BB/151RH/W. Make your own fuse board. Price 22p per pair.



AUTO TRANSFORMER. Primary 220-240v. Secondary 110-120v. Well built and varnish impregnated. 250 watt intermittent rating. 150w. continuous rating. Size approx. 3 1/2 x 3 x 3 in. £1.10 plus 20p post and insurance.

3 BANK CONTACTORS. Coil closing voltage only 24V A.C. Just the thing for switching heaters with the Honeywell precision thermostat which we have. Heavily insulated, could also be used for 3 phase working. These have two main switch contacts rated at 30A 600V and auxiliary contacts rated at 10 amp. Price £1.85 each.

RELAYS BY KEYSWITCH. Makers Ref. KMK3. Our number REL A3. Open type mains operated coil—3 pairs change-over contacts rated at 6 amps each. Mounted by 1 screw. 5-ster 1st connections. Price 60p each. Ditto but 12V. operated coil. Our Ref. REL A4. Price 55p each.

INSTANT START UNITS. For 2ft. tubes. Phillip's or Smart & Brown in a tray complete with tube clips and tube ends. Price £1.65 each or 10 for £14.90.

SPT MOTOR. 200-250v. Induction Motor, driving a carter gear box with 1 1/2 in. of output drive shaft running at 5 revs. per minute. Intended for roasting chickens, also suitable for driving models: windmills, coloured disc lighting effect, etc., etc. £2.05 plus 20p post and insurance.

WIRE ENDED FUSES. Useful where you want a quick solder-in fuse. Rated 2A. 250v. These are about the size of a resistor. Price 6p each.

PANEL NEON INDICATOR. Our Ref. No. P101. Oiling type, self-fixing in oblong hole, suitable for 200-250v. Price 15p each.

THERMOSTAT WITH PROBE. Our Ref. No. TH01. Made by Kewco. Range 0-107°C. 16A. 250v switch. Joined to a 10 in. probe by approx. 40 in. of capillary tubing. 1 hole fixing. Normal control spindle. 94p each.

THERMOSTAT WITH PROBE. Our Ref. No. TH02. As TH01 but the range is 0-120°C and the capillary tube is approx. 46 in. long. Price 94p each.

FLOURESCENT TUBES. Standard types—Bi pin ends. ideal pinet lighting as well as for standard replacements—18 in. 15 watt, 24 in. 40 watt, 36 in. 40 watt, 39 in. 40 watt. All first grade tubes offered at one price—£3.90 per box of 24—i.e. less than 15p each. If not collecting then please add 50p per box per 200 miles.

DIGITAL DISPLAY

Panel mounting unit measuring approx. 3 1/2 in. x 1 1/2 in. x 1 1/2 in. deep. Size of the display aperture is approx. 1 1/2 in. x 1 in. Light up to 0-9. Ex equipment but unused and in perfect order. Price £1.10 each.

DIGITAL SWITCHES. Small type S.T.C. number 8W2/1 630CA. These are a snap in fit hole approx. 1 1/4 x 1/4 in. Knob engraved 0-9. Gold plated contacts 1 pole 10 way. Thumb wheel operation. These are designed so that they may be stacked in rows. Price 83p each.

6 DIGIT COUNTER. Operated by 240v. A.C. mains through resistor or direct from 115v. A.C. or from 80v. D.C. Made by Veeder-Root of America. Metal encased for surface mounting. Size approx. 3 1/4 x 1 1/4 x 2 1/4 in. Price £1.10 each. 10 for £9.90.

COLOURED 13 AMP SOCKETS. Standard Flush mounting available in the following colours: yellow, green, grey. These are a good quality socket with porcelain interior made by Ward and Golestone. Useful on control panels. Price 20p each, 10 for £1.98.

REED SWITCH COILS. These are solenoids wound on moulded formers of the correct shape and dimensions to take standard reed switches. They have printed circuit board mounting. Six types available: RC1 takes 1 reed—Operates 10-15v. 600 ohms. 33p. RC2 takes 2 reeds—Operates 10-15v. 180 ohms. 28p. RC3 takes 1 reed—Operates 15-30v. 1k ohms. 35p. RC4 takes 2 reeds—Operates 15-30v. 300 ohms. 50p. RC5 takes 1 reed—Operates 45-70v. 6500 ohms. 39p. RC6 takes 2 reeds—Operates 45-70v. 3500 ohms. 44p. Standard reed switches available 11p each or 10 for 99p

ROCKER SWITCH. Our Ref. RS02. 13 amp. self fixing into hole approx. 1 in. x 3/4 in. Made by the Carr Fastener Co. Very reliable. Price 9p each.

PHOTO TRANSISTOR. OCP70—ideal for burglar alarms and similar applications. Price 55p each. 10 for 49.90.

EXIT SIGNS

One of our customers has pointed out how easily our box signs can be converted to exit signs. These are illuminated having a 20W fluorescent lamp with associated control gear. The front is very thick clear plastic. Directly onto this you can stick down the letters available at most stations. There is room inside the box for a battery and low volt lamp in the case of power failure. Size of sign is 2ft. high x 1 1/2 in. wide x 5 in. deep. Solidly made from sheet steel and hammer finished in enamel. Price £3.90 plus 50p carriage and 200 miles.

MUTUAL INDUCTANCE COIL. Laboratory type. M—0-001H. Inductance of coils 0-0021H and 0-0021H. Coil resistance 0.53 ohms and 0.51 ohms respectively. Maximum current through coils—3 amps. Completely encased with 4 screw down terminals. Overall size 6 in. diameter by 3 in. deep. Price £4.40 each.

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.

0-260 v. at 1 amp	£7-70
0-260 v. at 2.5 amps	£8-86
0-260 v. at 5 amps	£12-93
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)
1 amp £5.23 1 amp £7.70 2 1/2 amp £8.86

L.T. TRANSFORMERS

Type No.	Sec. Taps	Price Incl. P.&P.
1	30, 32, 34, 36 v. at 5 amps	£5.53
2	30, 40, 50 v. at 5 amps	£7.95
3	10, 17, 18 v. at 10 amps	£5.83
4	6, 12 v. at 20 amps	£7.62
5	17, 18, 20 v. at 20 amps	£8.56
6	6, 12, 20 v. at 20 amps	£8.12
7	24 v. at 10 amps	£8.14
8	4, 6, 24, 32 v. at 12 amps	£8.42
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 metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £77 incl. p. & c.

MOTOROLA MACII/6 PLASTIC TRIAC 400 PIV 10 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price £1.23 incl. P. & P. Suitable Diac 30p (RCA40583).

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. 1/2 in. b.s.p. Inlet/outlet. Precision made. British mfg. PRICE: £2.45 Incl. P. & P. Special quotation for quantity. NEW in original packing.

FOOT SWITCH



Suitable for Motors, Drills, Sewing Machines, etc., etc. 5 amp. 250 Volt. Price £1.00.

POWER RHEOSTATS

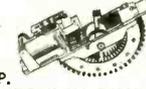
New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.

25 WATT	10/25/50/100/250/500/1k/1.5k ohm	£1-13
50 WATT	1/5/10/25/50/100/250/500/1k/1.5k/2.5k/5k ohm	£1-57
100 WATT	1/5/10/25/50/100/250/500/1k/1.5k/2.5k/3.5k ohm	£2-23

Black Silver Skirted knob calibrated in Nos. 1-9. 1 1/2 in. dia brass bush. Ideal for above Rheostats, 20p ea.

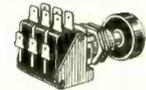
UNISELECTOR SWITCHES - NEW

4 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. operation. £6-74 incl. P. & P.
6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. £7-43, incl. P. & P.
8 BANK 25 WAY FULL WIPER 24 v. D.C. operation. £8-67, incl. P. & P.



'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 1/2 in. Prices: 1-bank 33p, 2-bank 44p, 3-bank 61p. (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. TYPES: N39, N95, N100, N101. 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 Veroboard S.C.R. Unijunction Xenon Tube + Instructions £7-20 incl. P. & P.
★ NEW INDUSTRIAL KIT
★ Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor. Adjustable 1-80 f.p.s., approx. 1/2 output of Hy-Light. Price £12-10. Incl. P. & P.
★ HY-LIGHT STROBE
★ Designed for use in large rooms, halls and the photographic field and utilizes a silica tube, printed circuit and a special trigger coil, Speed adjustable 1-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. Price £13-75. Incl. P. & P.

★ 'SUPER' HY-LIGHT KIT
★ Approx. 4 times the light output of our well proven Hy-Light strobe.
★ Incorporating Heavy duty power supply.
★ Variable speed from 1-13 flash per sec.
★ Reactor control circuit producing an intense white light.

★ Never before a Strobe Kit with so HIGH an output at so LOW a price. ONLY £22-83. Incl. P. & P.
★ ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE specially designed for the Super Hy-Light Kit including reflector, £8-20 incl. P. & P.
★ FOR HY-LIGHT STROBE Incl. reflector, £4-90 incl. P. & P.
★ 7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 73p incl. P. & P.

★ RAINBOW STROBE FOUR LIGHT CONTROL MODULE
★ Will operate four of our Hy-Light or Super Hy-Light Strobes in either 1, 2, 3, 4 sequence; 2 + 1; or all together.
★ Thoroughly tested and reliable. Complete with full connection instructions. Price: £20-63 incl. P. & P. 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. £20-74, incl. P. & P.



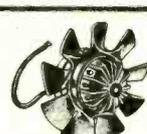
★ 6 INCH COLOURWHEEL
★ As used for Disco lighting effects, etc. Price £5-72 incl. p. & p.

★ BIG BLACK LIGHT
★ 400 Watt. Mercury vapour ultra violet lamp. Outer bulb designed to absorb visible light and transmit u.v. rays. 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 & bulb £18-15. Incl. P. & P. Spare bulb £8-03, incl. P. & P.



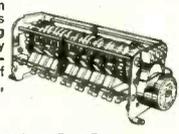
★ BLACK LIGHT FLUORESCENT U.V. TUBES
★ 4ft. 40 watt. Price £6-38 incl. P. & P. (For use in standard bi-pin fluorescent fittings). MINI 9 inch 6 watt black light U.V. tube. £1-60 incl. P. & P. Complete ballast unit and holder for 9 in. tube £2-04 incl. P. & P.

★ BLOWER UNIT
★ 200-240 Volt A.C. BLOWER UNIT
★ Precision German built. Dynamically balanced, quiet, continuously rated, reversible motor. Consumption 60mA. Size 60mm. dia. x 60mm. high. Price £3-50.



★ HONEYWELL PROGRAMME TIMERS
★ 240V. A.C. 5 r.p.m. motor. Each cam operating a c/o micro switch. Cams are individually variable, allowing innumerable combinations. Ideally suited for machinery control, automation etc. Also in the field of entertainment, for chaser lights, animated displays, etc.
★ 15 cam model £6-80 incl. P. & P.
★ 10 cam model £5-50 incl. P. & P.
★ 2 cam model with 15 r.p.m. motor £2-20 incl. P. & P.

★ 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 £4-13 incl. P. & P.



★ 24 HOUR TIMER
★ Can be adjusted to give a switching delay of between 1 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 incl. P. & P.



★ VENNER ELECTRIC TIME SWITCH
★ 200/250 volt. Ex-G.P.O. Tested, perfect condition. Two ON, two OFF, every 24 hrs. at any manually pre-set time. Price: 15 amp. £3-80. 20 amp. £4-35. Incl. P. & P. 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 1 1/2 in. x 1 1/2 in. x 1 1/2 in. Price only 83p including P. & P.



AMMETERS NEW! 2 1/2 in. FLUSH ROUND available as D.C. Amps 1, 5, 15, 20 or A.C. Amps 1, 5, 10, 15, 20. Both types £1-93 incl. P. & P. 0-300V. A.C. £2-09 incl. P. & P.



RELAYS

SIEMENS PLESSEY, etc. MINIATURE RELAYS			
1	2	3	4
52	4-6	6M	69p*
52	4-6	4 c/o	86p*
150	6-12	4 c/o	86p*
150	8-12	6M	86p*
280	9-12	2 c/o	86p*
410	10-18	4 c/o	86p*
600	9-18	2 c/o	86p*
700	16-24	4M2B	86p*
700	16-24	4 c/o	86p*
700	15-35	2c/oHD	80p*
700	6-12	1c/oHD	55p*
700	16-24	6M	69p*
700	20-30	6 c/o	83p*
1250	24-36	4 c/o	89p*
2500	36-45	6M	69p*
2400	30-48	4 c/o	55p*
9000	40-70	2 c/o	55p*
15k	85-110	6M	55p*

12 VOLT D.C. RELAY
Type 1: Three sets c/o contacts 5 amp. 86p incl. P. & P. (Similar to illustration below).
Type 2: One set c/o contacts 66p incl. P. & P.
Type 3: 4-8 volt 3 c/o HD, 67 ohm coil. 86p incl. P. & P.

SPECIAL OFFER
700 ohm. 4 c/o Ex. new equipment. £55-00 per 100 Incl. bases (minimum 100).

'DIAMOND H' 230 VOLT A.C. RELAYS (Unused)
Three sets c/o contacts rated at 5 amps. Price 66p. Incl. P. & P. (100 lots £44-00 incl. P. & P.)



230 VOLT A.C. RELAYS
One set c/o contacts rated at 7.5 amps. Boxed. Price 50p. Incl. P. & P. (100 lots £35-20 Incl. P. & P.)

MINIATURE RELAYS
9-12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1 in. x 1 1/2 in. Price 64p incl. P. & P.
30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1 1/2 x 1 1/2 in. 47p incl. P. & P.

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 80p, incl. P. & P.

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 carriage paid
1,000 VOLTS, 1,000 megohms £37-40 carriage paid



230V/240V COMPACT SYNCHRONOUS GEARED MOTORS

Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.
5 RPM A/cw 3 RPM A/cw 20 RPM cw
2 RPM cw 6 RPM cw 12 RPM cw
cw = Clockwise, A/cw = Anti-clockwise

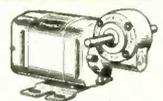


REVERSIBLE SPLIT PHASE MOTOR

250 r.p.m. 100-115/210-240V AC. 2 in. x 1 in. Ideal for rim-drive models, display etc. Extremely powerful for size 83p. incl. P. & P. (including small capacitor.)

PARVALUX

Type: SD1.S/86896/OJ
230/250v. A.C. 50 r.p.m. 7 lb/In. Continuously rated. Less base £8-30



TYPE: SD1.S/89400/OM

230/250v. A.C. 50 r.p.m. 22 lb/In. Continuously rated. Incl. base £8-83
The above motors are new and unused.

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 £4-81 incl. P. & P. or less transformer £2-77 incl. P. & P.



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 incl. P. & P.



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 including P. & P.



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SERVICE TRADING CO.

SHOWROOMS NOW OPEN
AMPLE PARKING

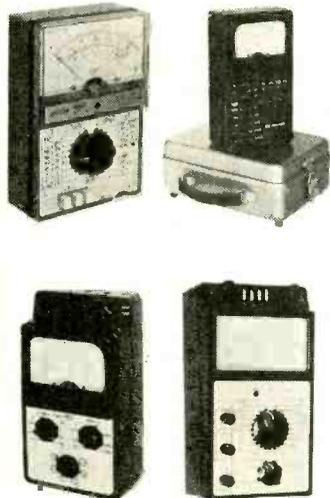
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Tel.: 01-437 0576

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(Made in U.S.S.R.)

Large selection of multimeters with prices ranging from £4.95 to £10.80.

Please write for full Catalogue.

ALL PRICES ARE EXCLUSIVE OF VALUE ADDED TAX. WHEN ORDERING BY POST PLEASE ADD £0.12 1/2 IN £ FOR HANDLING AND POSTAGE (SUBJECT TO A MINIMUM CHARGE £0.15) AND 10% OF THE TOTAL VALUE FOR VAT.

FULL WAVE SILICON BRIDGE RECTIFIERS 1B100M10
100 p.i.v., 10 AMPS EPOXY ENCAPSULATED CHARGING RECTIFIERS.

AT A SPECIAL PRICE OF £3.50.

PHOTO EMISSIVE DEVICES

Photo-Transistors			
OCP71	£0.90	BPX25	£1.00
ORP12	£0.50	ORP90	£1.10
ORP60	£0.50	ORP93	£1.00
ORP61	£0.32		
Photocells			
90AG	£2.40	90AV	£2.50
90CG	£2.40	90CV	£2.40

SOLID STATE LIGHT EMITTING DIODES MV10R

TO18 outline. Brightness 500 FT.-L. at 50 mA. Forward voltage. 1.65 to 2V. Diode gives bright red pinpoint of light when supplied from a 2V source. Lens diameter 0.170 in. PRICE £0.85.

AVALANCHE RECTIFIERS

1A8029	1000 p.i.v., 1.5A, 1 surge 125A.	£0.30
RA8310AF	1000 p.i.v., 1.5A, 1 surge 40A.	£0.35
RA5508AF	960 p.i.v., 6A, 1 surge 100A.	£0.40

HIGH CURRENT THYRISTORS

BTX47-1000R	1000V 11.5A.	£2.00
BTX47-1200R	1200V 11.5A.	£2.50
BTX48-1000R	1000V 16A.	£2.50

SILICON POWER RECTIFIERS

Wire Ended		
BY101	450 p.i.v. 1.1A.	£0.15
BY105	800 p.i.v. 1.1A.	£0.20
BY126	650 p.i.v. 1A.	£0.10
BY127	1250 p.i.v. 1A.	£0.12
Stud Mounted		
KD202B	50 p.i.v. 1A.	£0.15
KD202A	50 p.i.v. 3A.	£0.25
KD202G	100 p.i.v. 1A.	£0.15
KD202V	100 p.i.v. 3A.	£0.25
KD202E	200 p.i.v. 1A.	£0.20
KD202D	200 p.i.v. 3A.	£0.30

ZENER DIODES

1 watt	5%, series BZX61: 7.5 to 68V.	£0.20
2 watts	5%, series BZX70: 10 tp 27V.	£0.25
5 watts	10%, series D818: 22 to 47V.	£0.35
5 watts	10%, series D817: 56 to 100V.	£0.35
8 watts	10%, series D815: 4.7 to 18V.	£0.35

0A2	£0.40	5V4G	£0.50	6BX6	£0.25
0A3	£0.48	5W4GT	£0.55	6BX7GT	
0A4G	1.00	5X8	0.70		
0B2	£0.40	5Y3GT	£0.45	6BZ6	£0.45
0B3	£0.70	5Z5	0.75	6C4	£0.35
0C2	1.00	5Z4G	0.45	6CB5A	1.50
0C3	£0.40	6/30L2	0.90	6CB6	0.40
1A3	£0.45	6A86	0.45	6CD6GA	
1A5GT	£0.45	6AB4	0.45		
1A5B	£0.60	6AC7	0.50	6CG7	0.60
1B3GT	£0.45	6AF4A	0.80	6CH6	0.60
1C3GT	£0.45	6A95	0.25	6CL6	0.60
1G4GT	£0.60	6AG7	0.45	6CL8	0.80
1G6GT	£0.60	6AH6	0.60	6CV6	0.80
1H6GT	£0.55	6A18	0.30	6CW4	0.70
1L4	£0.25	6AK5	0.40	6CY5	0.50
1N5GT	£0.55	6AK6	0.60	6CC7	0.75
1Q6GT	£0.60	6AL5	0.43	6D2	0.45
1R4	£0.50	6AL5	0.22	6DCE	0.80
1R5	£0.45	6AM6	0.37	6DE7	0.70
1R4	£0.30	6AN8	0.60	6DK6	0.60
1R6	£0.30	6AQ5	0.42	6DQ6B	0.75
1T4	£0.30	6AR5	0.55	6D8A	1.25
1T5GT	£0.60	6AR6	0.55	6E7	0.70
1U4	£0.40	6AR6	0.65	6EA8	0.65
1U5	£0.75	6AR11	1.25	6EH7	0.30
1V2	£0.55	6AN5	0.60	6EJ7	0.35
1X2B	£0.55	6AN6	0.45	6EJ7	0.35
2A3	£0.50	6AR7G	0.55	6E7	0.35
2AP1	3.00	6AT6	0.38	6FGG	0.45
2C26A	£0.60	6AU5GT	0.60	6F11	0.50
2C40	5.00		1.25	6F13	0.50
2C61	£0.50	6AU6	0.30	6F14	0.70
2C64	0.75	6AV6GT	0.60	6F15	0.65
2D21	£0.40		0.90	6F17	0.70
2E22	5.00	6AV6	0.40	6F18	0.60
2E24	3.20	6AW6A	0.65	6F22	0.30
2X2	£0.60	6AX4GT	0.60	6F23	0.90
3A4	£0.45		0.70	6F24	0.80
3A5	£0.75	6AX5GT	0.75	6F25	1.00
3B2B	3.00		0.75	6F28	0.70
3D6	£0.35	6B4G	1.00	6GK5	0.60
3D12A	3.50	6B7	0.60	6GK6	0.60
3Q4	£0.60	6B9G	0.30	6J4	0.60
3Q5GT	£0.55	6BA6	0.28	6J5GT	0.40
3B4	£0.40	6BE6	0.32	6J6	0.30
3V4	£0.70	6BF6	0.55	6J7	0.45
4-125	9.00	6BH6	0.75	6K6GT	0.75
4-250A		6BK6	0.55	6K7	0.43
4-400A	14.50	6BK4B	1.25	6K8G	0.45
4THA	0.60	6BK7A	0.75	6K8GT	0.60
5AR4	£0.60	6BL7GA	1.00	6K23	0.75
5B/254M	2.80		0.80	6L25	0.70
5B255M	3.20		0.80	6L26	0.70
5C1	£0.50	6BQ7A	0.55	6N7GT	0.55
5D1	£0.60	6BR7	0.90	6P28	0.65
5R49Y	0.75	6BR8	0.75	6Q7	0.50
U4G	£0.40	6BS7	1.35	6R7G	0.55
		6BW6	0.90	6S2	0.50
		6BW7	0.90	6S4A	0.70

FULLY GUARANTEED



FIRST QUALITY VALVES

68A7	£0.45	12AV6	£0.45	30FL12	1.10	725A	25.00	CL4	7.50	EB91	£0.22	ECL82	£0.35	EL822	1.50	HF94	£0.45	PCF200	0.75	PY801	£0.50	UBL1	£0.70
68C7	£0.80	12AV7	0.70	30FL14	0.80	805	11.00	CL33	1.50	EB93	£0.60	ECL83	0.70	ELL80	0.85	HK90	0.50	PCF201	0.75	PZ30	0.35	UBL21	0.70
68G7	£0.45	12AX4GTB	30L1	0.40	807	0.50	CY31	0.50	EBC41	0.65	ECL84	0.65	EM71	0.80	HL23	0.50	PCF801	1.00	QQV02-8	2.25	UC92	0.45	
									EBC81	0.38	ECL85	0.65	EM80	0.45	HL23DD		PCF802	0.50	QQV03-10	1.25	UC98	0.70	
									EBC90	0.40	ECL86	0.40	EM84	0.35	HL42DD	0.55	PCF805	0.90	QQV03-20A	1.25	UCF41	0.85	
									EBC91	0.38	ECL87	0.60	EM85	1.00			PCF806	0.75	QQV03-20A	1.25	UCF42	0.85	
									EBC91	0.38	ECL88	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF43	0.85	
									EBC91	0.38	ECL89	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF44	0.85	
									EBC91	0.38	ECL90	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF45	0.85	
									EBC91	0.38	ECL91	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF46	0.85	
									EBC91	0.38	ECL92	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF47	0.85	
									EBC91	0.38	ECL93	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF48	0.85	
									EBC91	0.38	ECL94	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF49	0.85	
									EBC91	0.38	ECL95	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF50	0.85	
									EBC91	0.38	ECL96	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF51	0.85	
									EBC91	0.38	ECL97	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF52	0.85	
									EBC91	0.38	ECL98	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF53	0.85	
									EBC91	0.38	ECL99	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF54	0.85	
									EBC91	0.38	ECL100	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF55	0.85	
									EBC91	0.38	ECL101	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF56	0.85	
									EBC91	0.38	ECL102	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF57	0.85	
									EBC91	0.38	ECL103	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF58	0.85	
									EBC91	0.38	ECL104	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF59	0.85	
									EBC91	0.38	ECL105	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF60	0.85	
									EBC91	0.38	ECL106	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF61	0.85	
									EBC91	0.38	ECL107	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF62	0.85	
									EBC91	0.38	ECL108	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF63	0.85	
									EBC91	0.38	ECL109	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF64	0.85	
									EBC91	0.38	ECL110	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF65	0.85	
									EBC91	0.38	ECL111	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF66	0.85	
									EBC91	0.38	ECL112	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF67	0.85	
									EBC91	0.38	ECL113	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF68	0.85	
									EBC91	0.38	ECL114	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF69	0.85	
									EBC91	0.38	ECL115	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF70	0.85	
									EBC91	0.38	ECL116	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF71	0.85	
									EBC91	0.38	ECL117	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF72	0.85	
									EBC91	0.38	ECL118	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF73	0.85	
									EBC91	0.38	ECL119	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF74	0.85	
									EBC91	0.38	ECL120	0.60	EM85	1.00			PCF808	0.90	QQV03-20A	1.25	UCF		

APPOINTMENTS VACANT

DISPLAYED APPOINTMENTS VACANT : £9.00 per single col. inch.
LINE advertisements (run-on): 50p per line (approx. 7 words), minimum two lines.
BOX NUMBERS : 25p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.)
PHONE : Allan Petters on 01-261 8508 or 01-928 4597.
Classified advertisement rate are currently zero rated for the purpose of VAT.

Advertisements accepted up to 12 p.m. Thursday, June 7th for the July issue, subject to space being available.

We're looking for a Radio Enthusiast

Comprehensive publicity services to the rapidly expanding Racal Group of Companies are the responsibility of a central organisation based in Wokingham, Berkshire.

An opportunity now exists for an additional Technical Copywriter to join a team involved in the preparation of data sheets, brochures, articles and advertisements for advanced radio communication equipment.

Applicants must have a sound electronics background with a genuine interest in modern radio communications. Previous writing experience, while preferable, is not essential as full in-house training can be provided.

The work is varied, exciting and progressive, as would be expected of a young growth company whose annual turnover is now in excess of £25,000,000. Own car required for which mileage allowance is payable.

If your experience is compatible with our requirements, this could be your chance to join a dynamic publicity organisation.

Communicate with Racal

Please apply in writing, enclosing brief details of qualifications, experience and present salary to :
L. A. Jemmett, Personnel Manager, Racal Group Services Limited, The Elms, Broad Street, Wokingham, Berks.

RACAL
The Electronics Group

Middlesex Polytechnic at Hornsey

Technical Assistant

Required to work in educational film and television unit based in Alexandra Palace Badminton Suite. A knowledge of electronics and experience of lighting and sound work essential, film editing an advantage. The post involves working with staff and students on CCTV studio production and on filming.

Salary on Technical T3 scale—£1,416 to £1,635—entry point according to experience and qualifications.

The appointment is initially for six months only, but there is a real prospect of a permanent appointment for a suitable candidate. The Polytechnic works a 36-hour 5-day week.

Application forms from The Bursar (Ref. WW/6), Middlesex Polytechnic at Hornsey, Crouch End Hill, London, N8 8DG, to whom they should be returned within fourteen days of this advertisement.

[2656

ELECTROSONIC LIMITED

have a vacancy for an:—

AUDIO-VISUAL TECHNICIAN

to be responsible for the repair and maintenance of our expanding range of audio and projection control equipment in the Hire and Presentation Departments.

Electrosonic Ltd. are responsible for the design, manufacture and hire of complex electronic units and systems in the sound, lighting, projection and control fields.

We offer the opportunity to work in a young, expanding and rewarding environment.

Whilst qualifications are desirable, preferably H.N.C., careful consideration will be given to practical experience, although it is unlikely that suitable applicants will be under 26 years of age.

Please write stating qualifications, age, experience and salary expected to:—

The Personnel Officer,
ELECTROSONIC LIMITED,
815 Woolwich Road,
London, SE7 8LT

[2674

AUDIO PRODUCTS PRODUCTION; TEST; INSPECTION

Thorn Consumer Electronics are one of Europe's largest manufacturers of unit audio equipment and a continued increase in demand for our products, both at home and abroad, creates staff opportunities at all levels of the production, test and inspection functions.

Applications are invited for a wide range of positions from trainee technical and supervisory through to qualified senior management levels. The vacancies occur on any of three sites situated in Essex.

Experience and qualifications required will depend on the level of enquiry but senior appointments will be offered to applicants conversant with high volume flow line production, test and inspection methods in the radio/hi fi audio equipment field. Alternatively, applicants capable of team motivation and sound administration in the electronics industry should also apply.

Written applications, setting out career details to date and current salary level to:—

**The Personnel Manager,
Thorn Consumer Electronics Ltd.,
62/70 Fowler Road,
Hainault,
Ilford,
Essex.**



A member of the Thorn Group

2627

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



TECHNICIAN VACANCIES

Senior Laboratory Technicians at Research Department, Kingswood Warren, Surrey. (Ref: 73.E.4039)/WW

The work will involve field strength measurement and planning work associated with the development of the sound and television transmitter networks. Candidates should have a good knowledge of basic electronic circuits and of radio propagation theory, and preferably be qualified to O.N.C. or an equivalent level. Following a brief period of training, they will be expected to work with a minimum of supervision. Applicants must be prepared to travel and work for periods anywhere in the United Kingdom, including working some weekends. Starting salary in the range £1908 to £2118 rising by annual increments of £105 to £2433 p.a. Inexperienced candidates may initially be appointed at a lower grade and salary.

Laboratory Technicians at Equipment Department, Chiswick, London W.4. (Ref: 73.E.2098)/WW

Work will involve the checking and alignment of new electronic systems which are being made for the colour television and radio services. Applicants should have some knowledge of basic electronic circuits and be able readily to familiarise themselves with the test techniques employed on audio and video equipment. After gaining experience, Laboratory Technicians are encouraged to apply for vacancies which occur from time to time for Senior Laboratory Technicians. Starting salary £1674 to £1860 p.a., rising by annual increments of £93 to £2139 p.a. for Laboratory Technicians. Senior Laboratory Technicians rise to a maximum salary of £2433.

Receiver Technician at Equipment Department, Balham, London, S.W.12. (Ref: 73.E.4040)/WW

Duties include the overhaul, maintenance and installation of colour television and stereo sound receivers which are used for the critical appraisal of technical quality and programme content. Candidates should have a good general scientific education and have or be studying for an appropriate technical qualification. They must have had considerable experience in radio and television receiver servicing and be physically fit and be capable of undertaking roof work. Candidates must possess a current driving licence. Starting salary in the range £1674 to £1860 rising by annual increments of £93 to £2139. There are opportunities for progression to a higher grade with a roof salary of £2433.

All the above vacancies are pensionable and day release facilities for higher education will be considered in appropriate cases. Requests for application forms to the Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting the appropriate reference number and enclosing an addressed foolscap envelope. The closing date for completed application forms is the 11th June 1973.

2691

BBC

HER MAJESTY'S GOVERNMENT COMMUNICATIONS CENTRE

HANSLOPE PARK, MILTON KEYNES, MK19 7BH

has vacancies in the following fields of work

- | | |
|-----------------------------|---|
| (a) Microwaves. | (e) General Electronic Circuit Design. |
| (b) HF Communications. | (f) Operational Analysis. For these posts applicants should be experienced scientists/engineers who have moved into Operational Analysis rather than the inverse. |
| (c) VHF/UHF Communications. | |
| (d) Acoustics. | |

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

HONGKONG POLYTECHNIC

The Polytechnic was established in 1972 as an autonomous institution controlled by a Board of Governors and financed by the Hongkong Government through the Universities and Polytechnic Grants Committee. A six year period of expansion is planned from an existing Technical College with 1,800 full-time students to the equivalent of 8,000 full-time and 20,000 part-time students.

Applications are invited from candidates with extensive teaching and industrial experience for appointment as

Head of Department of Electronic Engineering

to be responsible for the development of full-time and part-time courses up to final professional level.

SALARY not less than HK\$6,750 per month (approximately £6,336 p.a.). Appointments on contract, with 25% gratuity for not less than 4 years in the first instance with probability of transfer to superannuable service. Subsidised furnished flats. Free passages, including dependants, on appointment and overseas leave.

Application forms and further information from the Appointments Officer, Council for Technical Education and Training for Overseas Countries (TETOC), 35/37 Grosvenor Gardens, London, SW1W 0BS quoting ref: TET/HP/WW. Closing date for receipt of applications 22nd June 1973.

SUMLOCK COMPTOMETER LTD.

ANITA

**ELECTRONIC DESK CALCULATORS
PROGRAMMABLE CALCULATORS
VISIBLE RECORD COMPUTERS
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**



Lanson Industries Group

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. L48

Post Office
Telecommunications

91

SPANISH COMMUNICATIONS EQUIPMENT MANUFACTURER

Applications are invited from qualified design engineers specialized on:

- Ground/Air Communications
- TV Colour Transmitters
- 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]

Time for VHF/UHF Testers to start going places!

Like Cambridge or Haverhill. Why? Just consider. What are the chances you'll be doing more or less the same as now in 18 months/2 years? Nil — if you join Pye Telecom! You'll have learned a lot — and be ready to start going places in a more sophisticated field like systems design/development.

Which is simply why Pye Telecom are always after more Testers!

Pay and benefits include a great many relocation allowances including temporary accommodation. At Haverhill, you may get housing assistance through the local Council too.

So it's well worth looking further into this chance to accumulate substantial experience, to move up fast with the U.K. leaders in the UHF/VHF radio communications field — and to live in either of two exceptionally attractive locations. Detail your background (formal qualifications not essential, experience is) in your letter to:

Mrs. Audrey Darkin, Pye Telecommunications Ltd.,
Cambridge Works, Elizabeth Ray, Cambridge CB4 1DW
or

Mrs. Cath Dawe, Pye Telecommunications Ltd., Colne Valley
Road, Haverhill, Suffolk. 2672



Pye Telecommunications Ltd

MARCONI INSTRUMENTS LIMITED

**ELECTRONIC
TECHNICIANS**

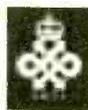
are required to work on calibration, fault-finding and testing of telecommunications measuring instruments. The work is varied and will enable technicians with experience of r.f. circuits to broaden their knowledge of the latest techniques employed in the electronics and telecommunications industries 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 WW 177 for application form to:



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

The NEVE GROUP OF COMPANIES specialise in the design, manufacture and sale of sound control equipment for the recording, broadcasting, television and film industries. The product has an international reputation and is an acknowledged leader for quality, reliability and flexibility. In order to meet the needs of our full and steadily growing order book we need additional personnel in the following categories:

- SALES ENGINEERS**
- SERVICE/INSTALLATION ENGINEERS**
- PROJECT ENGINEERS**
- TEST ENGINEERS**

Applicants for the above vacancies should be suitably qualified in electronics and preference will be given to those who have had experience in the audio industry, or who are knowledgeable and keenly interested in the audio field. Working conditions are excellent and the modern factory has a pleasant rural setting in the village of Melbourn, on the A10 between Cambridge and Royston.

Apply to: Mrs. J. P. Wythe, Personnel Manager, The Neve Group of Companies, Melbourn, Royston, Herts.
Tel: Royston 60776.

[2661

Telesonic Marine Limited

Radio-Telephone SSB, D.F. F. 3? Radar, Auto-Pilots (on boats) mean anything to you?

If so you live near London, you can drive, you can work on your own, you are the

MARINE FIELD ENGINEER

we are looking for
Apply **TELESONIC MARINE LIMITED**,
243 Euston Road, London, NW1 2BT
01-387 7467/8

[2692

**Engineers and
Technicians**

For Cable TV and Aerial Systems

The Telecommunications Division of EMI Sound and Vision Equipment Ltd., the largest British exporters of Cable TV Equipment and major U.K. suppliers of transmitting aerial equipment requires additional engineers to meet the demands of its expanding business.

In the field of **broadband UHF & VHF** active and passive devices we require all grades of development & test engineers and technicians. Applicants should have some knowledge of transistor circuits at these frequencies and a degree or equivalent qualification will be necessary for senior positions.

In the field of **Aerial Systems** we are seeking engineers with knowledge of transmission line techniques to join the development and project teams engaged in U.K. and overseas UHF & VHF

Transmitting Aerial projects. Preference will be given to engineers willing to climb mast structures and be free to travel in U.K. and abroad for short periods.

Good salary-related to qualifications and ability will be paid. Assistance in re-location and good pension scheme.

We will arrange an interview to suit you. Please write or telephone:
C. W. T. Mott, Chief Recruitment Officer, EMI Limited, 135 Blyth Rd., Hayes, Middlesex.
Tel. 01-573 3888, Ext. 3099.



International leaders in Electronics, Records and Entertainment.

DESIGN DRAUGHTSMEN

Electrical and Instrumentation and Control

TBA Industrial Products Limited require an Electrical Design Draughtsman and an Electrical Detail Draughtsman with a minimum H.N.C. and O.N.C. respectively, who have practical and technical experience in the field of industrial and electrical distribution and control. The work involves the design and detailing respectively, of electrical controls on a wide range of special purpose machines, processes and related services, including lighting within the company's factories. Cost estimation and participation in commissioning of installations is also involved. The successful applicants will preferably have served a recognised apprenticeship and will be responsible to a Senior Design Engineer.

Instrumentation and Control Design Draughtsman

Applicants should have a minimum H.N.C. in an appropriate subject with at least 3 years experience in the design of both electronic and pneumatic industrial process control systems. The work involves preparation of designs and drawings for the construction and installation of new systems and supervision of detail draughtsmen. He will assist with the testing and commissioning of new installations and with investigational work using both data logging and conventional recording equipment.

Salaries for the above positions will be commensurate with age, qualifications and experience with membership of Pension and Life Assurance Scheme. 26 days holiday per year and recreational facilities.

Applications should be addressed to:-
Mr. R. Law, Assistant Manager, Personnel Department, TBA Industrial Products Ltd., P.O. Box 40, ROCHDALE, OL12 7EQ, Lancs. [2667

Electronics in Medicine

A technical assistant is required in the Medical Electronics Department, St. Thomas' Hospital. Applicants should be less than 26 years of age, and have some experience in electronics and workshop practice. Duties will include construction and testing experimental electronics equipment and servicing existing apparatus. Salary will be in the range of £1,206 — £2,043 plus £175 L.W., point of entry dependent upon experience. This is a medical school appointment but applicants should write in the first instance to the

Personnel Officer,
79 York Road,
London, S.E.1

[2668]

Electro-Medical Service Department
requires

ENGINEERS

for testing and servicing electronic apparatus. Applicants should be aged 20-30, and should be of O.N.C. standard.

Apply in first instance in writing to:—

SIEREX LTD.,
Electro-Medical Department,
Heron House, Wembley Hill Road,
Wembley, Middlesex, HA9 8BZ

[2594]

VICTORIA HOSPITAL, BLACKPOOL

CHIEF PHYSIOLOGICAL MEASUREMENT TECHNICIAN (CARDIOLOGY),

required at this modern acute hospital of 566 beds which is a sub-regional cardiac centre. There is a staff of 5 excluding the Chief Technician. In addition to providing an E.C.G. service to the wards and out-patients clinics, the work includes cardiac catheterisation, open-heart surgery, coronary care and an out-patient pacemaker clinic. The salary scale is £1,656 per annum rising to £2,076 per annum. Applications in writing giving the names of two referees to the Hospital Secretary.

2639

ELECTRONICS TECHNICIANS

South Africa

The Department of Audiology at the Tygerberg Hospital, Tierulei, Cape Town, now has vacancies for the following qualified personnel:

SENIOR TECHNICIAN

£2395 × £85 — £2737 approx + annual
vacation savings bonus

with a minimum of 4 years training and at least 3 years appropriate experience. A degree, H.N.C. or other academic qualification is desirable but candidates with exceptional experience in Audiology and Acoustics may apply.

TECHNICIAN

£1300 — £1368 × £85 — £2395 approx + annual
vacation savings bonus

with a minimum of 4 years appropriate training.

Both positions call for a good background in electronics, both theoretical and practical and a knowledge of acoustic measurements and techniques. Preference will be given to candidates with experience in the Audiological field who are conversant with the installation, calibration and maintenance of Audiological and allied equipment.

The successful applicant for the senior post will take charge of a new, fully equipped electronics workshop which functions in co-operation with electrical, mechanical and other workshops in the hospital, under the control of the Senior Hospital Engineer. He will also be responsible for the maintenance, calibration and, where necessary, the installation of a wide range of equipment. Other duties will include the development of new equipment and research work in the Audiological/Acoustics fields.

Applications must be made, in duplicate, on the prescribed form, Staff 23, which is obtainable from the Chief Migration Officer, South African Embassy, Trafalgar Square, London WC2N 5DP, and should be forwarded as follows:

(a) Senior Technician; to the Director of Hospital Services, P.O. Box 2060, Cape Town, South Africa. (b) Technician; to the Medical Superintendent of the hospital concerned.

Applications must please be received by
31 May 1973.

RADIO OFFICERS

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 THE
COMPOSITE SIGNALS ORGANISATION

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on scale rising to £2,365 p.a.; commencing salary according to age — 25 years and over £1,664 p.a. During training salary also by age, 25 and over £1,238 p.a. 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. Application 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 (TRO.2.)
Government Communications Headquarters
Room A/1105
Oakley Priors Road
CHELTENHAM Glos GL52 5AJ
Telephone: Cheltenham 21491 Ext 2270

Electronics Engineers

for today's career using tomorrow's technology.

As a Field Engineer with ICL, Europe's premier computer company, you can build yourself a rewarding and profitable career, with excellent prospects.

We start you off with a paid training course of up to six months that adds the necessary computer knowledge to your electronics experience. You learn how to use computers, deal with their operational problems, and maintain them and keep them running smoothly.

Then you go out into the field—to consolidate your training and become a complete professional, working unsupervised, with the most sophisticated equipment in the best possible conditions. And you'll be highly involved with our customers—right up to top management. Often, you will be the principal day-to-day contact.

The money is really attractive. You can pick up 40% extra for any work done after 6 pm and before 8 am—without even having to do any overtime!

Aged over 21, you'll need to have HNC or C & G in electronic engineering, coupled with some industrial experience, or a Forces training in electronics. We will also be looking for important personal qualities like tact, adaptability, resourcefulness.

There are opportunities of starting with us in several areas in the UK. Get the full details now by completing and returning this coupon today.

To: Mr A E Turner, International Computers Limited, 85/91 Upper Richmond Road, Putney, London SW15 2TQ.

Please send me an application form for job openings in Field Engineering.

Name _____
 Address _____

International Computers



(WW 6)

SECTIONAL ENGINEER EAST AFRICAN COMMUNITY

- * Salary up to £2860
- * Low taxation
- * 24 Month tour
- * Appointment Grant £100/£200 normally payable*
- * 25% Gratuity on total salary drawn
- * Subsidised accommodation
- * Education Allowances
- * Free family passages

* Holiday visit passages

Required for the maintenance and installation of equipment in the Telecommunications Section of the Meteorological Department, including facsimile, SSBs, transmitters, teletype and converters, meteorological radars and switching equipment.

Candidates must possess either:—

(i) A Degree in Electrical Engineering with specialisation in Electronics plus one year's practical experience.

or

(ii) City and Guild "C" passes in Mathematics, Telecommunications, Principles and Radio plus five years' practical experience

Apply to:

crow agents

M. Division, 4, Millbank, London, SW1P 3JD for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/730367/WF

2606

Wandsworth Technical College

Wandsworth High Street, London, SW18 2PP

IBEA

TELEVISION STUDIO

Senior Technician

up to £1,209

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.

Technician

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]

TECHNICIAN TRAINEE

Intelligent young man 16-18 yrs old offered opportunity to train ultimately as a Public Address and Sound Recording Engineer. Must be of smart appearance and live with parents in Central London area. Write for interview to:

Managing Director,

GRIFFITHS HANSEN (RECORDINGS) LTD.
 12, Balderton Street, London W1Y 1TF

2641

AUDIO ENGINEER

Required to maintain professional equipment. Experience in the field of studio and/or domestic sound essential.

Current driving licence an advantage.

Please write, giving full details to:

FELDON AUDIO LTD., 126 Great Portland Street, London, W1N 5PH. Attention W. Dyer.

[2638]

BROMLEY GROUP HOSPITAL MANAGEMENT COMMITTEE

ELECTRONICS MAINTENANCE TECHNICIAN

for the acceptance, testing and maintenance of a variety of electronic control and communication equipment and electro-medical apparatus.

Salary £1896 by increments to £2448.

Applicants must hold, as a minimum, O.N.C. or O.N.D. in Electronics or Light Current Electrical Engineering or the City & Guilds Final Certificate in Telecommunications Engineering. Practical experience in industry or the armed services is essential; hospital experience an advantage but training with manufacturers possible. Own transport, for which mileage is payable, essential.

Applications, with details of training, experience, age, etc., and naming two referees, to reach the Group Engineer "Bassetts", Starts Hill Road, Farnborough, Kent (Tel: Farnborough 53333), not later than 31st May, 1973.

No accommodation available for married applicants.

[2655]



ATV NETWORK LIMITED
has a vacancy in BIRMINGHAM for an

ENGINEER (Vac. 34)

APPLICANTS should have a good knowledge of television engineering, practical experience in the appropriate field being considered an advantage. Duties will include the operation and maintenance of VTR equipment and associated apparatus.

ENGINEER (Vac. 35)

A vacancy exists for an Engineer in the Outside Broadcast Vision Section.

APPLICANTS must have thorough theoretical knowledge and understanding of colour television broadcast engineering. They must also have experience of operating colour vision control equipment.

Previous O.B. experience would be an advantage. The job entails travelling and working away from base possibly for several days at a time.

SALARIES for both posts will be in the range £1,992 — £2,944 per annum according to qualifications and experience.

Application Forms may be obtained by writing to:

**Head of Staff Relations,
ATV Network Limited,
ATV Centre,
Birmingham B1 2JP.**

2673

Please quote the appropriate vacancy number.

ELECTRONICS TECHNICIANS, TEST, AND SERVICE ENGINEERS REQUIRED.

Interesting work on digital Instruments and Radio Control Equipment.

Apply in writing to:—

**J. A. BONIGENT,
Radio Control Specialists,
National Works, Bath Road, Hounslow.**

2642

VTR ENGINEERS

up to

£6,000 p.a.

Home counties & Overseas

Box WW2666

SALESMEN AND SERVICE ENGINEERS

required by busy, expanding private company in one of Britain's pleasantest areas. These positions carry good salaries, life insurance and pension schemes and other benefits. We have a contented staff and good working conditions in comfortable modern premises. We require personable and knowledgeable staff and a number of vacancies are available in each category. The service engineers would need to be fully experienced with audio equipment and colour television.

Please apply in writing to:

**MERROW SOUND LTD.
205-207 EPSOM ROAD,
GUILDFORD, SURREY.**

2618

Production Engineer

We are well established with our Leak and Wharfedale range of equipment as quality brand leaders in the expanding hi-fi market. We shall be introducing shortly a new range of products into our Electronics factory and now wish to appoint an additional Production Engineer. He will liaise between the Development and Production departments, and his job will be to construct document and test electronic prototypes according to specifications and thus ensure that production standards are maintained throughout the pre-production phase.

This is a most interesting position and would be suitable for a man aged 25-40 with qualifications in Electronics and who has a sound knowledge of production methods and experience of similar work on radio and amplifier manufacture and testing.

Terms and conditions of employment are most attractive and prospects are good with this expanding company.

Please write to:

**Mr. J. S. Bateman
Personnel Manager
Rank Radio International
Bradford Road
Idle
Bradford BD10 8SF**



RANK RADIO INTERNATIONAL

[2605]

A leading Radio Manufacturer in
JOHANNESBURG, SOUTH AFRICA

requires several experienced

FACTORY SUPERVISORS

AS WELL AS

RADIO TECHNICIANS

with good knowledge of Radio & Tape Recording circuits

For further information, please apply in writing, giving details of qualifications and résumé of career to:—

**MR. G. MOSER,
Factory Manager,
TELTRON INDUSTRIES (PTY.) LTD.,
11, RICHARD STREET,
SELBY, JOHANNESBURG,
REPUBLIC OF SOUTH AFRICA.**

[2614]

WORK AS A

RADIO TECHNICIAN

ATTACHED TO SCOTLAND YARD

You'd be based at one of the Metropolitan Police Wireless Stations.

Your job would be to maintain the portable VHF 2-way radios, tape recorders, radio transmitters and other electronic equipment which the Metropolitan Police must use to do their work efficiently.

We require a technical qualification such as the City & Guilds Intermediate (telecommunications) or equivalent.

Salary scale :
£1,415 to £1,715 according to age from 21 to 25, to a maximum £2,025 p.a. (plus a London Allowance of £175 or £90 p.a.).

Promotion to Telecommunications Technical Officer will bring you more.

For details of this worthwhile and unusual job write to: Metropolitan Police, Room 733 (RT/WW), New Scotland Yard, Broadway, London SW1H 0BG or telephone 01-230 3122 (24 hour service).

[2613

ELECTRONICS ENGINEER

Required at the central research laboratories of the Wiggins Teape Group of Papermakers in Beaconsfield, Bucks. Applicants should be aged 21-27 and qualified to H.N.C. or equivalent. To work on the development of Electronic systems and instruments both digital and analogue.

A further post for a Technician is also available. Candidates should be aged 18-20 with O.N.C. (Engineering). Previous experience in an electronics laboratory desirable but applicants with an amateur interest considered.

Staff appointments with excellent salaries and conditions.

Please apply to: The Head of Personnel Service, Wiggins Teape Research and Development Ltd., Butler's Court, Beaconsfield, Bucks.

[2602

**NORTH BIRMINGHAM & DISTRICT HOSPITAL MANAGEMENT COMMITTEE
GOOD HOPE DISTRICT GENERAL HOSPITAL**

MEDICAL PHYSICS TECHNICIAN II

A post is being created at the above hospital within the Group Engineer's Department to initiate a unit dealing with maintenance of electro-medical, laboratory and other scientific equipment.

The successful candidate will possess an HNC, HND in electronics or equivalent, preferably with hospital experience.

Ability to organise servicing programmes for Electronic equipment, supervise activities of other technical personnel together with ability to liaise with medical staff is essential.

He will be concerned with enhancing reliability, capability and safety of all electro-medical equipment. With the expansion of the department there will be opportunities for promotion. Some travelling between centre and peripheral hospitals will be involved, travelling allowances will be paid at standard rates.

Basic salary commences at £1,911 increasing by eight increments to £2,508 p.a.

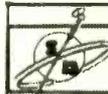
Application form, job specification and conditions of service may be obtained from: The Group Engineer, Holly Lodge, St. Michael's Hospital, Lichfield. [2652

HEARING AID SERVICE MECHANIC

(experienced) required. Top rates.

Tel:- Mr. Allen 01-549 2611

[2654



DESIGN ENGINEER

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**

ELECTRONIC ENGINEERS

CBS Records, part of the largest recorded music company in the world, are continuing their expansion into the pre-recorded tape market with their manufacture of cassettes and cartridges at Aylesbury, Bucks.

We now require Engineers with electro-mechanical or electronic experience for the maintenance of various types of machinery in the tape audio field.

There is an attractive salary, four weeks holiday, a good canteen, social club and pension scheme.

Interested? Please write or phone R. J. Black, Personnel Officer, for an interview.



CBS RECORDS

**CHAMBERLAIN ROAD, AYLESBURY.
TELEPHONE : AYLESBURY 84331**

Wandsworth Technical College

IBEA

Wandsworth High Street, London, SW18 2PP

CLOSED CIRCUIT T.V. & AURAL-VISUAL AIDS

Senior Technician up to £2,109

To be responsible to the Vice-Principal for the Closed Circuit T.V. system in the College (including operation, use and 1st line maintenance of equipment), and also for organising the use and maintenance of other Aural-Visual Equipment in the College. He will be assisted by a Technician. This is a new job, full of interest and requires a person with sufficient technical background but also with clear thinking and organising ability. Post Ref. 3ST.

Technician up to £1,788

to assist the Senior Technician and to have a prime interest in Aural-Visual Aids. Post Ref. 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. Please quote post Ref. 4T. [2660]

SOUND ENGINEER

Experienced man with high standards required in the Public Address and Sound Recording Field, capable of organising and operating temporary P.A. Systems covering Conferences etc.—Knowledge of Electronics, tape editing and recording desirable. Smart Appearance Essential—Salary negotiable—Full written details to: Managing Director, GRIFFITHS HANSEN (Recordings) LTD., 12, Balderton Street, London W1Y 1TF [2640]

VIDEO ENGINEER

to take charge of operation and maintenance of B & W CCTV system Apply: P. Sowerby. Tel: 01-240 5354 [2657]

LONDON BOROUGH OF BRENT Willesden College of Technology
Danzli Road, London, N.W.10 2XD
DEPARTMENT OF ELECTRICAL ENGINEERING

Required: LECTURER GRADE I to teach on C & G Radio, Television and Electronic Technicians and Mechanics courses. Applicants should be well qualified and have appropriate practical experience. SALARY: LI—£1,618 to £2,643. incl. London Allowance with increments for qualifications and experience. Further particulars and application forms from the Registrar, to be returned within two weeks from the appearance of the advertisement. 2612

Test Engineers enjoy more variety at Redifon

... and one of the best-equipped electronics test departments in Britain.

You'll be working on a vast variety of solid-state devices, including — high-power transmitters, communications receivers, military pack-sets, MF beacons, mobile HF, marine VHF and teleprinter terminal equipment.

The job involves a wide area of testing operations—from GO/NO GO sub-assembly testing through to fault-diagnosis on complex systems.

Interesting work with one of the U.K. leaders in electronics expertise—located in London.

To qualify, you'll need to be thoroughly experienced in the field—with considerable knowledge of semi-conductor or logic circuitry.

We pay well—from £1,450 to over £2,200 p.a. (depending on experience) for a 37½ hour week with ample opportunities for overtime. Additional benefits include an excellent company pension scheme and generous sickness allowances.

Please write, including full details of your past experience, to:

Chief of Test
Redifon Telecommunications Ltd.,
Broomhill Road, Wandsworth, SW18 4JQ.



A Member Company of the Rediffusion Organisation

ASSISTANT ENGINEERS Grade I/II BOTSWANA

up to £3070 + Gratuity

- ★ Gratuity 25% of total 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 install open-wire carrier and VFT systems, VHF/UHF and microwave systems up to 300 channel capacity at 2 GHz.

Candidates for the GRADE I post must possess the City and Guilds Telecommunications Final Certificate and for the GRADE II post, the Intermediate Certificate, or equivalent qualifications. For either post candidates must be aged 25/45 years and have had five years' experience, excluding training, of the above mentioned equipment. Experience of single channel HF and VHF systems is also required.

Apply to:

M. Division, 4, Millbank, London, SW1P 3JD for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/720470/WF

2619

ELECTRONICS ENGINEER

International company requires Electronic Field Service Engineer to install and maintain analogue computers supplying a service to the colour printing industry. Applicants must have sound electronic knowledge, fault finding experience and mechanical aptitude. Successful applicants will receive training in U.K. on completion of which they will be expected to take up residence in northern Italy (or Holland) although travel in Western Europe can be anticipated.

BOX WW 2693

CSSL

EXPERIENCED REPAIR AND CALIBRATION ENGINEERS
EARN UP TO £2,700 P.A.
ATCSL

Our premium rates for non-standard working hours make these earnings possible without excessive overtime.

We are one of the leading Repair and Calibration Companies with a consistently good growth record and in the process of still further expansion.

We offer stimulating and rewarding work to Engineers with a sound knowledge of circuitry and with some experience of one or more types of equipment in the range d.c. to microwaves, analogue or digital.

To find out more about job opportunities in our Company contact

The Technical Manager,

CALIBRATION SYSTEMS LTD.

Blackwater Station Estate, Camberley, Surrey
 Tel. Camberley 28121

2682

Technician C.C.T.V.

Required to take charge of small studio in West London for industrial training productions using 1" VTR's.

The Company operates a fully equipped training centre and distributes video tape programmes to regional and overseas branches.

The successful applicant will be required to produce programmes with the assistance of instructional staff and carry out maintenance of equipment.

Some travel is involved and salary is negotiable. Experience in C.C.T.V. or allied fields preferred. Interest or experience in photographic work also an advantage.



Metal Box

Write giving full particulars to:—
Assistant Personnel Manager,
The Metal Box Co. Ltd.,
Kendal Avenue,
Westfields Road,
Acton, W.3

2689

SPANISH COMMUNICATIONS EQUIPMENT MANUFACTURER

Has an immediate opening for An experienced Design and Development Engineer for Audio Equipment, including Highly Professional Mixing Desks, Compressors, Limiters, Audio Monitoring Amplifiers, etc. Systems Experience is desirable.

Send resumé to:
NORTRON
Fernando el Católico, 63
Madrid 15
SPAIN

[2540

SITUATIONS VACANT

A SENIOR DEVELOPMENT ENGINEER who has knowledge of HF SSB radio receivers and transmitters up to 10 KW is required to lead a small team engaged in new designs. Minimum qualifications HNC, salary negotiable up to £3,500 p.a. Assistance will be given with re-location expenses. Company is situated South West of London. Apply in writing to Box No. WW 2629.

AUDIO ELECTRONICS DESIGNER required to work on the development of sound recording equipment for the film and television industry. Previous experience in this field an advantage. For further details please contact Glyn Powell-Evans, P.A.G. Films Ltd., 492 Kingston Road, London, S.W.20. Tel. 01-542 1171. [2601

EXPERIENCED ENGINEER offers field service facilities London area covering Electronic and Electro-mechanical equipment.—Box No. WW2676.

HIFI AUDIO ENGINEERS. We require experienced Junior and Seniors and will pay top rates to get them. Tell us about your abilities. 01-437 4607. [18

PART-TIME INSTRUMENT SALES. Expanding company seeks part-time Sales Engineers. High commission paid. Write with full particulars to Box No. WW 2637.

TELEVISION COLOUR SERVICE ENGINEER. Private Firm Glorious Devon. Some audio experience advantage. Pleasant Flat available suit young couple, no children.—Full particulars, Coles, 14, Wolborough Street, Newton Abbot. [2683

ARTICLES FOR SALE

AUTOMATIC audio frequency response plotter. "Radiometer" B.F.O. and chart recorder. Excellent condition, £450. Heath 10 18U oscilloscope, as new, £40. Roband 0-50V 2 Amp power supply transistorised, £20. Box No. WW 2621.

ARVAK ELECTRONICS. 3-channel sound-light converters, £18. Strobes, £16. Rainbow Strobes, £132.—12A Bruce Grove, N17 6RA. 01-808 9096. [23

BUILD IT in a DEWBOX quality plastic cabinet 2 in. x 2½ in. x any length. D.E.W. Ltd. (W.), Ringwood Rd., Fernwood, Dorset. S.A.E. for leaflet. Write now—Right now. [76

BRAND NEW FIBRE GLASS P.C. BOARD — NOT OFFCUTS. Custom cut to your own specified sizes, up to 12 x 11½ in. per piece. High quality FLAME RETARDANT approved NEMA grade 1/16in. single sided one ounce copper at just 5½p per 6 sq. in. including all VAT charges. We offer a first-class service of a quality branded product. Minimum order value 50p. Add 10p p. and p. per sq. foot. (10p min.). Send CWO (not stamps) to S. & D. Systems Ltd., The Ridgeway, Trading Estate Iver, Bucks., SL0 9HW. [2663

COLOUR UHF and TV SERVICE SPARES. Colour and UHF lists available on request. Varicap/Varactor UHF Tuners ELC1043 £4.50, VHF Varicap Tuners for Band 1 and Band 3 £2.85, Salvicap Varicap Tuners £1.50, incl. Connection Data, P/P 25p. Delay Lines DL20 £3.50, DL1 £1.50, P/P 25p. Luminance Delay Line 50p. P/P 15p.

PHILIPS G6 Convergence Control Panel. Single Standard, 16 Controls Switches, etc. £5.00, P/P 25p. Philips G6 Decoder Panel incl. DLIE, Crystal, etc., £6.50, P/P 30p. G8 Decoder Panels, almost complete, incl. I/C, £2.50, P/P 25p. BUSH CTV25 surplus Time Base Units, Frame, Line & EHT, £3.95, P/P 80p. GEC 2040 surplus Panels suitable for parts, Decoder £3.50, Time Base £1.00, RGB £1.00, P/P 25p. Mullard type colour Scan Coils plus latest convergence coils for electronic control of static convergence £5.25, P/P 35p. PYE CT70 Colour LOPT assy. incl. EHT output and focus control £3.50, P/P 35p. Integrated transist. decoder unit incl. circuits £1.25, P/P 10p. Colour Crt. Base 25p, P/P 25p. B9D valve bases for colour valves and PL500 series 10p, P/P 5p. UHF tuners transist. £2.85, incl. slow motion drive, indicator £3.95. 6 Position transist. push button £4.95.

UHF/VHF basic integrated tuner £3.25. Cyldon UHF valve tuners £1.50; all tuners P/P 25p. Transist. UHF/VHF IF panels £4.75 (or salvaged £2.50) P/P 25p. MURPHY 600/700 series complete UHF conversion kits incl. tuner, drive assy., 625 IF amplifier, 7 valves, accessories housed in cabinet plinth assembly £7.50 P/P 50p. SOBELL/GEC 405/625 Dual standard switchable IF amplifier and output chassis incl. cct. £1.50 P/P 30p. THORN 850 Dual standard time base panel £1.00 P/P 30p. PHILIPS 625 IF amplifier panel incl. cct. £1.00 P/P 25p. VHF turret tuners AT7650 incl. valves for KB featherlight, Philips 19TG170, GEC 2010 etc. £2.50, PYE miniature incremental for 110 to 830, Pam and Invicta £1.95, A.B. miniature with UHF injection suitable KB, Baird, Ferguson, 75p, Ekco, Ferranti, Plessey push button with UHF injection £1.00, all tuners P/P 25p. New fireball tuners Ferguson, HMV, Marconi £1.90 P/P 25p. Large selection LOPTs, Scan coils, FOPTs available for most popular makes. PYE/LABGEAR transist. Masthead UHF Booster £5.25. Power unit £4.25 P/P 25p, or setback battery operated UHF booster £4.25 P/P 25p. **MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No. 28, 59, 159 Buses or W. Hampstead Bakerloo and Brit. Rail).** MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. Tel. 01-794 8751. [60

CLOSED CIRCUIT TV CAMERA Shiba HV-14 and Video Tape Recorder Shibaden SV700E in nearly new condition for sale together £300. Contact Jersey Central 24809 or write Arkay Music, 16 York Street, St. Helier, Jersey. [2610

CROSSOR 1035 Double Beam Scope, good condition, space needed hence bargain at £12.50.—Phone 01-449 8409 after 6.30 p.m. [2679

CONTRACT WANTED with outlet for high quality components. Large quantities of bankrupt stock, surplus components, transistors, caps, resistors, tuners, audio from W. German sources, could be reciprocal arrangement. Write SIMAC, Thames House, Thames Street, Sunbury on Thames, Middx. [2583

ELECTRONICS
TECHNICIAN

We require a specialist to join a small team engaged on the design and construction of transistorised and integrated-circuit equipment for electro-hydraulic control. In order to contribute to our product development effort the successful candidate will

either: have a minimum of 3 years experience covering the use of electronic instrumentation, and circuit checking, together with formal instruction, such as City & Guilds, or training with the Armed Forces.

or: be qualified to HNC level and have approximately 1 year's experience in this field.

We are a major international company offering secure employment and good working conditions. Benefits include 4 weeks annual vacation, subsidised canteen, life assurance and pension scheme.

SPERRY VICKERS

EUROPEAN GROUP
SPERRY RAND LTD
78 PORTSMOUTH ROAD
COBHAM KT11 1HY SURREY
TEL COBHAM 4161

2645

TECHNICIANS

FOR

PRODUCTION ENGINEERING (ELECTRICAL) DEPARTMENT

Good Remuneration & Prospects. Preference will be given to those with experience in design, construction and maintenance of T.V. test gear.

Write with experience details to



Personnel Manager
Pye Ltd: Manufacturing Division
Oulton Works, School Lane
Lowestoft, Suffolk

2603

TV Studio Engineer

The Road Transport Industry Training Board has in operation at its Wembley Headquarters, a 3-camera broadcast-quality colour television studio with full telecine and video recording facilities, which includes R.C.A. TR 50 and 1" Helical Scan systems. We now wish to appoint an experienced studio engineer to join a small team working on the production of training and educational television programmes.

The applicant should not be less than 24 years of age and have a good working knowledge of the above equipment. Salary will be negotiable depending on qualifications and experience. Three weeks' holiday, contributory pension and life assurance scheme.

Please send all relevant personal history stating how the above requirements are met and quoting reference ZH.297 to:



Mrs. H. M. Brown, Personnel Manager,
Road Transport Industry Training Board,
Capitol House, Empire Way,
Wembley, Middlesex, HA9 0NC.

OFFICER COMMANDING

Force Electronic Workshop

Brunei

- ★ Salary up to £4500
- ★ 12½% gratuity
- ★ Tour of 24 months with prospect of renewal
- ★ Free family passages

- ★ NO INCOME TAX
- ★ Free accommodation
- ★ Education Allowances
- ★ School children's visit passages

Required by the ROYAL BRUNEI MALAY REGIMENT to run the air conditioned Workshop, which will include equipment repair and the implementation of a scheduled inspection and testing programme; administration of personnel under his command; part-time training of small numbers of local technicians.

Candidates, 38-45 years, must be ex-Services, Technical Branch (e.g. R. Signals, REME) and possess at least 15 years' experience in Service Communications with a good record of man-management and administrative ability. They need possess no formal qualifications although AMBIM or equivalent, AMIEE or AMIERE would be an advantage. Previous experience of the Far East is desirable.

For further particulars you should apply, giving brief details of experience to:

M. Division, 4, Millbank,
London, SW1P, quoting
reference number
M2K/730414/WF.

2643

TEST ENGINEERS

The leading U.K. manufacturer of high grade TV monitors require Test Engineers for their expanding Test Department.

Situated in the Berkshire town of Maidenhead, the Company offers pleasant working conditions, good salaries and friendly environment.

Duties will cover the testing and trouble-shooting of monochrome and colour TV monitors together with other ancillary sophisticated TV broadcast equipment manufactured by the company. Previous experience of TV equipment would be an advantage. Please apply to:

PROWEST ELECTRONICS
Boyn Valley Road, Maidenhead, Berks.
Maidenhead 29612

[2670

ABILITY

IS THAT YOUR MIDDLE NAME ?

Then come and join us at TELENG, we need you.

JUNIOR AND SENIOR ELECTRONIC DEVELOPMENT ENGINEERS

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 & Training Officer,
ARISDALE, AVENUE, SOUTH OCKENDON, ESSEX.
Tel. South Ockendon 3477.

[2599

Broadcast Video Tape Engineer

required for expanding company near London Airport. To have good knowledge of TV Broadcasting and use of Tele-Recording equipment would be useful. Excellent salary for man with right experience. The Company operate a length of service incremental scheme and pay London weighting allowance.

Phone: 01-759 5432

ask for Mr. R. Hallen or write:

THE VIDTRONICS CO. (U.K.) LIMITED,
Bath Road, Harmondsworth, West Drayton, Middlesex.

2644

DIODES SILICON RECT. GLASS lamp 100 to 800PIV. Offers for 2,600 complete stock. Box No. WW2597.

EARPHONES, ZA-Can 0842, with matching ear-cushions. About 125 pairs, as new, to be sold in one lot. Buyer collects. Phone: Littler, Woodbridge (Suffolk) 2647. [2624

ELECTRIC WIRE: 3 core rubber covered cable, 28/0076, £4.00 per roll, plus p.&p. 75p; 3 core pvc black cable, 14/0076, £3.50 per roll, plus p.&p. 50p; single core black pvc, 14/0076, 60p per roll, plus p.&p. 20p; 3 core black pvc flat, 28/0076, £3.50 per roll, plus p.&p. 50p; single core pvc black, 14/36, 60p per roll, plus p.&p. 20p. **Flat Instrument Case Braid 5/16in. wide,** 50p per roll, plus p.&p. 20p. (All the above in 100 yds. rolls.) **Plastic (Rigid) Sheet, ABS brown 38in. x 40in. x .10 thick,** 25p each, plus p.&p. 10p; 1/20 hp Fracmo motor, fitted with W51 gearbox, complete with capacitor £4.50 each, plus p.&p. 50p. **Plastic sheet (grey), 54in. wide x 100 yds. rolls,** £12.50 per roll, plus p.&p. £2 or £1.00 per 3 yds., plus p.&p. 30p. Broxbourne Eng. Co., Salisbury Road, Hoddesdon, Herts. [2554

ERIE CERAMICS—PRICES 1/3p. 10/25p, 100/£1. Values In PF: 1, 1.5, 1.8, 2.2, 2.5, 2.7, 3.3, 3.9, 4, 4.2, 4.4, 4.7, 5, 6, 6.8, 9.1, 10, 12, 13, 15, 16, 18, 18.5, 22, 33, 43, 47, 50, 60, 68, 70, 82, 120, 175, 390, 470, 550, 656, 700, 820, 1000, 1200, 1500, 1800, 2200, 2500, 3300, 3900, 5600, 8200PF. Postage 10p. **ELECTRONIC MAILORDER,** Ramsbottom, Bury, Lancs. [2685

FRY'S 10in. Wave Flow solder Machine complete with Stand and Motorised conveyor 230/250V, 50 cycle, filled with solder. Good working condition. Can be viewed by appointment. Contact: Mr. L. Clark, telephone Lodge Hill 3441, ext. 34. [2562

FOR SALE: 8 Pye Westminster W15 and ex-commercial, recent, band-A 148-174 MHz, in working order, £70 each. Evans, 104 Stonnall Road, Aldridge, Staffs. Tel: Aldridge 51551. [2622

GLASS FIBRE P.C. BOARD large supplies available. 1/16 in single sided one ounce copper 2p per 3 sq. inches (under 1 ft). 75p per sq. ft. (over 1 ft). 1/16 in double sided one ounce copper 1p per sq. inch (under 1 ft). £1 per sq. ft. (over 1 ft). Please add 10p per sq. foot postage and packing. We can cut to your size at 1p per cut. Solid State Lighting, The Firs, Smallworth Lane, Garboldisham, Diss, Norfolk. [16

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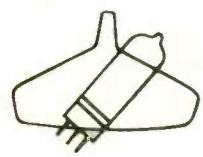
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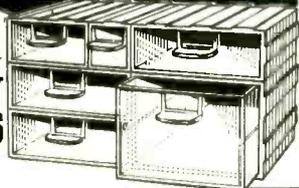
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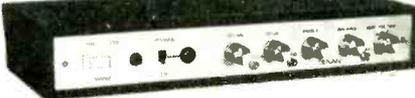
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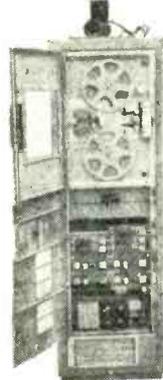
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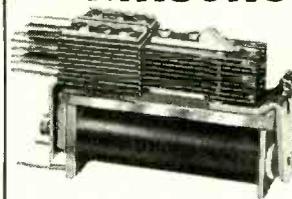
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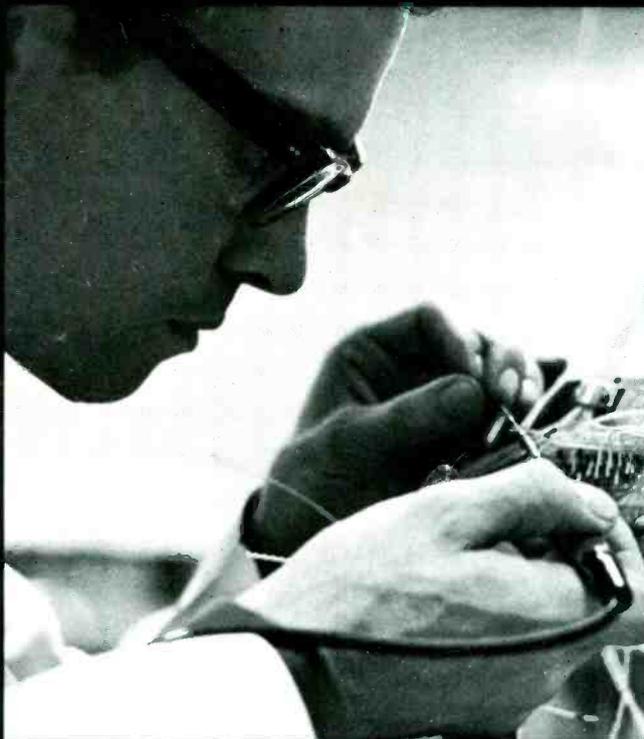
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