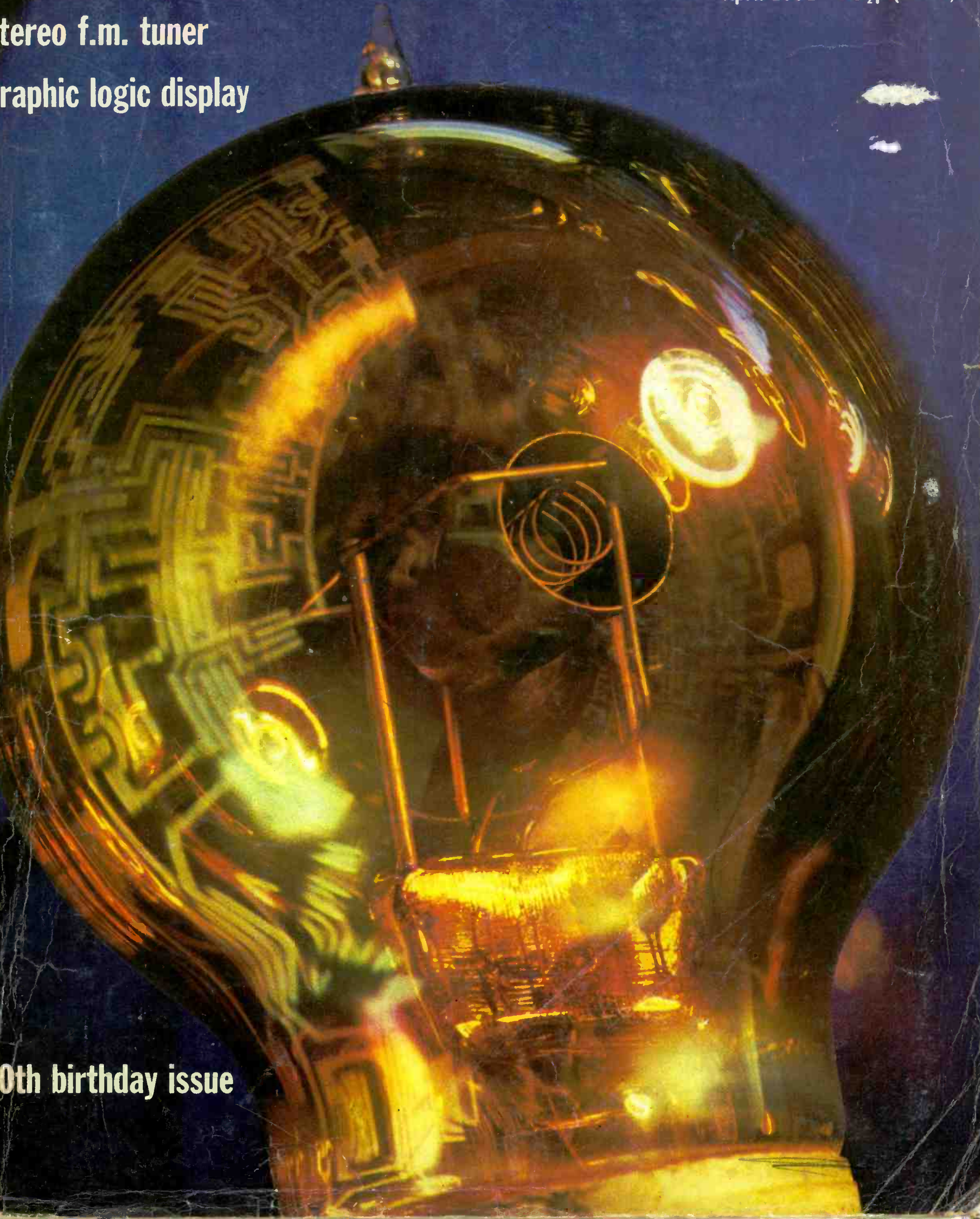
Wireless World

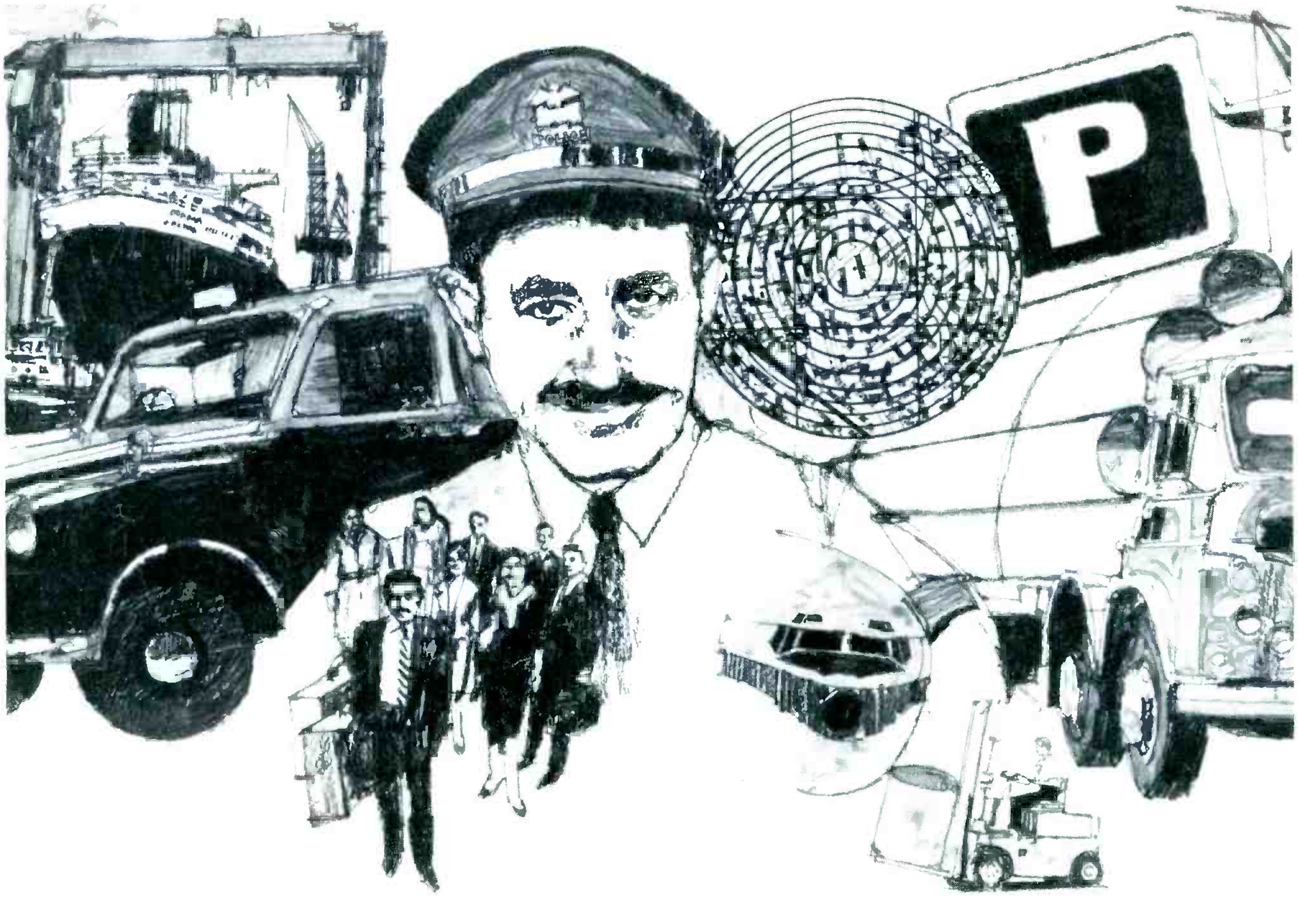
April 1971 17½p (3s 6d)

Stereo f.m. tuner

Graphic logic display



60th birthday issue



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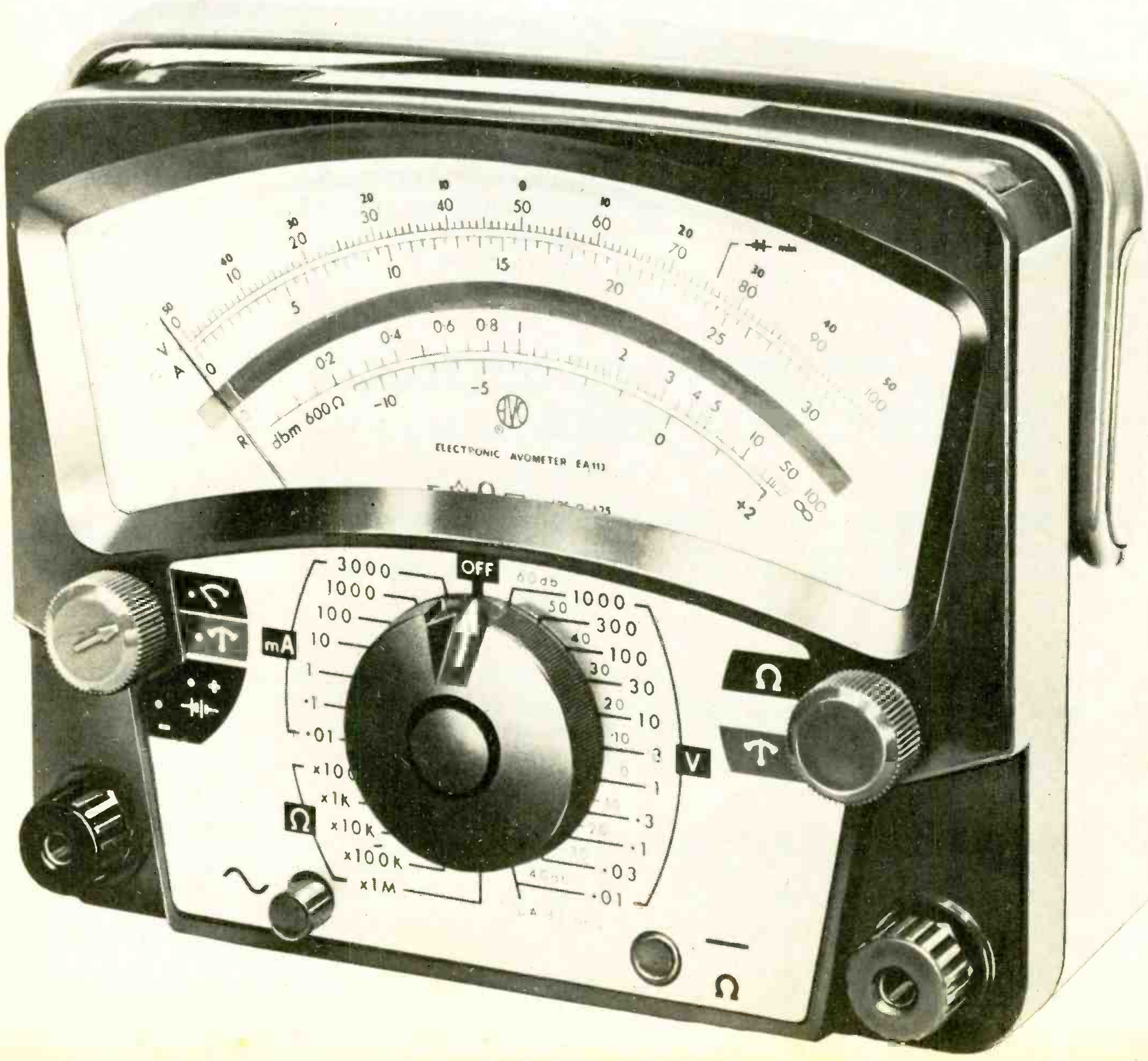
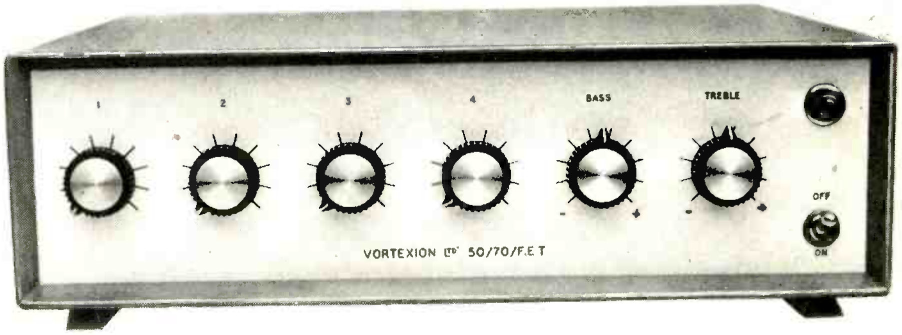


WW—006 FOR FURTHER DETAILS

Vortexion

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

This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable—100 Watt Amplifier (no failures to date) 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.



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

THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4 channel F.E.T. mixer, 2-30/60Ω 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.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms–15 ohms and 100 volt line. Bass and treble controls fitted.
Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s–20 Kc/s ± 1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100–120 V or 200–240 V. Additional matching transformers for other impedances are available.

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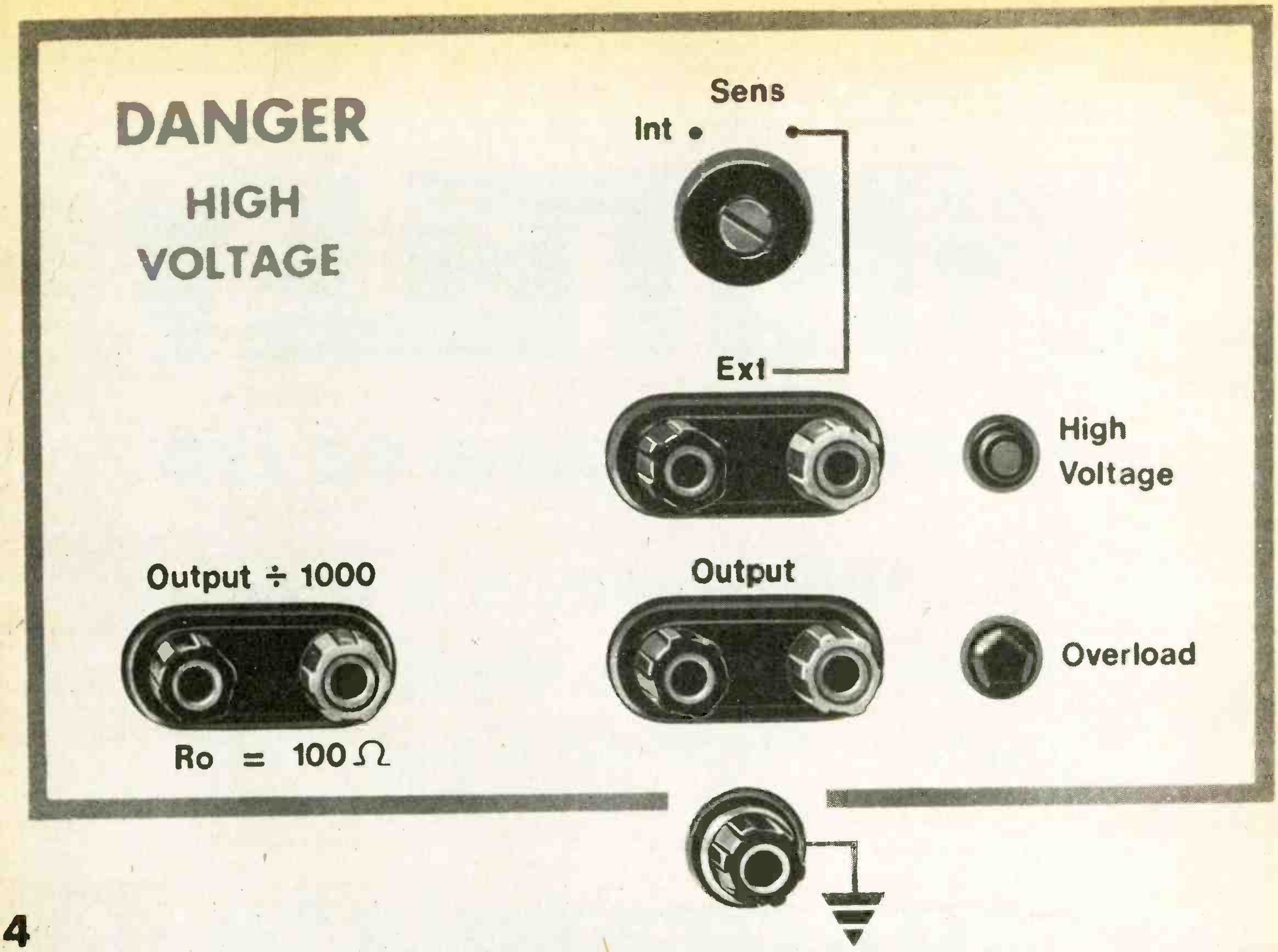

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From Bradley. A new face in our calibrator family.

It is called the type 134 D.C. Calibrator. An accurate high voltage source for the calibration of panel meters and electronic instruments, or as a precision laboratory reference source.

The 134 provides output voltages up to 1000V d.c. at an accuracy of 0.05% of dial setting, and with a current capability of 50 mA. A deviation control gives direct reading of percentage error, a feature pioneered by Bradley and now incorporated in all our calibrators

You will probably recognise some of the other faces we show here.

The 127B for instance. A 500V D.C. Calibrator for use as a precision voltage source, having an accuracy of 0.05% and a current capability of

20mA. The 127B gives high accuracy.

The A.C. Calibrator in the range is the 125B. This can be used for the production line testing of meters or as an extremely stable a.c. source. Output voltages up to 500V a.c. are available at spot frequencies of 50, 400, 1000 and 2400 Hz. Alternative frequencies are available if required. The accuracy is normally 0.2% of setting, but 0.1% instruments can be supplied complete with an official B.C.S. certificate

The 132 D.C. Current Calibrator provides stable d.c. current from 1pA to 100mA with an accuracy of 0.05% of dial setting. Its principal uses are the calibration of current sensitive devices, including panel meters, relays and transducers, and the production testing of semiconductor devices, and thin film resistors. It is particularly useful as a development laboratory reference source.

For use with the Bradley 132, is the 144 D.C. Current Multiplier, an add-on unit which extends the range to 10 amperes. The combination of these two instruments provides a versatile high current source which covers the testing of most panel meters and which amongst numerous other applications has been used as a precise current source in chemical electrolytic experiments.

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(Founded 33 years ago)

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Merlin *(Falco columbarius)*

Our wing span – a third of a century

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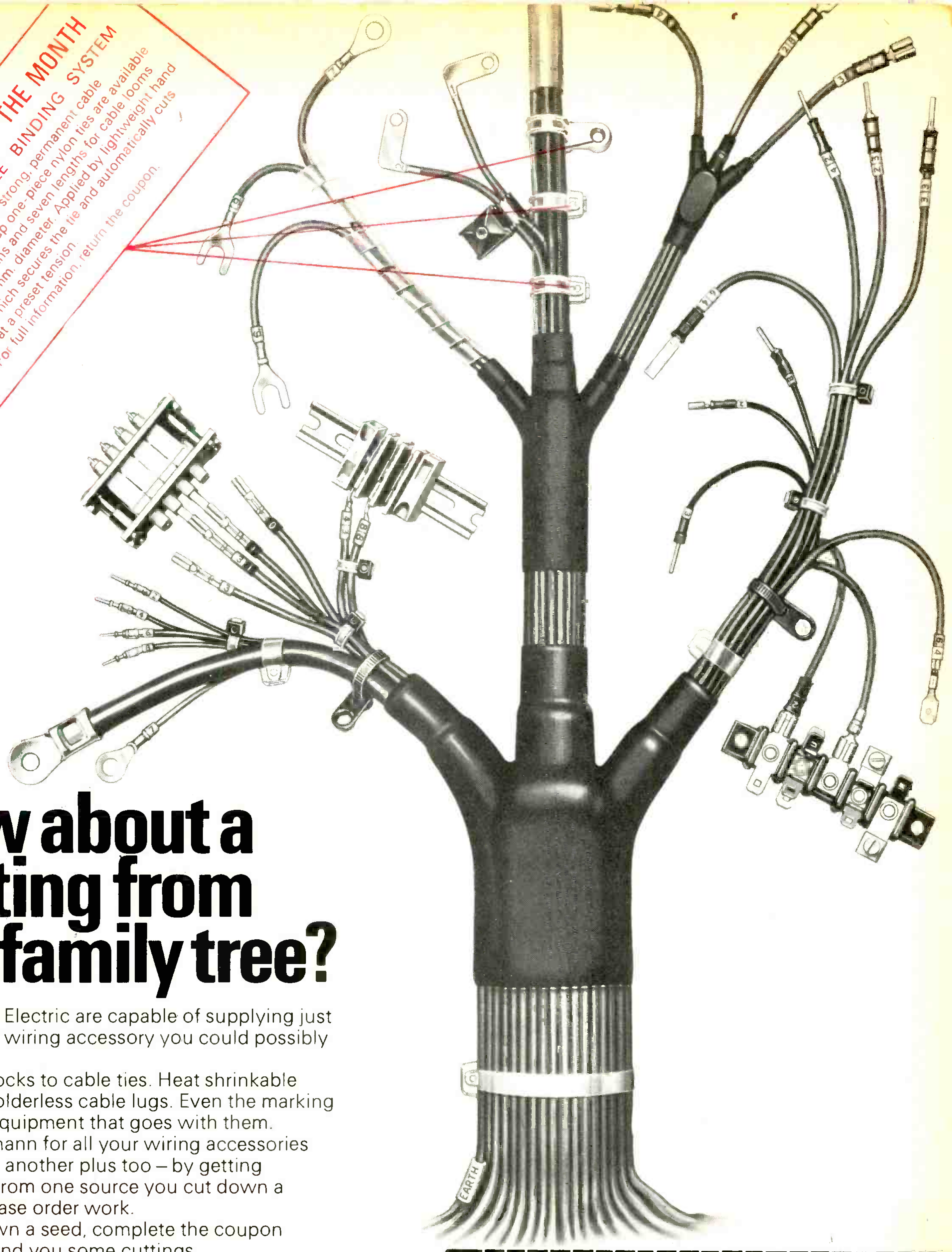

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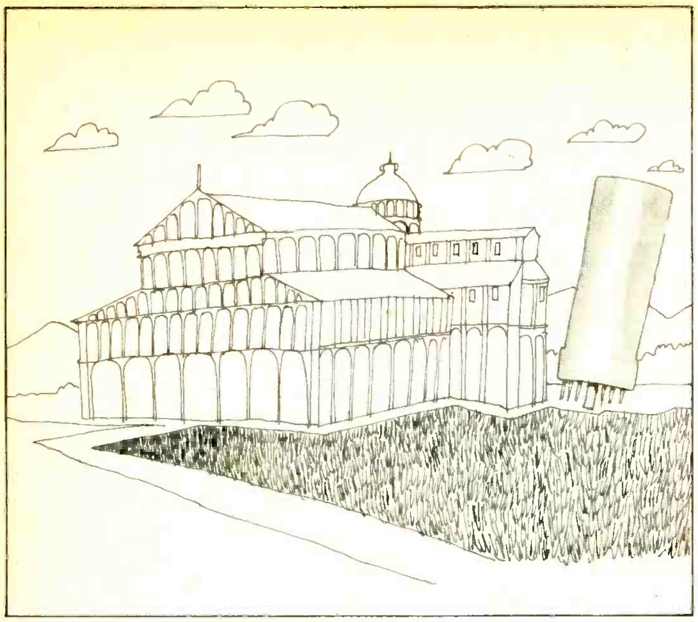
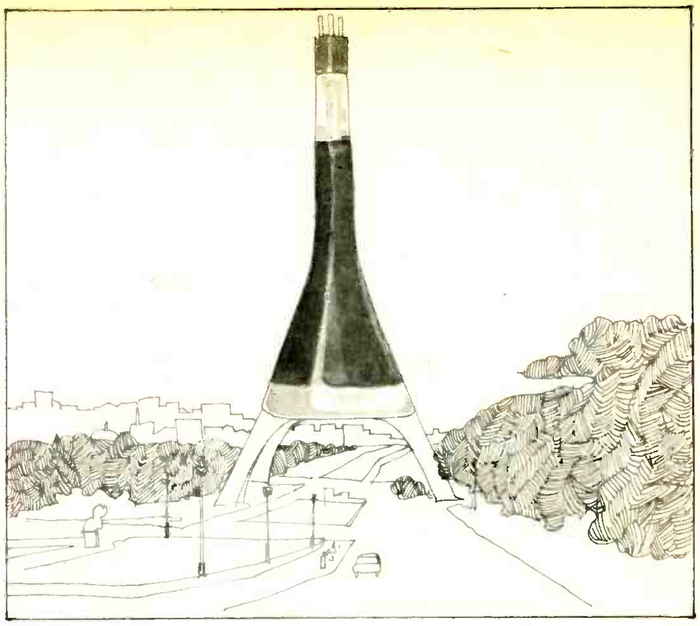
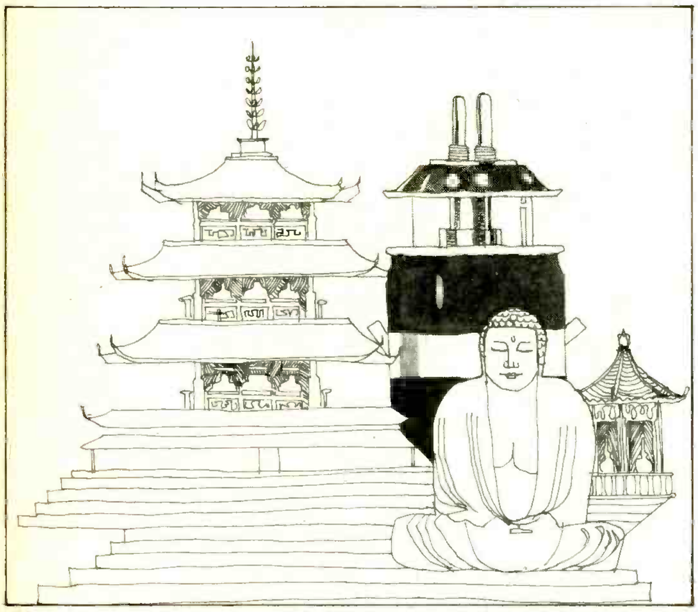
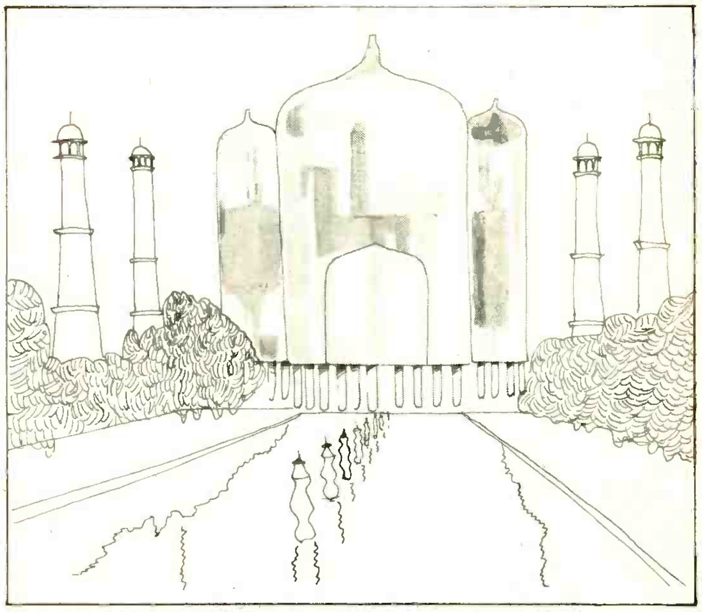
WW4/71









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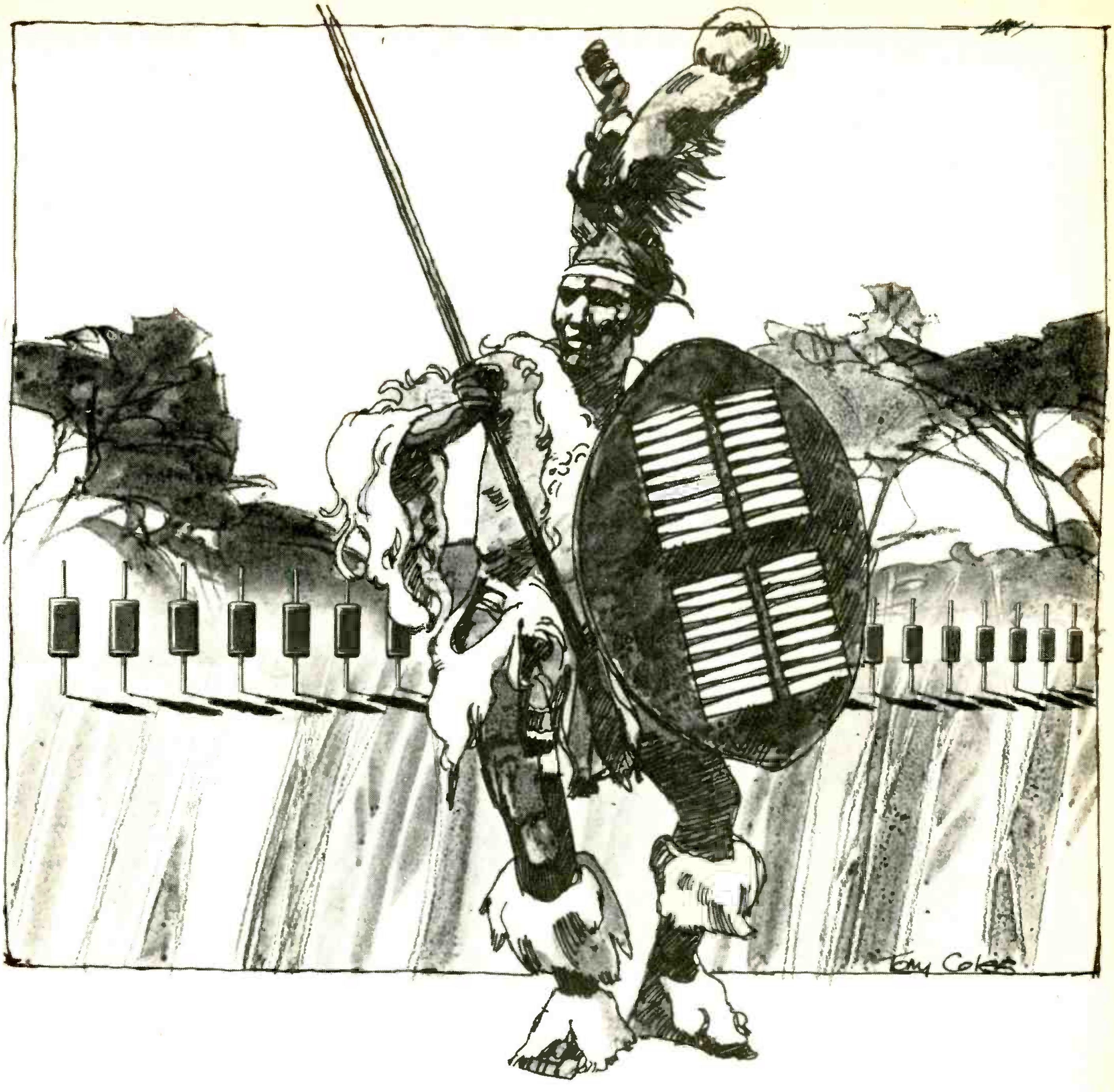
Tony Coles

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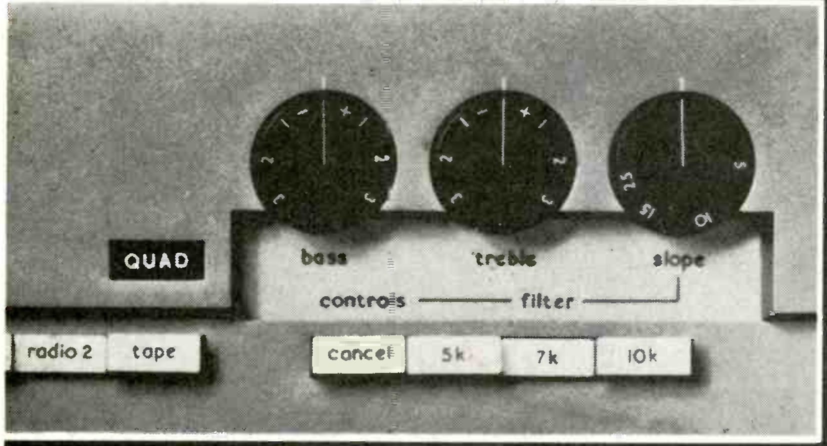
numbers

Set up a QUAD 33 with +1 on the treble control, and you will obtain a response precisely defined; readily and accurately repeatable. This response has a shape rather different from most run of the mill tone controls and there are, as you may guess, good reasons for this.

Then as the listener is not expected to know just what a given response curve does to the signal off the record, we provide a button marked 'cancel'. This enables him to make a direct comparison with the original and so learn just which recording defects need what correction. A QUAD user gets the best out of every record – every time – and enjoys the music to the full.



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Send postcard for illustrated leaflet to Dept. WW
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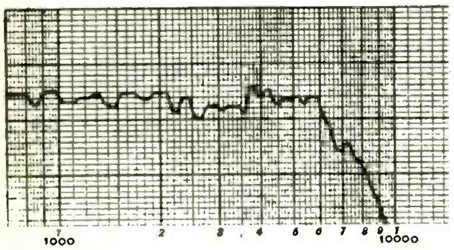
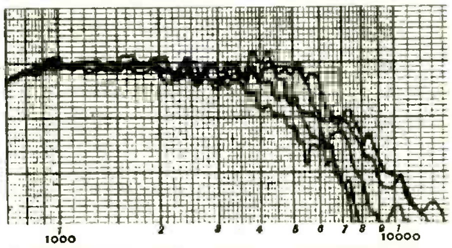
Acoustic Research has measured the response of more than a million high-fidelity speakers.

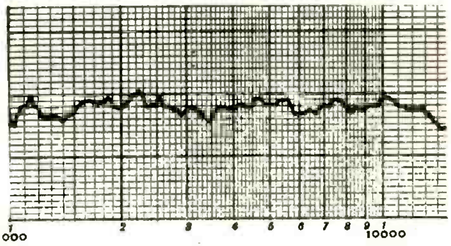
Here are some things we have learned about listening.



1. The frequency response of a midrange driver unit of an AR-3a, on axis. This corresponds to what one would hear outdoors, listening directly in front of a speaker.

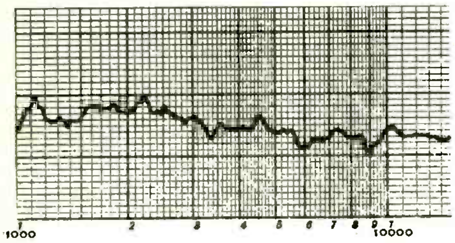


2. What happens when a listener moves over to one side of the speaker in 15° increments.

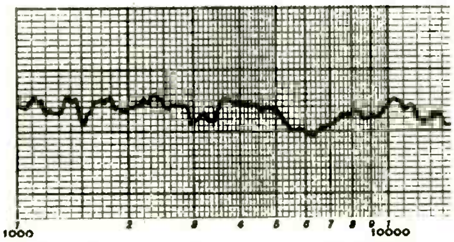


3. The integrated power output of the AR-3a above 1000 Hz, measured in a special reverberant chamber. Reflection from the walls of the chamber mixes together all of the sound emitted by the speaker system in all directions, an effect much more like that of a listening room than the anechoic chamber used for 1 and 2. A speaker system which measured well in both types of chamber would be accurate under almost all listening conditions.

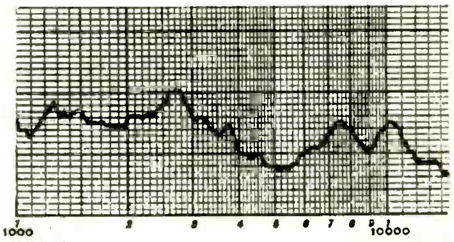
Integrated power output curves.



AR-3a and AR-5 with high-priced magnetic cartridge. It is interesting to see that the cartridge introduces somewhat more degradation of the signal than the speaker system, at least in the frequency range observed. Nevertheless, a small adjustment of the amplifier treble control could restore uniformity of response.



AR-2ax with moderately-priced magnetic cartridge. Although not as accurate as the AR-5 or AR-3a the AR-2ax displays the same kind of performance, that is, its integrated power output curve is relatively level. Because its dispersion, especially in the lower midrange, is less uniform the AR-2ax is more dependent on optimum placement than the others.



A 'multi-directional' system and a very expensive cartridge Such systems are designed to take advantage of room reflections to smooth response and create spatial effects.

Vertical divisions ½ dB

Fidelity means accuracy.
Accuracy distinguishes high-fidelity speaker systems from the speakers in simple radios and gramophones. It is therefore reasonable that evidence of accuracy should take precedence over descriptions of a speaker system's size, shape or theory of design. Acoustic Research offers exact measurement data for AR speaker systems to all who ask for it: music listeners, audio enthusiasts, science teachers, even competitors.

The accuracy of a speaker system can be evaluated by listening tests or by measurement. Both methods give the same information in different ways.

Testing for accuracy.
To perform a listening test, an extremely accurate recording must be made and played back alongside the original source of sound. Amplifier and speaker system controls are adjusted to obtain as close a match as possible; and the speaker system judged by the degree of similarity. Acoustic Research has presented public concerts at which the Fine Arts Quartet and other musicians could be compared with recordings played back through AR speaker systems; even seasoned critics were deceived. Obviously, listening tests cannot be made with commercial recordings of music since the listener has no way of knowing which adjustment is most accurately reproducing the recording.

Objective measurements.
While it is not always convenient to carry out scientifically controlled listening tests, properly conducted measurements can give the same information in permanent, quantitative form. AR knows something about this, having already tested the response of well over a million speakers – every one that we have ever made, and many made by competitors. Our findings are that the most important measurements required to assess the accuracy of a speaker system are (1) frequency response on-axis, (2) frequency response off-axis, (3) integrated power output.

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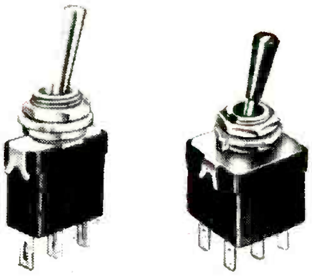

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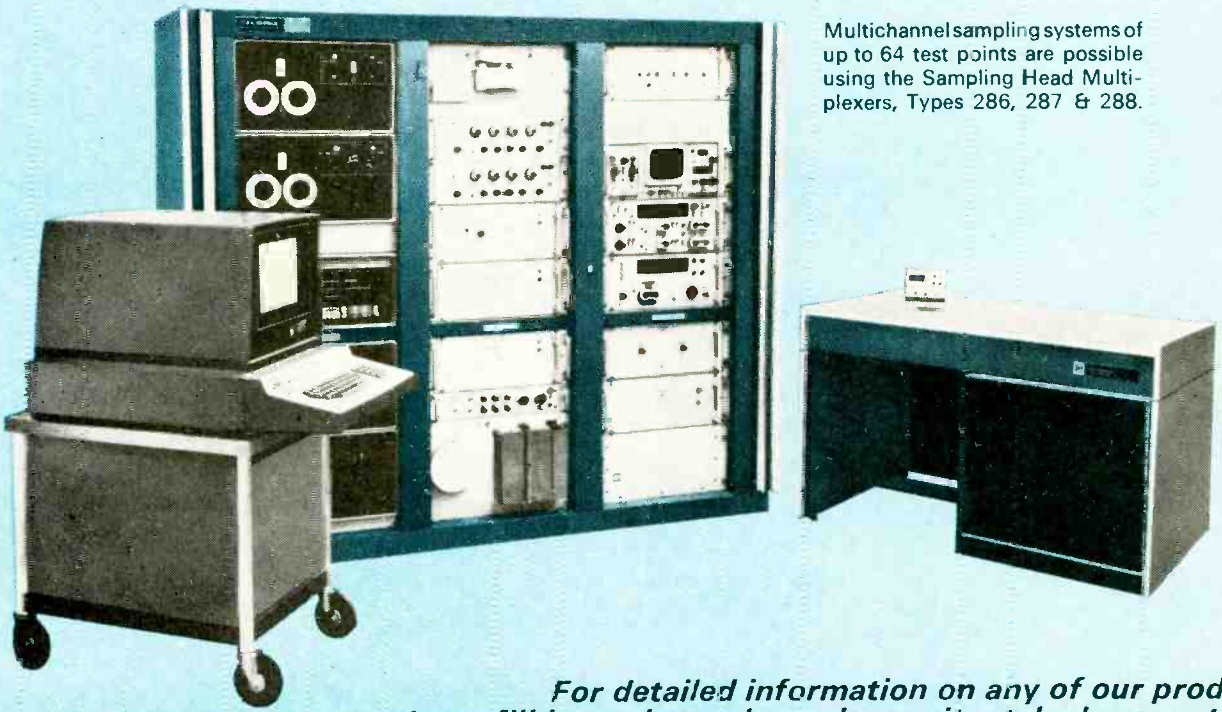

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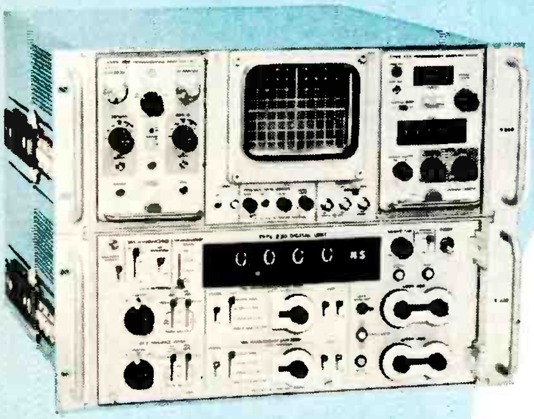
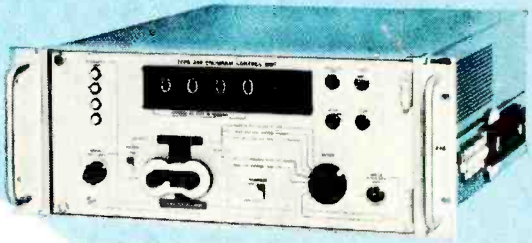


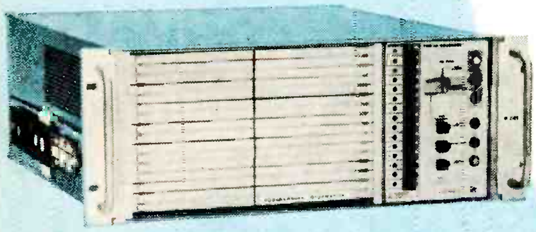
The Type 568/230 Digital Oscilloscope provides digital readout of measurements that are displayed in analog form on the CRT. With programmable plug-in units, all the measurement functions of the 568/230 can be externally programmed.



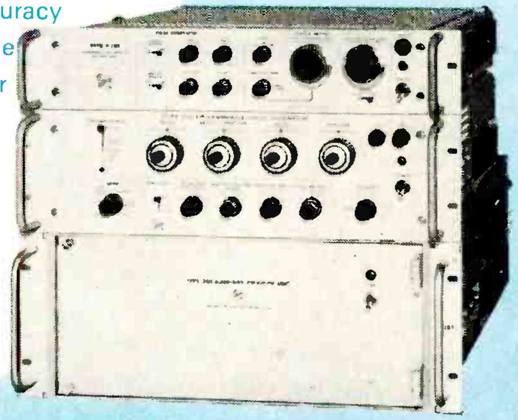
The Type 240 Programme Control Unit, in conjunction with a disc memory, can programme the 568/230 at speeds up to 100 measurements per second.

Prefer to buy the best systems modules available? Tektronix offers a digital oscilloscope with programmable plug-in units, multiplexers, programmers, programme control units and programmable pulse generators. Dynamic, switching-time measurements are made with greater speed, accuracy and convenience when you tailor your system around these modules.

The Type 250 Auxiliary Programme Unit provides additional programming capabilities to the 240 and buffering for pulse generators, power supplies, etc.



The Type 241 will automatically sequence through 15 programmes, stopping on out-of-limits measurements. Programmes are easy to set up and change.



I.L.E.C. SHOW STAND 1-115/131

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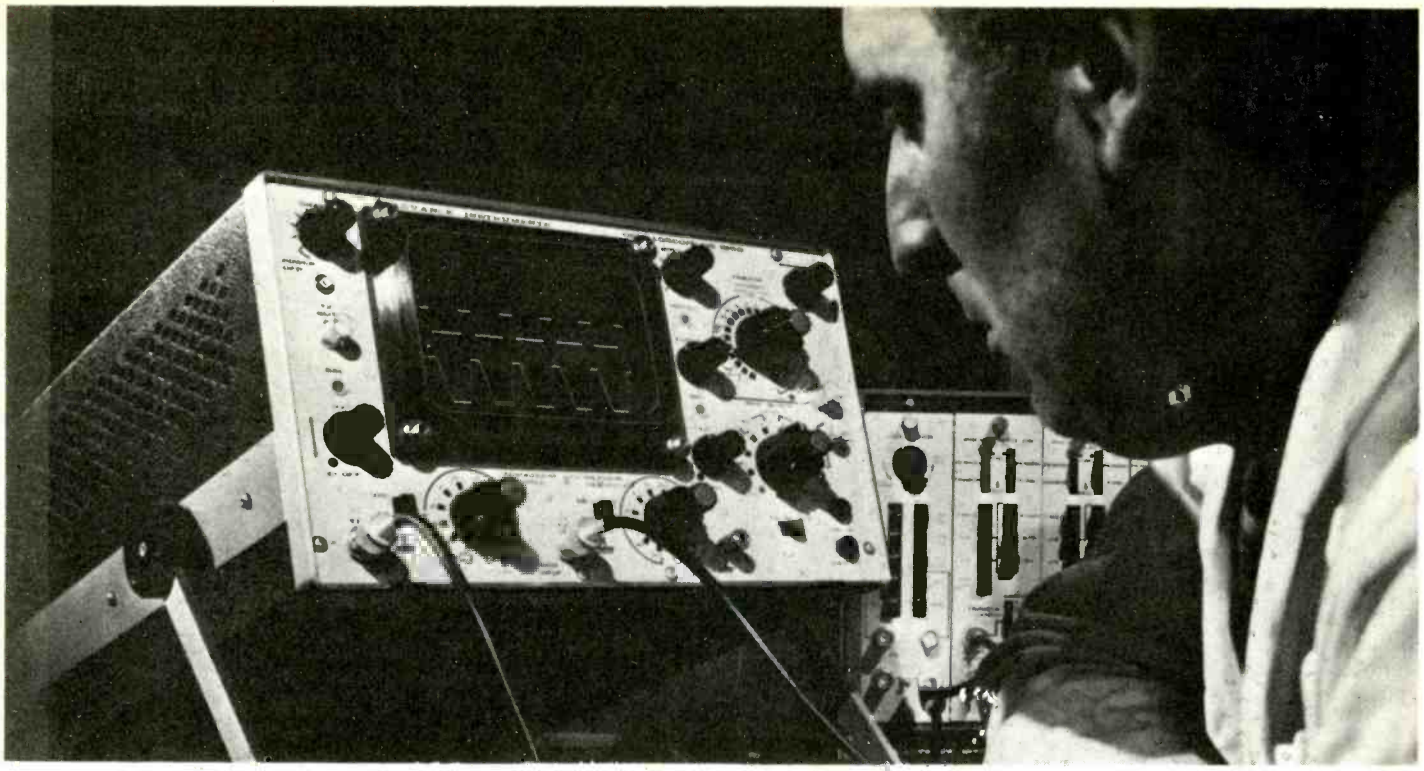

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Here's the 'scope that gives you more
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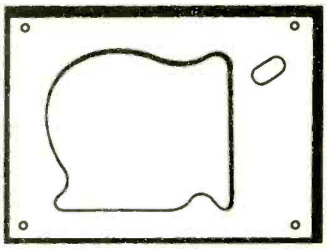
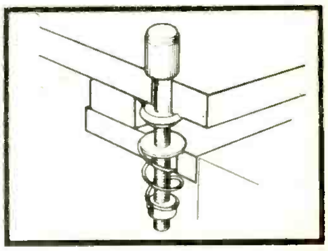


Motor boards in matching veneers are ready cut and drilled for screwdriver assembly with the appropriate pick-up arm and turntable. An uncut board is also available.



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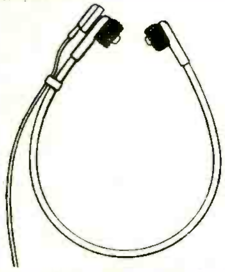

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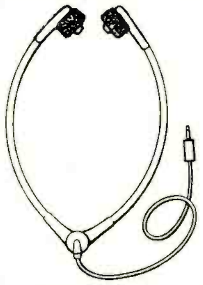
JUNIOR 60
HEADSET



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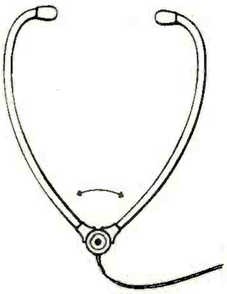
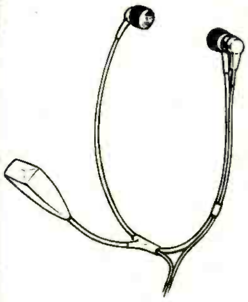
LIGHTWEIGHT
HEADSET



STETOCLIP
SENIOR
HEADSET



STETOMIKE
BOOM MICROPHONE
HEADSET

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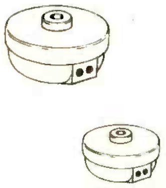
& NYLON
EARHANGERS



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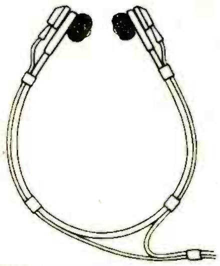

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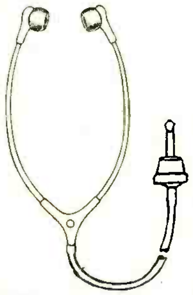

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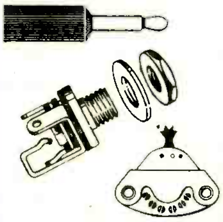

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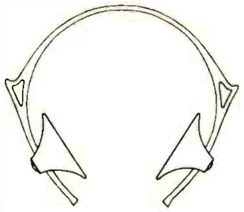

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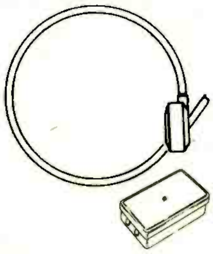
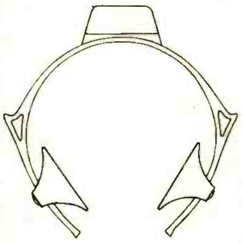
WITH OR WITHOUT BOOM
MICROPHONE



THROAT
MICROPHONE
E.M. MICROPHONES



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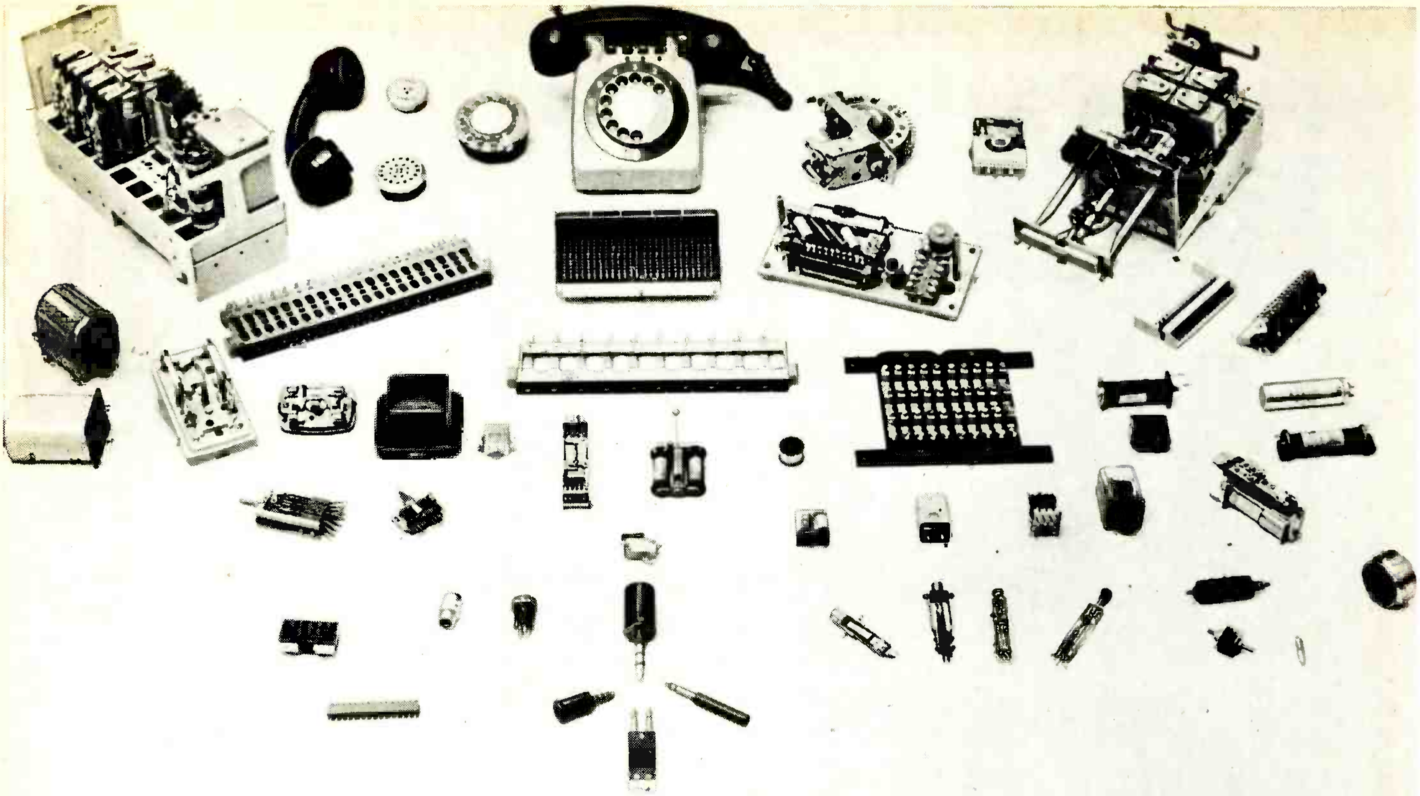

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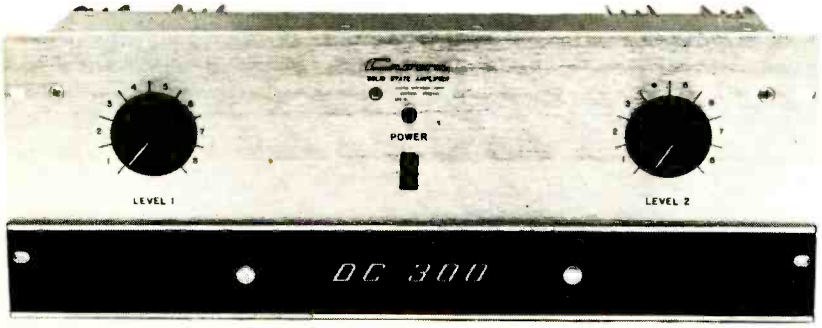

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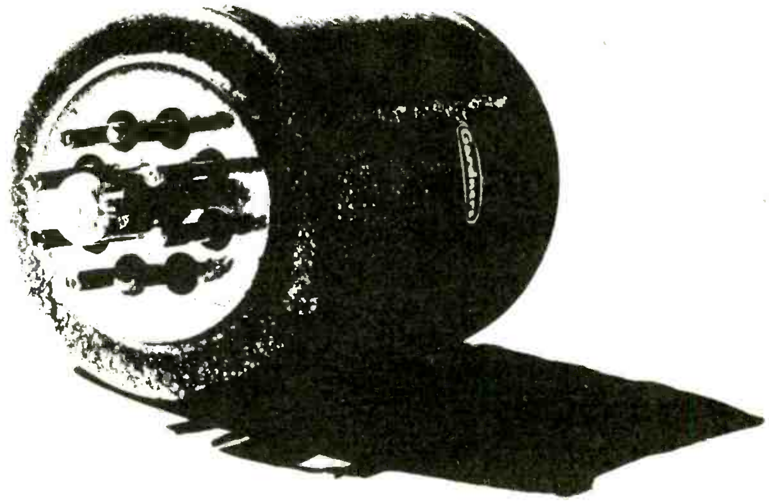
GT5?



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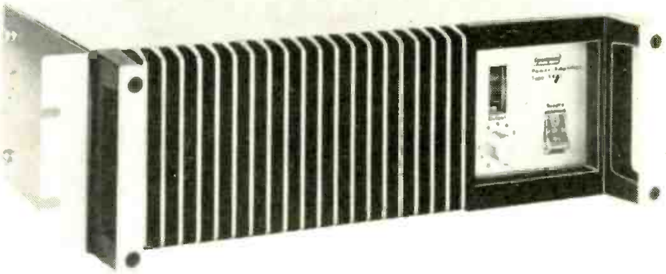

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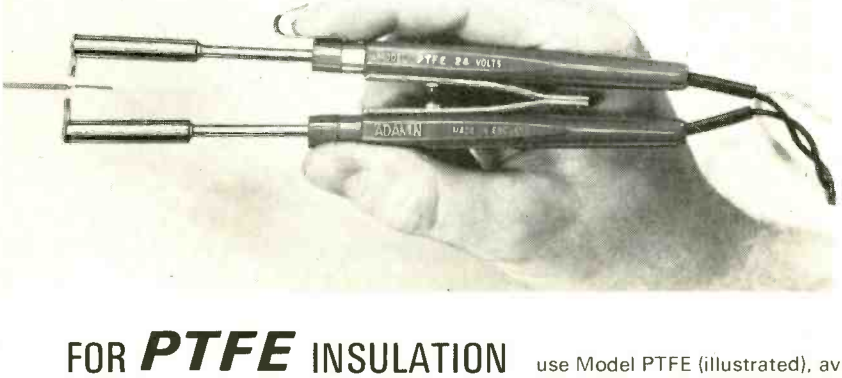

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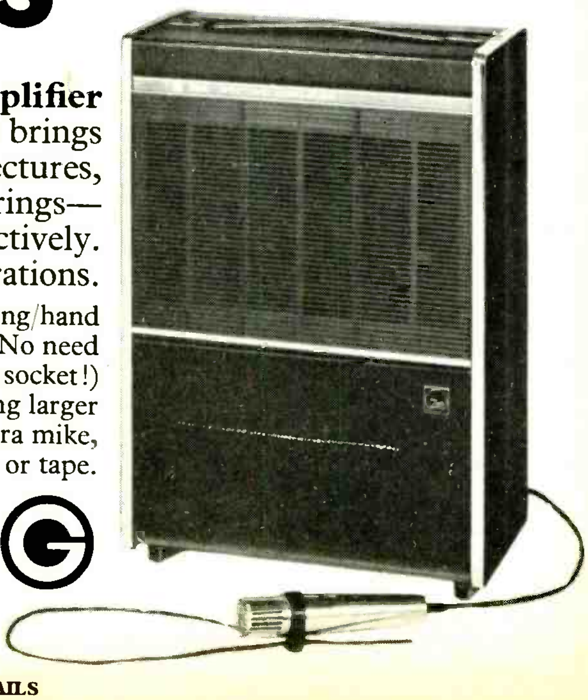

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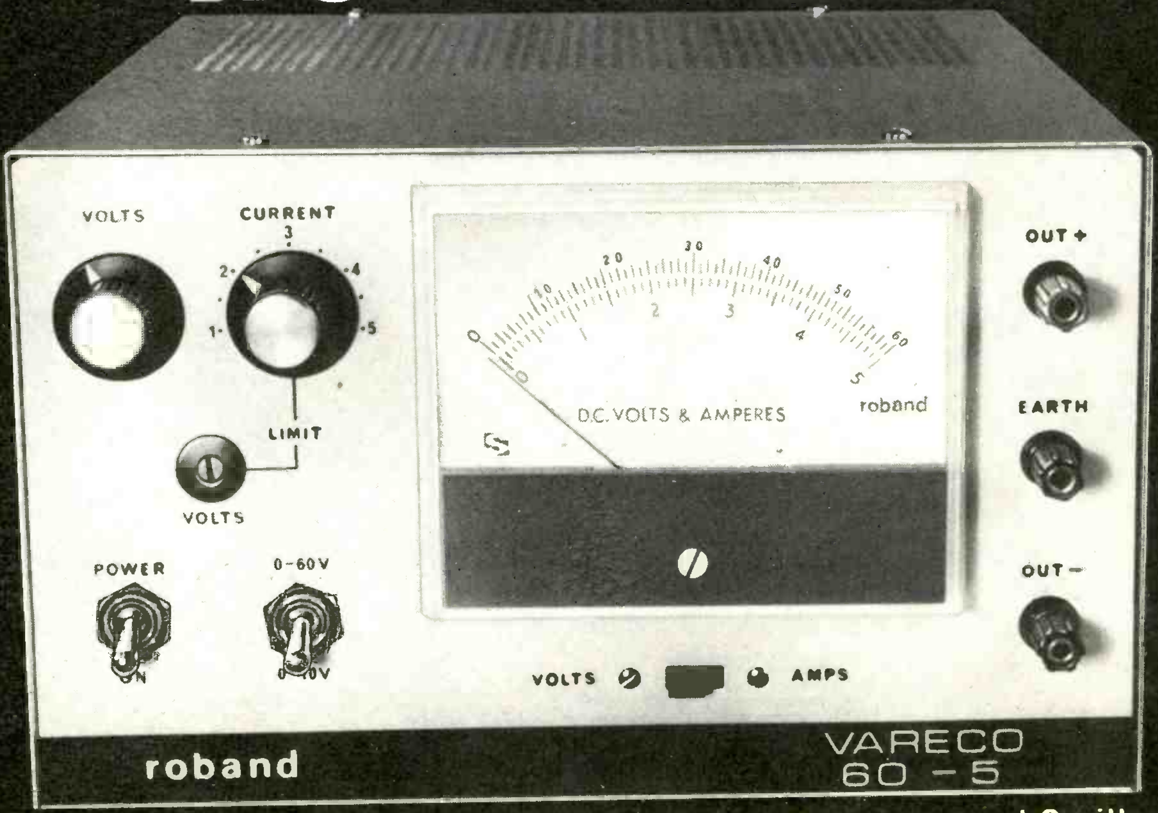

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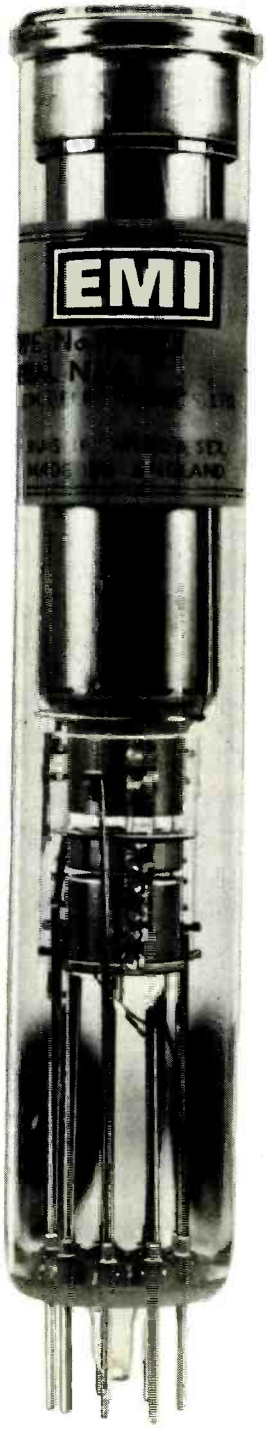

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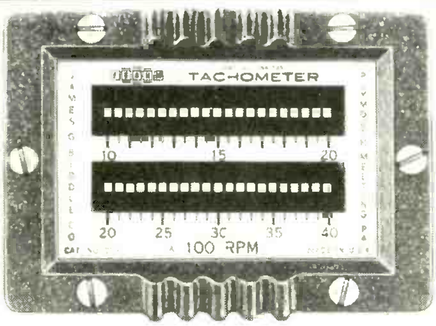

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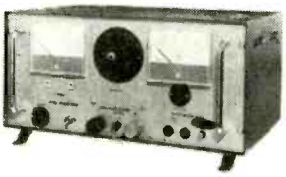

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Will provide accumulator performance from AC mains for production testing and servicing of battery operated equipment. Output continuously variable 0-30V at up to 20A.

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Series TU18-2TQ

Selenium high voltage tripler multipliers
for colour & monochrome television EHT supplies

This assembly is a direct replacement for British Radio Corporation Group EHT. Part Nos. OM3-700 and 6M3-034 and will clip straight into the existing transformers.

Operating Characteristics

Horizontal frequency	10-16	(kHz)
Imput pulse	6.8	(kV)
D.C. output voltage	18	(kV)
D.C. load current	0.300	(μA)

Ratings

Imput pulse	7.3	(kV)	Max.
D.C. output voltage (zero beam current)	20	(kV)	Max.
D.C. load current	400	(μA)	Max.
Ambient temp.	65	(°C)	Max.
Surface temp.	80	(°C)	Max.
Frequency (pulse)	20	(kHz)	Max.

Price

1-9 £2.25 each, postage paid. Prices for larger quantities on application.

Also available

HALF WAVE UNIT for B.R.C. GROUP TU18-2HD
Price 1-9 £2.00 each

Fill in coupon below and send cheque with order.

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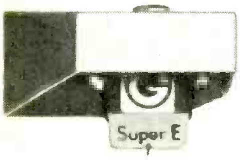
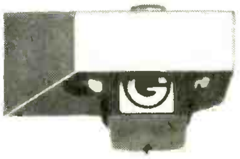
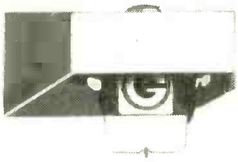
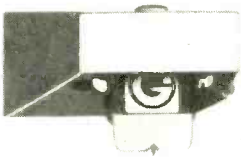
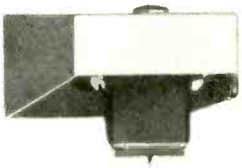

Super E









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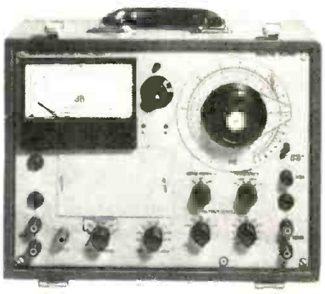
DC Differential Voltmeter – 6-figure readout from 100mV to 1kV, accuracy 0.01%. Calibrated null meter, analog output for recorders. Ask for M400 Data Sheet.



Transmission Measuring Set – portable equipment for checking a.f. lines and equipments from 20Hz to 120kHz. Suits 75, 140 and 600-ohm circuits, balanced or unbalanced, terminated or unterminated. Details on application, quoting 44C.

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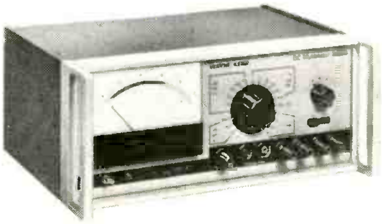
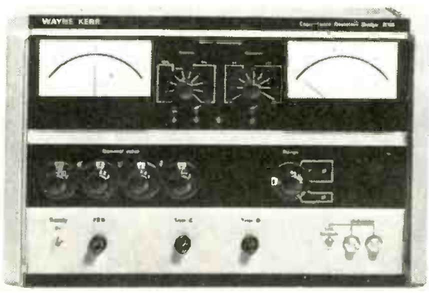


DC Multimeter – full-scale ranges 30μV-300V, 30pA-100mA and 10 Ω-1 G Ω. Switched filter. Constant 100MΩ for 1% voltage measurements. Analog output. Ask for M300 Data Sheet.



Capacitor Test Set – direct readout of percentage deviation from a pre-set value, and of dissipation, with automatic limit circuits showing pass/high/low. Also 4-figure capacitance measurement. Ask for B700 Data Sheet.

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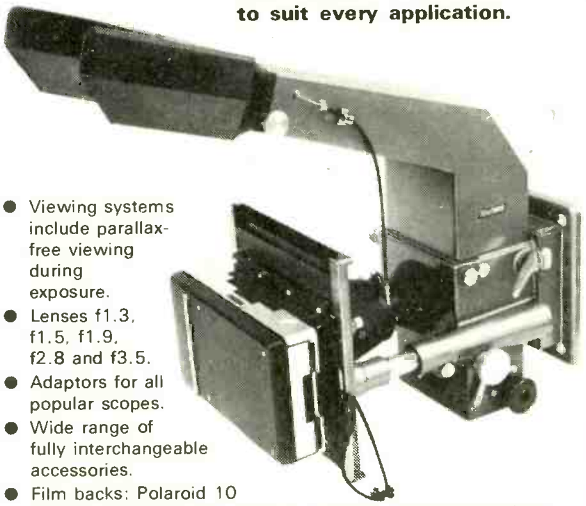

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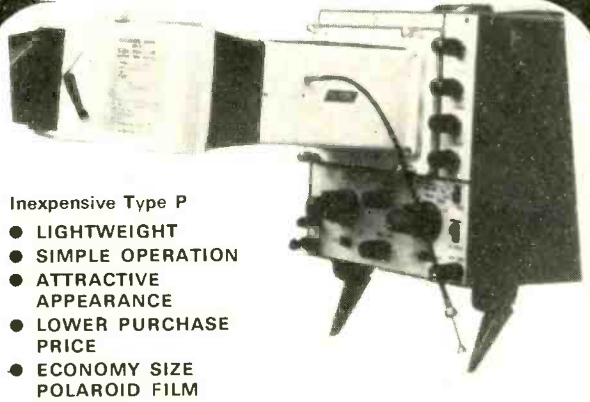

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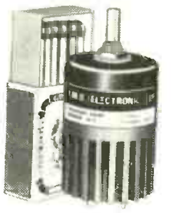
Inset shows latest pattern Brush gear ensuring smooth continuous adjustment.



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Maintain spot-on test gear readings with Automatic Mains stabilizer.

Specification:
- ★ Output 240V
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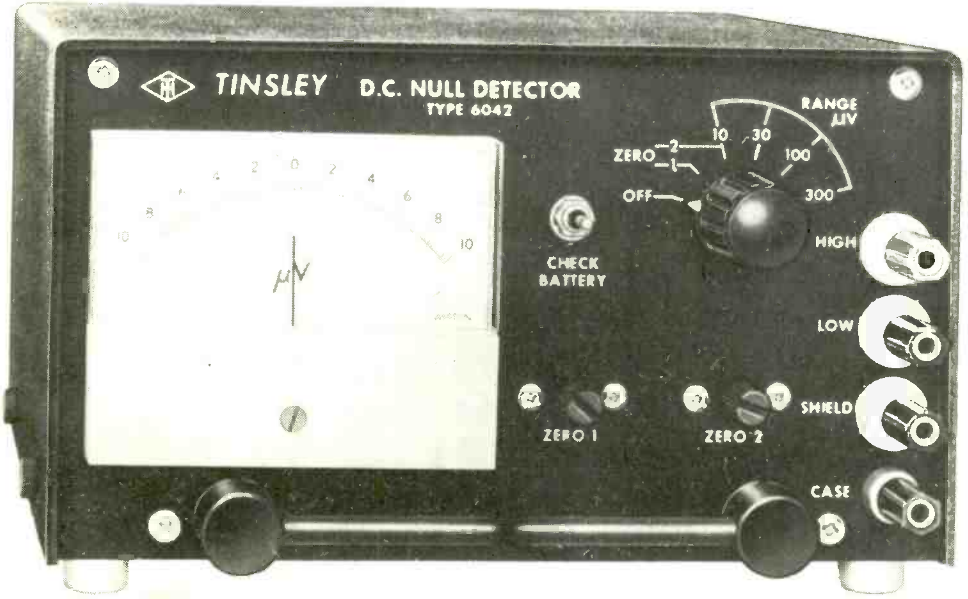

D.C. NULL DETECTOR, TYPE 6042 ✳

Portable detector for use with d.c. bridges and potentiometers. Sensitivity 10 µV full scale. Input impedance 14,000 Ω. Fully transistorised. 4 ranges. Resolution 1µV in 10,000 Ω source resistance. Noise less than 0·15 µV peak to peak.

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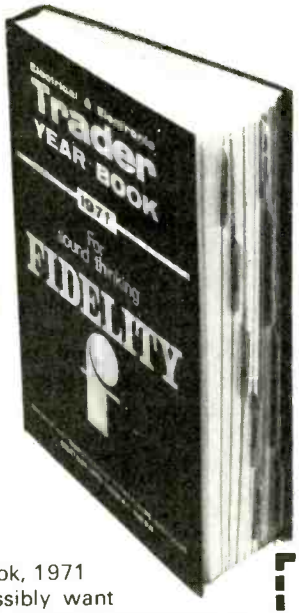
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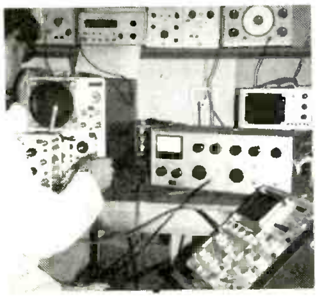

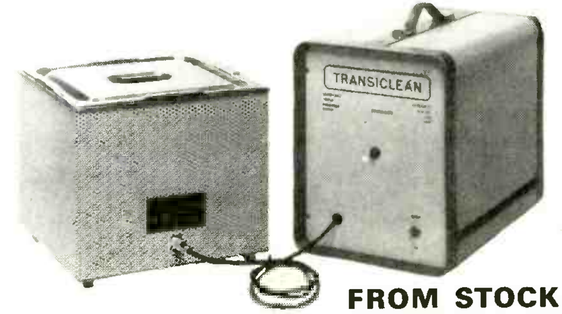
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Better looking—*obviously* . . . Better performing, *definitely* . . . and certainly lower priced compared with other top line high fidelity equipment. Yet with all this, the new Englefield 840 range has still further plus features. **Only with the 840 system can you incorporate the tuner within the amplifier itself,** enabling you to convert it to a Stereo & F.M. tuner amplifier of unsurpassed performance in a matter of minutes. The Englefield Add-in 'Press-tune Stereo F.M. Link can also be used with other amplifiers if so desired. See and hear the new Englefield 840 range at your hi-fi stockist NOW or send coupon for full details by return.

Englefield 840 equipment is guaranteed for 5 years.

840A amplifier design features

Swing-up lid enables all input and output connections to be reached instantly and easily from interior of cabinet. Audio connections are via DIN sockets (plugs supplied). Combined speaker muting switch and headphone socket on front panel. Silicon transistors throughout. Full complementary output stages with current limiting circuitry. Rotary controls fitted with dual wipers and lubricated tracks for long life and silent action. 18 gauge plated steel chassis. Unconditionally stable. For shelf or cabinet mounting.

840T stereo F.M. tuner design features

4 pre-tunable push button stages for instant programme selection. Switchable A.F.C. Automatic stereo reception. Sensitivity better than one micro-volt. Incorporates dual gate FET and I.C. circuitry, back to back varactor diodes and ceramic filters. Can be used separately or inserted in the 840 cabinet. 75Ω and 300Ω balanced aerial sockets.

● *Recommended retail prices* — Englefield 840A Amplifier **£45**: Englefield 840A Press-tune Stereo FM Tuner **£45** (inc. P/T): Englefield 840TA Stereo Tuner Amplifier **£95** (Inc. P/T).

AT

SONEX '71

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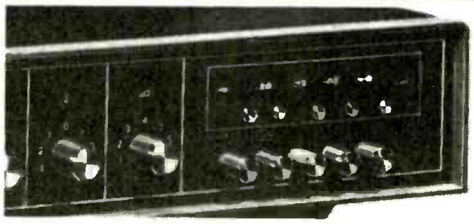

Specifications

THE AMPLIFIER

Inputs — Pick-up, (sensitivity 2.8mV into 47Kohms) Overload factor —100MV (32dB): Tape: Radio 80mV: Microphone 5mV.

Signal to noise ratio — mag. P.U. better than 67dB: 64dB for other inputs.

Cross-talk at 1 KHz —54dB

Distortion —0.08% at 1 KHz at all powers up to 20 watts R.M.S.

Power bandwidth and output —35Hz to 30KHz at 1dB for 20 watts R.M.S. into 8 ohms, per ch. driven together.

Controls —Volume: Bass (±16dB at 40Hz): Treble (±14dB at 10KHz): Balance.

Push-button for P.U., Radio, Tape, Mic., and mono/stereo: on-off, filter and (disguised) headphone socket/speaker muting switch.

Connections — via DIN sockets at rear, plugs supplied also. Mains A.C. 110/250 V. 50/60Hz. Two mains outlets for gramo. motor, etc. one direct, one switched on with amplifier.

Facilities —Swing-up lid for instant access to connections, permitting cabinet to stand flush to wall; also space to take Englefield tuner if required.

Cabinet — steel, hand covered with simulated soft black leather and immensely durable, with black base, size 16¼" x 4¼" x 11" (413 x 109 x 28 mm).

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With four tunable press button controllad stages each 88-108 MHz. Also press-button for A.F.C.

Sensitivity —1 micro-volt for 30dB quieting.

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Wideband noise —60dB.

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Aerial —Sockets for 75 ohms and 300 ohms, balanced.

Tuning meter and indicating beacon automatic stereo reception on the front panel.

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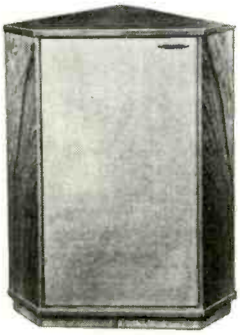

"Lancaster"
corner-mounting
fitted with 12" or
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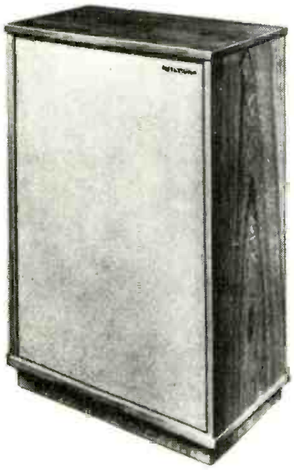
Concentric.
Height 2' 9"
Width 2' 1"
Front to rear
corner 1' 4¾"



"Lancaster"
free-standing
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15" Dual
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Height 2' 9½"
Width 1' 9½"
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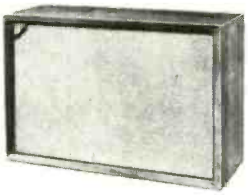

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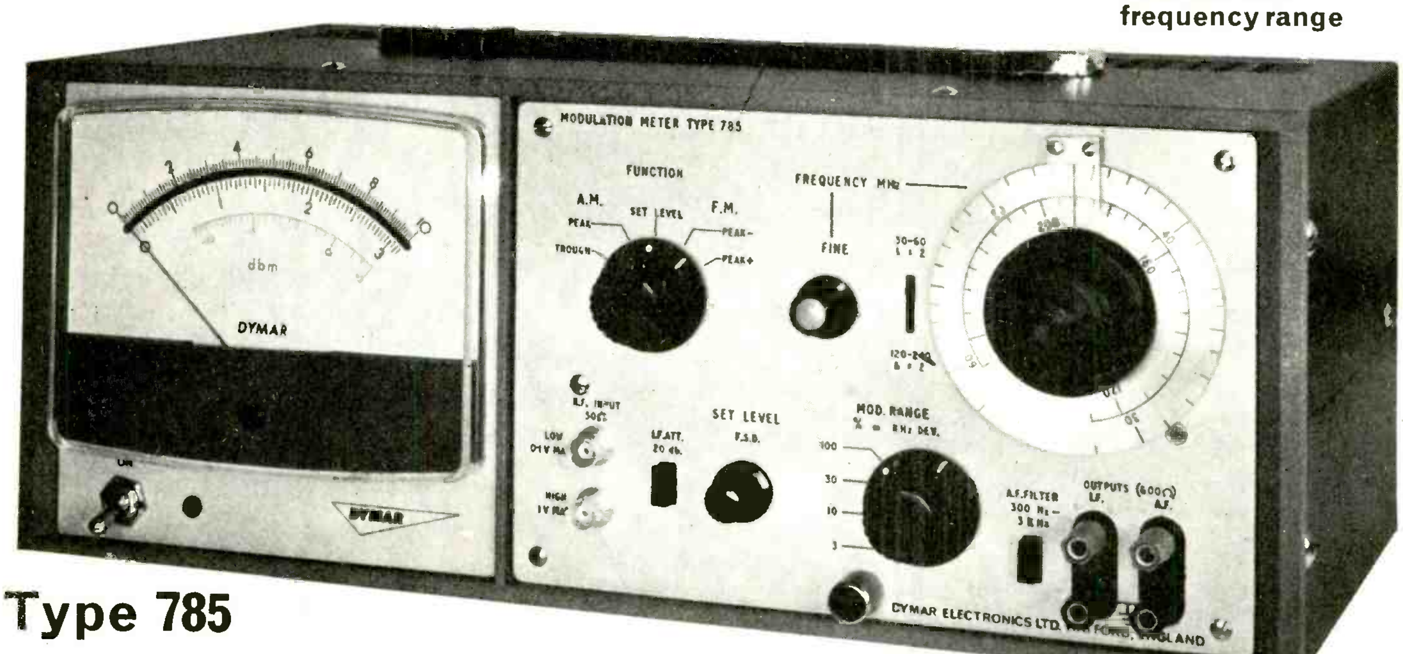
A.M. Modulation Depth:	**3% f.s..d – 100%**
Sensitivity:	**Better than 2 millivolts over the whole frequency range**



Type 785

A.M./F.M. Modulation Meter only £260

Other Dymar Instruments

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After each unit has been passed through visual inspection it is given a full specification check in the test laboratories prior to going on 'soak test'.

When the 72 hours are completed the unit is then given a further full specification check before despatch.

Why have we incorporated this in to our established test procedures, which have always been considered rigorous?

Simply as an added safeguard to ensure that our customers throughout the world receive equipment with the highest possible reliability.

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range of sound equipment

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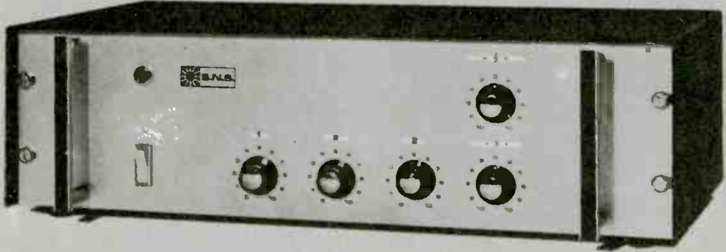
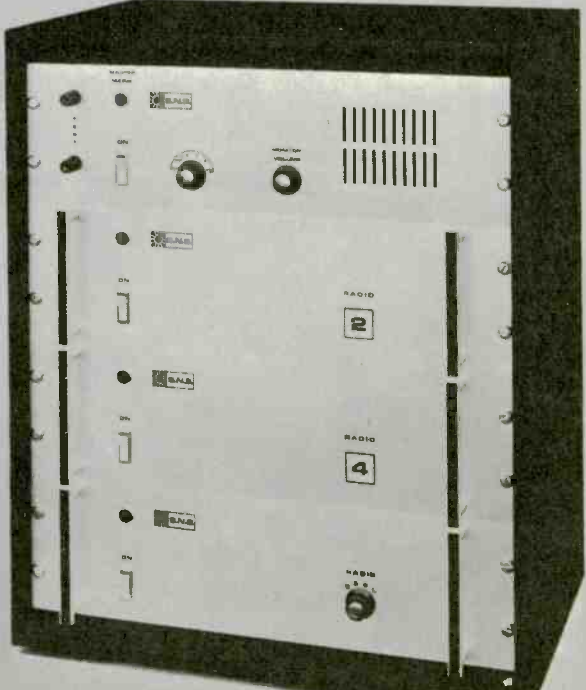
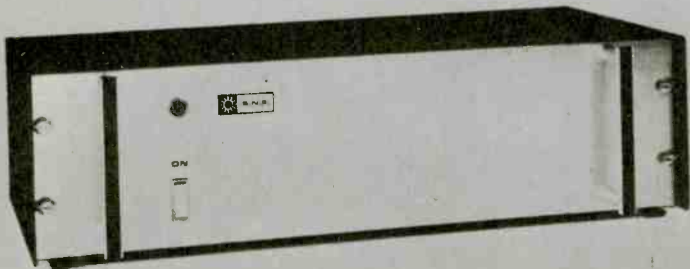
Tested for 72 LONG hours



40 watt multi input amplifier Type PA40



3 channel radio rack
with monitor facilities incorporating
FM crystal controlled tuner amplifiers



100 watt single input amplifier Type CD100

WW—051 FOR FURTHER DETAILS

News of the Decade

Capacitance boxes available from 20pf.-140uf. Accuracies up to 0.05%

Inductance

Air space 1mH-1H
Accuracy 5%

Resistance Boxes

from 0.1-10 MΩ
Average accuracy 0.1%

Resistance Elements suitable for use up to 1MHz.

Jay-Jay Capacitance Boxes

Cat. Ref.			
	Three Decade Model		
C3	100 pf. to 0.111 mfd.	1% Tolerance	**£22.00**
PC3	100 pf. to 0.111 mfd.	½% Tolerance	**£31.50**
	Four Decade Model		
C4	100 pf. to 1.111 mfd.	1% Tolerance	**£35.00**
PC4	100 pf. to 1.111 mfd.	½% Tolerance	**£48.00**
	Switched Capacitance Boxes		
C100	1 mfd. to 100 mfd.	5% Tolerance	**£65.00**
C140	1 mfd. to 140 mfd.	5% Tolerance	**£75.00**
C60	0.1 mfd. to 61 mfd.	5% Tolerance	**£59.00**
C60P	0.1 mfd. to 61 mfd.	1% Tolerance	**£110.00**
	Air Spaced Capacitors		
VC1	10 to 160 pf.	1% Tolerance	**£12.00**
	Variable Capacitors		
VC2	20 to 1130 pf.	1% Tolerance	**£22.00**
VC4	50 pf. to 0.1114 mfd.	1% Tolerance	**£28.75**
VC5	50 pf. to 1.1114 mfd.	1% Tolerance	**£43.00**
	Precision Air Spaced Capacitors		
PVC1	5 to 200 pf.	½% Tolerance	**£36.00**
	Precision Variable Capacitor		
PVC2	15 to 100 pf.	½% Tolerance	**£44.00**
	Precision Incremental Capacity		
PVC4	±0.5 pf. and ±5 pf.	1% Tolerance	**£36.00**
	Precision Variable Capacitor		
SVC5	50 pf. to 1.1114 mfd. ±0.05% tolerance—major decade		**£230.00**

Jay-Jay Junior Decade Capacitance Boxes

Cat. Ref.	Accuracy 1%	
JC1	3 Decade 100 pf. to 0.111 mfd.	**£12.90**
JC2	3 Decade 30 pf. to 10,140 pf.	**£13.70**

High Dissipation Resistance Boxes

	Five Decade		
HD1	0 to 1,111,100 ohms by 10 ohm steps	1% Tolerance	**£45.00**
HD5	0 to 1,111,100 ohms by 10 ohm steps	5% Tolerance	**£35.00**
HD1/L	0 to 111,110 ohms by 0.1 ohm increments	1% Tolerance	**£47.00**

Jay-Jay Inductance Boxes

Cat. Ref.		
L1	3 Decade 1 mH to 1 Henry	**£37.00**
L2	2 Decade 1 mH to 100 mH	**£26.00**
L3	2 Decade 10 mH to 1 Henry	**£29.45**

Jay-Jay "Point One" Resistance Boxes

Cat. Ref.	Average Accuracy 0.1%	
	Four Decade	
R5	0 to 111,100 ohms by 10 ohm steps	**£24.00**
R4	0 to 11,110 ohms by 1 ohm steps	**£24.50**
R3	0 to 1,111 ohms by 1/10 ohm steps	**£25.00**
	Five Decade	
R11	0 to 10 meg ohms by 100 ohm steps	**£34.50**
R7	0 to 1,111,100 ohms by 10 ohm steps	**£29.25**
R9	0 to 111,110 ohms by 1 ohm steps	**£29.75**
R10	0 to 11,111 ohms by 1/10 steps	**£30.25**
	Six Decade	
R20	To 1,111,110 by 1 ohm steps	**£36.00**
R21	02 111,111 by 0.1 ohm steps	**£36.50**
R22	0 to 11,111.1 by 0.01 ohm steps	**£37.00**

Jay-Jay Junior Decade Resistance Boxes

Cat. Ref.	Average Accuracy 0.4%	
	Six Decade	
J60	Range 0 to 1,111,100 ohm by 1 ohm steps	**£18.90**
	Five Decade	
J1	Range 0 to 1,111,100 by 10 ohm steps	**£15.60**
J2	Range 0 to 111,110 by 1 ohm steps	**£15.40**
	Four Decade	
J3	Range 0 to 111,100 by 10 ohm steps	**£12.40**
J4	Range 0 to 11,110 by 1 ohm steps	**£12.20**
	Three Decade	
J5	Range 0 to 11,100 by 10 ohm steps	**£9.95**
J6	Range 0 to 1,110 by 1 ohm steps	**£9.90**

JJ INSTRUMENTS

R.E.C.M.F.
STAND NO.
2.135

Most ranges available from stock.
Write for descriptive leaflet or demonstration.

J.J. Lloyd
Instruments Limited
Brook Avenue, Warsash, Southampton SO3 6HP.
Tel: Locks Heath 4221

WW—052 FOR FURTHER DETAILS

CONCEPT FOR THE 70's

The new Storno fully automatic VHF/UHF radio communication system permits direct two-way selection dialling between mobiles and any telephone extension connected to a private automatic exchange. There are also facilities for car-to-car dialling and for predetermined selection of most frequently used extensions.

Storno is ready for the 70's—and beyond

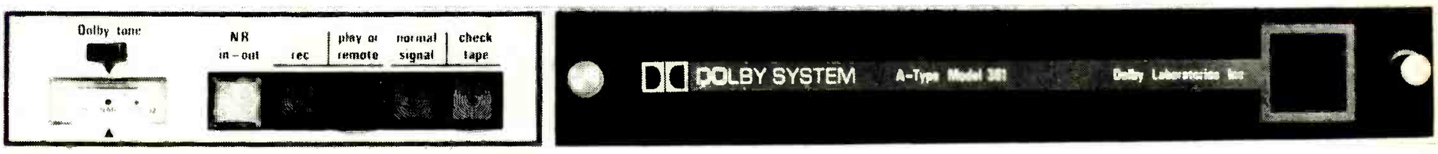
FM radiotelephones are better

Storno Ltd Frimley Road Camberley Surrey Telephone Camberley 0276 5201 Telex 85154

WW—053 FOR FURTHER DETAILS

The Dolby 360 Series

Nearly a thousand of these new units are already in use.



Each Series 360 unit is only $1\frac{3}{4}$ inches (44 mm) high. 16 channels therefore require only 28 inches of rack space.

Full compatibility with the A301

Models 360 and 361 are single-channel A-type (professional) noise reduction units which process signals identically to the two-channel A301. The new units are small in size and are designed for simplified installation and use of the Dolby System with 16-track recorders. The cost of the 360 series is somewhat less than that of the A301 for an equivalent number of channels.

Automatic record/play changeover in the 361

The Model 360 is a single-channel noise reduction processor unit. The Model 361 is identical to the 360 in size and appearance, but contains facilities for automatic record/play changeover controlled from the recorder. In the new series, the operating mode is set and clearly displayed by illuminated push-button switches.

Internal oscillator An internal "Dolby Tone" oscillator is provided for establishing correct operating levels. The characteristic modulation of the tone also identifies Dolby-processed tapes. All oscillators in a multi-track installation can be controlled by a single switch.

High stability The circuit is highly stable and does not require routine adjustment. A removable front panel allows input and output levels to be adjusted from the front of each unit. The panel also provides access to relays and the noise reduction module.

Single-module design The noise reduction circuitry is contained in a single module which can be purchased separately. Should failure ever occur, plug-in substitution will restore operation of the system in seconds with no adjustments necessary.

Prices, delivery information and complete specifications are available from

DOLBY LABORATORIES INC

333 Avenue of the Americas New York NY 10014
(212) 243-2525 cables: Dolbylabs New York

UK and International
346 Clapham Road London SW9
(01) 720-1111 telex: 919109 cables: Dolbylabs London

WW—054 FOR FURTHER DETAILS

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are

Demonstrating their Range

of

UNIT AUDIO SYSTEMS

in

Room 1010

SKYWAY HOTEL

March 31st SONEX '71 April 4th

WW—055 FOR FURTHER DETAILS

TELEPRINTERS · PERFORATORS REPERFORATORS · TAPEREADERS DATA PROCESSING EQUIPMENT

SALE OR HIRE

2-5-6-7-8 TRACK AND MULTIWIRE EQUIPMENT

Special Codes Prepared

TELEGRAPH AUTOMATION AND COMPUTER PERIPHERAL ACCESSORIES DATEL MODEM TERMINALS, TELEPRINTER SWITCHBOARDS

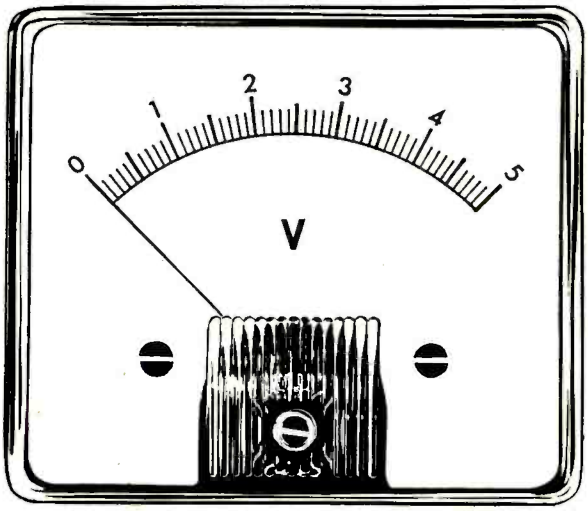
Picture Telegraph, Desk-Fax, Morse Equipment: Converters and Stabilised Rectifiers; Line Transformers and Noise Suppressors; Tape Holders, Pullers and Fast Winders; Governed, Synchronous and Phonic Motors; Teleprinter Tables and Cabinets; Silence Covers; Distortion and Relay Testers; Send/Receive Low and High Pass Filters; Teleprinter, Morse, Teledeltos Paper, Tape and Ribbons; Polarised and specialised Relays and Bases; Terminals V.F. and F.M. Equipment; Telephone Carriers and Repeaters; Diversity; Frequency Shift, Keying Equipment; Racks and Consoles; Plugs, Sockets, Key, Push, Miniature and other Switches; Cords, Connectors, Wires, Cables, Jack and Lamp strips, and Switchboard Accessories; Teleprinter Tools; Stroboscopes and Electronic Forks; Cold Cathode Matrics; Test Equipment; Miscellaneous Accessories, Teleprinter and Teletype Spares.

W. BATEY & COMPANY

Gaiety Works, Akeman Street, Tring, Herts
Tel: Tring 3476 (STD 0442 82) Cables: RAHNO TRING
Telex: 82362, A/B BATEY TRING

WW—056 FOR FURTHER DETAILS

METER PROBLEMS?



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

Full Information from:

HARRIS ELECTRONICS (London)

138 GRAYS INN ROAD, W.C.1 Phone: 01/837/7937

WW—057 FOR FURTHER DETAILS

Sansui control amplifiers. Whenever you're ready.

Whenever you're ready for the added professionalism of a control amplifier, Sansui is also ready. With a complete line of quality units in every power and price range. Each a distinguished example of Sansui's dedication to stereophonic perfection.

If you're ready for the most complete, the most powerful such amplifier, then the 180 watt solid state AU-999 is for you. The undisputed champion in the field, it offers the most advanced circuitry yet developed, boasts a 10 to 30,000Hz power bandwidth and keeps distortion of any type to 0.4% or less. The AU-999 also offers separately usable pre- and power amplifiers, a Triple Tone Control circuit, and the capability of handling three sets of speaker systems and two tape decks.

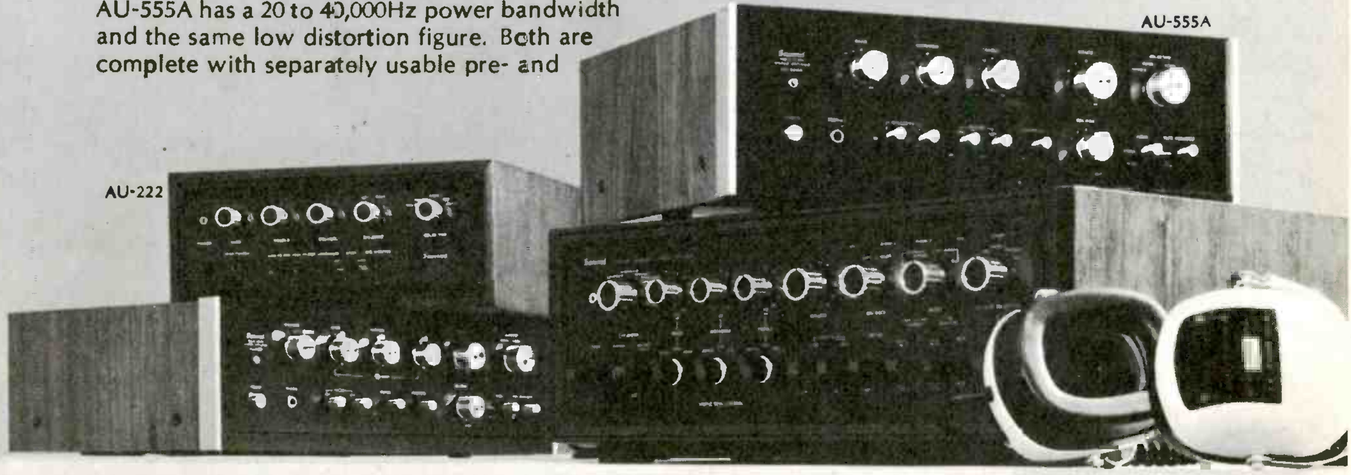
For those more inclined toward the middle power ranges, there's the 100 watt AU-666 and 85 watt AU-555A, both striking examples of engineering excellence. The AU-666 has a wide 10 to 40,000Hz power bandwidth and limits distortion to a low 0.5%, while the AU-555A has a 20 to 40,000Hz power bandwidth and the same low distortion figure. Both are complete with separately usable pre- and power amplifier sections and Sansui's unique Triple Tone Control circuit.

And in compacts, nothing quite approaches Sansui's 46 watt AU-222 for completeness and versatility. Endowed with a 20 to 20,000Hz power bandwidth, it minimizes distortion at 0.8% or less, and offers no fewer than six inputs—more than any other amplifier of its size.

Whichever you choose, enjoy it more fully with Sansui's advanced SS-20 stereo headphone set, a 2-way 4-speaker unit complete with separate controls for tonal quality and volume. No other stereo headphone set is geared so perfectly to exploiting Sansui control amplifiers.

So whenever you're ready for the undeniable advantages of such an amplifier, see your nearest authorized Sansui dealer. He's ready with a full selection.

Sansui



England: VERNITRON (UK) LTD. Thornhill Southampton S09 5QF Tel: Southampton 44811 / Ireland: RADIO CENTRE 122A, St. Stephen's Green, Dublin 2 /West Germany: COMPO HI-FI G.M.B.H. 6 Frankfurt am Main, Reuterweg 65 / Switzerland & Liechtenstein: ECLI, FISCHER & CO. LTD. ZURICH 8022 Zurich, Gotthardstr. 6, Claridenhof / France: HENRI COTTE & CIE 77, Rue J.-R. Thorelle, 77, 92-Bourg-la-Reine / Luxembourg: LUX Hi-Fi 3, rue Glesener, Luxembourg / Austria: THE VIENNA HIGH FIDELITY & STEREO CO. A 1070 Wien 7, Burggasse 114 / Belgium: MATELECTRIC S.P.R.L. Boulevard Léopold II, 199, 1080 Brussels / Netherlands: TEMPOFOON N.V. Tilburg, Kapitein Hatterasstraat 8, Postbus 540 / Greece: ELINA LTD. 59 & 59A Tritis Septemvriou Street, Athens 103 / Italy: GILBERTO GAUDI s.a.s. Piazza Mirabello 1, 20121 Milano / South Africa: GLENS (PTY) LTD. P.O. Box 6406 Johannesburg / Cyprus: ELECTROACOUSTIC SUPPLY CO., LTD., P.O. Box 625, Limassol / Portugal: CENTELEC LDA. Avenida Fontes Pereira de Melo, 47, 4.o dto., Lisboa-1 / Malta: R. BRIZZI 293, Kingsway, Valletta / Canary Islands: R. HASSARAM Calle la Naval, 93, Las Palmas / SANSUI AUDIO EUROPE S.A. Diacem Bldg., Vestingstraat 53-55, 2000 Antwerp, Belgium / SANSUI AUDIO EUROPE S.A. FRANKFURT OFFICE 6 Frankfurt am Main, Reuterweg 93, West Germany / SANSUI ELECTRIC CO., LTD. 14-1, 2-chome, Izumi, Suginami-ku, Tokyo, Japan

WW—058 FOR FURTHER DETAILS

We take it all back!

We were right about the sales support we'd need to sell our LM 1240 digital multimeter.

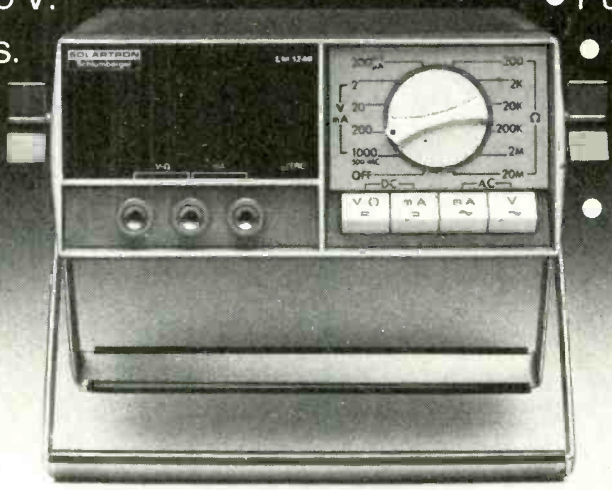
It doesn't need any, it's selling itself.

So if when you order your LM 1240 direct from this ad., you are not completely satisfied that it does all we say of it, we'll take it back within 14 days and return your money in full.

Beat that for reassurance!

Just look at this spec.

- Volts: 100 µV–1,000 V.
- Amps: 100 nA–2 amps.
- Ohms: 100 m–20 M.
- 26 ranges.
- Bi-polar.



- Full overload protection.
- 1999 scale length.
- Dual slope integration for noise rejection.
- Go-anywhere portability.

SIMPLY SEND THIS COUPON TO YOUR PURCHASING DEPARTMENT—OR TO US.

I would like to buy Solartron's LM 1240 Multimeter. If it doesn't give full satisfaction we can return it within 2 weeks of delivery and cancel our order without further obligation.

Please order me LM 1240s at £195 each, including P. & P.

ORDER NO.

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COMPANY

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ADDRESS FOR SHIPMENT

SIGNED

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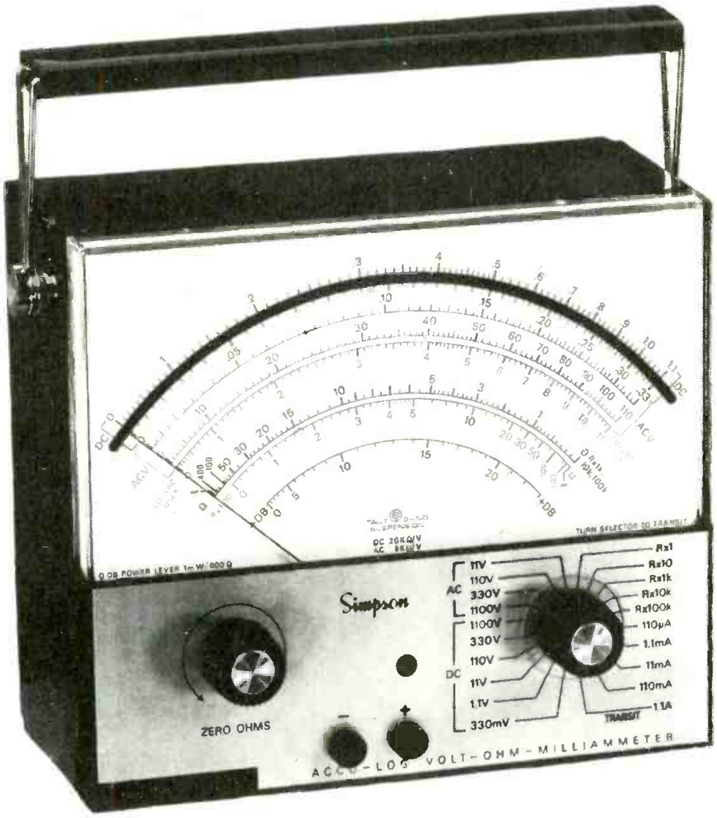
Schlumberger

The Solartron Electronic Group Ltd
Farnborough Hampshire England
Tel: 44433

WW—059 FOR FURTHER DETAILS

Simpson Electronic Multimeters

Introducing the ACCU-LOG



The first Multimeter to give you consistent "percent-of-reading" accuracy . . . anywhere on the readout scale.

Model 202 offers:

- MAXIMUM ACCURACY ANYWHERE ON THE SCALE
- RANGES OVERLAP FOR CONVENIENT OPERATION
- RUGGED TAUT BAND SUSPENSION
- OVERLOAD PROTECTED

BACH-SIMPSON LIMITED
331 UXBRIDGE ROAD, RICKMANSWORTH, HERTS. WD3 2DS Telephone Rickmansworth 76900

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TRANSFORMERS

MAINS

2VA to 2kVA

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10W to 5000W

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224 HORNSEY ROAD, LONDON, N.7
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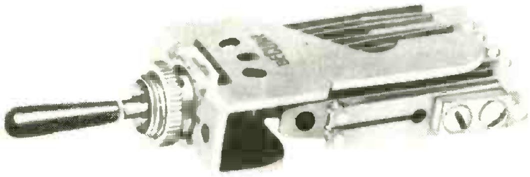
"BECUWE" MINIATURE LEVER KEYS



Designed for compact modern equipment, for all climates, these miniature keys are only 0.425" wide by 0.78" long and 1.76" deep behind panel.

BRITEC LIMITED
17 CHARING CROSS ROAD, LONDON, WC2H OER. Tel: 01-930 3070

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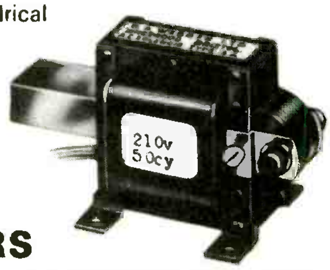
ENCAPSULATION –

low tool cost method of cylindrical coils and potting. Enquiries also for:—



REED RELAYS
SOLENOIDS
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to 8 K.V.A.

A.C. SOLENOID TYPE SAM/T.

R. A. WEBBER LTD.
9 Knapps Lane, Bristol 5. 0272 657228

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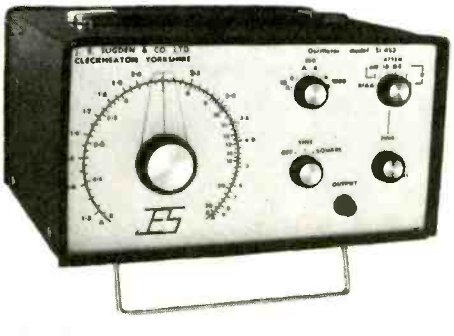


JES AUDIO INSTRUMENTATION

Illustrated the Si453 Audio Oscillator

SPECIAL FEATURES:

- ★ very low distortion content—less than .05%
- ★ an output conforming to RIAA recording characteristic
- ★ battery operation for no ripple or hum loop
- ★ square wave output of fast rise time

£40.00

also available

Si451 Millivoltmeter
- ★ 20 ranges also with variable control permitting easy reading of **relative** frequency response

£35.00

Si452 Distortion Measuring Unit
- ★ low cost distortion measurement down to .01% with comprehensive facilities including L.F. cut switch, etc.

£30.00

J. E. SUGDEN & CO. LTD., BRADFORD ROAD, CLECKHEATON, YORKS. Tel: Cleckheaton (OWR62) 2501

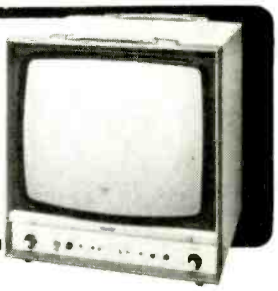
WW—063 FOR FURTHER DETAILS

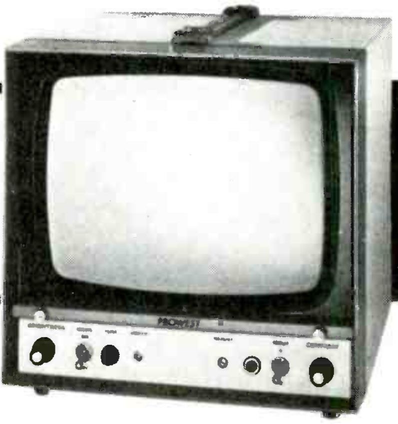
prowest *for* PICTURE MONITORS

Brief details of the wide range of all-silicon solid-state monitors are shown below. Please contact us for full information.

Screen Sizes
14"
19"
20"
(20" illuminant D)
Series 1A

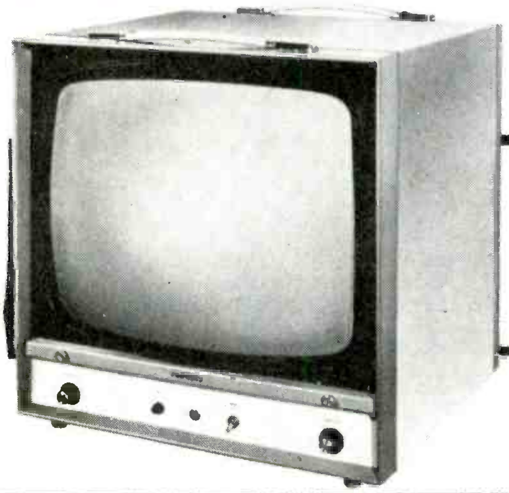
High quality monochrome monitors suitable for use either in T.V. studios or laboratory applications demanding the highest possible performance. Facilities include electrical centering, modular circuit design and separately stabilised E.H.T. These together with exceptional stability and high brightness capability are some of the notable features of this range.





Designed for a wider range of less demanding applications and offering an extended choice of screen sizes. Ideally suited for general studio uses, high performance industrial systems and data display. Many optional features are available including remote control facilities and special c.r.t. phosphors.

Screen Sizes
11"
14"
19"
24"
Series 3A



The economy range of monochrome monitors incorporating the already familiar Prowest high standards of construction and design. The attractive price, smart appearance and rugged construction make these displays suitable for a wide range of office and industrial environments.

Screen Sizes
12"
19"
Series 5A

Screen Size
22"
Series 7A

A keenly priced precision colour monitor in the grade 1 class using the latest 22″ 4 : 3 aspect ratio shadow mask c.r.t. Excellent stability, remote operation of certain user controls, integral plug-in PAL or N.T.S.C. decoder, natural convection cooling and front panel purity control are some of the notable features.

CUSTOM-BUILT UNITS

From a wide range of tested and proven sub-units, Prowest are able to offer attractively priced custom-built display assemblies in special packaging. Applications include data terminals, military and scientific displays, and airport flight indicators etc. Your enquiries are invited.

prowest

Prowest Electronics Limited
AIRFIELD ESTATE
WHITE WALTHAM
MAIDENHEAD, BERKS. ENGLAND
Telephone Littlewick Green 3226/8
Telex 847241

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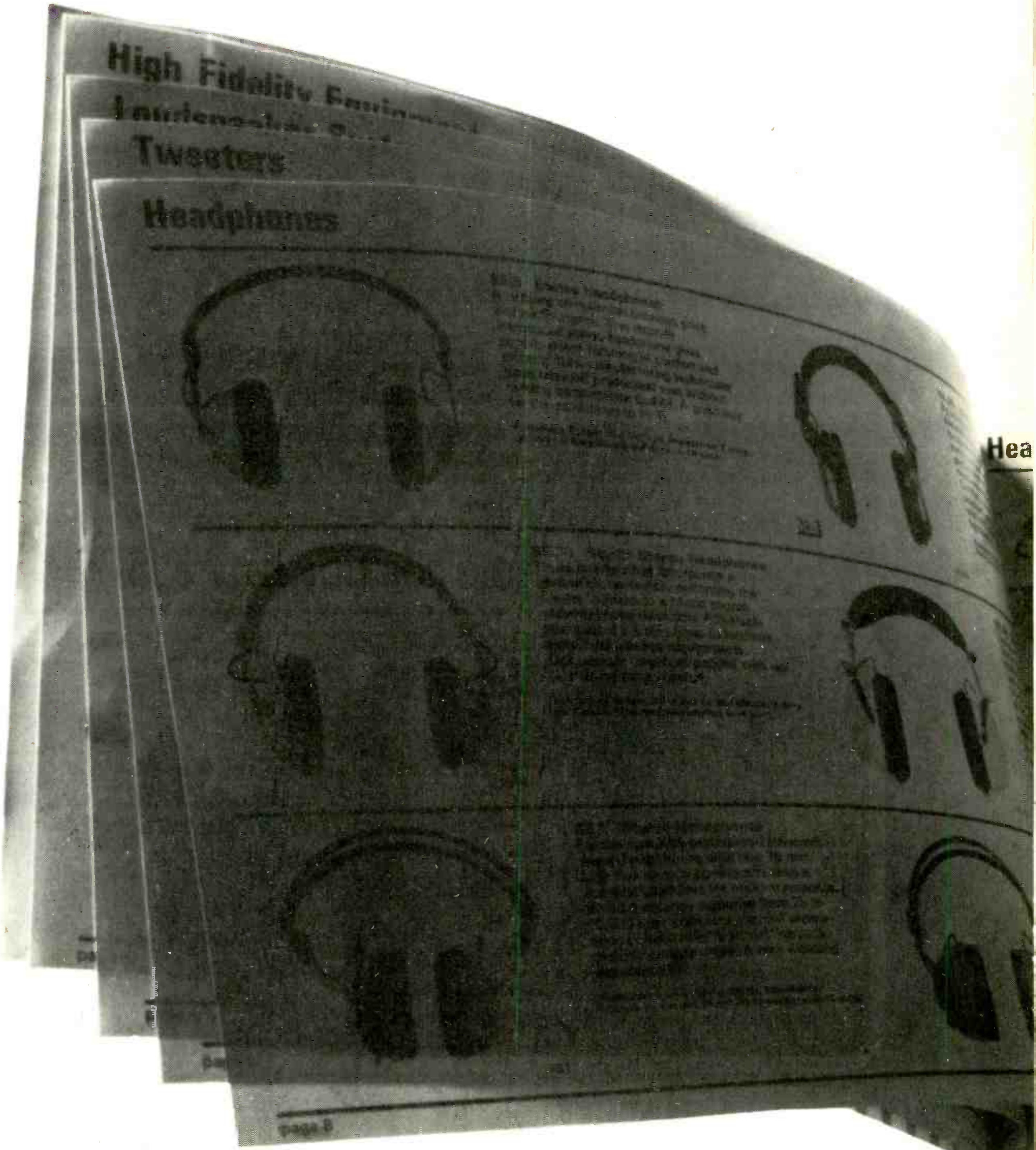

High Fidelity Equipment
Tweeters
Headphones
Hea
page 8

The Eagle Annual.

Sorry, no Dan Dare, Digby or P.C. 49. Because this is the new Eagle annual catalogue. And it's packed with interesting things. Like the new TSA 151 stereo amplifier: it uses a new block construction silicon output device for absolute reliability. It's got low noise silicon transistors throughout. Its output is 15 Watts per channel. That's 15 Watts RMS, not an exaggerated figure for maximum music power.

The price? A very reasonable £36.

And for people who like to listen to stereo undisturbed, we've got the new SE 100 headphones.

Dual cone transducers are used throughout, and to keep the weight down, the independent volume controls are mounted on a separate unit with a pocket clip. £16·00.

Every item in the annual has been specified or selected by Gerry Adler. Eagle is Gerry's baby, and he's very fussy about what goes out under the Eagle banner. He gets very twitchy at the thought of a duff diode. A bit like the Mekon in fact.

But he does it for a reason.

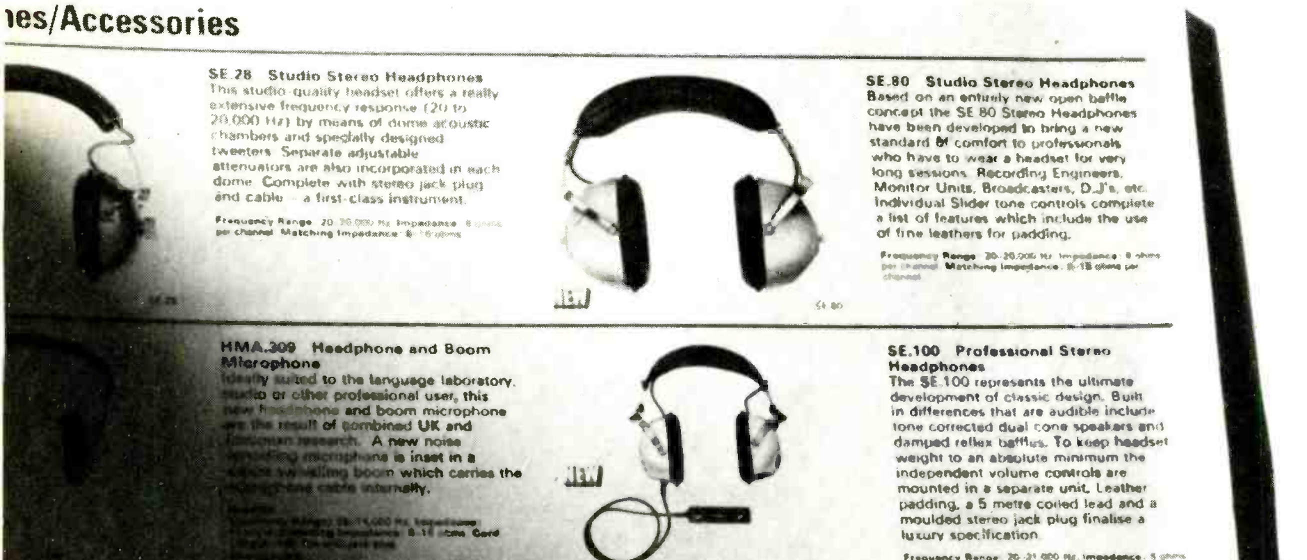
He believes that if the first Eagle product you buy is O.K., you'll come back for more.

That's what's made Eagle a success.

Eagle International

we don't stand still.

Coptic Street, London WC1A 1NR
Tel: 01-636 0964



ies/Accessories

SE.28 Studio Stereo Headphones
This studio-quality headset offers a really extensive frequency response (20 to 20,000 Hz) by means of dome acoustic chambers and specially designed tweeters. Separate adjustable attenuators are also incorporated in each dome. Complete with stereo jack plug and cable — a first-class instrument.

Frequency Range 20-20,000 Hz Impedance 8 ohms per channel Matching Impedance 8-16 ohms

SE.80 Studio Stereo Headphones
Based on an entirely new open baffle concept the SE 80 Stereo Headphones have been developed to bring a new standard of comfort to professionals who have to wear a headset for very long sessions. Recording Engineers, Monitor Units, Broadcasters, D.J's, etc. Individual Slider tone controls complete a list of features which include the use of fine leathers for padding.

Frequency Range 20-20,000 Hz Impedance 8 ohms per channel Matching Impedance 8-16 ohms per channel

HMA.309 Headphone and Boom Microphone
Ideally suited to the language laboratory, studio or other professional user, this new headphone and boom microphone are the result of combined UK and [illegible] research. A new noise [illegible] microphone is inset in a [illegible] swivelling boom which carries the microphone cable internally.

[illegible]

SE.100 Professional Stereo Headphones
The SE.100 represents the ultimate development of classic design. Built in differences that are audible include tone corrected dual cone speakers and damped reflex baffles. To keep headset weight to an absolute minimum the independent volume controls are mounted in a separate unit. Leather padding, a 5 metre coiled lead and a moulded stereo jack plug finalise a luxury specification.

Frequency Range 20-21 000 Hz. Impedance 8 ohms Matching Impedance 8-16 ohms

[illegible] Carrying Case
[illegible]

JB.3 Stereo Headphone Junction Box
This simple, inexpensive unit is essential to stereo headphone users. It connects to amplifier and loudspeakers, giving attenuated stereo headphone output, with a three-position switch to give headphones only, speakers only, or both together.

Input: Suitable for connection to any amplifier up to 30 watts output. Output: 50 mW Size: 74 x 80 x 28 mm.

page 9

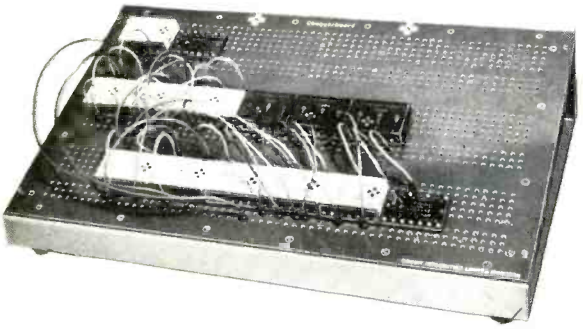
See us at RECMF, Stand No. 3. 142, Olympia

WW—065 FOR FURTHER DETAILS

I. C. Breadboarding ?

then you need . . .

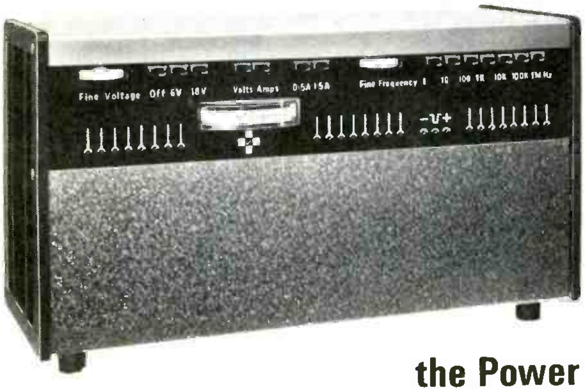
CHEQUERBOARD PATCHBOARDS . . .



Chequerboards provide an easy plug-in facility for all integrated circuit modules. Interconnection is via plug-in cords for easy non-soldering interchange of all modules.

The Chequerboard Patchboard consists of a series of bussed sockets on a 0.250" pitch. Integrated circuits or discrete components are then mounted on standard carriers, which can easily be inserted and removed by hand from the Patchboard. Thus, integrated circuits can be used again and again without fear of mechanical damage. Paper designs can be checked, modified and proved with ease and simplicity—quickly.

and . . .



the Power

The CU 100 series of power supplies are designed for use with the Chequerboard series of Patchboards. They provide the necessary stabilised power, a set of logic indicators and a source of clock pulses.

- 1.5 amps — 2 to 6 volts ■ or 0.5 amp — 6 to 18 volts.
- Overload protection.
- 0.5 c/s to 5 Mc/s square wave generator.
- Integral neon logic level indicators.

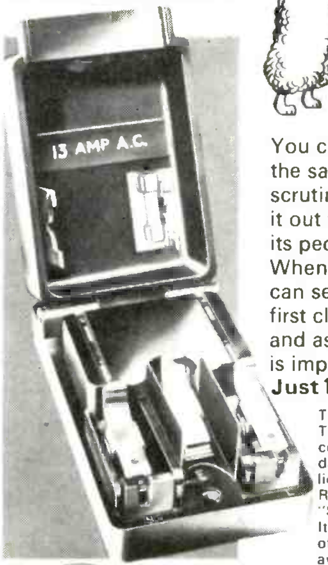
We shall be glad to send you our 15 page fully illustrated brochure, telling you all about CHEQUERBOARD PATCHBOARDS — ACCESSORIES — POWER UNITS — EDUCATIONAL KITS, etc.

If your enquiry is urgent—contact:
JEFF JEVANS (Sales Director)
17 RYE WALK INGATESTONE ESSEX
Telephone: INGATESTONE 3185

CIRCUIT INTEGRATION LIMITED
CANAL STREET RUNCORN CHESHIRE TEL: 75973/4

WW—066 FOR FURTHER DETAILS

Looking for a safer breed of Connector?



You choose electrical equipment in much the same way you choose a dog: you scrutinise and examine carefully, and take it out for a trial run. And you ask to see its pedigree.
When you handle a Rendar product, you can see at once that it's a better breed: first class materials; precision machinery and assembly; sound design. Its pedigree is impeccable.

Just 1 winner from the Rendar kennel

The Rendar Safebloc saves time and saves life. There's no need to fit a plug for testing – just connect the apparatus direct. And there's no danger of shocks – no current can pass until the lid is closed.
Rendar pioneered this concept, and introduced the "Safebloc" to the British market over 12 years ago. It's indispensable on testing lines, and for all kinds of electrical demonstrations. Double Safebloc available for 3-phase applications.

INSTRUMENTS FOR LAND WATER & AIR

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INSTRUMENTS LTD
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Tel. 2642-4, Cables RENDAR Burgess Hill

WW—067 FOR FURTHER DETAILS

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KONTAKT "Cold Spray 75"

For rapid and effective fault location

Non-toxic, non-inflammable, Cold Spray 75 is a chemically inert coolant capable of producing temperatures of down to —42 centigrade. It can also be used to prevent heat damage during soldering processes, for the rapid freezing of small articles for biological and technical purposes and the prompt location of hairline cracks and other faults in temperature dependent components.

Other Kontakt products:
Kontakt 60 and Kontakt 61 for relay contact cleaning.
Plastic Spray 70, transparent protective lacquer.
Insulating Spray 72.
Kontakt WL. Spray Wash.
Antistatic Spray 100. Antistatic agent for plastics.
Politur 80. Polish and cleaner.
Fluid 101. Dehydrating Fluid.

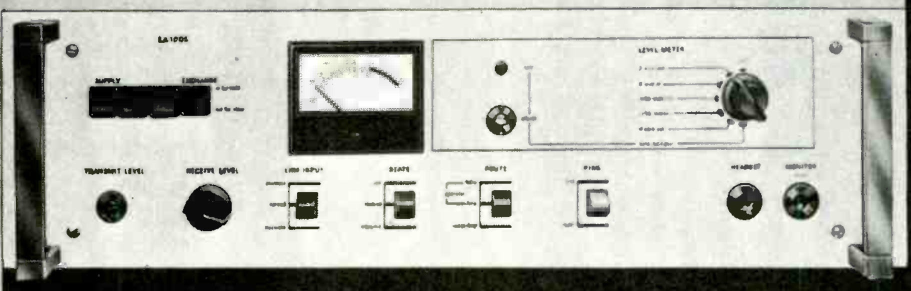
Details from UK distributors.

SPECIAL PRODUCTS DISTRIBUTORS LTD.
81 Piccadilly, London, W.1 Tel: 01-629 9556

WW—068 FOR FURTHER DETAILS

Racal bridges a gap in communications

with this new radiotelephone terminal type LA 1005



In quantity production after successful world-wide acceptance trials, the Racal LA 1005 provides exceptional system flexibility and operational facilities at low cost. Extremely compact, it is suitable for Post and Telegraph Administrations' circuits and ideal for military or civil operation.

- **4 wire radiotelephone to 2 wire or 4 wire telephone circuit.**
- **Automatic voice operated switching.**
- **Fully transistorised.**
- **Visual and aural calling indicators.**
- **Access for speech privacy.**
- **Built-in test oscillator.**

Obtain full details NOW about this essential communication link

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WW—069 FOR FURTHER DETAILS

Celestion

NEW CELESTION LOUDSPEAKERS

MODEL: PS12 TC 1798
TYPE: DUAL CONE 12″
RANGE: 40Hz - 12KHz
POWER: 20 WATTS RMS
FLUX: 128,000 MAXWELLS
IMPEDANCE: 15 or 4-8 OHMS
PRICE (R.R.P.) **£9·00**

MODEL: PS8 TC 9470
TYPE: DUAL CONE 8″
RANGE: 50Hz - 12·5KHz
POWER: 6 WATTS RMS
FLUX: 38,500 MAXWELLS
IMPEDANCE: 15 OHMS
PRICE (R.R.P.) **£2·90**

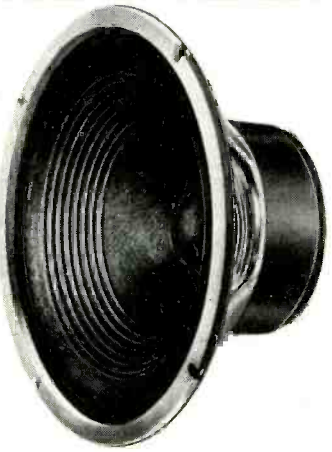
* *Both recommended for Unilex*

NOW AVAILABLE

The Celestion "Ditton 120"

Placed in top Hi-Fi class by reviewers
Supplied in matched pairs — Teak or Walnut
Superb Performance — Economical Price **£48·00** pair

CELESTION 'POWER RANGE'



MODEL: G12M
RANGE: 40Hz - 8KHz
POWER: 25 WATTS RMS
FLUX: 145,000 MAXWELLS
IMPEDANCE: 8 or 15 OHMS
PRICE (R.R.P.) **£12·95**

MODEL: G12H
RANGE: 40Hz - 8KHz
POWER: 30 WATTS RMS
FLUX: 180,000 MAXWELLS
IMPEDANCE: 8 or 15 OHMS
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Forty years of service to particular people

High fidelity is not an end in itself.

The discriminating listener who has gone to considerable trouble in buying and installing equipment in order to hear music to the greatest advantage, will be particular in his choice of records. This is where E.M.G. can help.

E.M.G. is an outstandingly interesting shop which for forty years has specialised exclusively in selling records of classical and serious music. Very large and attractive stocks are carried. But it is not for records and equipment alone that E.M.G. are so widely recognised. The company publishes a privately circulated monthly review of current record releases which is accepted as the finest of its kind by any standards. With the help of the recommendations of **The E.M.G. Monthly Letter** (£1.50 a year, post free) you can choose with confidence and at all times be well informed about records both technically and musically. From now on, then, choosing records could be a much easier and more pleasurable business by starting with 'The Monthly Letter' and if you cannot reach E.M.G. in person to purchase the records you want, the postal department can send them securely to any part of the world (free of purchase tax overseas). (N.B. There is also an exceptionally well stocked equipment department at E.M.G.)

Specimen copy on request

Although it costs only £1.50 for a 12 months' subscription, post free, for **The E.M.G. Monthly Letter,** *if you prefer to see a copy before ordering, a specimen will be sent free on request. Please enclose stamps for 3p when writing.*

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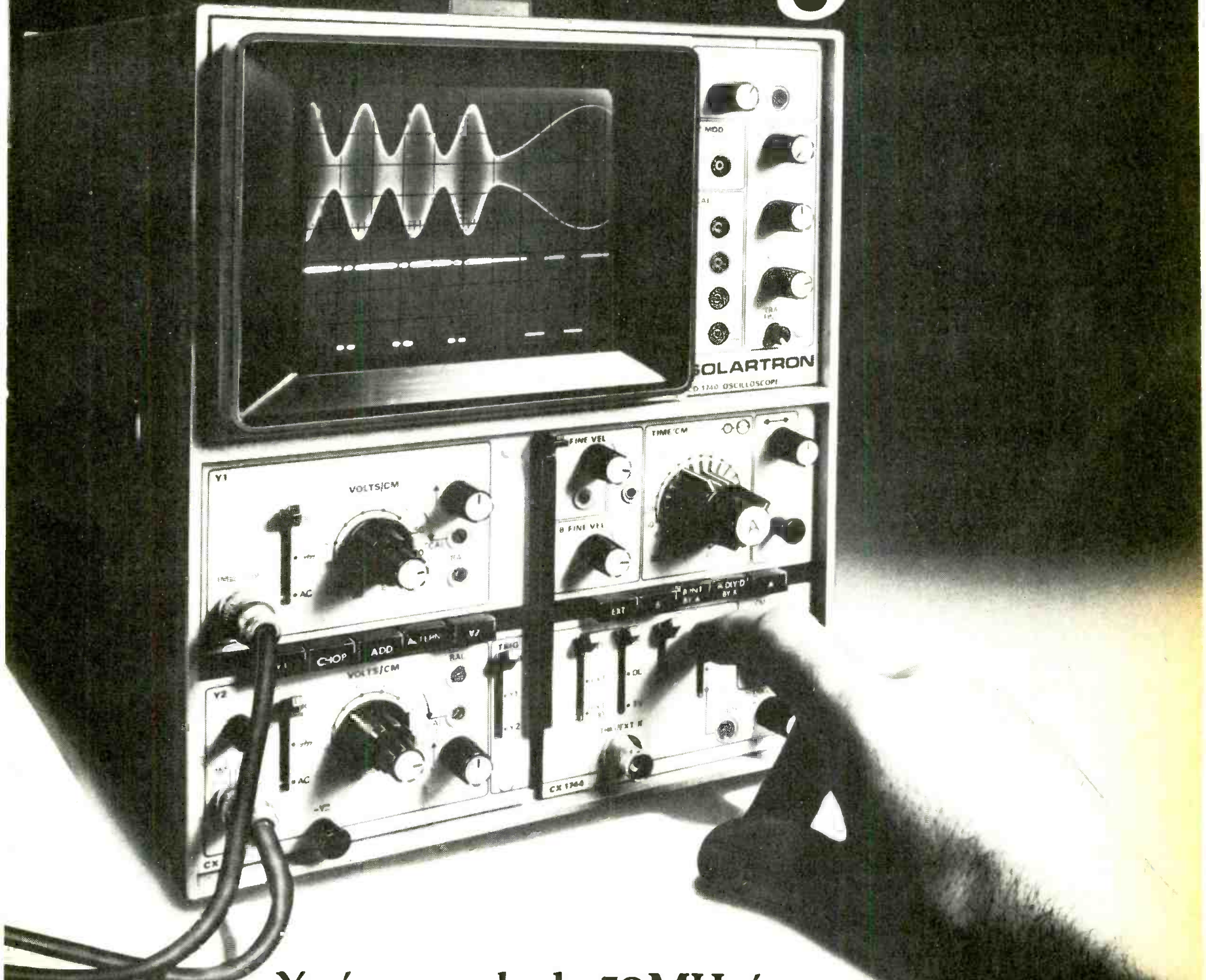
Nearest Underground station Tottenham Court Road.

WW—071 FOR FURTHER DETAILS

The touch of genius!



You've never had a 50 MHz 'scope handle this well–or perform better.

This is the one that handles like a dream, Solartron's outstanding new 50 MHz CD1740.

The push-buttons and lever switches are where you want them, when you want them, on a compact 8$\frac{3}{4}$" × 10$\frac{1}{2}$" front panel.

Take the trigger controls for example. With the five lever switches up, you have fully automatic triggering over the full bandwidth with a bright base line under no signal conditions.

And you simply operate the appropriate clearly designated lever to select a special source, slope level, single shot or coupling (which includes TV sync).

Further, there's a sure-fire trace finder button which brings a free-run brightened trace on screen – whatever the control settings.

But handling apart, the CD1740 packs *real* performance.

The timebase push-buttons give you 10 sweep modes including delayed and delayed gating with the capability of closely inspecting complex wave forms without jitter.

Two identical Y channels with fet inputs give low noise and drift, 600V protected, chopped or alternate, added or differential. And you get 5 mV/cm sensitivity on both X and Y when Y amplifier feeds the X unit.

Add to this an advanced internal graticule mesh tube – run at 12.5 kV – and you have a bright crisp 10 x 8 cm display of excellent geometry right up to the nanosecond speeds available from the timebase.

Just 'feel' the performance and you'll give it the thumbs up.

Post this magazine's reply-paid card and we'll send you our data sheet of full details.

SOLARTRON
Schlumberger

WW—072 FOR FURTHER DETAILS

The Solartron Electronic Group Ltd Farnborough Hants England Tel: 44433

RELIABLE LONG DISTANCE HF SSB RADIOTELEPHONES FOR INDUSTRY, GOVERNMENT AND CONSTRUCTION PROJECTS. FAST DELIVERY.

ASTROFONE "150"

*For point-to-point, mobile and marine use. From US $925**

- 2 to 8 channels; 2 to 18 MHz
- 150 watts P.E.P. Output (Tested beyond 2500 Km.)
- Compact for easy installation. Built-in power supply
- Models for 115/230 volt AC and 12 volt DC operation
- Optional selectable sideband, squelch, crystal ovens, VOX, CW

The Astrofone "150" High Frequency Single Sideband Transceiver is powerful, easy-to-operate and economical. Transistorized receiver and exciter for reliability and performance. Meets applicable International (Geneva) Radio Regulations.

PATROLFONE SC120

The 7.5 kilogram manpack portable with the giant voice. From US $1499 ready to use.*

- 1 to 20 channels, 2 to 10 MHz
- 20 watts rated P.E.P. output (Tested beyond 1000 Km.)
- Operates from any 12 volt source—internal flashlight or rechargeable batteries, vehicular battery, hand-crank generator. AC power supply available
- Military design and rugged construction for field use

Now in use in over 50 countries in every environment from the Amazon to Antarctica by military forces, explorers, geophysical research teams and construction project managers. Completely transistorized.

*Write for quantity prices or see your distributor.

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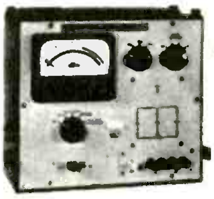
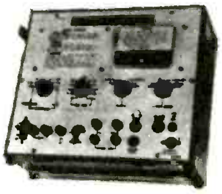
WW—074 FOR FURTHER DETAILS

Put Hatfield to the test





The Hatfield range of Transmission Test Equipment includes the Psophometer Type 1000 which is specified by the Post Office. This rugged battery operated unit incorporates solid state circuitry throughout and is designed for measuring flat or weighted wide-band noise.
The Milliwatt Test Set Type 747 gives laboratory accuracy in portable form making it unnecessary for more than one instrument to standardise signal levels on 75, 140 and 600 ohm circuits. *Send for full details of Hatfield Transmission Test Equipment and a copy of our Short Form Catalogue.*

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THE POWER BEHIND THE

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CONSTANT POTENTIAL CHARGER

Unattended standby units and vital battery installations are supported and protected by the Erskine C.P. charger. The conservatively rated 3-1000 amp range offers: Soft start, independent settings, current protection to short circuit, natural convection cooling . . . and all at a value engineered price. *Send for leaflet.*

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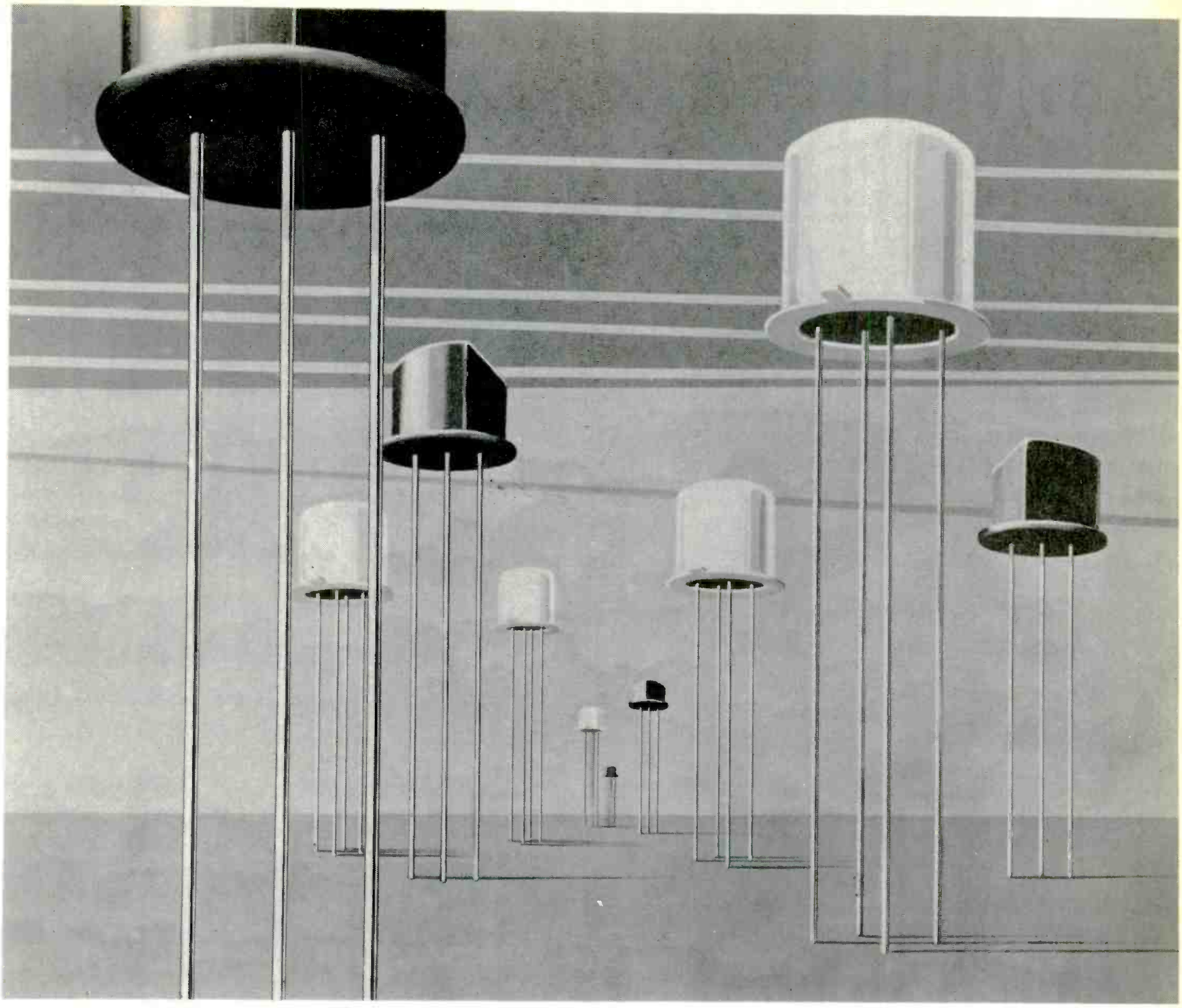

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Or if you have a semiconductor problem why not tell us about it – it's likely we already have the answer.

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T2/71

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A QUALITY BENCH POWER SUPPLY FOR JUST £25!

For only £25, Farnell have produced a bench power supply with a high performance:

Line Stability
± 10% mains change   output change < 2 mV
Load Stability
zero-full load change   output change < 3 mV
Ripple and Noise
at 80 KHz bandwidth   < 1 mV r.m.s.

The output can be switched to provide either 0-30 V, 0·5 A or 0-15 V, 1A with full current capability over the entire voltage range. Precise levels of voltage and current are monitored by a large clear scale meter. The power supply is protected from overload by current limiting circuitry.

This compact general-purpose unit is ideally suited for Industrial and Educational laboratories with limited budgets.

THE E30 FROM

Farnell

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Visit stand 3. 155 R.E.C.M.F.

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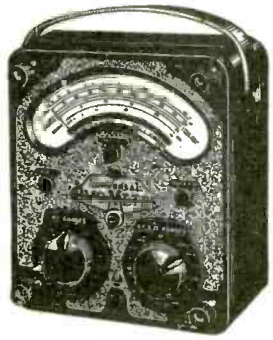

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MODEL AT-1

USED THROUGHOUT THE WORLD, SANWA'S EXPERIENCE OF 30 YEARS ENSURES ACCURACY, RELIABILITY, VERSATILITY, UNSURPASSED TESTER PERFORMANCE COMES WITH EVERY SANWA.

6 Months' Guarantee. Excellent Repair Service.

Model P-28	£4.87	Model K-30THD	£12.60
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Cases available with most meters

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SOLE IMPORTERS IN U.K;

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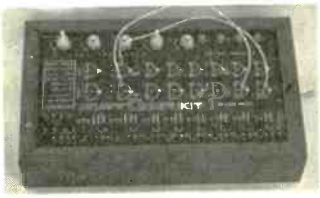
at a *cost you can afford ! !*



Compukit 1 Deluxe Model

"STUDENT PROOF" Electronics
SOLDERLESS System

Comprehensive Instruction Book
Accessories for classroom use.

Specially designed for schools etc., Compukit 1 Deluxe Model is an ideal teaching aid for computer electronics, digital logic and Boolean algebra.

ONLY £17.75

24 Patch leads £2.75
Battery 4½v. Type 126 20p.
Also, standard model Unassembled, Only £10.50 and, Compukit 2 I.C. Patchboard Only £48.00.

Further details of the above a other computer training aids from

LIMROSE ELECTRONICS (WW), LYMM, CHESHIRE
Tel. 092 5753019

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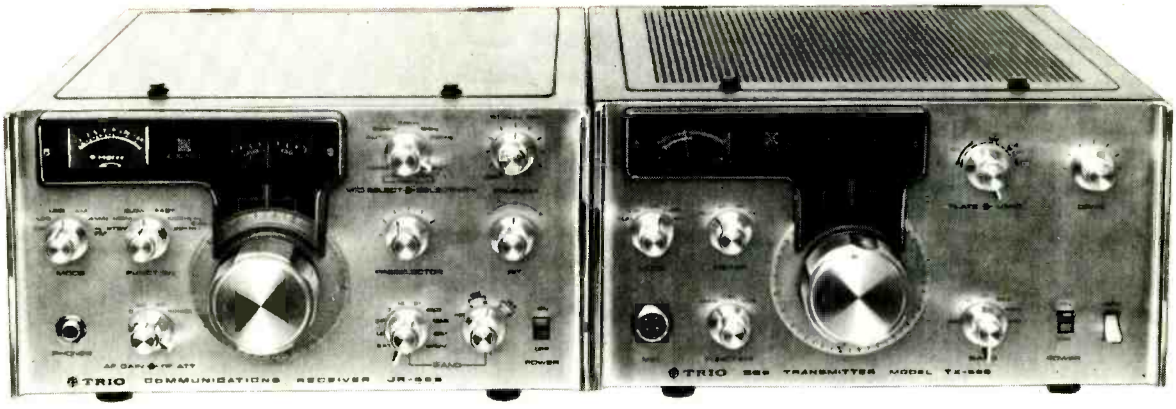

ALL BAND COMMUNICATIONS RECIVER JR-599

ALL BAND SSB TRANSMITTER TX-599

TRIO IS FULLY-EQUIPPED FOR FULL-CYCLE COMMUNICATIONS

TRIO's JR-599 communications receiver brings the highest-type, professional, all-bands potential to amateur bands on an allocated 1.8 to 29.7 MHz frequency range, 50 and 144 MHz bands and WWV's 10 MHz standard signal. A receiver frequency readable to the nearest 500 Hz is guaranteed due to precision type double gear mechanism and variable capacitor with linear characteristic for main tuning dial of a 25 kHz band at one full turn. The all-band SSB TX-599 transmitter matches the JR-599 with its wide-spread IC and FET network. All HF bands are covered with its single switch mode on LSB, USB, AM and CW positions. All of TRIO's equipment—or equipment combinations—is designed to provide entirely full-cycle communications capability.

SP-5D
COMMUNICATIONS SPEAKER
- Communications Speaker which has been designed for use with the 9R-59DS.
- Dimensions: 3-9,16"(W), 7-1/8"(H), 5-3/16"(D).

9R-59DS
BUILT IN MECHANICAL FILTER 8 TUBES COMMUNICATION RECEIVER
- 4 Bands Covering 540KHz. to 30MHz.
- Two Mechanical Filters Ensure Maximum selectivity.

the sound approach to quality—

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TRIO ELECTRONICS, INC.

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W 081 FOR FURTHER DETAILS

Before you even look at Rotel hi-fi equipment get one thing clearly in your head...

The Sound

We promise you that all Rotel equipment is clean lined, good-looking and handsome enough to please the most critical wife.

But, before we even give you a sight of it, we want you to hear something first. For example, that Rotel, still a fairly new name on the hi-fi scene, is building a reputation for the best value-for-money equipment available. That Rotel sports some technical features surprisingly advanced for its price range. That Rotel equipment is being handled and serviced in the UK by The Rank Organisation. And that the Rotel sound sounds right to even the keenest ear.

For starters, we've shown you the details of two Rotel amplifiers and one tuner. If you write to the address below, we'll send you all the information we have on the whole of the big-value range. Or better still, drop in on your dealer.

But whichever you do, do it soon, d'you hear?

RA 310 Stereo Amplifier
Power output: 15 watts RMS per channel into 8 ohm.
Frequency response: 20-30,000 Hz + 0 − 1·5.
Input sensitivity: Mag 3 mV, Aux 200 mV, X'tal 100 mV, Tape Monitor 300 mV.
Hum and noise: Phone 60 dB, Aux 65 dB, Tuner 65 dB.
Separate bass and treble control. Tape monitor switch. Provision for two pairs of speakers (perfect for parties, or upstairs-downstairs listening).
£42.50 (rec. retail price).

RT 320 Stereo AM/FM Tuner (Matching Tuner to RA 310).
Sensitivity: 2·5 μV.
Signal to noise: 60 dB.
Stereo separation: 35 dB.
Price complete with stereo decoder
£54.50 (rec. retail price).

RA 610 Stereo Amplifier
Power output: 30 watts RMS per channel into 8 ohm.
Frequency response: 20-50,000 Hz + 0 − 1·5.
Input sensitivity; Mag 3 mV, Aux 200 mV, X'tal 100 mV, Tape Monitor 300 mV.
Hum and noise: Phono 60 dB. Aux 70 dB, Tape 70 dB, Tuner 70 dB.
Separate bass and treble slide controls for each channel.
Additional facilities include: 2 Phono inputs, 2 auxiliary inputs, low and high filters (which pretty well makes you the owner of a discotheque).
£69.00 (rec. retail price).

ROTEL

Rank Audio Products
Rank Audio Visual Ltd
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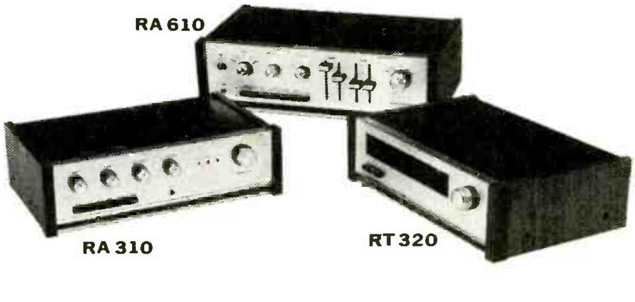
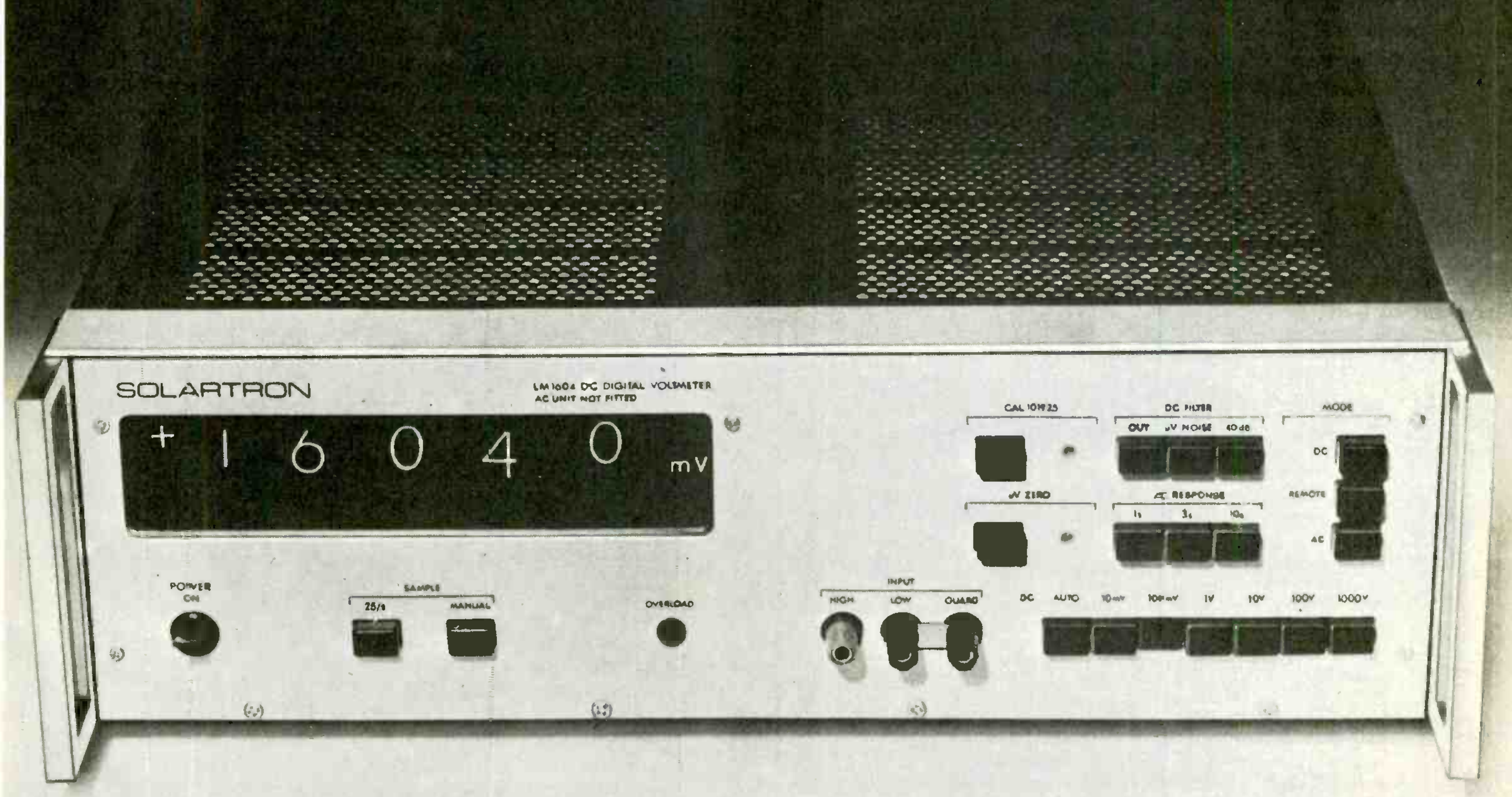
Middlesex Telephone 01-568 9222



WW—082 FOR FURTHER DET .S

Proven great!



Europe's engineers have been acclaiming Solartron's LM 1604 as the most magnificent all-round performance, value-for-money DVM on the market.

They've put it to the test, given it their enthusiastic approval and are coming back with repeat orders.

And the British Armed Forces have had a go. They put it through their rigorous environmental tests and it came through with flying colours and CT number 577.

Now armed forces in Europe are using it.

The LM 1604's proven specification speaks for itself. 1 microvolt sensitivity, infinite noise rejection, 19999 full scale, remote programming–which makes it ideal as the DVM for systems instrumentation–0.005% accuracy at 25 readings/sec., a.c. or d.c. readings, mains locked integration period and auto ranging.

Choose the DVM with built-in integrity.
The proven one.

Post the magazine's reply-paid card and we'll send you full details.

SOLARTRON
Schlumberger

The Solartron Electronic Group Ltd
Farnborough Hampshire England Telephone 44433

WW—083 FOR FURTHER DETAILS

The new PG-71 Pulse Generator costs £150, has two independent channels and one unusual characteristic...

- ✳ High output–dual 10 volts into or from 50Ω
- ✳ Fast <10 ns rise/fall times
- ✳ Wide ranges–period 200 ns–1 sec. (1 Hz–5 MHz) delay 50 ns–1 sec. width 50 ns–1 sec.
- ✳ Gating, external trigger and manual one-shot facilities
- ✳ *True double pulse*–two channels each with independent delay, width and amplitude
- ✳ Pulse advance capability to +1 sec.
- ✳ Super-portable: only 3½" x 9¼" x 11", 7½ lb –battery operation available
- ✳ Internal channel mixing facilities

it sells itself!

More details of the new PG-71 please.

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Position ____________

Company ____________

Address ____________

LI

LYONS INSTRUMENTS
Lyons Instruments Ltd. Hoddesdon England
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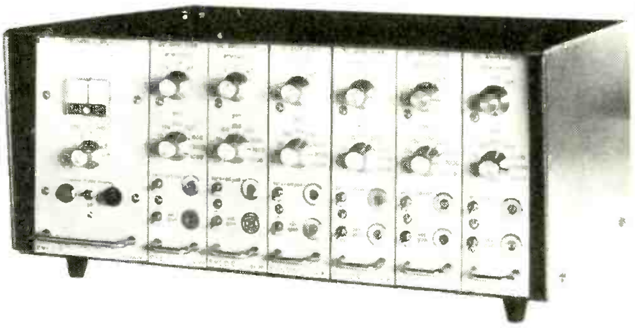
WW—084 FOR FURTHER DETAILS

RECORDER AMPLIFIERS

AND INSTRUMENTATION SYSTEMS



150 *series* DIFFERENTIAL DC AMPLIFIERS

Wide dynamic range—
high common mode rejection
Low noise, low drift performance
Modular or cased presentation

also

MINI-AMP *FE-251-GA*

differential dc pre-amplifier

Compatible modules and cards ensure ease of application and great flexibility.

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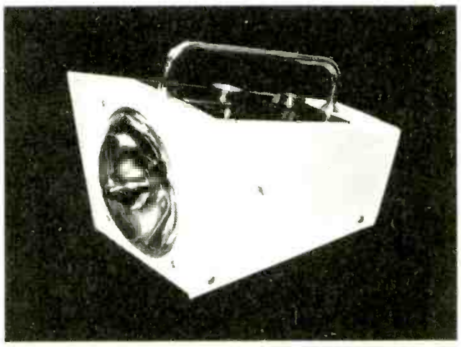
WW—085 FOR FURTHER DETAILS

XENON STROBOSCOPE



A Stroboscope designed primarily for laboratory, industrial and educational applications where the elaboration and expense of more complex equipment may not be required. Features include simplicity of operation, robust construction, exceptionally low price and built in reliability.

The instrument is of modern appearance, small, light in weight, convenient to use and portable. A wide range of flashing rates is covered by the large accurately calibrated dial, allowing operation at low frequencies for strobo photographic experiments and at high speeds for observation of rapidly rotating or reciprocating phenomena.

The external triggering facility permits single shot operation by an external closing contact and also provides a synchronising input for high and low speed repetitive phenomena which might otherwise be difficult to maintain in exact phase.

Light source.	High intensity Xenon tube mounted in a parabolic reflector.
Flashing rate.	1-250 flashes/second in 3 ranges.
Frequency accuracy.	Typically ± 2% of each full scale.
Triggering.	(a) by internal oscillator (b) by external closing contacts.

Price: £38.50

Edwards Scientific International Ltd.
Knowle Road, Mirfield, Yorkshire. Tel: 092484 4242

WW—086 FOR FURTHER DETAILS

new Goodmans Module 80 Tuner Amplifier

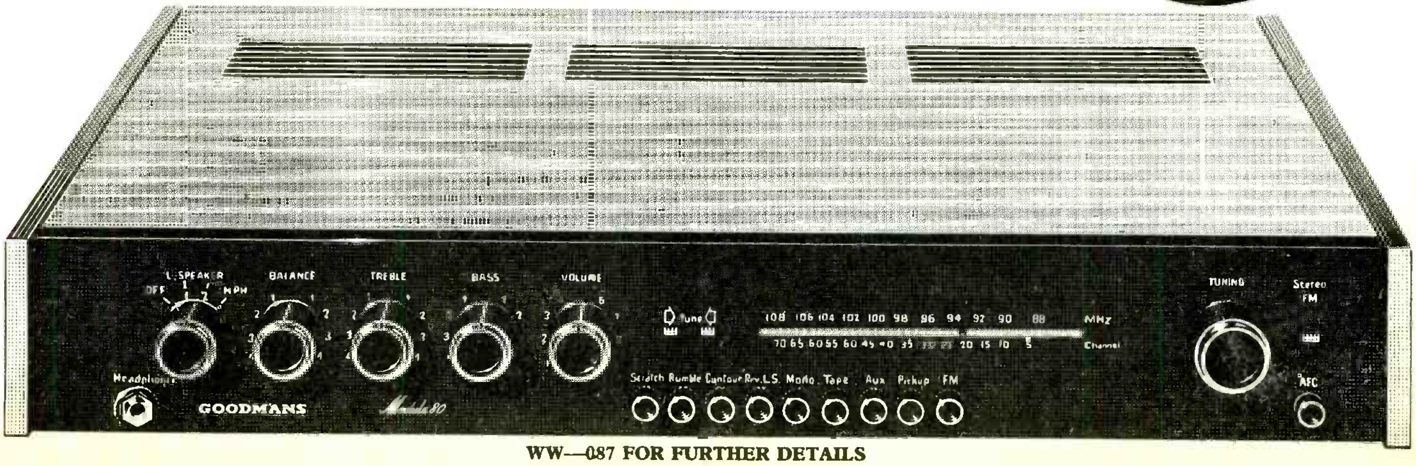
Europe's big selling tuner amplifier is here now.
The Module 80 has been tested and proven over the past six months on the continent with great success.
This is why:—

- ∗ Superb selectivity
- ∗ Highly sensitive
- ∗ Genuine 70 watts output
- ∗ Good stereo channel separation and definition

Goodmans
Module 80

Goodmans Loudspeakers Ltd.,
Axiom Works, Lancelot Rd.,
Wembley HA0 2BJ Tel. 01-902 1200

See and listen to the Module 80 at
Sonex
or send for leaflet



WW—087 FOR FURTHER DETAILS

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TIME INTERVAL CONVERSION METER

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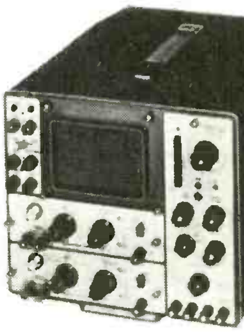

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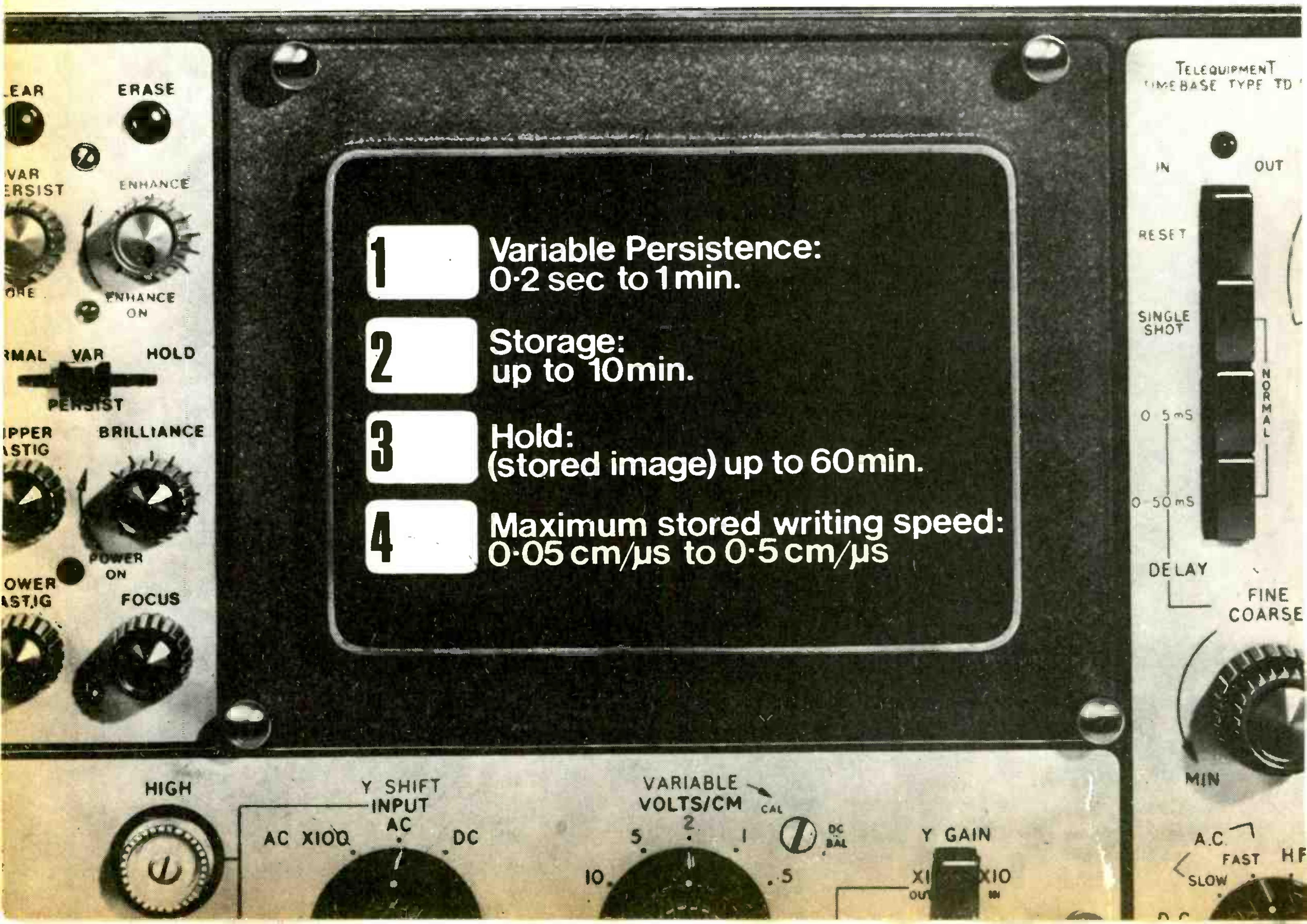


1 Variable Persistence: 0·2 sec to 1 min.

2 Storage: up to 10 min.

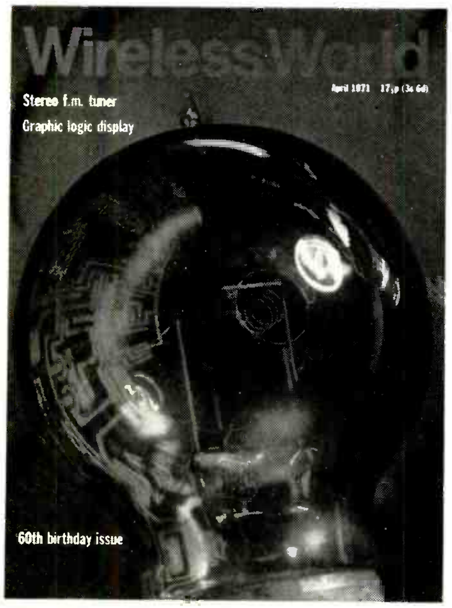
3 Hold: (stored image) up to 60 min.

4 Maximum stored writing speed: 0·05 cm/µs to 0·5 cm/µs

Wireless World

Electronics, Television, Radio, Audio

Sixty-first year of publication **April 1971** **Volume 76 Number 1426**



The reflected image of an integrated circuit on the gettering of an R valve on **this month's cover** symbolizes the advances in technology during *Wireless World's* 60 years. (*Photograph by Paul Brierley*)

IN OUR NEXT ISSUE

Artificial vision. A microelectronic implant for directly stimulating the brain of blind people in order to restore some degree of vision; r.f. signals are conveyed by inductive-loop transmitters and receivers. Full description of Medical Research Council work.

Circuitry for a **five-channel stereo mixer** will be described along with constructional hints. The various high-quality amplifiers can be used as components for an audio pre-amplifier.

Experimental **miles-per-gallon meter.**

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Wireless World

Sixty Years

The editorial regularly presents us with an opportunity to express an opinion on some topic of interest. We rarely discuss ourselves and it is not our practice to have "guest editorials", but on this occasion, as we celebrate our 60th birthday, we have broken with tradition and have invited Hugh S. Pocock, F.I.E.E., to occupy the editorial chair once again. To him, more than any other one person, must go the credit for the development of Wireless World *both in its formative years and in its later growth. He was editor from 1920 to 1941, then managing editor, and successively director, managing director and chairman of our publishing company until his retirement in 1962.*

We also include in this issue several contributions reviewing progress during the past 60 years in various fields—audio, receiver techniques, basic theory, communications and radio propagation.

Looking back through the volumes of Wireless World *we are conscious of the debt we owe to our contributors (some whose names became household words) whose knowledge and ingenuity has enabled us to maintain the ideals set in the first issue of* W.W.*—"This then is our policy: to be of use and interest to our readers, and through them to be a factor for progress."*

We are also deeply grateful for the support given us by our advertisers and last, but by no means least, for the loyalty of our readers. Now we temporarily vacate the chair!

When the *Marconigraph* was published by the Marconi Company in 1911 the intention was to provide a means of giving wider publicity to the Marconi System than had been possible through Guglielmo Marconi's lectures to scientific bodies and references in the Press. The circulation, however, was mainly amongst Marconi engineers and marine operators with a small readership amongst those interested in the Marconi Company as an investment or speculation.

After two years of publication it was decided to broaden the scope of the journal and put it on sale on bookstalls, with the new name of *The Wireless World*, the idea being to remove the impression that it was merely a Marconi publicity publication. Under the new title it was to continue to favour the Marconi System but to be broader in its attitude towards other activities outside the company.

In making preparations for the launching of the first issue of *The Wireless World* the Marconi Company put out an advertisement for an editorial assistant preferably with some knowledge of wireless. This advertisement caught the eye of one who was to be closely identified with the journal's fortunes for the next fifty years. His qualifications were a fluent pen (at that time), the holder of an Experimental Wireless licence, and that he had absorbed almost everything published on the subject at that date, although he admitted to dodging the mathematical analysis of the spark in Fleming's "Wireless Telegraphy".

Being accepted for the job he found himself installed in Marconi House in the

Strand, London. The site for the present Bush House, alongside, had just been cleared for building. Preparation for the first *The Wireless World* was being made but that was not a full-time occupation for the new recruit so to him was assigned, as an extra duty, the editorship of the new publication "The Year Book of Wireless Telegraphy and Telephony".

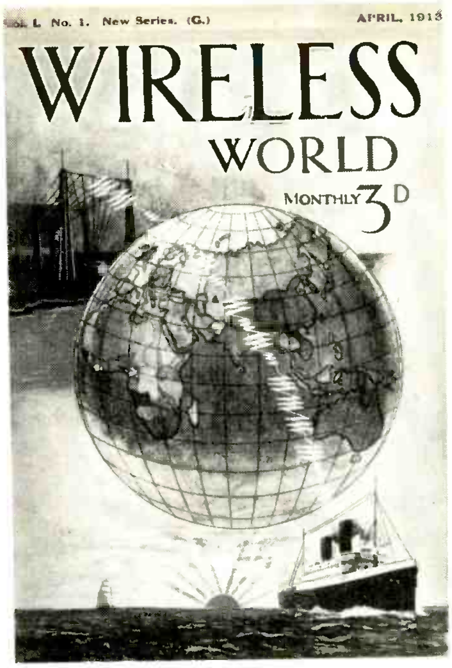
The Postmaster General had granted a good many Experimental Wireless licences by this time and Gamages produced a directory of them and ran a department to supply experimenters with the gear they required. The Wireless Society of London (which became the Radio Society of Great Britain) was a focal point and the then editor was keenly supported in the idea of fostering amateur interests. *The Wireless World* became the official organ of the society and published, in full, its lectures and discussions.

With the outbreak of the first world war there was strict censorship, experimental licences were withdrawn, and our publishing activities greatly circumscribed. We were, no doubt, the first wireless journal to have to submit material to censorship and we well remember taking our 'copy' to Whitehall, where the chief censor, F. E. Smith (later Lord Birkenhead), dealt with it personally.

A commission in the Royal Engineers with wireless and intelligence duties at home and then overseas meant a break in association with the journal until late in 1920, when the invitation, sent to Baghdad, to return to occupy the editorial chair of *The Wireless World* was a rewarding prospect.

When the present Editor recently did me the honour to invite me to make some contribution to the 60th anniversary number he said he had in mind that (for a very short time, I presume!) I should be back in the editorial chair and contribute a guest editorial.

The cover of the first issue of the journal under its original title.



The four-colour cover of April 1913 "Wireless World".

As that is the nature of the invitation it gives me every excuse to adopt the editorial 'we' as we proceed and we propose to confine ourselves mainly to touching on certain events and outside influences which have affected the journal's career.

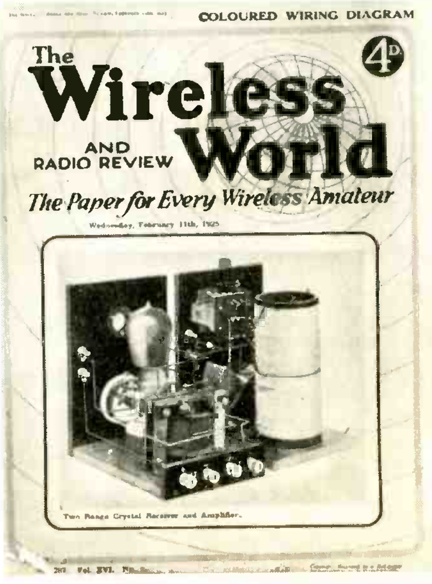
With the lifting of censorship after the first world war a wealth of material became available for publication. The general availability of the valve provided great scope for inventors and experimenters.

Naturally, with such a promising field, *W.W.* did not long remain without competitors and a number of new journals appeared. The journal was taunted with its Marconi bias and consequent neglect of rival systems.

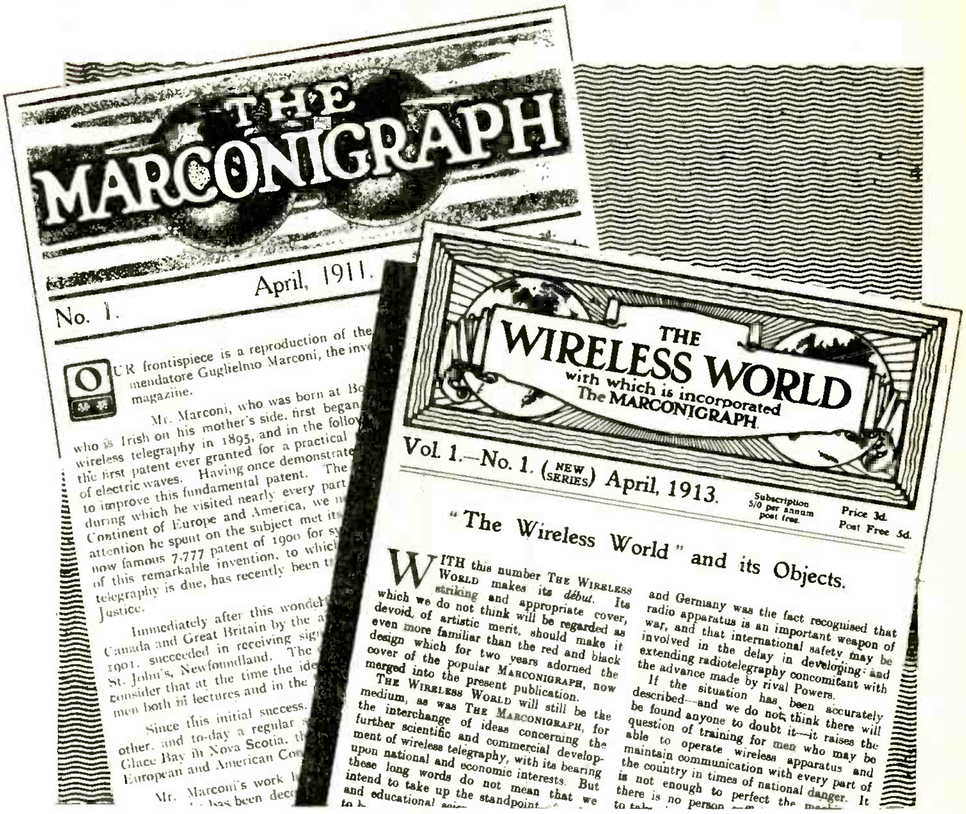
The Postmaster-General did not re-issue experimental licences despite the clamouring of the wireless societies and amateurs. Eventually the wireless societies decided to seek legal advice to obtain what clearly appeared to be their rights under the Wireless Telegraphy Act. Then something occurred which was to prove of great importance to our future. We were telephoned one evening by a press friend and told that a rival radio publisher had put out a news item to the press that £500 was being offered to the Wireless Society of London to assist in its legal show-down with the Post Office. A prompt telephone to the home of the manager of Marconi publications procured the authority to make a similar offer if we felt it necessary in the interests of the journal. So, the next morning our offer and that of the rival publication both appeared in the press. Nothing very interesting about that, one might say, but it had its repercussions! That morning we received a summons from the managing director of Marconi's, (F. G. Kelloway, a former Postmaster-General) to attend his office with the publisher. The Post Office had apparently taken the line with the Marconi Company that it could not continue the present negotiations for wireless station contracts while the company's publication supported an attack on the Post Office monopoly. The outcome of that stormy interview was the decision to find a buyer for the offending *Wireless World.* This is how the journal came into the fold of Iliffe & Sons, Ltd in 1924. Though respecting our former proprietors, we welcomed the change wholeheartedly because it gave us editorial independence and we could no longer be charged with bias, while we had the very important advantage that we now had the resources of a top publishing house ready with financial support and experience of publishing. One of the first moves was to change the format to suit rotary presses for a much increased printing order. The competition from other journals in the field remained intense but we were able to hold our own and establish a reputation for sound designs for constructional articles and all round technical reliability.

We remember the occasion when the first issue under our new proprietors was on the machines we spotted a letter from a reader which expressed his disapproval of stunt circuits, but this appeared as STunt circuits. At that time our rival publishers gave a serial number to the constructional designs which they published and prefixed the number with ST, being the initials of the designer. With alacrity the printing machine was stopped and the offending capital letters reduced to lower case.

The most active competition in the field eventually closed down and those journals of the rival group which continued did so under other publishers. It is interesting to recall that we later received from the former proprietor of the Radio Press (John Scott-Taggart) a generous tribute to *The Wireless World.* (We hope he reads this in his Beaconsfield retreat!)



Constructional feature in this 1925 issue was a two-band crystal receiver and amplifier.



THE
MARCONIGRAPH

No. 1.
April, 1911.

OUR frontispiece is a reproduction of the
mendatore Guglielmo Marconi, the inv
magazine.

Mr. Marconi, who was born at Bo
who is Irish on his mother's side, first began
wireless telegraphy in 1895, and in the follow
the first patent ever granted for a practical
of electric waves. Having once demonstrate
to improve this fundamental patent. The
during which he visited nearly every part
Continent of Europe and America, we n
attention he spent on the subject met its
now famous 7,777 patent of 1900 for sy
of this remarkable invention, to which
telegraphy is due, has recently been t
Justice.

Immediately after this wonder
Canada and Great Britain by the a
1901, succeeded in receiving sig
St. John's, Newfoundland. The
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Since this initial success.
other, and to-day a regular s
Glace Bay in Nova Scotia, th
European and American Co

Mr. Marconi's work h
has been dec

THE
WIRELESS WORLD
with which is incorporated
The MARCONIGRAPH.

Vol. 1.—No. 1. (NEW SERIES) April, 1913.
Subscription 5/0 per annum post free.
Price 3d. Post Free 5d.

"The Wireless World" and its Objects.

WITH this number THE WIRELESS WORLD makes its *début*. Its striking and appropriate cover, which we do not think will be regarded as devoid of artistic merit, should make it even more familiar than the red and black design which for two years adorned the cover of the popular MARCONIGRAPH, now merged into the present publication.

THE WIRELESS WORLD will still be the medium, as was THE MARCONIGRAPH, for the interchange of ideas concerning the further scientific and commercial development of wireless telegraphy, with its bearing upon national and economic interests. But these long words do not mean that we intend to take up the standpoint
and educational

and Germany was the fact recognised that radio apparatus is an important weapon of war, and that international safety may be involved in the delay in developing and extending radiotelegraphy concomitant with the advance made by rival Powers.

If the situation has been accurately described—and we do not think there will be found anyone to doubt it—it raises the question of training for men who may be able to operate wireless apparatus and maintain communication with every part of the country in times of national danger. It is not enough to perfect the
there is no person

Our object "to be of use and interest to our readers, and through them to be a factor for progress" remains unchanged.

Hardly had the competition of the Radio Press faded out than we were confronted with another problem. The B.B.C., which had launched *Radio Times*, now produced a new journal *World Radio*. Profiting from the monopoly of their own programmes, they were able to obtain, by exchange, advance details of a wide selection of foreign programmes for publication in *World Radio*. This at a time when there was very great interest in receiving the foreign transmissions and designers of receivers here competed to achieve a degree of selectivity which made it possible to sort out the individual programmes. Next, *World Radio* added to its contents technical articles and constructional designs, carried a sub-title 'The Technical Journal of the B.B.C.', and competed with us for contributors. In addition to protesting, which seemed to have little effect, we felt we had to take steps to safeguard our position especially when the B.B.C's use of the microphone to publicize its journals was taken into account.

That is why *Wireless World* began the very expensive policy of breaking the monopoly by publishing foreign programmes, as well. Both journals became unprofitable and eventually *World Radio* discontinued publication of technical articles of the type we objected to and we agreed in return to discontinue foreign programmes. In a general agreement between the B.B.C. and the Press the B.B.C. undertook to confine its future publishing activities to what was 'pertinent to the service of broadcasting'. *World Radio* was closed down at a later date and in any case could hardly have continued to obtain advance foreign programmes as the cloud of war in Europe darkened.

As events seemed to be moving towards war we felt that there could soon be an urgent need for people skilled in the very field for which our journal catered. We believed our readership would be the ideal medium through which to recruit for such services. So we launched a '*Wireless World* Register', inviting our readers, who would be ready to give their services in an emergency, to complete a form giving such particulars as we thought would be most useful. Having got the approval of the Services we published the form in the journal with the address side carrying O.H.M.S. (on the recommendation of the Admiralty). We believe that such a permission had never been given previously to any technical journal nor has it been granted since, as far as we are aware. There was a rewarding response from our readers and the completed forms went to the Wireless Telegraphy Board as a convenient clearing house. Perhaps this resulted in our getting less credit for our enterprise than would otherwise have been the case. The register proved very valuable especially in meeting the need for radar personnel.

The imminence of war made things very difficult for us. It is well known that technical journals depend very largely on their advertising pages for a healthy existence. Manufacturers were now so overwhelmed with orders for war needs that they saw no purpose in advertising and we suffered badly. So unpromising was the position that a boardroom decision was made that we should close down. That might well have been the sad end of *Wireless World* but fortunately our board of directors was not composed of Medes and Persians and they were prepared to reverse a decision. We produced facts and figures to show how *Wireless World* could be expected to continue, even profitably, by changing from weekly to monthly publication with a corresponding reduction in paper and printing costs and a reduced staff which was already inevitable with departures of a number to the Services. Actually, with the change to monthly publication, we never looked back.

From this point onwards in our history the editorial 'we' should be taken to include successive editors, the late H. F. Smith, and also F. L. Devereux, two names which will always be associated with the very best that we have been able to put before our readers issue by issue through the years. We are proud to have been followed by men of such outstanding qualities. Throughout its history *Wireless World* has enjoyed the co-operation of a loyal and efficient editorial team and the journal's success must, of course, be credited to them and to our many outstanding contributors, both staff and outside, who have devoted their energies to the needs of our readership. Our present editor, H. W. Barnard, carries on the tradition with that dedication and competence which can be expected from one who has devoted the whole of his working life to *Wireless World*.

It would seem appropriate here to make reference to the transfer of Iliffe's to new proprietors. A good many years ago Iliffe's, being a private company, was attached, for convenience, to a public company (the Amalgamated Press) then controlled by Lord Iliffe with his partners. Some time later Amalgamated Press was sold to I.P.C., the *Daily Mirror* Group, and we believe the new proprietors only later discovered how important an acquisition had come their way with the Iliffe journals. There was much reorganization and change, but *Wireless World* together with other electrical and electronic publications was gathered as one unit which still continues as a distinct entity constituted much as it was when we vacated the chairmanship of the unit to rest from our labours some eight years ago.

In "The Torrington Diaries"* which record the travels through England of John Byng (later Viscount Torrington) the author states, in his introduction, "If my Journals should remain legible, or be perused at the end of 200 years, there will, even then, be little curious in them relative to travel, or the people: Because our Island is now so explored: Our roads, in general, are so fine; and our speed has reached the summit". This he wrote during a tour in Lincolnshire in June, 1791. But we can have sympathy with John Byng for how could we, at the time the *Wireless World* was launched, foresee the future through successive stages of the invention of the valve, with all its applications, short wave communication, radio telephony, broadcasting, radar, television, the transistor and the employment of electronic devices in almost every human activity. And we do not think anyone today would venture to suggest that we have "reached the summit"!

---

* The Torrington Diaries (Eyre & Spottiswoode)

Loud and Clear

Developments in audio over 60 years

remembered by F. L. Devereux, B.Sc.

Of necessity the Editor has had to comb the park benches for someone long enough in the tooth to remember when *Wireless World* began and who at the same time was engaged in sound recording—albeit in the humble capacity of holder of the hot flat-iron near the wax cylinder while his father made records of piano playing.

Yes, home recording was well established before the first issue of *W.W.* made its appearance on the bookstalls, and my father's Edison-Bell phonograph boasted an exponential horn, sapphire stylii for recording and playback and a hill-and-dale groove—recently revived in the Telefunken-Decca video disc. But wireless signalling was in a much more primitive state. There was no broadcasting as the term is now understood; indeed, wireless telephony, except for a few sporadic experiments of limited range and duration, was unknown.

When *Wireless World* began, signals were in morse—nice digital stuff. All you had to do to get the message clearly was to make it loud enough to stand above the threshold of background noise. Power at the transmitter and *sensitivity* at the receiver (amplification was to come later) were the first essentials in getting the signal from point to point; then it was a case of cutting down ambient noise in the receiving room until one could almost hear the blood circulating in the ear. My own dodge was to retire to an unventilated but heavily damped clothes closet, floor area 4ft × 4ft, with sufficient air for nearly half an hour, at the end of which time noisy breathing drowned all but signals from Eiffel Tower and Poldhu.

In those days when the very idea of a loud-speaking telephone seemed like science fiction, the most sought-after piece of equipment was the Brown reed-driven headphone. This highly sensitive earpiece, with an aluminium cone diaphragm and a slack gold-beater's skin surround, was designed by S. G. Brown (honoured also as a pioneer of the gyro-compass). It had micrometer screw adjustment of the air gap between reed and electro-magnet and was a great advance on run-of-the-mill iron diaphragm types then current.

Having made the signal audible the next step was to try to amplify it so that several people could hear it simultaneously without diluting it further among several headphones. Brown was again to the fore, first with a truncated conical horn added to the reed movement and later with current amplification by attaching a button microphone to the reed.

It is significant that at this time any device for augmenting the signal after detection was termed a 'note magnifier'. Oh, happy days, when all one had to design for was a single frequency! Success was measured by the amount of noise the device produced, and if a few harmonics crept in so much the better—the note was "crisper" and probably easier to read. (Incidentally, I wonder how many present-day pilots and R/T operators see any incongruity in the expression 'How do you read me?' As a fugitive from the morse era, whenever I hear it I see in my mind's eye the written message and the pencil flying across the signal pad at 20 w.p.m.)

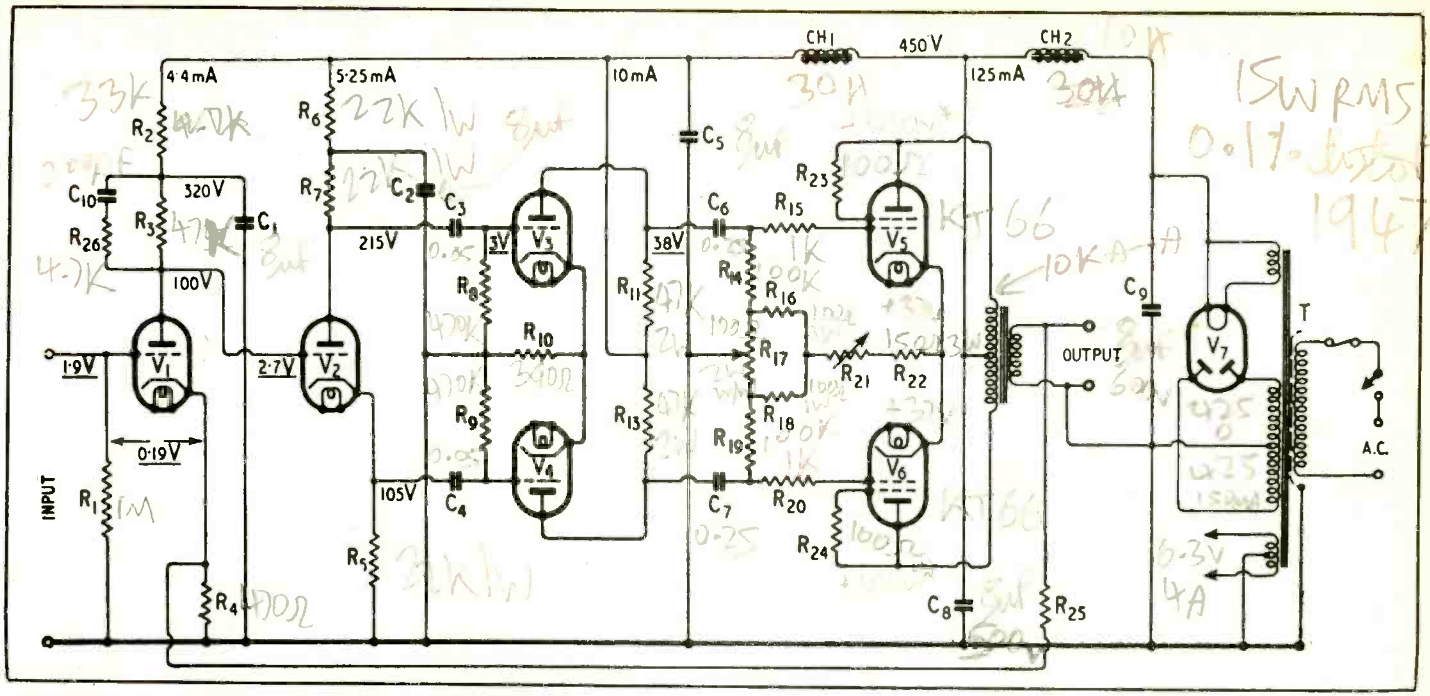
Many mechanical devices as well as electrical were developed to augment the sound, e.g. the Brown 'Frenophone' in which pressures from a reed unit were made to control the friction between a rotating glass disc and a pad to which the apex of a cone diaphragm was attached; the Johnsen and Rahbek system where the friction between a partially conducting rotating drum and a band brake was augmented by electrostatic forces at the interface; and the aptly named 'Stentorphone' in which compressed air was released through an electromagnetically controlled valve.

The signal was by now quite definitely LOUD, and to the excitement induced by the exercise of these new powers of amplification was added, in the early 1920s, the thrill of hearing voices and snatches of music through the babel of morse. And that's when our troubles really began: the primitive digital days were at an end and, headed by Fourier, analogue methods were rearing their ugly heads.

Meanwhile during the 1914-18 war, the thermionic valve (originally partially gas-filled) had got rid of its early flatulence and with the emergence of the hard-pumped 'R' valve took over entirely

Wireless World's *first R-C coupled amplifier caused consternation among transformer manufacturers.*

F. L. Devereux retired in 1965 after more than 40 years with *Wireless World*, including eight as Editor. In 1917, at the age of 17, he went to Parkeston Quay, Harwich, as a laboratory mechanic in the Board of Invention & Research engaged on anti-submarine methods. He later joined the Navy as a midshipman and after demobilization in 1919 went to Birmingham University where he graduated in physics. Before joining *Wireless World* in 1923 he spend a short time in industry.



The Williamson amplifier—a vintage design of the valve era.

R25=√15 ~~m~~ X1200

≏ 3500

the amplification of audio-frequency signals. At first all amplifiers were transformer-coupled using bundled iron-wire cores and later laminations.

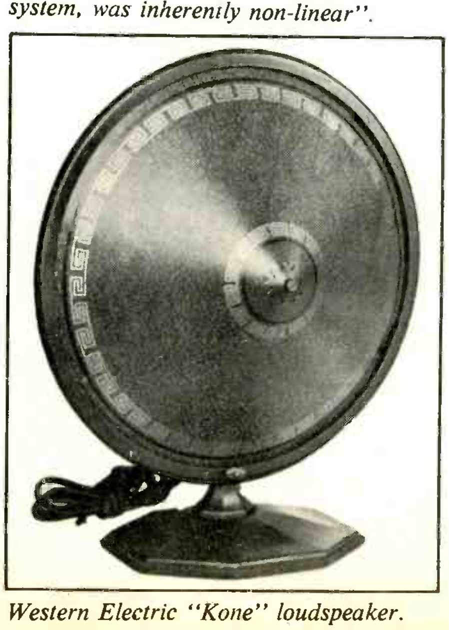
The transformer became the focus of attention as the site of all the virtues of a.f. amplification and a whole industry of new firms sprang up to compete for the supply of this vital component. When a practical resistance-capacitance-coupled amplifier was first described in *W.W.* (October 10th, 1923) under, as it subsequently turned out to be, the rash title of 'Distortionless Telephony Reception', the article opened, in the prose style of the period, with these immortal words: "The methods adopted for low-frequency amplification applicable to the increase in volume of morse signals must no longer be regarded as satisfactory for the purpose of reproducing telephony with loud-speaking apparatus".

On the day following publication we were besieged by an angry mob (for such the rival transformer makers had joined to become in face of a common enemy) demanding instant recantation with veiled threats of withdrawal of advertising or, failing that, some retribution less painful to themselves like burning the author at the stake. The Editor of that day, never at a loss when choosing the appropriate means of surmounting, circumventing or just quietly infiltrating an impasse, subsequently wrote a skilfully worded note which, capable of being read both as a recantation and an endorsement, gave all interested parties so much to think about that we were able quietly to get back to the work of preparing future issues.

So the controversies began as to how, having got the signal loud, we should set about making it clear. Decoupling of anode circuits to control instability, 'straight-line amplification', 'tone-compensated volume control', 'harmonic', 'intermodulation' or just simply 'non-linearity' distortion, negative feedback, even 'ultra-linear' amplification (did they mean that having got the line straight we should go beyond and bend it the other way?)—all these topics, according to the fashion of the moment, have engaged the minds of high-quality enthusiasts, eventually to be absorbed into the technology or refuted and quietly forgotten. Some of the early practical embodiments of those ideas which have so far stood the test of time will not be forgotten when future histories come to be written. The *W.W.* Quality Amplifier of 1934 designed by W. T. Cocking and using PX4 output valves without feedback can still hold the candle to many more complex and over-sophisticated modern types. Nor should we forget the vintage years of 1947-49 which produced the Baxandall and Williamson high-quality valve amplifiers. "Not a ha'porth of difference" (to borrow a phrase from a current detergent commercial) might describe their performance; but most people could not afford to build both, and while they hesitated, the stampede in favour of Williamson started in Australia with endorsement by the Amalgamated Wireless Valve Co. Pty. Ltd, and rapidly spread back across the world to Europe.

From the beginning, amplifier design and performance have always been several jumps ahead of the loudspeaker, which is not really surprising when one starts to make a list of the factors involved—strength and elasticity of materials, internal friction, magnetism, dielectric properties, even thermodynamics when one considers the possible transitions from isothermal to adiabatic working in the throat of a high-power horn loudspeaker or the plasma of an Ionophone. But such complexities did not trouble us in the 1920s. Efficiency was the ticket and the competition then, as now, was chiefly between horn-loaded and direct-radiating diaphragms. Actuating mechanisms of both types were of the

Vogt electrostatic loudspeaker of 1939 working on the "constant voltage" system, was inherently non-linear".

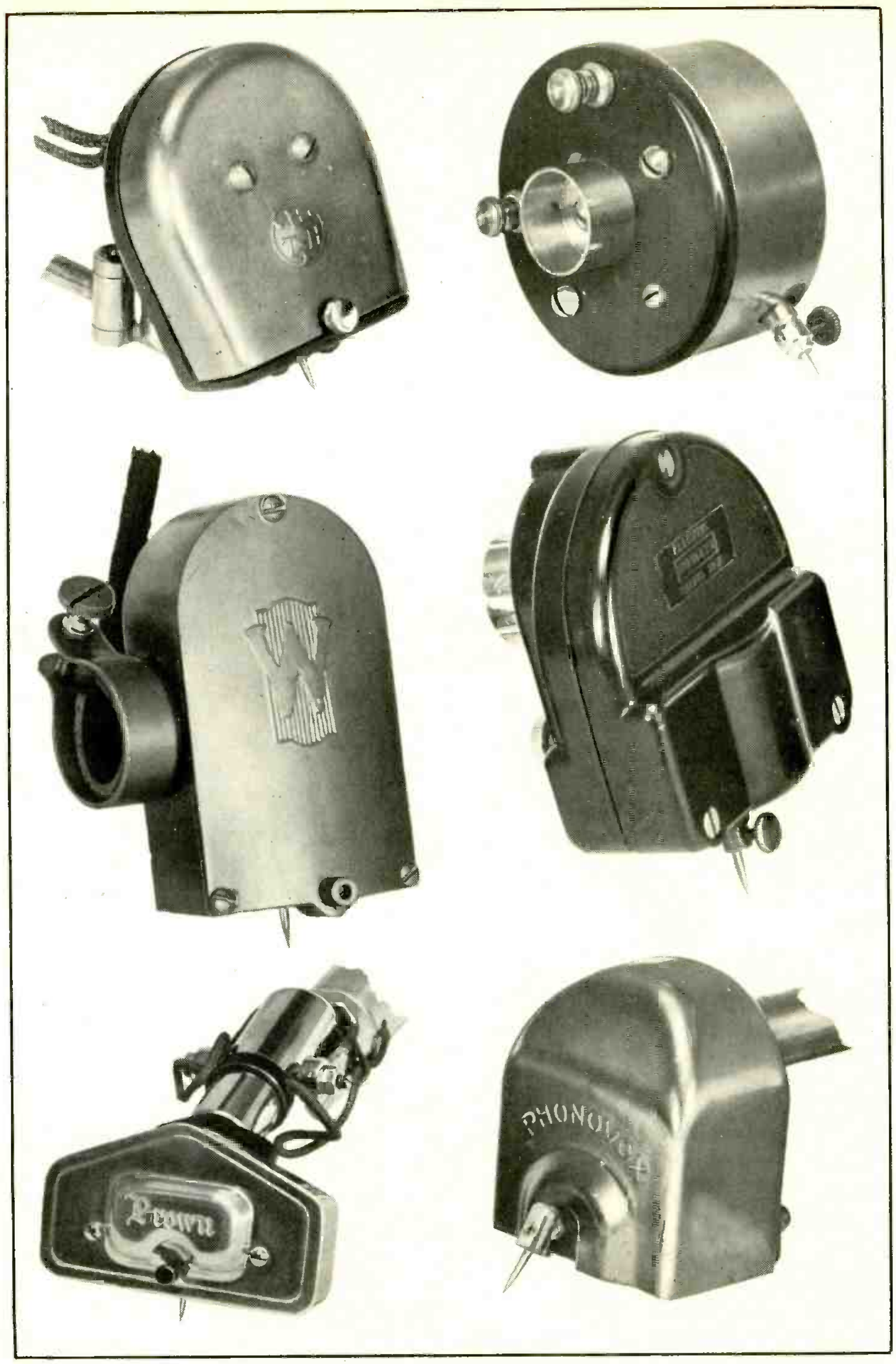


Western Electric "Kone" loudspeaker.

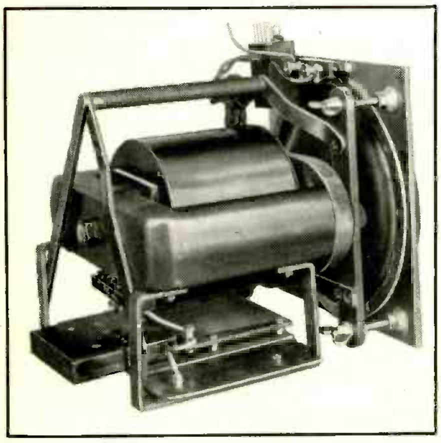
moving-iron variety—telephone diaphragms driving the fashionable swan-necked horns and reed mechanisms for the larger paper cone diaphragms. Both introduced prodigious asymmetrical distortion, proportional to the inverse square of the varying air gap. But who cared? The music kept good time, and by Edison-Bell phonograph standards the quality was quite acceptable.

At this time and for years to come the B.B.C. set a standard of quality which was streets ahead of the capabilities of commercial receivers to reproduce. Protagonist in the drive for better sound quality was the B.B.C's first chief engineer, P. P. Eckersley, whose energy and wit did much to stir the listeners from their indifference and the industry from its lethargy. His campaign was powerfully reinforced by the introduction in 1924 of the Marconi-Round-Sykes moving-coil microphone in place of carbon-granule types.

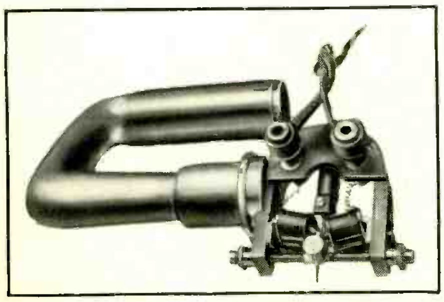
Returning to loudspeakers, the Baldwin balanced armature unit and the Western Electric 'Kone' showed how non-linearity distortion could at least be reduced and bass response improved, and there was a final fling of the moving-iron principle in the so-called 'inductor dynamic' unit with motion parallel instead of normal to the magnet pole-pieces. But this was a last despairing effort to stem the advancing tide of the moving-coil, patented in 1874 by Siemens, again by Lodge in 1898, and brought up to date in 1924 by Rice and Kellogg of the GE Company of America.



Of 19 pickups tested by Wireless World *in 1929 only these six (BTH, Brown, Burndept, Igranic, Magnum, Webster) recorded any output above 4kHz!*



A new standard of performance was set in 1933 by the Voigt unit with a 20 kilogauss magnet.



A gramophone pickup of 1925. "Tons per square inch on a refined macadamised roadway".

No single step in the progress of sound reproduction has ever equalled that from moving-iron to moving-coil, or fired so much enthusiasm. Those who were first privileged to hear the results felt compelled to spread the good tidings, and mass meetings were organized by the redoubtable Dr. N. W. McLachlan in London, by Dr. F. W. Lanchester in the Midlands and by *Wireless World's* Assistant Editor, F. H. Haynes at the leading radio societies. At last the good things which for years the B.B.C. had been wasting on the desert air could be appreciated and we entered the first golden decade of high-quality sound, culminating in the work of P. G. A. H. Voigt, whose many-sided genius showed that the lily could indeed be painted. Through the medium of his domestic corner horns with their massive 20 kilogauss field magnets and twin diaphragms, and with a temerity which smacked of *lèse-majesté,* he disclosed faults in the B.B.C's own transmissions. I well remember turning up at his home in South London for a demonstration of his latest model, only to be told that it was 'off'. "They're still using that mic. with the shrieking 6-kilocycle frontal cavity resonance that I complained about last week". He was right, of course, and that microphone was subsequently taken out of service.

Thus is progress made, sometimes waiting for the man, sometimes for the means. The detailed design of stereophonic recording on disc, as it is used today, was worked out and patented in 1933 by A. D.

Blumlein, but at that time discs were made of heavily loaded shellac and, to quote Stuart Black (*W. W.* December 1943) "We get our music by scraping a steel point carrying some tons of weight per square inch over what is virtually a refined macadamized roadway". Not until the advent of vinyl co-polymers and microgroove recording could Blumlein's ideas be fully exploited.

And speaking of Blumlein reminds me of another story. When high-definition television started in England in 1936 all the high-quality enthusiasts were agog with excitement at the prospect of unlimited bandwidth on v.h.f. On medium waves the B.B.C. did not modulate above 10kHz because of international agreements on channel spacing. Sure enough, when the Alexandra Palace station opened up the improvement in quality of the accompanying sound channel was so marked that readers were demanding constructional details for v.h.f. receivers —just to demonstrate to their friends the virtues of unlimited bandwidth. At an I.E.E. discussion on the design of the A.P. transmitter several speakers rose to thank the B.B.C. for acceding to the public demand for greater bandwidth. To which Bluntlein replied that he was sorry to disillusion the gentlemen concerned, but the improvement had nothing to do with bandwidth; for some time the B.B.C. had been in process of redesigning its microphone 'A' amplifiers and it just so happened that the new equipment, with greatly reduced non-linearity distortion, had been put into service for the first time at Alexandra Palace. And wasn't it P. P. Eckersley at another I.E.E. meeting who said: "The wider you open the window the more dirt blows in?"

When one is stirring up memories of technological progress, why is it that people so often keep popping up among the hardware? W. S. Barrell of E.M.I.: "When I want to impress other people I play Tchaikovsky but when my staff ask my opinion of their latest improvement I always insist on Bartok". G. A. Briggs, who came into the loudspeaker business from the textile industry and who, if he brought a pair of cloth ears with him when he started, must have quickly used them up for diaphragm surrounds, for no one can so unerringly detect a false sound—and that without benefit of scientific aids (who is likely to forget his demonstration, at the start of the Festival Hall recitals, of the qualities of loudspeaker enclosures using nothing more sophisticated than a carpenter's mallet?). And C. E. Watts: I once made the mistake of saying to him that I did not see the sense of square-wave testing since such sounds were not to be found in nature, or for that matter in music. On my desk next morning I found a beautiful photomicrograph of three consecutive square-groove traces (triangular, of course, with constant velocity recording). Attached was a compliments slip endorsed "From Danse Macabre". I found out later that C.E.W. had spent most of the night chasing up and down the groove of that well-known test-piece of the period until he found what he sensed must be there.

Here I think we are getting near to the gist of the matter. When you know all about the physics of vibration and its transmission through the air—even about the mechanism of the cochlea of the ear—you do not yet know the first thing about sound which is the *perception* of vibration. After all the trouble with Fourier and sine waves we are back where we started with the digital spikes of trains of nervous discharge travelling in times of the order of milliseconds along multiple paths, many of them redundant, to be subjected to correlation processes of the order of micro-seconds between the two halves of the brain—then probably to be overridden or ignored altogether by the recipient. As with sight the human capacity for instantaneous attention to detail is limited. Who knows or cares if there is a cut-off at 8 or 18kHz when the back desks of the violins are out of tune or the woodwind is dragging its feet?

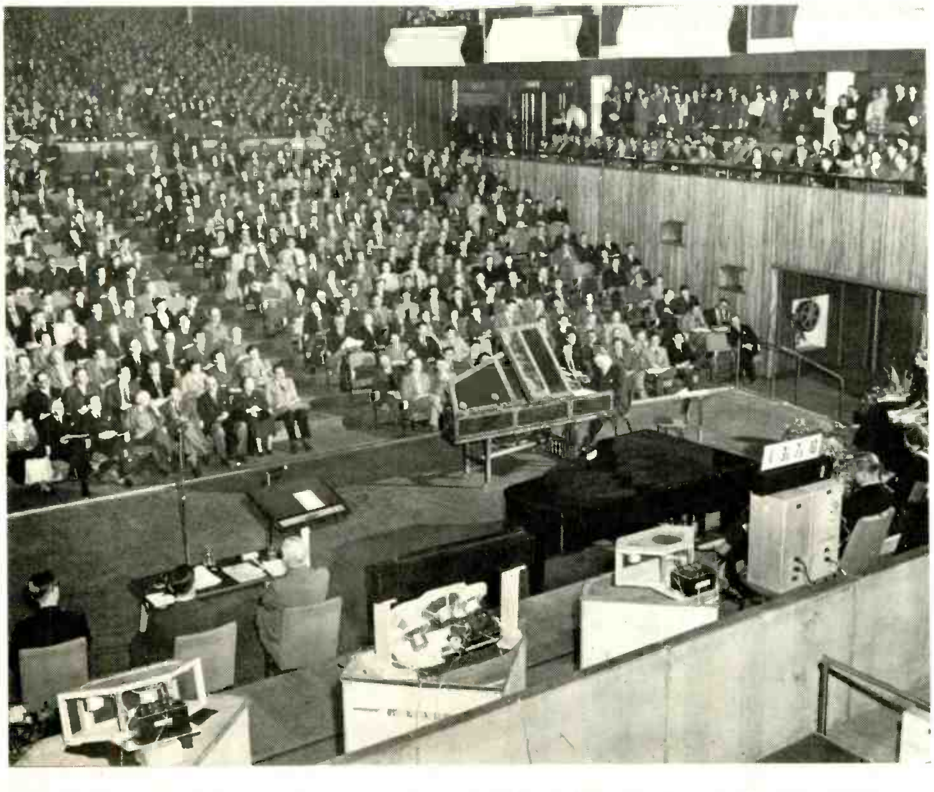
Looking into the future it would seem that startlingly new technological advances will be few and far between, though it is always possible that some simple improvement awaits discovery under our noses. One need only cite the electrostatic loudspeaker which seemed to have been fully exploited by Hans Vogt in the late 1920s until Prof. F. V. Hunt and his colleagues at Harvard, after thorough mathematical analysis, showed thirty years later that what seemed to be inherent distortions could be removed by the simple expedient of working under 'constant charge' conditions.

Much remains to be done in the field of psychoacoustics, to find how judgments are conditioned by previous experience, why the mind accepts the false as the norm and often rejects improvement for no other reason than unfamiliarity. I am old enough to remember that switches marked 'mellow' had to be fitted to many broadcast receivers after the makers had tried to give the public better high-frequency response.

Envoi

As I drift, in the sixth age of man "into the lean and slippered pantaloon, with spectacles on nose" I know that if my old age pension does not run to a colour television licence I can still enjoy music, talks and plays—all those things that enter the mind's eye through the ear.

One small regret. The old *W. W.* Quality Amplifier was such a comfort on winter nights in my "den", but since changing over to integrated circuits I have had to buy an electric fire with *two* bars. We seem not so much to have miniaturized the watt as to have mislaid it altogether.



For his large scale lecture-demonstrations of high-quality sound on both sides of the Atlantic, G. A. Briggs might well have taken his motto from Danton: "De l'audace, et encore de l'audace et toujours de l'audace." *Fears for their success were completely routea.*

Milestones in Receiver Evolution

W. T. Cocking*, an innovator in the field, recalls some of the highlights in radio and television receiver development

The real beginning of radio can be said to date from James Clark Maxwell's hypothesis, which he formulated in the latter half of the 19th century, that a displacement current (i.e., a changing electric field) could produce a magnetic field. He formulated this hypothesis in order to improve the symmetry of his equations relating electric and magnetic fields and he showed that, if it were true, one solution of them indicated electromagnetic waves travelling in space with finite velocity. There was at that time no way of proving or disproving his hypothesis, but later Heinrich Hertz succeeded in generating such electromagnetic waves. Still later, Marconi developed the elevated open aerial and the way was then clear for the practical development of wireless communication.

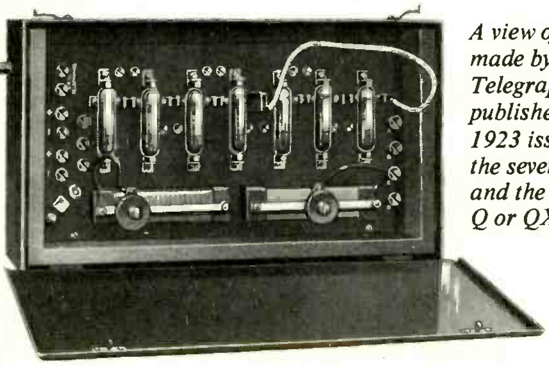
Sixty years ago when *Wireless World* started, all normal transmissions were by spark telegraphy using Morse code and receivers were very simple affairs using one or two tuned circuits with magnetic coherers or crystal detectors.

The triode valve had been invented (1907) but few people had heard of it and it was not until World War I that it became widely known and was manufactured in any quantity. Practical radio-telephony had to wait for this moment because a source of continuous oscillations was needed as a carrier for speech signals and the valve proved the only suitable way of generating them.

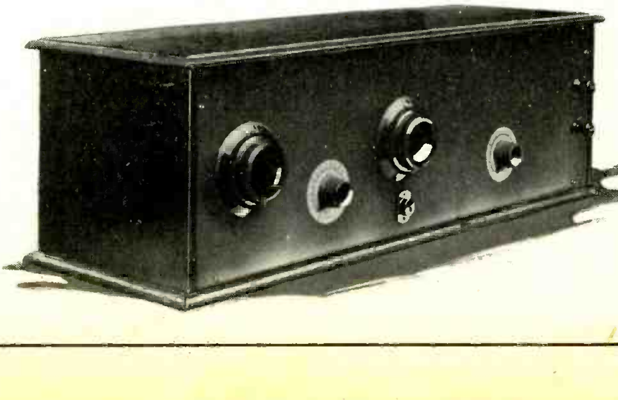
The early '20s may be said to be the real beginning of radio as we know it today. There was military equipment available on the disposals market and valves could be bought. Receivers existed using up to five r.f. 'amplifiers' in cascade with special valves having contacts at each end of a glass tube for the filament and one on each side for the grid and anode (V24. Q or QX). Even with these low-capacitance types the stage gain was very low.

The normal receiving valve was the R type. This was a bright emitter with a filament taking about 0.6A at 5V. It had an a.c. resistance of about 40 kΩ with a μ of about ten. All equipment was battery operated with a large accumulator for the l.t. supply and an h.t. supply of 60 to 120 volts from dry batteries. The usual valve receiver was a reacting detector with or without one transformer-coupled a.f. stage. Headphones were normal and many receivers had nothing but a tuned circuit and crystal detector.

W. T. Cocking's first contribution to *Wireless World* was in 1929, but it was not until 1936 that he joined the staff. During the war he served in the R.A.O.C. and R.E.M.E., attaining the rank of major, and from 1942 to 1945 was attached to the Ministry of Supply. After the war he was appointed editor of our sister journal *Wireless Engineer* and in 1965 became editor-in-chief of *Wireless World* and *Industrial Electronics* (successor to *W.E.*) which ceased publication in 1969.



A view of a seven-valve receiver made by Marconi's Wireless Telegraph Company as published in the February 3rd 1923 issue of 'W.W'. Six of the seven valves are type V24 and the remaining one is type Q or QX.



The exterior of the famous 'Everyman's Four-valve receiver designed by W. James and described in the 1926 article as "a 'two-control' receiver of remarkable efficiency".

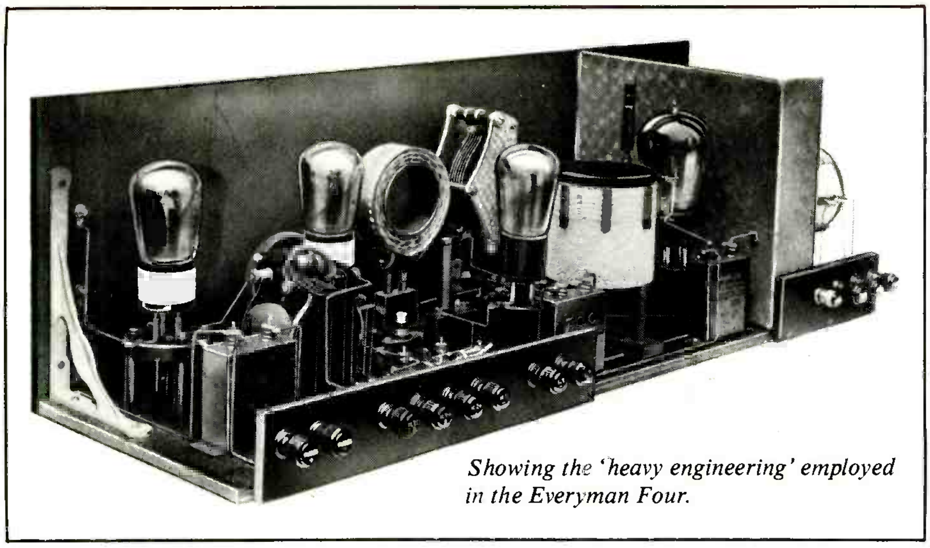
Broadcasting in this country began in 1922 and was the start of major development in receivers. Throughout the history of receiver development receiver designers have been quick to exploit, to the full, the potentialities of components available to them and the major advances have usually had to await component development—especially in valves.

The first valve improvement was the dull-emitter filament. The DER needed a 2-V supply only. Then came the '0.06' types, which took only 60mA at 3V and permitted the use of a dry battery for the filament supply; but this had too short a life to become really popular. The other characteristics of these valves were very similar to those of the R type.

Broadcast listeners began to dislike using headphones and the loudspeaker became popular. The results of the early loudspeakers driven by a grossly overloaded valve of the time were so horrible that power valves were developed. We should hardly call them so today, for few gave more than two or three times the output of an R valve! Then came the LS5 and LS5A. The latter, especially, did give useful power but needed 400V h.t. supply.

In this period there was great interest in the design of tuning coils. In the crystal-set days a solenoid of about 4 inches diameter and 12 inches long was used with a slider for tuning. Then variable capacitors (we called them condensers then) were used with plug-in coils of the honeycomb or Burndept types of windings.

Wireless World organized a competi-



Showing the 'heavy engineering' employed in the Everyman Four.

tion among its readers who were invited to send sample coils. A prize of £5 was offered for the best. The results were published in the 17th, 24th Feb. and 3rd March 1926 issues (*W.W.* was then a weekly). At around the same period S. Butterworth published a series of articles in *Experimental Wireless & The Wireless Engineer* (April-July 1926) on 'Effective Resistance of Inductance Coils at Radio Frequency' and an abbreviated version appeared in *Wireless World* for 8th and 15th Dec. 1926 under the title 'Designng Low-Loss Coils'. Butterworth's work was of outstanding importance because for the first time it enabled unscreened air-core coils to be designed not merely for a required inductance but also for a required r.f. resistance.

At around this period, or a little earlier, the neutrodyne circuit was developed by Hazeltine in the U.S.A. and it enabled stable and useful r.f. amplification to be obtained. The typical American receiver of the period had two neutralized triode r.f. stages, triode detector and two transformer-coupled a.f. stages. There were three separate tuning capacitors, for ganging was still to come.

In *Wireless World* for 28th July and 4th August 1926 there appeared constructional details for a very famous receiver indeed, the Everyman Four. (Incidentally the original title was 'Everyman's Four-Valve', a prototype of which is kept at the Science Museum, London.) This had one r.f. stage neutralized with a DE5B valve (r_a=21 kΩ μ= 18) with two tuned circuits. The coils were of 3-in diameter and $3\frac{1}{2}$-in long and had 74 turns of 27/42 Litz wire, each strand s.s.c. and overall d.s.c. The stable r.f. gain was 36.5 to 46 over the medium-wave band. The detector was an anode bend type using a Cosmos SP18 Blue Spot valve *RC* coupled to a DE5B, which was transformer coupled to a DE5 output valve. The whole set took 10mA at 150 V and the output valve took 4.75 mA. The input power to the output stage was thus 710 mW and so the output to the loudspeaker could hardly exceed 150 mW.

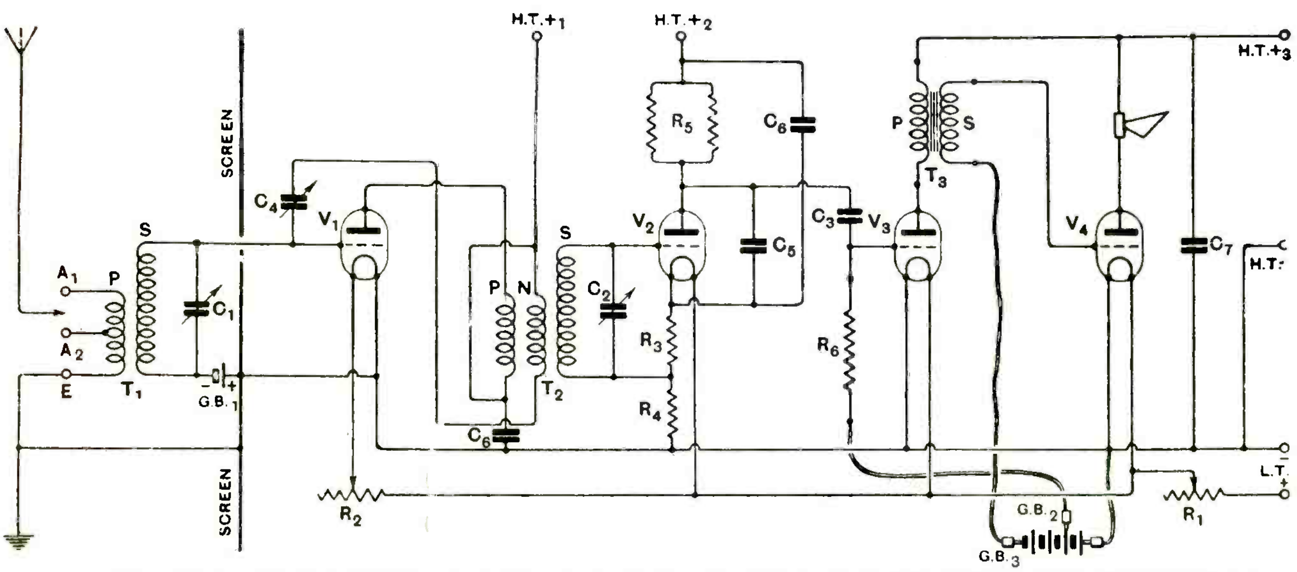
The performance of this receiver far outshone its competitors of the time and it set an entirely new standard of medium-wave broadcast reception. Its success depended largely upon the r.f. coil development referred to above, but also on the development of neutralizing.

In this country the neutrodyne never achieved the prominence that it did in the U.S.A., for it had barely reached here when the screened grid tetrode made its appearance and made neutralizing unnecessary. Shortly after this the output pentode appeared, and the introduction of the indirectly heated cathode made mains operation practicable.

From 1926 onwards valve development was rapid and receiver designs changed accordingly until in the early 30s the 'standard' receiver was mains operated with one r.f. stage, grid detector, and pentode output stage. Ganged tuning arrived. This was an obvious development, but its possibility depended on achieving much higher accuracy of manufacture of variable capacitors and it was not really satisfactory until this was done.

At this time the increasing number of broadcasting stations in Europe called for a great increase of selectivity in receivers. At the same time, much more attention was being paid to quality of reproduction. This led to the use of coupled-pairs of tuned circuits operating as bandpass filters ('Band-Pass Four' *W.W.*, June and July 1930) and then to the revival of the superheterodyne.

This first appeared during World War I, but was comparatively little used until the early '30s. The main reason for this was that it required more valves than the straight set and it was not until the advent of mains operation that many people could afford the extra power supply for these valves. Mains operation and better valves made the superheterodyne at last practicable but it was for a time held



Schematic diagram of connections. T_1, aerial-grid transformer ; T_2, high-frequency valve transformer ; T_3, Ferranti 3.5:1 low-frequency transformer ; C_1 C_2, 0.00027 mfd. square law tuning condenser ; C_3, 0·01 mfd. ; C_4, balancing condenser ; C_5, 0.0005 mfd. ; C_6, 1 mfd. ; C_7, 2 mfd. ; R_1, filament rheostat 2 ohms ; R_2, rheostat 30 ohms ; R_3 R_4 fixed resisters 15 and 7.5 ohms ; R_5, 1 megohm each ; R_6, 3 megohms ; GB, 15 volt grid battery.

A photograph of the original circuit, complete with caption, of the Everyman Four.

back by the problem of ganging the oscillator with the signal circuits.

An early design ('Super-Selective Six' *W.W.* June 1931) had separate controls for the two, but ganging was achieved quite soon ('Monodial', *W.W.*, April, 1932). Around this period, some unorthodox designs appeared. They achieved temporary prominence and then fell into disuse because of certain drawbacks, so they are really side shoots to the main line of development.

One such was the Stenode. This was a superheterodyne using a quartz crystal in the i.f. amplifier to obtain high selectivity together with tone correction in the a.f. amplifier for the severe sideband cutting. It aroused great controversy about the physical reality of sidebands and some of the claims made for it appeared to contravene accepted theory. The true explanation eventually appeared, but the Stenode never achieved any real popularity. One feature of it, the correction of sideband cutting by a suitable a.f. amplifier response, was adopted in the Monodial.

Another sideshoot was the Single-Span (1934). In this a high intermediate frequency (1.6MHz) was used with a fixed tuned input bandpass filter covering 150 kHz to 1.5 MHz. This enabled all tuning to be done by the oscillator ($f >$ 1.6 MHz) and eliminated ganging and waveband switching. Although satisfactory when first described it did not long remain so. The increasing numbers and powers of broadcasting stations soon produced so many whistles that it became impracticable without excessive refinement.

All this time spasmodic attention had been paid to quality of reproduction. An outstanding example was the Science Museum Receiver (*W.W.*, July and August 1930) which probably provided the best reproduction of any equipment of its date.

An early Hi-Fi amplifier (this term had not then been invented) was the *Wireless World* 'Push-Pull Quality Amplifier' (May 1934). This had two PX4 triodes in push-pull driven with *RC* coupling from push-pull MHL4 triodes in turn driven by a concertina phase-splitter. The output transformer was specially designed for the job and contributed greatly to the performance. The output stage operated in a mode which might be called slight class AB. It was nearly class A but not quite. The amplifier gave 4 W output at an unspecified, but quite low, distortion level.

Some examples of it exist today and judged aurally the results compare well with much more modern designs.

In 1934 Black in the U.S.A. 'invented' negative feedback, primarily for amplifiers in cable circuits. This, as always, was a specialized field and it took sometime for the principle to work its way out for more general usage (*W.W.*, Nov. 1936), but within a few years it became common, although it was not at first always used to the best advantage.

At about this time the triode valve began to die as an audio output valve. Larger powers were being demanded and the biggest triodes (PX25, 25 W dissipation) were directly heated types. Indirectly heated cathodes did not seem to go with large power and in any case the pentode was more efficient (theoretical maximum 50% against 25% for a triode). The drawback of the pentode was that it introduced much more distortion than a triode and many quality enthusiasts would have nothing to do with it.

Here negative feedback came to the rescue and made pentode quality as good as triode quality and spelt the demise of the triode output valve. It was eventually realized that the triode could be regarded as a pentode with 100% negative feedback from anode to screen! It was around this period (1936) that a.g.c., which is a form of negative feedback, came in.

The 'Monodial A.C. Super', designed in 1932 by the author. One of the first examples of superhet using a single tuning control.

To return to the early '30s, there were two other important developments. One was a kind of negative feedback, automatic gain control (*W.W.*, September 1932), although it was not then recognized as being such. It came into popular use long before true negative signal feedback. The second development (*W.W.*, Sept. 1932) was 'Ferrocart', which was the first iron-dust core for r.f. coils. Of German origin, it consisted of iron dust sprinkled on waxed paper which was then rolled and compressed to form a solid block which could be cut to the desired shape. Sometimes a ring core toroidially wound was used, at others the material was formed into E and I sections. It enabled a big reduction to be made in the size of r.f. coils and stimulated the development of the methods of construction and was soon replaced by cores of iron dust compressed with a binder into a solid. These were much nearer the cores of today.

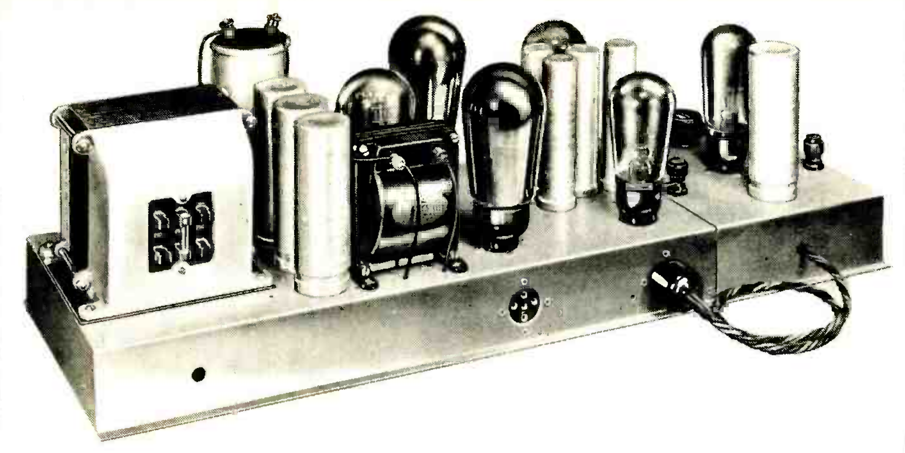
During the '30s there was intense activity in valve development not only in entirely new types, but in building multiple valves. The duo-diode-triode was one of the first, but by 1939 there were double triodes, double pentodes and triode-pentodes. The new types were mainly multi-grid ones for superheterodyne frequency changing. The first was the pentagrid or heptode and this was followed by the octode. A parallel line of development for the same purpose produced the triode-hexode, and triode-heptode.

Indirectly heated valves usually had 4V, 1A heaters, but in the U.S.A. 6.3-V, 0.3-A heaters soon became standard because of the introduction of car radio. American cars had 6-V batteries. When car radio came to this country a range of 13-V, 0.3-A valves was produced to suit our 12-V batteries. These could be series-connected for use in a.c./d.c. sets.

It was not long, however, before some degree of standardization with the U.S.A. occurred and 6.3-V, 0.3-A heaters became general and was followed just before the war with the all-glass construction of which the best known early member is the famous EF50.

The advent of television in 1936 shifted the emphasis in valve development to r.f. pentodes of high-g_m and low capacitance. An early example was the TSP4 with g_m = 6mA/V, but this was quite soon replaced by the EF50 which had about the same mutual conductance but which was much better screened and was much smaller physically. Further valve development was interrupted by World War II and for a good many years the EF50 was the standard valve in radar receivers.

In the U.S.A. the small all-glass construction was adopted and later in the war such types were made here. These were more robust and had lower capacitances and higher mutual conductances, so that radar i.f. amplifiers, for instance, became smaller and more reliable. After the war



'Push-pull Quality Amplifier' designed by the author in 1934. Some examples of this design are still giving satisfactory performance today!

this form of construction continued and it is now employed in nearly all valves.

The next major development was the transistor in 1948. Of outstanding technical interest, it took a long time to have effect upon receiver design. The crystal detector, which is a semiconductor diode, was used in the very early days of radio. The commonest types were carborundum with a steel plate, zincite-bornite (Perikon) and galena with a catswhisker. During World War II it was revived as a centimetre-wave radar detector and properly designed with a pre-set capsule so that the user was presented with a little cartridge requiring no adjustment. Quite early on certain crystals were known to be able to generate oscillations under certain conditions, but little or nothing was known about how they worked.

As power rectifiers, copper-oxide and, later selenium, types were widely used from about 1930 onwards; little was known about how they worked, and their design was largely empirical. Nevertheless, they were very satisfactory.

The development of the transistor and the enormous amount of work on semiconductors which preceded and followed it cleared up all these other matters. The first transistors were point-contact types and it was not until the junction transistor arrived and became manufactured in quantity that its effect became evident.

Apart from the computer, its first main application was to hearing aids. It had the outstanding advantages of much smaller physical size than a valve and of requiring no filament-heating power. It was also more efficient in that, because the minimum permissible voltage drop across the device could be under 1 V (with a valve it had to be 10 V or more) the h.t. supply power could be reduced.

In receivers, the transistor for the first time permitted the construction of a really practicable portable receiver. Portables were made and sold from quite early days, but they were large and heavy, had a poor performance and short battery life. The transistor changed all this as soon as types capable of amplifying and oscillating up to about 2 MHz became available. So much is this the case that the old table-model receiver is now virtually obsolete. It is now the mains-operated radiogramophone or the battery-operated transistor portable. The development of ferrites, too, made the ferrite rod aerial possible and eliminated the cumbersome frame aerial from the portable. In the domestic market valves are now rarely used except in television receivers, but even here there are some which depend entirely upon semi-conductors.

During World War II, as we have said, valves began to get smaller. To match this components generally got smaller, too. The process of miniaturization had started. The transistor accelerated this and discrete components are now incredibly small by pre-war standards. But this is far from the end. Integrated circuits are with us and are coming into use in the domestic radio field. Even the variable-capacitor seems to be on the way out. It is starting to be replaced by a special semiconductor diode known variously as a varactor or varicap which has a capacitance dependent upon the voltage applied to it. At the moment, the only difficulty seems to be to manufacture diodes which all have the same capacitance at the same applied voltage; it is virtually the ganging problem again.

We cannot conclude without some mention of television. This started as a regular service in 1936 with one transmitter at Alexandra Palace, and after a short trial period the present 405-line system was adopted. Receiving cathode-ray tubes had a 12-in. diameter screen with electric focusing and deflection and operated at 4kV. By modern standards the tubes had poor focus and brightness.

Constructional details of a television set were given in *W.W.*, 2nd-30th July 1937. The receiver was of the t.r.f. type with three r.f. stages, diode detector and one video stage. The power supplies formed a large part of the cost and bulk, for three separate ones each with its own mains transformer were needed. Supplies of 250V for the receiver proper, 1000V for the time bases and 4kV for the c.r.t. Commercial practice of the time was similar, but a few manufacturers employed the superheterodyne. A major difficulty was to obtain stable and high r.f. gain with the necessary bandwidth, because the valves available were not really suitable.

In the next two years, great improvements were made, partly because better valves became available and partly because of a change to magnetic deflection and focusing of the c.r. tube. To reduce costs the 9in. tube was adopted, and at least one set (Murphy) sold for £30. A second constructional receiver was described in *W.W.*, 29th June-20th July 1939, which took great advantage of these developments and gave a performance greatly superior to that of the first.

The war interrupted television, of course, and it was not until 1946 that transmissions started again. The post-war receivers naturally followed the immediate pre-war practice and the whole trend was to 9in. tubes with magnetic focusing and deflection. The service restarted on 7th June 1946.

Another constructional receiver was described in *W.W.*, Jan.-Dec. 1947. This was probably unique in that it included full constructional details of deflector and focusing coils, the reason being that such parts were not available on the retail market at that time. The receiver was initially of the t.r.f. type, but later a superheterodyne of much higher gain was described as an alternative. The e.h.t. supply, which was still no more than 5kV, was obtained from the line flyback using a voltage-doubler with selenium rectifiers.

War-time, and early post-war, valve developments made a big difference to television receiver design, especially on the r.f. side. The development of ferrites, too, had a big effect, for it so greatly reduced the losses in line-scan transformers and deflector coils that it permitted a further development—the energy-recovery scanning systems. These are now universal, but on them depended the practicability of wide-deflection angles and, hence, large screen tubes and the higher voltages needed for adequate brightness with them. The period 1947-1957 was an exceptionally interesting one in development.

Then, of course, came a 625-line system on v.h.f. and, finally, colour and a constructional receiver (*W.W.*, June 1968-June 1969), again appeared.

In this article, some may feel that undue stress has been laid upon designs for the home constructor. There is a sound reason for quoting these, however, which is that much more information about them is available than of commercially produced receivers of the time, especially in the early days. The heyday of the constructor was in the '20s and early '30s. After that, it became less popular as receivers became more complex, but the commercial pattern changed also and it gradually became more expensive to make a receiver than to buy one!

The demand for constructional articles fell off but the old saying, "An ounce of practice is worth a ton of theory", is still true. It is not that theory is unnecessary. It is more necessary than ever. It needs the practice, however, to drive it home and make one realize to the full what it means.

Radio Wave Propagation

Ten more years

by R. L. Smith-Rose, C.B.E., D.Sc., F.C.G.I., F.I.E.E.

In the 50th birthday issue of *Wireless World* a review was presented on the development of our knowledge of the manner in which electromagnetic waves travel over the earth's surface and through the lower and upper atmospheres, and of the experience which has resulted in the development of practical communications on a world-wide basis[1]. It is the purpose of this article to review the progress that has been made during the past ten years, taking note, as appropriate, of the associated developments in radio astronomy and space communications.

Because electromagnetic waves travel, subject to conditions of absorption, refraction and reflection, not only round the surface of the earth but also into the surrounding space, it has long been recognized that international collaboration is essential if confusion and interference are to be avoided in the practical development of communications, navigational guidance and the satisfactory broadcasting of sound and television programmes. It is on account of the international aspects and the need to avoid a chaotic state of radio interference, that organizations such as the International Radio Consultative Committee (C.C.I.R.) and the International Union of Radio Science (U.R.S.I.)[2] are continuously in operation to guide and control both the practical development and the scientific research associated with this subject. The introduction of sound and television broadcasting, advanced radio aids to both aerial and marine navigation and, more recently, the pursuit of research in radio astronomy and the space around us, have all served to emphasize the need for such international co-operation.

Influence of terrain on wave propagation

The development of medium-wave broadcasting has, for many years past, stimulated the continued study of the effect of the electrical conductivity and dielectric constant of the ground on the propagation of radio waves over the earth's surface. The C.C.I.R. has produced, and published from time to time, sets of curves showing the decrease of field strength with distance from the transmitter which is assumed to be radiating a power of one kilowatt. It is further assumed that both the sending and receiving stations are on the ground and that the waves travel over a smooth homogeneous earth, neglecting any effect of the troposphere. Five sets of such curves were revised in 1970[3] and have recently been published from Geneva. These sets of curves relate to four different values of the conductivity of the earth over which the waves travel, while the fifth set is appropriate to the much higher conductivity and dielectric constant of sea-water. Individual curves relate to a series of frequencies between 10 kHz and 10MHz.

Recommendations covering the use of the curves emphasize that they should be used to determine field strengths only when it is known that ionospheric reflections at the frequency under consideration will be negligible in amplitude. An example of such application is given as propagation in daylight at frequencies between 150 kHz and 2 MHz, and for distances less than about 2000 km. These sets of curves continue to form the basis of international discussions on the siting of broadcasting and other radio transmitting stations.

Methods have also been developed for computing the propagation conditions over ground paths of mixed electrical constants, such as are encountered in travelling from dry sand to a fresh-water lake, or from normally moist soil to sea-water of greatly increased conductivity. Similarly the effect of a variable terrain, including hills and mountain ridges which may be regarded as sharp irregularities in relation to the wavelength, has been studied in considerable detail to obtain information on such effects required for the planning of broadcasting and other services which depend on ground-wave transmissions. Renewed emphasis on the desirability for further study of this subject has arisen during the past decade by the need for such earth-bound services to share some of the bands of frequencies with space telecommunication systems. Practical experimental work in this field has been conducted in parallel with a large amount of theoretical study, so that the combined results may be used in planning radio systems and predicting their performance with a good measure of reliability.

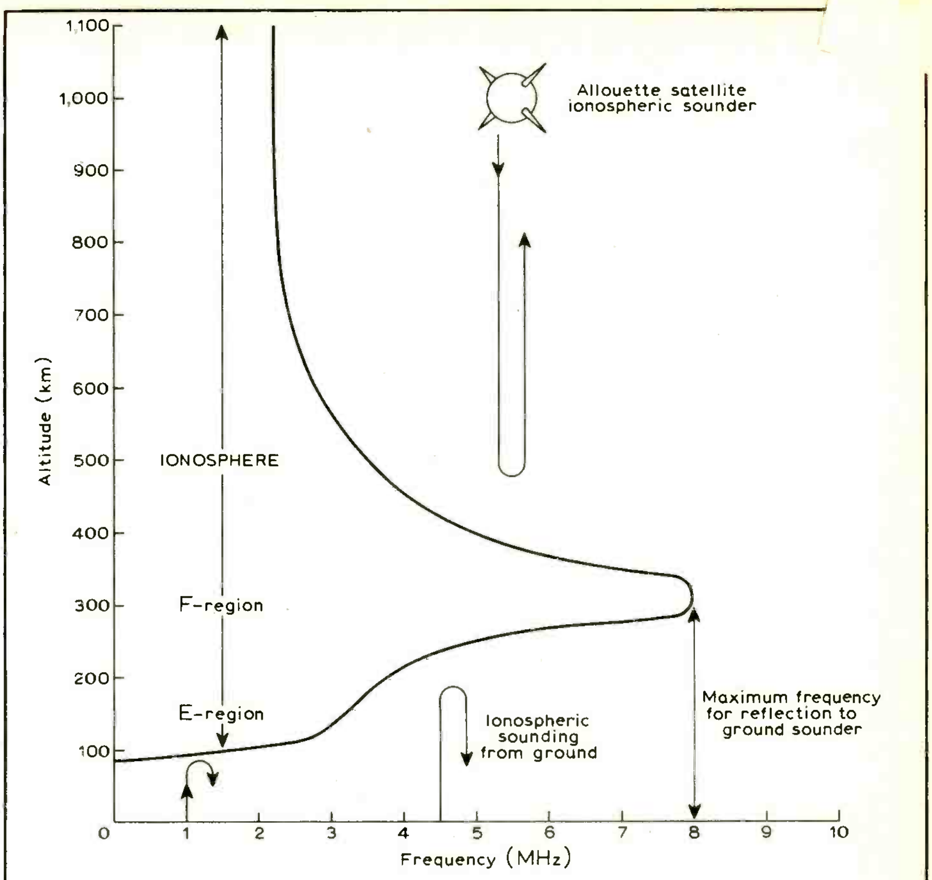
Dr. R. L. Smith-Rose, who is 76, retired from the Scientific Civil Service in 1960 after 41 years' service. A graduate of Imperial College, University of London, Dr. Smith-Rose was superintendent of the Radio Division of the National Physical Laboratory from 1939 until 1948 when he became the first director of radio research in the Department of Scientific and Industrial Research (now the Science Research Council). He is a past president of the International Scientific Radio Union and is at present chairman of the Frequency Advisory Committee of the Ministry of Posts and Telecommunications, and secretary-general of the Inter-Union Commission on Frequency Allocations for Radio Astronomy and Space Science.

Ionospheric research and long-distance propagation

Apart from national internal services, the major portion of the world's communications is conducted in high frequency radio waves, taking advantage of the appropriate reflection of such waves from the several regions of the ionosphere. It is now over 45 years since the classical experiments of Sir Edward Appleton demonstrated the existence of ionized regions in the earth's upper atmosphere, which reflect radio waves within suitable bands of frequencies, resulting in the transmission of the waves all round the earth's surface.

Continuous research carried out in various countries has shown that the frequencies of waves that can be so reflected depends upon the density of ionization in the atmosphere at heights from about 100 to 400 km above the earth's surface. It was established some years ago that this ionization process is dependent upon the intensity of emission of ultra-violet radiation from the sun. Furthermore, physicists have known for a long time that this emission is subject to variation on a basis with a period of the order of 11 years. As a result the range of frequencies or wavelengths which can be used for the world's long-distance services is much greater during a period of maximum solar activity than in the corresponding period about 5 years later.

In a previous article[4], mention was made of the co-operative scientific study which was conducted on a world-wide basis of conditions in the ionosphere during the period of maximum solar activity (1957-58)—the International Geophysical Year (IGY), as it was termed. With the knowledge provided by astronomers that the mean period of the sun's activity is about 11 years, a similar and enhanced programme of studies of the ionosphere was planned and carried out during the period 1964-65, which was designated the International Quiet Sun Year (IQSY). During this period, for the first time observations at observatories on the earth's surface were supplemented by direct measurements of conditions in the ionosphere, made first with the aid of rockets and later by the launching of complete radio sounding equipments through and above the ionosphere.



Diagrammatic representation of ionospheric sounding from a ground station and from a top-side sounder in a satellite.

The topside ionospheric sounder

Prior to 1960 rockets and artificial earth satellites were already in use for the measurement of solar radiation and the study of its effect on conditions in the ionosphere.

It was in September 1962 that a complete radio ionospheric transmitting and receiving equipment, known as the Alouette I top-side sounder, was launched into an approximately circular orbit at a height of about 1000 km. The frequency of the transmitter swept over the range 1 to 11.5 MHz in a period of eleven seconds, during which time the satellite had moved about 120 km; so that one complete ionogram was produced for approximately every degree of latitude.

The results obtained from this investigation have proved a most valuable supplement to the information provided by the world network of ionospheric sounding stations on the earth's surface. The fact that it was examining the properties of the ionosphere from above, in a virtually continuous world-wide orbit, brought to light some new and interesting points concerning anomolous geomagnetic conditions at the equator and the interaction between the previously identified radiation belts and the ionosphere below them.

The Alouette I satellite has provided a valuable series of observational emissions over a period of several years. It was still operating when, in November 1965, another artificial satellite—called Alouette II and also built in Canada—was launched into an elliptical orbit with major and minor axes of about 2980 and 500 kilometres respectively. This second satellite operates on command for about six hours per day, carrying out five experiments, which include a topside sounder, a radio-noise experiment over the frequency range 0.2 to 14 MHz, and the measurement of very low frequencies over the range 50 to 30,000 hertz. Both these and other satellites launched more recently have proved very successful in materially adding to our knowledge of radio transmission conditions at heights well above the ionosphere.

Radio meteorology and the troposphere

For many years past the meteorologist has used radio sounding technique to give him detailed information of the temperature, pressure and humidity changes in the earth's atmosphere up to heights of 10 km or more. In return, this information has proved invaluable in the planning and operation of radio communication services operating at very short—metre and centimetre—wavelengths. Under what is termed a normal or standard gradient of atmospheric temperature with height, such waves may travel in a path curved toward the earth at a radius of about four-thirds that of the earth itself. Variation of atmospheric conditions along the path may, however, change this to a greater or less curvature, including what is virtually rectilinear propagation[5].

The development of direction finding and, later, radar techniques, has also enabled the radio scientist to explore wind movements up to the maximum heights in the troposphere, varying from 10 to 15 km depending on latitude and season. By international collaboration, a considerable amount of useful empirical knowledge has been gained from such combined radio and meteorological investigations in different parts of the world. But the search for a simple method of applying a knowledge of meteorological conditions to the determination of radio propagation has not led to very satisfactory results. In spite of such difficulties, however, the combined experience of scientists and engineers has enabled a certain amount of guidance to be made available to those responsible for the installation and operation of radio services at decimetre and centimetre wavelengths. A useful recommendation recently brought up to date by the C.C.I.R. incorporates a revised set of curves relating field strength to distance of transmission for the v.h.f. (30-250 MHz) and u.h.f. (450-1000 MHz) bands. These curves display a statistical average of received field strength for 50% of the terminal locations and for periods of from 1 to 50% of the operating time. Associated reports enable the effect of changing the receiving aerial height to be estimated, and describe a method for determining the corresponding field strengths when the path of transmission is of a mixed land and sea nature.

But it is not only for the design and operation of radio systems with earth-bound terminals that a detailed knowledge of the effects of the troposphere is necessary. Modern developments of unmanned satellites in orbit round the earth for radio relay communication purposes also require a detailed knowledge of the propagation of radio waves through the non-ionized regions of the atmosphere, taking account of spatial variations of refractive index which can cause both refraction and scattering of the waves. With this type of work is associated an investigation of the absorption of radio waves by oxygen and water vapour of the variable densities encountered in the earth's atmosphere, and of the corresponding scattering of the waves particularly caused by various types of rainfall.

The development of telecommunications on an international scale depends to a major extent on an agreement as to the type of investigations to be carried out and, particularly, on the nomenclature used in organizing the work and describing the results achieved. It has been evident for many years past that the propagation of radio waves of frequencies greater than 30 MHz is greatly influenced by meteorological conditions in the troposphere. In recognition of this the C.C.I.R. has drawn up a recommended list of terms used in the study of radio propagation through the troposphere. This vocabulary[3] was started nearly twenty years ago, and it has been constantly extended and revised as necessary at successive meetings of the international committee dealing with radio communications. Associated with the vocabulary are the agreed definitions of a basic reference atmosphere and the recommended formula for the radio refractive index. All these activities have done much to extend the successful application of the upper portions of the electromagnetic spectrum to practical use.

Radio astronomy

It may not be out of place to conclude this review with a brief reference to radio astronomy, a science which has made great advances during the period under review in many parts of the world. Excluding the relatively small activity in the field of radar astronomy, which uses a combined transmit-receive technique, the activities of the radio astronomer are confined to studying the natural radiations from sources in space, not only within the solar system but out to the limits of the explorable universe.

By the aid of either an extensive fixed aerial array or, more usually, of a large steerable aerial system, the astronomer is able to record and investigate the radiations emitted over the entire radio spectrum. So valuable has this work become in the past decade that a special international commission was set up in 1960, to review the requirements of the radio astronomer and to take all appropriate steps to ensure that his observations of these natural phenomena should be protected from interference by other services operating within the terrestrial environment.

In some cases the radio astronomer has identified specific emissions from natural phenomena, such as the radiation from neutral hydrogen in the frequency band 1400-1427 MHz. But more generally the astronomers have sought protection from interference in a series of frequency bands at approximately octave intervals throughout the spectrum, so that they may conduct a co-ordinated long-term series of continuous observations of the phenomena which give rise to these radiations. The results so far obtained have materially added to our knowledge of the history of the universe which was already available from the much older work of the optical astronomer. While the major additions to our knowledge have been obtained from installations on the earth's surface, space radio astronomy has developed rapidly in recent years, culminating in the launching of the first Radio Astronomy Explorer Satellite for the observation of solar and galactic radiation free from the absorption caused by the earth's atmosphere.

It is perhaps of interest to note, in conclusion, that while up to a few years ago radio communications and control systems operated within the limitations of the earth's circumference, the modern astronaut seeks and receives a corresponding service which has already operated successfully at a range of about a quarter of a million miles—the mean distance between the moon and the earth.

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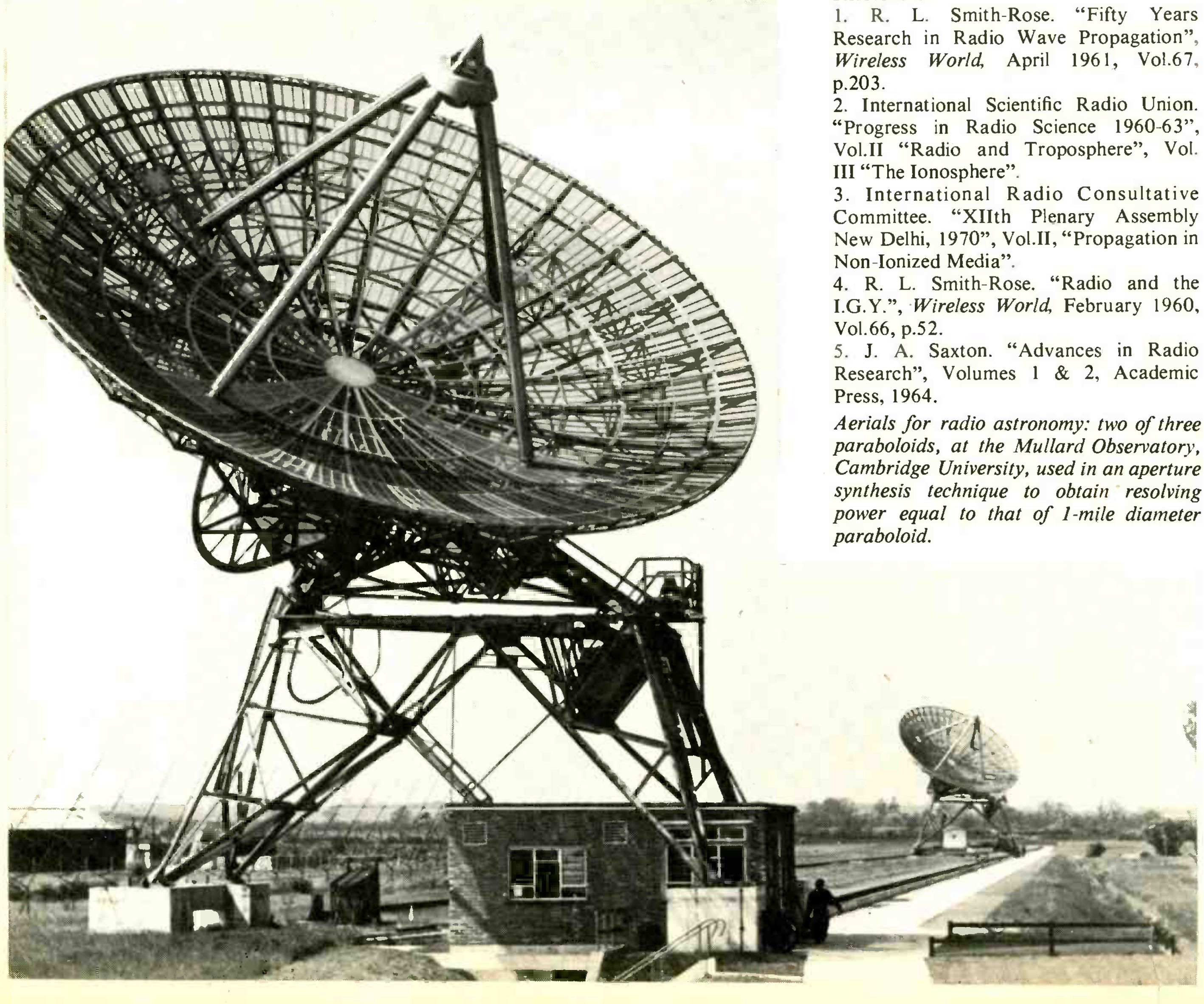


Aerials for radio astronomy: two of three paraboloids, at the Mullard Observatory, Cambridge University, used in an aperture synthesis technique to obtain resolving power equal to that of 1-mile diameter paraboloid.

Some Significant Steps in Radio Communication

*by W. J. Baker **

Anno Domini 1911 . . . the coronation of King George V . . . . Sherlock Holmes in the *Strand* magazine . . . hansom cabs jingling through the streets, fighting a defensive battle against the noisome motor car . . . the heavier-than-air machine, a frail contraption of bamboo, wire and canvas, staggering uncertainly into the sky . . . no sound broadcasting . . . television no more than a *Punch* cartoon. It was in this year that *Wireless World* (then called *The Marconigraph)* first saw the light of day. Wireless telegraphy was fourteen years old, solidly established as the only means of long-range maritime communication but by no means so sure of itself in terms of inter-continental message-carrying; for in that area it constantly fell foul of the powerful cable interests, with tooth-and-nail battles being fought.

The first decisive step in wireless communication had been taken in 1895 when Guglielmo Marconi had the inspiration of adding an elevated wire and an earth system both to his transmitter and receiver, (thereby increasing the range from yards to miles) and of incorporating a morse key as a means of sending messages in code. It was strange that no one had thought of doing either of these things before, because the aerial wire had often been used as a collector of static electricity ever since the Benjamin Franklin experiment, while the use of the morse key (invented sixty years earlier) seems an obvious application. But the fact remains that no one did; and (what seems more incredible) no one, with the exception of Sir William Crookes, seems to have even considered the possibility of using Hertzian waves as a communications medium until Marconi arrived in England with his apparatus. A collection of scientific curiosities which he had improved and turned into a commercial communication system.

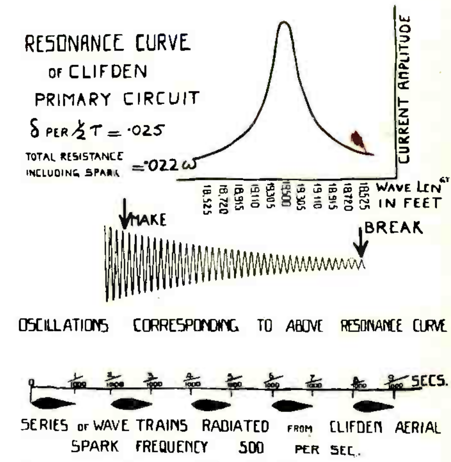
The second great step forward was the 'Four Sevens' (No. 7777) patent for tuned circuits, granted to Marconi in 1900. This again was not completely original work; it owed much to such workers as Lodge and Braun but embodied logical extensions which had not previously been thought of. Hitherto, two or three stations operating within range of one another had brought chaos to the ether. The tuned circuit permitted multi-station operation (albeit the tuning was flat by our standards) and in so doing destroyed one of the most valid of the criticisms levelled at wireless telegraphy.

Signals across the Atlantic

The hat trick was brought off in the following year (1901) with the Poldhu to Newfoundland transmissions of the letter 'S'. This was achieved against all odds; it defied the known laws of Hertzian wave propagation; it was done using lashed-up aerials (the main aerials on both sides of the Atlantic had been blown down in severe gales); the transmitter was beset with teething troubles; the wavelength of 366 metres was, it subsequently transpired, not a good choice; and the transmission took place at the most unsuitable time of the day, with daylight over the whole path. The project was one of the greatest technological gambles of all time—and how near to failure it was! The success of the experiment was all the more remarkable when it is remembered that the receivers of the day embodied no form of amplification and so the onus was entirely on the transmitter.

Spectacular as the spanning of the Atlantic was, some years were to elapse before a reasonably reliable commercial system of message-carrying became possible. The real triumph lay in the technology. Up to that time, wireless apparatus had consisted of toughened-up laboratory equipment—small, table-mounted and battery-driven. Thanks to Marconi's vision and the engineering genius of Dr. J. A. (later Sir Ambrose) Fleming, who designed the high-power equipment, the transition was effected in one tremendous leap. Poldhu brought wireless telegraphy out of its swaddling clothes and straightaway set it to man's work.

The experiment also provided a classic illustration of the dangers of leaning too heavily on laboratory results. In the laboratory it had been proven time and time again that Hertzian waves could not follow the earth's curvature to any significant degree, whereas Marconi's field work had shown they were doing so to a far greater extent than theory allowed. The question was, could the waves surmount a hump of ocean more than a hundred miles high and arrive at destination on the far side? When the transatlantic experiment showed that they could, science was confounded, because it seemed to make nonsense of Maxwell's theories and Hertz' wave propagation experiments. The anomaly arose because the ionosphere did not exist on paper or in the laboratory but it most emphatically did over the Atlantic, although no one knew it at the time (even twenty years later its existence was still causing controversy.)



Characteristics of the Clifden, connemara, spark transmitter given by Marconi in a Royal Institution lecture in June 1911.

The Maggie

The following year (1902) saw the introduction of the Marconi magnetic detector, a device which enabled traffic to be handled at a rate of about 30 w.p.m.—more than three times that permitted by the best coherers. The cable companies, already alarmed by the transatlantic feat, were further perturbed by the advent of the 'Maggie' which brought wireless operating speeds on a par with their own. This detector remained as standard Marconi receiving equipment for a number of years and is known to have survived to the 1920s.

Short-wave beam system

All experimental work done after the 1901 transatlantic experiment seemed to

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*Technical Editor (Research), The Marconi Company; and author of the recently published book "A History of the Marconi Company".

indicate conclusively that the use of long waves in conjunction with high powers was the correct formula for long-distance communication. Thus by 1918 we find the Marconi 'timed spark' station at Caernarvon transmitting on 14,000 metres with a power of 200 kW, using a directional aerial which could radiate towards New Brunswick or the Antipodes. To this was added, in 1920, a long-wave 100 kW valve telephony transmitter which also established contact with Australia.

Ever since 1910 Guglielmo Marconi had had the dream of providing the British Empire with a chain of wireless stations to link its units together in a manner which would not be nearly so vulnerable as the cable circuits in time of war. Various governments, for various reasons, had procrastinated over this and the issue had not been settled by 1924, but matters then looked more hopeful and in fact, orders for long-wave high-power (1000 kW) stations had already been received by the company from Australia and South Africa. At long last, Marconi's cherished ambition was coming true.

Into this situation Marconi and his assistant C. S. Franklin themselves inserted what was very like a spanner in the works. Various experiments on wavelengths between 10 and 100 metres had been undertaken since 1917; these were primarily for short-haul links, but it had been noted that on occasion the signals, while dying out at a comparatively short distance were reappearing hundreds of miles away. Wireless amateurs too, having had these 'useless' wavelengths forced upon them, were reporting trans-oceanic ranges which occurred at some times and not at others. Marconi and Franklin, in 1923, conducted exhaustive experiments between a specially built short-wave station at Poldhu and Marconi's yacht *Elettra* and these fully confirmed the skip-distance effect. Further tests, using various wavelengths from 32 to 92 metres established a rough rule-of-thumb as to the best wavelength to use at a given time of day to reach a given destination; it was also established that Australia could be contacted with a fraction of the power used by the longwave giants.

This, then, was the nature of the spanner. Orders were on hand for two huge, expensive long-wave stations. But, secreted in the company files, were details of an entirely new concept; the use of short waves which, by reason of the manageable dimensions of the aerial arrays, could be beamed to destination instead of being scattered broadcast. Should the long-wave orders be executed notwithstanding, or should the customers be informed of the new development?

The solution was not so simple as all that. Freak propagation conditions might account for the extraordinary ranges; time alone could tell whether this was so or not. Again, the short-wave beam equipment used had been strictly experimental; it all needed engineering. Was it justifiable to put forward a largely untried experimental rig against a proven (but very much more expensive) system?

Marconi had everything to gain by proceeding with the original order and then developing the beam system at leisure, producing it some years later. Characteristically, he did it the hard way and kept faith with his customers, the Australian and South African governments. He told them the exact situation, offered beam stations in lieu of the long-wave giants and let them decide for themselves. Both opted for the beam system, with Canada following suit. The British Government and the Post Office agreed to the provision of an Empire beam system, provided that the first circuit (between Canada and Britain) fulfilled the stringent conditions laid down. It did so, and by the end of 1927 the Empire beam service was in full operation.

Not the least remarkable part of the story is the technical feat of C. S. Franklin and his small team. With the decision made, Franklin had to engineer the experimental transmitter into production form, to modify valve design, to design the various aerial systems to operate on the wavelengths selected and to devise a means of conveying the output power of the transmitter to the aerial system without undue loss. All this was done in a matter of weeks—the last-mentioned by Franklin's invention of the concentric feeder, forerunner of the coaxial cable.

Thermionics

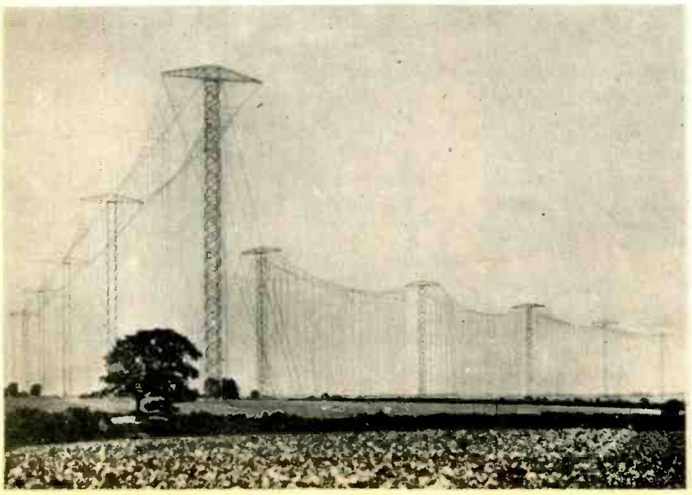
Not all momentous steps are immediately recognized as such. An instance occurred in 1904 when Dr. J. A. Fleming, Marconi's Scientific Adviser, utilized the Edison effect (originally noted 22 years earlier) to develop the first thermionic valve, the diode. Although not the first electronic device to be used (the 'Italian Navy' or 'Solari' detector of 1901 was a form of semiconductor rectifier) the Fleming diode was, nevertheless, the foundation stone of electronics as we know it today.

In 1906 Dr. Lee de Forest, of the U.S.A., set the cat among the pigeons by patenting a three-electrode valve, for which powers of amplification were claimed. Fleming was never a man to suffer rivals graciously and the Marconi Company promptly filed an action to restrain de Forest from manufacturing and to invalidate his patent, claiming then the diode constituted the master patent and that the third electrode, the 'grid-iron', was an appendage. The first lawsuit, heard in the U.S.A., gave Marconi's the verdict, but this ruling was overset by another court. There followed an interminable series of legal actions which dragged on for years. Although World War I brought an easement of the situation, the wrangle was not finally resolved until the 1920s, when a compromise was effected.

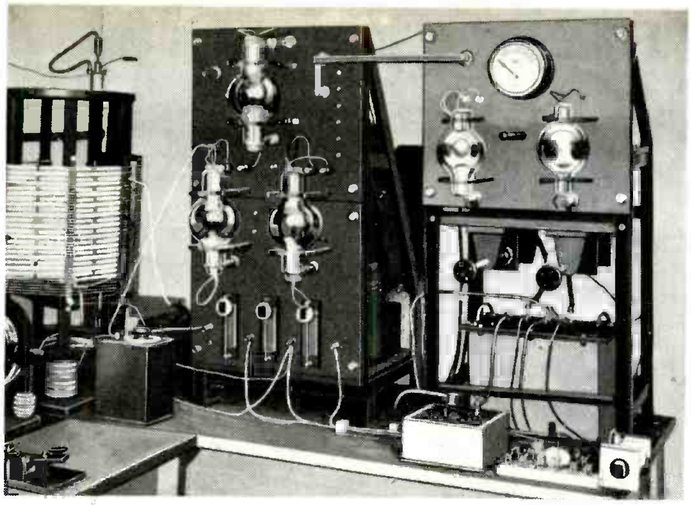
The circumstance was ironic in that, at the onset, the squabble was over a virtually useless device. The early triodes had practically no amplification factor and were, at best, temperamental performers. Their theory of operation was imperfectly understood and it was widely accepted that a 'soft' vacuum or a gas filling was essential. Not until 1911-12 when research by Dr. Irving Langmuir and others produced the 'hard' or high-vacuum valve, was the device transmuted into a really effective component. The importance of this work cannot be over-emphasized because, for the first time, a batch of valves with reasonably similar characteristics could be predicted and manufactured.

In 1913 came another tremendous technical advance when A. Meissner (Germany) patented the first thermionic generator. In this he was closely followed by Franklin and Round (Britain) and, a little later, by Armstrong and de Forest (U.S.A.) This discovery not only made wireless telephony a practical proposition (although it had been done before by non-thermionic means) but it formed a critical point in the history of electronics. Until that time there had been one broad highway and one only—wireless telegraphic communication. The development of the triode valve in its dual roles of amplifier and generator (a process accelerated by the Great War) brought a post-war diversification which has continued to this day.

Sound and television broadcasting, the present gramophone industry, the talking picture industry, public address systems, electronic navigational aids, television, radar and electronic test instrumentation are just a few of the roads which branched from the wireless telegraphy highway as a result of the



Receiving station at Bridgwater, Somerset, typical of the Marconi-Franklin beam stations set up in 1926 for the Post Office.



2MT, the Writtle, Chelmsford, transmitter operated by P. P. Eckersley in 1921/2.

Lauritz Melchior broadcasting from the Chelmsford works of Marconi in 1920—two years before the formation of the B.B.C.

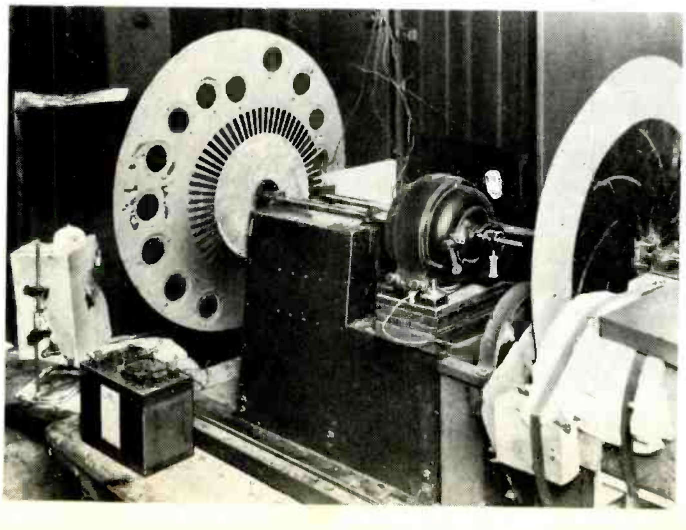
development of the triode, and which are now arterial roads in their own right.

Broadcasting

All these diversifications, like Topsy, 'just growed'. Sound broadcasting for instance, came into being after World War I largely by accident when engineers at Westinghouse in the U.S.A. and Marconi's in this country, becoming bored with reciting into their respective microphones for range tests, used gramophone records as interludes during which they could restore their vocal chords. To their surprise they found they had a small but coviferous ready-made audience of amateurs clamouring for more. In Britain, this situation led, via the Melba and Melchior concerts, the joyous 'send-up' approach of P. P. Eckersley and his team at 2MT Writtle and the sobriety of the original 2LO at Marconi House in the Strand, to the formation of an association of British radio manufacturers known as the British Broadcasting Company in 1922. (It became a Corporation in December 1926.)

Television had a rockier road to tread. Historically its concept (as a closed circuit system with wires as the transmission medium) pre-dates sound broadcasting by more than half a century. Its practical realization, however, had to await the development of the valve amplifier. For example, the apparatus designed by Nipkow in 1884 did not come to fruition until 1926 when John Logie Baird, using the Nipkow system of spinning-disc scanning, with the indispensable additions of an improved photo-cell and valve amplifiers, became the first man to give a public demonstration of television pictures which had movement and a degree of light and shade in them. He also implemented a suggestion made by A. Sinding-Larsen in 1911, namely that the signals generated by the televising apparatus might be used to modulate a radio-frequency carrier wave.

Not all steps which are taken are forward ones. In 1907 Professor Rosing (Russia) had pioneered the use of the cathode-ray tube as a means of picture display and achieved still pictures of simple geometric shapes. In the following year A. A. Campbell Swinton (a Scot) outlined a proposal for an all-electronic scanning system; he followed this three years later (1911) with a more detailed account and set down the essentials of the modern camera tube. He also visualized the receiver as using a cathode-ray tube type of display. Nothing significant was done to develop such a scheme, however, until V. Zworykin (U.S.A.) patented his iconoscope in 1923 and P. Farnsworth, another American, was known to be working on his image dissector. Zworykin's camera tube embodied the important inter-scan storage principle, which Farnsworth's did not. Neither inventor, it seems, knew anything about Campbell Swinton's proposal at that time.



Using the Nipkow system of spinning-disc scanning, Baird gave public demonstrations of television in 1926.

Both devices presented immense difficulties in manufacture and it was not for some years that a practical demonstration of either could be given. In the meantime Baird demonstrated, in rapid succession, the production of television pictures in darkness, colour television, and stereoscopic pictures and in 1930 began a limited experimental 30-line public service, using two B.B.C. medium-wave stations, one for vision, one for sound.

The publicity he gained in the late 1920s encouraged many of the bigger radio manufacturers to investigate the possibilities of television. Unfortunately almost all their effort was concentrated on various mechanical systems and in consequence a good deal of money went down the drain.

Electric and Musical Industries Ltd was one company which thoroughly investigated mechanical scanning, the EMI team being under the brilliant leadership of Isaac Shoenberg. By 1932 Shoenberg saw clearly that electronic scanning was the system for the future and intensive research was done on camera tube design, resulting in the Emitron tube. The team also developed interlaced scanning.

In 1934 the television interests of EMI were merged with those of the Marconi Company to form a new organization, the Marconi-E.M.I. Television Company ; by so doing the skills of E.M.I. in video work were allied to Marconi expertise in wideband modulation and amplification (it had been realized for some time that the complex high-definition video signals would have to be transmitted at v.h.f.)

Two years later (1936) the Government-appointed Selsdon Committee recommended a public trial of the Marconi-E.M.I. system against a new high-definition system developed by the Baird Company. Transmissions on both systems, on a turn-and-turn-about basis, were radiated by the B.B.C. from Alexandra Palace, North London, for

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*The partnership was dissolved in 1948.

several months from November 2nd, 1936. The Marconi-E.M.I. Company transmissions employed all-electronic scanning at 405 lines per frame, interlaced, while Baird used 240 lines sequential scanning; high-speed Nipkow discs performed the scanning process for televizing individual subjects in the Baird studio, while an intermediate film system took care of larger scenes. By February 1937 the battle was over, the Marconi-E.M.I. system emerging the winner. Transmissions were, however, suspended from the outbreak of war in 1939 until June 7th, 1946.

Electronics diversification

Over the years, from the mid-1930s to the present time, electronics research effort has mounted steadily; gone are the days of the lone-wolf investigator, his place taken by the mass-attack technique or by a sizeable team. The resultant multiplicity of inventions in a great diversity of directions makes it extremely difficult to select those which constitute the most significant advances from a list that would fill a book.

Which to mention in a limited space? The development of v.h.f. and microwave techniques immediately clamours for attention. So also does the study of the ionosphere and troposphere; the development of the super-het and frequency modulation by Armstrong; the pioneering of radio astronomy by Jansky and others; these and dozens more cry out for comment. But, in the space available, three innovations, radar, the transistor and satellite communications stand out as vital steps in the technology.

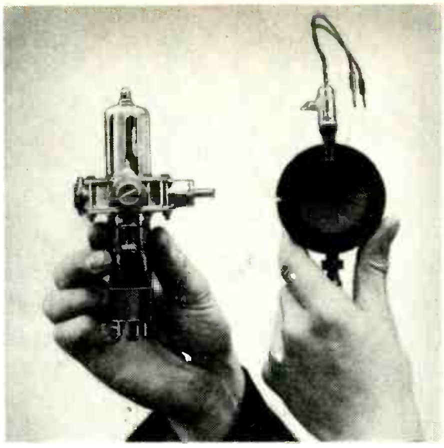
Radar

Hertz in his earliest experiments had shown that wireless waves could be reflected from a metallic screen; Tesla, in 1900, suggested that such waves might be used to detect moving objects, while in 1904 Hülsmeyer actually patented a rudimentary form of radar. Then the dark ages set in; not until 1916, when Marconi and Franklin were working on two metres, was interest revived in reflected waves. This was referred to by Marconi in 1922 in the course of a speech to the American Institute of Engineers when he gave a remarkably accurate prophecy of how the detection of remote objects might be accomplished.

The practical development of what is today known as radar began with the work of Appleton, Barnett, Briet, Tuve and others in ionospheric sounding; the two last-mentioned seem to have been the first to have used pulsed transmissions for the purpose.

The first proposal for the use of pulsed transmissions for radar purposes was made in 1931 by Butement and Pollard of the Signals Establishment at Woolwich. They built a 50 cm equipment using a rotating beam and succeeded in detecting echoes from objects at a range of about 100 yards, but neither the War Office nor the Admiralty were interested and so the work was abandoned for lack of support.

Robert Watson-Watt's paper "Detection and Location of Aircraft by Radio Methods", produced in 1935, is well known, as also is his work on the development of a practical radar system, for which he was subsequently knighted. Watson-Watt's work in this connection provided the chain of radar stations of various types established in Britain by the beginning of World War II. In 1939, the development of the resonant cavity magnetron by Randall and Boot was another momentous forward stride, in that it made high-power centimetric radar a reality. Centimetric Air-to-Surface Vessel radar, when introduced, brought a dramatic increase in U-boat destruction. Airborne radar for the interception of night raiders and a form of secondary radar which identified 'friendly' from 'hostile' aircraft were also introduced early in the war.



Examples of early klystron and magnetron tubes.

In the post-war years, to date, both ground and airborne radars have come into wide usage on civil aircraft and have become an indispensable air traffic control aid at busy airports.

The transistor

Beyond question no other single component developed in the post-war period has influenced radio communications (and electronics in general) to anywhere near the same extent as the transistor. The rectification properties of certain crystals were known in the early 1900s and in 1906 Dunwoodie introduced the carborundum detector. Various crystal rectifiers have been used over the years, reaching their hey-day in the sound broadcasting boom of the mid-1920s but surviving in enormously improved form to the present day.

In 1911 Dr. Eccles announced the oscillating crystal but experimental interest in this lapsed for many years until *W.W.* in 1924-5 published various articles dealing with the phenomenon.

Contrary to general belief, it would seem that the first solid-state amplifiers as we know them were not, after all, invented at Bell Telephone Laboratories. The distinction goes to Dr. J. L. Lilienfeld who filed a patent entitled "Method and Apparatus for Controlling Electric Currents" in Canada in 1925. Although his description of how his invention worked is wrong, the drawings show it to be a form of n-p-n transistor. Just why the potentials of this device were not explored is not known, but the next announcement of a solid-state amplifying device is that of Shockley, Bardeen and Brattain of Bell Telephones who, in 1948, announced their development of the point-contact transistor, for which, subsequently, a Nobel Prize was awarded.

Communication via satellite

The evolution of radio communications has, until fairly recently, been largely a matter of coming to terms with the ionosphere. No single frequency band is ideal for all purposes; each has its advantages and limitations. The l.f. and m.f. bands are, for example, suitable for long- and medium-range transmission, but can accommodate only one information channel per carrier. H.F. transmission systems also provide long-range facilities but can carry only a few channels. The very high frequencies and ranks above give progressively greater channel-bearing capacities but the direct signals are limited in range to line-of-sight and therefore, as a generalization, could only achieve long-distance working by employing a series of installations as point-to-point links†.

In 1945, Arthur Clarke, in a *W.W.* article entitled "Extra-Terrestrial Relays" prophesied that future progress lay in the direction of artificial earth satellites equipped with receivers and transmitters. This forecast came to practical fruition in the early 1960s and, in particular, in 1962, when the Telstar satellite was the medium of a successful series of communication transmissions (including television programmes) between the U.S.A. and England; subsequent launchings of synchronous satellites have provided a 24-hour service to the point where communication via satellite is commonplace. By such means, v.h.f. and the higher frequencies have been freed from their former short-range limitations and can have their multi-channel capabilities exploited for long-distance communications. To date, however, h.f. still remains the backbone of long-distance radio communications, on economic grounds.

Knowledge versus wisdom

As is, I suppose, proper in a technical journal, the discussion has been confined to technical advances. Whether the application of such discoveries has made for a better world is not the business of the engineer and the physicist. Or is it? How far are we responsible for the part radio communication has played—and continues to play—in the destruction of lives in war-time? Again, sound and television broadcasting has affected the pattern of living to a profound degree, the extent of which we cannot fully appreciate. Its vast potential for moulding social behaviour and world opinion is, however, all too often concentrated on holding a distorting mirror to the faces of its audience. Are our hands clean in this respect?

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† Scatter links are exceptions.

Basic Theory Since 1911

Some of the controversies that have raged over the years

by "Cathode Ray"

One basic theory which, I suspect, is held by many today is that way back in 1911—and no doubt for many years after—'wireless' was developed in scientific darkness on a 'try it and see' basis, quite different from the modern approach. A look through the early issues of *The Wireless World* would surprise and enlighten any who think that the theoretical basis of those far-off days was good only for a giggle.

The first thing that pulled me up when I did some browsing was an article by H. M. Dowsett in the May 1913 issue, 'Molecular Structure of Insulators'. That title wouldn't look at all out of place in 1971. It was quite a simple treatment which one could hardly improve upon for present-day beginners. After all, though Fermi-Dirac statistics have entered our ken in the meantime and would have to be included in any full treatise on insulators, one doesn't need them in an elementary picture.

Prof. G. W. O. Howe's treatises on electromagnetic waves (Nov. 1913) and aerial capacitance (1915) were *not* elementary. I suspect the Editor would quickly turn them down today as too mathematical. All levels of intellect were catered for in *The Wireless World* and besides theory articles for beginners a free wireless instruction course was offered by a certain Robert Baden-Powell. (*The Wireless World* itself was almost free, by our standards, being 5s a *year*—12 issues—including postage.)

One notes with interest that as early as 1911 someone was asking 'Does Wireless Affect the Climate?' Nuclear explosions, moon rockets and the Concorde have now largely taken the place of wireless as a scapegoat for unusual weather. It is worth noting that 60 years ago Campbell Swinton delivered a paper which included a detailed outline of essentially the present system of television, using cathode-ray cameras and receiving tubes.

Among people still living, John Scott-Taggart seems to have been the first to appear in *The Wireless World* (Dec. 1914), followed closely by H. S. Pocock (Feb. 1915). P. G. A. H. Voigt, better known now for audio, wrote on reflex receivers in Dec. 1921. It was not until 23rd Aug. 1923 that I came in, but still far enough back to make it hard for me to imagine what it is like to start now. Is there anything to compare with the excitement we had on first hearing spark morse signals, very memorable still after 50 years? Observation of the way children now accept colour television leads me to doubt it. But such reminiscing is an intolerable self-indulgence by the aged, and anyway is outside my present brief.

As we look back have we any ground at all for a feeling of superiority about our present-day theory? Well, however sound people like G. W. O. Howe may have been (and he long continued to get us on the right tracks with his famous editorials in *Wireless Engineer*, the sister journal of *W. W.*) one must admit that many in the amateur fraternity (and some even of the professionals) were a bit hazy. The principles of tuning caused a lot of difficulty. One of the main problems at the relatively low radio frequencies used was interference due to atmospherics, or *X*s as they were called. All sorts of ideas for tuning them out were thought up, usually in ignorance of the fact that interference of this kind, being almost aperiodic, shock-excited the tuning circuits at their own natural frequency.

The urge of amateurs to achieve the maximum ranges of communication was often unaccompanied by a corresponding grasp of the factors involved, and a belief grew up that results were essentially outside the scope of theory and were maximized by following the superstitions of the most successful DX witch doctors. So it was refreshing to read (in *Experimental Wireless and Wireless Engineer*, Dec. 1924) a letter from E. H. Robinson demolishing one of these fetishes, broadly-tuned c.w. transmissions', and ending 'I should like to suggest that the many amateurs who despise theory as not in agreement with practice should inquire more closely into their actual knowledge of theory and the precision with which they observe practical facts'—advice that ought to be pasted in large letters on the walls of many labs as well as shacks.

In fairness to amateurs we must remember the other side of the coin: the professionals relied on their theory that short waves were no good for long-distance communication, so they allocated them to amateurs. They regretted their generosity when the amateurs opened up communication with the antipodes on a few watts. The old theory had to be replaced by a better one.

The supreme example of the ultimate triumph of theory is, of course, the semiconductor revolution. So long as work in this field was guided by practical people it was restricted mainly to fiddling with the catswhisker to find a sensitive spot on the chip of natural galena crystal for better reception of 2LO. That, and perhaps copper oxide rectifiers in the charger needed to keep the l.t. battery fit to heat the bright-emitter valves which were displacing crystals. How vastly different since the physicists stepped in with their Fermi levels and things!

Although examples can be quoted of progress being made with the aid of theories afterwards proved to be wrong, in general it is helpful to pick the right theory. The most entertaining situations arise when theories clash. When Galileo was threatened with dire penalties unless he recanted his theory that the earth moves round the sun (instead of being the fixed centre of the universe) he did so, but is said to have muttered under his breath

'Cathode Ray' started his inimitable series of expository articles in *Wireless World* in 1934. Many of these articles have since been published in book form—'Second Thoughts on Radio Theory' and Essays in Electronics'. For many years the identity of 'Cathode Ray' was closely guarded but eventually it became known that it was M. G. Scroggie who has contributed to the Journal under his own name since 1923. When accepting our invitation to contribute to this 60th birthday issue he wrote 'Your letter started me on to calculating how much I have had published in *W. W.*; the result is 725 contributions (including reviews and letters over 47 years, totalling 1,400,000 words. Can anyone top this record?' If we exclude members of the staff, the answer is no! Mr. Scroggie graduated at Edinburgh University and was chief engineer of Burndept Wireless Ltd from 1928 to 1931 and since then, except for the war years, has been a consulting radio engineer. During the war he was first in charge of the early CH radar station at Pevensey, Sussex, and then at No. 9 R.A.F. Radio School before going into the Air Ministry.

'and yet it moves'; just as in my young days we inaudibly added I *don't* think' to the declarations of good intent forced on us by parent or teacher. The classic example of a clash of theories in our own field was the great sideband controversy.

Anything of the kind would probably be impossible today. Persons who declare that the earth is flat stand no chance of raising a furore. But around 1930 a world-famous authority in the field of radio, Sir Ambrose ('the valve, invented by me') Fleming, F.R.S., declared—and stuck to it—that sidebands were imaginary; a mere mathematical fiction. This was of more than academic importance. As W. T. Cocking mentions elsewhere in this issue, a new and supposedly revolutionary type of receiver (the Stenode) was claimed to be proof of the wrongness of orthodox sideband theory. And the future of television appeared to hang on it.

Not even the caustic wit of G. W. O. Howe succeeded altogether in dispelling doubts, and in the end a Government-sponsored committee was set up to investigate. Its findings, Special Report No. 12 of the Radio Research Board, published by H. M. Stationery Office in 1932, coldly and relentlessly re-established orthodox theory.

Although hardly such a *cause celebre,* the biggest correspondence I ever had on any article arose from one on a very similar subject, under the title 'Fourier —Fact or Fiction?' (*W.W.* Sept. 1955). Here again the theory is that a current (or other variable) which in pratice is generated as a whole, is nevertheless equivalent to a number (if necessary, infinite!) or harmonic components of constant amplitude. Coming 25 years later, this controversy revealed hardly any doubt about the reality of the harmonic components, but centred on a rather more subtle question posed in the article. Granted that there are good practical grounds for the unique place of sine waves in theory of this kind. Could some waveform other than sine wave be regarded as basic and an entirelydifferent but valid theory be erected on that basis? One correspondent declared this discussion to be 'singularly fruitless'. So it may have been in this particular case, but one of the most fruitful mental exercises is to do just what was suggested: question our assumptions. This is a hard mental exercise, so is seldom done. Progress is made by doing it. We tend, lazily, to cherish the concepts we have been brought up on and which have served us well, until we are convinced there can be no reasonable alternative.

I have become only too familiar with this kind of inertia in connection with phasor diagrams. This valuable aid to visualizing the workings of electronic circuits is rejected by all but a few because it looks like an unfamiliar—and therefore difficult—variety of the 'vector' diagrams that we know so well. These we have already found to be almost useless for electronic circuits and no help in understanding ordinary electrical a.c. circuits unless those circuits are simple enough to be [illegible] valuable without. These old 'vector' diagrams must bear a lot of the responsibility for the widespread teaching (even in textbooks) that there is a phase reversal between primary and secondary of a transformer. (With incredible self-control I'm going to say no more here about my alternative!)

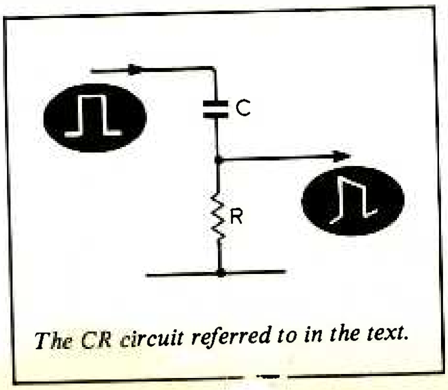
Just after the last World War another controversy raged, about valve equivalent circuits. This time even G. W. O. Howe seemed to lack his usual gift for clearing away the red herrings and revealing the essential, which in this case is that the valve and its equivalent circuit are two quite different things. So the source of anode d.c., necessary for one, has no place in the other. The reference direction of output signal current in the equivalent circuit must be decided without reference to that d.c. source. A pity that muddled thinking on this plagues present-day transistor conventions.

More unnecessary confusion was introduced into valve amplifier theory by the work of Bode admittedly classic, but misguided) on negative feedback in that the symbol μ (a universally accepted standard symbol for voltage amplification factor) was used for actual voltage amplification; which is better denoted by A. The devil of it was that μ is correct in the formula for output impedance with feedback, but not in the others, for gain, distortion reduction, etc.

During the last War I was shocked to find many radar instructors teaching that when (say) a positive-going input signal is applied to a *CR* circuit, as shown in Fig. 1, the output also goes positive *because of the charging of C.* In fact, of course, any charging or discharging of *C* appears only as *distortion* of the signal at the output.

Talking about distortion, I would like to mention a variety which I named scale distortion (*W.W.* 24th Sept. 1937, p.318; also Nov. 1948, p.392). When thrown into any assembly of audio experts this term used to act like a petrol bomb in Bogside. Guaranteed instant controversy. I don't know whether it still works. The main point was that unless an audio scene' is reproduced at the same intensity at the listener's ear as the original, what he hears is a distorted version, in that the tonal balance (especially the proportion of bass) is upset.

In this statement, only the word 'distortion' could be seriously questioned. Often it was denied that it could be distortion, since the same effect was noted if one moved away from the original sound, or nearer to it. Not quite true, for certain spatial effects would change too; but ignoring them I feel that if the objector had paid for the best seat, acoustically speaking, for a piano recital, and was obliged to sit half-way along the corridor, with the door open, or close against the piano, he might well use an even ruder word than distortion'. The comparison should be with the original heard *in a favourable position.* The other main argument concerned what, if anything, one could do about it when the reproduced intensity was unavoidably not the same as the original. Attemps to 'compensate' by having a tone control linked with the volume control were, in my view, misconceived.



The CR circuit referred to in the text.

Controversy tends to wax especially hot when, as in this example, *subjective* aspects are involved. Even a stone deaf man can measure sound *intensities,* but neither he nor anyone else is likely to agree about *loudness;* still less, unpleasantness. And all our work ultimately does involve subjective perception, rather than purely physical

What of the future? Since in all our theories we use concepts (such as fields) which of their nature cannot be said to be absolutely true or false (Essays in Electronics (Iliffe), Chap. 1.) there may come a day when it will be found more convenient to use some alternative concepts. But human inertia tends to keep established concepts established. Then of course we can look forward to the discovery of new phenomena, possibly calling for new concepts. But the way things are going I would expect the greatest developments to concern the aforementioned mysterious link between objective phenomena and subjective perception. As a result of new theories of perception we may well be able to improve our equipment by discovering more precisely the physical factors that yield desired or undesired subjective effects. The Haas effect, which decides whether voice reinforcement appears to come from the actual speaker or not, is an example of what has been done along these lines.

To realize how difficult is investigation in the subjective, compare the most sophisticated computer that exists or can be imagined with a human being of very limited attainment—say, an average young child. Even a child has aesthetic likes and dislikes, outside the capacity of the computer. Why? Can strictly scientific investigation tell, or is it for ever beyond its scope? Is it because human beings are not just machines?

The World of Amateur Radio 1911—1971

By Pat Hawker, G3VA

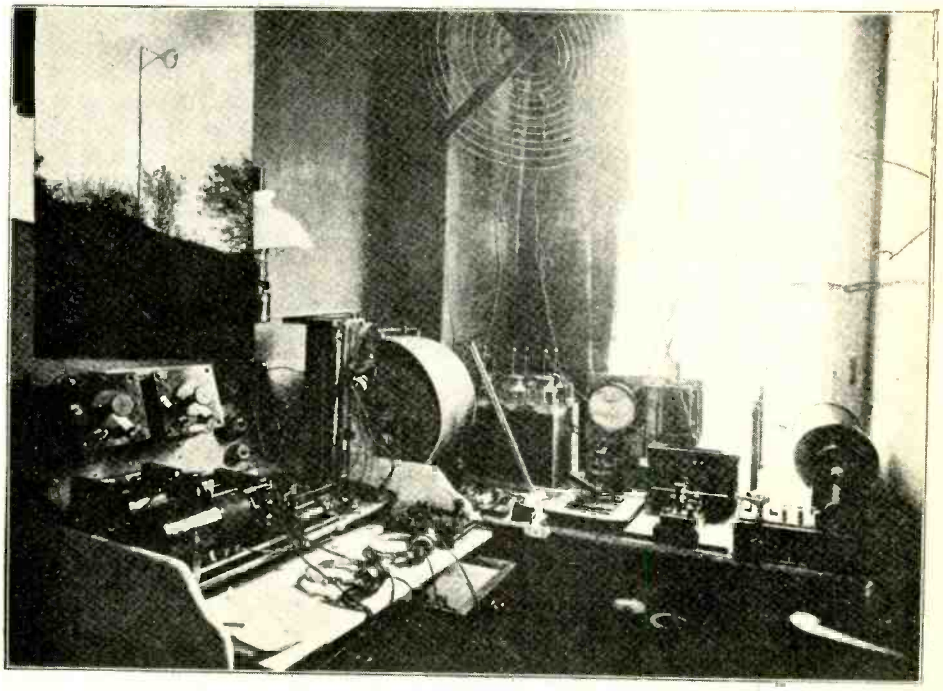
From a few thousand to half-a-million transmitting amateurs . . . from spark to s.s.b. . . . from a few miles to moonbounce . . . from coherers and crystal detectors to m.o.s.f.e.ts and integrated circuits . . . from jiggers, slide tuning coils, high-speed rotary gaps, motor ignition coils and Wimhurst machines to transceivers and transistors . . . from the bright emitter valves of the twenties and the wide open spaces of "200 metres and down" to the current pressures on the narrow frequency assignments . . . from causing broadcast interference on the old 440-metre band to television interference, the dominating problem of the past few decades. Yet always the same interest in extending working ranges whether on 200 metres or 2400 MHz: the same problems of how to improve receiver selectivity and sensitivity—and almost always the same fears that other interests and authorities may wish to limit the scope of amateur communication.

Historically, amateur or 'experimental' radio reaches back more than 60 years—indeed it began as soon as the results of Marconi and the other pioneers started to reach outwards from purely scientific circles. In the U.K., its official beginning was determined by the Wireless Telegraphy Act, 1904, with its provisions for the use of 'wireless telegraphy for experimental purposes'—though the hobby remained unregulated in the U.S.A. until December, 1912, when the amateurs there were banished to the 'useless' and unwanted regions of '200 metres and below'.

In the pages of 60 years of *Wireless World* one can trace the major events which make up this durable interest. You can find descriptions of pre-1914 amateur stations, including W. K. Alford's station TXK the forerunner of his present call G2DX; the formation in 1913 of the Wireless Society of London which, in 1922, became the R.S.G.B. and for which *Wireless World* was the official journal until February, 1925.

Early days

It was in the years from 1911 that amateur radio emerged as an activity distinct from the early dabbling in wireless telegraphy—then, as now, with strong links with similar activity in the U.S.A.



This illustration accompanied a description of W. K. Alford's station in the October 1914 issue of Wireless World.

Yet the links with modern operating were by no means tenuous. *Wireless World* in 1914 reported an attempt by the Wireless Society of London to put an end to 'jamming' that reads as though it could have been written yesterday. Among the 13 rules were: transmitter to be sharply tuned; receiver to be as selective and sensitive as possible. Those early amateurs were advised: 'do not transmit at less than 12 w.p.m.; listen carefully before calling a station; never carry out testing work with the aerial on that can be done equally well with it off; always use minimum power; refrain from answering a station that is calling some other station; listen in after finishing a conversation to see whether anyone is waiting to call you . . .'

And the clubs were forming. A Junior Wireless Club (later to become the Radio Club of America) had been formed in New York in 1909 at the same time as Hugo Gernsback began publishing *Modern Electrics* with a large radio content. In 1911, the year *W.W.* began as *The Marconigraph*, five enthusiasts formed the Derby Wireless Club, which—as the Derby and District Amateur Radio Society—is currently engaged in marking its own 60th anniversary. The club met weekly, possessed a library, carried out experiments—one of these was to use two buckets as a variable capacitor; one suspended from a pulley by a cord to raise and lower it into the other! Those Derby enthusiasts soon decided that 'the secret of successful reception is a high aerial and a good pair of headphones'.

In 1912, the first British Commonwealth 'national' radio society was formed—the Wireless Institute of Australia (still the society representing Australian amateurs) and it was reported that some 400 experimenters in New South Wales were covering distances up to 30 miles with converted $\frac{1}{2}$-inch motor ignition spark coils.

In Britain, by 1914, 990 of the old three-letter experimental calls had been issued; there was even, in 1913, a 'directory of stations' published by Gamages which had emerged as one of the main suppliers of equipment to amateur experimenters. Meanwhile the hobby was going great guns in the United States, with A.R.R.L. formed in 1914, but then as only one of a number of groups catering for amateurs. After the close-down of British stations in August, 1914, the Americans continued active until 1917 with as many as 6000 stations, occasionally working distances over 1000 miles. One of the early American amateurs was none other than Edwin Howard Armstrong whose regenerative receiver, used in his amateur station, was the first of this brilliant engineer's many inventions.

Broadcasting and short waves

After World War I came a long struggle to re-establish amateur radio transmitting (and even receiving which had equally been banned during the war). In this struggle *Wireless World* played a major role. As early as March 1919 an editorial, with the support of Marconi, Fleming and Eccles, made a strong plea for the removal of restrictions; Marconi wrote 'I consider that the existence of a body of independent and often enthusiastic amateurs constitutes a valuable asset towards the further development of wireless telegraphy.'

But it was late in 1920 before transmitting licences were again issued with callsigns of current form (except for the absence of official international prefixes until 1928) for 1000 metres (later changed to 440 metres) and below 180 metres. By this time word was trickling through of long distances being covered by American amateur spark and valve (c.w.) stations: 500, 1000 and even 2000 miles on wavelengths of about 200 to 230 metres.

Soon plans were launched for transatlantic tests, with the British listeners organized by Philip Coursey, 2JK, then research editor of *Wireless World*. The first tests in February, 1921, proved a failure, but new tests were planned for the following winter. Paul Godley, American 2ZE, brought over receivers which he set up at Ardrossan, Scotland. During the December tests he logged 27 American and one Canadian station, but this time several British listeners also heard transatlantic signals. On 11th December, 1921, the special Radio Club of America station 1BCG sent the first complete amateur message across the Atlantic—one of the signatories was Armstrong. These tests finally settled the spark versus c.w. controversy, overwhelmingly in favour of valve transmitters.

During his stay in England Paul Godley lectured to the Wireless Society of London saying 'one has far greater hopes of being able to travel greater distances on shorter wavelengths than on higher wavelengths'. This was a hint of things to come—the historic pioneering of short waves by amateurs. The breakthrough came in late November 1923 when Leon Deloy, French 8AB, worked the A.R.R.L. station of Fred Schnell, 1MO, on about 100 metres, initiating a mighty rush to short waves. Jack Partridge, 2KF, was the first British station to work the Americans, on 8th December, 1923. In January, 1924, E. J. Simmonds, 2OD, made contact with the States with an input of only about 30 watts. In the autumn Cecil Goyder, a 16-year-old schoolboy at Mill Hill, and Gerald Marcuse, 2NM, made contact with Frank Bell, Z4AA, in New Zealand. It was feats such as these that really woke communication companies to the possibilities of the short waves they had previously scorned.

Not all amateurs in the 'twenties were interested in long-distance working. In 1920-21, with no regular broadcasting in the U.K., British amateurs began putting out gramophone records and even live concerts—sometimes with official blessing, sometimes without it. The Wireless Society organized a massive petition, signed by 63 clubs representing 30,000 enthusiasts, asking for regular broadcasting. Amateurs can also claim to have initiated Empire broadcasting when Gerald Marcuse, 2NM, began a series of transmissions on about 30 metres, well in advance of the first B.B.C. station G5SW.

But the coming of broadcasting soon brought problems to the amateurs, and 440 metres was lost. By then Hugh Pocock had been writing in *Wireless World* of the extent that petty rivalry was threatening to split the ranks of amateur enthusiasts. But the biggest threat was in the new regulations of April 1924 when the authorities attempted to impose a total ban on all casual international working by British stations. *Wireless World* immediately offered to place £500 at the disposal of the R.S.G.B. to allow a test case to be argued in the Courts. Fortunately the authorities gradually gave way (although the ban on the use of 'CQ' remained until 1946).

Later days

In the years that followed, amateur radio became established as something quite distinct from broadcasting and turned more and more to h.f. and v.h.f. Strictly speaking all licences in the U.K. were 'experimental' as the first 'amateur' licences were not issued until 1946. But, in practice, in the 'thirties the hobby was recognized, even if newcomers were restricted to 10 watts and 1.8, 7 and 14 MHz.

Frequencies continued upwards. Jimmy Matthews, G6LL, (still active) made the first transatlantic contact on 28 MHz in October, 1928, but the band went dead for some years. About the same time, amateurs began to explore frequencies around 56 and 112 MHz, then wide-open and unused. In the 'thirties came the annual contests and the operating certificates. Equipment which until then had been virtually all home-built began to be purchased. The superhet communications receiver began to displace the 0-V-1* and 1-V-1 receivers. Names such as Eddystone, HRO, Hammarlund and Hallicrafters were heard increasingly. The crystal filter, developed for h.f. by Lamb of A.R.R.L., exploited a British development for stenode reception.

By now crystal control had replaced the old t.p.t.g. and master oscillators (and was later to be partially replaced by v.f.o.). The 'Zepp' was the popular aerial of the 'thirties. Near Chicago, Grote Reber, W9GFZ, was making the first-ever radio telescope to plot radio sources in the sky—while Dennis Heightman, G6DH, identified solar hiss. A.M. stations on 14 and 28 MHz made intercontinental phone working a daily occurrence.

On 31st August, 1939, all British experimental licences were withdrawn and amateur activity, as such, ceased until January, 1946. Many amateurs used their operating skills in the Services—and incidentally were responsible for many of the most successful feats of both British and German intelligence! Indeed, interest in the hobby did not fade away, and the R.S.G.B. actually increased membership from 3800 to 9600 during this period.

In February, 1941, a controversy arose following the publication of an article 'The future of amateur radio' in *Wireless World* (and which I can now reveal was written by me), as to the form that post-war licences should take. Many of the ideas put forward during this controversy were later adopted by the Post Office when, in January 1946, the first-ever U.K. amateur licences were issued, though a number of 'incentive' elements of this licence were later to be abandoned.

But the basic terms of the 1946 licence continue through several revisions to govern the hobby in this country, though the introduction in 1964 of Class B (phone-only, v.h.f.-only) licences poses the likelihood of further erosion of interest in c.w. telegraphy, which to some of us continues to be 'inescapably the basic form of amateur communication'.

By the 1950s, the first steps towards the now dominant s.s.b. mode of operation had been taken, 144 MHz had displaced the old 56 MHz band, 420 MHz had been opened to amateurs (including the new interest in amateur television), rotary Yagi and Quad aerials had become popular, amateurs had discovered transequatorial propagation. Two further decades have brought the transceiver and the semiconductor revolution, but the hobby has changed remarkably little in its essentials.

One might ask what is the appeal of amateur radio that attracts recruits from both inside and outside electronics and succeeds in retaining their interest not just for the average 10 years or so, but for 30, 40, 50 and even 60 years? Its recruits have included such giants as Armstrong, Ryle, Kraus, Campbell-Swinton, Fink, Terman, Henney, Collins, Eckersley, Reber, Villard, Crosby, Beverage . . . and also 'outsiders' such as Barry Goldwater, Brian Rix and King Hussein.

Perhaps *Wireless World* summed it all up when, in 1914, it quoted Tennyson:

I hear at times a sentinel
Who moves about from place to place
And whispers to the worlds of space
In the deep night that all is well.

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* Old method of classifying stages in a receiver; first numeral, number of r.f. stages; letter 'V', detector; second numeral, number of a.f. stages.

F.M. Stereo Tuner

High-performance design for home construction

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

In recent years there have been a number of developments in the components field, particularly in semiconductor devices, that have led to great improvements in the design possibilities for f.m. broadcast receivers. In particular these have been the advent of the dual-gate m.o.s.f.e.t., integrated-circuit i.f. amplifiers and demodulators, ceramic filters and improved variable-capacitance diodes. This two-part article describes an f.m. tuner design using these devices, discusses the advantages of the devices and gives constructional and alignment details. It does not attempt to be all-embracing and there will doubtless be some who disagree with the author's views of the current scene. It is hoped however that they do show some ways in which f.m. tuner design is currently evolving.

The work is the result of many months of design and measurement on five prototypes, so that results are not based on a one-off, and should be reproducible by readers who wish to copy the design. The receiver was designed to achieve in a relatively simple way a performance equal to the better examples of the commercial models available, but at a much lower price. (Total material cost comes out at about £11.) Comparison with the figures given in a recent *Wireless World* survey of commercial tuners (September 1970) suggest this aim has been achieved. The performance of the tuner under normal conditions of use has been excellent. One of the units is in use in Blandford Forum in Dorset—very much a fringe area—and gives noise-free reception from the Isle-of-Wight transmitters, including the new local station Radio Solent.

The design for the front-end of the f.m. receiver is shown in Fig. 1. Both r. f. amplifier and mixer stages use dual-gate f.e.ts with gate protection diodes. In the r.f. stage the upper gate is decoupled and acts as a screen between drain and gate 1, much as the g_2 electrode of a thermionic valve does. In the mixer stage this second gate is used as the injection point for the local oscillator voltage. There is not the same need for a screen between drain and gate 1 in a mixer stage as the drain load is not tuned to either the signal or oscillator frequencies. There is therefore little or no gain at signal frequencies to cause oscillation provided care is taken with the layout, particularly the length and placing of leads.

The magnitude of the local oscillator injection at gate 2 will affect the mixer gain and the spurious signal response characteristics of the mixer stage. This local oscillator voltage will be higher than in transistor tuners using bipolar devices by up to an order of magnitude and for the circuit conditions used a value of

Fig.1. Front-end of receiver using dual-gate f.e.ts.

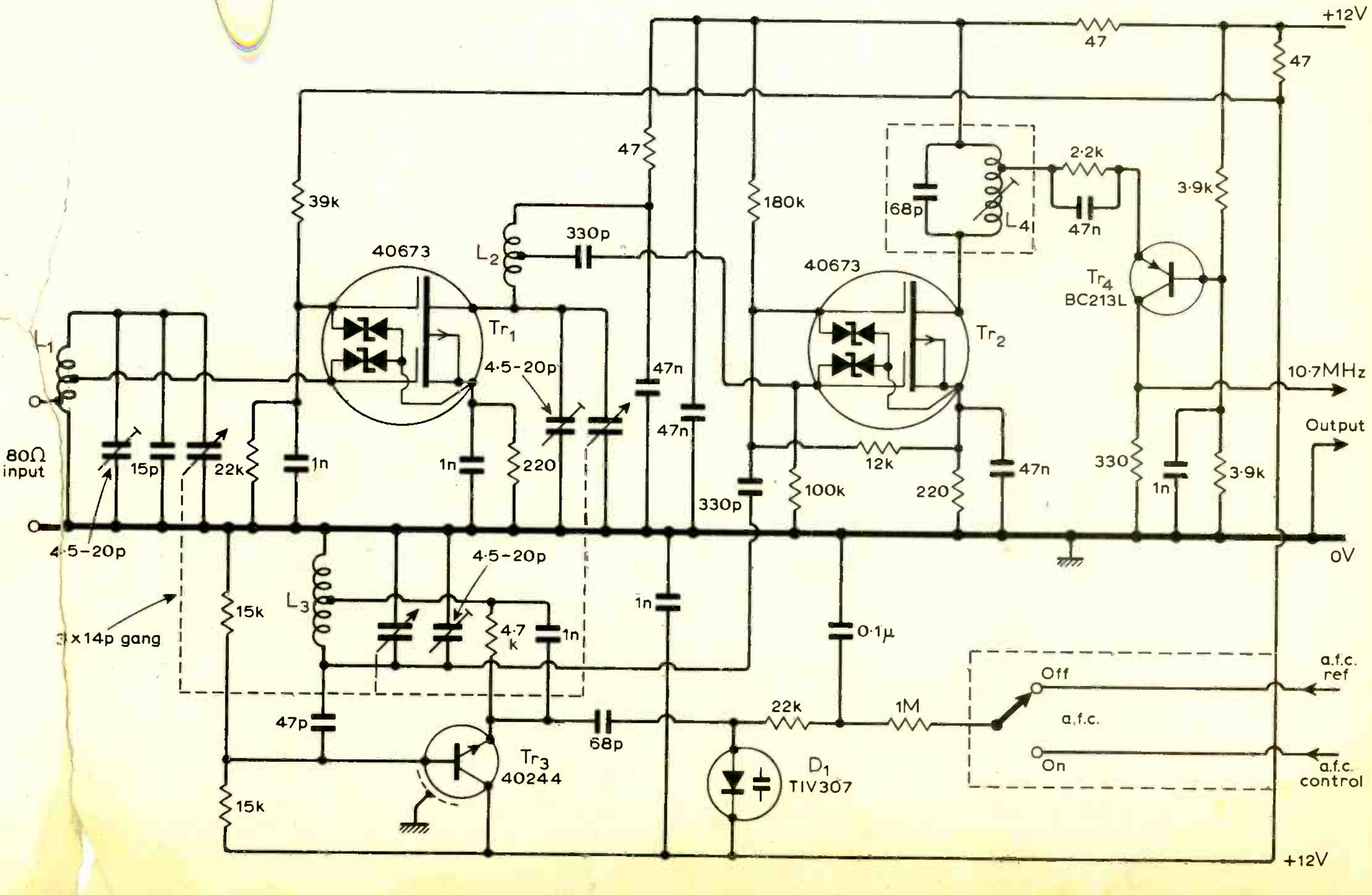
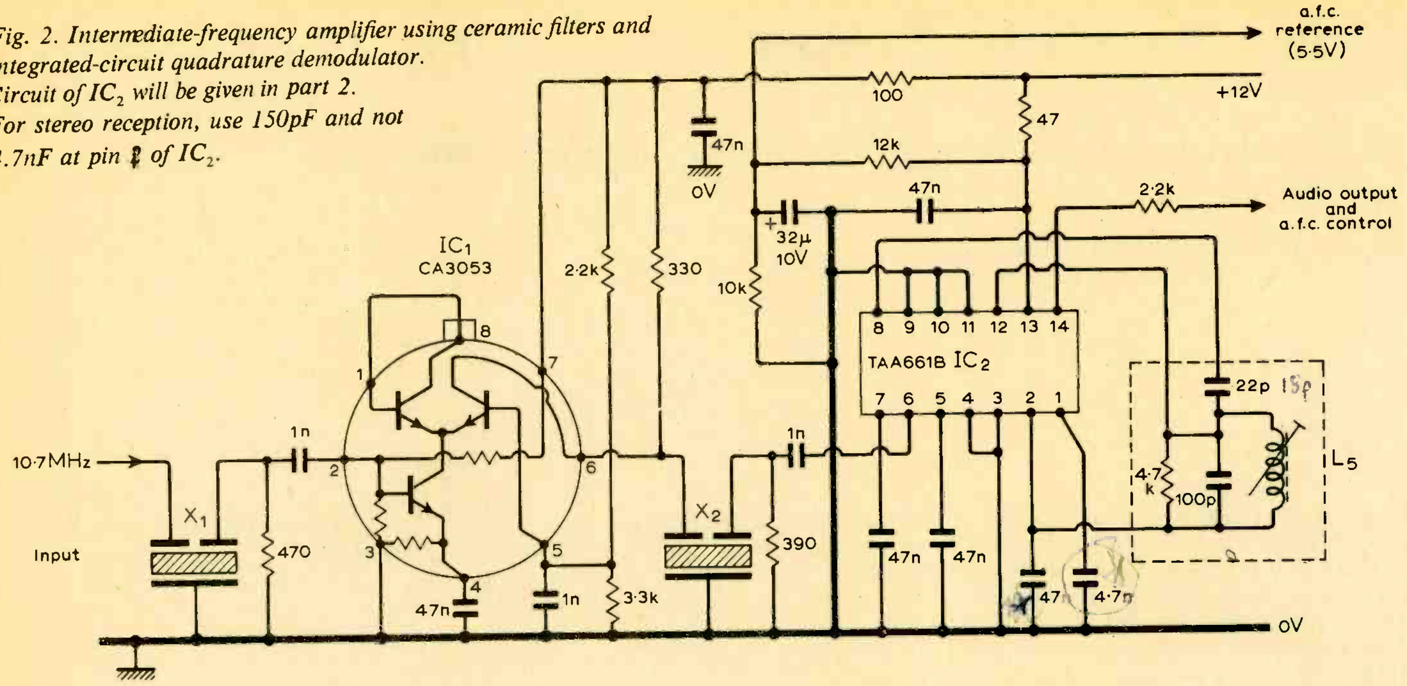


Fig. 2. Intermediate-frequency amplifier using ceramic filters and integrated-circuit quadrature demodulator. Circuit of IC_2 will be given in part 2. For stereo reception, use 150pF and not 4.7nF at pin 1 of IC_2.



500mV r.m.s. gives a reasonable mixer gain without too high a spurious signal response. In fact higher levels have been used without great trouble from spurious signals. Far greater trouble can be caused by lack of screening, leading to i.f. harmonics being picked up by the front end—especially with the high sensitivity of this tuner and, because of its small size, the close proximity of the front-end and the i.f. amplifier.

The oscillator is a conventional Hartley circuit with the ground point moved to give a grounded-collector design. There is no particular advantage to be gained in using an f.e.t. in this stage so that the cheaper bipolar device is preferred. Automatic frequency control is applied by the variable-capacitance diode D_1 coupled to the emitter of the oscillator stage. A resistor of 22 kΩ prevents the decoupling capacitor of 0.1μF from shorting out the oscillator voltage. The 0.1-μF capacitor together with the 1 megohm resistor form a low-pass filter to prevent audio voltages in the a.f.c. voltage from reducing the modulation of the carrier by audio frequency modulation of the local oscillator.

The a.f.c. can be switched out of operation by connecting the diode to a constant reference voltage from the i.f. amplifier. Diode D_1 is returned to the 12-volt supply line of the oscillator so that the a.f.c. control voltage changes the diode reverse voltage in the correct direction to reduce any oscillator drift. An increase in local oscillator frequency increases the intermediate frequency, which in turn leads to a rise in the output potential of the demodulator of the i.f. integrated circuit IC_2 (Fig. 2). As the diode is connected to the +12V supply, this increase reduces the reverse bias across D_1, increasing the diode capacitance and reducing the local oscillator frequency to correct its drift.

The mixer has a grounded-base stage feeding the 330-ohm resistor needed to correctly terminate the first filter unit X_1 (Fig. 2). This resistor also makes a convenient low-impedance output point from the front-end. A cheap p-n-p bipolar device is more than adequate for this position, because in a grounded-base configuration the requirements in respect of high frequency or noise performance are not stringent. The working Q of the tuned circuit is less than 20 so that tuning is not critical, and it is set to maximize gain in the usual way.

The supply for gate 2 of the r.f. stage is derived from the decoupled oscillator supply rather than from the top of L_2. This is brought about purely by layout convenience on the printed wiring board and, as gate 2 is additionally decoupled, has no effect on the performance.

I.F. amplifier

Two ceramic filter units X_1 & X_2 are separated by a buffer amplifier (IC_1) of moderate gain (about 20dB). The reason for this moderate gain is that it is desirable to place the filters as early as possible in the i.f. amplifier so that as successive stages limit with increasing signal level there is no change in bandwidth. This would be fully achieved if the whole of the i.f. gain were after the filter, and provided the mixer did not limit.

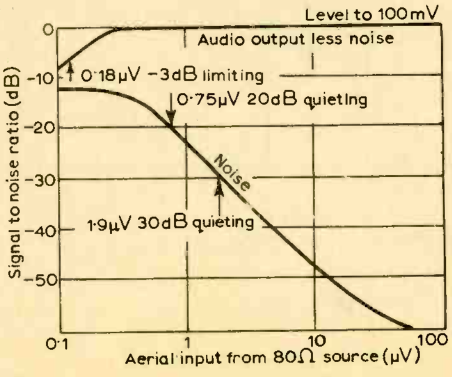


Fig. 3. Graph of low-level performance shows sensitivity of 0.75µV (for ± 75kHz) for 20dB quieting. Above 50uV input, signal-to-noise ratio is better than 60dB.

In practice it is not possible to achieve this ideal, but the compromise of using only moderate gain before the second filter unit is a reasonable one and does not give rise to any undue increase in bandwidth over the normal range of signal levels. The performance obtained is a great improvement over normal bipolar i.f. amplifiers using discrete components with several double-tuned i.f. transformers. In such an amplifier the selectivity of the transformers is gradually lost starting at the output end as successive stages limit and the overall selectivity can leave a lot to be desired at high signal levels.

The first integrated circuit is a long-tailed pair circuit, used as a cascode amplifier by ignoring one of the top pair of transistors and driving into the long-tail transistor. The input impedance of this stage is suitable for the ceramic filter unit so far as resistance is concerned, but is above the maker's recommendations so far as input capacitance is concerned. For this reason the resistor terminating the filter X_1 is raised to 470 ohms, which compensates for the increased capacitance loading of the stage in restoring the top of the filter characteristic to reasonable flatness.

The load of the cascode stage is a 330-ohm resistor—to drive the filter X_2 from the correct source impedance. This low value results in the stage gain being low, especially when the loading effects of the filter are accounted for, so that although the slope of the cascode stage is around 100mA/V the overall gain from the output of X_1 to the input to X_2 is only a little over 20dB.

The input impedance of the IC_2, around 2 kΩ, is not very much greater than 330 ohms so that a terminating resistor of 390 ohms is used at the output of X_2. The value of the feed capacitor to the ‘quadrature’ tuned circuit L_5 is la ger than the maker's recommended valu of 18pF.

The value is not very critical in practice and up to 47pF has been used with little change in performance once the circuit had been retuned. It is likely that with large departures from the recommended value there will be an increase in distortion, but no appreciable effect is likely to stem from the increase to 22pF, a value more readily available than 18pF.

One possible reason for the apparent insensitivity to the value of this capacitor is that the quadrature drive voltage is derived from a resistive tap on the load resistor of the final stage of the i.f. amplifier of IC_2. The value of the impedance at this tap is fairly low, and as the coupling to the circuit is increased by increasing the value of the capacitor, the damping effect of this resistor increases, lowering the Q of the quadrature circuit, and compensating—at least to some extent—for the increased drive and tending to restore the correct phase relationship.

The audio output from pin 14 is taken via a 2.2-kΩ resistor to provide additional overload protection.

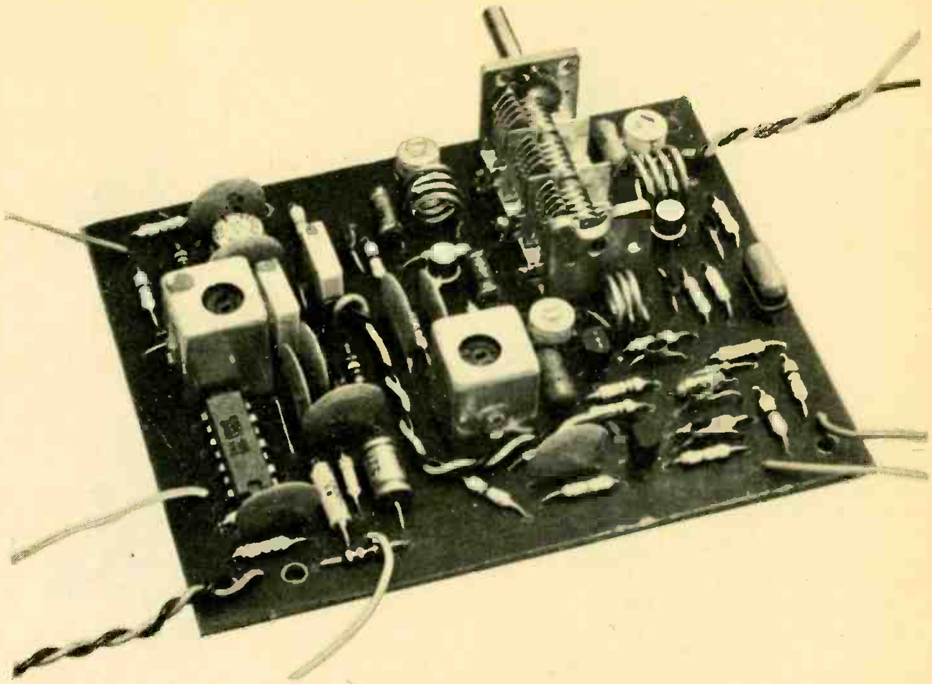
The reference used when a.f.c. is not required is derived from a potentiometer across the supply. The values chosen give a voltage close to that obtained at pin 14 of IC_2 (when there is either no signal or the signal is at centre frequency). The output level at pin 14 of IC_2 stays fairly close to around 46% of the supply voltage over the range 10-16 volts, and thus a simple potential divider is adequate for this reference voltage as this will also provide such a percentage of the supply voltage.

Because the output at pin 14 is a percentage of the supply voltage it is essential that the supply to the tuner be very well smoothed if hum and noise on the output is to be prevented. This is also important as the a.f.c. diode is returned to the 12-volt supply, and supply rail hum will therefore produce frequency modulation of the intermediate frequency whether or not a.f.c. is switched on.

The requirement for a ripple-free supply was one of the reasons for the choice of a 12-volt supply, so that adequate resistive smoothing could be used with a large reservoir capacitor. The drain of the tuner is almost constant and fairly well defined at a little under 35mA so that simple resistive dropping is satisfactory. An important point is that with such a network it is essential that the supply to the resistor be switched to disconnect the receiver, and not the supply to the receiver from the reservoir capacitor. In this latter case the capacitor would charge up to the full supply voltage with the receiver off, and on switching on the receiver would momentarily receive the full supply, which might well be enough to permanently damage the active devices of the receiver, especially IC_2. For supplies much above, say, 36 volts some form of simple stabilizer would be preferable.

Performa ce

The low el performance of the tuner is show ig. 3. At signals above 50μV



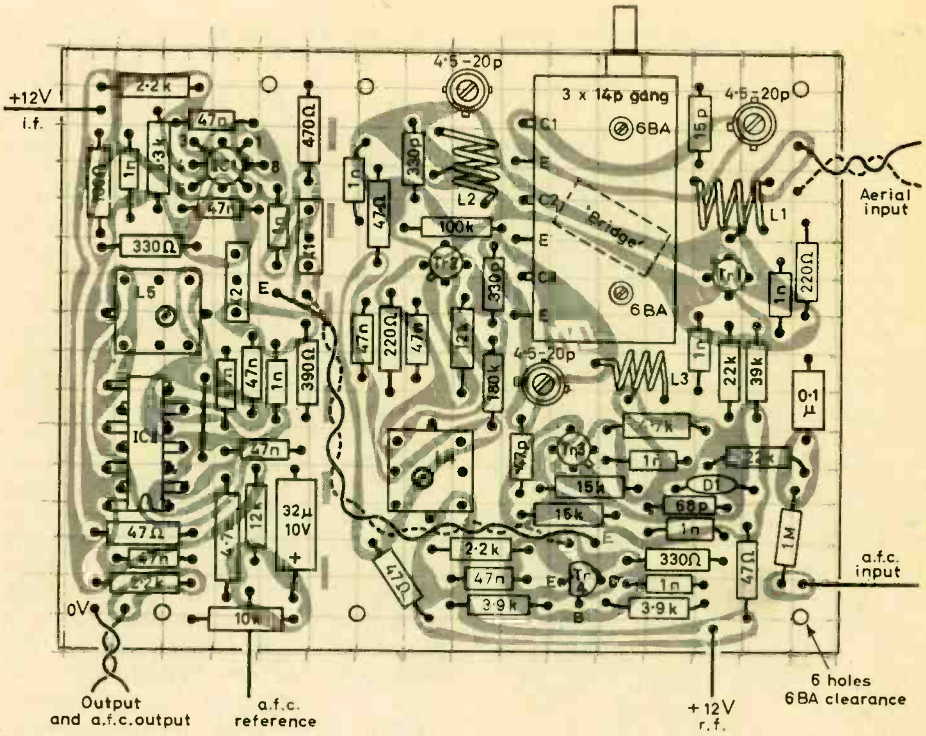


Fig. 4. Metal bridge—covering lead from Tr_1 drain to its tuned circuit—under the tuning capacitor is essential to maintain stability. Bridge, which can be tinplate, is detailed in Fig. 7. Complete tuner is screened by fitting into a die-cast box. FIG 7

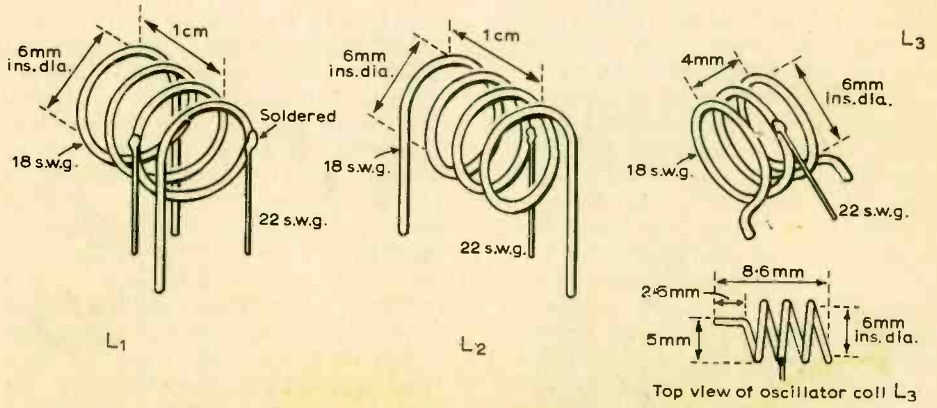


Fig. 5. Self-supporting r.f. coils, wound with slightly stretched wire, are shaped on a ¼-in dia. rod.

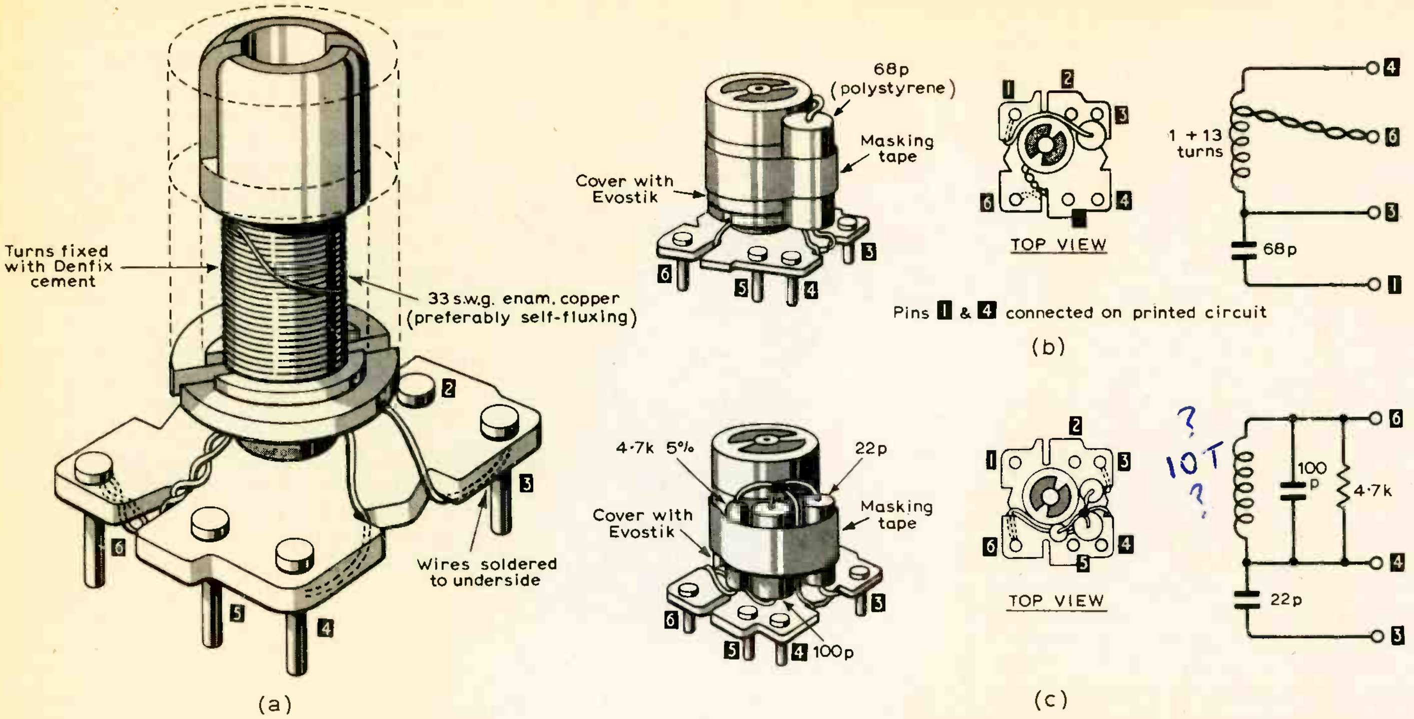


Fig. 6. Two screened i.f. coils are wound with 33-gauge enamelled wire and secured with a little Denfix cement. Capacitors are fixed with masking tape.

the signal-to-noise ratio is better than 60dB, and the 20 and 30dB quieting figures are 0.75 and 1.9μV respectively. Limiting (−3dB) of the demodulated audio signal (single-tone filtered from noise) occurs at only 0.18μV so that at all usable signal levels the i.f. section is limiting.

Unfortunately no signal generator was available which had an output with amplitude modulation-free from f.m., and it has therefore not been possible to check the a.m. rejection of the receiver. However, it is expected that the result will be close to the figure quoted for the i.f. integrated circuit (IC_2) at moderate signal levels, with an improvement when the first i.f. amplifier limits. The figure quoted for the TAA661B is 40dB at 10mV input, equivalent to around 10μV input at the aerial. Performance is summarized in the table on this page.

General layout

The tuner is constructed on a single-sided printed circuit board and is divided into two areas. The front-end and the i.f. amplifier are laid out separately, side by side, on a printed circuit board about 10 × 8 × 5cm overall, and in such a way that they may be separated if desired.

The complete tuner is enclosed in a screened box to cut down on spurious responses due to radiation from the i.f. amplifier, and to reduce local oscillator radiation to a minimum. This screening is especially necessary with this design because of its very high sensitivity.

The dial drive system suggested gives a scale length of 13.7cm with a reasonably linear frequency change over the centre 80% of this scale. A cord drive system is used which has the advantage of retaining the pointer at both ends, thus eliminating the problem of sliding friction at one end of the pointer, and giving a much smoother drive.

The overall layout of the components is shown in Fig. 4 as seen from the components side of the board, and also in the oblique view.

In construction keep leads short and if possible test all components on a bridge before fitting them on the board, as this can save ruining a good p.c. board should the tuner not work first time. It cannot be emphasized too strongly that such component checks can save much wasted money and temper. It is also vital to check that the components are correctly located, the diode connected with the right polarity, and that there are no breaks or shorts on the 'track' of the p.c. board. This latter point is of importance on such a small board with roughly 200 component holes, as tracks are necessarily fine and gaps small. A watchmaker's eyeglass has been the constant companion of the author during the construction and design of this tuner.

Coil construction

The r.f. coils are all made from 18-gauge tinned copper wire and are self-supporting. Taps are made by soldering leads of 22-gauge tinned copper direct to the turns of the coils—Fig. 5. The coils were made by winding the wire on a ¼-in rod such as a drill shank. The wire should be straightened by placing one end of a length in the vice and pulling the other end until the wire stretches very slightly, when the wire will have lost all kinks.

The coil wires should be a firm push fit in the board, if undue strain on the copper foil of the board is to be avoided when adjusting the coils. At all cost avoid the wires being loose in the board before soldering and if necessary apply the minimum of Araldite epoxy adhesive around the 18-gauge coil wires on the components side of the board after soldering in position. The joints should then be quickly reheated with the soldering iron to cause the Araldite to run into the holes in the board, thus securing the coils rigidly. After using such an adhesive the board must be left in a slightly warm place, e.g. an airing cupboard, for 24 hours to ensure that the adhesive has set hard.

The coils should be mounted on the board in the positions shown in Fig. 4, and with the turns of the coils nearest the board surface 2.5mm clear of the board. In the case of the oscillator coil this must also be 3.5mm clear of the rear face of the tuning capacitor. It is best to adjust the coils before soldering them into the circuit board to minimize subsequent adjustment, and the overall coil lengths given (over the outside of the end turns) are close to the

Performance

Sensitivity	
−3dB limiting	0.18μV
20dB quieting	0.75μV
30dB quieting	1.9μV
Spurious response	
image rejection	−70dB
i.f. rejection	−85dB
other unwanted signals	−94dB
Audio output	0.5V r.m.s. for ±75kHz
*Capture ratio**	2dB approx.

* Difficult to measure. There does not appear to be much dependence on signal level provided the signals are reasonably above noise level—a result to be expected from the very low level at which limiting starts. Figures varying from 1 to 4dB were measured at various signal strengths on repeated measurements. In general a signal 10dB below produced no noticeable effect on th demodulated output.

final adjusted lengths required for correct tracking.

An alternative method of mounting is to open up the main coil mounting holes in the board and insert 'eyelets' which are big enough to allow the 18-gauge coil leads to pass through them. The eyelets are riveted into the board so that the strain is removed from the copper track. Overall connection is obtained by soldering the track to the eyelet and to the coil leads. All the main pads for the ends of the coils are large enough to allow this to be done.

The two screened i.f. coils are both constructed on Neosid coils type NS/E3, and both are wound with 33-gauge enamelled wire, preferably of the self-fluxing variety. The two coils are wound as shown in Fig. 6 and the turns secured in place for stability with a minute quantity of Denco Denfix polystyrene cement. (Do not use modelmaker's polystyrene cement as some varieties can have high loss factors.) It is essential to use the least possible quantity as the bobbin of the coils is made from polystyrene loaded with iron dust and is very easily dissolved by this cement. When the cement has dried, place the ferrite sleeve over the coils, ensuring that the leads are well pressed down in the slot at the base of the bobbin so that this ferrite sleeve does not scratch the wires.

Next push on the polythene retaining disc. Secure the ferrite sleeve to the coil former with a smear of Evostik latex-resin contact adhesive around the join between the sleeve and the coil former near the base. When dry connect the capacitors (and the resistor in the case of L_5). Tape these components to the former as shown to hold them clear of the coil can. Make sure all leads are well clear of the can when this is slipped over the coil. Next fix the core into the coil. The ferrite core cuts its own thread into the polythene top retainer. Set the top of the core level with the top of the polythene retainer–Fig. 6b. This should be close to the final adjustment position. In the case of L_4 the capacitor is connected to the coil on one side via the printed circuit, which connects pins 1 and 4, thus placing the 68-pF capacitor across the coil.

Fitting components to the board

Due to the small size of the board and components it is absolutely essential to use a soldering iron with a small tip which is adequately hot and clean. Lead lengths must be kept short and the components close to the board. This is especially important with the ceramic disc decoupling capacitors (1 and 47nF types). The transistors should be pushed down onto the board until the body is 2.5mm above the board; pushing the transistors closer than this will strain the leads unnecessarily. This rule applies also to IC_1. The second i.c. should be placed down on the board until the shoulders on each lead contact the board; the body of the i.c. will then be just clear of the board.

There will be some difficulty in locating the polarity of the diode due to the small size of this device. If in doubt check it with an ohmmeter on the ohms × 1 range, when the cathode will be the one connected to the positive lead of the multimeter when the meter shows conduction. (On a multimeter the polarity of the leads on the resistance ranges is the opposite to that shown on the meter panel so that the red positive lead is negative, and when connected to the cathode results in the diode being forward biased.)

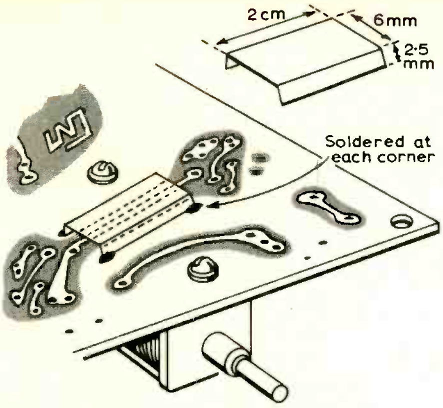


Fig. 7. Metal bridge—covering lead from Tr_1 drain to its tuned circuit—under the tuning capacitor is essential to maintain stability.

There are two wire links on the board, one on either side of L_5 in the i.f. section. These links may be either 22-gauge tinned copper or 1-024 p.v.c. covered wire. Connections to the 3-gang capacitor are by similar wires. The capacitor is secured to the board by two 6BA screws not longer than 4.5mm of thread.

The link from the r.f. to i.f. sections is by a twisted pair of 1-024 p.v.c. insulated wire as shown in Fig. 4 and in the oblique view. Take care to see that this is correctly connected, i.e. the live lead of the pair connects between the collector of Tr_4 and the input to X_1.

The two screened coils L_4 and L_5 are soldered into circuit after being pushed well down on the circuit board so that when the can is placed over the coil it just rests on the polythene retainer at the top of the coil, while also just contacting the p.c. board. The can is put on the coil after soldering the coil into the board, and the two can tags are then also soldered to the board.

There is one component not shown on the circuit because it is not a circuit component. This is a 'bridge' across the lead from the drain of Tr_1 to its tuned circuit under the tuning capacitor. This bridge continues the earth plane as well as screening the lead. It is essential to use this bridge to maintain stability in the r.f. amplifier. The bridge is necessary because of the layout limitations set by the capacitor having its connections on only one side of the body, and the need to keep the coils well spaced to obtain good stability and keep oscillator radiation low.

The dimensions and location of this bridge are shown in Fig. 7. The bridge may be made of any metal that will not corrode but will solder. Tinplate was used in the original units. Take care not to short the wire to the centre-section stator of the variable capacitor at the end of the bridge nearest to L_2.

If the ceramic filters need removing from the board, take care not to apply pressure when applying heat to the connections, otherwise the component will be damaged. Remove solder first with a desoldering tool or with copper braid.

In the photograph the alternative type of oscillator transistor is shown. If this type is used then the fourth connection on the transistor won't exist—used to earth the can on the TO-72 type specified (40244). Only the three connections nearest the 3-gang capacitor will then be used. In addition, an extra lead is shown in the photograph adjacent to the integrated circuit IC_2 that is not shown in Fig. 4. This lead connects to pin 14 of this i.c. to control the a.f.c. However, as the output lead (via the 2.2-kohm resistor) will

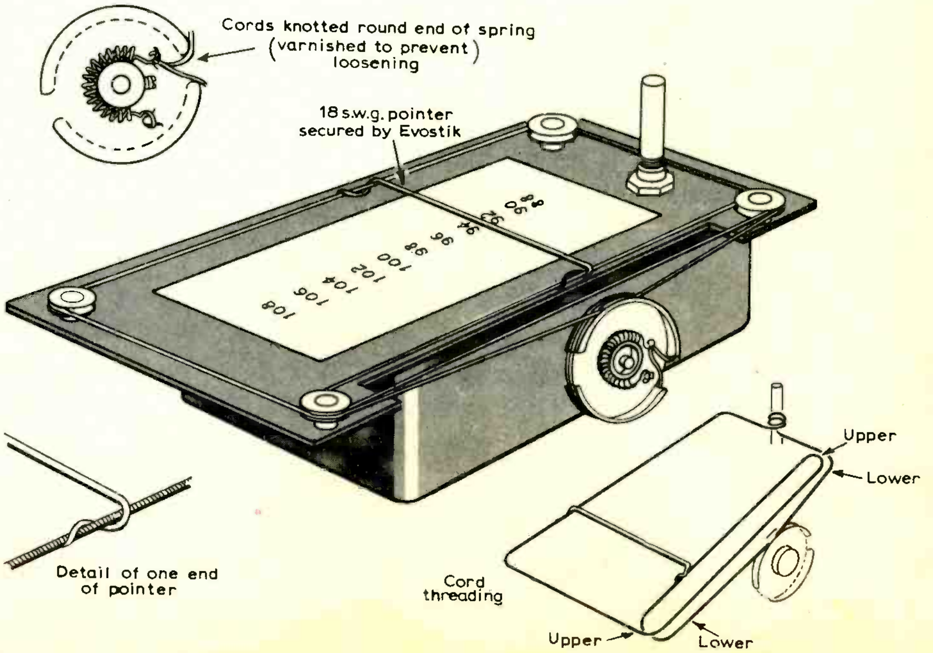


Fig. 8. Suggested cord system eliminates pointer friction and can be mounted in any plane.

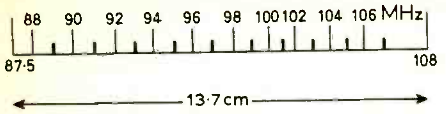


Fig. 9. Typical scale graduations for the band 87.5 to 108 MHz.

normally have a d.c. blocking capacitor in series, it will be at the same potential as pin 14, and is therefore suitable for the same purpose.

Screening of the tuner

It is essential to screen the tuner to avoid instability in the i.f. section due to pick-up, particularly from the output lead. Although the de-emphasis capacitor removes most of the 10.7-MHz signal and its harmonics, the output lead can still have sufficient of these signals present to cause spurious whistles when tuning if this lead is anywhere near the r.f. section. A great improvement results from connecting a capacitor of 470pF from the output to ground which, with the 2.2k Ω series resistor, removes these high-frequency signals sufficiently to make the position of this lead less of a problem. (In stereo applications the capacitor used will probably need reducing to 100-200pF to avoid attenuating the stereo switching waveform unduly, and if a long screened lead is used for the output the capacitance of this lead should be enough by itself.)

Prototypes were fitted into an ITT die-cast case with internal dimensions 12 × 9.5 × 2.5cm and is a tight fit with regard to height. Connections to the tuner should be made through insulated feed-through terminals close to the board so that all leads are as short as possible inside the screened box. A slot will have to be cut in the side of the box to allow the tuning capacitor shaft to pass through. The author found it easiest to fit the tuner board to the lid of the box, and to use the box as a cover, with holes drilled in line with the trimmer capacitors and L_4 and L_5 to enable final alignment with the box closed.

The board is mounted by four 6BA screws as shown in Fig. 4 and must be spaced about 5-8mm from the surface of the screened box, to prevent the track-side of the board from shorting on the box. Extra nuts or spacers may be used to achieve this spacing.

Dial drive system

Fig. 8 shows the layout of the suggested cord drive system which eliminates the problem of pointer friction, and is suitable for mounting in any plane. The parts required are made by the manufacturers of the 3-gang capacitor with the exception of the pointer, made of 18-gauge tinned copper, or similar, and the cord. Typical scale graduations for the 87.5 to 108-MHz band are shown to scale in Fig. 9.

To be concluded with a discussion of devices used and alignment methods.

Parts list

Set of parts is available from Integrex Ltd, P.O. Box 45, Derby DE1 1TW.

Inductors
See illustrations and text for winding details
L_4 & L_5 inductor assemblies are Neosid NS/E3

Dial components (all Jackson)
$\frac{1}{2}$-in brass pulleys, type 4879 (4 off)
$\frac{1}{2}$-in brass pivots, type 4539 (4 off)
brass spacers, type 4880 (4 off)
type 'G' drive spindle, type 5080
drive drum 2.5cm dia. 4-mm bore

Variable capacitors
3 × 14pF tuning capacitor, part no.5560/3/14 (Jackson)
4.5 to 20pF trimmer (3 off) (Piher make from Henry's Radio or Rosenthal type STSE-7, N750 from Radio Resistor Co. or type 7S-Triko 02 from Steatite Insulations)

Fixed capacitors
1nF disc ceramics, 50V, 1-cm mounting centres (10 off)
0.1μF, 16V (Mullard type C280)
32μF, 10V (Mullard type C426)
22, 68 (2 off) & 100pF, 160V, polystyrene
15, 47 & (2 off) 330pF ceramic tubular or disc, or polystyrene mounting centres 1cm
4.7nF miniature tubular polystyrene 1.65-cm mounting centres. Use 150pF for stereo reception
4·7nF disc ceramics, 1cm, 8off -
47nF

Resistors
Miniature carbon film type, $\frac{1}{8}$ watt ±5% tolerance (Mullard)

Active devices
40673 (RCA 2 off). In mixer stage, lack of gate protection diodes may be acceptable, in which case types 40604 or 3N141 can be used. If the risk of not using diodes is acceptable for r.f. stage, types 40603 or 3N140 can be used. N.B.: retain protective spring until power is applied
40244 (RCA), alternatively TI409 (TO-92) —now avaialable as TIS64 (TO-18), Texas
BC213L (Texas) or BCY70
CA3053, 3028A or 3028B (RCA)
TAA661B (SGS)
TIV307 (Texas)

Also needed are
printed circuit board (available drilled, solder coated and with component locations)
ceramic filters type FM-4 (Vernitron). Order as pair with same colour coding (orange-10.625 MHz, yellow-10.6625 MHz, green-10.700MHz, blue-10.7375MHz, violet-10.775MHz)
trimming tool for L_4 and L_5 cores
nylon cord
die-cast box
Denfix cement
Denfix cement (from Home Radio)
Evostik latex-resin impact adhesive

Baird's Video Disc turns again

The video disc is not a new idea, as J. C. G. Gilbert pointed out in his article on the Teldec system last year.* John Logie Baird recorded video signals from his 30-line television camera on a 78 r.p.m. wax disc as far back as July 1928. Copies were made and sold to the public by Selfridge's store, London, in the early 1930s, the idea being that they should be played from an electric gramophone into the Nipkow-disc Baird Televisor of the time.

Recently *Wireless World* was able to examine one of these discs, and see the kind of pictures it produced on a Televisor, at a demonstration put on by the I.T.A. at the television museum in its London headquarters. The disc, which looks like a 10-inch black gramophone record with a red label, was acquired from Mr. G. Diment of Herne Hill, London, who bought it from Selfridge's in 1935 at a price of 7 shillings. On the label are the words 'Recorded Television Record No. 1, Speed 78, Scanning Speed 750, Lines 30, For Private Use Only'. Because the disc is very fragile a magnetic tape recording had been made of its video signals, and it was this taped copy which was played into the Televisor at the demonstration.

The Televisor was a 40-year old model, one of two acquired by the museum and restored to working order by I.T.A. engineers at the Fremont Point transmitter, Jersey. The authenticity of the results was assured by H. J. Barton-Chapple, who worked with Baird, and by P. J. Packman, who built one of the two Televisors in 1928 at Plessey.

All that can be said of the pictures seen is that they were a sequence of patterns, in the characteristic orange light of the Televisor's neon tube. What the patterns depicted was anybody's guess, though we were told they were caricatures of human faces. Certainly, the first video disc cannot be regarded as anything more than a technical curiosity. It is nonetheless a further tribute to Baird's ingenuity and enterprise in the face of the public's indifference at that time.

*"The Video Disc", *Wireless World*, August 1970, p.377.

Correction

Peter Blomley, author of the articles **'New approach to class B amplifier design'** (February and March issues), tells us Tr_5 in Fig.1 of the second article should be type 2N3904 and not 2N3905, and that in Fig. 5 the ordinate should be labelled 0.00075%/cm, and not 0.0012%/cm.

News of the Month

'W.W.' amateur radio station

As part of the journal's 60th birthday celebrations we are to operate during April an amateur radio station using the specially assigned call GB3WW. The station is being set up in Dorset House, where we have had our editorial offices for nearly 40 years, and will operate in the amateur h.f. bands.

Our contributor Pat Hawker, G3VA, will be in charge of the station and among those manning the station from time to time will be F. C. Ward (G2CVV) president of the R.S.G.B., D. A. Findlay (G3BZG) general manager of the R.S.G.B., R. S. Roberts (G6NR), B. M. Johnson (G3LOX), J. Brodzki (G3HQX), S. Andrews (G3OGY), D. R. Bowman (G3LUB) and G. M. C. Stone (G3FZL).

The station will comprise a KW2000B transceiver, KW1000 linear amplifier, Eddystone 1830/1 receiver, Heath SB303 receiver and the s.s.b. receiver described by David Bowman in our July-September 1969 issues. The microphone is a Shure 444. A trap dipole is being installed on the roof of Dorset House about 100 ft above street level.

We are grateful for the co-operation of manufacturers and the Minpostel in enabling us to operate this station. A special QSL card embodying a reproduction of the front cover of this issue is being prepared.

Electronics industry manpower

For the first time the manpower problems of the electronics industry in the U.K. have been studied in isolation from those of the electrical industry. This has been done by a working group of the electronics 'Little Neddy' (Economic Development Committee), under the chairmanship of Professor G. D. Sims of Southampton University, and some conclusions and recommendations are presented in a preliminary report 'Qualified Manpower in the Electronics Industry' published by the National Economic Development Office. The conclusions are not exactly startling, the main points being that while the availability of qualified engineers and scientists is satisfactory there is evidence of a serious shortage both of technicians and of graduate production engineers willing to work in the electronics industry.

There seems to emerge from the report a picture of an industry in a confused and mulish state of mind about its own problems. It does not understand what facilities and information are available to assist with the education and use of technological manpower; it does not have adequate statistics and forecasts for manpower requirements; it is not sponsoring students for 'Bosworth' bridging schemes in sufficient numbers to make the courses fully viable; and it does not regard the release of qualified workers at regular intervals for continuing education as normal and desirable.

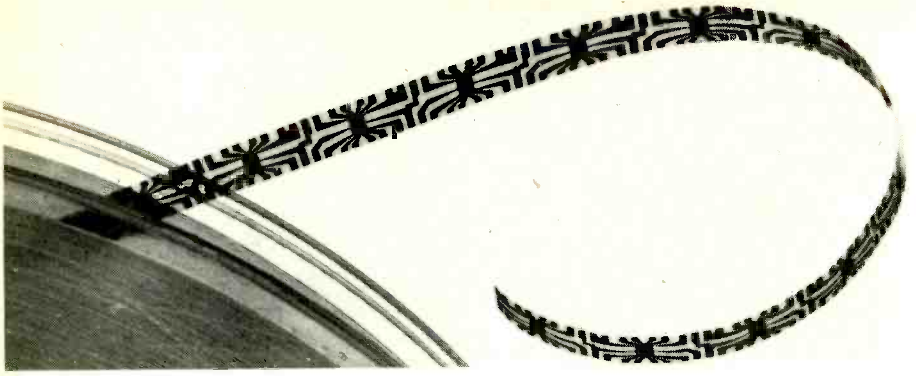
Among the working group's recommendations is one that the electronics EDC should sponsor a study of manpower utilization in the context of the management of innovation and its consequences. The fact that U.K. industry is well behind the U.S.A. and Japan in the speed and effectiveness with which it can turn an R & D project into a commercially available product is now well known, and has been made painfully apparent by the Rolls-Royce debacle. The working group is convinced that 'a better use of manpower, better management and control of projects, and a more appropriate mix of manpower resources could all make very substantial contributions to shorter lead-times, and thus to more effective innovation.' The EDC has agreed in principle to the proposal and asked the NEDO to start the study.

New sector control consoles in the Mediator air traffic control system are now in full operational use for controlled airspace at the West Drayton centre. Consoles include flicker-free bright displays—made possible by a scan conversion technique—which combine both primary radar information in the form of blips and secondary radar data in the form of digitally generated characters. Secondary radar can provide aircraft identification, route and height information depending on the kind of transponding equipment installed on board aircraft (see 'Progress in air traffic control' page 200).

Film and chips

A new method of mounting integrated circuit chips, which looks like being very suitable for use with automatic assembly methods, has been developed by the Philips Research Laboratories, of Eindhoven, Holland. The processed integrated circuit chips are mounted on a long strip of Polymide film and can be stored on reels like recording tape. The Polymide film has a metallic film contact pattern on which the chips are mounted in the same way as 'flip-chips' are mounted in hybrid integrated circuits. After the chips have been mounted the reels of tape holding the chips are treated to improve mechanical strength and are then passivated. During testing faulty chips on the film are marked so that they can be rejected automatically during subsequent circuit building.

The film-mounted chips can be applied



The metalization pattern on the Polymide film can be clearly seen. Integrated circuit chips mounted in this way could easily be used in automatic assembly machines.

to a printed circuit board, or to any other substrate for that matter, or they can be mounted on specially designed headers for conventional insertion into printed circuit boards. When mounted in the header Philips are claiming excellent heat dissipation characteristics. An experimental monolithic audio amplifier with an output of 3W has already been built and operated successfully using the technique.

Amateur radio history

As mentioned elsewhere in this issue the Derby Wireless Club (now called the Derby and District Amateur Radio Society) was formed in 1911, and, like *W.W.*, is marking its 60th birthday with special events. The first is an exhibition to be held in the Derby Museum and Art Gallery from 3rd to 17th April (excluding Good Friday). The aim of the exhibition is to illustrate the various activities of the society, but space will also be devoted to the history of amateur radio. Exhibits will include items constructed by early members of the society, and there will also be a life-size reproduction of a typical amateur station of the period 1911-13. A modern amateur station will be in operation at the exhibition and the call-sign will be GB3ERD.

The exhibition will be opened at 3 p.m. on 3rd April, by the Mayor of Derby, Alderman Miss M. E. Grimwood-Taylor, whose father, S. Grimwood-Taylor, was one of the founders of the society.

Being the oldest amateur radio society in the U.K. (now with 245 paid-up members it has many historic pieces of equipment and components and an effort is being made to set up a permanent museum.

100MHz m.o.s. i.cs

Metal oxide silicon transistors have been successfully made at the Hirst Research Centre (G.E.C.) with channel lengths of only 1μm against the 6 to 10μm normally employed in commercial m.o.s. integrated circuits. Apart from increasing packing density by a factor of ten it is estimated that 100MHz integrated circuits can be made with these devices and could mean that m.o.s. will soon be knocking t.t.l.

The short channel transistors were made from masks produced by Cambridge Scientific Instruments Ltd using electron beam methods. The ion implanted source and drain regions have a low feedback capacitance giving the device its high operating speed.

The work had been carried out under a Ministry of Defence contract and is part of a much larger programme of research into m.o.s. devices being carried out at the Hirst Research Centre.

Top of the short-wave pops

The International Short Wave Club reported a record response to their poll, held once every three years, to establish the most popular short-wave station. Votes have been received from most countries in the world including China and the U.S.S.R. Each voter could give five-votes for his first choice, four for his second and so on. It was found that many individuals did not go any further than a first choice. Of the 30,836 valid votes cast (4,712 arrived too late) Radio Australia won with 7,010 votes followed by the B.B.C. World Service with 4,493. Third and fourth were Radio Nederland (3,877) and Voice of America (3,711), followed by Deutsche Welle (1,269), Radio Japan (1,051) and Radio Canada (1,018).

Printed circuit patent

A decision taken recently in the House of Lords ended a ten-year legal battle by Technograph Printed Circuits (London). The decision confirmed that the patent taken out in 1943 by Technograph describing the manufacture of printed circuits was valid until it expired in 1967 after a seven-year extension. In this particular case the decision was against Mills and Rockley (Electronics) who had been sued for patent infringement by Technograph. However, the implications are much greater and writs have been issued against forty other British printed circuit manufacturers.

In America a similar ten-year law suit has been going on involving Technograph Printed Circuits' associate company Technograph Inc. although a decision has not yet been reached.

Selective crystallization

Work is in progress at the Battelle Development Corporation, an international independent research institute, on a new process to produce m.o.s.t. microcircuits on a sapphire substrate. Instead of coatino the sapphire with a film of silicon and using masking and etching processes to form active devices and interconnection patterns as is usual the new method does all this in one very complex process called selective crystallization.

The work so far has shown that the process is feasible but more research is needed before the method could be used for production.

A new low-cost navigation system, installed on the Blue Funnel cargo liner Prometheus, intended to operate with the American navigational satellite system. The equipment, which was built by S.T.C., carries out dead-reckoning navigation between satellite passes.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Birthday greetings

Congratulations to *Wireless World* on completing its sixtieth year of publication. It was the world's first radio journal and has always been in the forefront in reporting technical developments in broadcasting. It is regarded as essential reading by most B.B.C. engineers.

The B.B.C. is a slightly younger organization, but during the forty-nine years of its existence, B.B.C. engineers have had the pleasure and privilege of contributing to *Wireless World* many articles on broadcasting and associated subjects. We value these close links with *Wireless World* and send it our best wishes for continuing success.

J. Redmond,
Director of Engineering,
B.B.C.,
London.

I am sure that thousands of radio and electronics engineers throughout the world will wish to congratulate *Wireless World* on reaching its sixtieth anniversary. Over this period, longer than any other journal in this field, *Wireless World* has accurately and honestly surveyed the broadest aspects of communications and electronics engineering, and initiated many designs of equipment using advanced techniques.

One of my most treasured possessions is a complete set of bound volumes of the journal. In these is recorded the whole history of the remarkable developments over the past sixty years, and perhaps the only regret is that the advertisements were not bound in for they record the changes in component design and the economics of the industry.

It was fortunate that my physics master at Westminster City School was a senior telegraphist in the R.N.V.R. during the first World War, and his enthusiasm for wireless and line communications continued into the school classroom and laboratory. Soon he had his students winding hundreds of feet of insulated copper wire on 4in diameter paraffin impregnated cardboard tubes and sending us *off to Lisle Street, which was* already the mecca for radio components. So in place of visiting the school tuckshop and buying Fives balls we spent our pennies with Kate Raymond who sold ebonite end plates, aluminium vanes, 2BA rod and brass spacers, with which we made variable condensers. Farther along the road was Will Day, an outstanding inventor of cinematograph apparatus, who saw the potential development of the radio industry, and who later financially assisted John Logie Baird with his early television experiments. Will Day was the source of galena crystal, and, if one had the money, quite sophisticated micrometer adjustment cat's whisker crystal detectors. Then a trek to Shoreditch to buy some continental headphones from Ted Rosen who later became the chairman of Ultra Electronics, Ltd. Already the school had a good aerial consisting of two parallel 50 foot 7/22 s.w.g. copper wires on spreaders and a copper plate earth. Thus early in 1922 one was thrilled to hear the time signals from the transmitter on the Eiffel Tower.

These were the days of the amateur constructor and the founding of many radio clubs, the activities of which were regularly recorded in *Wireless World*. Although other journals sprang up to encourage the newcomer to wireless, already *W.W.* held the esteem of the relatively few professional engineers and the band of enthusiasts who followed the advanced constructional articles published in the journal. Many outstanding designs followed and one remembers the first to use a double ended screen-grid valve as an r.f. amplifier, and the using of Litzendraht inductances. Over many years *Wireless World* has sponsored designs for high-quality amplifiers of which The *W.W.* Push-Pull Quality Amplifier probably laid the foundation of the audio industry. Also in the early 'thirties members of the *W.W.* staff set up the first investigation into the performance of loudspeakers with a large baffle board mounted on the roof of the building and a microphone mounted on a mast.

Throughout the years since 1925 when I first made personal contact with members of the staff of *Wireless World*, I have always regarded it as a privilege to enjoy the friendship and advice of the successive Editors and their staff. Each has set a high standard and given devoted service to the journal, their readers and the industry. Many of the articles have been contributed by world famous scientists, physicists and engineers and in spite of changing economic conditions and wars every issue has maintained a high and accurate standard.

Long may *Wireless World* continue to be published and its team of contributors and staff maintain the high standard of technical journalism that has made it the pre-eminent journal in the communications world.

J. C. G. Gilbert
Northern Polytechnic,
London N7 8DB.

Stereo decoder using sampling

Referring to D. E. O'N. Waddington's article in the February issue, I have found that the second harmonic distortion level (0.6% at 30mV input) and the signal attenuation (9dB at 5kHz) can both be reduced by simple modifications to the circuit.

The de-emphasis network accounts for 5dB of the 9dB attenuation quoted, but what of the other four? As resistors R_{25} and R_{27} (Fig. 7 page 73) bias Tr_{10} and Tr_{11} near pinch-off, particularly for a transistor with low $V_{(P)GS}$, the operating point is one at which g_m is low and non-linearity comparatively high. Further, the low-value load resistor of 2.2kΩ implies low gain.

The 2V adjacent to the source of Tr_{10} suggests that transistors close to the lower limit of $V_{(P)GS}$ were used in the prototype. The manufacturer's data sheet shows g_m to be 2mA/V, and hence a gain of about five times open-loop or 0.8 (−2dB) as a source follower. These figures were confirmed by measurement and a harmonic distortion figure of 0.1% obtained at 100mV r.m.s. level—relating to the source follower only.

Turning now to the f.e.t. switch Tr_8 or Tr_9 it is important to bear in mind the inherent capacitance C_{gd} between gate and drain of the transistor. Were this fixed in value, its effect would simply be to cause an error between the input sample voltage and the output hold voltage across C_{12} or C_{17}. This error is caused by the transference of charge to C_{gd} on the trailing edge of the sampling pulse, and is minimized when C_{gd} is small and the hold capacitance as large as possible.

As the capacitance C_{gd} in practice is voltage-dependent in a highly non-linear manner the hold voltage error is also non-linearly related to the input sample voltage. This voltage is the instantaneous sum of the sample pulse amplitude and the composite signal at the source. The situation is summarized in the following expression

$$V_e = -\frac{1}{C_{12}} \int_{V_1}^{V_2} C_{gd}(V)\, dV$$

where V_e is the error voltage, and V_1 and V_2 define the input amplitude limits.

Measurements on Mr Waddington's sample-and-hold circuit show an harmonic distortion figure of approximately 0.5%

to 100mV r.m.s. output across C_{12}, and an attenuation of 2dB was obtained.

To minimize both attenuation and distortion, the hold capacitor can be increased in value so long as it is able to become fully charged during the sampling interval. This is to say $5CR=250$ns. No value is given for $R_{ds(on)}$ in the BFW10 data but it seems this is below 300Ω, so that C_{12} and C_{17} can be increased to 180pF. Taking this opportunity to consider $R_{ds(off)}$, it is essential that the sampling pulse at the gate has an amplitude of at least 8V to ensure that limit transistors switch off as required, and this necessitates an increased supply voltage. Taking all these factors into consideration the following modifications can be made.

1. Increase supply to 12V and feed the drains of Tr_{10} and Tr_{11} from a 20 to 24-V supply.
2. Omit C_{15}, C_{18}, R_{24} and R_{26}, directly coupling the drains of Tr_8 and Tr_9 to the gates of Tr_{10} and Tr_{11}.
3. Increase C_{12} and C_{17} to 180pF. R_{25} and R_{27} to 22kΩ and R_{28} and R_{29} to say 33kΩ while reducing C_{19} and C_{20} to 1.5nF. These modifications reduce susceptibility to spread in f.e.t. characteristics, reduce distortion to 0.05% and reduce attenuation in the sample-and-hold and source follower sections to less than 1dB.

It is desirable to disable the sampling action for monophonic reception, by open-circuiting R_{13} and R_{21} for example, otherwise noise components around 38kHz are translated to audible frequencies causing appreciable degradation of signal-to-noise ratio, especially in view of the triangular noise spectrum associated with an f.m. system.

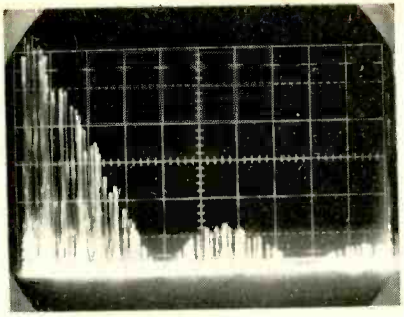
This type of decoder is very attractive in terms of cross-talk performance, suppression of 19kHz and 38kHz components, and reduction of subcarrier sidebands. Perhaps fuller advantage of the technique could be taken by using a phase-locked-loop sampling oscillator, which would enable both setting adjustments and wound components to be eliminated.

Incidentally, one of the transistors suggested for Tr_8 to Tr_{11}—the BFW10—has a $V_{(P)GS}$ max of 8V—dangerously close to the supply of 9V.

D. R. Birt,
Oxted,
Surrey.

In his letter in the March issue D. E. O'N. Waddington states that for a sample-and-hold network it "... is not the 'sampling' but the 'hold' which causes noise harmonics to be heterodyned into the audio bandwidth" and that "The mark-to-space ratio of the sampling waveform has very little to do with the interference introduced. . . "

It must be remembered that sampling is a process whereby each component in one signal is multiplied by each component in the other signal, producing sum and difference frequencies. It follows that the difference frequency produced when h.f. noise is sampled at a high rate will be l.f. noise.



Further, because the h.f. spectrum content of the sampling waveform is a function of mark-space ratio, the amount of l.f. noise produced will depend on the mark-space ratio of the sampling signal. The hold network does not appreciably alter the frequency content in the audio bandwidth as it does not perform a non-linear function. Above the audio bandwidth the h.f. signals are attenuated by the hold function.

The photograph shows the approximate response of Mr Waddington's sample-and-hold circuit on a scale of 0-100kHz. Zero amplitude occurs at integral multiples of 38kHz. The response has a $|(\sin x)/x|$ shape and it is interesting to note that at 15kHz the theoretical response is 2.4dB down, agreeing very closely with the practical result.

I agree that low-pass filtering the input signal will prevent the generation of audio noise. The low-pass filter should ideally have a linear-phase response to maintain high-frequency separation. I think Mr Waddington's suggested 80kHz is a little high—the 2nd harmonic of 38kHz will be able to operate on noise down to 61kHz to produce audible noise.

Improving the h.f. response of the decoder to reduce the 2.4-dB loss at 15kHz may be difficult if suppression of h.f. signals is to be maintained.

R. T. Portus,
Rolls-Royce Ltd.

Components for constructors

I must add my heartfelt agreement to the comment on this topic contained in "World of Amateur Radio" (*W.W.* Jan. 1971). Only in recent years have I been able to even contemplate building many pieces of equipment that captured my imagination when a teenager in the 1950s. Alas now that I can afford such luxuries I am faced with the near impossibility of finding parts.

My own immediate problem is quite simply that I wish to build a receiver covering from, say, 10 to 2,000m in the usual bands. I would like the receiver to have a reasonable sensitivity but not be in the communication receiver class. Basically, I feel able to "design" such a receiver along conventional lines.

Tuning coils can be obtained, and older readers will be delighted to know that Home Radio still include the famous Wearite "P" coils in their catalogue. Alas no one to my knowledge markets a suitable dial or tuning scale covering the above ranges to match a specified tuning capacitor gang and the Wearite coils or for that matter anyone else's coils.

There are some of us who wish to build such equipment from scratch and who do not want to buy a kit complete to the last length of wire.

All I want to do is to build a reasonably simple receiver and my mind boggles at the trials in store for anyone brave enough to consider the *Wireless World* colour receiver. Construction will be a simple task compared with obtaining replies to enquiries about component availability. It is evident that people like myself must be a dying race and it is for this reason that supplies seem to have disappeared from the market. Some of us might even be prepared to pay through the nose for what we require if only someone would realize we exist and set out to exploit us!

F. Brian Kyle,
Workington,
Cumberland.

About a year ago we formed a buying group with a number of other dealers* in the London area which we provisionally call "Group One". Its primary object is to buy components at the best prices in reasonable quantities. There are several secondary aims such as exchange of surplus stock and exchange of information. To some extent this action has been forced on us because we wished to buy certain items that wholesalers do not wish to handle and the manufacturers will only sell in quantities that are beyond the pocket of *one* dealer to buy. But I would like to stress the fact that this is not aimed at distributors or wholesalers (I for one, have always believed that they do a useful job and earn their money); in fact any small wholesaler or equipment manufacturer would be welcome to join. I feel sure that you will agree that this is a desirable scheme as ultimately it means the Group can offer your readers a greater range of goods at the lowest prices. Initially we were going to limit it to about 20 dealers (not on account of any closed shop principle, but because we thought, quite wrongly, that we could not handle the administration of a larger number). Now we would like to offer membership to any bona fide trader in the U.K. and I would be very grateful if you could make this generally known through the courtesy of your columns. At the moment there is no entrance fee or subscription. If anyone is interested please write to me at Home Radio (Components) Ltd, 234-2 0 London Road, Mitcham, Surrey CR4 3HD.

Alan Sprox ton,
Mitcham,
Surrey.

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*Crescent Radio; EGE Components; Garland Bros; Gurneys Radio; Hi-Fi & Components; H. C. Smith; Lovering ; Bros; Newbury Radio; Odeon Electronics; Radio Unlimited; Servio Radio; Stan Reed; Ti Radio; T. R. Radio; Watts Radio; Radio Comp s.

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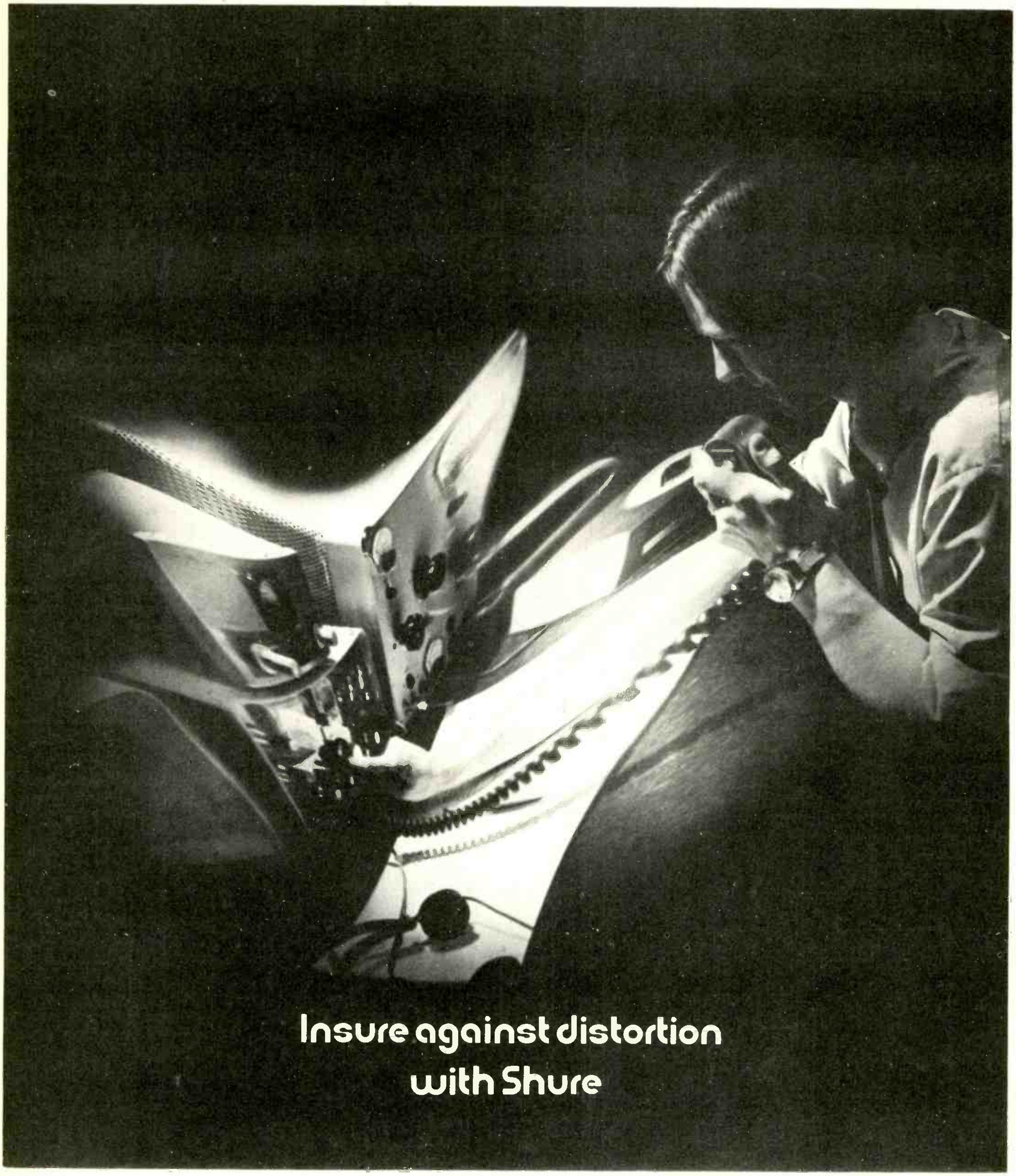
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A low-cost instrument which may be used to assist in teaching logic and Boolean algebra

*by Brian Crank**

Although this instrument employs the same basic principles as the earlier *Wireless World* Logic Display Aid (May to December 1969) any resemblance ends there. The present instrument is simpler and is very much cheaper. The circuit has been reduced to just four integrated circuits, three digital and one linear, and four transistors plus a few resistors, capacitors and diodes. The cost need not exceed a few pounds.

Mind you, the present instrument is not nearly so versatile as the earlier design although the display is more pleasing to the eye. The instrument will produce, on the screen of an oscilloscope, the Karnaugh map of any combinational logic circuit. If you are not completely familiar with Karnaugh maps a simple description will be found in the appendix to this article.

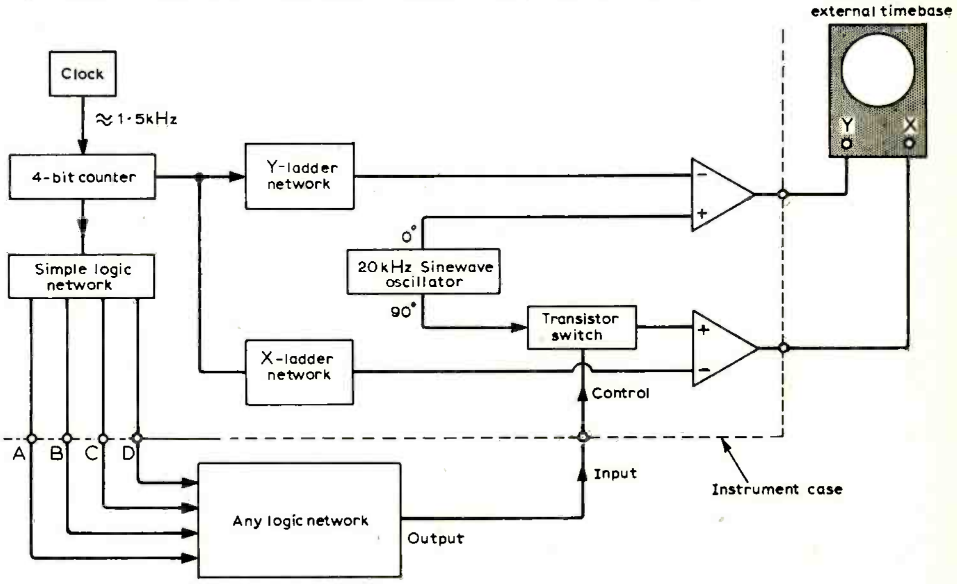
The reason for designing an instrument which will produce a Karnaugh map for any circuit is quite simple. The student is often taught Boolean algebra and logic through the use of the Karnaugh map. It completes the circle for the student to see a logic circuit producing the same map that was used to explain the operation of the circuit in the first place. In other words the theory and the practice can be brought closer together.

You may remember that in the earlier display the characters nought and one were displayed on the oscilloscope screen in the form of a pattern of dots. In the present design the characters are drawn as continuous lines exactly as you would draw them by hand. A typical display is shown in Fig. 11(a). Another advantage over the earlier design is that only two leads are needed between the instrument and the oscilloscope. These are the leads for X and Y deflection; an intensity modulation lead is not required.

As already mentioned the circuit is hybrid in that both linear and digital circuits are employed. Broadly the characters are positioned using a combination of both linear and digital techniques and the characters themselves are formed by linear circuits. The choice of whether to display a nought or a one at a particular position is taken by the logic circuit the Karnaugh map of which is to be displayed.

To use the instrument all one does is to connect it to the X and Y inputs of an oscilloscope, and connect any logic circuit to the instrument; the Karnaugh map for that circuit will then appear on the screen.

Fig. 1. A simplified block diagram of the instrument. Practically any oscilloscope will be suitable because the demands made upon it are small although it must be capable of operating from an external timebase.



A block diagram of the instrument is given in Fig. 1. In brief, a clock pulse generator is used to drive a four-bit counter. The counter is split into two and each half drives a resistive ladder network. The ladder networks perform digital-to-analogue conversions and the resulting four-step staircase waveforms are fed to operational amplifiers which are used to drive the oscilloscope's X and Y deflection inputs. The oscilloscope is switched for external timebase operation. This produces sixteen dots on the screen arranged in a four-by-four matrix.

A sine wave oscillator, with a frequency much higher than the clock generator, produces two outputs which have a 90° phase difference. The sine wave corresponding to 0° is fed to the Y operational amplifier and the 90° waveform is fed to the X operational amplifier via an attenuator and a transistor switch. The result of the two sine waves on the screen of the oscilloscope is a vertical ellipse similar to the '0' printed here. The net result of both the sine and staircase waveforms is to display on the c.r.t. a four-by-four matrix of 0s. If the switch in the sine wave lead to the X operational amplifier is open there will be no horizontal sine wave component in the deflection waveform so on the screen will appear sixteen 1s. The 1 is formed by the sine wave input to the Y amplifier.

The counter that drives the ladder networks also drives a logic circuit which produces outputs that comply with the rules of a Karnaugh map. These outputs are used to drive the logic circuit you wish to display and the output of this logic circuit is used to control the 0/1 switch at the input to the X operational amplifier. Each section of the instrument will now be described in detail.

Sine wave oscillator

The sine wave oscillator is used to produce a Lissajous figure which represents 0 in the display and to do this, as we have already seen, it must produce outputs at 0° and 90°. An early version of the instrument used a sine wave *RC* oscillator followed by a 90° phase-shift network. Although this worked it was unsatisfactory because it was necessary to specify close tolerance components for the frequency

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* Deputy Editor, *Wireless World*

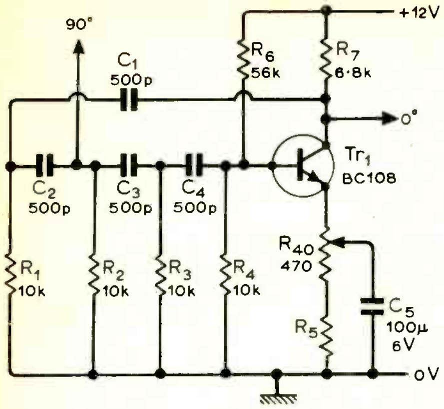


Fig. 2. The four-section phase-shift oscillator used to produce the characters which form the display. Operating frequency is about 22kHz.

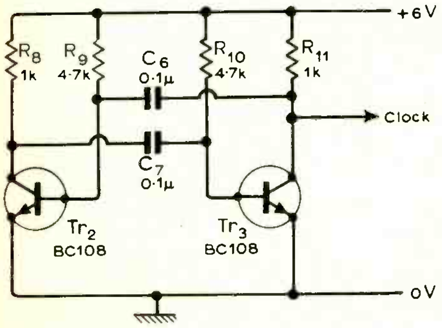


Fig. 3. Astable multivibrator clock generator which runs at about 1.4kHz.

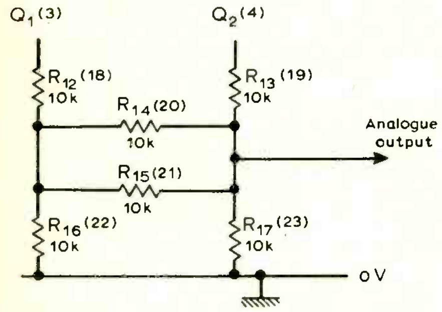


Fig. 4. The Y ladder network. Component reference numbers in brackets refer to the X ladder. The circuit converts the output of a counter into a staircase waveform by performing a digital-to-analogue conversion.

to be right for the phase shift required. An *LC* oscillator could have been used with the advantage that the frequency adjustment, to line the oscillator up with the phase-shift network, would have been no problem. However, coils, as well as being fairly bulky at the frequency we are interested in, are not the most popular items in constructional articles so it was decided to find a solution using *RC* circuitry.

The circuit employed is shown in Fig. 2. As can be seen it is a single transistor phase-shift oscillator. Normally a phase-shift oscillator employs three *RC* sections, each section phase shifting by 60°, to obtain the 180° phase shift necessary to obtain positive feedback and oscillation.

In the present design four *RC* sections are employed, each section shifting by 45° (4 × 45° = 180). It is now a simple matter to pick off the 90° signal after two 45° phase shifts at the output of the second *RC* section.

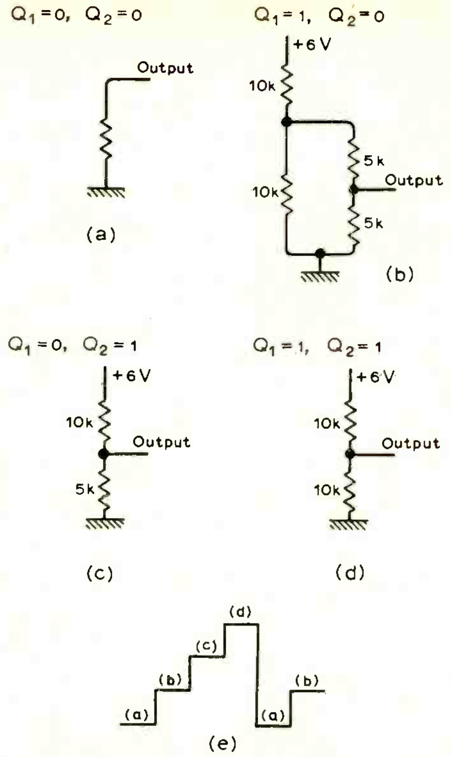


Fig. 5. The equivalent circuits of the ladder network for the four different conditions of the counter driving it.

The potentiometer R_{40}, the only adjustment in the whole instrument, is used to vary the a.c. gain of Tr_1 while maintaining d.c. conditions. The gain must just be enough to overcome the losses in the phase-shift network. If the gain is too low oscillation will not occur; if it is too high distortion will result. Potentiometer R_{40} is adjusted for a good sine wave output from Tr_1. The frequency of oscillation is about 22kHz but this is not at all critical.

Clock generator and counter

The clock generator is shown in Fig. 3. Little need be said about it as it is a conventional astable multivibrator which runs at about 1.4kHz.

The four-bit counter is formed by one t.t.l. (transistor-transistor logic) integrated circuit type SN7493N. This i.c. comes in the m.s.i. or medium scale integration class. It contains four *J-K* flip-flops and is connected as shown in the main circuit diagram (Fig. 10). The four flip-flops are cascaded to form a standard binary counter.

Looking at only the first two flip-flops, the outputs of which are called Q_1 and Q_2, the following outputs are produced:

Q_2	Q_1
0	0
0	1
1	0
1	1

The outputs of the second pair of flip-

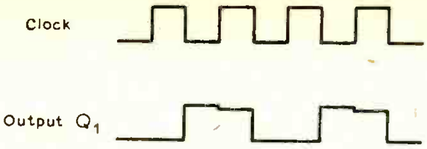


Fig. 6. Shows how the output of the t.t.l. binary counter is affected by the clock generator. The steps in the waveform are removed by a clamping circuit.

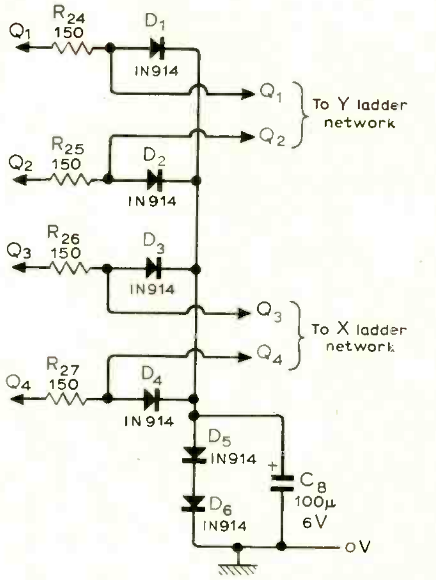


Fig. 7. The clamping circuit. The outputs to the ladder networks are the voltage drops across three forward-biased diodes in series.

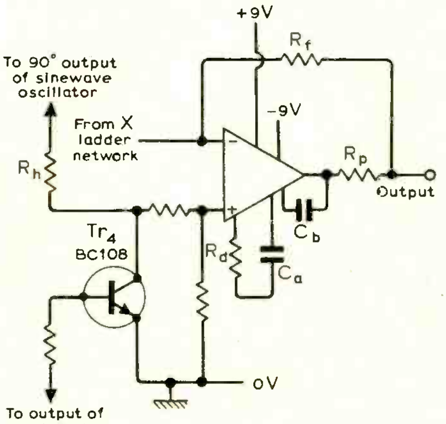
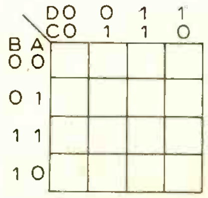


Fig. 8. The X deflection amplifier complete with the single-transistor 1/0 switch. The Y deflection amplifier circuit is the same but Tr_4 and its associated components are omitted.



B A \ D C	0 0	0 1	1 1	1 0
0 0				
0 1				
1 1				
1 0				

Fig. 9. Karnaugh map edge coding. A graticule, the same as this drawing, should be made so that the display on the c.r.t. can be viewed through it.

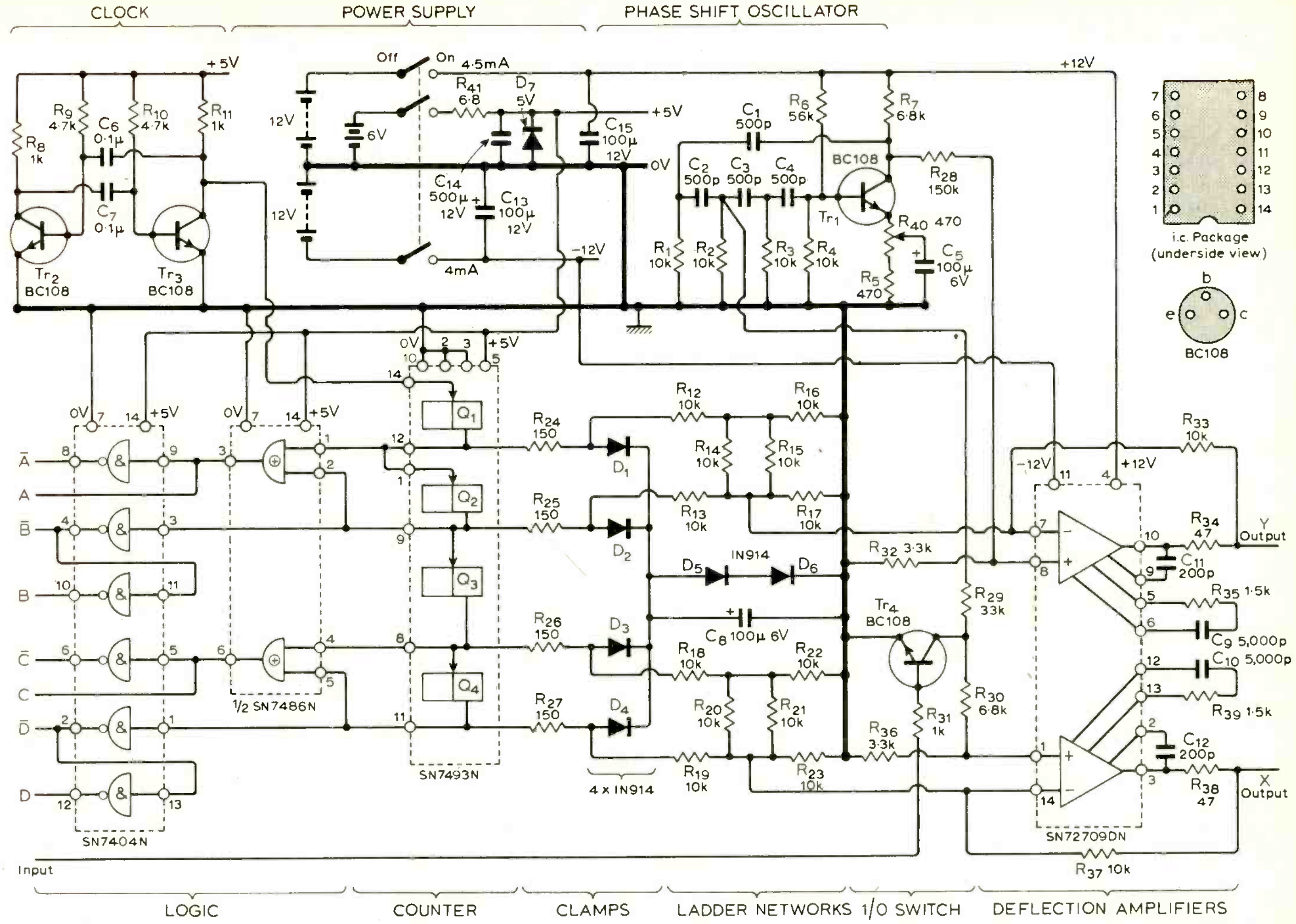


Fig. 10. The complete circuit of the Karnaugh map display instrument. The SN7486N actually contains four exclusive-OR gates, however, only two are used here.

flops, Q_3 and Q_4, produce exactly the same output but at one quarter of the frequency.

Ladder networks

The two ladder networks are connected to the binary counter. When the flip-flop Q_1 is at 0 the Q_1 output is connected, via a saturated transistor, to the 0V line. When the output Q_1 is at 1 it is connected via a saturated transistor to +6V.

The circuit of one ladder network is given in Fig. 4. The inputs Q_1 and Q_2 are switched according to the table given earlier. So Fig. 4 can be redrawn for each of the four states of the counter, so far as the output voltage is concerned (Fig. 5). If you would care to do the sums you will find that the output will rise from 0V in equal steps to produce a staircase.

Clamping network

Unfortunately the output of the flip-flops is not a good square wave. Although the rise and fall times are far more than adequate for the instrument the output of a particular flip-flop is affected by its input conditions. Fig. 6 illustrates this point.

The step in the waveform causes a corresponding step in the output of the ladder network which in turn causes certain characters on the display to appear double. The cure for this trouble is to add a clamping network which slices the top off the output from the flip-flops. This network is shown in Fig. 7.

The diodes $D_{1 \text{ to } 4}$ isolate the outputs of the flip-flops from each other and resistors $R_{24 \text{ to } 27}$ limit the current to a safe value. The output to the ladder network is now the voltage drop across three diodes in series.

Operational amplifiers and 1/0 switch

The well known operational amplifier type 709 is used in the instrument. The particular version employed (SN72709DN) is manufactured by Texas Instruments and includes two 709 amplifiers in a single dual-in-line package. The circuit of the X deflection amplifier is shown in Fig. 8. The Y deflection amplifier is identical except that the 1/0 switching transistor, Tr_4, and its associated components are omitted.

Resistors R_p and R_f combine to form the feedback resistor which sets the overall gain of the amplifier. Additionally R_p protects the amplifier from accidental short circuit of the output leads by limiting the output current. R_d, C_a and C_b are frequency compensation components which ensure stability.

The BC108 (Tr_4) is the switch which is controlled by the external logic circuit. It short-circuits the 90° output of the sine wave oscillator to ground when a 1 is required on the c.r.t. R_h is of a sufficiently large value to prevent the switch from significantly affecting the oscillator itself.

Logic circuit

Imagine that the Karnaugh map of Fig. 9 is superimposed on the c.r.t. face. Because of the action of the previously discussed circuitry the c.r.t. spot first rests in the top left-hand square, it then moves to the next square down, then to the square below that until it reaches the bottom of the column. The spot then flies back to the top but this time to the second column. The process continues until all 16 squares have been scanned. The spot then goes back to the first square again and the process is repeated, such is the effect of the two staircase waveforms. Each square on the map corresponds to a particular state of the counter. For instance, the top left-hand square is scanned when the counter outputs are all 0, that is at the top of both staircase waveforms (both the X and Y amplifiers invert).

We also know that each square on a Karnaugh map corresponds to a particular set of variables as defined by the coding at the edge of the map (see appendix if necessary). We must ensure that when the spot is in a particular square that the set of variables represented by that square are available at the output of the instrument for

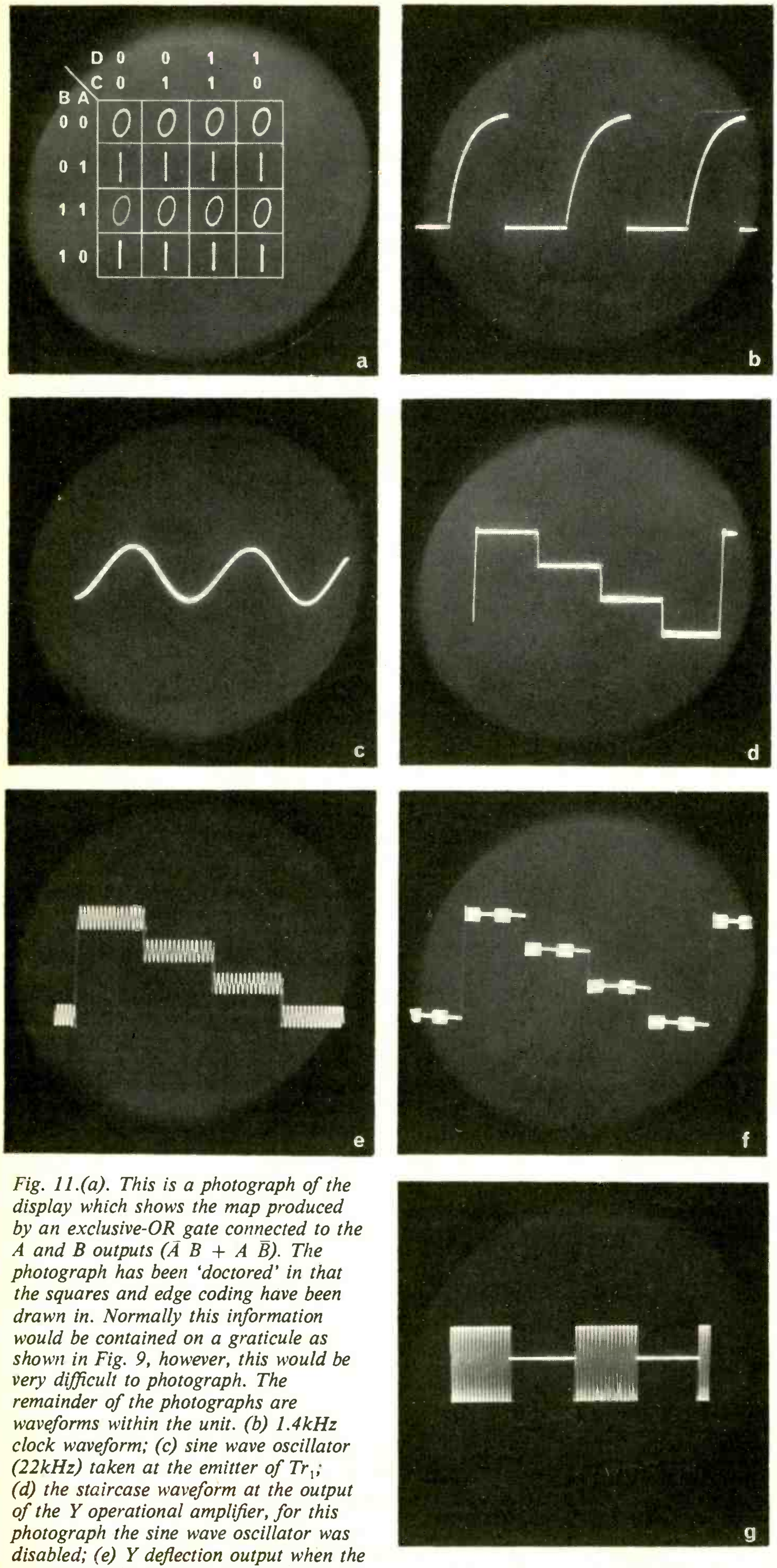


Fig. 11.(a). This is a photograph of the display which shows the map produced by an exclusive-OR gate connected to the A and B outputs ($\bar{A}\,B + A\,\bar{B}$). The photograph has been 'doctored' in that the squares and edge coding have been drawn in. Normally this information would be contained on a graticule as shown in Fig. 9, however, this would be very difficult to photograph. The remainder of the photographs are waveforms within the unit. (b) 1.4kHz clock waveform; (c) sine wave oscillator (22kHz) taken at the emitter of Tr_1; (d) the staircase waveform at the output of the Y operational amplifier, for this photograph the sine wave oscillator was disabled; (e) Y deflection output when the display at (a) is being produced and (f) X deflection waveform under the same conditions; (g) waveform at the collector of Tr_4 when the display at (a) is being produced.

feeding to the external logic circuit. We must therefore compare the output of the counter with the Karnaugh map edge codings and rectify any differences that occur.

Karnaugh map edge coding		counter outputs	
B	A	Q_2	Q_1
0	0	0	0
0	1	0	1
1	1	1	0
1	0	1	1

The above table compares the output of the Y counter with the map's A B edge coding. The last two terms are different and therefore some logic is necessary to correct this.

Firstly on examination we can say that $Q_2 = B$ so a direct connection from the counter output Q_2 will form the output variable B.

Also, on examination, it can be seen that:

$$A = Q_1.\bar{Q}_2 + \bar{Q}_1.Q_2$$

which is our old friend the exclusive-OR function. We have already stated that the X counter outputs, Q_3 and Q_4, have the same outputs as Q_1 and Q_2 but at a slower rate and we can see that the Karnaugh map coding for C and D is the same as for A and B. We must therefore conclude that an identical logic function is required, namely

$$D = Q_4$$

and $C = Q_3.\bar{Q}_4 + \bar{Q}_3.Q_4$

The circuit of the logic section of the instrument can be seen on the lower left-hand side of the main circuit diagram, Fig. 10, and it can be seen that only two integrated circuits are required. The output variables, A, B etc., are buffered by simple inverters to prevent external connections from upsetting the operation of the counter. These inverters also provide the complement of the variables, $\bar{A}$, $\bar{B}$ etc.

Complete circuit

Fig. 10 combines all the circuits discussed so far and therefore little need be said about it. The various waveforms present for a particular display are shown in Fig. 11. Because the sine wave oscillator and the clock are not synchronous flyback between characters takes a different route every time and is not visible on the screen at normal brightness levels. Because of this blanking (a Z connection to the oscilloscope) is not required.

Construction

Making the unit is quite straightforward and no special precautions need be taken. A photograph of the layout employed in the prototype is given in Fig. 12; several components will not be found in this picture because they are mounted on the reverse side of the board.

It is important to connect pins two and three of the binary counter (SN7493N) to the 0V line. These pins are inputs to a gate which resets the counter. If this is not done the counter will be held at 0000 and the unit will not function. The only adjustment is R_{40} which must be set to give a nicely shaped 0. If you wish to adjust the size of the characters changing the value of R_{28}

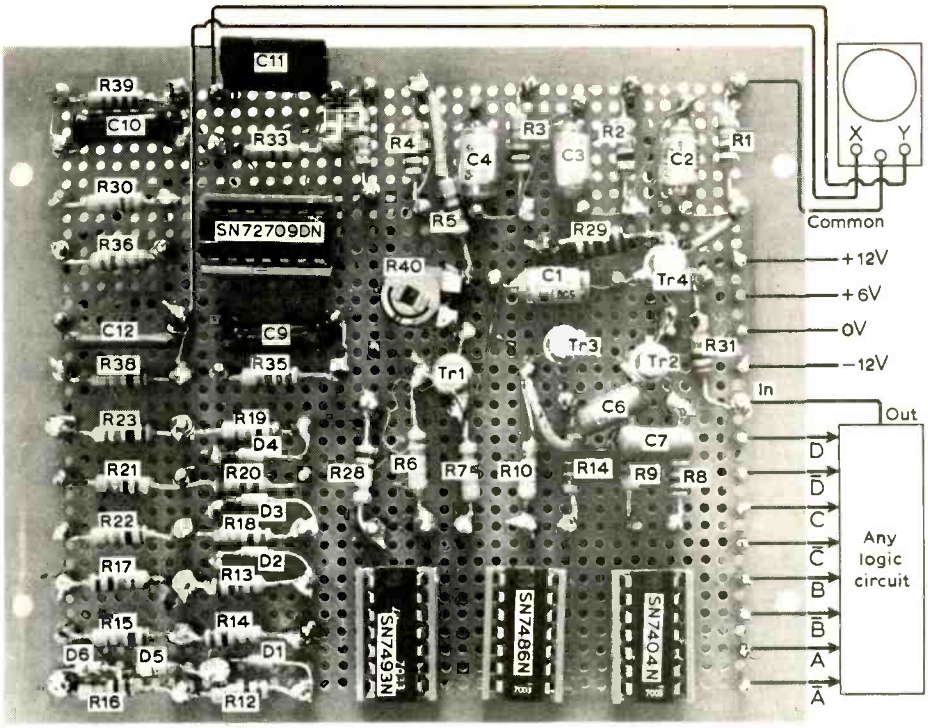


Fig. 12. A photograph of the prototype showing component positions. It should be noted that some parts have been mounted on the reverse side of the board and are therefore not marked. The integrated circuits are plugged into dual-in-line sockets which makes for easy removal.

will alter the height and R_{30} will alter the width.

Appendix

Karnaugh maps: The Karnaugh map is a means of pictorially showing all possible combinations of a number of two-state variables. Because of the way it is constructed it has other properties which make it possible to simplify Boolean expressions with the minimum of effort although it must be said that for more than four variables it is usually better to employ a more advanced method.

We will construct a Karnaugh map for four variables. The map will be the same as that displayed on a c.r.t. using the instrument described in the article. The basis of a Karnaugh map is a square. Each variable (usually labelled A, B, C and D for convenience) is allocated half the area of the square. To indicate the area occupied by a particular variable a simple edge coding system is employed. Fig. 13(a) shows the area occupied by the variable A and it is the area adjacent to the 1s under A in the edge coding. What is the area adjacent to the 0s under A in the edge coding? This is obviously the area representing $\bar{A}$. If the square of Fig. 13(a) is cut out and rolled into a cylinder the areas representing A and $\bar{A}$ become continuous—but more about that later. In Fig. 13(b) the areas representing B and $\bar{B}$ have been added. The square is now divided in four and each section represents one of the four possible combinations of A and B. From top to bottom, reading the edge coding, the sections are $\bar{A}\ \bar{B}$, $A\ \bar{B}$, $A\ B$, $\bar{A}\ B$.

You may have noticed that as you progress down the map, or up for that matter, only one of the variables alters at a time and this still applies if the map is rolled into a cylinder again because $A\ B$ becomes adjacent to $\bar{A}\ \bar{B}$.

In Figs. 13(c) and (d) the variables C and D have been added. If you consider only these two variables and roll the map into a cylinder the opposite way each section differs by only one variable. Reading round the tube so formed we get $\bar{C}\ \bar{D}$, $C\ \bar{D}$, $C\ D$, $\bar{C}\ D$, $\bar{C}\ \bar{D}$ etc.

Looking at the map as a whole it is plain to see that each one of the sixteen squares we have formed represents one of the possible combinations of the four variables. For instance the top left-hand square, as can be seen by the edge coding, represents $\bar{A}\ \bar{B}\ \bar{C}\ \bar{D}$ and the bottom right-hand square represents $\bar{A}\ B\ \bar{C}\ D$.

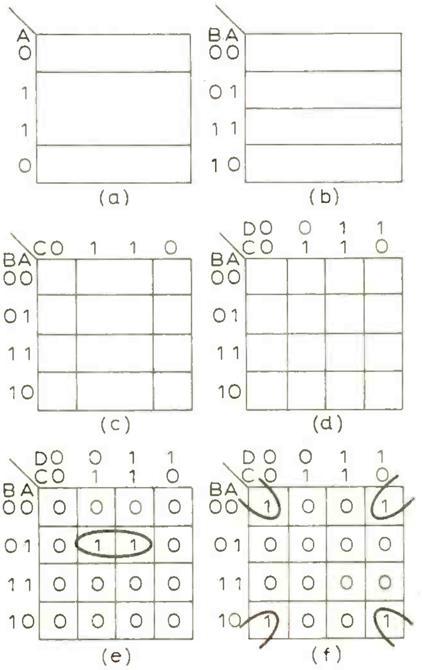


Fig. 13. The construction of a Karnaugh map and two examples. See text for full explanation.

But more important still is that adjacent squares, horizontally or vertically not diagonally, differ only in the negation of one of the variables. We have also proved, by rolling the map into a cylinder, that the top of the map is adjacent to the bottom and the left-hand-edge is adjacent to the right-hand-edge.

Two simple examples will show how these properties can be used to simplify Boolean expressions. Consider the expression $A\ \bar{B}\ C\ \bar{D} + A\ \bar{B}\ C\ D$. Draw a map as in Fig. 13(d) and put a 1 in the two squares representing the terms in the expression and an 0 in all the other squares. Because the 1s are adjacent to one another they are ringed as shown in Fig. 13(e). The simplified expression is derived by taking only variables which are common in adjacent terms. So $A\ \bar{B}\ C\ \bar{D} + A\ \bar{B}\ C\ D$ reduces to $A\ \bar{B}\ C$.

Fig. 13(f) shows the Karnaugh map for the expression $\bar{A}\ \bar{B}\ \bar{C}\ \bar{D} + \bar{A}\ \bar{B}\ \bar{C}\ D + \bar{A}\ B\ \bar{C}\ \bar{D} + \bar{A}\ B\ \bar{C}\ D$. All terms are adjacent and form a square of their own so only variables common to all four terms need be used. Therefore, from the map of Fig. 13(f):

$$\bar{A}\ \bar{B}\ \bar{C}\ \bar{D} + \bar{A}\ \bar{B}\ \bar{C}\ D + \bar{A}\ B\ \bar{C}\ \bar{D} + \bar{A}\ B\ \bar{C}\ D = \bar{A}\ \bar{C}$$

This brief explanation will serve to give the reader some idea of what a Karnaugh map is all about.

Next month a memory unit will be described which can be used with the Karnaugh map display unit, in place of the external logic circuit, to form an 'electronic blackboard'. Up to two Karnaugh maps can be stored, displayed or amended at will.

Shopping List

Resistors

All resistors, except the potentiometer, are 0.25W 5%.

10kΩ	×	18	150	×	4
470Ω	×	1	150k	×	1
56kΩ	×	1	33k	×	1
6.8kΩ	×	2	3.3k	×	2
1kΩ	×	3	47	×	2
4.7kΩ	×	2	1.5k	×	2
6.8Ω	×	1			

470Ω preset potentiometer.

Capacitors

500p	×	4	5,000p	×	2
100μ, 6V	×	2	200p	×	2
0.1μ	×	2	100μ, 12V	×	2
			500μ, 12V	×	1

Semiconductors

SN7493N, 4-bit binary counter,	×	1
SN7486N, quad exclusive-OR gate,	×	,,
SN7404N, hex inverter,	×	,,
SN72709DN, dual op-amp,	×	,,
BC108 transistors,	×	4
1N914 diodes,	×	6
5V, 400mW zener diode	×	1

Miscellaneous

dual-in-line sockets,	×	4
Lektrokit board type LK141,	×	1
Lektrokit pins,	×	100

SONEX 71

Hotel hi-fi show at London Airport

Over 150 rooms have been booked by more than 60 exhibitors for the second Sonex exhibition to be held at the Skyway Hotel, London Airport. The show will be open to the trade only on Wednesday 31st March and Thursday 1st April, between 11.00 and 18.00. It will be open to the public for the next three days, from 11.00 to 21.00 on Friday and Saturday and from 11.00 to 18.00 on Sunday April 4th.

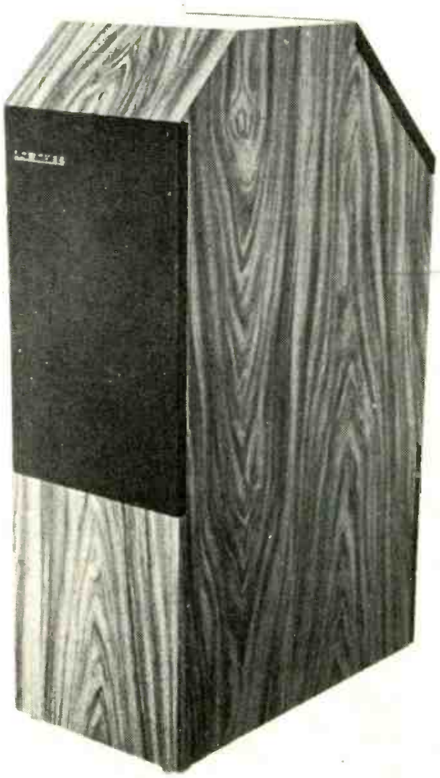
Because of the postal strike admission tickets will not be required. Each visitor will receive a free sixteen-page show guide.

Features of the exhibition that are new this year include a 'Living with Hi-Fi' display arranged by *Homemaker* magazine, and the promise of considerable activity by Radio London.

Brand names at the show

A.D.C.
A.K.G.
Acos
Acoustic Research
Akai
Alpha-Arena
Armstrong
Audio Packs
Audio Technica
B.S.R. McDonald
B & W Electronics
Bib
Brenell
Cambridge Audio
Celestion
Connoisseur
Decca
Empire
F.A.L.
Fane
Gabraphone
Garrard
Goldring
Goodmans
Grampian
Harman-Kardon
I.M.F.
J.B.L.
J.V.C. Nivico
Jordan-Watts
K.E.F.
KMAL (Monks Audio
Koss
Leak
Lowther
Luxor
Metro-Sound
Mordaunt-Short
Musitapes
National Panasonic
Ortofon
Peak Sound
Peerless
Philips Electrical
Pickering
Pioneer
Poly-planar
Quad
Radford
Revox
Richard Allan
Rogers
Rotel
Sansui
Sheppard
Shure
Sinclair
Skandia
Sonab
Sonotone
Sugden, J.E.
Telefunken
Teleton
Thorens
Wharfedale

An f.m. tuner from J. E. Sugden employs a varicap tuned front end and a four stage i.f. section with double tuned couplings. A switchable filter permits reduction of L–R information thus allowing separation to be traded for reduced noise on weak signals.



The Lowther Auditorium Acousta is an enclosure combining two sound sources—one forward, the other rearward. Using two such enclosures in place of a pair of conventional single perspective speakers gives increased solidity to stereophonic reproduction.

Futuristic Aids will be demonstrating a loudspeaker from Fane Acoustics which employs a new ribbon unit for mid range and top frequencies and a 12in driver for bass.

Cambridge Audio have a new speaker called the Junior, and a 'slave unit' to boost the output of their amplifiers.

Rogers will be demonstrating a modified and improved version of their Studio Monitor loudspeaker which is being manufactured under licence from the B.B.C.

Elements of Linear Microcircuits

7: Radio- and intermediate-frequency amplifiers

*by T.D. Towers,** M.B.E., M.A.

We tend to think of silicon monolithic technology (in which complete circuits are produced in small crystal chips little larger than the dot on a printed 'i') as being very modern. Technologically this is so, but any reader who has access to Vol. 1 of *Wireless World* could well be surprised to find in the July 1913 issue a long article by Dr. A. E. H. Tutton entitled 'Crystals as Rectifiers and Detectors' examining crystal lattice structures in detail and pointing the way to the use of 'the very best procurable single individual crystals'. Some of the semiconductors examined by Tutton such as 'perikon', 'anastase' or 'brookite' may only evoke nostalgic memories from more elderly readers. On the other hand, unexpectedly, Tutton also devoted attention to pure silicon (so important now to monolithic integrated circuits), and to such sophisticated materials as silicon carbide and liquid crystals (important now in semiconductor opto-electronics).

The celebrated H. J. Round in a reply to Dr. Tutton in the August 1913 issue was curiously prophetic in his remark 'Crystals work well as wireless receivers'. In the 1970s we have indeed reached the stage where virtually the complete receiver circuitry can be produced in a silicon chip. The present article examines the state of the art for r.f. and i.f. amplifier microcircuits.

A survey of r.f./i.f. amplifier microcircuits in early 1971 showed about 100 commercial types available, all produced by semiconductor device manufacturers. Of these, virtually all are monolithic, although hybrid circuits are beginning to appear. Before we devote the remainder of the article to monolithics, it might be well to consider why hybrids are appearing alongside them.

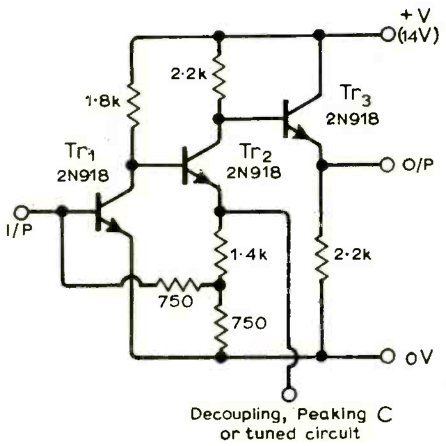


Fig. 1. Example of a thick film hybrid r.f./i.f. wideband amplifier; Newmarket Transistors NMC809A.

Fig. 1 gives the circuit of the Newmarket NMC809A, a thick-film hybrid r.f./i.f. amplifier. The seeing engineer's eye will note that it is a d.c. coupled feedback pair Tr_1, Tr_2, with an emitter follower buffer Tr_3, the transistors being 2N918 family devices with a typical frequency cut-off approaching 1,000 MHz. The circuit has a frequency response from d.c. to over 40 MHz. The resistor trimming possible with thick film assembly gives it a very narrow gain spread; typically ±1dB in 22dB at 1 MHz. It can be used as a wideband amplifier or as a tuned r.f./i.f. amplifier up to 40 MHz. The separate connection to the emitter of Tr_2 allows for full decoupling for low-frequency applications, or for a peaking capacitor for top-end video expansion, and series or parallel tuned circuits for band-pass or band-reject purposes. Designed to work on 14V with typically 14mA current, the NMC809A does not require any external biasing components, as bias levels are set up by resistor trimming during manufacture.

Monolithic r.f. circuits

In conventional discrete component r.f./i.f. amplifiers it is normal to use a single transistor per stage, usually in a common-emitter arrangement, or, at very high frequencies, in a common-base arrangement. In both of these methods feedback from output to input can lead to instability and various neutralization techniques have to be used when high stage gain is called for.

Where higher stage power gain is wanted, some d.c.-coupled arrangement of two transistors can be used instead of a single transistor between tuned circuits. Three configurations often met with are the long-tail pair, the cascode arrangement and the d.c. feedback pair.

Now with discrete circuitry the single transistor common-emitter stage has such advantages in gain, noise figure and impedance matching convenience that you only come across the other arrangements mentioned where abnormal performance is required.

When we come to monolithic i.cs, cost per transistor becomes less significant, being replaced by cost per stage. Here we find single transistors abandoned, and one

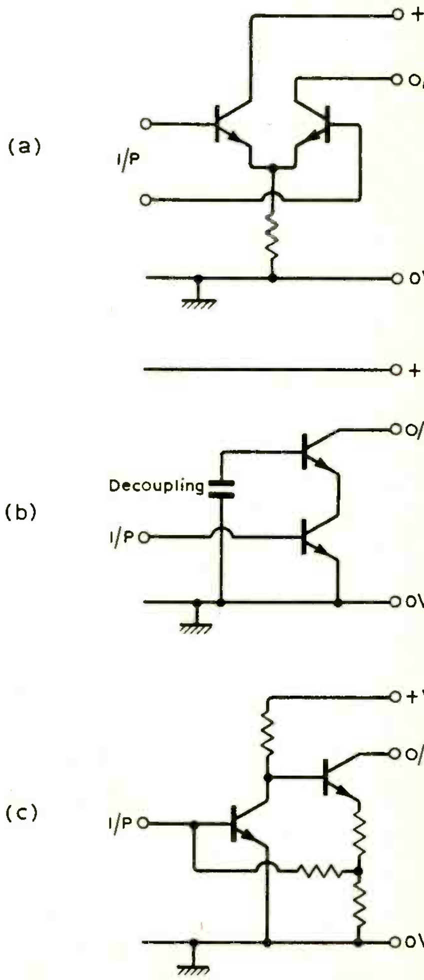


Fig. 2. Basic transistor configurations used in monolithic r.f./i.f. amplifiers; (a) long-tail pair; (b) cascode; (c) d.c. feedback pair.

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*Newmarket Transistors Ltd.

of the three multiple-element arrays used. For ease of analysis, these are shown in basic form, without isolating and biasing networks, in Fig.2. Each has its advantages. The long-tail pair of Fig.2 (a) has fairly low noise, high power gain, high stability, simple biasing, inherently symmetrical operation, non-saturating limiting action, fast recovery from overdrive and easy interstage matching. The cascode of Fig.2(b) has low noise, high power gain, high stability, and easy interstage matching. The d.c. feedback pair of Fig.2(c) is distinctive for low noise, large signal handling capacity and low power consumption.

Long-tail pair

The long-tail pair with a resistor tail is widely used in r.f./i.f. monoliths. One example is given in Fig.3, which is the circuit diagram of the Philips TAA380A. This is an i.f. amplifier suitable for use in TV intercarrier sound circuits and f.m. broadcast receivers and comes packaged in the small multi-lead TO-5 ou/line metal can. Transistors Tr_1 and Tr_2 form a long-tail pair with tail resistor R_1 and buffer isolating emitter follower Tr_3 feeding to further long-tail pairs Tr_4, Tr_5 and Tr ,' Tr_8 to drive an output tuned circuit connected to terminal five. Transistors Tr_9 and Tr_{10} provide stabilized voltages for close control of d.c. bias; reference voltages being provided from selected points in the series diodes D_{1-8} which are forward biased through R_{11}.

The resistive-tail long-tail pair is used as a basic element in many other commercial monolithic r.f./i.f. amplifiers such as the General Electric PA189, RCA CA3041, 3043, Fairchild μA717, Motorola MC1350, Siemens TBA120 and the Philips TAA570. Most of these are complex multi-stage circuits to provide a complete block of functions for a receiver.

Some monolithic multi-stage r.f./i.f. amplifiers use a transistor instead of a resistor as the constant-current source for the long-tail pair. This three-transistor type of gain block can be seen forming repetitive elements in cascode in commercial microcircuits and Fig.4, the Philips TAA350 is an example of this technique. The long-tail pair with transistor tail, Tr_1, Tr_2, Tr_3, with its output buffer emitter followers Tr_4, Tr_5 are repeated for the four stages. The bias for the tail transistor is provided from a common rail voltage defined by the forward voltage drop across the diode-connected Tr_{21} fed from the positive rail through a 2.1k Ω resistor. The differential amplification with current-driven long-tail pairs gives high a.m. rejection making the amplifier suitable for use with very simple f.m. detectors.

Several monoliths have been made which can be used in a large number of different ways. Fig. 5 gives the circuits of a number of the more common commercially available ones. These can, in most cases, be used as a cascode or a transistor-tail long-tail pair.

All the circuits of Fig.5 are basically a balanced emitter coupled transistor pair with a third transistor providing the emitter current for each of the pair. Such a configuration would be costly to fabricate with discrete components because of the difficulty of getting adequately matched balanced pairs and the need for separate biasing networks stable with temperature and supply voltage variations. With monolithic fabrication these difficulties do not arise. The different examples in Fig.5 reflect different manufacturers' design approach to versatile microcircuits with many circuit connection options.

The RCA CA3053/3028 of Fig.5(a) uses resistor networks to bias the tail transistor Tr_3. The Motorola MC1550 of Fig.5(b) features a diode in the biasing network for temperature stability; the Fairchild μA703 of Fig.5(c) uses two biasing diodes; and the Amelco 911 (also National Semiconductors devices LM171/271/371 of Fig.5(d) uses as many as three bias semiconductors for maximum stability. Fig.5(e), the Signetics NE511, is a different approach and offers two amplifier stages in the one package together with one biasing diode. This gives the equipment designer great flexibility for special circuit requirements. Another example of extreme versatility is the RCA3004/3020 shown in Fig.5(f).

Cascode circuits

So far we have not mentioned cascode operation. It will be found that in monolithic microcircuits a true two-transistor cascode arrangement is almost never found. This is because a cascode circuit can be made up by taking a transistor-tailed long-tail pair such as Fig.5(a) and using the tail transistor Tr_3 as the common emitter input of the cascode pair and one of the balanced pair as the common-base output. Some of the circuits of Fig.5 have direct access to the base of the tail transistor and can be used as

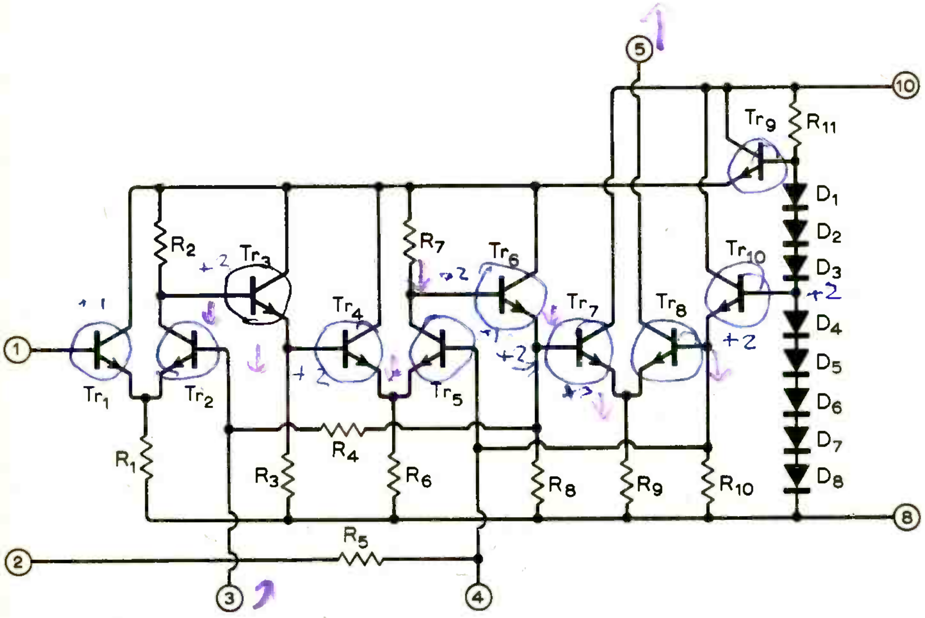


Fig. 3. Commercial i.f. amplifier microcircuit illustrative of use of resistor-tail long tail pair as basic amplifying element in monolithic microcircuit construction (Philips TAA380A).

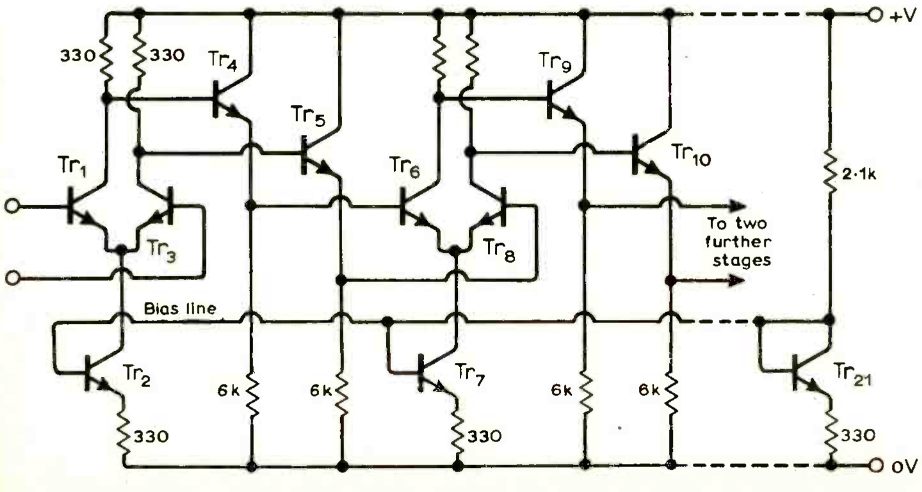


Fig. 4. Monolithic r.f./i.f. amplifier long-tail pair with transistor constant current tail (Philips TAA350).

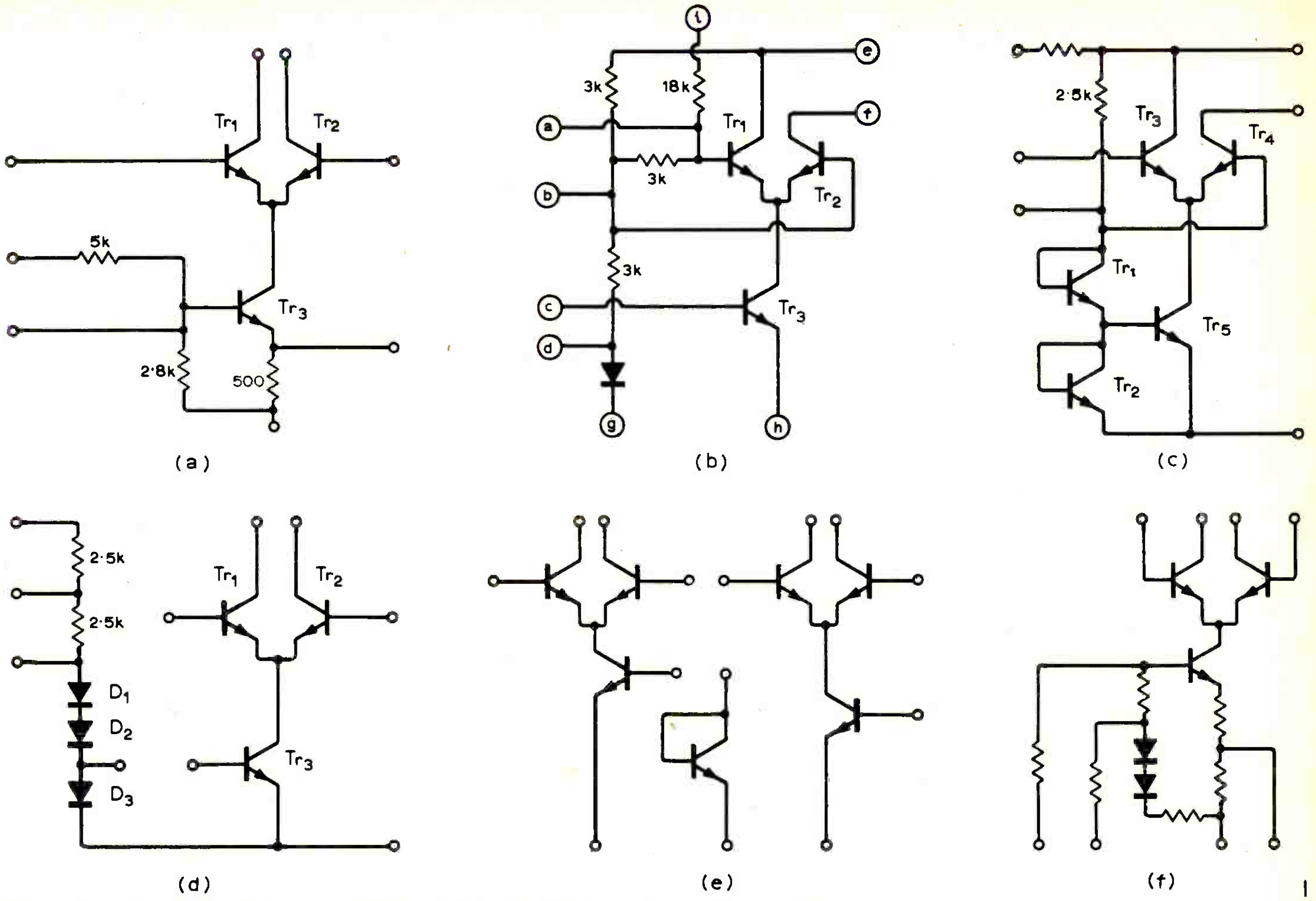


Fig. 5. Commercial single-stage monolithic r.f./i.f. amplifiers using long-tail pairs with transistor tails; (a) RCA CA3053/3028; (b) Motorola MC1550; (c) Fairchild μA703; (d) Amelco 911; (e) Signetics 511; (f) RCA 3004/3020.

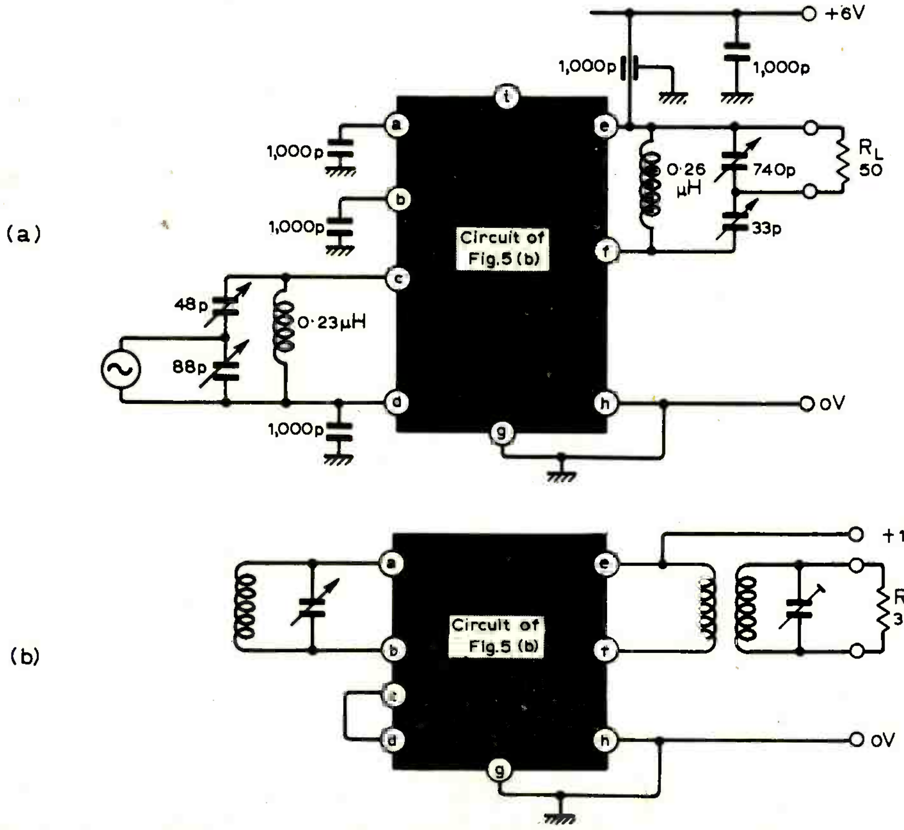


Fig. 6. Alternative cascode and long-tail pair tuned amplifier arrangements of Motorola MC1550 microcircuit; (a) cascode 60MHz, 30dB 0.5MHz bandwidth; (b) long-tail pair 10.7MHz f.m. i.f.

effectively in cascode as in long-tail pair mode (where the input is applied to one of the balanced pair). One feature not to be overlooked is that the three-transistor configuration (whether it be cascode or long-tail pair) always leaves an unused terminal which can be employed to apply automatic gain control.

Perhaps the easiest way to understand the versatility of the transistor triplet is to look at one specific example, say the Motorola MC1550 whose basic circuit is given in Fig.5(b). This microcircuit can be connected, for example, as a cascode 60MHz tuned amplifier in the arrangement of Fig.6(a) or as a long-tail pair 10.7MHz i.f. amplifier as in Fig.6(b).

D.C. feedback pair

The cascode and long-tail pair are not the only configurations used by monolithic manufacturers. The d.c. coupled feedback pair shown for discrete circuitry at Fig.2(c) above has advantages that have led to its adoption by some manufacturers. One example of this is the Plessey SL612 r.f. amplifier (Fig.7). The design is essentially an emitter coupled d.c. feedback input pair Tr_1, Tr_3 providing d.c. bias from the emitter of Tr_3 to the input of Tr_1 via a 5k Ω resistor. The d.c. coupled pair is followed by an emitter follower Tr_5 providing feedback into the emitter of Tr_1 via a 525 Ω resistor. The overall circuit gain is 20 dB Low noise is ensured by running Tr_1 at low current and good signal handling by the overall feedback. Effective a.g.c. control of 50dB is achieved via Tr_8 and

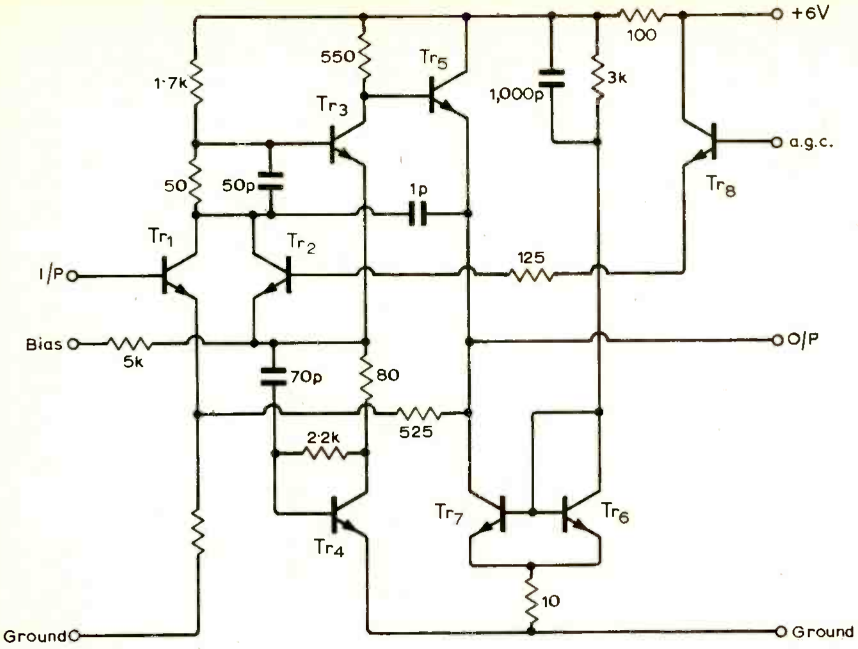


Fig. 7. Commercial r.f. amplifier monolithic microcircuit using basic d.c. coupled feedback pair configuration: Plessey SL612 r.f. (2-76MHz) tuned amplifier.

Table 1

Directory of r.f./i.f. microcircuit manufacturers

Company	Microcircuit type numbers
Amelco (Teledyne)	911
Fairchild	μA703/717/719
General Electric (USA)	PA189
Intermetall	TAA710
Marconi-Elliott Microelectronics	M316
Mitsubishi	M5142P
Motorola	MC1100/1350/1352/1550
Mullard (Philips)	TAA350/380/380A/450/570/640
National Semiconductors	LM171/172/271/371/372/703
Newmarket Transistors	NMC 809A
Plessey	SL501/502/503/551/552/553/610/611/612
R.C.A.	CA3002/3004/3005/3006/3028/3041/3042/3043/3044/3053
S.G.S.	L103, TAA661/730
Siemens	TAA981/991, TBA120/400
Signetics	NE510/511, SE510/511

Tr_2 and power consumption is some 15mA on a 6V supply. The circuit is optimized to give a 150MHz cut-off frequency ensuring satisfactory operation over the 2-76 MHz communications band.

To help readers see what is commercially available in the way of r.f./i.f. amplifier microcircuits, Table 1 lists the major manufacturers whose products of this type are on the U.K. market, with a selected list of types known to the author.

The wide range of microcircuits available to the equipment designer vastly simplifies the production of tuned amplifiers from 100kHz to 100MHz, whether for fixed frequency i.f. use, with high gain, low current consumption and narrow bandwidth, or for variable r.f. use, with low noise, large signal handling, a.g.c., without substantial change of characteristics, and without a performance change across the tuning band.

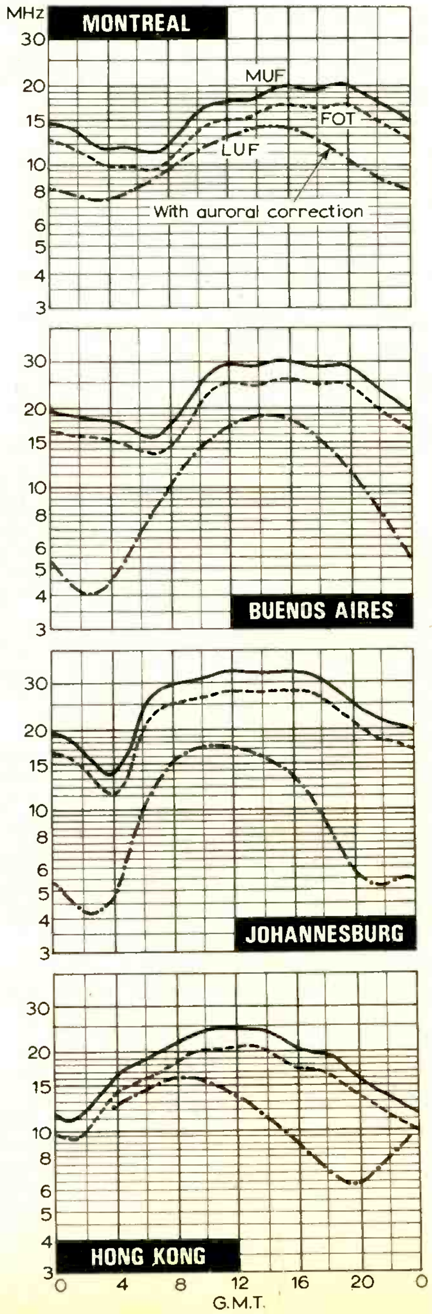
(to be continued next month)

H.F. Predictions—April

The charts are based on an Ionospheric Index of 96, the corresponding sunspot number being 83. Similar predictions were made for April 1970 but the observed index value jumped to 130 and remained high the following month. There was a similar trend in 1969.

Transequatorial paths have their highest MUFs during equinox months and conditions should be good above 20 MHz. Evening fading is relatively independent of season and cycle on the South African path but is worse during this season on others. Poor conditions are expected from the Far East midnight to 09.00 G.M.T. and North America will be liable to several days of weak signals 06.00 to 16.00 G.M.T.

MUFs apply to both directions of a route while LUFs are for reception in the U.K. only.



Don't Look Now

Sampled Data Controlled Systems, and . . . . .

by Thomas Roddam

Some years ago, when the book *Principles of Feedback Design* was in preparation, I did not dream of discussing a topic which, I then thought, was way out of our world. The airlines tell me the world is getting smaller, but if it is, there is still the simple fact that it gets more packed every day. Having started on non-linear systems, and found that the describing function is relatively easy to use, we must examine the sampled-data systems because we need this method for practical equipment. We need it, in fact, for power supplies.

Simple sampled-data systems we use in everyday life. You come home, look at the thermometer, or just guess, and having sampled the room temperature you either switch on a heater, or you don't. There are two sampling modes which follow. Either you take a data sample, am I hot or cold, at regular intervals in the natural breaks of the telly programme, or you operate with a relay dead-band characteristic: it's getting too hot in here, and off goes the heater. It's so tempting to continue with this example until it collapses in confusion. There is one feature which can be examined. Suppose that you have a very powerful heater, and that it is a very cold day. With regular sampling you may never be comfortable: it gets too hot before the next sample is due, if the heater is on; if it is off it gets too cold. This is the characteristic behaviour of a non-linear loop with an intolerable instability.

The theoretical study of sampled data systems is complicated by a number of factors. The sampling may not be exactly regular in period: this is a very common situation. The sample may not be taken, as the simple theory demands, in an infinitely short time. I do not propose to be pernickety about this, because this is merely an introduction to the subject. Furthermore, I have some numbers in mind. A particular system contains, in the loop, an inductor which is nominally 50 mH at 8 A d.c. An inductor of this kind, of course, is really 50–70 mH at best, and may be up to 200 mH at lower values of polarizing current. And then there is a big electrolytic capacitor. Details of the sampling data process are trivial compared with the large range of uncertainty of the response of the linear system. It does not make engineering sense to impose close tolerances on these components just to enable the theory to be made more precise.

In most of the literature it would seem that the forward path and the feedback path are shown as combined. This is because so much of the theory has been carried out in terms of control systems. For regulated power supplies this means, quite simply, that we connect the monitoring voltmeter in a different place. The essential bit of a linear regulator can take the form shown in Fig. 1. There are refinements, but they do not affect what we are considering. Normally we regard the voltage across the output terminals as the object of study, but in fact it is the voltage at point *B* which is the significant term so far as the regulator is concerned. The long-tail pair can be considered as a combiner and the complete unit rearranged into the form of Fig. 2. The actual output is then given by V_B/(pot' ratio). It is just the same for an audio amplifier, although we may put frequency dependent terms into the divider path. Stability depends on $\mu\beta$, not on either μ or β alone.

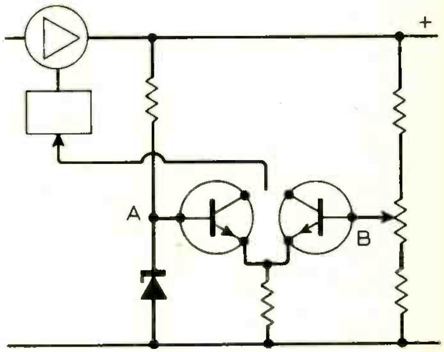


Fig. 1 Heart of a power supply regulator.

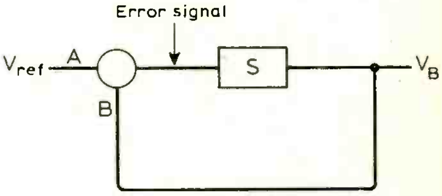


Fig. 2. Symbolic view of Fig. 1.

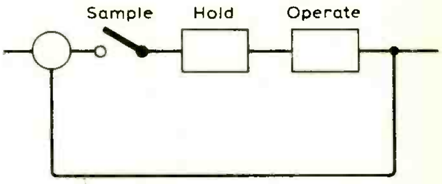


Fig. 3. Sampled data control system.

A sampled data system begins by looking at the error signal. This is done by the sampler. The output from the whole system will be a continuous one, and so the system must have a continuous instruction supplied to it. This is provided by a hold circuit, which stores the latest news of the error, provided by the sampler, until the next sample is taken. You plan your Sunday by the sea on the basis of Saturday night's weather forecast: you can even get it in stored form, in the evening paper. The overall system takes the form shown in Fig. 3. In this the box marked "operate" would be marked ($\mu\beta$) if we left out the sample and hold processes, and we should study the term $(1-\mu\beta)$, the difference signal, the error signal.

The elegant way of studying the stability of a system characterized by a function $F(s)$, or $f(t)$, is to study the roots of the equation

$$F(s) = 0.$$

In a simple world, all we know is $f(t)$, the way the system behaves when we give it a momentary impulse, but we find that we are urged towards the use of the Laplace transform and then to the Cauchy theorem, so that we finish up with a result which is simply the Nyquist diagram. It is usually fairly easy to find $F(s)$ for a linear system in the world of electronics. If we can find a form of $F(s)$ for the sample and hold part of Fig. 3 we shall be able to proceed absolutely along the established lines. One way of attacking this would be by the route of the describing function. The alternative is a bold frontal attack to determine the behaviour in time of the hold output when a standard signal is applied to the sampler. If the Laplace transform can be used on this process we have just two functions, $F_1(s)$ and $F_2(s)$, for the two parts of the circuit which are in tandem, and overall we have

$$F(s) = F_1(s) . F_2(s).$$

As it turns out, the Laplace transform which is obtained for a sampling system is an infinite series. I suppose this could have been expected, because the sampling process is one which implies infinite currents to reset the holder in an infinitely short time. A modified transformation, which is called the Z-transformation and which is related to the Laplace transform, is used. It has a rather interesting effect on the stability rules.

We had better look at the process we want to put into mathematical terms. Fig. 4 shows how an input signal is first converted into a train of pulses and is then processed by the hold circuit, a circuit which is often called a box-car circuit. If we think of the conversion of 4(a) into 4(d) in terms of the describing function there are two points which are obviously fairly true. The first point is that the describing function is not a function of amplitude, as it is with dead band or saturation non-linearities. The sample-hold operation is a linear one, in this sense. The second point is that the sample-hold operation provides a delay of about one-half the sampling period. This delay does not depend on the input frequency so that it is not a phase angle. Thus far, then, the s.h.o. behaves very much like a transmission line for the purpose of its describing function. Things get rather odd, however, if the input frequency is increased to around one-half the sampling frequency. If the samples are taken at 0 deg and 180 deg the output will be zero: if they are taken at 90 deg and 270 deg the s.h.o. will show a small gain. The output will show characteristic slow beats. This can be interpreted by treating the whole thing as a modulator, with input frequencies of f_i and ($f_s+2f_s+3f_s$ . . .), the spectrum of the sampler. The term $2f_s-f_i$ is very close to f_i when $f_s \approx f_i$, and this is one way of looking at the beat source: another is to fix attention simply on f_s-f_i. From the first, however, we see that we are likely to get this sort of thing happening when $f_i = 2f_s$, and so on right up the spectrum.

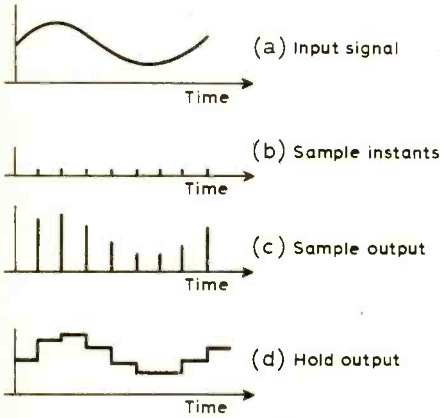


Fig. 4. Sample and hold process.

Two consequences can be guessed. The first is that any attempt to find a simple describing function in the form $G(s)$ will need to deal with an infinity of odd spots. This is because our sampler is what we might call an infinity generating function. The second is that we may get trouble with those beats in a practical system. Hold circuits do not normally hold for ever: if we think of a power supply filter as a hold circuit it will do its job nicely at 100 Hz, getting rid of ripple, but if there is an instability near the sampling frequency which produces an input, will the beat frequency get suppressed? The describing function technique is at its safest if one is throwing away harmonics. Here there is a nasty danger of subharmonics, and in practical systems it is found that oscillations at a subharmonic of the sampling frequency are, indeed, produced.

The formal approach is, as we have said, by means of the Z-transform. This is developed in the following way. Suppose that the input to the sampler is a waveform $f(t)$. The output is a series of pulses, separated by time T. The nth pulse, at time $t = nT$, is quite simply $f(nT)$ and is fully expressed by

$$f(nT)\delta(t-nT)$$

Where $\delta(t)$ is the impulse function, a unit impulse at time $t = 0$, or, for $\delta(t-nT)$, at time $(t-nT) = 0$, or $t = nT$. As we know from our delving into the Laplace transform, the impulse function is $\mathscr{L}$-transformable. In fact we can write

$$\mathscr{L}\, f(nT)\delta(t-nT) = f(nT)\exp(-nTs)$$

This takes advantages of the fact that while we are looking at this pulse, nT is a constant, and so $f(nT)$ is also a constant.

The whole pulse series which comes out of the sampler is the sum of all the individual pulses:

$$\sum_{n=0}^{\infty} f(nT)\exp(-nTs)$$

Now we write $z = \exp(Ts)$ and the pulse becomes:

$$\sum_{n=0}^{\infty} f(nT)z^{-n}$$

We call this $F^*(z)$, the Z-transform of $f(t)$, and write

$$F^*(z) = \mathcal{Z} f(t)$$

Just as when we are dealing with functions of the complex frequency, s, we take the ratio of input $I(s)$, and output $O(s)$, and call its inverse the transfer function

$$\frac{O(s)}{I(s)} = G(s)$$

so in sampled systems we can take $F^*_{in}(z)$ and $F^*_{out}(z)$ and write

$$\frac{F^*_{out}(z)}{F^*_{in}(z)} = G^*(z)$$

the sampled transfer function. It is a special kind of system gain. Fortunately it is related to the ordinary meaning of gain. The mathematics is of a kind best studied in privacy by consenting adults, with long expressions all over the place. The final answer is elegant:

$$G^*(z) = \mathcal{Z}\,\mathscr{L}^{-1}G(s)$$

Thus all you do is work out $G(s)$, with all those $(s+a)$ and (s^2+as+b) terms that come from X, R and L, C, R circuits, find the inverse Laplace transform, using tables if you are idle, and then find the Z-transform, for which you should have another set of tables.

Although it is not uncommon for the hold function to be provided by a network of capacitance and inductance there are practical as well as theoretical circuits in which the box-car hold system is used. It is a circuit element of a rather special kind. It has what we may call a frequency response, that is to say a transfer characteristic expressed in terms of s, which is obtained by using the Laplace transform on the behaviour in the time domain. It is rather unusual, in circuit theory, to find ourselves working this way round. Again the mathematics is a mass of long expressions, but in the end we obtain a transfer function for the hold circuit, $G_h(s)$, given by

$$G_h(s) = (1-\exp(-sT))/s$$

Remembering that s is a generalization from $j\omega$, we see that we have a sort of $j\omega T$, and the exponential function gives us a power series of this, a harmonic series of the sampling frequency.

Although I do not expect that, from this article alone, readers will be in a position to design sampled data systems, it is nevertheless of some value to know the form which some basic functions take when they are Z-transformed. The obvious one to begin with is the unit step, the most basic function which can be meaningful. Although we took the unit impulse for our normal kind of circuit, sampling a unit impulse is an exercise in probability which I will not attempt, especially as we would be considering the chance of two infinitely short pulses coinciding. The Z-transform of the unit step, however, is quite easy. All the pulses are the same height, and

$f(nT)$ is a string of 1, 1, 1 . . .

This makes

$$\begin{aligned} F^*(z) &= \sum_{0}^{\infty} z^{-n} \\ &= 1+1/z+1/z^2 \ldots \\ &= z/(z-1) \end{aligned}$$

It is more elaborate than the Laplace transform, which is simply $1/s$.

A key waveform is the one we get from a single root on the real axis, for which the s-function is $1/(s-a)$. For this the inverse Laplace transformation gives us

$$f(t) = \exp(at)$$

Each pulse in the train which comes out of the sampler is $\exp(aT)$ the size in the preceding one: a is usually negative, of course. The Z-transformation gives us

$$\begin{aligned} \mathcal{Z}\exp(at).u(t) &= \Sigma z^{-n}\exp(anT) \\ &= \Sigma(z^{-1}\exp aT)^n \\ &= \frac{z}{z-\exp(aT)} \end{aligned}$$

Once all the analysis has been gone through, we have the overall sampled transfer function. In the familiar case of a linear system we, if we are using the Laplace approach, find $\mu\beta(s)$, and then substitute $j\omega = s$. Most of us go by a different route, to get $\mu\beta$ as a function of ω without using s at all. When we have this expression for $\mu\beta$ we plot it out as ω goes from 0 to ∞. We should in theory plot it from $\omega = -\infty$ to $\omega = \infty$, but we only need to do this in some very tricky systems. Where is the critical point (1, 0), or if you don't slip the 180°, (−1, 0)? This is the Nyquist test for stability. In a previous article we saw that this trick of standing at the critical point and saying "are we surrounded" is the equivalent of searching the whole half-plane for roots by

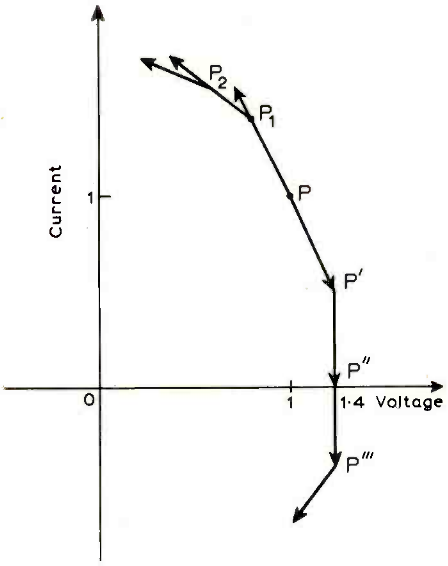


Fig. 5. Phase plane diagram.

going round it on a contour. We can be Indians or Wagon Train.

In a sampled data system we have

$$z = \exp sT.$$

Let us put $s = j\omega$, so that

$$z = \exp(j\omega T)$$

But $\quad \exp j\omega T = \cos \omega T + j \sin \omega T$

and as we vary ω this means that z goes round and round on a circle of unit radius. Instead of varying ω from 0 to ∞ we need only go once round this circle. From then on, use Nyquist.

The underlying mathematics would seem to have evolved from the use of the Fourier and Laplace methods. Whenever one has a simple, powerful, mathematical technique one finds that there are mathematicians nibbling away at the foundations. Whenever the engineer says of a solution— that bit does not make sense, let's leave it out—the mathematician goes away to find a technique which will leave it out automatically. In the describing function method we leave out the harmonics, and sometimes land in trouble. The mathematics of the Z-transform comes from a study of where the Laplace transform goes wrong. There is less chance of applying the more rigorous theory which lies behind the Z-transform to functions which will have some odd feature which makes the procedure give the wrong answer. The difficulty, as always, is that the more general the rules, the harder it is to live with them: read the regulations at the park gate before you take the dog for a walk and you will see just what I mean.

Even if I had devoted ten times as much space to a very detailed explanation of how to use this classic sampled-data approach it would not have been a help in the real world. Practical sampled-data systems do not work with infinitely short sampling pulses, and the sampling pulses may not be evenly spaced.

One form of practical sampled-data system which is of both theoretical and practical interest is obtained when the sampling switch is closed for a finite time. This means that the sampler output is a normal pulse amplitude modulated signal, with pulses which can pass reasonably well through at least a part of the linear system. The type of hold circuit is then probably not the zero order hold which produces the box-car effect, but a first or second order integrator. One important feature of this is that the theory must fit at the ends. When the pulse becomes very short the situation is the one we have just discussed, for which the Z-transform or other short-pulse techniques must give the same answer. If the pulse length is T, the sampler switch is closed all the time, and the answer must be the usual linear, $\mu\beta$, answer.

The sampler may produce pulse length modulation. I simply will not start on this. Except, there is one form of pulse length modulation which we must consider. Suppose that the sampler switch closes at a moment determined by the sign of the error signal, and is opened at regularly occurring times. This produces pulse length modulation with a modulated leading edge. Suppose also that the pulses are an odd shape. Who would want to build such a circuit? This is, in fact, just what one gets with thyristor regulation in phase-control and is not too different from some switching regulators.

Other switching regulators behave even more awkwardly. Both pulse frequency and pulse length vary over the controlled range. These, in fact, are probably best dealt with by using the describing function, treating them as relay circuits with hysteresis. But if you feed in some jitter signal deliberately they look like sampled data systems.

I want to look at some practical systems next month: there is not enough space here. There is, however, one other theoretical approach which I think deserves just about the space I have left if I am to stick to my standard length. The mechanical people call this the velocity-phase diagram technique, which does not mean much to us. It is chiefly used for rather simple systems, which are, in fact, just the sort of systems we want to use it for. That sentence expresses my meaning precisely: up with changes I will not put.

A typical circuit equation is

$$L\frac{dI}{dt}+RI+\frac{1}{C}Q = E$$

It is not necessary that L, C, R or E should be constant. We can always write:

$$\frac{dI}{dt} = \frac{E-RI-(1/C)Q}{L}$$

If $I = dQ/dt$ we have

$$\frac{dI}{dQ} = \frac{dI}{dt}\Big/\frac{dQ}{dt}$$

and thus $\quad \dfrac{dI}{dQ} = \dfrac{E-RI-Q/C}{LI}$

This expression contains no mention of time, not even in the disguise of frequency, unless time is hidden in one of the parameters. The most likely place to find time is in E, but even the $t = 0$ idea of the unit step can be eliminated in the plot which is adopted. Actually I never know what charge is: we used to catch it on little drops of oil. Volts I know, I've got a meter for finding them. And

$$Q = CV, \quad \text{so}$$

$$\frac{dI}{dV} = \frac{E-RI-V}{(L/C)I}$$

The validity of one or two steps needs checking in each particular problem by running through this process writing not just C or L or R or E, but $L_0 f(I)$ for an inductance which saturates, for example. The essential feature of this technique is that it is basically a practical one, working from the problem to the solution. The methods we normally adopt, like the Nyquist diagram, really start with the answer and we just test the problem against it.

The technique now is this. We choose our starting condition, when all the terms on the right-hand side are known. Let us begin by using the specific example we have, although this is not the only circuit we can handle in this way. To make life very easy, let us take $E = 0$, $R = 1$, $(L/C) = 1$ and initial conditions $V = 1$, $I = 1$. We plot this point at P in a voltage-current diagram (Fig. 5).

Now at P

$$\frac{dI}{dV} = \frac{-RI-V}{(L/C)I} = \frac{-I-V}{I} = -2.$$

We draw in an arrow to describe this slope. Let us go along this line to $V = 0{\cdot}8$, $I = 1.4$, and call this P_1. Here

$$\frac{dI}{dV} = \frac{-1{\cdot}4-0{\cdot}8}{1{\cdot}4} = -1{\cdot}57$$

A new arrow is drawn to show the path from P_1. Using the approximation

$$\frac{dI}{dV} = -1{\cdot}5$$

the next point is $V = 0{\cdot}6$, $I = 1{\cdot}7$, P_2.

Here $\quad \dfrac{dI}{dV} = \dfrac{-1{\cdot}7-0{\cdot}6}{1{\cdot}7} = 1{\cdot}35$

There is no reason why we should not go on like this, building up a trajectory which shows how the circuit behaves. Except this: where does the arrow head come from? We must let time into the system just a little way. The time to go from P to P_1 is

$$t_{PP_1} = \int_P^{P_1} dt = \int_P^{P_1} \frac{dV}{dV/dt} = \int_P^{P_1} \frac{dV}{I}$$

and as in this short stretch $I \approx 1$ and $dV = -0{\cdot}2$, the time in the movement from P to P_1 is negative. We should head off in the other direction, instead of looking back into history. So we build up P', P'', P''' and in the end we get the spiral path sketched in Fig. 6, which must, of course, decay to the

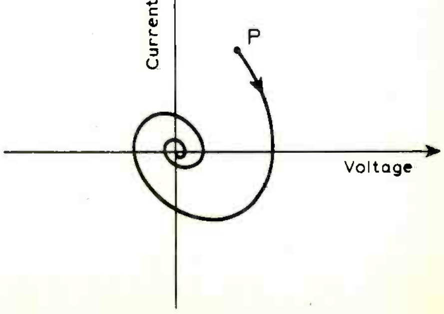


Fig. 6. The final picture.

origin, as we have no supply E to provide any final voltage. In this particular circuit a fixed voltage input would have given a spiral centred, if that is the word, on the point $(E, 0)$. This is obviously a stable system: in the long run it settles down. It is not a very exciting system, although it is easy to watch the spiral on an oscilloscope. If the brightness can be modulated it is possible to put time markers on as well.

In a non-linear system we can get up to all sorts of tricks. For simple folk like me a rather coarse stage by stage calculation is carried out. The example I am using now has been chosen so that it does not overlap the material I have in mind for the next article. Let us stick to our *LCR* circuit, but let us take some special cases. If we take $R = 0$ we have

$$\frac{dI}{dV} = -\frac{V}{I}$$

$$IdI + VdV = 0$$

$$I^2 + V^2 = \text{const.}$$

This is the equation of a circle and I really do not think we need a figure. If we make R rather small we know that the oscillations die away very slowly. For convenience the system will be started off at the point $I = I_0$, $V = 0$, and we shall get a spiral path which lies inside the circle. The first half-cycle is shown in Fig. 7 as the path from I_0 to $-I_1$.

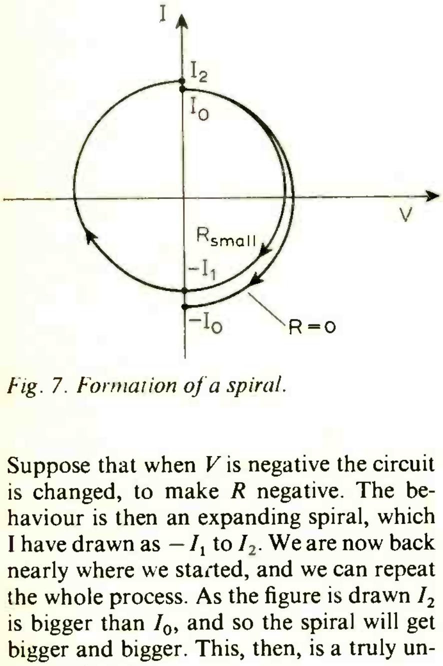


Fig. 7. Formation of a spiral.

Suppose that when V is negative the circuit is changed, to make R negative. The behaviour is then an expanding spiral, which I have drawn as $-I_1$ to I_2. We are now back nearly where we started, and we can repeat the whole process. As the figure is drawn I_2 is bigger than I_0, and so the spiral will get bigger and bigger. This, then, is a truly unstable situation.

In circuit terms this corresponds to an ideal class-B oscillator which drives for exactly half a cycle and decays for the other half. In terms of the s-plane the pole spends equal amounts of time on each side of the imaginary axis, but goes rather further into the right-hand half than it does into the left-hand half. The oscillator designer would disagree with the description "ideal". He wants the amplitude to stay constant. One way of doing this is to adjust the values of $R+$ and $R-$ very precisely, so that what we lose on the swings we make on the roundabouts. This is the function of a thermistor in such a circuit. There are two other ways, which are more in our line: the thermistor is a linear operator, after all. We can use a limiter of some kind. It is a matter of taste how the limiting is done. A diode can be used to clip the voltage used in this analysis: a diode can also be used to clip the current. Examination of particular circuits will show how a non-linearity is added to each. Without giving any particular preference to any method, the sort of behaviour we get is shown in Fig. 8. This would be analysed in three pieces, $A \rightarrow B$, $B \rightarrow C$ and $C \rightarrow A$.

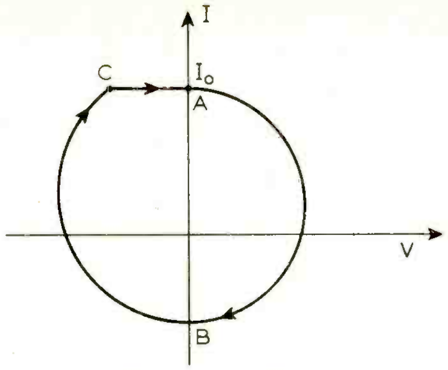


Fig. 8. Stabilization of oscillation by clipping at I_0.

An alternative technique is to change the point at which R is switched from negative to positive. This is indicated in Fig. 9. From A round to B the damping is positive, and from B to A the spiral is a growing one. The change now takes place at $-V_0$ and if this is chosen correctly the system remains in an equilibrium oscillation. It is, of course, a class-C oscillator and will be designed, with a d.c. loop study, to make $-V_0$ self-adjusting. If the d.c. loop is not correctly designed the system has a different instability and is either a blocking oscillator or a squegger.

Circuits of this kind often have a dead-band characteristic. When this is so, the initial conditions become of great interest. There are two circles on the diagram of Fig. 10. If the circuit is set off at the point $(I_1, 0)$, inside the circle C_1 the dead, or partly-dead, band means that the gain, in the describing function sense, is not enough to keep the circuit oscillating, and it just dies slowly. If the circuit is set off at $(I_2, 0)$ it will begin to oscillate, and we have at first no restraint on the oscillation so that the spiral is a diverging one, until the circle C_2 is reached, when the oscillation settles down. For the initial condition $(I_3, 0)$ the limiting mechanism is rather over-working, bringing the trajectory in towards C_2, the steady state oscillation.

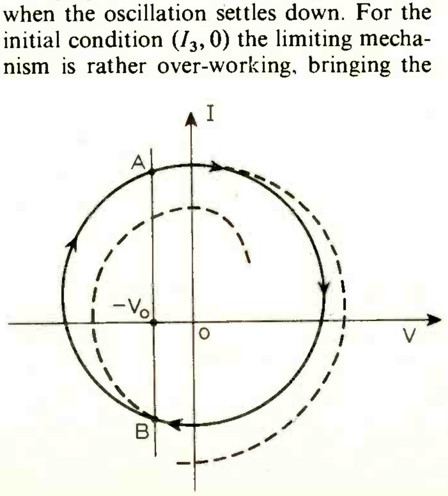


Fig. 9. Stabilization by change of transition voltage.

For systems of reasonable simplicity these plots can be constructed on a point by point basis. They are also easy to produce by analogue modelling and to observe with an oscilloscope. Timing marks can be put along the trajectory, even when it is being constructed in this step-wise way. It is thus perfectly practicable to apply this method to a sampled-data system. The case against the method is one with which I have a good deal of sympathy. You are doing all this work on just this problem: you will have to do it all over again for the next problem. How nice to have general solutions. I am not satisfied, however, that the second, third, tenth problems of the same kind will involve the same amount of work. One great point in favour of this approach is that it keeps currents and voltages in your mind. They cannot slip off to infinity for an instant, leaving you with a sound analysis and a pile of dead transistors.

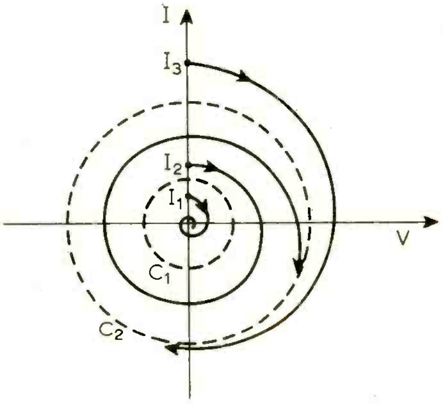


Fig. 10. Three initial conditions.

Non-linear circuit analysis, and especially that part of it connected with feedback systems, seems to be in a rather awkward phase of its existence. There exists a very large amount of theoretical work in the form of original papers, some of great subtlety. The textbooks, when they are up to date, deal with the more elegant refinements of linear theory before they come to non-linearity. Not only does this discourage the student, who, if he is studying in his own time, collapses before he reaches the non-linear material: the academic knows that non-linear systems are either trivial or too complicated to be subjects for an examination question. Meanwhile, we all need to build them. So let us stop thinking about Aspects of Non-linear Control Theory and start remembering, You, too, will go round the bend.

Low Distortion Tone-control Circuit

Bipolar transistors used in a Baxandall configuration

*by P. M. Quilter**

Now that very high quality transistor power amplifiers are definitely with us, attention must be refocused on the pre-amplifier. The main source of distortion in the pre-amplifier is often the tone control circuitry as the power amplifier may require 1V r.m.s. or more to drive it fully, and it usually takes this directly from the output of the tone-control circuit.

The standard one-transistor circuit, as used by A. R. Bailey[1], gives a total harmonic distortion figure in the region 0.1% to 0.2%. The circuit, adopted by J. L. Linsley Hood[2] is an improvement but necessitates the use of an f.e.t. which is not yet as cheap as a bipolar transistor and, because of its high drain load, requires an output buffer. Ideally a distortion figure in the region of 0.01% at 1V output is desirable.

To achieve this using bipolar devices requires that either the inherent open-loop distortion in the amplifier be reduced, or the open-loop gain increased to give a higher feedback factor for the same closed-loop gain.

The distortion in a transistor with a very high ratio of collector-slope resistance to collector-load is very nearly a function of output current alone. Therefore if the collector load can be raised the output current required to produce a given voltage will be reduced with a consequent reduction in distortion (and an increase in open-loop gain). Unfortunately, the high value of collector load would ordinarily make a high value of supply voltage necessary, and might also make loading effects of the feedback network significant. These difficulties can be overcome simply with an emitter follower performing two functions—providing an output buffer for the high collector load, and giving a bootstrap voltage to raise the effective value of collector load.

The function of bootstrapping is to reduce the actual voltage swing across the collector load resistor for a given collector current required to produce this change, and hence raise the effective resistance of the collector load. This can be achieved by driving the top end of the collector resistor in step with the collector voltage. The final arrangement is shown in Fig. 1.

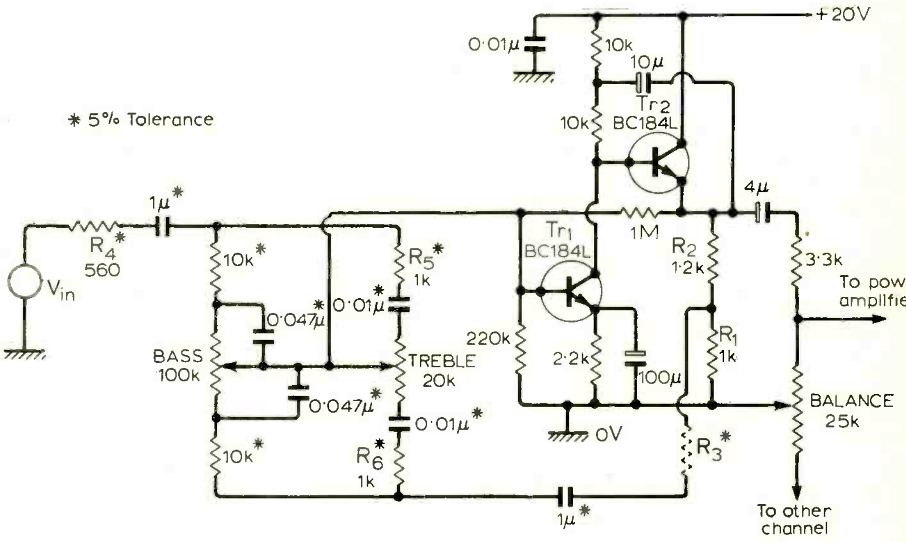


Fig. 1. The complete tone-control circuit built round two n-p-n silicon transistors.

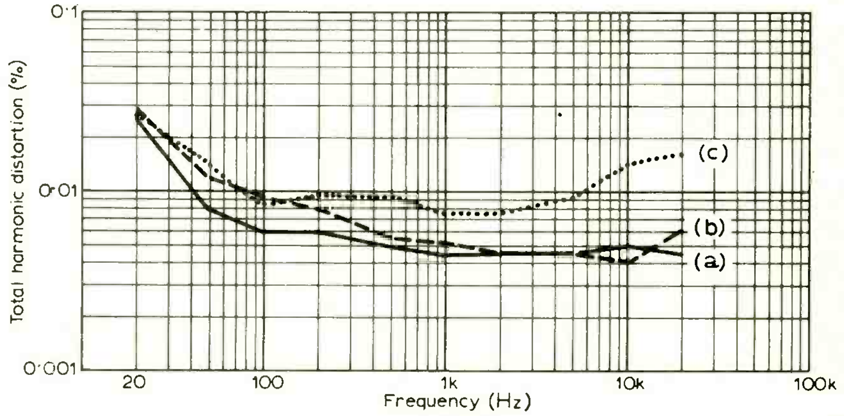


Fig. 2. Total harmonic distortion as measured at 2V output. (a) is the measured t.h.d. of the signal generator, (b) the distortion curve with the tone control flat, and (c) the distortion curve with maximum bass and treble boost.

The circuit as tested omitted R_3 giving R_4 equal to 560Ω with the values of R_1 and R_2 shown. The gain was 2.2:1 at centre frequency with a subsequent loss of about 1.2:1 with the balance control fitted as shown. The distortion figures for a constant output of 2V r.m.s. are shown plotted against frequency (Fig. 2). The distortion curves for the test oscillator used and the distortion measured at the output of the amplifier are substantially the same up to 2kHz but, with the treble control set for maximum boost, there is a slight rise at high frequencies. This may have been due to emphasis of the harmonics produced by the test oscillator itself because of the rising characteristic of the amplifier at high frequencies.

The output clips at 6V r.m.s. and with the controls set to the "flat" position, the

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*University of Sussex

total harmonic distortion from 40Hz to 20kHz was measured to be 0.01% or less at 5V r.m.s. output.

The signal-to-noise ratio measured with reference to 1V r.m.s. output over a 20kHz bandwidth was 104dB and the rise time to a step input, 0.1μs.

The circuit may be modified to suit personal taste as required. The relevant equations are as follows:

$$\text{gain} = \frac{R_1 + R_2}{R_2} \qquad (1)$$

$$R_1 + R_2 \approx 2\text{k}\Omega \qquad (2)$$

$$R_3 = R_4 - \frac{R_1 R_2}{R_1 + R_2} \qquad (3)$$

Some increase in distortion may result if the gain of the circuit increases beyond 5 or 6 although this may be acceptable especially if the required output voltage is fairly low, as the distortion is a function of output voltage.

Balancing equation (3) is important in order to ensure the controls will be set at their electrical centre when the frequency response is flat. In fact a perfect square wave response cannot be achieved for any setting of the controls unless this equation is balanced.

It should also be noted that the output impedance of the stage driving the circuit is part of R_4 because R_4 is the total source resistance. If this is not taken into account equation (3) will be invalid.

If R_4 is greater than about 500Ω the two 1kΩ resistors R_5, R_6 can be omitted. They are included only to limit the ultrasonic gain to prevent instability. It is not advisable to increase R_4 above 2kΩ as the treble control range within the audio range will then be restricted.

The transistor type BC184L was used for this circuit in preference to the more common BC109 because, from experience, the latter type had a tendency to oscillate parasitically due to its collector connected metal can.

In conclusion, this circuit has the advantages of a high output voltage with very low output impedance, negligible distortion and good signal-to-noise ratio.

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2. J. L. Linsley Hood, "Modular Pre-amplifier Design", *Wireless World*, July 1969.

Progress in Air Traffic Control

The first stage of the national air traffic control scheme—code name Mediator—has been introduced at the National Air Traffic Control Service centre at West Drayton, Middlesex. Civil and military radar units operating until recently at Heathrow and serving South-east England have now been closed. With 2,500 movements per day at peak times, increasing at about 10% per year, the new system is needed to increase capacity as well as safety. Work on Mediator was initiated by N.A.T.C.S. in 1962 when it was set up to organize a comprehensive air traffic control system for both civil and military use.

Mediator recognizes radar as the controlling agent whereas in the past radar has been a back-up to 'procedural' control. With it, a whole new range of radar, communications, and automatic data processing equipment is being brought into operation with its associated engineering control, maintenance, power station, and new traffic control techniques. Thinking behind the scheme is similar to that proposed in the early 1960s–see 'Electronics for Mediator' *Wireless World* vol.71, September 1965, pages 426-9--but there have been changes since then, partly as a result of difficulties with equipment.

Difficulties with the computer for flight plan processing have meant postponement of the full implementation of stage 1 but in the words of Michael Noble, Minister for Trade '. . . This was not a reason for delaying other improvements . . . not dependent on this particular development.' Improvements include completely new consoles–illustrated on page 181–with bright radar displays and a secondary radar facility, providing controllers with aircraft identification codes superposed on the primary radar display.

The secondary system, of course, works only with those aircraft installed with transponders, at present in the minority. They either have a 64-bit coded transponder–which enables a two-digit route code to be shown on the radar display–or 4096-bit coded transponder which allows aircraft to be identified with two additional decimal digits. Further, some aircraft are fitted with altimeter telemetry equipment, allowing flight level to be shown as well.

Facilities which make up stage 1 of Mediator fall into four main parts–radar outstations, communications links, processing and distribution, and display. The most interesting parts of the system are to do with processing and display, but of course the outstations and communications links are vital and much effort has been devoted to their reliability. Of the long-range primary radar stations at Ash, Ventnor, Lowther and St Annes using 50-cm radars–chosen in preference to the alternative 10-cm radar which would give more precisely defined blips but is susceptible to rain effects–three have dual aerial heads.

All the secondary radars, co-sited with the primary radars, have dual heads. The main heads have duplicated electronics to give a high degree of reliability and to facilitate maintenance without interruption to the service. . . .

Bright radar displays use a scan conversion technique in which primary video data is written into the storage surface of a conversion tube. This is read with a 1024-line scan many times a second reinforcing the 55-cm display and thus achieving television-screen brightness level. This system differs from other scan conversion systems in the way the secondary radar information is added to the primary. Use of two electron guns–with consequent registration problems–is avoided by sharing gun writing time between the two data. When secondary radar information is available, the normal 'square' scan (equal forward and 'flyback' trace time) for primary information is interrupted and the aircraft designation written on the 256-bit line using digital character generation.

With this system it had been possible to superpose primary and secondary displays to an accuracy of ± 1.5mm.

There is also a third kind of information on the display tube—a locally generated map together with range rings and other static information.

One problem found with this technique of digitally writing the secondary radar information relates to the equal forward and reverse scans. If a display's digit is not accurately matched in position on the forward and reverse scans a jagged sawtooth effect can be produced–an effect which did in fact occur. Attempts to right this by adjusting electrical lengths of cables between scan conversion unit display were unsuccessful and passive delay networks had to be introduced. This needed extra gain from the video amplifiers to maintain display brightness and consequently these are being replaced.

Flight plan processing for controlled airspace is now done with a 32,000-word store using a Ferranti Hermes computer. The system stores flight plans–aircraft identification and certain other information–wind speed and direction, airways structure, link routes, reporting points, and runways in use at Heathrow, verifies the flight plans, calculates an e.t.a. for each reporting point en-route, and prints-out flight progress strips.

For middle airspace a Marconi Myriad computer system will be brought into use by March 1972 at which time R.A.F. middle airspace controllers move to the new centre. This triplicated real-time system was originally planned to be operational by now but software problems led to its postponement. Although only one of the three computers is connected on-line at any time, the others contribute through a kind of self-checking voting

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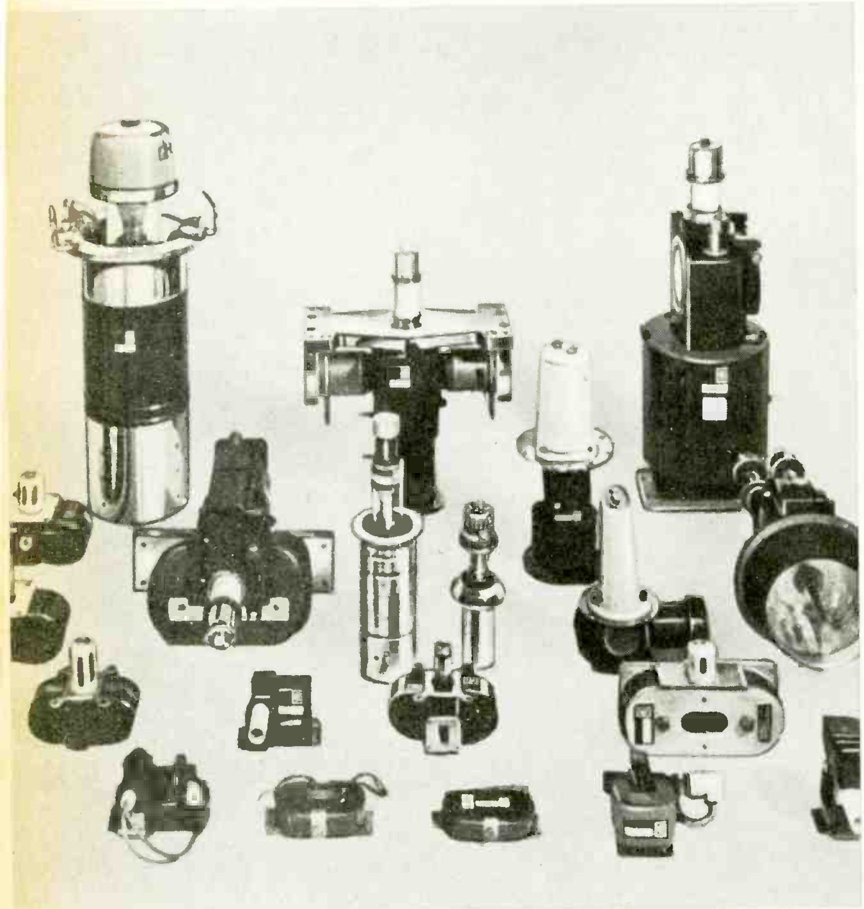

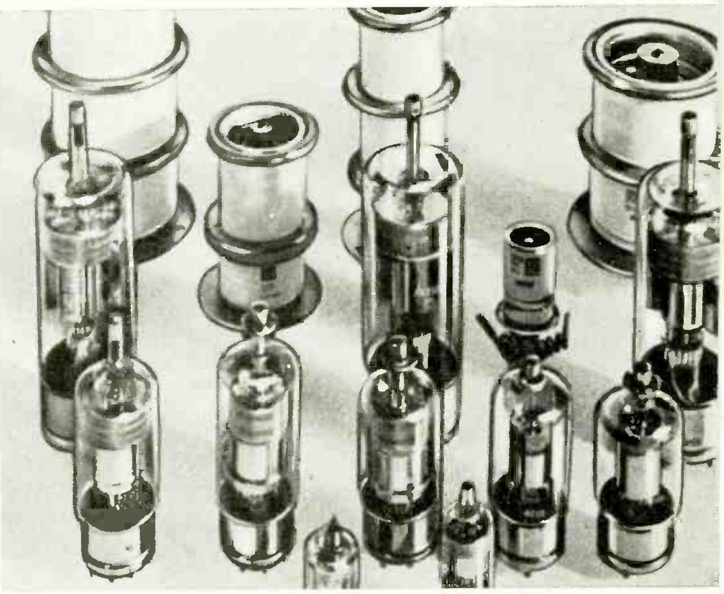

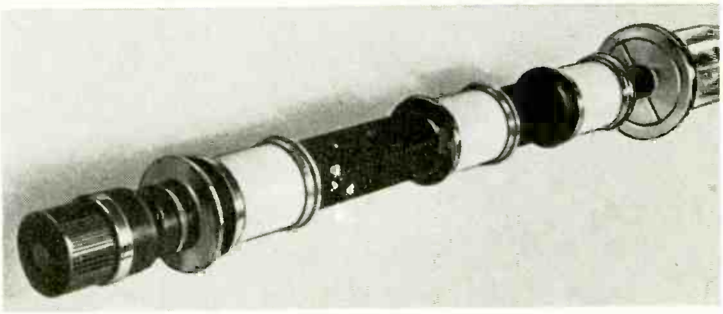

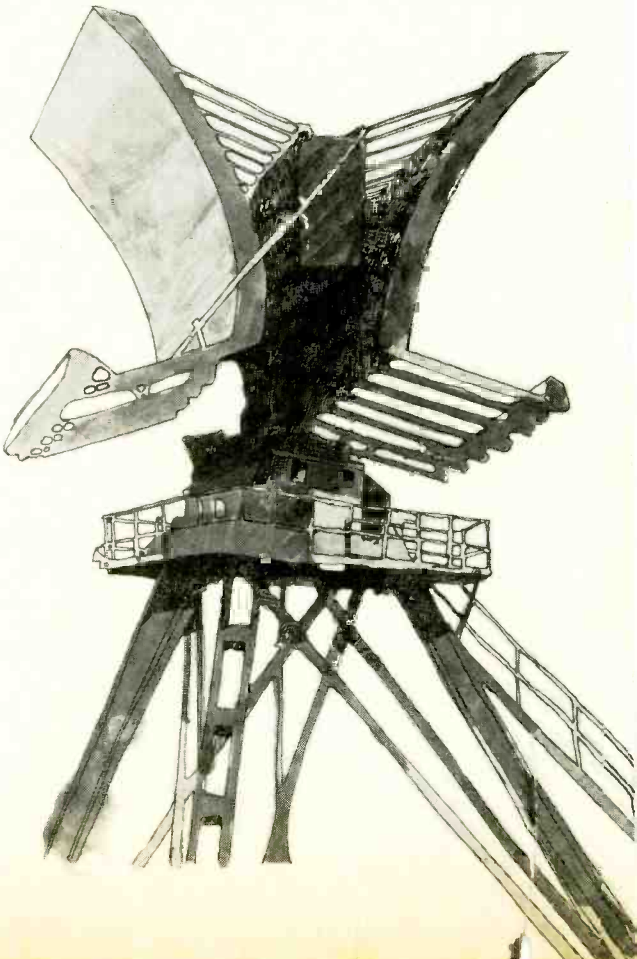

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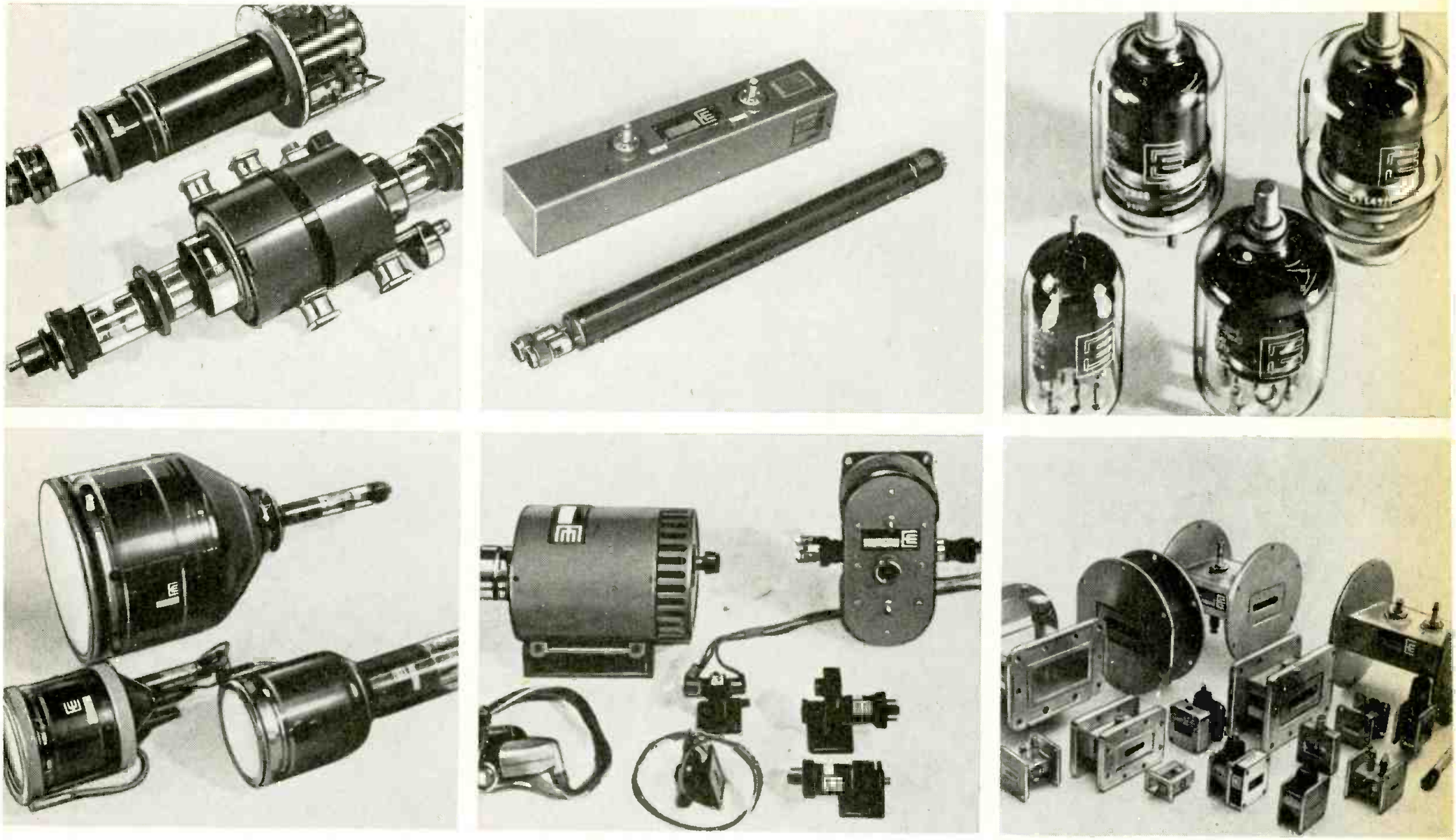

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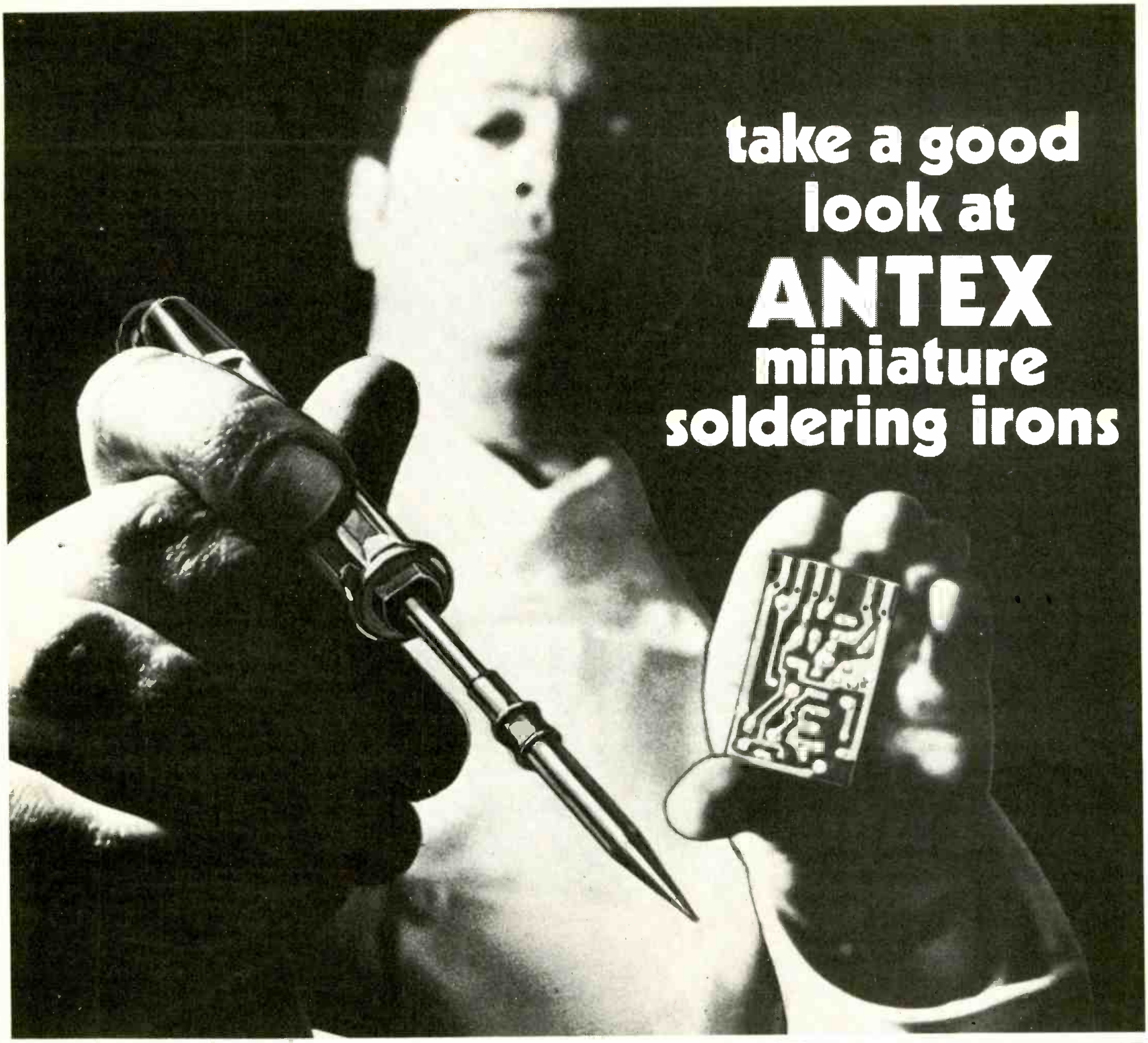

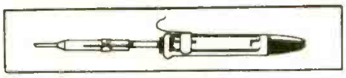

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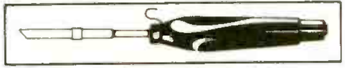

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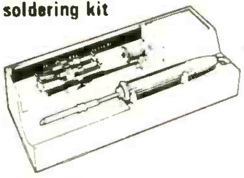

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Power Amplifier for A.C. Servomotors

A simple general-purpose 10-W design that will drive size-11, -15 or -18 servomotors

by R. J. Wallace, M.I.E.R.E. and J. M. Clarke*, M.Sc.*

An amplifier was required for use in the closed loop carrier servo system shown in Fig. 1 to drive the servomotor. The standard operational amplifier would obviously not supply the required amount of power and an investigation of commercially available amplifiers failed to reveal one that could be used in this system.

Amplifiers were found that would drive 20V centre-tapped servomotor windings. However, these were not a lot of use as 20V is not standard for servomotor tacho and reference windings. The reason for this is that suppliers of servo components are closely allied to the aircraft industry, where there is no need for an amplifier to drive the reference and tacho windings, since they are usually driven from the internal 400 Hz aircraft supply. However, in an industrial electronic system, it is not always convenient or desirable to use the 50 Hz line supply for excitation purposes and for the reasons of standardization one amplifier should be capable of driving any winding. The example given is a case in point. Here the inherent property of the a.c. servomotor to remove quadrature signal components is utilized by deriving the reference signal from optical sources. The excitation frequency in such a system can be anywhere in the region of 50 Hz to 1 kHz.

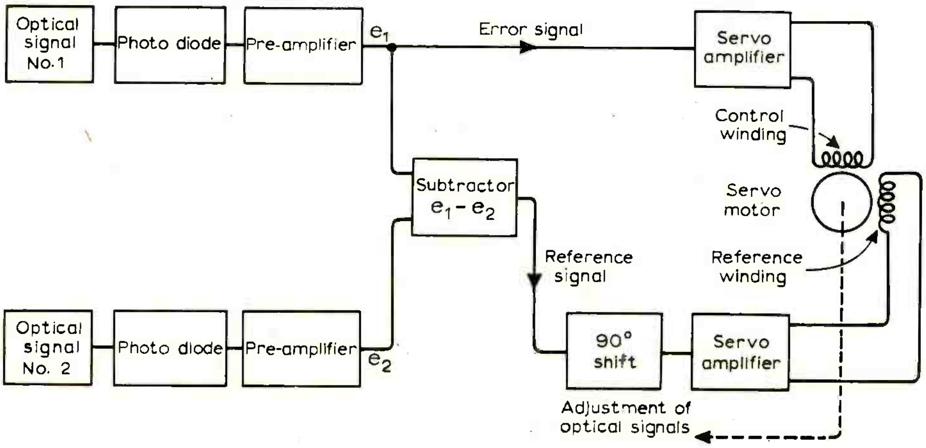

Fig. 1. A closed loop carrier system where an a.c. servomotor is used. Here two optical signals, which are varying at the same time at 440 Hz, are combined to derive a reference signal. In addition one signal is used as the error signal.

These signals are so close to the 400 Hz commonly used for a.c. servomotors, they can be directly used to excite a servomotor via suitable amplifiers. However to find a source of supply of such amplifiers is a problem.

An alternative source of power amplifiers and power amplifier designs is the audio field. But here, in order to obtain very low distortion figures, these designs are unjustifiably complicated for industrial application.

In short, there is a need for a simple amplifier, capable of driving any winding of a suitable servomotor which might also be suitable for any application which requires a general purpose a.c. power amplifier.

Design

It was decided, as discussed, that the amplifier should be able to drive any winding of the servomotor, that all windings should operate at the same voltage and that the amplifier should have no need of the centre tap often available on the control winding.

With regard to power output, one amplifier for reference and tacho windings and one amplifier for the control winding was considered acceptable. The most often used motor is size-11 which dictates that the amplifier should have a power output of 10 W. Incidentally, this is also sufficient to drive single windings on a size-15 or -18 motor.

Since the frequency at which a servomotor may be required to operate can depend on the system as well as the nominal operating frequency of the motor, the frequency response at the amplifier was made as wide as possible, consistent with stability into complex loads, and the final design will drive either 50-, 60-, or 400-Hz motors, and any complex load up to 20 kHz.

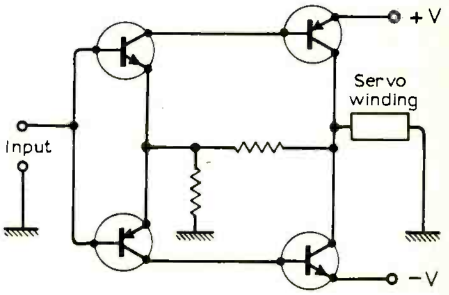

Fig. 2. Basic circuit of the class B output stage employed. Several other possibilities were considered and rejected.

The most generally available servomotors have either 26- or 115-V windings. The 26-V version was chosen as this allows a transformerless output stage to be employed. Because the amplifier may be used in systems where the preservation of phase information is important, clipping of the output waveform was arranged to be symmetrical. In addition, no damage will result from reasonable overloads.

Commercial amplifiers often incorporate a 90° phase shift circuit but, since the required phase shift often depends on system phase relationships, such a circuit was not included.

The fact that a.c. servos can tolerate a small amount of distortion suggests the use of a class B, rather than class A, output stage. The higher efficiency of class B means lower heat dissipation and smaller size.

After considering a number of possibilities the simple output stage of Fig. 2 was chosen because of its simplicity, because feedback is easily applied and because the loop gain is low enough to make instability due to complex loads unlikely.

Circuit details

The circuit of the amplifier is shown in Fig. 3. Each output transistor is driven by a common emitter stage and coupling capaci-

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*Sira Institute

tors are avoided by the use of complementary circuitry. Overall feedback is by R_7, R_8 and R_9, R_{10}, with a separate path for each 'half' of the amplifier to assist in stabilizing the bias currents.

The high frequency response is restricted to 23 kHz by C_1 and C_2. The bandwidth can be increased to about 400 kHz by removing C_1 and C_2 if due care is taken with the component layout. Diodes $D_{1 \text{ to } 4}$ are for bias current temperature compensation, the final value of the output stage bias being set by RV_1 and RV_2. All the transistors and diodes are mounted on a common heat-sink which should have a thermal resistance of less than 2.5°C/W.

Fuses F_1 and F_2 provide protection against damage when the amplifier is used into a load below the permitted minimum, or short circuits of small duration. They do not give full protection and the provision of additional safeguards was not considered to be worth while. The clipping action protects the amplifier when it is overdriven.

Performance

Three amplifiers were built and subjected to the tests detailed below. The amplifier load resistance was 68Ω and the signal frequency was 400 Hz.

Voltage gain versus ambient temperature: The gain of the three amplifiers was measured for 10 V r.m.s. output. The results were as follows.

Amplifier	Gain	
	20°C	70°C
1	5.72	5.85
2	5.72	5.9
3	5.72	5.84

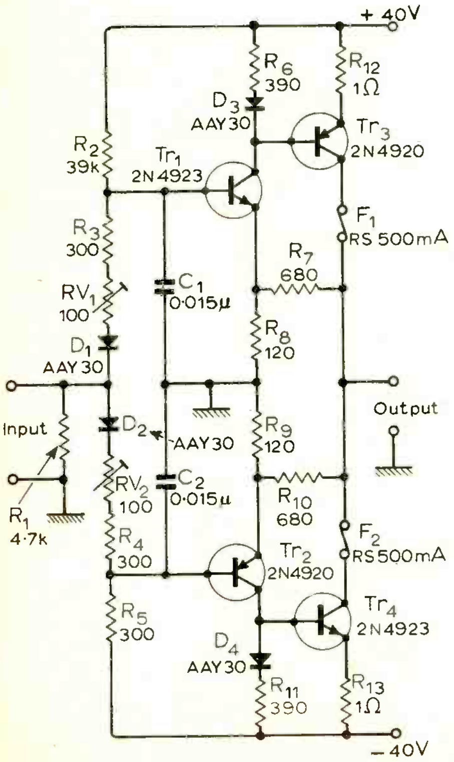

Fig. 3. Final circuit. With the input shorted to ground RV_1 and RV_2 should be adjusted for 1mA quiescent current through Tr_3 and Tr_4.

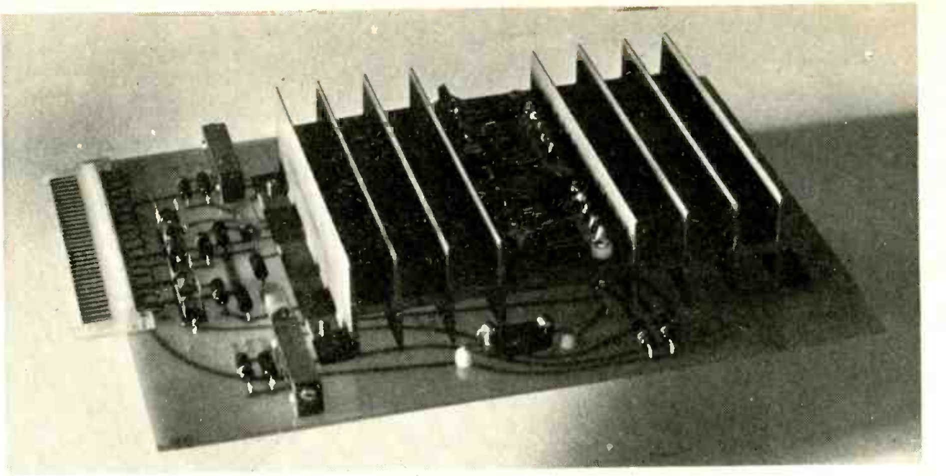

Fig. 4. The completed prototype.

Clipping levels: The r.m.s. output voltages at the clipping points of the three amplifiers were measured and are set out below. These voltages are marginally higher than might be expected because of the small amount of distortion.

Amplifier	Clipping voltage (r.m.s.)	
	20°C	70°C
1	28.9	29.2
2	28.7	29.3
3	28.8	29.2

Frequency response: The high frequency response has been limited as described earlier and is 3 dB down at 23 kHz. As the amplifier is d.c. coupled, the minimum frequency for full output is determined by the maximum period over which it is permitted to average the instantaneous dissipation. While 40 Hz has been specified as the minimum, a margin of safety has been allowed for constructional and device parameter variations. One amplifier, has in fact operated satisfactorily down to 30 Hz.

Input impedance: The input impedance is slightly dependent on level, the lowest value being 3.5 k Ω.

Quiescent current stability: Since the diode and transistor V_{be} characteristics are not matched perfectly, some change in bias current is observed with change in temperature. The figures were as follows:

Amplifier	Bias current in mA			
	20°C		70°C	
	Tr_3	Tr_4	Tr_3	Tr_4
1	1	1	26	25
2	1	1	28	28
3	1	1	27	26.2

The change of bias current with temperature is determined by the type of compensating diodes and the current through them. Since it is not practically possible to achieve a constant bias current with respect to temperature, a positive temperature coefficient is accepted so that increase of temperature will not lead to distortion because of insufficient bias current. Typically the bias current falls to 0.1mA at 0°C but the major change, to approximately 27mA at 70°C, occurs between 50°C and 70°C. The figure of 27mA represents only about 5% of the peak current at full output.

D.C. current in the load: The amplifier is completely d.c. coupled and any d.c. appearing at the input, perhaps, due to offset errors in a preceding operational amplifier, for example, causes a d.c. current to flow in the servomotor. In the worst case approximately 60 mA at the input causes 5 mA to flow in a 68Ω resistive load.

Since completion of this amplifier (Fig. 4) integrated circuit audio power amplifiers have become available in the U.K. with power outputs up to 5 W. Perhaps one of the integrated circuit manufacturers would think it worth while to market a servomotor-amplifier with a similar performance to that described by the authors.

Announcements

Duty free. All approved v.h.f. multi-channel radio communication and navigation equipment used in light aircraft is now exempt from U.K. import duty.

The entire share capital of **General Video Systems Ltd**, the main U.K. distributor of Shibaden broadcast and c.c.t.v. equipment, has been purchased by Shibaden. The name of the company has been changed to **Shibaden (U.K.) Ltd**, which will continue to trade from 61/63 Watford Way, Hendon, London NW4 3AX. Tel: 01-202 8056.

Nortronics Company Inc, of Golden Valley, Minnesota, manufacturers of magnetic recording heads, have formed **Nortronics, S.A.** in Brussels to market their products in Europe. A manufacturing facility will be formed at a later date.

The Avionics Division of Plessey Electronics Group are to supply **IFF shipborne transponders and auto-decoders** valued in excess of £½M to the Royal Navy.

The Canadian Department of Transport has awarded a £118,000 contract to Decca Radar (Canada Ltd, for a **harbour radar system** to cover the Chedabucto Bay area, Nova Scotia.

The Scottish Northern Lighthouse Board has purchased four **radio beacons and ancillary equipment**, valued at £25,960, from AGA (U.K.) Ltd.

High-gain Audio Voltage Amplifier

*by D. Leblebici**

One of the commonly used feedback amplifier circuits is the 'feedback pair', where feedback is applied from the collector of the second transistor to the emitter of the first transistor (Fig. 1(a), ref. 1).

The feedback circuit described here is a modified form of the conventional feedback pair (Fig. 1b). Feedback is the series voltage type applied from the emitter of Tr_3 to the emitter of Tr_1. The circuit has some advantages as compared to the conventional feedback pair:

- The output as well as the input terminals of the circuit are outside the feedback loop and consequently the amount of feedback is independent of the source and load impedances.
- The input and output signals are in phase opposition and as a consequence it is possible to apply a second feedback loop (parallel voltage feedback) from the collector of Tr_3 to the base of Tr_1.

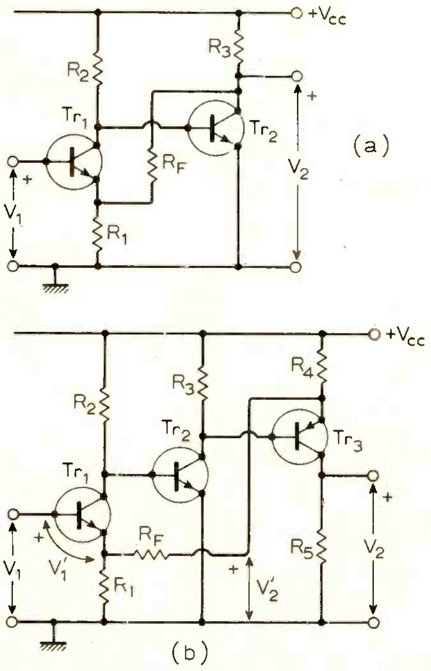

Fig. 1. Comm form of feedback pair (a), and modifie n (b). One advantage of the modifie is that feedback is independen d impedance.

- The feedback voltage is taken from the emitter of Tr_3. The negative feedback acts to decrease the distortion of the voltage wave at that point. The relation between the output voltage V_2 of the amplifier and the voltage V_2' fed back can be written as

$$\frac{V_2}{V_2'} \approx \frac{R_5}{R_4} \frac{I_{e3}}{I_{e3}}$$

provided that $R \gg R_4$. For a high-gain transistor I_{c3}/I_{e3} is very close to unity. Hence

$$\frac{V_2}{V_2'} \approx \frac{R_5}{R_4}$$

This shows there is an additional and practically linear (low distortion) voltage gain of magnitude R_5/R_4 from the emitter to the collector Tr_3.

As the voltage gain from the collector of Tr_2 to the emitter of Tr_3 is approximately equal to unity, the voltage gain from the input terminal to the emitter of Tr_3 must be equal to the gain of a conventional feedback pair using the same transistors Tr_1 and Tr_2 and the same circuit components R_1, R_2, R_3 and R_F. As this gain is approximately equal to $(R_F + R_1)/R_1$ (ref. 2), the total voltage gain becomes

$$A_v = \frac{V_2}{V_1} \approx \frac{R_F + R_1}{R_1} \cdot \frac{R_5}{R_4}$$

The only drawback of the circuit is its relatively high output resistance, which is approximately equal to R_5.

Experimental circuit

The experimental circuit diagram is shown in Fig. 2. The stages are directly coupled. To stabilize the quiescent points a d.c. feedback across the first two transistors is used. A collector current of about 200 μA is chosen for Tr_1 this being the optimum collector current of transistor BC109 for minimum noise. The transistor operating points and component values have been calculated for a sufficiently high open-loop gain and as high a dynamic range as possible.

The calculated open loop gain V_2'/V_1' is 11600, a value that is sufficiently high. The additional gain provided by Tr_3 is about 10.

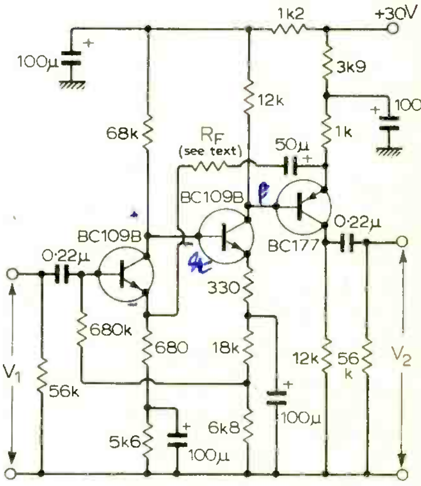

Fig. 2. Practical circuit of preamplifier with voltage gain of 100 for R_F = 5·6 kΩ or 1000 for R_F = 78 kΩ. Total harmonic distortion is 0·02% and 0·04% respectively.

The measured overall voltage gain for R_F = 5·6 kΩ was A_v = 100 (calculated value: A_v = 92) and the available maximum output swing was 18 V pk – pk (6·4 V r.m.s.). For an output voltage of 5 V r.m.s. the total measured harmonic distortion was 0·02%. For R_F = 78 kΩ the measured A_v was 1000 (calculated value: A_v = 1150). The maximum output voltage was again 18 V pk – pk and the total harmonic distortion was 0·04% (V_2 = 5 V r.m.s.). The measured lower and upper cut-off frequencies for both cases were 17 Hz and 200 kHz.

Consequently, the circuit is very convenient as a high-gain audio preamplifier. The possibility of applying a second, independent, parallel voltage feedback loop makes it possible to use the circuit as a low output impedance, moderate gain and high dynamic range booster amplifier. With frequency dependent feedback, it is also possible to use the circuit as a low distortion equalizer amplifier.

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*Elektrik Fakültesi, Teknik Üniversite, Istanbul.

[1] National Bureau of Standards, preferred circuit no. 201.

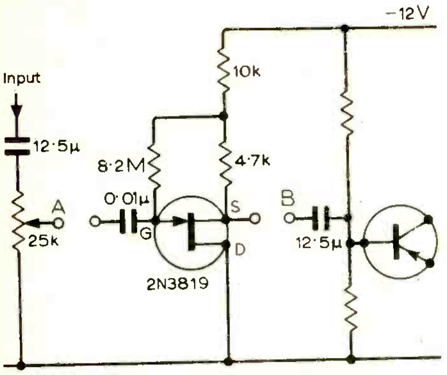
[2] Millmar & Holkias, 'Electronic devices and circuits', pp. 502, 3.

ircuit Ideas

system enabling the system to meet a reliability specification which allows only one failure lasting 30 seconds or less in five years.

Reducing noise in volume controls

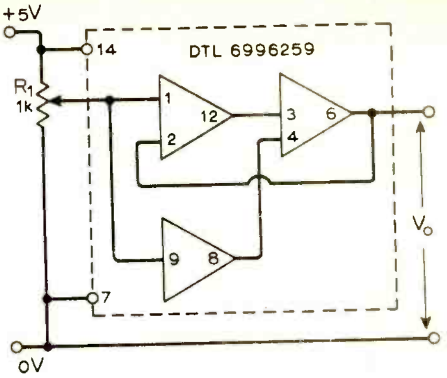
Noisy volume controls have been a problem since the early days of radio and although solutions do exist they are generally expensive and/or inconvenient. In transistorized equipment the problem is often worse, or much worse. If there is a steady voltage between the ends of the track of the control as well as the signal voltage, when the control is varied a varying proportion of both voltages will be present at the slider and if the circuit connected to the slider can conduct d.c. then a varying current will flow between the track and slider. Because of contact irregularities noise will be generated. It is usual to include capacitors in the input and output of volume controls to eliminate such d.c. noise. Even when they are included, however, current will flow as they become charged or discharged at switch on or off of the equipment. For a given type, the higher the capacitance the higher the leakage, and in high-quality equipment high value capacitors must be used for good low-frequency performance. Silicon n-channel f.e.ts are now available at a price comparable with that of volume controls. The inclusion of a source follower between the slider of a volume control and the following circuit will usually make the control much less noisy. The circuit shown is one used by the writer. The original circuit was broken at A B and the source follower inserted. In some circuits it may be necessary to reverse the electrolytic to maintain correct polarity. In equipment using a positive h.t. line the whole source follower circuit should be inverted. The input impedance of the source follower is very high and as the input capacitor need be only 0.01μF for very adequate low-frequency response, a paper capacitor with virtually no leakage can be used.



C. H. BANTHORPE,
Northwood,
Middx.

Single i.c. trip unit

D.T.L. nand gates may be connected so that they function as a trigger circuit from an analogue voltage. When a d.t.l. 6996259 integrated circuit —which contains three triple input nand gates—is connected as shown, the logic level output V_o will be dependent on the setting of the potentiometer R_1. With an input of 5V the output voltage V_o is at logic 1. Reducing the input voltage by adjustment of R_1 will, at a critical voltage, cause the nand gate 1 to switch over, thus switching nand gate 2. The output voltage V_o will now be at logic 0. Feedback from gate 2 to gate 1 ensures that V_o stays at logic 0, until the input voltage is raised above the critical value. The nand gate 3 switches over which resets nand gate 2, and then V_o once again becomes logic 1. The critical value for this particular unit was found to be 1.35V. This circuit was used in place of a Schmitt trigger in a voltage-level detector.

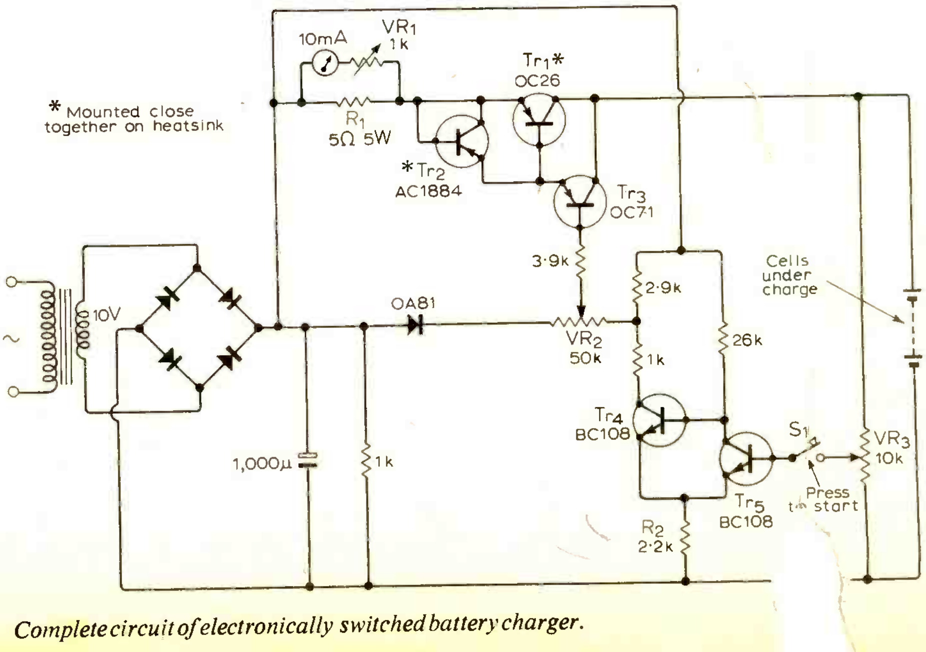


W. E. PRICE,
Laindon,
Essex.

Nickel-cadmium battery charger

The circuit charges the battery at a constant current and switches off when a certain voltage is reached. The charging current can be varied by means of VR_2. For currents above 1A R_1 should be reduced. The switch-off voltage can be varied by means of VR_3. Should a battery of less than 4V be connected for charging, then R_2 would have to be reduced to about 1kΩ. The circuit functions as follows: Tr_4 and Tr_5 form a Schmitt trigger circuit with Tr_4 on after S_1 has been pressed; when the preset voltage has been reached Tr_5 goes on and Tr_4 off, thus switching off the charger. The circuit was designed for 550mA and 6 to 7.5V.

F. BALLERINI,
Rome,
Italy.



Complete circuit of electronically switched battery charger.

Electronic Building Bricks

11. Information paths between units

by James Franklin

We have seen that information—which might be numbers of objects in an electronic counting system or light intensity in a television system—may be represented by electrical variables. We have also looked fairly closely at some of these variables, and seen how they exist in circuits (Part 5). We have not, however, studied how the electrically represented information is actually conveyed from one electronic unit to another.

Part 1 showed block diagrams of a television set and a computer and explained that the lines joining the blocks indicate paths for information. Some readers may have thought it odd that these paths, as well as the functional units themselves, were considered as "building bricks". The justification for this idea is that in practice these information paths are provided by *circuits*—particular arrangements of conductors.

At this point we should get to know one of the conventions of electronic diagrams—conventions, incidentally, which are automatically understood all over the world. The electrically represented information which comes out of an electronic unit is called the *output*, and is normally shown emerging from the right hand side of the unit. Conversely, the information an electronic unit receives is called the *input* and is shown going into the left hand side of the unit. Thus, in Fig.1 the output of unit *A* becomes the input of unit *B*.

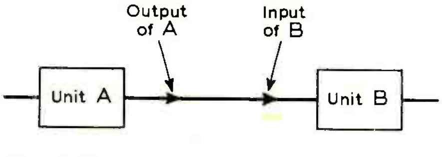


Fig. 1. The convention of a single line used to indicate an information path, the output of one unit becoming the input of another. (This line is not an electrical conductor as such.)

As we have said the basic means by which the information is conveyed is electrical energy—more specifically the rate of delivery of energy, which is power (Part 8). In practice, however, we don't usually consider power as representing the information, mainly because it is not very convenient to detect and measure the varying power that flows from unit *A* to unit *B*. The measuring instruments commonly used in electronics respond to other electrical variables, variables that are proportional to the power, in particular potential difference and current. This complicates the picture, because in any circuit where electrons are moving there must be an e.m.f., and this creates both potential difference and current. Which one, then, represents the information?

The answer is, simply, whichever one the electronic designer has chosen to represent the information. The other variable is there as well, in the sense that it can be measured, but it is not taken as significant as a bearer of information.

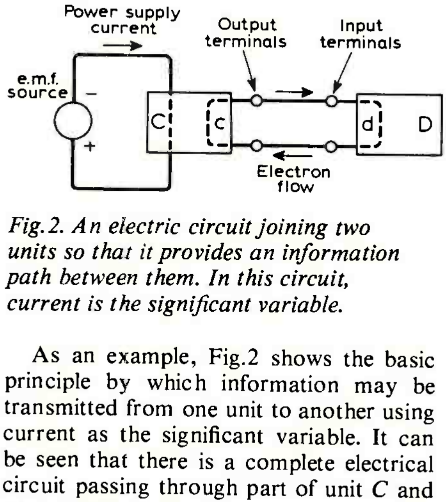


Fig. 2. An electric circuit joining two units so that it provides an information path between them. In this circuit, current is the significant variable.

As an example, Fig.2 shows the basic principle by which information may be transmitted from one unit to another using current as the significant variable. It can be seen that there is a complete electrical circuit passing through part of unit *C* and part of unit *D*. Electrons are made to flow in this circuit by an e.m.f. existing in section *c* of unit *C*. (We will not discuss exactly how this e.m.f. comes to be there, as we are not at the moment concerned with the actual functions of units *C* and *D*, but it originates from the e.m.f. source supplying electrical power to unit *C*.) The electron flow rate (current) varies with time and this variation represents information (Part 2). In unit *D*, at section *d* of the circuit, there is a means of continuously detecting or responding to the value of the current. Thus the information represented by the current variation is conveyed into *D*.

It would be possible to detect a potential difference (resulting from the e.m.f. at *c*) between the two output terminals of unit C, or between the two input terminals of unit D, but this in itself is not significant because current has been chosen as the information bearing variable.

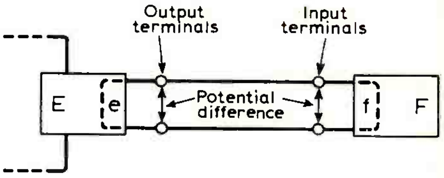


Fig. 3. Another circuit providing an information path between units, but using potential difference as the significant variable.

Fig. 3 shows how information may be transmitted using potential difference (p.d.) as the significant variable. Here again there is a circuit completed through the two units. There is a p.d. between the output terminals of unit *E*, resulting from the e.m.f. existing at *e*, and it is the variation of this p.d. which represents the information. The input terminals of *F*, being connected to the output terminals of *E*, have the same p.d. between them (analogy: the water level in a water gauge is the same as the water level in the tank to which it is attached). This p.d. is present at *f*, where there is a means of continuously detecting it, so that the information represented by the variation of p.d. is conveyed into *F*.

Again there is a current flowing in the circuit, but here it is this current which is not significant as an information bearer. In some electronic systems designed to use p.d. as the significant variable the current flowing is extremely small, for example less than a millionth of an ampere. In such cases one can think of the information virtually as being conveyed by a variation of p.d. alone. In other cases the circuit is not completed at *f* (imagine broken line absent), and unit *F* detects the information as an electric field (Part 5) which is created by the p.d. between the input terminals.

As a practical example, *E* and *F* in Fig. 3 could be two stages of an electronic amplifier (Part 9). The potential difference at *e* would be that developed across a load in the high-power circuit of stage *E*, while circuit *f* would be the low-power control circuit of stage *F*.

Personalities

D. B. Weigall, C.B.E., M.A., F.I.E.E., retires from the position of deputy director of engineering at the end of March after more than 37 years of service with the B.B.C. A graduate of Christ Church, Oxford, he joined the Corporation in 1933. After three years in the Research Department he became assistant to the superintendent engineer, studios. From 1940 to 1942 he was seconded as chief engineer to the Malaya Broadcasting Corporation and from 1943 to 1946 he was technical adviser on broadcasting to the Ministry of Information. After his return to the B.B.C. Mr. Weigall joined the Planning and Installation Department in 1948. He was appointed chief engineer, External Broadcasting, in 1962; assistant director of engineering in 1963 and deputy director of engineering in 1967.

G. Stannard, B.Sc., F.I.E.E., A.C.G.I., retires on May 24th from the position of chief engineer, communications, in the B.B.C. Educated at the City & Guilds College, London University, he joined the B.B.C. in 1932 and after working in the London control room and the recording section he transferred to the Lines Department in 1935. He has been chief engineer, communications, since 1965. In this position he has been responsible for the planning and commissioning of the vision, sound and communication networks used for the distribution of programmes and the provision of other communication facilities.

As a result of the retirements of D. B. Weigall and of G. Stannard, the B.B.C. has announced the following appointments:

D. E. Todd, B.Sc.(Eng.), F.I.E.E., at present assistant director of engineering, will assume the responsibilities of deputy director, in addition to his present responsibilities for the engineering specialist departments. Mr. Todd joined the B.B.C. in 1946 and was head of Transmitter Planning and Installation Department from 1965 until his appointment as assistant director of engineering in 1968.

T. B. McCrirrick, F.I.E.E., F.I.E.R.E., will become assistant director of engineering and will be responsible for the Transmitter and Communications Departments, the Engineering Information, Engineering Training and Engineering Personnel Departments. Mr. McCrirrick joined the Corporation in 1943 and transferred in 1949 to the television service, where he later held the posts of engineer-in-charge, television studios, and head of engineering, television recording. Since last June he has been chief engineer, radio broadcasting.

D. R. Morse, F.I.E.E., lately chief engineer, capital projects, has been appointed to the new post of chief engineer, networks and communications. He will have special responsibilities for negotiations with the Post Office and the Ministry of Posts and Telecommunications regarding the provision of B.B.C. programme and communication networks.

J. D. MacEwan, B.Sc., F.I.E.E., M.I.E.R.E., A.Inst.P., becomes chief engineer, radio broadcasting. Mr. MacEwan joined the B.B.C. in 1947. He was appointed a senior lecturer at the Engineering Training Centre, Evesham, in 1956. Since August 1969 he has been chief engineer, regions.

Tony Martin, who joined International Rectifier in 1959 when they commenced manufacture at their Oxted, Surrey, plant, has been appointed Northern European sales manager. He worked for several years as an application engineer and then transferred to the marketing department where he held successive posts of sales office manager and product sales manager. He will be responsible for the industrial sales organization in all Northern European countries.

James Lionel West, aged 35, has been appointed manufacturing manager of the m.o.s. division of Emihus Microcomponents Ltd at Glenrothes, Fife. Mr. West's previous appointments were with General Instruments, Elliott Automation and the A.E.I. research laboratories at Harlow.

P. Scargill, M.I.E.R.E., general manager of the Electronics Division of Union Carbide U.K. Ltd, is transferring to Union Carbide Europe, in Geneva, where he will be responsible for the group's European electronics business. Mr Scargill, who is 36, joined Union Carbide in 1966 from Hughes International (U.K.) and was previously U.K. capacitor sales specialist with International Electric Co. of New York.

Tony Wynter, who recently joined Devices Instruments Ltd, of Welwyn Garden City, Herts, has been appointed managing director of Devices Pty. Ltd, the sales and service organization set up in Sydney, Australia. Before joining Devices Mr. Wynter was a member of the medical electronics staff at the National Hospital for Nervous Diseases, Queens Square, London.

Peter D. Simmons has joined SE Laboratories as product manager of their new digital instrumentation division. Immediately prior to joining SE Labs he was sales manager for Racal, and before that was with Solartron and Dowty.

Guy Barnes, PhD., B.Sc., has joined Emihus Microcomponents Ltd as technical manager. Dr. Barnes, aged 38, graduated in physics and mathematics at Reading University. He then undertook on behalf of the Admiralty four years research at the University into the surface properties of semiconductors. He joins Emihus from Texas Instruments where he was integrated circuit department manager. From 1958 to 1963 he was chief physicist with Mining and Chemical Products Ltd.

Dr. Guy Barnes

A. G. Touch, M.A., D.Phil., who is 60, is retiring from the post of chief scientist at the Government Communications Headquarters. A graduate of Jesus College, Oxford, Dr. Touch joined Watson-Watt's radar team at Bawdsey research station in 1936. For his contributions to the development of meter-wave AI and ASV he received a substantial award on the recommendation of the Royal Commission on Awards to Inventors. From 1941 to 1947 he was liaison officer with the British Joint Services Mission in Washington. On his return to this country he became superintendent of the Blind Landing Experimental Unit at Martlesham Heath, Suffolk, and from 1952 to 1954 was deputy director of electronics research and development (air) in the Ministry of Supply. From 1954 to 1959 he was director of electronics research and development (ground), M.o.S., and then senior superintendent of the Radio Department at R.A.E., Farnborough. He is to be succeeded as chief scientist at the Government Com. H.Q. by **Ralph Benjamin,** Ph.D., who is at present director of Admiralty Underwater Weapons Establishment at Portland. Dr. Benjamin, who is 47, joined the Admiralty Signal Establishment in 1944. His particular fields of research at A.S.E. were pulse techniques and weapon control. Dr. Benjamin's place at Portland is being filled by **G. L. Hutchinson,** Ph.D., at present head of the Military and Civil Systems Department at the Royal Radar Establishment, Malvern. A graduate of King's College, London, Dr. Hutchinson joined the Scientific Civil Service in 1939 working on the installation of the coastal radar chain. In 1943 he joined the Telecommunications Research Establishment, then from 1948 to 1954 was at R.A.E. Farnborough and later on the staff of the British Joint Staff Mission in Washington.

Siliconix Ltd., of Swansea, recently announced two new appointments. **David Thomson,** has joined the company as sales engineer. In 1963 he joined A.E.I. Telecommunications as a student apprentice concentrating on the design of linear and digital telecommunication equipment and gained an honours degree in electronic engineering at The City University, London. In 1968 he went to Elliotts, Rochester, as a development engineer on airborne digital computers. **David J. West,** aged 23, who graduated in electrical engineering only this year from the University College of Swansea, has joined the company as applications engineer.

OBITUARY

Leonard Walter Fillmore, managing director of Jackson Brothers (London) Ltd, which with his father and brother he founded in the early 'twenties, died on January 30th aged 67. During the war years he was very active on Ministry Standardization Panels and right up to the time of his death he worked on the Variable Capacitor Standardization Panel of R.E.C.M.F.

New Products

Beam tetrodes

Two compact conduction-cooled beam tetrodes are available from M-O Valve Co. Typically they give 400W output in f.m. service up to 175MHz, and 200W up to 500MHz. In s.s.b. service 300W p.e.p. output is obtainable up to 175MHz. Both tubes are electrically identical but differ in construction. The CCS1 has a square copper block fitted to the anode which is intended to be bolted to a heat sink directly or by means of a beryllia heat conducting block when electrical isolation is required. The CCS2 incorporates an electrically isolated flange intended to be clamped directly to a heat sink. Thermal resistance between anode and flange is made low by the use of beryllia ceramic. There is no significant increase in output capacitance. These conduction cooled tubes are fully replaceable in new equipment for existing well established forced air cooled types. The conduction cooling assists circuit designers by eliminating moving parts in the cooling system and so achieves greater reliability and compactness at reduced power consumption. M-O Valve Co. Ltd, Brook Green Works, London W.6.

WW315 for further details

R.M.S. voltmeter

Model A130 r.m.s. voltmeter from Prosser Scientific Instruments allows waveforms from d.c. to 100kHz with crest factors (peak to r.m.s. ratio) up to 10:1 to be analysed. An averaging time constant facility allows integration from 1 to 300s. At very low frequencies it is sometimes useful to measure the instantaneous power by measuring the instantaneous square of the voltage. This facility is provided on the A130 with a time constant of 10ms. The instrument, designed for bench use or rack mounting, employs a large meter display (±2% accuracy) as well as providing an output for higher accuracy readings. The specification includes the following:

input impedance	1MΩ 25pF
overload	300V d.c. or peak on ranges 1mV-10V. 1000V d.c. or peak on ranges 30V to 300V.
output	4 inch panel meter scaled 0-10V, 0-3V, and −15dB to +2dB. Linear d.c. output 0-10V and 0-3V full scale depending on range selected.
output impedance	<10Ω. 10mA max.
accuracy	±0.5% of full scale.
power requirements	115/240V a.c., 50/60Hz, 50VA.
dimensions	445mm × 133mm × 344mm.
weight	5kg.

Prosser Scientific Instruments Ltd, Lady Lane Industrial Estate, Hadleigh, Ipswich, Suffolk.

WW317 for further details

Miniature silicon bridge rectifiers

A range of 1.2A silicon bridge rectifiers is available from General Instrument (UK). The assemblies are of flat construction with in-line leads, and measure 23.5 × 4mm. Called the FB series they have a p.i.v. rating of up to 600V and a one cycle surge capability of 50A at operating temperatures from −55°C to 150°C. General Instrument (UK) Ltd, Stonefield Way, Victoria Road, South Ruislip, Middx.

WW314 for further details

Numeral indicator tubes

ITT Components Group Europe, by arrangement with Burroughs Corporation, are manufacturing two new long-life side-view cold-cathode indicators. The 5853S is designed for use in time-sharing by anode strobing applications; the 5870S is intended for d.c. and pulsed operation with peak cathode currents up to 10mA. Both tubes have a display of numerals 0 to 9 inclusive with one decimal point on the left and right of each main character, and a character display area of 13.5mm (height) × 7.6mm. Maximum overall height is 30.5mm, and diameter 13mm. Base connections are 14 tinned leads with in-line configuration for printed circuit or socket use. Typical operating conditions are:

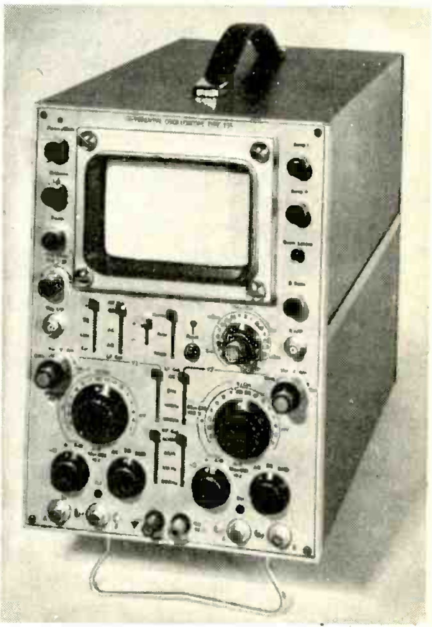
type 5853S	
anode supply voltage	200V
peak cathode current	14mA
pulse duration	100μs
pulse repetition frequency	500Hz
type 5870S	
anode supply voltage	200V
cathode current (with decimal point)	3.2mA
cathode pre-bias voltage	67V

ITT Components Group Europe, Valve Product Division, Brixham Road, Paignton, Devon.

WW313 for further details

Twin-channel oscilloscope

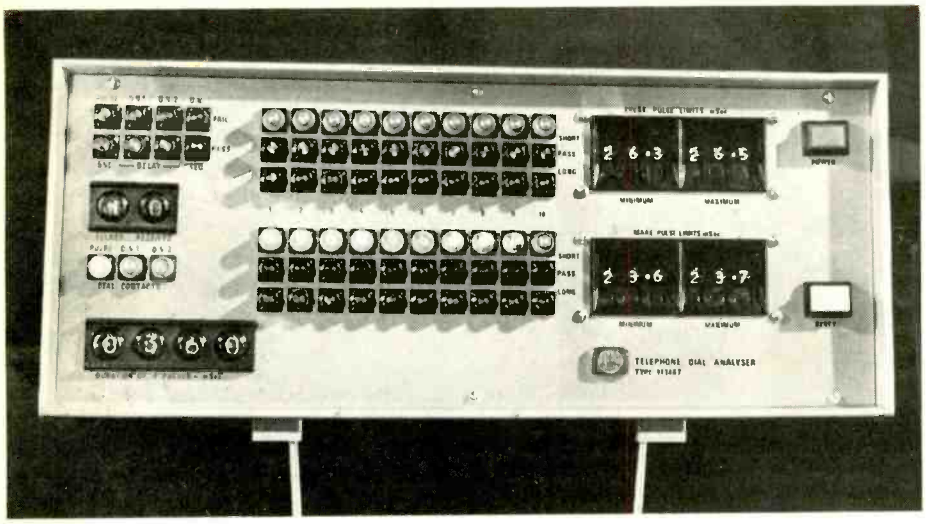
Differential oscilloscope type 155 from Bradley Electronics has an input impedance of 100MΩ shunted by 1pF, and 100dB common-mode rejection. The common-mode signal may be as high as ±15V at maximum sensitivity. Sensitivity is 100μV/cm, but this can be increased to 10μV/cm by cascading the two channels. The timebase will operate down to 5s/cm. Outputs suitable for driving pen recorders are provided and the oscilloscope can be used as an *X-Y* plotter. Trigger arrangements include auto and single shot and the general facilities provided include beam locate and internal calibration. G. & E. Bradley Ltd, Electral House, Neasden Lane, London N.W.10.



WW 303 for further details

Telephone dial testers

An instrument which tests telephone dial pulsing—in terms of operate and release times of individual dial pulses—is made by Amalgamated Wireless (Australasia) Ltd. Traditionally, dial performance during



production adjustment is done by measuring pulsing speed and make-to-break ratio on an average basis. But the telephone dial pulse monitor type IT1466 compares make and break duration of each pulse with preset tolerance limits. Indication is given if any interval is outside the limits set by the operator by lighting a 'short', or 'long' lamp. In addition the instrument detects excessive contact bounce, counts the number of pulses received, and checks sequence and relative timing of off-normal contact re-closure. Pulse analyser type IT1467 performs similar tests and additionally gives 'short', 'pass' and 'long' indication for each of ten contacts. Both incorporate a crystal oscillator timing standard. Available in the U.K. from Amalgamated Wireless (Australasia) Ltd, Aldwych House, 81 Aldwych, London W.C.2.
WW311 for further details

Capacitors for s.c.r. commutation

A range of capacitors for high-power controlled rectifier circuits is made by Aerovox Corpn. Developed to provide low inductance and low series resistance needed to turn off s.c.rs, the capacitors are said to be made more reliable than general-purpose types. They are made with three kinds of dielectric—paper, metallized paper and polycarbonate—and are designed to dissipate internally generated heat. Paper dielectric gives lowest cost, but as might be expected gives largest bulk. Size is reduced by using metallized paper, but cost increases and the ability to handle alternating current is reduced. This is circumvented by using polycarbonate, but at higher cost. Paper dielectric capacitors are available in voltage ratings from 200 to 2000V d.c. and the values of capacitances available depends on voltage rating (in the region of 1 to 50μF). Polycarbonate types, rated at 600V d.c., have values from 1 to 20μF and metallized paper types, rated at 200V d.c., have values from 25 to 150μF. U.K. agents are Auriema Ltd, 23 King Street, London W.3.
WW 305 for further details

Cathode-ray display unit

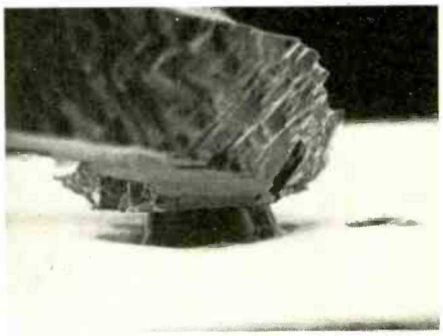
A self contained c.r.t. display unit, the EV8000 from Electronic Visuals, has a 100 × 80mm flat-faced tube, regulated power supplies, balanced input amplifiers for vertical and horizontal deflections, and brightness (Z axis) control via either a simple blanking amplifier or an optional wideband linear amplifier. The vertical amplifier has a bandwidth of d.c. to 10MHz and all inputs are compatible with t.t.l. and d.t.l. levels. The unit can be supplied in various case types and is suitable for 19in rack-mounting. Electronic Visuals Ltd, P.O. Box 16, Staines, Middx.
WW 304 for further details

High-voltage multiplier discs

A series of 10kV high-voltage multiplier discs developed by Aerovox Corp and marketed by Auriema are made with high K dielectric materials. The coating is epoxy resin. Available in 1,000 and 2,000pF capacitances as standard (other values are available) the discs have a capacitance tolerance of ±20%, a 2% maximum dissipation factor, insulation resistance of 20,000MΩ, and are designed for working voltages up to 10,000V d.c. Other capabilities include a temperature characteristic of ±15% change in capacitance from +10°C to +85°C, a corona voltage of approx. 2,700V r.m.s. at 50Hz and a corona level of less than 100 picocoulombs. Auriema Ltd, 23-31 King Street, London W.3.
WW318 for further details

60-GHz varactor diode

A gallium arsenide varactor diode capable of operating at 60GHz has been developed by the Services Electronics Research Laboratory and is manufactured by Marconi. The diode, of the diffused mesa type, is used in the 50-cm circular waveguide system of TE_{01} mode propagation.



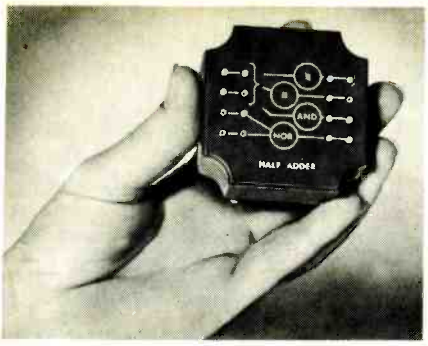
Known as type XMD3A, it is available in three figures of merit—from 40 to 90GHz—in a ceramic leadless inverted device package for simple integration into stripline structures. Photograph shows the gold connection to the chip magnified 2000 times. Marconi Co Ltd, Chelmsford, Essex.
WW 308 for further details

High-speed leadless diodes

Switching diodes for use in hybrid large- and medium-scale integrated circuits are made by Dickson Electronics Corpn (U.S.A.). They are rated for 75mA forward current at 75V d.c. with a dissipation of 250mW. The diodes can be mounted upright with wire bonding or inverted with reflow solder bonds. Dual types are made with either common anode or common cathode connections. Available from Dage (G.B.) Ltd, Haywood House, 64 High Street, Pinner, Middx.
WW 310 for further details

Logic modules

Feedback Instruments have added a reed relay unit RU336 and a lamp display unit LD265 to their range of logic and analogue teaching elements. The RU336 contains two reed relays which, when either is operated by a logic '1' input, will switch currents up to 1A in external circuits, thus providing single-pole changeover switching controlled by the logic. The LD265 supplements the display lamps



already available on the Logikit mounting decks. Four buffered lamp circuits operate in the presence of a '1' at the input. All the logic (Logibit) elements are of identical size and are compatible with any of the Feedback logic teaching equipment. Prices of individual elements vary but all are under £10. Feedback Instruments Ltd, Park Road, Crowborough, Sussex.

WW316 for further details

Ferrite limiters

A series of solid-state ferrite limiters introduced by EMI-Varian is claimed to gives a ten-fold increase in life expectancy over conventional TR tubes and limiters. The VFX 9500 device for example operates from 8.5 to 10.0GHz (X-band). The integral unit consists of a ferrite limiter followed by a diode limiter. The ferrite portion provides about 10dB of high-power isolation while the diode limiter reduces spike and flat leakage power to levels which provide reliable protection to the receiver diode.

Operating characteristics include:

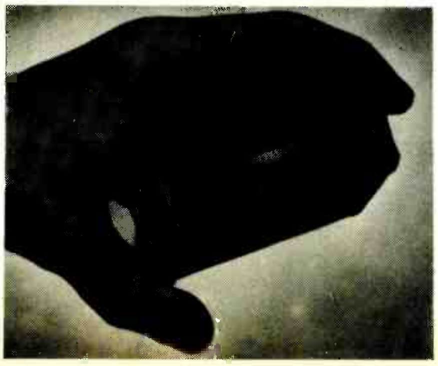
bandwidth	any 5% b.w. from 8.5 to 10.0GHz
peak power	10kW
v.s.w.r.	1.5:1 max.
insertion loss	1.0dB max.
spike leakage energy	0.02 erg max.
flat leakage energy	20mW max.
recovery time	0.5μs max.
insertion length	88.9mm
weight	680g

EMI-Varian Ltd, Hayes, Middlesex.

WW312 for further details

V.H.F. frequency synthesizer

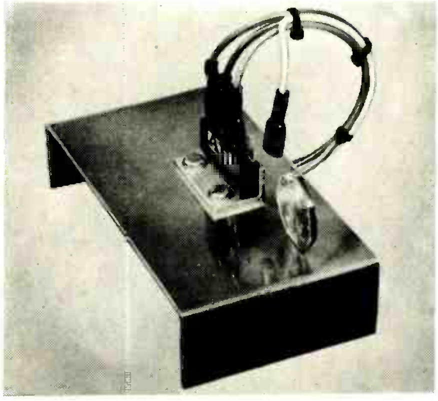
A frequency synthesizer for 27 to 70MHz and tunable in increments of 25kHz is made by Akers Electronics, a Norwegian microelectronics manufacturing company. Using thin-film hybrid circuits and designed as a phase-locked loop it occupies only 86 × 60 × 40mm and weighs 0.35kg. It is intended as a frequency source in simplex military f.m. 'manpack' transceivers in the 27 to 70MHz band. During transmission it operates as a modulated exciter and during reception as local oscillator, when frequency range is 37.7 to 80.7MHz for an i.f. of 10.7MHz. Akers Electronics, 3191 Horten, Norway.



WW 301 for further details

Power diodes in plastic

Two new power circuits from AEI handle double the power of earlier circuits. Type PM7A-Q, a bridge rectifier with 16-amp mean output and 44-watt dissipation, is available in seven voltage ratings from 200 to 1400 *V* r.m.s. Type PM6A-Q, two separate diodes of 10-amp mean current and 34 watts dissipation, is also available in the seven ratings. (The other kind of circuit PM5A is a diode-thyristor combination, but remains as originally specified.) These three combinations are used in BDA 'Hotpoint' washing machines and enable universal motors to be used in place of expensive induction motors with the multiple windings required by electro-mechanical regulators. AEI Semiconductors Ltd, Carholme Road, Lincoln.



WW 302 for further details

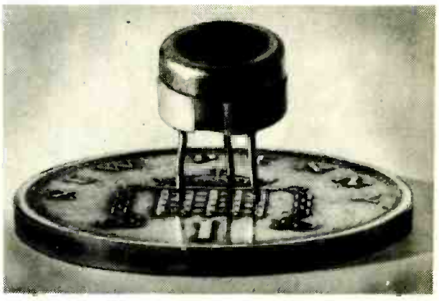
U.H.F. field-strength indicator

Designed and manufactured by Rohde & Schwarz the u.h.f. field-strength indicator, type Huze, comprises a transistor receiver and a log-periodic broadband aerial. The aerial is fixed to the receiver during measurement and can be adjusted in any direction and plane of polarization. The signal picked up is applied via a decade attenuator and a tunable bandpass filter to a mixer diode, where it is converted to the first i.f. of 150MHz. The instrument is operated from built-in sealed chargeable batteries. Battery power is sufficient for about eight hours with the a.f. section switched on (charging the storage batteries takes about 14 hours). The charger may also be used as the power supply, the storage batteries acting as buffers. Field-strength range is 31 to 110dB above 1μV/m and voltage range 16 to 90dB above 1μV. Aveley Electric Ltd, Arisdale Avenue, South Ockendon, Essex.

WW 307 for further details

6-mm potentiometer

Sub-miniature metal glaze potentiometers to MIL specifications are made by TRW Inc. Available from 10Ω to $1M\Omega$ in $\frac{1}{2}$-watt rating (at 85°C) with temperature coefficient of 1 in 10^4/deg C. It measures 6.4mm dia and 4.5mm high. Type 171 is for vertical adjustment and type 172 for horizontal adjustment. Available in the U.K. from Dubilier Ltd, Victoria Road, London W.3.



WW 306 for further details

I.C. for active filters

Three identical amplifiers are included on an integrated circuit made by Mullard. Designed for use in *RC* active filters up to 150kHz, each amplifier has an input resistance of $25k\Omega$ and an output resistance of $9k\Omega$. Gain is 39dB or 117dB in cascade. An emitter follower is included which reduces output impedance to 500Ω. Designated type TAA 960 it operates from a 6-volt supply and consumes about 2mA. Mullard Ltd, Torrington Place, London, WC1E 7HD.

WW 309 for further details

D.I.L. pulse transformer

Bourns (Trimpot) have introduced Model 4252-1005 miniature d.i.l. pulse transformer—a 16-pin unit with high insulation resistance, fast rise and fast fall time, clean pulse performance and low coupling capacitance. The specifications include:

operating temperature range	0° to 70°C
pulse inductance (±10%, 0° to 70°C)	150μH
leakage inductance	1.0μH
coupling capacitance	5pF
pulse width	400ns

Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx.

WW319 for further details

Literature Received

For further information on any item include the appropriate WW number on the reader reply card

ACTIVE DEVICES

We have received the following literature from General Instrument Microelectronics, Stonefield Way, South Ruislip, Middlesex

'An introduction to the Giant family' (m.o.s., l.s.i.) WW401
'Reliability aspects of low-voltage nitride' (m.o.s.) WW402
A large number of data sheets on insulated-gate n-channel, p-channel, enhancement- and depletion-mode f.e.ts WW403

The English Electric Valve Co. Ltd, of Chelmsford, Essex, have published a 40-page reprint of a section of their main catalogue called 'Hydrogen thyratrons—preamble'. Principles of operation, terminology and circuitry are all discussed and a list of thyratrons available from E.E.V. is given ... WW404

Akers Electronics, 3191 Horten, Norway, have sent us the following data sheets:

AE501/2, positive/negative voltage regulator, <30V, 0.6W, TO-5 .... WW405
AE801/3, semiconductor transducer WW407
AE830, miniature pressure transducer .. WW408
AE61, semiconductor accelerometer WW409
AE900 series, infrared detectors, visible light to 5.6 microns WW410
S1401P, integrated active modulator WW411
UH3000, thin film substrate containing 34 unconnected resistors from 100Ω to 10kΩ and four semiconductor chip mounting areas for constructing your own hybrid using a lead bonding machine WW412
UH3011, integrated light sensitive Schmitt trigger WW413
UH3027, integrated relay/lamp driver, 28V, 300mA WW414
UH3021/3, analogue gate WW415
A number of data sheets devoted to f.e.ts WW416

Nortronic A/S, 1380 Heggedal, Norway, produce the following data sheets:

Active filter unit (Butterworth) WW417
Detector Unit (bridge), <150kHz WW418
Squaring unit, 80dB dynamic range WW419

PASSIVE COMPONENTS

'A designer's guide to battery systems' describes the construction, operation and use of mercury cells and gives an equivalents list. Mallory Batteries Ltd, Gatwick Rd, Crawley, Sussex WW420

'Co-ordinated manual controls' is the title of a 16-page catalogue produced by the Microswitch Division of Honeywell Ltd, Windsor Rd, Slough, Bucks. It gives details on a matching range of control switches, push-buttons and indicator lamps. The square panel outline (56mm) of the devices is divided into four uniform display areas WW421

APPLICATION NOTES

A pamphlet lists accessories for audio equipment manufactured by the British Radio Corporation (Ferguson, H.M.V., Marconiphone, Ultra). The list includes slide synchronizing equipment, leads microphones, head sets and the like. British Radio Corporation Ltd, P.O. Box 121, Lea Valley Trading Estate, Angel Rd, London, N.18 .... WW422

Monograph # 3 'Real time signal processing in the frequency domain' is published by the Federal Scientific Corp., 615 West 131st St, N.Y.10027, U.S.A. WW423

RCA Ltd, Lincoln Way, Windmill Rd, Sunbury-on-Thames, Middlesex, have produced the following application notes.

AN4474 'Audio applications of the RCA HC1000 hybrid linear power amplifier' WW424
AN4483 'General application considerations for the RCA HC1000 hybrid linear power amplifier' WW425
AN4421 '16 and 25W broadband power amplifiers using RCA 2N5918, 2N5919 and TAA 7706 u.h.f. microwave power transistors' WW426

A 30-page booklet 'A review of some main applications of Melinex polyester film' has been published by Industrial Film Sales Department, Imperial Chemical Industries Ltd, Plastics Division, P.O. Box 6, Bessemer Rd, Welwyn Garden City, Herts. WW427

General Instrument Microelectronics, Stonefield Way, South Ruislip, Middlesex, have published the following application notes:

T-6069, 'R.F. applications of the n-channel, dual-gate m.o.s.f.e.t. MEM554' WW428
T-6032, 'A 30MHz amplifier stage utilizing a 2N4353' WW429
T-6082, 'F.M. receiver using the n-channel, dual-gate, m.o.s.f.e.t. MEM554C' WW430
T-6167, 'Uses of shift registers for data storage' WW431
'Applying the m.o.s. read-only memory .. WW432
'F.E.T. application guide' (table) WW433

EQUIPMENT

A leaflet describes a low-cost (£56) d.c. to 4.5MHz oscilloscope with 5 × 4cm screen. The 'scope has a 100ns to 10ms calibrated timebase, an input of 1MΩ and 15pF, a sensitivity of 50mV/cm and X and Z inputs. Meteronic, Birchen Napps Platt, Nr. Sevenoaks, Kent WW434

Reprints of the following articles which originally appeared in *Broadcast News* are available from R.C.A. Ltd, Lincoln Way, Windmill Rd, Sunbury-on-Thames, Middlesex:

'How to get the best pictures from the TK-27 film system' WW435
'New a.m. ampliphase transmitters' WW436

A family of timers covering the range 0.025 to 5min is described in a leaflet produced by Tempatron Ltd, 65 Milford Rd, Reading, Berks. WW437

Among the products manufactured by N H Research Inc., of California, is a precision a.c. source with a stability of ± 10 parts in 10^6 per week. This, together with other products, is described in a booklet available from Lyons Instruments Ltd, Valley Works, Ware Rd, Hoddesdon, Herts. WW438

Aveley Electrics Ltd, South Ockendon, Essex, have sent us the following literature which originated from Rhode and Schwarz of West Germany and Scientific-Atlanta of Georgia, U.S.A.

Rhode and Schwarz:

'Semitest 111' (ISP) for testing digital integrated circuits. Can be used on r.t.l., d.t.l., d.t.l.z., t.t.l., e.c.l., and m.o.s. logic WW439
'Power signal generator' (SLRE), 6.7 to 12.7GHz, 0.5 to 3W WW440
'Modules for data aquisition and processing' (UC) WW441
'Antenna rotators' (HA455/3 & 555/1) with hydraulic drive for directional aerial systems WW442
'V.H.F. compact directional finder' (NP8), 117.5 to 136.5MHz WW443

Scientific-Atlanta:

'Swept-frequency microwave measuring system' (series 1700) WW444
'Horn antenna' (series 6800) WW445
'Transportable u.h.f. telemetry tracking system' (series 3000-R18) 1435 to 1535 and 2200 to 2300Mhz WW446

A new catalogue has been produced by Eagle International, Coptic St, London WC1A 1NR., which lists audio and test equipment as well as a variety of components WW447

We have received the following literature from Lyons Instruments, Valley Works, Ware Rd, Hoddesdon, Herts., which describes goods manufactured in Switzerland by Institut Straumann.

OSC104, hermetically sealed tuning-fork oscillators operating at frequencies in the range 1 to 6kHz at temperatures from −55 to +85°C. Power supply between 5 and 12V ... WW448
DIV-, MUL-, FOS-104, frequency divider, frequency multiplier and sine-wave shaping unit for use with the tuning-fork oscillators WW449
STP-70/A, price list for the above range . WW450

A leaflet is available which describes the 'Miniscope' low-voltage soldering iron manufactured by Enthoven Solders Ltd, Dominion Buildings, South Place, London ECM 2RE WW451

Nortronic A/S, 1380 Heggedal, Norway have sent the following literature:

703, multi-filter 35Hz to 14kHz. Contains 26 $\frac{1}{3}$-octave filters WW452
Sound level indicator; versatile sound measuring set WW453
Logic simulator for tuition, etc. WW454
702, universal filter 0.2Hz to 20kHz in 5 bands WW455
701, universal filter 40Hz to 16Hz WW456
Automatic tracking filter and wave analyzer (audio) WW457

Intended for use with Tektronix 540 and 550 oscilloscopes a light coupled oscilloscope plug-in unit is described in literature available from Lyons Instruments Ltd, Valley Works, Ware Rd, Hoddesdon, Herts. Called the IsoAmp model 6150 the unit provides 1.5kV isolation and will accept signals up to 300V peak-to-peak at up to 35MHz. The signal is converted to light and the only connection to the oscilloscope is via a fibre optic light guide WW458

The leaflet 'Short-wave puts you where it's at' describes the range of Hallicrafters communications receivers. The Hallicrafters Co, 600 Hicks Rd, Rolling Meadows, Illinois 60008, U.S.A. ... WW459

Second-hand computers are the subject of a catalogue from Computer Sales and Services, 49/53 Pancras Rd, London N.W.1. .... WW460

Kampel Electronics Ltd, 99 Old Christchurch Rd, Bournemouth, BH1 1EP, have produced a leaflet describing a stereophonic source simulator which is designed to be used with a stereo amplifier to produce a stereophonic effect from a monophonic signal source WW461

GENERAL INFORMATION

The Scientific Instrument Manufacturers' Association of Great Britain, SIMA House, 20 Peel St, London W.8, have produced a second edition of their 'Metrication Guide'. This revised edition costs £2.50

April Meetings

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

LONDON

1st. IERE—"Future techniques for cockpit display" by D. R. Evans and Capt. D. S. Kirkland at 18.00 at 9 Bedford Sq., W.C.1.

1st. RTS—"Sound techniques for television and commercial recording" at 19.00 at Intersound Recording Studios, Park Drive, Wembley, Middlesex.

6th. IEE—"Business, society and the professional engineer" by B. M. Maskell at 17.30 at Savoy Place, W.C.2.

7th. IEE—"The use of telecommunications in meteorology" by A. A. Worthington at 17.30 at Savoy Place, W.C.2.

15th. IEE—Discussion on "Development of electrical and electronic systems during flight testing of new aircraft" at 18.00 at Savoy Place, W.C.2.

15th. RTS—"New techniques in video mixing" by W. R. Hawkins at 19.00 at I.T.A. 70 Brompton Rd., London S.W.3.

16th. IEE—Discussion on "Engineering science in schools and further education" at 14.00 at Savoy Pl., W.C.2.

16th. IEE—"The effective training of professional engineers as managers" by P. H. L. Thomas at 17.30 at Savoy Pl., W.C.2.

19th. IEETE—Panel under the chairmanship of Prof. R. C. G. Williams discussing "Panel connecting problems" at 18.00 at Savoy Pl., W.C.2.

20th. IERE—"Automatic camera line-up in colour television" by D. V. Ryley and Mrs. G. Claydon at 18.00 at the London School of Hygiene and Tropical Medicine, Keppel St., Gower St., W.C.1.

20th. AES—"Wide range ribbon loudspeaker development" by Stanley Kelly at 19.15 at the Mechanical Engineering Dept., Imperial College, Exhibition Rd., S.W.7.

21st. Inst. Navigation—"The application of low light television to navigation" at 17.00 at the Royal Geographical Society, 1 Kensington Gore, S.W.7.

21st. SERT—"System 24" by C. P. Davies at 19.00 at London School of Hygiene & Tropical Medicine, Keppel St., W.C.1.

21st. BKSTS—"Recording techniques for multichannel stereo" by Michael A. Gerzon at 19.30 at I.T.A., 70 Brompton Rd., S.W.3.

23rd. IEE—Discussion on "Light emitting diodes and their utilization" at 17.30 at Savoy Pl., W.C.2.

27th. IERE—"Communications through space, flame and fibre" by Prof. P. J. B. Clarricoats at 18.00 at the London School of Hygiene & Tropical Medicine, Keppel St., Gower St., W.C.1.

28th. IERE—"Applications of Camac" by H. Bisby at 18.00 at 9 Bedford Sq., W.C.1.

29th. IEE/IERE—Colloquium on "Design and application of minimal computers" at Savoy Pl., W.C.2.

29th. RTS—Fleming Memorial Lecture: "Perspectives in television" by Huw Wheldon at 19.00 at The Royal Institution, Albemarle St., W.1.

BALLYMENA

20th. IERE—"Loudspeakers" by R. L. West at 19.30 at Ballymena Technical College.

BIDEFORD

20th. British Computer Soc.—"Computer aided design" by B. Gott at 18.15 at the Library Theatre.

BIRMINGHAM

19th. SERT—"Electronic music" by A. Douglas at 19.30 at Aston University.

21st. RTS—"Radio telescopes" by Dr. Guy Pooley at 19.00 at the A.T.V. Studio Centre, Bridge Street.

BOURNEMOUTH

21st. SERT—"Remote control and indication systems" by N. Greene at 19.30 at Bournemouth Municipal Technical College.

CHELMSFORD

28th. IEE—"Radio meteorology" by Dr. J. A. Saxton at 18.30 at King Edward VI Grammar School, Broomfield Rd.

EVESHAM

20th. IERE—"World satellite communication systems" by G. H. Banner at 19.00 at B.B.C. Club.

HIGH WYCOMBE

28th. IEE—"Plasma—the fourth state of matter" by Dr. J. E. Allen at 19.15 at the High Wycombe College of Technology and Art.

LIVERPOOL

21st. IERE—"Computer aided circuit design" by E. Wolfendale at 19.00 at the Department of Electrical Engineering, University of Liverpool.

MANCHESTER

15th. IERE—"Radio astronomy" by E. J. Daintree at 19.15 at the Renold Bldg., U.M.I.S.T., Altrincham St.

22nd. SERT—"Integrated circuits" by J. Tomson at 19.30 at U.M.I.S.T.

NEWCASTLE-UPON-TYNE

14th. IERE—"Electronics and the entertainment industry—the future" at 18.00 at Ellison Building, The Polytechnic, Ellison Place.

PLYMOUTH

7th. RTS—"Computers in television programming" by N. W. Green at 19.30 at the Studios of Westward Television Ltd.

READING

29th. IERE—"Direct digital control—the case for the special purpose computer" by P. Atkinson and A. J. Allen at 19.30 at the J. J. Thomson Laboratory, University of Reading, Whiteknights Park.

ROMFORD

21st. IERE—"Management of R & D" by D. C. Dalton at 18.30 at Central Library.

ROTHERHAM

22nd. IEETE—"Yorkshire TV studios, Leeds" by P. G. Parker at 19.00 at College of Technology, Main Hall, Howard Street.

SWANSEA

1st. IERE/IEE—"The use of satellites for civil communication" by C. F. Davidson at 18.15 at Department of Applied Science, University College.

WALSALL

28th. IEETE—"Electronics in the automobile" by W. F. Hill at 18.45 at Midlands Electricity Board District Offices, Green Lane.

WOLVERHAMPTON

6th. IERE—"Direct digital control—the case for the small special purpose computer" by P. A. Atkinson at 19.30 at the Polytechnic.

WORCESTER

22nd. B.Computer Soc.—"Introduction to computer simulation" by G. S. Perdue at 19.30 at Worcester Technical College.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Apr. 15 & 16 Imperial College
Britain's Modern Standards—the contribution and the Gain
a (British Standards Institution, 2 Park St., London W1A 2BS)

Apr. 19 & 20 I.E.E., Savoy Place
Hybrid Microelectronic Circuits
(International Society for Hybrid Microelectronics, c/o Dr. R. G. Loasby, A.W.R.E., Building A37, Aldermaston, Reading RG7/4PR)

Apr. 19-22 Alexandra Palace
Physics Exhibition
(I.P.P.S., 47 Belgrave Sq., London S.W.1.)

Apr. 21-29 Earls Court
International Engineering and Marine Exhibition
(Industrial & Trade Fair Ltd, Commonwealth House, New Oxford St., London WC1A 1PB)

BRIGHTON

Apr. 4-6 University of Sussex
Vacuum Equipment
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Apr. 20-23 Hotel Metropole
Technical Communication in the 70s
(Business Conference & Exhibitions, Mercury House, Waterloo Rd., London S.E.1.)

LANCASTER

Apr. 5-7 The University
Elementary Particle Physics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

YORK

Apr. 5-8 The University
Atomic and Molecular Physics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

OVERSEAS

Apr. 5 & 6 Atlanta
System Theory
(C.O. Alford, School of Electrical Eng., Georgia Institute of Technology, Atlanta, Georgia 30332)

Apr. 12-15 Washington
Telemetering Conference
(Washington Technical Consultants, 422 Washington Bldg, Washington D.C. 20005)

Apr. 13-15 Boston
Electronics in Medicine
(Electronics in Medicine, 330 W. 42nd St., New York, NY10036)

Apr. 13-15 New York
Computers and Automata
(Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn, New York 11201)

Apr. 13-16 Denver
Magnetics Conference
(C.D. Mee, IBM Corp., Building 015, Monterey & Cattle Rds, San Jose, California 95114)

Real & Imaginary

by "Vector"

Salute to "Free Grid"

Mention the name of Norman Preston Vincer-Minter to *W. W.* readers and I warrant that blank expressions will be the order of the day. But mention "Free Grid" and all of those of more than seven years' standing in readership will know at once who you're talking about. And will not only know, but almost invariably the mention of the name will provoke reminiscence of the "Do you remember what he said about—?" type.

But first, to the young among us, a word or two of explanation. The name N. P. Vincer-Minter appears in *W. W.* volumes prior to 1930, mostly as a contributor of constructional articles. Then, on September 17th, 1930, "Free Grid" made his entrance with a regular page feature under the heading "Unbiased". At first, to judge from his remarks, he was very much on trial (editors are adept at suspending the sword of Damocles) but before long his inimitable style made his place assured. For thirty-four years (he died, aged 67, on 11th March 1964) he continued to delight readers with his wit, his scholarship, his anecdotes and his "inventions". "Free Grid" became as much a part of the journal as the front cover.

At first the drawings which accompanied his page were relatively characterless but by the end of 1930 the "F.G." image (which, incidentally, bore no resemblance to Vincer-Minter) emerged, together with those of the formidable Mrs. "Free Grid" and the little "Grid Leaks". The illustrations became a perfect complement to the writing. Here, epitomized, was the middle-class little man of the period—bowler, spectacles, neat suit, furled umbrella and all—ever ready to do battle with bureaucracy, intransigent manufacturers, slipshod terminology or sheer stupidity. The aggressive chin of the cartoonist's little man added emphasis to the prose, for "F.G." was an arch-puncturer of balloons and the sworn enemy of sacred cows.

But it is in the role of prophet that "Free Grid" is best remembered. Here he was in a league of his own. In the Jubilee issue of *W. W.* in 1961 he really let himself go and as no commemorative issue would be complete without "Free Grid" I make no apology for turning over the rest of the page to him. Ladies and gentlemen (and particularly new readers), here is the incomparable "Free Grid" writing ten years ago:

A.D. 1971, 1986, 2011

Another 50 years will have to pass before *Wireless World* can publish another jubilee number, and that will be the centenary number of April A.D. 2011. However, it is customary to celebrate 60th and 75th anniversaries of things. I shall be very surprised if by the 60th anniversary in 1971 we do not have coloured television and by the 75th anniversary in 1986 stereoscopic coloured TV.

By 1971 our television sets will probably have a scanning unit so that we can show our coloured slides and also our home ciné films on the c.r.t. and by 1986 our home ciné films will be returned to us from the processing station in the form of magnetic tapes holding both sound and vision recordings.

By 1986 every set will, of course, have a built-in multi-channel tape recorder for vision and sound so that while we are watching one programme we can simultaneously bottle one or more of the several alternative programmes that will be available.

Fettered by Physics

I will now . . . venture to glance into the future of electronics but I am definitely not going to inflict on you any of the unimaginative and rather obvious ideas which most science-fiction writers present to their readers. . . .

The reason for their unimaginative stories is that writers of science fiction allow their minds to be fettered by physics, or, more accurately, by our contemporary knowledge of physics. The "sciction" scribes, as I call them, write fantastic stories—doubtless accurate by contemporary scientific knowledge—about travel to distant worlds while overlooking the possibility of travel to another kind of world which is right under their noses. The world to which I refer is the extra-spatial and extra-temporal one which I discussed fully in the March, 1959, issue of this journal. I am greatly indebted to "Cathode Ray" for my ideas and gladly acknowledge it. As I explained in my original thesis on the subject it was he who set me thinking by his article in the November 1958 issue. In that article he gave us a very vivid picture of electrons as being "waves of which nobody knows" which it is usual to call ψ waves. As a result of reading this I expressed the view that if we could manage to alter one of the properties of the ψ waves, such, for instance, as their λ, we should probably find that these metamorphosed electrons vanished, like H. G. Wells's Time Machine, out of our world of time and space into that extra-spatial and extra-temporal "world" inhabited by ghosts, fairies, poltergeists and other seemingly shadowy and clammy entities who seem to pass through brick walls, to be able to be in two places simultaneously and, in general, to ignore many if not all the laws of physics.

In actual fact I don't believe they do ignore them; they merely seem to ignore physical laws because our knowledge of physics today is very limited in comparison with what it will be in 2011.

I am reluctant to call this spaceless and timeless place the metaphysical world because I don't think it *is* "beyond physics" as the name would imply. I will, therefore, call it the psychotronic world which simply means that it is built of metamorphosed electrons, or, in other words, psychotrons, a word which I coined in the May 1960 issue to describe these extra-spatial and extra-temporal electrons or ψ waves which had had their wavelength or other property changed or metamorphosed and had, therefore become $\mu\psi$ waves.

Electrovision

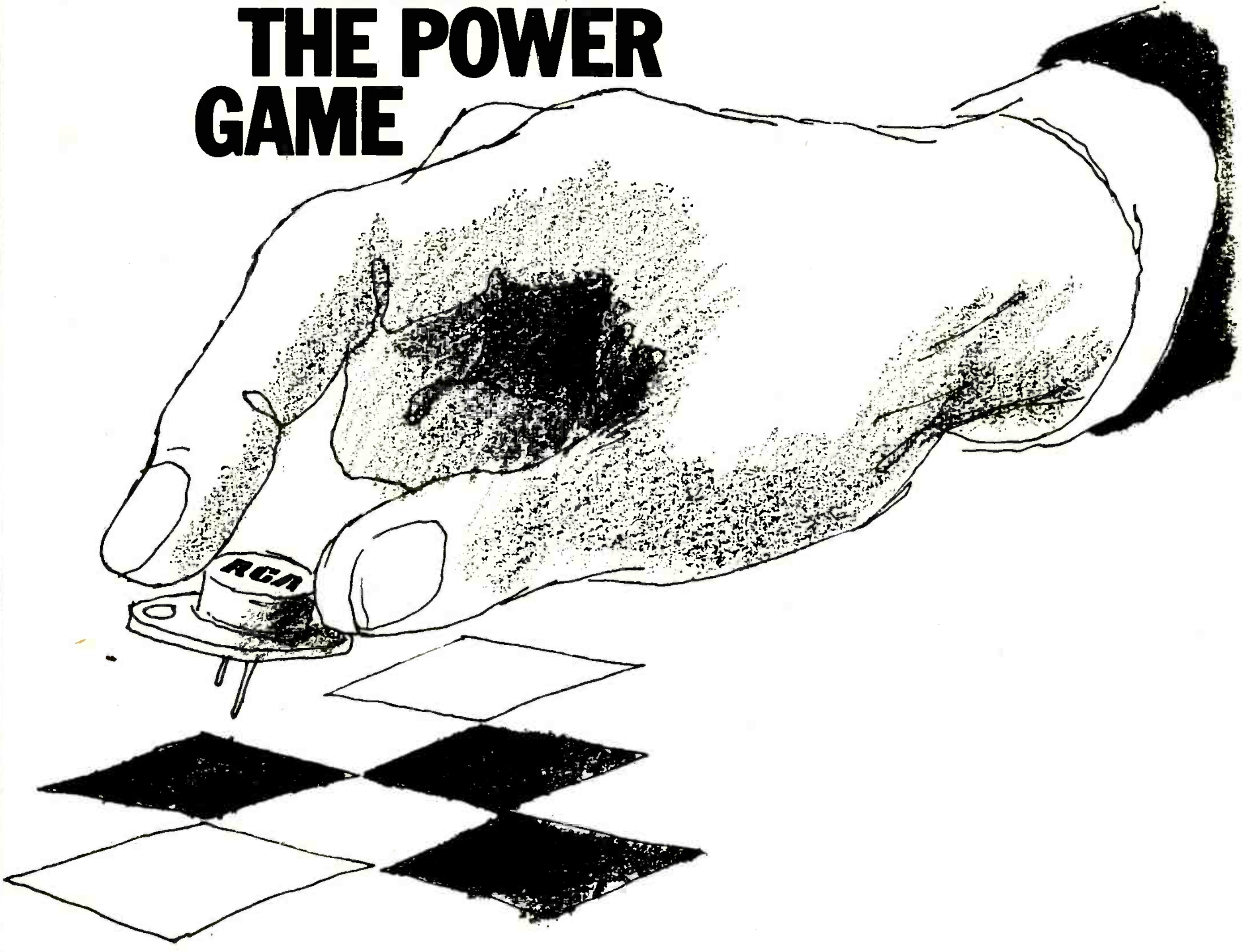
I will venture only one prophecy on more ordinary lines . . . . by suggesting that before 2011 our electronic experts and ophthalmic surgeons will have got together to do something very drastic for people like myself suffering from failing sight.

I have in mind the development of something like the special kind of cathode-ray tube used for transmission but in very miniature form so that it would actually take the place of an eye and convert vision into pulses along the optic nerve, as the natural eye does now.

Requiescat in pace "Free Grid"

"Books cannot always please, however good" was the caption to this cartoon illustrating "Free Grid" suffering from the symptoms of "uxorogenic cacophoria".

NOW YOU CAN MOVE AHEAD IN THE POWER GAME



RCA ANNOUNCE NEW POWER TRANSISTORS FOR QUASI COMPLEMENTARY AUDIO AMPLIFIERS.

Now available, six of the best from RCA.

Six new power transistors for output levels from 5W to 70W (8Ω impedance).

Manufactured by RCA to the highest professional standards.

Available from your local stockist as of now

Make a note of the right number for your project.

Type	40629	40630	40631	40632	40633	40636
Power Output	*5W*	*7W*	*10/12W*	*25W*	*40W*	*70W*

Or phone Sunbury-on-Thames 85511 and we'll tell you more. There's plenty more to tell.

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OFFICIAL DISTRIBUTORS:
Semicomps Northern Ltd., The Square, Kelso, Roxburghshire. Tel: 2366.
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ECS (Windsor) Ltd., Thames Avenue, Windsor, Berks. Tel. 68101 (20 lines).

RCA Solid State

Sinclair Project 60

the world's most advanced high fidelity modules

Sinclair Project 60 presents high fidelity in such a way that it meets every requirement of performance, design, quality and value and now that the remarkable phase lock loop stereo FM tuner is available, it becomes the most versatile of high fidelity systems. With Project 60, it is possible to start with a modest mono record reproducer and expand it to a sophisticated stereophonic radio and record reproducing system of fantastically good quality to hold its own with any other equipment, no matter how expensive. Project 60 is a unique high fidelity module system where compactness and ease of assembly are combined with circuitry that is far in advance of any other manufacturer in the world. Thus it is extraordinarily easy to assemble any combination of modules using nothing more complicated than the simplest of tools, and you certainly do not have to be experienced to build with complete confidence. The 48 page manual free with Project 60 equipment makes everything easy and you can house your assembly in an existing cabinet, motor plinth, free standing cabinet or virtually any arrangement you wish. Once you have completed your assembly you will have superlatively good equipment to give you years of service and enjoyment. You will have obtained superb value for money because Project 60 is the best selling modular system in Europe and can therefore be produced at extremely competitive prices and with excellent quality control.

	System	The Units to use	together with	Cost of Units
A	Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control	**£4.48**
B	Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control etc.	**£9.45**
C	20+20 W. R.M.S. stereo amplifier for most needs	**2 x Z.30s, Stereo 60, PZ.5**	Crystal, ceramic or mag. P.U., most dynamic speakers, F.M. tuner etc.	**£23.90**
D	20+20 W. R.M.S. stereo amplifier with high performance spkrs.	**2 x Z.30s, Stereo 60, PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
E	40+40W. R.M.S. de-luxe stereo amplifier	**2 x Z.50s, Stereo 60 PZ.8, mains trsfrmr**	As for D	**£34.88**
F	Outdoor P.A. system	**Z.50**	Mic., up to 4 P.A. speakers controls, etc.	**£5.48**
G	Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**
H	High pass and low pass filters	**A.F.U.**	C, D or E	**£5.98**
J	Radio	**Stereo F.M. Tuner**	C, D or E	**£25.00**

Sinclair Radionics Ltd., London Road, St. Ives,
Huntingdonshire PE17 4HJ.
Tel: St. Ives (048 06) 4311

sinclair

WW—101 FOR FURTHER DETAILS

Sinclair Project 60

Z.30 & Z.50 power amplifiers

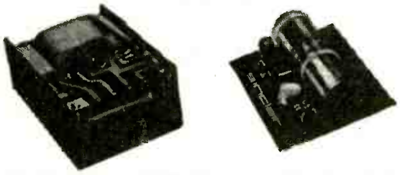
The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

SPECIFICATIONS ***(Z50 units are interchangeable with Z.30s in all applications).***
Power Outputs
Z.30 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M.S. into 3 ohms using 30 volts.
Z.50 40 watts R.M S. into 3 ohms using 40 volts: 30 watts R.M.S. into 8 ohms, using 50 volts.
Frequency response: 30 to 300,000 Hz ±1dB.
Distortion: 0.02% into 8 ohms.
Signal to noise ratio: better than 70dB unweighted.
Input sensitivity: 250mV into 100 Kohms.
For speakers from 3 to 15 ohms impedance.
Size 3½ x 2¼ x ½ in.

Z.30
Built tested and guaranteed with circuits and instructions manual **£4.48**

Z.50
Built, tested and guaranteed with circuits and instructions manual. **£5.48**

Power Supply Units



Designed specially for use with the Project 60 system of your choice.
Illustration shows PZ.5 to left and PZ.8 (for use with Z.50s) to the right. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stablised supply is essential.

PZ-5 *30 volts unstabilised* **£4.98**
PZ-6 *35 volts stabilised* **£7.98**
PZ-8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ-8 *mains transformer* **£5.98**

Guarantee

If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.

Stereo 60 pre-amp/control unit

Designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

SPECIFICATIONS
Input sensitivities: Radio–up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ± 1dB: 20 to 25,000 Hz. Ceramic p.u.–up to 3mV: Aux–up to 3mV.
Output: 250mV
Signal-to-noise ratio: better than 70dB.
Channel matching: within 1dB.
Tone controls: TREBLE + 15 to —15dB at 10KHz: BASS + 15 to—15dB at 100Hz.
Front panel: brushed aluminium with black knobs and controls.
Size: 8¼ x 1½ x 4 ins.

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

Active Filter Unit

For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two stages of filtering are incorporated – rumble (high pass) and scratch (low pass). Supply voltage – 15 to 35V. Current – 3mA. H.F. cut-off (–3dB) variable from 28kHz to 5kHz. L.F cut-off (–3dB) variable from 25Hz to 100Hz. Distortion at 1kHz (35V. supply) 0.02% at rated output.

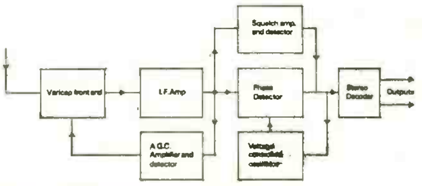
Built, tested and guaranteed **£5.98**

Stereo FM Tuner

first in the world to use the phase lock loop principle

Before production of this tuner, the phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio over other systems. Now, for the first time, the principle has been applied to an FM tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Sensitivity is such that good reception becomes possible in difficult areas. Foreign stations can be tuned in suitable conditions and often a few inches of wire are enough for an aerial. 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 as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system.

SPECIFICATIONS:
Number of transistors: 16 plus 20 in I.C.
Tuning range: 87.5 to 108 MHz
Capture ratio: 1.5dB
Sensitivity: 2μV for 30dB quieting: 7μV for full limiting.
Squelch level: 20μV.
A.F.C. range: ±200 KHz
Signal to noise ratio: >65dB
Audio frequency response: 10Hz—15KHz (±1dB)
Total harmonic distortion: 0.15% for 30% modulation
Stereo decoder operating level: 2μV
Pilot tone suppression: 30dB
Cross talk: 40dB
I.F. frequency: 10.7 MHz
Output voltage: 2 x 150mV R.M.S.
Aerial Impedance: 75 Ohms
Indicators: Mains on: Stereo on; tuning indicator
Operating voltage: 25-30 VDC
Size: 3.6 x 1.6 x 8.15 inches: 91.5 x 40 x 207 mm



Price: **£25** built and tested. Post free

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Please send

for which I enclose cash/cheque/money order.

Name

Address

WW471

WW—102 FOR FURTHER DETAILS

Sinclair IC10/Q16/Micromatic

IC10

The world's most advanced high fidelity amplifier

This is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself is a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, having 5 watts RMS output (10 watts peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, and is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is more rugged and has considerable performance advantages, including complete freedom from thermal runaway and a very low level of distortion. The IC10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. It may also be used in other applications including car radios, electronic organs, servo amplifiers (it is dc coupled throughout) etc.

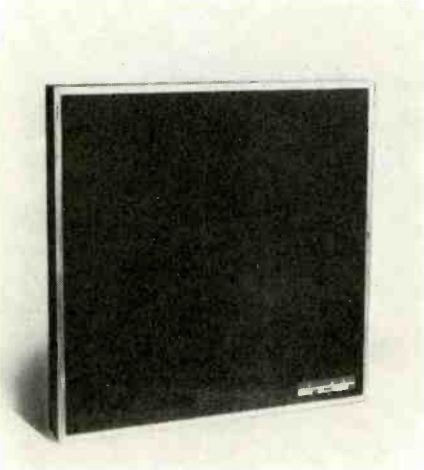
Circuit Description

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. There is generous negative feedback round both sections and the amplifier is completely free from crossover distortion at all supply voltages, making battery operation eminently satisfactory.

Each IC10 is sold with a comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include oscillators, etc. The pre-amp section can be used as an RF or IF, amplifier without any additional transistors.

Specifications:
Output: 10 watts peak, 5 watts RMS continuous.
Frequency response: 5Hz to 100kHz 1 ± dB.
Total harmonic distortion: Less than 1% at full output.
Load impedance: 3 to 15 ohms.
Power gain: 110 dB (100,000,000,000 times) total.
Supply voltage: 8 to 18 volts. (A Sinclair power unit, PZ.7 is available for mains operation).
Size: 1 x 0.4 x 0.2 in. plus heat sink and tags.
Sensitivity 5 mV.
Input impedance: Adjustable externally up to 2.5 Mohms.
Price (with manual): **£2.98** post free.

Q16



High fidelity loudspeaker

The Q16 employs the well proven acoustic principles specially developed by Sinclair in which a special driver assembly is meticulously matched to the characteristics of the uniquely designed cabinet. In reviewing this exclusive Sinclair design, technical journals have justly compared the Q16 with much more expensive loudspeakers. Its shape enables the Q16 to be positioned and matched to its environment to much better effect than is the case with conventionally styled enclosures. A solid teak surround with a special all-over cellular foam front is used as much for appearance as its ability to pass all audio frequencies.

This elegantly designed shelf mounting speaker brings genuine high fidelity within reach of every music lover.

Specifications:
Construction: Special sealed seamless sound or pressure chamber with internal baffle.
Loading: up to 14 watts TMS.
Input impedance: 8 ohms.
Frequency response: From 60 to 16,000 Hz, confirmed by independently plotted B and K curve.
Driver unit: Special high compliance unit having massive ceramic magnet of 11,000 gauss, aluminium speech coil and a special cone suspension for excellent transient response.
Size and styling: 9¾ in square on face x 4¾ in. deep with neat pedestal base. Black all-over cellular foam front with natural solid teak surround.
Price £8.98.

Micromatic

Britain's smallest radio

Considerably smaller than an ordinary box of matches, this is a multi-stage AM receiver brilliantly designed to provide remarkable standards of selectivity, power and quality for its size. Powerful AGC counteracts fading from distant stations; bandspread at higher frequencies makes reception of Radio 1 easy. The plug-in magnetic earpiece provided matches the Micromatic's output to give wonderful standards of reproduction. Everything including the special ferrite rod aerial and batteries is contained within the minute and attractively designed case. Whether you build a Micromatic kit or buy this amazing receiver ready built and tested, you will find it as easy to take with you as your wrist watch, and dependable under the severest listening conditions.

Specifications:
Size: 36 x 33 x 13 mm ($1^{4}/_{5} \times 1^{3}/_{10} \times \frac{1}{2}$ in.)
Weight: including batteries, 28.4 gm (1 oz.).
Case: Black plastic with anodised aluminium front panel and spun aluminium dial.
Tuning: medium wave band with bandspread at higher frequencies. (550 to 1,600 Hz).
Earpiece: Magnetic type.
On/off switching: By inserting and withdrawing earpiece plug.
Kit in pack with earpiece, case, instructions and solder **£2.48.**
Ready built, tested and guaranteed, with earpiece **£2.98.**
Two Mallory Mercury batteries type RM675 required. From radio shops, chemists, etc.

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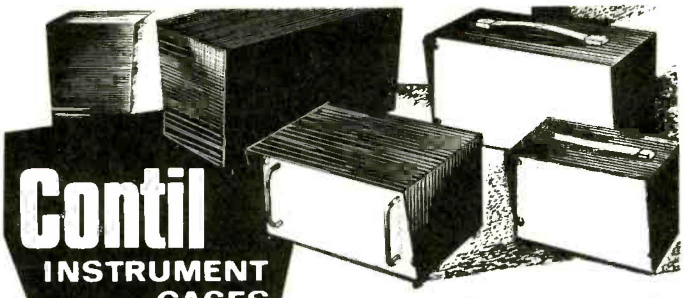
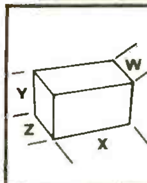


Contil
INSTRUMENT CASES



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755	5	7	5	4
975	7	9	5	6
867	6	8	7	5
1277	7	12	7	6
16127	12	16	7	11
191010	$10\frac{1}{2}$	$19\frac{1}{4}$	$10\frac{3}{4}$	$9\frac{1}{2}$
1910100	$10\frac{1}{2}$	$19\frac{1}{4}$	$10\frac{3}{4}$	$9\frac{1}{2}$

(Panel size—$10\frac{1}{2}$ x 19 x $4\frac{1}{2}$ with 6" vertical)

The ideal 'off the shelf' low cost instrument housing. 21-gauge steel. Finished hammer blua, with 18-gauge panel supplied with easy-to-strip protective covering for easy marking out. Individually packed, including feet and screws.

TYPE	1 off	10 off	100 off	P&P
755	£2.60	£2.45	£2.30	36p
867/975	£2.75	£2.65	£2.35	36p
1277	£3.10	£2.90	£2.70	45p
1277 un-painted	£2.50	£2.40	£2.05	45p
16127	£5.80	£5.60	£5.30	56p
191010	£7.90	£7.60	£7.25	66p
1910100	£10.95	£10.80	£10.35	105p

CHASSIS AND SPARE PANELS

Contil cases are also available with aluminium panels and Contilcote, applied after drilling and cutting. There is also a chassis to fit each size of Contil case. Three smaller sizes in 18 gauge aluminium and three larger sizes in 16 gauge. Prices from 15p to 75p.

GROMMETS 100 off	GROMMETS 500 off	PANEL HOLE SIZE INCHES	BLANKING PLUGS 100 off	BLANKING PLUGS 500 off
25p	20p	3/16 $\frac{1}{4}$ 5/16 3/8	35p	30p
35p	30p	7/16 $\frac{1}{2}$ 5/8		
55p	50p	$\frac{3}{4}$	55p	45p
		1	80p	70p

Assorted £1.40 lots (100 3/16", 50 ea. of others)

Assorted £1.70 lots (100 off 3/16", 50 ea. of others)

Postage & Packing 15p

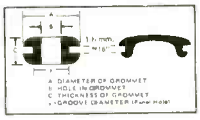
HANDLES

West Hyde carry stocks of four types of handles. The two Delrin types are 5.5/8" and $8\frac{1}{4}$" long with prices from 8p to 20p each. The two chrome panel handles are also in two sizes 3" and 5" with prices from 20p to 37p each. Both types of handles are ideal for our cases as the illustration shows.

FEET

You could tramp the World and not find better feet!

The West Hyde foot is moulded from a resilient, high hysteris material, giving a high friction coefficient. Self-adhesive or screw fixing or both (6BA countersunk). Size 5/8" dia. 3/8" high. Grey. Price from0 010 to 0.017 each.

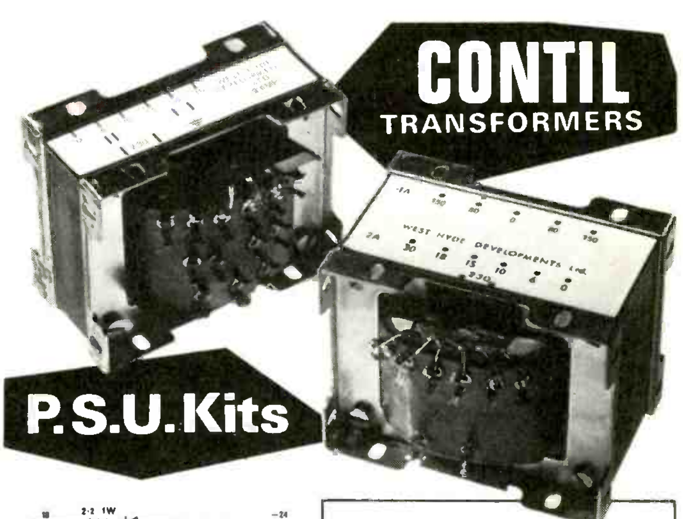


WEST HYDE **WH**

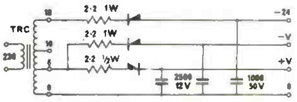
WEST HYDE DEVELOPMENTS LTD. RYEFIELD CRESCENT, NORTHWOOD HILLS, MIDDX. HA6 1NN
Telephone: Northwood 24941/26732 Telex: 923231 Code: West Hyde Nthwd.

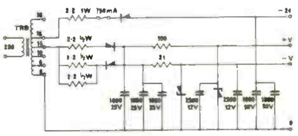
WW—104 FOR FURTHER DETAILS

CONTIL
TRANSFORMERS



P.S.U. Kits





TRA has 100mA high voltage winding to drive number tubes or neon indicators driven by transistors. Size: 4" x $3\frac{1}{4}$" x $3\frac{3}{4}$" O.P. 150-180-0-80-150 @ 100mA. 1, 6, 10, 15, 18, 30 @ 2 Amps. Therefore also gives 12-0-12 or 15-0-15 or 3, 4, 5, 6, 8, 10, 12, 18, 24 & 30 volts @ 2 Amps; and 300, 230, 180, 150, 80 and 70 volts @ 50/100mA. £2.50 P & P 37p.

TRB. Size: 4" x $3\frac{1}{4}$" x $2\frac{3}{4}$"; I.P. 230 volts. O.P. 0, 6, 10, 15, 18, 30 @ 2 Amps L.T. of TRA as above £1.95 P & P 30p.

TRC. Size: $2\frac{3}{4}$" x $2\frac{1}{4}$" x $2\frac{1}{2}$" I.P. 230 volts O.P. 0-6-10-18 @ 1 Amp. Therefore gives also 4, 5, 6, 8, 10, 12, 18 volts. £1.45 P & P 22p.

P.S.U. KITS

P.S.U. KIT A. This kit containes a transformer, diodes, capacitors, resistors, tag strips, with chassis and neon indicator. £3.75 P & P 25p.

P.S.U. KIT B. This power supply kit is based on the TRB transformer giving zener limited +V and −V supplies with a −24 volt line protected by a fuse. £7.40 P & P 30p.

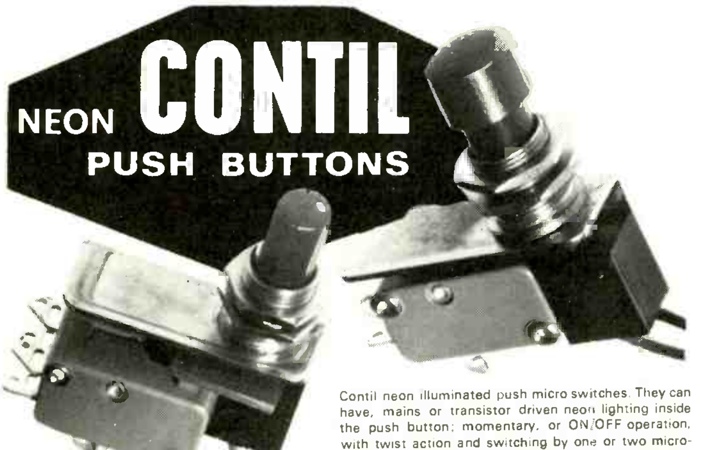
All Contil Transformers, primarily intended for use with transistorised equipment, give a wide range of voltages.

WEST HYDE **WH**

WEST HYDE DEVELOPMENTS LTD., RYEFIELD CRESCENT, NORTHWOOD HILLS, NORTHWOOD, MIDDX. HA6 1NN.
TELEPHONE: NORTHWOOD 24941/26732 TELEX: 923231 CODE: WESTHYDE NTHWO

WW—105 FOR FURTHER DETAILS

NEON CONTIL
PUSH BUTTONS



Contil neon illuminated push micro switches. They can have, mains or transistor driven neon lighting inside the push button; momentary, or ON/OFF operation, with twist action and switching by one or two microswitches or less neon. I.e. either a combined ON/OFF switch neon indicator, or a push button micro switch. West Hyde neons, nominally 25,000 hours, plus Pye switches, together make these push buttons remarkable value for money.

Supplied with or without neon.
1 or 2 microswitches.
Momentary or lock on. } Same price
Red or natural colour. }

COST	1 off	10 off
2 switches, illuminated	0.73	0.67
1 switch, illuminated	0.63	0.55
No switch, illuminated	0.44	0.39
1 switch, non-illuminated	0.43	0.38
2 switches, non-illuminated	0.58	0.50

less for quantities

SPECIFY
1 or 2 microswitches
Lock or momentary
240 or 110v or no neon
Whether cap is required

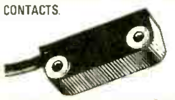
REED SWITCH

West Hyde reed switches have made 50,000,000,000 operations at over 2,000 per second. 1 off 0.75, 10 off 0.65. P & P 10p.

Already there are well over a million reed switches a week being used in Great Britian alone. The West Hyde version has the additional advantage of hermetically sealing and accurately positioning the reed in a protective polypropylene moulding.

IDEAL FOR
OVER SPEED MONITORS, FLOW MONITORING, CONVEYOR MONITORING, COUNTING, POSITION DETECTION, PROXIMITY DETECTORS (Fe), REV. COUNTERS, LIMIT SWITCHES, PRESS TOOL PROTECTION.

ITS ADVANTAGES ARE:
LOW COST, EASY MOUNTING, LONG LIFE, SAFETY, VIBRATION RESISTANCE, IDEAL FOR DRIVING LOGIC, HIGH OPERATING SPEED, HERMETICALLY SEALED CONTACTS.



WEST HYDE **WH**

WEST HYDE DEVELOPMENTS LTD., RYEFIELD CRESCENT, NORTHWOOD HILLS, NORTHWOOD,
MIDDX. HA6 1NN. Telephone: 24941/26732. Telex: 923231 West Hyde Northwd.

WW—106 FOR FURTHER DETAILS

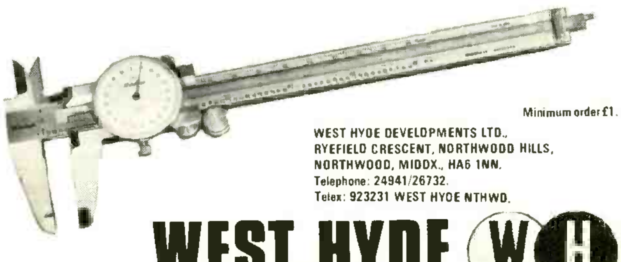
LABEL-MATE

DIAL CALIPERS

The Mini Label Mate is a new miniaturised labeller, that is small enough to slip into the pocket, but big enough to do the job. Made in durable shock-resistant plastic, it has a full view embossing wheel with a precise action, which gives fast finger tip embossing with clear, sharp impressions on 12ft x $\frac{3}{8}$" tape. Labeller in Blue, Green, Yellow, Red. Tape in Black, Red Blue, Green, Gold.

Labeller: £1. P & P 8p.
Tape reels: 33p. P & P 5p.

West Hyde Dial Vernier Calipers are magnificent value and an enormous help on both development work and production. The direct reading dial is very clear, and they provide inside, outside, depth and step measurements. Satin chrome stainless steel with hardened slides. Packed in a velvet-lined metal case; available in four sizes: 6" x .001 or 150mm x .05mm @ £10.75. 12" x .001 or 300mm @ £22.75. Less for quantity.



Minimum order £1.

WEST HYDE DEVELOPMENTS LTD.,
RYEFIELD CRESCENT, NORTHWOOD HILLS,
NORTHWOOD, MIDDX., HA6 1NN.
Telephone: 24941/26732.
Telex: 923231 WEST HYDE NTHWD.

WEST HYDE **WH**

WW—107 FOR FURTHER DETAILS

OSCILLOSCOPE PROBE TM8119

High impedance 100/1 resistive attenuated probe for accurate display of HF waveforms or short rise time pulse signals, offered brand new with all accessories and instruction manual. List price £17. Our price **£7·50** including earth bayonet TM8194. A MARCONI PRODUCT

HIGH VOLTAGE TRANSFORMERS

Input 240 v., output 2560 v. and 2820 v. at 1 amp. Weight 75 lb. Price **£15.**

AUDIO OSCILLATORS
TS 382/U

Range 0-200kHz in 4 ranges. Output voltage 1 micro volt to 12 volt. in seven ranges. Frequency check meter 60 and 400 Hz. Very good stability and low distortion. Contains thermostatically controlled heater. Supplied complete with leads circuit diagram etc. in as new condition. Price **£35** P.P. £1.

* MANY OTHER TYPES AVAILABLE *

SOLARTRON OSCILLOSCOPE
523S.2

The best of the surplus scopes for £52, fully serviced and calibrated, compare the specification with others. Bandwidth DC-10MHz at 3 dB. Sensitivity is 1 MV/cm. Time Base 0.1 usec-1cm/sec in 7 decades with fine control on each range. Uses C Core mains transformers/4 in. High resolution flat face PDA CRT and many other features make this scope very suitable for colour television servicing and many other applications. Price **£52** P. & P. £1·25.

BARGAIN OFFER 6V DC TAPE RECORDER MOTORS Type DM148·1. Fully screened * reversible * constant speed * specially designed for Portable Recorders * Price only **£1·75** P.P. 10p

SCHOMANDL FREQUENCY METER TYPE FD.1 AND CONVERTER UNIT TYPE FDM.1

Range 1 KHz to 900 MHz an approved standard for telecommunications equipment. Offered calibrated to manufacturers specifications.

CROYDON INSTRUMENTS

Precision Kelvin Wheatstone Bridge, type KW1. Measurements can be made from 0.0001 of an ohm. 100,000 ohms contains insitu Sullivan Galvo, four decade ranges, four standards and six Kelvin divide/multiply ratio's offered in excellent condition ready for use. Price **£95.**

MARCONI 12 KHz QUARTZ CRYSTAL contained in B7G envelope with flying lead connections. Brand new only **62½p** each.

MORGANITE GLASS ENCLOSED RESISTORS Value 2.5k. meg ohms, tolerance 10%. **£1·25** per carton of four.

WATSON MARLOW ORBITAL LOBE PUMPS

Specially designed for corrosive liquids etc. Rated output against 10 ft. head—110 G.P.H. direction of flow reversible. Supply 240 v. A.C. mains. Nett weight 14 lb. Supplied as new. Price **£12·50.** P. & P. 50p. List £22·50.

Voltage and Current regulators—heavy duty rheostats—1 ohm rated at 10A. Brand new by famous manufacturer, **62½p** each. Also 1.5 ohm at 7A., **62½p**, p.p. 7½p.

Lucas diode rectifiers—full wave bridge rectifier mounted on special heat-sink. 50V.-60V. operation rated at 50A. Has many uses for heavy duty charging plants, plating rectifiers, etc., etc. Per pair **£8** (two complete bridge rectifiers(, p.p. 37½p

GEC UNISELECTOR. GPO pattern. **8 BANK 25 POSITION 75 ohm BRIDGING WIPERS.** Brand new. Boxed. Only **£2·50** P.P. 22p.

RF SIGNAL GENERATORS AM AND FM

AVO Ltd. Model CT 378. Good quality AM generator 2-225 MHz in seven ranges—calibrated output level 1 uV to 1 V—frequency range directly calibrated with set level meter. Small size modern instrument complete with instructions. RF leads and mains lead for price only **£35.** Airmec Ltd. Model CT-212 AM/FM signal generator 85 kHz to 32 MHz directly calibrated output level calibrated 1 uV to 1 V deviation 0-30 kHz, fully portable for 24 DC and 240 v. AC operation in first class condition. Our price, only **£45.**

SPECIAL OFFER

"INSULATION TESTERS" TYPE No. 11 METROHM by famous British manufacturer. All solid state. No handles to crank. Runs off 9 volt transistor battery. Simply press button for function. Range 0·1 to 25M ohms for insulation testing. Also 0·1 to 100 ohms for resistance and continuity checking. Clear, concise scale. Small size modern instrument, complete with carrying strap and protecting cover. Offered in good used condition with battery ready to work. For 250 volt pressure only. List Price £19·50. Our Price **£6·00** plus 22½p post/packing.

Rhode & Schwarz ESM300	UHF Receiver AM/FM	85MHz—300 MHz.
Rhode & Schwarz BN15031	Field strength test receiver AM/FM	90 MHz—470 MHz.
Rhode & Schwarz BN4151/2"60	Noise generator	3 MHz—1000 MHz.
Rhode & Schwarz BN18042	Unbalanced standard Attenuator 0-100db 50 ohm	0 MHz—600 MHz.
Rhode & Schwarz BN33664/50	UHF Load resistor 100 watt 50 ohm	0 MHz—600 MHz.
Rhode & Schwarz BN4521	Vibration Meter	30Hz—12 KHz.
Rhode & Schwarz	ZD Diagraph.	
Advance Q meter type T.I.		100 kHz—100 MHz.
Marconi Q meter type 329G		50 kHz— 50 MHz.
Marconi Q meter type 886A		15 MHz—170 MHz.

DOUBLE BEAM OSCILLOSCOPE
SOLARTRON CD7115/2
DC—7MHz CALIBRATED A1
CONDITION, ONLY **£65** P.P. £2

RHODE & SCHWARZ POLYSKOP (SWOB 2)

With accessories for sale or hire.

Airmec portable RF signal generator. AM/FM Type CT212. Specially designed for field use for mains or 12v operation. Frequency range 85kHz to 30MHz. Accurate scale calibration. *Variable output from 1 micro V 100mV 0 to 80db. Offered in excellent condition. Only **£45.**

TEKTRONIX 551 WITH TWO PLUG INS PERFECT CONDITION

MARCONI 801D A.M. SIGNAL GENERATOR 10-470 MHz OUTPUT 0.1 μV to 1V

Marconi TF867 Standard RF Signal Generator. range 15kHz to 30MHz. Variable output from 4 micro V to 4 Volts. Extremely accurate attenuator, high output stability and discrimination make the generator very suitable for precision measurements on networks and filters. Modulation up to 100% may be applied at 400 or 1000 Hz. Built in crystal calibrator. Offered in first class condition. Price **£175.**

Precision Multi Turn Indicating Dials suitable for 10 turn Helical Pots, machined from solid dural with the skirt engraved 0 to 100 and inner dial engraved 0 to 10 suitable for standard ¼ inch spindles, these small dials are as easy to fix as screwing on an instrument knob, size 1¼ in. for skirt, 1¼ in. dia. for counter knob depth ⅞ in. Brand new, only **77½p.** A General Controls Manufacture.

TEKTRONIX 581 WITH TYPE 80 PLUG IN AND PROBE AS NEW CONDITION

WANTED. GOOD QUALITY TEST EQUIPMENT

Miniature solenoid driven wafer switches, type-Ledex single pole, 7 pos., 3 wafers. Primarily used for channel switching in Radio-Telephones. Wafers may be substituted for any type. Solenoid voltage, 12 or 24V. Brand new. **£1·50** each, p.p. 12½p.

CAMBRIDGE INSTRUMENT Co. Ltd. Precision test meters. Electrodynamic A.C. Ammeter 0 to 15 amps with test certificate	**£35**
Dynamometer A.C. Ammeter range 0 to 15 amps	**£45**
Cambridge Dynamometer A.C. test set 0-225 Watts/0-330 v./0-30 v.	**£55**
Tinsley Universal Shunt type 4309C	**£5**
Tinsley Vernier Potentiometer type 4363E Auto	**£95**
Foster Thermocouple potentiometer type DX	**£75**
Digital Voltmeter Solartron LM902·2 four digit readout	**£85**
Solartron A.C. Convertor LM 903 matching unit for LM902	**£75**
Hewlett Packard DVM 405CR four digit readout auto polarity	**£75**
Glouster DVM BIE 2123 A.C./D.C. transistor portable 0-1000 v.	**£75**

CANNON XLR AUDIO PLUGS AND SOCKETS
3 POLE and 6 POLE
AVAILABLE EX STOCK
BRAND NEW

MARCONI 1094 A/S HF SPECTRUM ANALYSER
3-30MHz
LATE MODEL FOR SALE OR HIRE

SOLARTRON VF252/NSL PRECISION AC MILLIVOLT METER

Range 1.S milli volt (for full scale deflection) to 15 volts in eight ranges input impedance 30 M ohms. The meters offered are of the very latest type not to be confused with the older models. Price only **£75.**

LOW VOLTAGE POWER SUPPLY UNITS

To supply 12-15-20-24 and 30 volts at continuous 5 amps with current control and ammeter employs silicon heavy duty rectification and high quality components very suitable for light duty plating and charing duties. 240 v. AC supply, fully fused. Small size only 10×7×6 in. Offered brand new units. Price **£12·50.**

LUCAS CAR RELAYS. 12 v. Heavy duty make. Suitable for spotlights, horns, overdrives, etc. Brand new. Only **37½p.** Special price for quantities.

BARGAIN OFFER

200-yard reels equipment wire, size 1/024, STC quality, various colours. Brand new reels only **75p.** P. & P. 12½p.

HUNTER MAGSLIPS 3 inch Series, Type E-18-V/2. Very suitable for servo operation of hydraulic valves radar aerials and other applications for 50 volt S0 cycle operation. Offered brand new in transit boxes, at only **£3·25** each.

MUIRHEAD PHASEMETER D-729-bm. Complete with supply and D925A Tunable Filter. Offered as new, with manual. Price **£275.**

ADVANCE DC STABILIZED P.S.U. TYPE PM8

Fully stabilized power module PM8 15 to 30 volts 5 amps offered brand new, Price **£25**

50 DECO IMPULSE COUNTERS
4 DIGIT RESETT
10 Impulses per second.
27MA 22OV COIL AC/DC
OFFERED BRAND NEW
AT £2 EACH

P.F. RALFE
10 CHAPEL ST. LONDON N.W.1
Phone 01-723 8753

EIMAC SK-600A. Air spaced Valve Holders suitable for 4X250, etc. Power tetrodes, brand new, boxed, complete with clamps, screws; heavy silver plate finish. Normal list price £6·50. Our price **£2·50.**

A.E.I. MINIATURE UNISELECTOR SWITCHES

No waiting, straight off the shelf and into your equipment, the Catalogue Nos. are 2202A, 4/33A63/1; coil resistance is 250 ohms. Complete with base, and the price is **£5.** Limited quantity only available.
Also: 2203A, 2200A, 2202A.

Resolved Components Indicator VP 253/1a. Solartron Low Frequency Decade Oscillators. Solartron OS 103 and associated equipment. 2 Phase Low Frequency Oscillator, type Bo 567. Solartron. Solartron Synchro test set, type CT 428. Solartron AC Millivolt meter. Precision. Type VF 252.

AERIAL CHANGE/OVER RELAYS

of current manufacture designed especially for mobile equipments, coil voltage 12 v., frequency up to 250 MHz at 50 watts. Small size only, 2 in. × ⅞ in. Offered brand new, boxed. Price **£1·50**, inc. P.&P.

RECEIVERS COMMUNICATIONS

Marconi CR150. 2-60 MHz as new	**£60**
Hallicrafters S27C 110-220 MHz	**£40**
HRO Mx 500KHz-30MHz	**£30**
Redifon R50M. 13KHz-32MHz	**£95**
Reece Mace Double conversion 60KHz-31MHz	**£60**

COAXIAL SWITCHES
American Manufacture

Suitable for aerial changeover and high frequency switching up to 1,000 MHz miniature Vacuum drawn type 110 vdc operation connections BNC and N types. Offered brand new, boxed. Price **£3·25.**

Hilger & Watts Microspin X Band Bridge. Type W957. Microspin Proton Head Frequency Meter. Type FAZ08. Microspin Modulator. Type FA 210.
Microspin 1 cm Wave guide directional couples, associated measuring equipment. High Voltage Klystron Power Supply Units. Type FA 80.
Hilger & Watts Absorbance Convertor, and many other items of interest offered. Brand new equipment.

LEAD-ACID EQUIPMENT BATTERIES 10v 5AH.

Transparent casing. Size 2¼×5×7 in. Offered brand new and boxed, 2 batteries per box, complete with links and full instructions. Can supply voltages in the range from 2-20v. Price **£2·25**, inc. P.&.P.

Burndept RF Plugs still available. These hard to find plugs are used on a multitude of equipment, especially Londex aerial c/o relays. Offered new ex. equipment. 2 for **50p**, inc. p.p.

Nife traction Batteries Nickel Iron. 1.2V per cell rated at 180 A.H. Sold in crates of three cells or crates of five cells. **£4** per cell. Guaranteed best buy.

BT91-500R THYRISTORS

500 PIV Max rect. Current 16 amps. Guaranteed perfect. Price **£1·25** each.

COLVERN HELICAL POTS

1K ohms
5K ohms
10K ohms
20K ohms
30K ohms

ALL TEN TURN
PRICE £1·75

Wayne Kerr Impedance Bridge B521. Price **£45.**

Electronic Voltmeters for low level signal sources.

PYE High Impedance DC Amplifier for measurements better than 20 uV to 10 volts centre zero. Price **£56.**

Phillips GM 6010 1 mV FSD to 300 V in 12 ranges. Price **£45.**

Phillips PM 2520 1 mV FSD to 300 V in 12 ranges RMS voltmeter 10 Hz to 1 MHz. Price **£45.**

Dawe Model 616A transistorised Voltmeter 10 mV FSD to 300 volts. In 10 ranges. **£27.**

Levell Model TM2A transistor AC Voltmeter 1.5 mV FSD to S00 volts. **£22.**

Solartron VF-252. AC millivoltmeter 1.5 mV for FSD to 15 V 30 M ohms impedance. Price **£65.**

H. W. SULLIVAN STANDARD AIR SPACED CONDENSERS

Capacitance range 0 to 100 pf fully screened with engraved vernier subdivided into 100 equal divisions complete with vernier index and original manufacturers seal offered brand new, at only **£25** each.

G. F. MILWARD Mail Orders: **DRAYTON BASSETT, TAMWORTH, STAFFS**

ELECTRONIC COMPONENTS

Wholesale/Retail: **369 Alum Rock Road, Birmingham B8 3DR. Tel. 021-327 2339**

4,000,000 DIODES

SILICON · GERMANIUM · ZENER

LOTS OF 100,000 – £150
10,000 – £20
1,000 – £3
500 – £2

1,000,000 GERMANIUM TRANSISTORS

LOTS OF 100,000 – £250
10,000 – £30
1,000 – £3·50
500 – £2

SPECIAL 50p PACKS. ORDER 10 PACKS AND WE WILL INCLUDE AN EXTRA ONE FREE!!!!

RESISTORS, ¼/½ watt assorted	100	50p
Wire-wound 1 to 3 watt	20	50p
5 to 7 watt	15	50p
10 watts	10	50p
Multi-tapped	12	50p
PAPER CONDENSERS		
Tv types	50	50p
Miniature	100	50p
ELECTROLYTIC CONDENSERS		
Suitable for Mains Radio/Tv	10	50p
Transistor types	20	50p
Mixed (both types)	15	50p
POLYSTYRENE CONDENSERS	100	50p
MULLARD POLYESTER COND.	50	50p
SILVER MICA	100	50p
WIRE-WOUND 3-Watt SLIDERS	15	50p
VOLUME CONTROLS Assorted	5	50p
NUTS AND BOLTS. Mixed length/type		
8 B.A.	100	50p
6 B.A.	100	50p
4 B.A.	100	50p
2 B.A.	100	50p
METAL SPEAKER GRILLES 7½in. × 3½in.	6	50p
EARPIECES, MAGNETIC		
No Plug	6	50p
No Plug	6	50p
2·5mm Plug	4	50p
3·5mm Plug	4	50p
500 MICRO-AMP LEVEL METERS	1	50p
VEROBOARD TRIAL PACK 5 BOARDS + CUTTER		50p

TRANSISTORS		
P.N.P. Untested but mainly O.K.	50	50p
N.P.N. Untested but mainly O.K.	50	50p
OCP 71 equivalent	5	50p
Light-sensitive Diodes (*These produce up to 1ma from light*)	10	50p
OC44 Mullard 1st grade	4	50p
OC45 Mullard Boxed	4	50p
2G378 Output, Marked	4	50p
2G371 Driver, Marked	4	50p
ASY 22, Marked	5	50p
BY 127 Rectifiers	4	50p
IN4007 Rectifiers (1200V peak)	4	50p
STC 3/4 Rectifiers	6	50p
DIODES (0A 81 & OA 91)	40	50p
WIRE		
Solid Core. Insulated	100yds.	50p
Stranded ditto	50yds.	50p
SOLAR CELLS		
Large Selenium	2	50p
Small	3	50p
(6 cells will power a Micromatic radio)		
CO-AXIAL CABLE Semi Air-spaced	15yds.	50p
CRYSTAL TAPE RECORDER MIKES	1	50p
CRYSTAL EARPIECES 3·5mm Plug	2	50p
TRANSISTORISED Signal Injector	1	50p
TRANSISTORISED Signal Tracer	1	50p
TRANSISTORISED CAR REV. COUNTER KIT (Needs 1 ma. meter as indicator)	1	50p

MULLARD 'UNILEX' AMPLIFIERS

In our opinion these units are the best value for money ever offered. A complete stereo unit consisting of Control unit, Pre-amplifier, Two Main Amplifiers and Power Pack complete the ready for use—NO extra components to buy—yours for £15. (Normal retail price is £16·50.)

GARRARD SP 25 UNITS also offered at a discount. Our price only £12·50. Postage 50p.

TRANSISTOR RADIOS

Once again we have a supply of these excellent radios which offer superb quality sound and excellent sensitivity. They are packed in a colourful presentation box complete with battery, earpiece and carrying case. Each one is guaranteed. You would expect to pay at least £5—but our price due to bulk purchase is only £1·88.

SINCLAIR AMPLIFIERS AND SPEAKERS: Complete range in stock. All at 10% discount on list.

VEROBOARD

2½in × 1in × 0·15in	6p	5in × 3¾in × 0·15in	28p	3¾in × 3¾in × 0·1in	24p
3¾in × 2½in × 0·15in	16p	17in × 2½in × 0·15in	55p	5in × 2½in × 0·1in	23p
3¾in × 3¾in × 0·15in	20p	17in × 3¾in × 0·15in	74p	5in × 3¾in × 0·1in	28p
5in × 2½in × 0·15in	20p	3¾in × 2½in × 0·1in	21p		

Spot Face Cutter 38p. Pin Insert Tool 48p. Terminal Pins (0·1 or 0·15) 36 for 18p. Special Offer Pack consisting of 5 2½in × 1in boards and a Spot Face Cutter—50p.

RECORD PLAYER CARTRIDGES. Well below normal prices!
G90 Magnetic Stereo Cartridges, Diamond Needle, 6mV output, **£4.** ACOS GP 67/2 (Mono, Crystal) **75p.** ACOS GP 91/3 (Compatible, Crystal) **£1.** ACOS GP 93/1 (Stereo, Crystal, Sapphire(**£1·25.** ACOS GP 93/1D (Stereo, Crystal, Diamond) **£1·63.** ACOS GP 94/1 (Stereo, Ceramic, Sapphire) **£1·50.** ACOS GP 94/1D (Stereo, Ceramic, Diamond) **£1·88.** ACOS GP 95/1 (Stereo, Crystal with two L.P./Stereo needles) **£1·25.**

TRANSISTORISED FLUORESCENT LIGHTS, 12 volt. All with reverse 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 × 2in × 1in **£5.** Postage/Packing 25p. THESE CAN BE SENT ON APPROVAL AGAINST FULL PAYMENT.

MULLARD POLYESTER CONDENSERS

1,000pf, 1,200pf, 1,500pf, 1,800pf, 2,200pf, **15p** per dozen (all 400V working). 0·15µf, 0·22µf, 0·27µf, **30p** per dozen (all 160V working). 25× discount for lots of 100 of any one type.

RESISTORS

¼ and ½ watt Most values in stock. **50p** per 100. **10p** per dozen of any one value. WIRE WOUND MAINS DROPPERS. Hundreds of values from 0·7 ohm upwards. 1 watt to 50 watts. A large percentage of these are multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered "assorted" at **50p** per dozen.

SILVER MICA/CERAMIC/POLYSTYRENE CONDENSERS

Large range in stock, 75p per 100 of any one value. 15p per dozen.

RECORDING TAPE BARGAIN! The very best British Made low-noise high-quality Tape! 5in Standard **38p.** Long-play **45p.** 5¾in 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?

£5 WORTH OF COMPONENTS FREE!!!!

Thinking of learning another language? If so apply to us for details of LINGUAPHONE courses. We will GIVE you **£5** worth of components of your selection quite free of charge when you purchase a course!!!!

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 10p.

TRANSISTORS

BRAND NEW
FULLY GUARANTEED

NEW LIST – NEW PRICES

Send today for your FREE copy of our new 1971 list

2N404	22p
2N696	17p
2N697	17p
2N706	10p
2N706A	12p
2N930	25p
2N1131	30p
2N1132	30p
2N1302	20p
2N1303	22p
2N1304	25p
2N1305	25p
2N1306	25p
2N1307	25p
2N1308	30p
2N1309	25p
2N1613	22p
2N1711	25p
2N2147	75p
2N2160	65p
2N2218	30p
2N2219	32p
2N2222	30p
2N2222A	37p
2N2369	20p
2N2484	35p
2N2646	50p
2N2904	30p
2N2904A	32p
2N2905	37p
2N2906	30p
2N2906A	32p
2N2907	37p
2N2926	12p
2N3011	25p
2N3053	25p
2N3054	50p
2N3055	75p
2N3525	£1·10
2N3702	12p
2N3703	12p
2N3704	17p
2N3705	15p
2N3707	15p
2N3709	12p
2N3710	12p
2N3819	35p
2N3820	60p
2N4058	17p
2N4061	15p
2N5457	35p
2N5458	37p
2N5459	50p
28301	50p
2S302	50p
2S303	60p
28304	75p
40250	50p
40361	55p
40362	60p
AAY30	10p
AAY42	15p
AAZ13	12p
AAZ17	10p
AC107	37p
AC126	25p
AC127	25p
AC128	25p
AC176	25p
AC187	30p
AC188	30p
ACY17	30p
ACY18	25p
ACY19	25p
ACY20	22p
ACY21	22p
ACY22	17p
ACY39	50p
ACY40	15p
AD140	50p
AD149	50p
AD161	37p
AD162	37p
AF114	25p
AF115	25p
AF116	25p
AF117	25p
AF118	62p
AF124	25p
AF125	20p
AF126	17p
AF127	17p
AF139	30p
AF178	47p
AF179	47p
AF180	52p
AF181	42p
AF186	40p
AF239	42p
ASY26	25p
ASY27	32p
ASY28	25p
ASY29	30p
ASY67	47p
ASZ21	42p
BA115	7p
BA164	10p
BAX13	6p
BAX16	7p
BAY31	7p
BAY38	17p
BC107	12p
BC108	12p
BC109	12p
BC113	25p
BC114	35p
BC115	32p
BC116	40p
BC116A	45p
BC118	37p
BC119	50p
BC134	37p
BC135	30p
BC136	35p
BC137	40p
BC138	40p
BC147	17p
BC148	12p
BC149	20p
BC154	37p
BC157	20p
BC158	17p
BC159	20p
BC177	25p
BC178	25p
BC179	27p
BCY30	25p
BCY31	30p
BCY32	50p
BCY33	25p
BCY34	30p
BCY38	40p
BCY39	60p
BCY40	50p
BCY41	15p
BCY42	15p
BCY43	20p
BCY58	25p
BCY59	25p
BCY70	20p
BCY71	30p
BCY72	15p
BCY78	30p
BCY79	30p
BCZ10	35p
BCZ11	40p
BD112	50p
BD121	65p
BD123	80p
BD124	80p
BD125	50p
BD131	75p
BD132	85p
BD153	62p
BD156	57p
BD131	75p
BDY10	£1·25
BDY11	£1·62
BDY17	£1·50
BDY18	£1·75
BDY19	£1·97
BDY61	£1·25
BDY62	£1·00
BF115	25p
BF152	30p
BF154	40p
BF158	30p
BF159	60p
BF167	25p
BF170	35p
BF173	30p
BF177	40p
BF178	25p
BF179	40p
BF180	37p
BF181	37p
BF182	32p
BF184	25p
BF185	25p
BF194	17p
BF195	15p
BF196	15p
BF197	15p
BF200	37p
BF274	37p
BFW87	25p
BFW88	23p
BFW89	20p
BFW90	22p
BFW91	20p
BFX13	25p
BFX29	30p
BFX30	32p
BFX37	32p
BFX84	30p
BFX85	40p
BFX86	32p
BFX87	32p
BFX88	30p
BFY18	30p
BFY50	22p
BFY51	20p
BFY52	22p
BFY53	17p
BFY64	42p
BFY90	65p
BSX20	17p
BSX21	37p
BSX76	15p
BSY95	15p
BSY95A	15p
BY100	15p
BY126	15p
BY127	20p
BY182	85p
BYZ10	40p
BYZ11	35p
BYZ12	30p
BYZ13	25p
BYZ15	£1·00
GET102	30p
GET111	40p
GET880	37p
GET882	25p
MAT100	25p
MAT101	30p
MAT120	25p
MAT121	30p
MJ2801	£1·37
MJ2901	£2·25
MJE370	97p
MJE520	87p
MJE2955	£1·37
MJE3055	87p
MPF102	42p
MPF103	35p
MPF104	37p
MPF105	40p
NKT213	25p
NKT214	15p
NKT216	37p
NKT217	40p
NKT277	20p
NKT403	75p
NKT404	62p
OA5	20p
OA9	10p
OA10	25p
OA47	10p
OA70	10p
OA73	10p
OA79	10p
OA81	10p
OA85	12p
OA90	10p
OA91	7p
OA95	7p
OA200	7p
OA202	10p
OC16	50p
OC20	97p
OC22	50p
OC23	60p
OC24	60p
OC25	37p
OC26	25p
OC28	62p
OC29	62p
OC35	50p
OC36	62p
OC41	25p
OC42	30p
OC43	40p
OC44	17p
OC45	15p
OC70	12p
OC71	15p
OC72	25p
OC73	30p
OC74	30p
OC75	25p
OC76	25p
OC77	40p
OC81	25p
OC82	25p
OC83	25p
OC84	25p
OC139	25p
OC140	37p
OC141	62p
OC170	25p
OC171	30p
OC200	40p
OC201	60p
OC202	75p
OC203	40p
OC204	40p
OC205	75p
OC206	90p
OC207	90p
OCP71	97p
ORP12	50p
ORP60	40p
ORP61	42p
ZTX107	15p
ZTX300	12p
ZTX500	20p
ZTX503	20p
ZTX531	30p

Discounts
10% 12+
15% 25+
20% 100+
Any one type

HENRY'S LOW COST INTEGRATED CIRCUITS

WE OFFER FROM STOCK AN EXCLUSIVE RANGE OF BRAND NEW CERAMIC FULL SPECIFICATION LOW COST TTL 7400 RANGE OF INTEGRATED CIRCUITS

Part No.	Description	Price 1-49	Price 50-99	Price 100-499	Price 500 +
7400	Quad 2—Input Nand Gate	25p	20p	18p	15p
7401	Quad 2—Input Nand Gate Open Collector	25p	20p	18p	15p
7402	Quad 2—Input Positive Nor Gate	25p	20p	18p	15p
7404	Hex Inverter	25p	20p	18p	15p
7405	Hex Inverter with Open Collector	25p	20p	18p	15p
7410	Triple 3-Input Nand Gate	250	20p	18p	15p
7430	Single 8-Input Nand Gate	25p	20p	18p	15p
7440	Dual 4-Input Buffer Gate	25p	20p	18p	15p
7441	BCD to Decimal Decoder and NIX Driver	£1·00	90p	80p	75p
7442	BCD to Decimal Decoder (TTL)	£1·00	90p	80p	75p
7450	Dual 2-Input and/or/not Gate—Expandable	25p	20p	18p	15p
7453	Single 8-Input and/or/not Gate—Expandable	25p	20p	18p	15p
7460	Dual 4-Input—Expandable	25p	20p	18p	15p
7470	Single JK Flip Flop—Edge Triggered	40p	35p	30p	25p
7472	Single Master Slave JK Flip Flop	40p	35p	30p	25p
7473	Dual Master Slave JK Flip Flop	45p	40p	35p	30p
7474	Dual D Flip Flop	45p	40p	35p	30p
7475	Quad Bistable Latch	50p	45p	40p	35p
7476	Dual Master Slave Flip Flop with Preset	50p	45p	40p	35p
7483	Four Bit Binary Counter	£1·00	90p	80p	75p
7490	BCD Decade Counter	£1·00	90p	80p	75p
7492	Divide by 12. 4 Bit Binary Counter	£1·00	90p	80p	75p
7493	Divide by 16. 4 Bit Binary Counter	£1·00	90p	80p	75p
7494	Dual Entry 4 Bit Shift Register	£1·00	90p	80p	75p
7495	4 Bit Up Down Shift Register	£1·00	90p	80p	75p
7496	5 Bit Shift Register	£1·00	90p	80p	75p

Data available for above series in booklet form, price 10p. *Larger quantity prices Extn. 4*
Dual Inline 14 Pin Sockets 30p each. 16 Pin 35p each.

TRIACS GENERAL ELECTRIC

(All stud mounting)

Type	P.I. Volts	Current	1-49	50 +	100 +	500 +
SC35A	100	3 amps	90p	75p	65p	60p
SC35B	200	3 amps	95p	80p	70p	65p
SC35D	400	3 amps	£1·00	85p	75p	70p
SC40A	100	6 amps	£1·00	85p	75p	70p
SC40B	200	6 amps	£1·20	£1·00	85p	80p
SC40D	400	6 amps	£1·25	£1·10	£1·00	90p
SC45A	100	10 amps	£1·25	£1·10	£1·00	90p
SC45B	200	10 amps	£1·35	£1·20	£1·10	£1·00
SC45D	400	10 amps	£1·50	£1·35	£1·20	£1·10
SC50A	100	15 amps	£1·65	£1·50	£1·35	£1·20
SC50B	200	15 amps	£1·75	£1·60	£1·45	£1·30
SC50D	400	15 amps	£2·00	£1·75	£1·60	£1·40
SC40E	500	6 amps	£1·50	£1·25	£1·10	£1·00
SC45E	500	10 amps	£1·75	£1·50	£1·35	£1·25
SC50E	500	15 amps	£2·25	£2·00	£1·75	£1·55

DIAC ST2 20p
Larger quantity prices on application Extn. 4

SILICON RECTIFIERS

1 AMP MINIATURE WIRE ENDED PLASTIC

Type	P.I.V.	1-49	50 +	100 +	500 +	1000 +
IN4001	50	8p	7p	6p	5p	4p
IN4002	100	9p	8p	7p	5½p	4½p
IN4003	200	10p	9p	7½p	6p	5p
IN4004	400	10p	9p	8p	7p	6p
IN4005	600	12p	10p	9p	7p	7p
IN4006	800	15p	14p	12p	11p	9p
IN4007	1000	20p	16p	13p	12p	10p

1·5 AMP MINIATURE WIRE ENDED PLASTIC

Type	P.I.V.	1-49	50 +	100 +	500 +	1000 +
PL4001	50	10p	9p	8p	7p	6p
PL4002	100	11p	10p	9p	8p	7p
PL4003	200	12p	11p	10p	9p	8p
PL4004	400	12p	11p	10p	9p	8p
PL4005	600	15p	13p	11p	10p	9p
PL4006	800	17p	15p	13p	12p	10p
PL4007	1000	20p	17p	15p	13p	11p

3 AMP PLASTIC WIRE ENDED RECTIFIERS

Type	P.I.V.	1-49	50 +	100 +	500 +	1000 +
PL7001	50	20p	18p	17p	16p	14p
PL7002	100	20p	19p	18p	17p	15p
PL7003	200	22p	20p	19p	18p	16p
PL7004	400	25p	23p	21p	20p	18p
PL7005	600	26p	24p	23p	22p	20p
PL7006	800	27p	25p	24p	23p	21p
PL7007	1000	30p	28p	26p	24p	22p

MINIATURE POTTED BRIDGE RECTIFIERS (Silicon) Size ¼ in. × ½ in. × ⅜ in.

Type	P.I.V.	Current	1-49	50 +	100 +	500 +
1002	100	2 amps	60p	55p	50p	45p
2002	200	2 amps	70p	65p	60p	55p
4002	400	2 amps	80p	75p	70p	65p
6002	600	2 amps	90p	80p	75p	70p
1004	100	4 amps	70p	60p	55p	50p
2004	200	4 amps	75p	70p	65p	60p
4004	400	4 amps	80p	75p	70p	65p
6004	600	4 amps	90p	80p	75p	70p
1006	100	6 amps	75p	70p	65p	60p
2006	200	6 amps	80p	75p	70p	65p
4006	400	6 amps	£1·10	£1·00	90p	80p
6006	600	6 amps	£1·25	£1·10	£1·00	90p

R.C.A. INTEGRATED CIRCUITS

Linear Types

CA3005	£1·20
CA3011	75p
CA3012	90p
CA3013	£1·10
CA3014	£1·45
CA3018	£1·10
CA3020	£1·25
CA3021	£1·55
CA3022	£1·30
CA3023	£1·25
CA3026	£1·00
CA3028A	£1·20
CA3035	£1·25
CA3036	90p
CA3039	85p
CA3041	£1·10
CA3042	£1·10
CA3043	£1·40
CA3044	£1·25
CA3045	£1·25
CA3046	85p
CA3048	£2·25
CA3051	£1·35

Application Notes 10p for each type

INTEGRATED CIRCUITS

MFC 4000P	Motorola	£1·12
I.C.10	Sinclair	£2·75
PA246	5 Watt	£2·45
TAA263	Mullard	75p
TAD100	Mullard	£1·97
TAD110	Mullard	£1·97
MC1303	Motorola	£2·60
UL900	Fairchild	40p
UL914	Fairchild	40p
UL923	Fairchild	60p
LA709C	Fairchild	75p
MC1304	Motorola	£2·75
PA230	G. Electric	£1·10
PA234	G. Electric	£1·00

Zener Diodes 400 M/W 5% Miniature
BZY 88 Range
All voltages 3·3 Volt-33 Volt.
15p each.
25 + …… 12p
100 + …… 10p
500 + …… 9p
1000 + …… 8p
Any one type.

Zener Diodes 1 Watt 5% Plastic Wire Ends
6·8 Volt all voltages to 100 Volts.
25p each.
25 + …… 20p
100 + …… 18p
500 + …… 16p
1000 + …… 15p
Any one type.

Zener Diodes 3 Watt Plastic Wire Ends 5%
All voltages 6·8-100 Volts. **30p** each.
25 + …… 27p
100 + …… 25p
500 + …… 23p
1000 + …… 21p
Any one type.

Zener Diodes 7 Watt Stud Mounting 5%
All voltages 5·1-100 Volts. **40p** each.
25 + …… 35p
100 + …… 30p
Any one type.

POWER RECTIFIERS

Stud Mounting 6 amp Range

	P.I.V.	1-49	50 +	100 +
BYZ10	800	40p	35p	30p
BYZ11	600	35p	30p	25p
BYZ12	400	30p	25p	20p
BYZ13	200	25p	20p	17p

10 amp Rectifiers

	P.I.V.	1-49	50 +	100 +
SK103	100	45p	40p	37p
SK203	200	50p	45p	42p
SK403	400	55p	50p	45p
SK603	600	60p	55p	50p
SK803	800	75p	70p	65p

SEMI-CONDUCTORS

LOOK AT THESE PRICES FOR QUANTITIES FROM STOCK

AF114 Mullard 25p
25 + 20p
100 + 17p
500 + 15p

AF116 Mullard 25p
25 + 20p
100 + 17p
500 + 15p

2N3055 55 75p
Mullard 115 watt Silicon Power
25 + 65p
100 + 55p
100 + 50p

BFY90 65p
1000 MC/S
25 + 60p
100 + 55p
500 + 50p
1000 + 45p

AF139 30p
Siemens V.H.F.
25 + 25p
100 + 22p..
500 + 19p
1000 + 17p

OC170 Mullard 25p
25 + 21p
100 + 17p
500 + 15p

OC171 Mullard 30p
25 + 27p
100 + 22p
500 + 20p

BY127 Mullard 20p
1000v 1 amp Plastic
25 + 17p
100 + 15p
500 + 13p

BC113 25p
SGS
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OA202 10p
SILICON Diodes
25 + 8p
100 + 6p
500 + 5p
1000 + 4p

OC42 Mullard 30p
25 + 25p
100 + 23p
500 + 21p
1000 + 18p

OC45 Mullard 15p
25 + 13p
100 + 12p
500 + 10p
1000 + 8p

OC75 Mullard 25p
25 + 21p
100 + 17p
500 + 15p
1000 + 13p

OC20 97p
Mullard 100v
25 + 85p
100 + 80p
500 + 75p

OC44 Mullard 17p
25 + 15p
100 + 13p
500 + 11p
1000 + 10p

OC139 Mullard 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC81 Mullard 25p
25 20p
100 + 17p
500 + 15p
1000 + 13p

AF115 Mullard 25p
25 + 20p
100 + 17p
500 + 15p

AF117 Mullard 25p
25 + 20p
100 + 17p
500 + 15p
20

2N3819 Texas 35p
25 + 30p
100 + 25p
500 + 23p
1000 + 20p
30

2N2646 50p
Motorola Unijunction
25 + 44p
100 + 37p
500 + 33p
1000 + 30p

AF186 40p
Mullard V.H.F.
25 + 35p
100 + 30p
500 + 25p
1000 + 23p
30

BYZ13 25p
Mullard 6a 200v
25 + 20p
100 + 17p
500 + 5p
1000 + 13p

BC107, BC108, BC109 12p each
I.T.T. Planars
25 + 11p
100 + 10p
500 + 8p
1000 + 6p
5

OCP71 97p
Mullard Photo
25 + 85p
100 + 80p
500 + 75p

OC28 62p
Mullard Power
25 + 55p
100 + 50p
500 + 42p
1000 + 40p

OC71 Mullard 15p
25 + 12p
100 + 10p
500 + 8p
1000 + 7p
10

ORP12 Mullard 50p
25 + 45p
100 + 42p
500 + 40p
1000 + 37p

2N930 25p
25 + 23p
100 + 20p
500 + 17p
1000 + 15p

OC72 Mullard 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p
15

OC83 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

OC84 25p
25 + 20p
100 + 17p
500 + 15p
1000 + 13p

AF239 42p
25 + 35p
100 + 30p
500 + 25p
1000 + 20p

HENRY'S RADIO LTD.

SEMI-CONDUCTOR DEPARTMENT
303 EDGWARE RD., LONDON, W2. TEL: 01-723 1008/9
CALLERS 356 EDGWARE ROAD W2.

NEW LIST - NEW PRICES
1971 TRANSISTOR
LIST 1000 +
SEND FOR YOUR FREE
COPY TODAY...

DISCOUNTS
10% 12+ ANY ONE
15% 25+ TYPE
POSTAGE 7p.
ALL ORDERS

We respectfully ask customers to include a minimum £1.00 per order, it helps to plan ahead & saves postage as well.

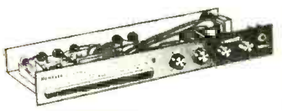
HENRY'S RADIO LIMITED

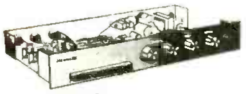
ENGLAND'S LEADING ELECTRONIC CENTRES

HENRY'S RADIO

HI-FI · COMPONENTS · TEST · PA · DISCOTHEQUE · ELECTRONIC ORGANS · MAIL ORDER

HENELEC SELF-POWERED PRE-AMPLIFIERS


IC STEREO


FET 154


FET9/4

Brochure No. 25 on request

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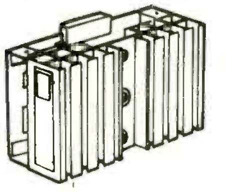

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PA 50 12 transistor version 50 watts Rms into 3 to 4 ohms. Size 5″ × 3″ × 4″.

MU 442. Power supply for one or two PA 25 or one PA 50.
PA 25 £7·50. p.p. 15p. **PA 50 £9·50.** p.p. 15p. **MU 442 £6·00** p.p. 25p.
All units. No soldering—just edge connectors and plugs.

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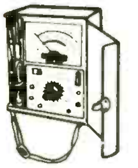

AF105 50k/volt multi-meter (illus.).
Price £8·50 p.p. 20p
Leather case **£1·42**

200H 20k/volt.
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Case **62p**

500 30k/volt multi-meter
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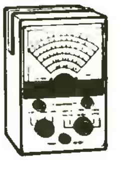

THL 33 2k/volt.
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Leather case **£1·15**

TE65 Valve voltmeter (illus.) **£17·50** p.p. 40p

VM51 Transistorised AF/RF millivoltmeter.
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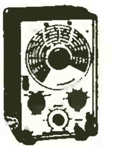
TE22 Audio Generator.
Price £17.00 p.p. 35p.



TE20D RF generator (illus.). **Price £15·00** p.p. 35p

TE22D Matching audio generator.
Price £17·00 p.p. 35p

TE15 Grid dip meter.
Price £12·50 p.p. 20p

TO3 Scope (illus.). 3″ tube. 1·5 Mc/s.
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***C1-5** Scope. 3″ tube 10 Mc/s PB.
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***C1-16** Double beam scope. **Price £87·00** p.p. 50p
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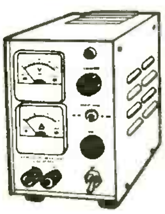

RP40 (Illus.) Variable 5-20v. 0-2 amps. **Price £25·50** p.p. 47p

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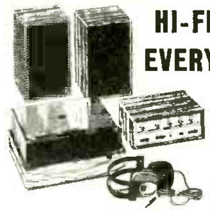

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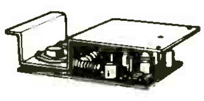

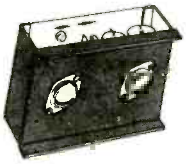

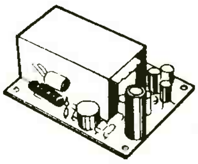

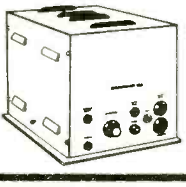

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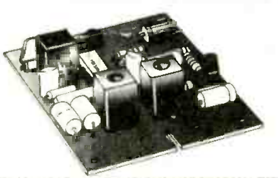

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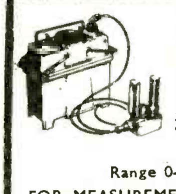

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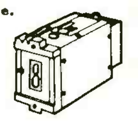

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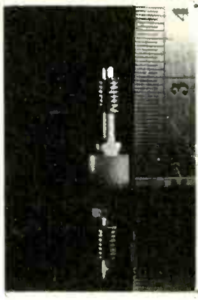

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2N918	0·30	2N3710	0·11	40347	0·57½	BC183L	0·10	BSX26	0·45½	NKT401	0·87½
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2N930	0·27½	2N3713	1·87½	40360	0·42½	BC212L	0·12½	BSX28	0·32½	NKT403	0·75
2N987	0·52½	2N3714	2·00	40361	0·47½	BCY10	0·27½	BSX60	0·82½	NKT404	0·62½
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2N1306	0·25	2N3855	0·27½	40467A	0·57½	BCY40	0·37½	BSY26	0·17½	NKT677F	0·30
2N1307	0·25	2N3855A	0·30	40468A	0·35	BCY42	0·15	BSY27	0·17½	NKT713	0·20
2N1308	0·30	2N3856	0·30	40528	0·72½	BCY43	0·15	BSY28	0·17½	NKT717	0·42½
2N1309	0·30	2N3856A	0·35	40600	0·57½	BCY54	0·32½	BSY29	0·17½	NKT734	0·27½
2N1507	0·17½	2N3858	0·25	40603	0·50	BCY58	0·22½	BSY32	0·25	NKT736	0·35
2N1613	0·25	2N3858A	0·30	AC107	0·30	BCY59	0·22½	BSY36	0·25	NKT773	0·25
2N1631	0·35	2N3859	0·27½	AC126	0·20	BCY60	0·97½	BSY37	0·25	NKT781	0·30
2N1632	0·30	2N3859A	0·32½	AC127	0·25	BCY70	0·20	BSY38	0·22½	NKT10339	0·32½
2N1637	0·30	2N3860	0·30	AC128	0·20	BCY71	0·42½	BSY39	0·22½	NKT10419	0·30
2N1638	0·27½	2N3866	1·50	AC154	0·22½	BCY72	0·17½	BSY40	0·32½	NKT10439	0·37½
2N1639	0·27½	2N3877	0·40	AC176	0·25	BCZ10	0·27½	BSY51	0·32½	NKT10519	0·32½
2N1701	1·62½	2N3877A	0·40	AC187	0·62½	BCZ11	0·42½	BSY52	0·32½	NKT20329	0·47½
2N1711	0·25	2N3900	0·37½	AC188	0·37½	BD116	1·12½	BSY53	0·37½	NKT20339	0·37½
2N1889	0·32½	2N3900A	0·40	ACY17	0·27½	BD121	0·65	BSY54	0·40	NKT80111	0·77½
2N1893	0·37½	2N3901	0·97½	ACY18	0·25	BD123	0·82½	BSY56	0·90	NKT80112	0·97½
2N2147	0·82½	2N3903	0·35	ACY19	0·25	BD124	0·60	BSY78	0·47½	NKT80113	1·12½
2N2148	0·57½	2N3904	0·35	ACY20	0·25	BD131	0·97½	BSY79	0·45	NKT80211	0·92½
2N2160	0·57½	2N3905	0·37½	ACY21	0·25	BD132	0·97½	BSY82	0·52½	NKT80212	0·92½
2N2193	0·40	2N3906	0·37½	ACY22	0·20	BDY10	1·37½	BSY90	0·57½	NKT80213	0·92½
2N2193A	0·42½	2N4058	0·17	ACY28	0·20	BDY11	1·62½	BSY95A	0·12½	NKT80214	0·92½
2N2194A	0·30	2N4059	0·10½	ACY40	0·20	BDY17	1·50	BSW41	0·42½	NKT80215	0·92½
2N2217	0·27½	2N4060	0·12½	ACY41	0·25	BDY18	1·75	BSW70	0·27½	NKT80216	0·92½
2N2218	0·32½	2N4061	0·12½	ACY44	0·40	BDY19	1·97½	C111	0·75	OC20	0·75
2N2219	0·32½	2N4062	0·12½	AD140	0·52½	BDY20	1·12½	C424	0·27½	OC22	0·50
2N2220	0·25	2N4244	0·47½	AD149	0·57½	BDY38	0·97½	C425	0·55	OC23	0·50
2N2221	0·25	2N4245	0·42½	AD150	0·62½	BDY60	1·25	C426	0·40	OC24	0·50
2N2222	0·30	2N4254	0·42½	AD161	0·37½	BDY61	1·25	C428	0·37½	OC25	0·42½
2N2287	1·07½	2N4255	0·42½	AD162	0·37½	BDY62	1·00	C744	0·30	OC26	0·27½
2N2297	0·30	2N4284	0·17½	AF106	0·42½	BF115	0·25	D16P1	0·37½	OC28	0·62½
2N2368	0·17½	2N4285	0·17½	AF114	0·25	BF117	0·47½	D16P2	0·40	OC29	0·62½
2N2369	0·17½	2N4286	0·17½	AF115	0·30	BF163	0·37½	D16P3	0·37½	OC35	0·50
2N2369A	0·17½	2N4287	0·17½	AF116	0·25	BF167	0·25½	D16P4	0·40	OC36	0·62½
2N2410	0·42½	2N4288	0·17½	AF117	0·25	BF173	0·32½	GET102	0·30	OC41	0·22½
2N2483	0·27½	2N4289	0·17½	AF118	0·62½	BF177	0·32½	GET113	0·20	OC42	0·25
2N2484	0·32½	2N4290	0·17½	AF119	0·20	BF178	0·52½	GET114	0·20	OC44	0·20
2N2539	0·22½	2N4291	0·17½	AF124	0·22½	BF179	0·72½	GET118	0·20	OC45	0·12½
2N2540	0·22½	2N4292	0·12½	AF125	0·20	BF180	0·35½	GET119	0·20	OC46	0·15
2N2613	0·35	2N4303	0·47½	AF126	0·20	BF181	0·32½	GET120	0·52½	OC70	0·15
2N2614	0·30	2N5027	0·52½	AF127	0·17½	BF184	0·25	GET873	0·12½	OC71	0·12½
2N2646	0·57½	2N5028	0·57½	AF139	0·37½	BF185	0·42½	GET880	0·30	OC72	0·12½
2N2696	0·32½	2N5029	0·47½	AF178	0·42½	BE194	0·17½	GET887	0·20	OC74	0·32½
2N2711	0·25	2N5030	0·42½	AF179	0·72½	BF195	0·20	GET889	0·22½	OC75	0·22½
2N2712	0·25	2N5172	0·12½	AF180	0·52½	BF196	0·42½	GET890	0·22½	OC76	0·22½
2N2713	0·27½	2N5174	0·52½	AF181	0·42½	BF197	0·42½	GET896	0·22½	OC77	0·30
2N2714	0·30	2N5175	0·52½	AD239	0·42½	BF198	0·42½	GET897	0·22½	OC81	0·20
2N2865	0·62½	2N5176	0·45	AF279	0·47½	BF200	0·52½	GET898	0·22½	OC81D	0·22½
2N2904	0·30	2N5232A	0·30	AF280	0·62½	BF224	0·20	MJ400	1·07½	OC83	0·25
2N2904A	0·32½	2N5245	0·45	AF211	0·32½	BF225	0·20	MJ420	1·12½	OC84	0·25
2N2905	0·37½	2N5246	0·42½	ASY26	0·25	BF237	0·22½	MJ421	1-12½	OC139	0·32½
2N2905A	0·40	2N5249	0·67½	ASY27	0·37½	BF238	0·22½	MJ430	1·02½	OC140	0·32½
2N2906	0·25	2N5265	3·25	ASY28	0·27½	BF244	0·32½	MJ440	0·95	OC170	0·30
2N2906A	0·27½	2N5266	2·75	ASY29	0·27½	BFW61	0·47½	MJ480	0·97½	OC171	0·30
2N2907	0·30	2N5267 -	2·62½	ASY26	0·25	BFX12	0·22½	MJ481	1·25	OC200	0·37½
2N2923	0·15	2N5305	0·37½	ASY50	0·25	BFX13	0·22½	MJ490	1·00	OC201	0·47½
2N2924	0·15	2N5306	0·40	ASY51	0·32½	BFX29	0·30	MJ491	1·37½	OC202	0·62½
2N2925	0·15	2N5307	0·37½	ASY53	0·25	BFX30	0·30	MJ1800	2·17½	OC203	0·42½
2N2926		2N5308	0·37½	ASY54	0·25	BFX43	0·37½	MJE340	0·62½	OC204	0·42½
Green	0·14	2N5309	0·62½	ASY62	0·25	BFX44	0·37½	MJE520	0·87½	OC205	0·62½
Yellow	0·12½	2N5310	0·42½	ASY63	0·17½	BFX51	0·20	MJE521	0·87½	OC207	0·75
Orange	0·12½	2N5354	0·27½	ASY72	0·25	BFX68	0·67½	MPF102	0·42½	OCP71	0·42½
2N3011	0·30	2N5355	0·27½	ASY83	0·25	BFX84	0·25	MPF103	0·37½	ORP12	0·62½
2N3014	0·32½	2N5356	0·32½	ASY86	0·32½	BFX85	0·32½	MPF104	0·37½	ORP61	0·50½
2N3053	0·25	2N5365	0·47½	ASZ20	0·37½	BFX86	0·25	MPF105	0·37½	P346A	0·22½
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2N3055	0·75	2N5367	0·57½	AUY10	1·50	BFX88	0·25	NKT0013	0·47½	TIS43	0·40½
2N3133	0·30	2N5457	0·37½	BC107	0·12½	BFX89	0·62½	NKT124	0·42½	TIS44	0·12½
2N3134	0·30	2S005	0·75	BC108	0·12½	BFX93A	0·70	NKT125	0·27½	TIS45	0·12½
2N3135	0·25	2S020	2·00	BC109	0·12½	BFY10	0·32½	NKT126	0·27½	TIS46	0·12½
2N3136	0·25	2S102	0·50	BC113	0·27½	BFY11	0·42½	NKT128	0·27½	TIS47	0·12½
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2N3349	1·30	2S104	0·25	BC115	0·40	BFY18	0·32½	NKT137	0·32½	TIS49	0·12½
2N3390	0·25	2S501	0·32½	BC116	0·62½	BFY19	0·32½	NKT210	0·30	TIS50	0·17½
2N3391	0·20	2S502	0·35	BC116A	0·37½	BFY20	1·60	NKT211	0·30	TIS51	0·12½
2N3391A	0·30	2S503	0·27½	BC118	0·32½	BFY21	0·42½	NKT212	0·30	TIS52	0·12½
2N3392	0·17½	3N83	0·40	BC121	0·20	BFY24	0·45	NKT213	0·30	TIS53	0·22½

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500-0-500	,,	1·25
1	Milliamp	1·25
5	,,	1·25
10	,,	1·25
50	,,	1·25
100	,,	1·25
500	,,	1·25
1	Amp	1·25
5	,,	1·25
10	Volts	1·25
20	,,	1·25
50	,,	1·25
300	,,	1·25
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PIV	50	100	200	400	600	800	1000	1200	1400
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1A	0·10	0·12½	0·15	0·16	0·17½	0·19	0·20	—	—
3A	0·15	—	—	0·22½	—	0·30	—	—	—
6A	—	—	0·25	0·30	0·32½	0·35	0·50	—	—
10A	—	0·52½	0·57½	0·65	0·77½	0·87½	0·97½	1·25	1·60
17A	—	0·57½	0·62½	0·77½	0·90	0·97½	1·20	1·57½	1·87½
35A	—	1·37½	1·60	1·97½	2·37½	2·70	3·10	3·50	4·50

* 5 amp only. 1 amp and 3 amp are plastic encapsulation.

DIODES AND RECTIFIERS

IN914	0·07½	AAZ17	0·12½	BAY38	0·25	OA5	0·17½
IN916	0·07½	BA100	0·15	BY100	0·17½	OA10	0·22½
IN4007	0·22½	BA102	0·22½	BY103	0·22½	OA9	0·10
IS44	0·10	BA110	0·32½	BY122	0·37½	OA47	0·07½
IS113	0·15	BA115	0·07½	BY124	0·15	OA70	0·07½
IS120	0·15	BA141	0·32½	BY126	0·15	OA73	0·10
IS121	0·17½	BA142	0·32½	BY127	0·17½	OA79	0·09
IS130	0·12½	BA144	0·12½	BY164	0·57½	OA81	0·07½
IS131	0·12½	BA145	0·20	BYX10	0·22½	OA85	0·07½
IS132	0·15	BA154	0·12½	BYZ10	0·35	OA90	0·07½
IS940	0·07½	BAX13	0·12½	BYZ11	0·32½	OA91	0·07½
AA119	0·10	BAX16	0·12½	BYZ12	0·30	OA95	0·07½
AA129	0·10	BAY18	0·17½	BYZ13	0·25	OA200	0·10
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4	10	0·07½	50	12	0·07½	640	16	0·17½
4	40	0·07½	50	25	0·07½	1000	16	0·25
4	350	0·11	50	50	0·10	1000	25	0·25
5	18	0·07½	64	25	0·07½	1000	50	0·37½
5	50	0·07½	80	16	0·07½	2000	25	0·42½
6·4	6·4	0·07½	80	25	0·07½	2000	50	0·62½
8	40	0·07½	100	6·4	0·07½	2500	12	0·25
8	450	0·15	100	12	0·07½	2500	25	0·47½
10	12	0·07½	100	25	0·10	2500	50	0·67½
10	25	0·07½	100	50	0·12½	2500	64	0·77½
12·5	25	0·07½	125	10	0·07½	3000	25	0·52½
16	10	0·07½	200	10	0·07½	4000	100	2·37½
16	15	0·07½	250	25	0·14	4500	64	2·25
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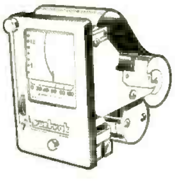

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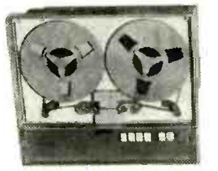

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MOTORS

LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enable relative high inertia loads to be driven up to 6-oz/in. Available in the following speeds and ranged: 240V 50 Hz 1½ r.p.m., 1/5 r.p.m., 1/12 r.p.m., 1/20 r.p.m., 1/60 r.p.m. 120V 50 Hz 1/6 r.p.m., 1/15 r.p.m., 1/16 r.p.m., 1/24 r.p.m., 1/3 r.p.m., 1/240 r.p.m., 1/300 r.p.m., 1/720 r.p.m., 1 r.p.m. M.P.10 Induction Motor. 120V 50 Hz 20 r.p.m. **£1·50** P. & P. inclusive.

CLUTCH MOTORS

240V 50 Hz 1/12 r.p.m., 1/6 r.p.m., 1/3 r.p.m. 120V 50 Hz 1/12 r.p.m., 1/10 r.p.m., 1/6 r.p.m., 5/12 r.p.m., 4/11 r.p.m., 1 r.p.m., 2 r.p.m. 120V 60 Hz 1/5 r.p.m., 1 r.p.m. **£1·50**. P. & P. inclusive.

WELDING POWER SUPPLY—Hughes Model

MCW 550. Constant voltage. Weld voltage and duration controls. Mains input. Price on application.

NEW LOW INERTIA INTEGRATING MOTORS

Electro-Methods Model. 901 and 906 PL. Permanent magnet D.C. Motor. High sensitivity. Ideal for instrument-type servo mechanisms, light loads driving mechanical counters performing integration, or as small power generators. Will operate directly off a photo-cell or thermo couple, etc. 6V. Nominal. Typical parameters. Starting voltage (no load) 15 mV at 0·375 mA. Full load speed 1845 r.p.m. (approx.). Moment of Inertia of Armature 1·8 gr. cm/cm. Weight of Motor 300 gms (approx.). **£15**. P. & P. included.

SPLIT-FIELD D.C. SERVO MOTOR

Evershed and Vignoles Type. FAE 2/C/B, FB5A/A1/B, FEX25/CG/30, FB6A/P1/B, FAD6/G4/BD, FB5/A1, FE16/C. **£13·50**. P. & P. included.

NEW D.C. STEPPING MOTOR

"Slo-Syn." 14V 0·53A 50 oz in torque.
BIFILAR Synchronous Motor. Stepping duty 200 steps/shaft revolution. Each step 1·8 degrees ± 3% accuracy. Non-cumulative. Made by Superior Electric Co., U.S.A. **£16·50**. P. & P. included.

E.H.T. GENERATOR, BRAND NEW D.C. CONVERTER MULLARD TYPE 1049

Input 12V D.C. 0·3A. Output 1800V (Min) at 1 mA, 2500V (Min) on No Load. Full spec. and circuit provided. Encapsulated module L. 5in., W. 2¼in., H. 1¾in. **£5·50**. P. & P. included.

MIDGET POWER RELAY ... Type Mk 1 (OMRON)

200V 50 Hz Coil, 1 pole double throw. Unused. Faulty plating on frame.
5 for **£1·50**. P. & P. included.

SYNCHRONOUS MOTORS

Model S 71 r.p.h. and 1/60 r.p.h. Self starting complete with gearing shaft ¼ in. dia. ¼ in. long, 200/250V 50 Hz. New condition Ex-Equipment. **£1·50**. P. & P. included.

D.C. TACHOGENERATOR

Type 9c/106 16v. at 1000 r.p.m. Drive shaft dia. 3/16 in., 3/8 in. long. Price **£16·50**. P. & P. inclusive.

R.F. ATTENUATOR MARCONI TF 1073A

DC—150 MHz 1dB steps 75 Ohms. Double Screened construction. Tested and in VG condition. **£25**.

ACTUATOR

By English Electric. Type 4519 Mk. 1 D.C. Motor AE 1560 Mk. 1 28V 3A. 500 r.p.m. Intermittent rating. **£16**. P. & P. inclusive.

ACCELEROMETERS

Model LA 2 3C Potentiometric + or — 10 G operating Voltage 30V. Nominal resistance 17.5K and Model LA 2 3C + or — 100G 34V, Rel 20 K. Price **£26**. P. & P. 5/-.

TYPE SE 55/A Range + or — 1G **£26**. P. & P. 5/-.
TYPE F by G.E.C. Up to 1,000 G. Ceramic type giving o/p of 23 mV. Supplied c/w technical leaflet. Weight 14.8 grammes. 2BA stud mounting. **£3.15.0**. P. & P. 5/-.
Many other types in stock

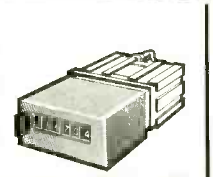
COUNTERS

Many other types of counters are available ranging from 3-6 digit with various supply voltages. Ring our Sales Office for further information.

TEKTRONIX Plug in Unit Type E—BRAND NEW. Price **£75** P. & P. 50p. Also Type 80 £25

Manufacturer	Type	No. of Digits	Impulses per sec.	Reset	Operating Volt	Operating Current	Size	Ref.	Remarks	Price £
Sedeco	ATCEZ3E	3	10	M.	48V D.C.	48mA	4"L×1"×⅞"	C.2		3·00
Sedeco	ATCEZ4E	4	25	M	60V D.C.	100mA	1½"×1"×4"L	C.6	600 Ω coil new 1000 Ω coil used	2·50 1·50
Sedeco	ATCEF4E	4	10	E/12V D.C.	12V D.C.	120mA	4"L×2⅜"×1⅜"	C.5	New .. .. Used	5·25 1·50
Sedeco	ATCEF5E	5	25	E/24V D.C.	24V D.C.	240mA	4"L×1½"×2½"		New	6·00
Sedeco	ATCEZ5E	5	25		160V				Coil 100K. New ..	6·00
Sedeco	T1F5 PIEH	5	10	M	110V 50Hz		4½"L×5⅛"×5⅛"		2 banks of 5 digits each bank independent. Used	8·00
Sedeco	ITPB3	6	10	M. & E.	240V 50Hz				Print out—Totalising	40·00
Counting Instrument	1506	4	15		24V D.C.			C.3	Each digit independently set, counts down to zero operating main switch	6·50
,,	429	4	15	E/240V 50Hz	24V D.C.			C.12		4·12½
,,	120	6	15	E/24V D.C.	24V D.C.		3⅜"L×3½"×½"			4·75
,,	101A	6		M.	48V D.C.		4"W×2⅜"×2½L		Used	3·12½
Veeder Root	BD134545	5							Mechanical operation. Ratchet reset Inverse Nos.	0·62½
,, ,,		6		M.	160V D.C.					2·75
,, ,,	B38	6		M.	48V D.C.					2·75
,, ,,		6			110V D.C.					2·00
,, ,,		6		M.	230V 50Hz					2·75
,, ,,		6		M.	24V D.C.					2·00
Haztler		6		M.	24V D.C.				500 Ω coil. New ..	4·50
,,		6		M/E 110V D.C.	110V D.C.				1100 Ω/800 Ω. Used	2·45

BRAND NEW ELECTRO-MAGNETIC COUNTER



A high precision counter offered at a fractional cost of other manufacturers of similar type. High counting speed. 25 impulse/sec. 6 digit display. 24 volt D.C. supply. 2·75 watts. 840 ohms. Size: 100mm×50mm×26mm. Immediate delivery. **£4·50**. (Carriage extra.) Other various voltage and impulse rates available. Phone or write for details.

NUMICATORS

End Reading	Quantity	Price Each (Less Base)	Price Base
GRIOM/U (Clear)	1– 3	(£1·40) 28/–	Bases
	4– 10	(£1·35) 27/–	(20p)
	11– 25	(£1·30) 26/–	4/–
	26–100	(£1·20) 24/–	Each

Side Reading			Quantity	Less Bases
XN3/FA	38 m/m lead	(Amber) ..		
XN3/F	38 m/m lead	(Red) ..	1– 3	(£1·15) 23/–
XN3A/F	6 m/m lead	(Red) ..	4– 10	(£1·10) 22/–
XN3A	6 m/m lead	(Clear) ..	11– 25	(£1·05) 21/–
XN11/F	38 m/m lead	(Red) ..	26–100	(£0·95) 19/–
XN23/FA	38 m/m lead	(Amber) ..		

Post Free

EICHNER 8 HOLE PUNCH

No motor drive required. Solenoid operated equipment using 48v Reader **£29·50**; Punch **£49·50**. Carriage £1·25.

7 HOLE NON PARITY TAPE PUNCH

New condition.

LOW SPEED 7 HOLE TAPE PUNCH

60 characters per second by well-known manufacturer.

TELETYPE 8 HOLE PAPER PUNCH BRPE11 £260.

Also available 5 hole punch BRPE2 as above. This model has interchangeable heads. Complete with spooler. Price **£75**.

5/7 HOLE OPTICAL READER BY FERRANTI

20 characters per second. £20.

(I83) **SIGNAL GENERATOR CT 480 SANDERS.** Range 7 KHz-12 KHz. O/p. 0-±50V. Attenuation range —10 to +100 dB. Price **£85**

TRANSDUCER OSCILLATOR-AMPLIFIER-DEMODULATOR. An. encapsulated unit for matching with S.E. Transducers. Suitable where space or adverse environmental conditions prevail. Supplied with a matching transducer a typical o/p is ± 3V into 50KOhms. Supply voltage 12v. D.C. Range of transducers available 0-50: 0-750: 0-1000: 0-4000 psi..............................Price **£65**

TRANSDUCER—New Resistive Bordon Tube Principle pressure Transducer by K.D. Instrument. Model TD 216 0-2000 psi. Ref. C. 6..............................Price **£15**

TRANSDUCER NEW EX-GOVERNMENT DISPLACEMENT BONDED RESISTANCE STRAIN GAUGES. Range ± ⅛ mechanical displacement equivalent to 0.3% resistive change. 3.5 + 3.5 KOhms. Model IT-2-31-35.............................. Price **£10**

OSCILLATOR. High discrimination, by Marconi T.F. 1168. This instrument suitable for H.F. Communication. Due to its high discrimination makes it suitable for crystal filter response in Tx and Rx drive units. Frequency range 90-110 KHz. 2Hz discrimination. Crystal and Standardised centre frequency. Calibration accuracy ± 1% Ref. I.5..............................Price **£135**

RECORDERS 4 PEN OSCILLOGRAPHS SOUTHERN INSTRUMENTS M942C. 4 Channel fitted with 4 speed gear boxes giving 1, 5, 25, 100 m.m. per sec. Frequency response 0-55 Hz, sensitivity 0/m.m./M.A..............................Price **£150**
2 PEN OSCILLOGRAPH MR450 as per 4 Pen. Ref. I.2. .Price **£90**
PLUS CARRIAGE

E.M.I.

Portable L.F. Tape Recorder. Ex-service equipment consisting of Three Unit housed in transit cases (Tape Deck, Amplifier, P.S.U.). ¼ in. track speed 30 in., 15 in., 7½ in. and ¼ in. min. Price **£75**. Many control facilities. This is a good quality recorder.

ELECTRONIC BROKERS LTD

EQUIPMENT AND COMPONENTS

MEASURING INSTRUMENTS AND RECORDERS

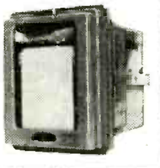
MULTIMETER TYPE CT471B

Fully transistorized multi-range instrument for measurement of voltage up to 1000 MHz (1500 MHz with reduced accuracy) and current up 2 kHz and D.C. Resistance A.C. and D.C. voltage and current divided into 11 ranges.
A.C./D.C. Volts 12mV-1200V.
A.C./D.C. Current 12 micro A-1·2A.
D.C. Resistance 5 ranges 0·1 ohm-1000 M ohm.
R.F. Voltages 5 range 40mV to 4V.
Battery powered. Offered in excellent condition. Tested before despatch. Complete with handbook. **£54.** Carriage 10/-.

FACSIMILE RECORDERS

D649 K 18 in. Chart Recorder. Helix speed: 60, 90, 120 rev./min. Transmission speed: ⅜ in.; 15/16 in.; 1⅞ in. per min. Scanning rate 96 lines/in.
Ref. C.3........ Price **£350.** Completely overhauled + carriage

SINGLE PEN RECORDER
By Record Electrical (R3)



3 in. chart, sensitivity 1 mA. Coil resistance 1·53k. Fully interchangeable gears available to make a wide range of chart speeds. 200/250V. Size: 8×11×6 in. Almost new—complete with chart and ink. List over £100.
Our price .... **£49·50**

POWER SUPPLY UNITS

O/P V	O/P A	S or U*	Input volt.	Make	Type	Dimensions W H L inches	Location	Ref. No.
6 adj 4-16v	7	S	240	£30 Coutant	ELV700/6	6½×5½×11½	876	36
6 adj 3-15v	5	S	240	£25 Coutant	ELV500/6	4½×7 ×12	876	37
4-15v	5	S	240	£20 Advance	PM7	4⅜×5½× 9½	876	38
12	1	S	240	£15 Farnell	SSU12-1	4 ×6×10$\frac{5}{16}$	876	39
± 200	150 mA	S	240	£12 Roband	B101/200	7½×6½× 9	876	40
28 adj 26-37	7	S	240	£30 Coutant	ES700/28	8½×7 ×12	875	42
+30 −20	300 mA	S	240	£10 B.P.L.	3	19×8½×12	875	41
12	20	S	110	£25 I.B.M.	Ex. comp.	6 ×5½×16	879	66
12	20	S	110	£25 I.B.M.	Ex. comp.	6 ×5½×16	878	70
12	20	S	110	£25 I.B.M.	Ex. comp.	6 ×5½×16	878	57
12	20	S	110	£25 I.B.M.	Ex. comp.	6 ×5½×16	878	56
12	20	S	110	£25 I.B.M.	Ex. comp.	6 ×5½×16	878	59
12	20	S	110	£25 I.B.M.	Ex. comp.	6 ×5½×16	878	58
12	20	S	110	£25 I.B.M.	Ex. comp.	6 ×5½×16	877	67
6	16	S	110	£23 I.B.M.	Ex. comp.	6 ×5½×13½	879	54
48	6	S	110	£19·50 I.B.M.	Ex. comp.	6 ×5½×16	879	55
30	7	S	110	£17 I.B.M.	Ex. comp.	6 ×5½×13½	879	62
12	15	S	110	£22·50 I.B.M.	Ex. comp.	6 ×5½×13½	879	64
12	12	S	110	£22 I.B.M.	Ex. comp.	6 ×5½×13½	874	60
12	12	S	110	£22 I.B.M.	Ex. comp.	6 ×5½×13½	874	61
20	6	S	110	£18 I.B.M.	Ex. comp.	6 ×5½×13½	874	65
6	8	S	110	£12·50 I.B.M.	Ex. comp.	6 ×5½× 9½	874	68
6	8	S	110	£12·50 I.B.M.	Ex. comp.	6 ×5½× 9½	874	63
12	4	S	110	£18 I.B.M.	Ex. comp.	6 ×5½× 9½	874	72
12	4	S	110	£18 I.B.M.	Ex. comp.	6 ×5½× 9½	874	71
6	8	S	110	£12·50 I.B.M.	Ex. comp.	6 ×5½× 9½	874	69
20 −10 −10	4½ 4 300 mA	U/S S S	240	£25 Power Electronics	SP110	8 ×6 ×13½	877	43
Do.	Do.	Do.	240	Do.	Do.	Do.	877	44
48	4	U/S	240	£18·50 Advance	DC8	5½×6 ×17	877	80
24	5	U/S	240	£18·50 Advance	DC22	5½×6 ×17	873	73
48	2	U/S	240	£15 Advance	DC122	5½×6 ×17	866	74
12/15	5	S	240	£25 Advance	DCR12/12	5½×8 ×17	873	53
6	20	S	240	£45 Coutant	R205	19×8¾×13½	873	51
+ 6 − 6	10 2	S	240	£45 Coutant	R206	19×7 ×12	873	47
28	20	S	240	£50 Coutant	R204	19×8¾×14	870	85
190- 350	250 mA	S	240	£16·50 Airmec	705	19×12× 8½	872	52

* = Stab./Unstab.
This is a small selection of our range. Further details on application.

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION (Ref. C5)
BRAND NEW

Res. Ohms	Linearity Per cent	Manufacturers	Model	Price
100/100/100		Beckman	A	£8·00
100	0·5	Beckman	A.S	£3·00
200	0·5	Beckman	A	£3·00
500	0·1	Beckman	S	£3·50
500		Colvern	2501	£2·25
500		Foxes	PX4	£2·00
500		Colvern	2610	£2·50
500		Colvern	26/1000/11	£3·00
500	1·0	Relcon	HEL107-10	£2·25
1K		Relcon	HEL0710	£2·25
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07-10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·5	Beckman	A	£3·00
10K	0·1	Beckman X	A	£3·50
10K	0·1	Colvern	CLR26/1001	£3·50
15K		Colvern	CLR2402	£3·00
18K		Beckman	A	£3·00
25K	0·5	Helipot	SA1337	£3·00
29K	0·05	Beckman	SA1244	£4·50
30K		Colvern	2402	£1·50
30K		Beckman	SA95C	£3·00
30K	0·1	Beckman	A.88	£3·50
30K	0·5	Beckman	SA1692	£3·00
30K	0·25	Beckman	SA1679	£3·25
30K	1·0	Colvern	2402/1	£1·50
50K		Reliance	07·10	£2·25
50K			07·5	£2·25
50K		Colvern	2503	£2·25
50K	X	Foxes	PX4	£2·25
50K	0·5	Beckman	A	£3·00
50K	0·1	Beckman	A	£3·50
100K/100K		Ford	A	£5·00
100K	0·1	Beckman	A	£3·50
100K	0·5	Beckman	A	£3·00
100K		Colvern	2501	£2·25
100K		Colvern	2610	£2·50
298K	0·1	Beckman	SA3902	£3·50
300K	0·1	Beckman	A	£3·50

THREE TURN 780° ROTATION

100/100	0·5	Beckman	C	£3·00
100/100		Beckman	Type C	£3·00
300		Beckman	9303	£2·25
1K		Fox	PX2/H3	£2·25
10K	0·5	Beckman	C.ss	£2·25
20K/20K	0·1	Beckman	C.S	£3·00
10K/10K	0·1	Beckman	C	£3·00
50K	0·5	Beckman	C.S	£1·75

FIFTEEN TURN 5400° ROTATION

25K/25K	Beckman B	10 watts	£6·50
46K/46K	Beckman B	10 watts	£6·50

TWENTY TURN 7200° ROTATION

1 Meg	General Controls	PXM130	£4·00
50K	Reliance		£2·00

156 TURN 56160° ROTATION

460	Kelvin Hughes	KTP0701	£9·50

FIVE TURN 1800° ROTATION

200	Relcon	HEL07·05-F/11	£2·25
500	Colvern	CLR2505	£2·00
U1·5K	Colvern	CLR2605	£2·00

FIVE-AND-A-HALF TURN

500	Colvern	2405	£2·00

TRIM POTENTIOMETERS (Ref. C7)

Just in Dobie McInnes Digital Analogue Converter and Plotter. (Ref. I.I)

Manufacturer	Value	Connection	Price
PAIGNTON	5 ohms	P.C.	50p
AMPHENOL	5 ohms	P.C.	50p
PAIGNTON	10 ohms	P.C.	50p
AMPHENOL	20 ohms	—	50p
AMPHENOL	50 ohms	—	50p
AMPHENOL	70 ohms	T.C. Turret Lugs	50p
AMPHENOL	75 ohms	P.C.	50p
MICROPOT	100 ohms	—	50p
AMPHENOL	200 ohms	P.C.	50p
AMPHENOL	250 ohms	P.C.	50p
AMPHENOL	300 ohms	P.C.	50p
PAIGNTON	500 ohms	T.C.	50p
AMPHENOL	600 ohms	P.C.	50p
PAIGNTON	1 Kohms	P.C.	75p
AMPHENOL	2 Kohms	P.C.	75p
PAIGNTON	2·5 Kohms	P.C.	75p
AMPHENOL	2·5 Kohms	T.C.	75p
AMPHENOL	3 Kohms	T.C.	75p
BOURNES	5 Kohms	Stud Connection	75p
BOURNES	5 Kohms	Flying lead	75p
AMPHENOL	10 Kohms	P.C.	£1
AMPHENOL	25 Kohms	P.C.	£1
AMPHENOL	30 Kohms	T.C.	£1

MONOCHROMATIC LIGHT "LAPMASTER"

110/220V. 1-ph. 50 Hz. Light area: 11in. × 8½in. **£15·00.** Carriage £2·00.

SOUND ANALYSER

General Radio Co. Type 760-A. Portable. Battery powered. Designed for use with Type 759 sound level meters, but can be used with any other microphone or vibration pick-up and amplifier with suitable characteristics. Supplied less microphone. **£50.** Carriage extra.

MARCONI TF899

20mV-2V A.C., 3 ranges. 50Hz-100MHz. Detected O/p for modulation monitoring RF probe. Mains P.S.U. Overhauled. **£25.** P. & P. £0·50.

PHILLIPS GM6020

100 micro V-10V, input 1. 10mV-1000V input 2. 100 pA-10 micro A. Accuracy ± 3%. Input Z 1 M ohm, input 1, 100 M ohm, input 2. Recorder output. Working order **£65.** P. & P. £1.

VHF ADMITTANCE BRIDGE

Wayne Kerr B801A. 1-100 MHz. Conductance 0-100 millimhos. Capacitance 0-230 pF and 0 to —230 pF. **£120** (40% of new price). Also B901. Indicates parallel components of conductance and positive or negative capacitance for lines, antennas and feeders. 0-100mMho. 0. to ± 75 pF and — 75 pF. Accuracy 2% up to 250 MHz. **£115** (40% of new price).

FENLOW LOW FREQUENCY ANALYSER

0.3 Hz to 1 K Hz. Power density 0-10. Bandwidth switching range. .06: 0.3: 1.5: 7.5: 37.5 Hz. Price **£275.**

TWENTY MILLION MEGOHMMETER

E.I. Model 29A. Test voltage 85 and 500V. S/C Current less than 4 mA 30M ohm-20×10⁶M ohm. Charging Delay 1½ secs. Mains input. **£75.** Carriage £2·50.

NEW ELECTRO PNEUMATIC TRANSDUCER TRANSMITTER

Taylor. Cat. No. XX701 TF13.
Input —50—0+50 Ma. Output 3-15 PSI. Spec. 670. Coil 3 ohms. This precision transducer accurately controls air pressure by a varying electrical signal. **£50.** P. & P. included.

R.C. OSCILLATOR

Solartron Type CO 1004·2. 10Hz-1 MHz in 5 ranges. O/P level adjustment. **£40.** P. & P. £1.
Also available Type CO 1004. **£30.** P. & P. £1.

PORTABLE FREQUENCY METERS

TF1026/1. A direct reading absorption meter, employing a concentric line closed at one end and turned by variable capacitor at the other end of the line, giving a frequency range: 250 MHz-500 MHz, on an almost linear scale approx. 9in. in length. Complete in polished wooden case. Price **£17·50.** Carriage extra.

DIGITAL INDICATORS KGM Type M3

A neat compact indicator providing selective display 0-9. Fig. height 18 mm. panel mounting. 6 mm. tubular midget flange lamps. Supplied with 28 v. bulbs. Finished matt black anodized. W. 1 in., H. 2 in. Wt. 4 ozs. Price **£3·25.** P. & p. Free.

MODEL 1706 VISICORDER

In almost new condition. This direct reading U/V Recorder can record up to 6 channels simultaneously from D.C. 5000 Hz at writing speed of 30000 m ohs/sec.

Recording range:	D.C.—5000 Hz.
Paper width:	4½ ins. wide.
Optical Arm:	19 cm.
Paper Speeds:	Eight speeds from 0·25—32 in./sec. and 6—800 mm/sc.
Dimensions:	H. 10½ in., W. 12 in., Depth 14 in.

Complete with 4 3k Hz Galvos. **£400**

BRAND NEW CAPACITOR REVERSIBLE SINGLE PHASE PARVALUX MOTORS

230/250 v. 50 Hz 2,800 r.p.m. 1/30 h.p. Cont. rated. $\frac{5}{16}$ in. shaft dia. × 3½ in. long. Foot mounting. Weight 6 lb. **£5·75** post free.

COAXIAL LINE OSCILLATOR

By Saunders. Type CLC 7-12. The Oscillator is adjustable from 7-12 MHz. A high reset accuracy with no backlash having ± ·1%. The instrument is supplied with a calibration chart and valve, and is suitable to be coupled to any waveguide size by using a coaxial to waveguide transformer. Price: **£55.**

7-TRACK DIGITAL MAGNETIC TAPE STORAGE DECK (Ref. I3)

These machines, originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay heads encased in one common unit. Low resistance heads. Frequency response approximately 0 Kc/s. to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools 230 v. to 380 v. A.C. Capstan Motor speed 1,500 r.p.m. 48 v. D.C. Rewind motors. Finished in brush aluminium and matt-black. Size 27 in. × 26 in. × 8 in. Weight 90 lb. Price **£65.** Carriage extra.

MEMORY PLANES (Ref. C4)

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 5×8 in. Consisting of matrices 40×25×4 cores each one individually addressable and divided into 2 halves with independent sense and inhibit wires. **£6·65.** P. & P. inclusive.

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Made by well known manufacturers

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½ in. N.A.B. centres 10½ in. spool only	£1·00

MULTI-RANGE TRANSISTORISED VOLTMETER 1063

Employing silicon planar F.E.T., this instrument gives long-term stability and negligible drift over a wide temperature range. Wide frequency band 0-300 MHz. using HPV 1063. Voltage range 0-30KV. Centre zero on DC ranges for differential circuit application. Input resistance 1 M.ohm/Volt on all DC ranges. Accuracy + 3— F.S.D. Meter scale 5in. with IM different colour for different scales.
Special price **£42·50** each. Carriage £1·50.

CLOSED CIRCUIT TELEVISION

Comprising PORTABLE E.M.I. Camera Type 8 using 1in. Vidicon Tube. Set to operate at 405 lines. Channel 2 (52 MHz). Can be tuned to other frequencies. W. 5in. H. 7in. D. 10½in. MONITOR. 19in. Ferguson Model 3622 405/625 Standard TV receiver. Working order. V.G. condition. **£100.** Carriage extra.

(Dept. W.W.) 49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2. Cables: SELELECTRO
Telex No. 267307 (Open Mon-Fri 9 a.m. - 6 p.m.)

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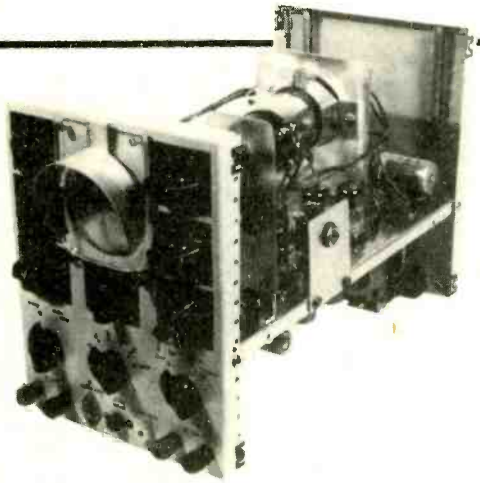
EXTRA

in April issue of "Practical Wireless" OUT NOW

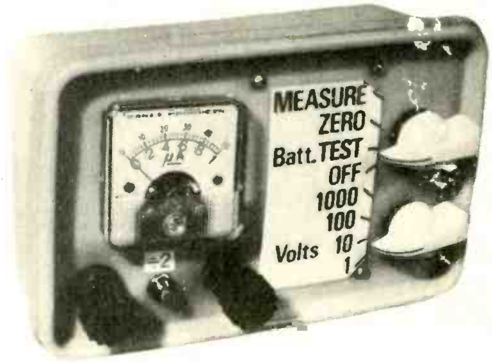
8-PAGE GUIDE TO TEST INSTRUMENTS

This illustrated eight-page supplement is a comprehensive guide to test gear now on the market for use in testing radio and audio equipment. Though complete in itself, it will also provide a useful introduction to an important new series on servicing by H. W. Hellyer and Gordon J. King, which starts in the following month's issue.



WORKSHOP OSCILLOSCOPE

This *Practical Wireless* design enables you to see what is going on inside a circuit, including the examination of waveforms, distortion and pulses. You can make this versatile test instrument — readily available c.r.t. and other components. Even the case is a stock item. Read all about it in the April issue, out now.



HIGH IMPEDANCE VOLTMETER

Winner of the *Practical Wireless* Project Autumn Trophy with ranges of 1-10-100-1000V and input impedance of at least 3MΩ. The cost is small, a 50μA meter and three 2N2926 transistors forming the basis of operation of this ingenious project. Full constructional details in the April *Practical Wireless*

Also other interesting constructional features

PRACTICAL WIRELESS

April issue out now—17½p

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40361	**55p**	2N2905	**44p**	2N4291	**15p**	BC148	**14p**	BFX87	**29p**
40362	**68p**	2N2905A	**47p**	2N4292	**15p**	BC149	**15p**	BFX88	**26p**
2N696	**20p**	2N2924	**20p**	AC107	**46p**	BC153	**19p**	BFY50	**23p**
2N697	**22p**	2N2925	**22p**	AC126	**20p**	BC154	**28p**	BFY51	**20p**
2N706	**12p**	2N2926	**11p**	AC127	**20p**	BC157	**19p**	BFY52	**23p**
2N930	**29p**	2N3053	**27p**	AC128	**20p**	BC158	**17p**	BSX20	**16p**
2N1131	**36p**	2N3055	**75p**	AC153K	**25p**	BC159	**18p**	C407	**17p**
2N1132	**40p**	2N3702	**13p**	AC176	**27p**	BC167	**13p**	MC140	**25p**
2N1302	**19p**	2N3703	**13p**	ACY20	**20p**	BC168	**11p**	MPS6531	**35p**
2N1303	**19p**	2N3704	**13p**	ACY22	**16p**	BC169	**13p**	MPS6534	**30p**
2N1304	**23p**	2N3705	**13p**	AD140	**56p**	BC177	**17p**	NKT211	**25p**
2N1305	**23p**	2N3706	**13p**	AD142	**50p**	BC178	**15p**	NKT212	**25p**
2N1306	**33p**	2N3707	**13p**	AD149	**60p**	BC179	**17p**	NKT214	**23p**
2N1307	**33p**	2N3708	**13p**	AD161	**40p**	BC182L	**13p**	NKT274	**18p**
2N1308	**36p**	2N3709	**13p**	AD162	**40p**	BC183L	**11p**	NKT403	**65p**
2N1309	**36p**	2N3710	**13p**	AF114	**30p**	BC184L	**13p**	NKT405	**79p**
2N1613	**23p**	2N3711	**13p**	AF115	**30p**	BC212L	**25p**	OC71	**29p**
2N1711	**26p**	2N3819	**35p**	AF117	**28p**	BC213L	**25p**	OC81	**25p**
2N1893	**54p**	2N3904	**35p**	AF124	**30p**	BC214L	**25p**	OC81D	**25p**
2N2147	**95p**	2N3906	**35p**	AF127	**28p**	BCY70	**19p**	ZTX300	**17p**
2N2218	**34p**	2N4058	**20p**	AF139	**48p**	BCY71	**33p**	ZTX301	**17p**
2N2218A	**43p**	2N4059	**20p**	AF239	**49p**	BCY72	**15p**	ZTX302	**22p**
2N2219	**38p**	2N4060	**20p**	ASY26	**27p**	BF115	**23p**	ZTX303	**22p**
2N2219A	**53p**	2N4061	**20p**	ASY28	**27p**	BF167	**27p**	ZTX304	**33p**
2N2270	**62p**	2N4062	**20p**	BC107	**14p**	BF173	**31p**	ZTX500	**25p**
2N2369A	**19p**	2N4124	**18p**	BC108	**12p**	BF194	**17p**	ZTX501	**25p**
2N2483	**35p**	2N4126	**27p**	BC109	**14p**	BF195	**18p**	ZTX502	**30p**
2N2484	**42p**	2N4284	**15p**	BC125	**15p**	BFX29	**31p**	ZTX503	**25p**
2N2646	**54p**	2N4286	**15p**	BC126	**22p**	BFX84	**25p**	ZTX504	**60p**
2N2904A	**42p**	2N4289	**15p**	BC147	**15p**	BFX85	**34p**		

RESISTORS

Code	*Power*	*Tolerance*	*Range*	*Values available*	*1 to 9*	*10 to 99* (see note below).	*100 up*
C	1/20W	5%	82Ω–220KΩ	E12	7	6·5	6
C	1/8W	5%	4·7Ω–330KΩ	E24	1·5	0·8	0·7
C	1/4W	10%	4·7Ω–10MΩ	E12	1·5	0·8	0·7
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·9
C	1W	10%	4·7Ω–10MΩ	E12	2·5	2	1·9
MO	1/2W	2%	10Ω–1MΩ	E24	4	3·5	3
WW	1W	10%±1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	12Ω–10KΩ	E12	7	7	6
WW	7W	5%	12Ω–10KΩ	E12	9	9	8

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW= wire wound, Plessey.

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.)

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.

ZENER DIODES 5% full range E24 values: 400mW: 2·7V to 30V, **15p each**; 1W: 6·8V. to 82V, **27p each; 1·5W:** 4·7V to 75V, **60p each.**
Clip to increase 1·5W rating to 3 watts (type 266F), **4p.**

CARBON TRACK POTENTIOMETERS, long spindles. Double wiper ensures minimum noise level.
Single gang linear 220 Ω to 2·2M Ω, **12p;** Single gang log, 4·7K Ω to 2·2M Ω, **12p;** Dual gang linear, 4·7k Ω to 2·2M Ω, **42p;** Dual gang log, 4·7K Ω to 2·2M Ω, **42p;** Log/antilog, 10K, 47K, 1M Ω only **42p;** Dual antilog, 10K only, **42p.** Any type with ½A D.P. mains switch, extra **12p.**
Please note: only decades of 10, 22 and 47 are available within ranges quoted.

CARBON SKELETON PRE-SETS
Small high quality, type PR, linear only: 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M2, 5M, 10MΩ. Vertical or horizontal mounting, **5p each.**

COLVERN 3 watt Wire-wound Potentiometers. 10Ω, 15Ω, 25Ω, 50Ω, 100Ω, 250Ω, 500Ω, 1K, 1·5K, 2·5K, 5K, 10K, 15K, 25K, 50K, **32p each.**

ENAMELLED COPPER WIRE even No. SWG only: 2 oz. reels: 16-22 SWG **25p;** 24-30 SWG **30p;** 32, 34 SWG, **33p;** 36-40 SWG, **35p.**
4 oz. reels: 16-22 SWG only **42p.**

TYGAN SPEAKER MATERIAL
7 designs, 36 × 27 in. sheets, **£1·57** sheet.

MULLARD polyester **C280 series**
250V 20%: 0·01, 0·022, 0·033, 0·047 **3p each;** 0·068, 0·1, **4p each;** 0·15, **4p;** 0·22, **5p.** 10%: **7p;** 0·33, 0·47, **8p;** 0·68, **12p;** 1μF, **14p;** 1·5μF, **21p;** 2·2μF, **24p.**

MULLARD SUB-MIN ELECTROLYTICS
C426 range, axial lead . . . . . . 6p each
Values (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·5/64; 4/10; 4/40; 5/64; 6·4/6·4; 6·4/25; 8/4; 8/40; 10/2·5; 10/16; 10/64; 12·5/25; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2·5; 50/6·4; 50/25; 50/40; 64/4; 64/10; 80/2·5; 80/16; 80/25; 100/6·4; 125/4; 125/10; 125/16; 160/2·5; 200/6·4; 200/10; 250/4; 320/2·5; 320/6·4; 400/4; 500/2·5.

LARGE CAPACITORS
High ripple current types: 1000/25, **28p;** 1000/50, **41p;** 1000/100, **82p;** 2000/25, **37p;** 2000/50, **57p;** 2000/100, **£1·44;** 2500/64, **77p;** 2500/70, **98p;** 5000/25, **62p;** 5000/50, **£1·20;** 5000/100, **£2·91;** 10000/15, **85p;** 10000/25, **£1·22;** 10000/50, **£2·20.**

COMPONENT DISCOUNTS
10% on orders for components for £5 or more.
15% on orders for components for £15 or more.
(No discount on nett items.)

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Free on orders over £2.
Please add 10p if order is under £2.
Overseas orders welcome: carriage and insurance charged at cost.

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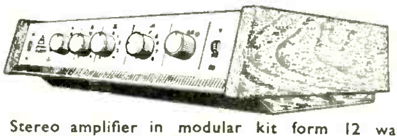
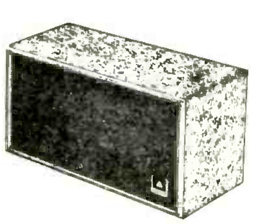


ENGLEFIELD 12+12 AMPLIFIER

Stereo amplifier in modular kit form 12 watts RMS per channel into 15 Ω **£38·45**
Cabinet kit only **£6.** These prices nett.
As reviewed in *Hi Fi Sound* and other important journals.



BAXANDALL SPEAKER SYSTEM

Designed by Peter Baxandall. Superb reproduction for its size. Handles 10 watts with ease. Uses ELAC 15Ω 59RM109 speaker unit. Kit **£13·90** nett; built **£19·40** nett.

MAINLINE AMPLIFIER KITS

RCA/SGS designed main amplifier kits. Input sensitivity 500–700mV for full output into 8Ω.

Power	*Kit price including components*	*Suitable unreg. power supply kit*
12W	**£8·40** nett	**£4·82**
25W	**£9·75** nett	**£5·92**
40W	**£10·50** nett	**£6·03**
70W	**£12·60** nett	**£6·87**

30 WATT BAILEY AMPLIFIER PARTS

Sensitivity 1·2V for full output into 8Ω.
Transistors and PCB for one channel **£6·46**
Transistors and PCBs for two channels **£12·92**
Capacitors and resistors (metal oxide), **£2·00** per channel.
Complete unregulated power supply pack, **£4·75**
Suitable heat sink 10DN space 400c, **55p**

INTEGRATED CIRCUITS

PLESSEY SL403A 3 watts into 7·5 ohms. Application data, **10p.**
Price per unit, nett **£2·10**

SINCLAIR IC.10 as advertised, complete with instructions and applications manual **£2·95** nett.
Components pack for stereo inc. transformer, controls, etc., **£4·75** nett.

S-DeCs PUT AN END TO BIRDS NESTING
Components just plug in—saves time—allows re-use of components. S-Dec (70 points), **£1·00**
Complete T-Dec, may be temperature-cycled (208 points), **£2·50**
Also μ-Decs and IC carriers.

MEDIUM RANGE ELECTROLYTICS
Axial leads: 50/50, **9p;** 100/25, **9p;** 100/50, **13p;** 250/25, **13p;** 250/50, **19p;** 500/25, **19p;** 500/50, **21p;** 1000/25, **20p;** 1000/50, **30p;** 2000/25, **30p;** 2000/50 **48p.**

SMALL ELECTROLYTICS
Axial leads: 4·7/10, 4·7/25, 5/50, **5p each;** 10/10, 10/25, 10/50, 33/10, 50/10, **5p each;** 25/25, 25/50, 47/25, 100/10, 220/10, **6p** each.

NEON INDICATOR LAMPS

all 200/250V. Square bezel, red only	**17p**
Round, chrome bezel red, amber, clear	**23p each**

TOGGLE SWITCHES, 250V a.c. 1·5A.
chrome dolly and chrome milled nut S.P.S.T. **19p,** S.P.D.T. **25p** D.P.D.T. **29p;** S.P.D.T. centre off **20p**

WAVECHANGE SWITCHES
LONG SPINDLES

1P 12W; 2P 6W; 3P 4W; 4P 3W	**24p each**
SLIDER SWITCHES D.P.D.T.	**15p each**

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NEW LOW PRICES FOR W.W. AMPLIFIER KITS

100 W AMPLIFIER (OVERLOAD PROTECTION INCLUDED)
Designer, Texas Instruments Approved.

Matched Set 22 guaranteed Texas transistors, diode, 13 caps, 32 resistors, 3 pots, choke, 2 h/sinks 4 in. × 4·6 in. × 1·3 in., drilled 2 × TO3, fibreglass P.C.B., construction notes	18·00
2 sets	35·00

Texas 2N3715	2·25	Texas 2N3791	3·50
Imported 2N3791	2·75	Drilled h/sink	0·40
F/glass P.C.B.	0·95	Mains transformer	6·00
4700 mfd. 63v.	1·70	1000 mfd. 64v.	0·70

Power supply; 42v. + 50v. transformer, all cpts., h/sink	15·00
2 power supply kits	28·50

30W BAILEY (SINGLE POWER RAIL)

10 transistors	5·60	Resistors, caps, pot	1·30

LINSLEY HOOD CLASS AB

MJ481, MJ491, MJE521, BC182L, BC212L, Zener	3·35
16 resistors, 10 capacitors, 2 pots	2·20

LINSLEY HOOD CLASS A (DEC., 1970, CIRCUIT)

4 transistors	1·55	Resistors, caps, pot	1·80

Please state 8 Ω or 15 Ω for L.H. amps.
Transistor matching and mica washers at no charge.
Resistors, except power types, ½W 5%. Low noise carbon film.

SEMICONDUCTORS

2N1613	0·30	BC182L	0·10	TIP29A	0·50
2N1711	0·25	BC184L	0·12	TIP30A	0·60
2N3055	0·60	BC212L	0·12	BFY50	0·20
2N3716	2·85	40361	0·50	1B08T20	0·60
2N3906	0·32	40362	0·60	1B40K20	1·60
BC109	0·12	MJ481	1·20	1S44	0·10
BC125	0·45	MJ491	1·30	1S3062	0·35
BC126	0·45	MJE521	0·72		

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BAILEY 30w POWER AMPLIFIER. Edge Connector Mounted Printed Circuit in Fibreglass or Paxolin material, size 4¼" × 2¾". This unit and the above Pre-amplifier can both be used in our new Metalwork Assembly.
BAILEY 30w POWER SUPPLY. We have now designed a Printed Circuit Board for the power supply, again intended to be used with our Metalwork, which also has edge connector mounting. Available in Fibreglass material only.
BAILEY 20w AMPLIFIER. Special driver transformer and bifilar wound mains transformer. Printed circuits and all parts available for this design.
LINSLEY HOOD CLASS A. Full sets of parts now available to the new specification given in the December, 1970, Wireless World.
FULL KITS OF PARTS including Edge Connector Mounting Printed Circuit now available for Linsley Hood AB Design. This unit is fully compatible with our Metalwork Assembly.
SUGDEN CLASS A AMPLIFIER. A Hi-Fi News design. All parts are in stock except the Metalwork.
WADDINGTON STEREO DECODER. Printed circuits now available in fibreglass and paxolin material.
J. R. STUART TAPE CIRCUITS. We will be designing Printed Circuit Boards and supplying parts for this interesting design.

Full details are given in our Free lists. Please send foolscap s.a.e.

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321 Great Western Street, Manchester M14 4AR
Personal callers are always welcome at our retail shop, but please note we are closed on Saturdays.

Complete Stereo System £43

This superb stereo system is a real price breakthrough. It comprises the VISCOUNT F.E.T. Mk I amplifier on which full details are given below, the famous Garrard SP 25 Mk III (including teak veneer base and transparent cover) with diamond cartridge or 2025 T C and the very successful DUO type 2 speakers.

Measuring 17½" x 10¾" x 6¾" the Duo type 2 speakers are teak finished with matching Vynair grills. They incorporate a 3 ohm, 13" x 8" drive unit and Parasitic tweeter. Max. power handling 10 watts. Price £13.50 per pair plus p&p £1.50.

WITH MK II amplifier and magnetic cartridge £48 plus £2.50 P&P

The Viscount **F.E.T.** Mk I **£14.25** plus 50p P. & P.

High fidelity transistor stereo amplifier employing field effect transistors. With this feature & accompanying guaranteed specifications below. the Viscount F.E.T. vastly surpasses amplifiers costing far more. *Size: 12½" x 6" x 2¾" in simulated teak case.*

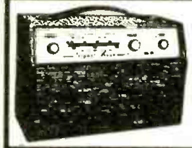
Specification: Output per channel 10 watts r.m.s. into 3 ohms. Frequency bandwidth 20 Hz to 20 kHz ± 1 dB @ 1 watt.
Total distortion: @ 1 kHz @ 9 watts 0.5%.
Input sensitivities: CER, P.U. 100mV into 3 meg ohms.
Tuner 100mV into 100K ohms.
Tape 100mV into 100K ohms.

Overload Factor: Better than 26 dB.
Signal to noise ratio: 70 dB on all inputs (with vol. max).
Controls: 6 position selector switch (3 pos. stereo & 3 pos. mono). Separate Vol. controls for left & right channels. Bass ± 14 dB @ 60 Hz. Treble (with D.P.S. on/off) ± 12 dB @ 10 kHz. Tape Recording output sockets on each channel.

BUILT & TESTED.

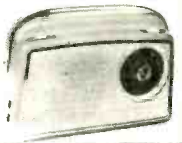
Mk II (MAG. P.U.) £15.75 *plus 50p p&p*

Specification same as Mk. I, but with the following inputs.
Mag. P.U. CER. P.U. Tuner. Spec. on Mag. P.U. 3mV @ 1 kHz input impedance 47K. Fully equalised to within ± 1 dB RIAA. Signal to noise ratio—65 dB (vol. max)



Elegant Seven Mk 3 (350mW)

7 transistor fully-tunable M.W.-L.W. superhet portable Set of parts. Complete with all components, including ready etched and drilled printed circuit board—back printed for foolproof construction.
MAINS POWER PACK KIT: 47p extra
Price **£5.25** plus 50p P. & P
Circuit 13p FREE WITH PARTS



The Dorset (600 mW)

7-transistor fully tunable M.W.-L.W. superhet portable—with baby alarm facility. Set of parts. The latest modulised and pre-alignment techniques makes this simple to build. Sizes: 12 x 8 x 3in.
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Circuit 13p FREE WITH PARTS

SOUND 50

SOUND 50 AMPLIFIER AND SPEAKER SYSTEM

The Sound Fifty valve amplifier and speakers are sturdily constructed with smart housings and thoroughly tested electronics. They are designed to last—to withstand the knocks and bumps of life on the road. Built for the small and medium sized gig, they are easy to handle and quick to set up and can be relied upon to come over with all the quality and power you need.

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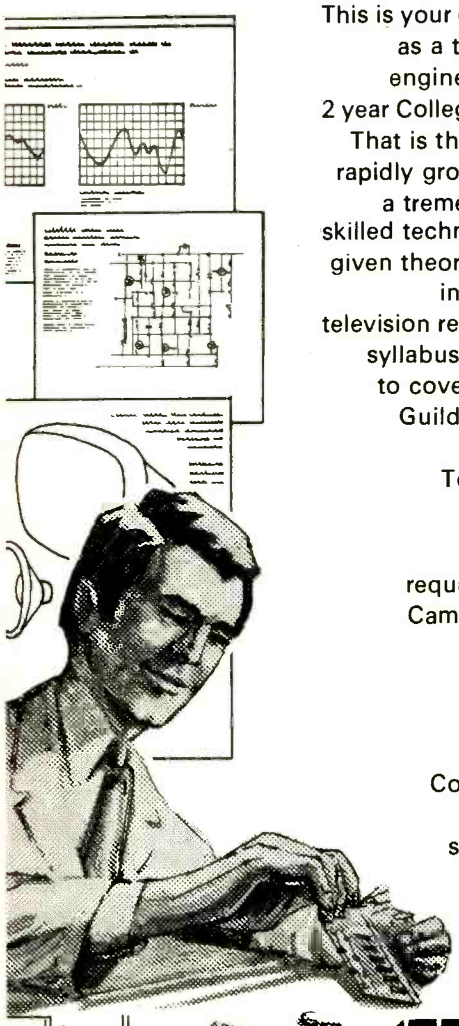

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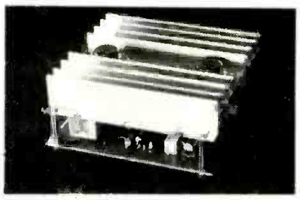
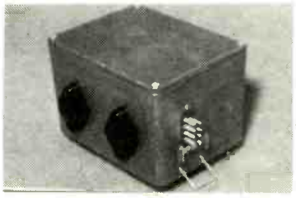
CAPACITOR DISCHARGE IGNITION SYSTEM





The popular Wireless World Capacitor-Discharge Ignition system is now available in two versions. The original unit, comprising a printed-circuit board with stand-off heat-sink and separate transformer, or the mechanically re-designed unit with printed-circuits and a transformer contained within a die-cast box; the transistors and thyristor being mounted on the outside of the case and supplied with snap-on plastic covers. This version also includes a plug and socket for ease of connection, together with a conversion plug providing instant change-over to conventional ignition.

Both versions embody printed-circuit boards designed for positive and negative earth ignition systems thus enabling simple conversion to opposite polarity if the vehicle is subsequently changed. A complete complement of components is supplied with each kit together with ready-drilled and roller-tinned printed-circuit board, fully machined heat-sink (or die-cast box) and a custom-wound transformer.

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22	1·30
23	1·30
26	1·00
28A	0·75
28B	1·05
29	0·90
29A	1·65
30	1·40
35	1·25
36	0·75
39	0·65
41	1·10
42	1·10
43	1·40
44	1·20
45	1·25
46	0·75
47	1·40
48	2·05
49	1·60
50	1·85
51	1·35
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53	0·50
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710C	0·75	0·67½	0·62½	0·55
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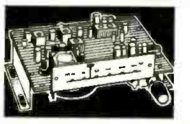
TRANSISTOR FM TUNER



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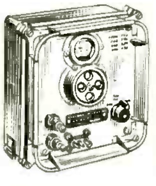

Small portable crystal controlled wavemeter. Size 7in. × 7½in. × 4in. Frequency range 500 Kc/s—10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. **£4·47½**. Carr. 37½p.

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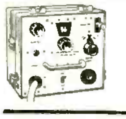
0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition, **£12·50**. Carriage 50p.

CLASS D. WAVEMETERS



A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition **£5·97½**. Carr. 37½p. or Brand New **£7·97½**. Carr. 37½p.

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Latest release 125 KHz-20 MHz. Excellent condition. Fully tested and checked and complete with calibrator charts. **£27·50** each. Carr. 50p.

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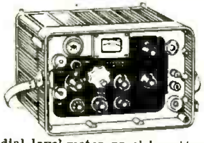

Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1µV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8½ x 9in. Supplied in brand new condition complete with all connectors, fully tested, **£45**. Carr. £1.

AVO CT.38 ELECTRONIC MULTIMETERS

High quality 97 range instrument which measures A.C. and D.C. Voltage. Current, Resistance and Power Output Ranges D.C. volts 250 mV-10,000v. (10 meg Ω -110 meg Ω input). D.C. current 10µA-25 amps. Ohms. 0-1,000 meg Ω A.C. volt 100mv.-250V (with R.F. measuring head up to 250 Mc/s) A.C. current 10µA-25 amps. Power output 50 micro-watts-5 watts. Operation 0/110/200/250V. A.C. Supplied in perfect condition complete with circuit lead and R.F. probe. **£25**. Carr. 75p.

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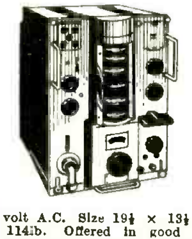
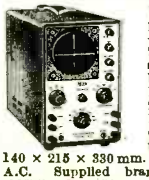


High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 150-300 Kc/s, 560 Kc/s-1.5Mc/s, 3.9-30.5 Mc/s. I.F. 500 Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition. **£22·50**, carr. £1·50. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. **£17·50**. Carr. £1·50.

TO-2 PORTABLE OSCILLOSCOPE

A general purpose low cost economy oscilloscope for every-day use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. illuminated scale. 2" tube. 115 × 180 × 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. **£22·50**. Carr. 50p.

TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE



Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps—1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook **£37·50**. Carr. 50p.

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100µA	£3·37½	300V. D.C.	£2·97½
100-0-100µA	£3·25	1 amp. D.C.	£2·97½
500µA	£3·12½	5 amp. D.C.	£2·97½
1mA	£2·97½	300V. A.C.	£2·97½
		VU Meter	£3·75

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TYPE S-80

80 mm.

square fronts

50µA	£3·12½	50V. D.C.	£2·47½
50-0-50µA	£2·97½	300V. D.C.	£2·47½
100µA	£2·97½	1 amp. D.C.	£2·47½
100-0-100µA	£2·87½	5 amp. D.C.	£2·47½
500µA	£2·62½	300V. A.C.	£2·62½
1mA	£2·47½	VU Meter	£3·37½
20V. D.C.	£2·47½		

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4¼in. × 4¼in. fronts.

50µA	£3·60	10mA	£2·60
50-0-50µA	£3·10	50mA	£2·60
100µA	£3·10	100mA	£2·60
100-0-100µA	£3·10	500mA	£2·60
200µA	£2·87½	1 amp.	£2·60
500µA	£2·75	5 amp.	£2·60
500-0-500µA	£2·60	15 amp.	£2·60
1mA	£2·60	30 amp.	£2·60
1-0-1mA	£2·60	20V. D.C.	£2·60
5mA	£2·60	50V. D.C.	£2·60
		150V. D.C.	£2·60
		300V. D.C.	£2·60
		15V. A.C.	£2·60
		300V. A.C.	£2·60
		S Meter 1mA	£2·87½
		VU Meter	£3·60
		1 amp. A.C.*	£2·60
		5 amp. A.C.*	£2·60
		10 amp. A.C.*	£2·60
		20 amp. A.C.*	£2·60
		30 amp. A.C.*	£2·60

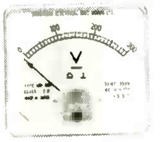
Type MR.52P. 2½in. square fronts.

50µA	£3·10	10V. D.C.	£2·00
50-0-50µA	£2·60	20V. D.C.	£2·00
100µA	£2·60	50V. D.C.	£2·00
100-0-100µA	£2·37½	300V. D.C.	£2·00
500µA	£2·25	15V. A.C.	£2·00
1mA	£2·00	300V. A.C.	£2·00
5mA	£2·00	S Meter 1mA	£2·10
10mA	£2·00	VU Meter	£3·10
50mA	£2·00	1 amp. A.C.*	£2·00
100mA	£2·00	5 amp. A.C.*	£2·00
500mA	£2·00	10 amp. A.C.*	£2·00
1 amp.	£2·00	20 amp. A.C.*	£2·00
5 amp.	£2·00	30 amp. A.C.*	£2·00

Type MR.65P. 3½in. × 3½in. fronts

50µA	£3·37½	10V. D.C.	£2·10
50-0-50µA	£2·75	20V. D.C.	£2·10
100µA	£2·75	50V. D.C.	£2·10
100-0-100µA	£2·60	150V. D.C.	£2·10
200µA	£2·60	100V. D.C.	£2·10
500µA	£2·37½	15V. A.C.	£2·10
500-0-500µA	£2·10	50V. A.C.	£2·10
1mA	£2·10	150V. A.C.	£2·10
5mA	£2·10	300V. A.C.	£2·10
10mA	£2·10	500V. A.C.	£2·10
50mA	£2·10	S Meter 1mA	£2·37½
100mA	£2·10	VU Meter	£3·37½
500mA	£2·10	50mA A.C.‡	£2·10
1 amp.	£2·10	100mA A.C.*	£2·10
5 amp.	£2·10	200mA A.C.*	£2·10
10 amp.	£2·10	500mA A.C.*	£2·10
15 amp.	£2·10	1 amp. A.C.*	£2·10
20 amp.	£2·10	5 amp. A.C.*	£2·10
30 amp.	£2·10	10 amp. A.C.*	£2·10
50 amp.	£2·37½	20 amp. A.C.*	£2·10
5V. D.C.	£2·10	30 amp. A.C.*	£2·10

Type MR.38P. 1 21/32in. square fronts.



50µA	£2·00	200mA	£1·37½
50-0-50µA	£1·87½	300mA	£1·37½
100µA	£1·87½	500mA	£1·37½
100-0-100µA	£1·75	750mA	£1·37½
200µA	£1·75	1 amp.	£1·37½
500µA	£1·50	2 amp.	£1·37½
500-0-500µA	£1·37½	5 amp.	£1·37½
1mA	£1·37½	10 amp.	£1·37½
1-0-1mA	£1·37½	3V. D.C.	£1·37½
2mA	£1·37½	10V. D.C.	£1·37½
5mA	£1·37½	15V. D.C.	£1·37½
10mA	£1·37½	20V. D.C.	£1·37½
20mA	£1·37½	100V. D.C.	£1·37½
50mA	£1·37½	150V. D.C.	£1·37½
100mA	£1·37½	300V. D.C.	£1·37½
150mA	£1·37½	500V. D.C.	£1·37½
		750V. D.C.	£1·37½
		15V. A.C.	£1·37½
		50V. A.C.	£1·37½
		150V. A.C.	£1·37½
		300V. A.C.	£1·37½
		500V. A.C.	£1·37½
		S Meter 1mA	£1·60
		VU Meter	£2·10

Type MR.45P. 2in. square fronts.

50µA	£2·25	5 amp.	£1·50
50-0-50µA	£2·10	10V. D.C.	£1·50
100µA	£2·10	20V. D.C.	£1·50
100-0-100µA	£1·87½	50V. D.C.	£1·50
200µA	£1·87½	300V. D.C.	£1·50
500µA	£1·60	15V. A.C.	£1·50
500-0-500µA	£1·50	300V. A.C.	£1·50
1mA	£1·50	S Meter 1mA	£1·87½
5mA	£1·50	VU Meter	£2·25
10mA	£1·50	1 amp. A.C.‡	£1·50
50mA	£1·50	5 amp. A.C.‡	£1·50
100mA	£1·50	10 amp. A.C.‡	£1·50
500mA	£1·50	20 amp. A.C.‡	£1·50
1 amp.	£1·50	30 amp. A.C.‡	£1·50

"SEW" BAKELITE PANEL METERS

Type MR.65. 3½in. square fronts.

25µA	£3·50	500mA	£1·75
50µA	£2·37½	1 amp.	£1·75
50-0-50µA	£2·25	5 amp.	£1·75
100µA	£2·25	15 amp.	£1·75
100-0-100µA	£2·25	30 amp.	£1·75
500µA	£2·10	50 amp.	£1·75
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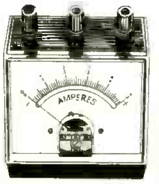

Type ED 107

Size overall 100mm × 90mm × 108mm

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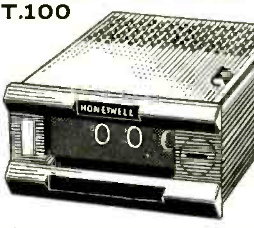

Can be panel or bench mounted. Basic meter measures 1 volt D.C. but can be used to measure a wide range of AC and DC volt, current and ohms with optional plug in cards.

Specification:

Accuracy: ± 0·2, ± 1 digit.
Resolution: 1mV.
Number of digits: 3 plus fourth overrange digit.
Overrange: 100% (up to 1·999)
Input impedance: 1000 Meg ohm.
Measuring cycle: 1 per second.
Adjustment: Automatic zeroing, full scale adjustment against an internal reference voltage.
Overload: to 100v. D.C.
Input: Fully floating (3 poles).
Input power: 110-230v. A.C. 50/60 cycles.
Overall size: 5⅝in. × 2 13/16in. × 8 3/16in.

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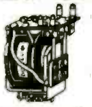

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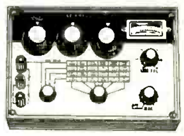

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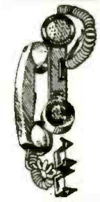

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2N697	17p
2N698	42p
2N706	10p
2N706A	12p
2N708	15p
2N914	22p
2N916	22p
2N918	37p
2N929	22p
2N930	25p
2N1131	30p
2N1132	30p
2N1302	20p
2N1303	22p
2N1304	25p
2N1305	25p
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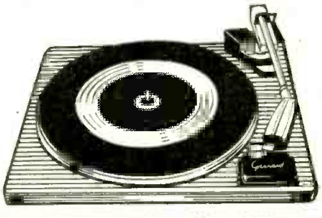

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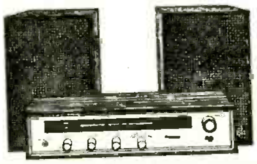
Garrard SP25 Mk III fitted Goldring G800 cartridge and wooden plinth with perspex cover, ready wired. Total list price £35. OUR PRICE £22,50 Carr. 50p.

GOLDRING GL69/2 fitted Goldring G800 cartridge complete with de luxe base and cover. Total list price £50.80 OUR PRICE £39. Carr. £1

TELETON SPECIAL OFFER!



CR10T AM/FM STEREO TUNER AMPLIFIER WITH MATCHING PAIR SA1003 SPEAKER SYSTEMS Output 4 watts per channel. Excellent reception AFC, built-in MPX. Cer/XTAL Input. Total List £50·25. OUR PRICE £29·95. Carr. 62½p.

Also available with Garrard 2025T/C Record Changer, Plinth, cover and stereo cartridge. Ready wired. £45. Carr. £1.

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First grade quality American tapes. Brand new and guaranteed. Discounts for quantities. Postage 10p Over £3 post paid.

3in. 225ft. L.P. Acetate	17½p
3¼in. 600ft. T.P. Mylar	50p
5in. 600ft. Std. plastic	42½p
6in. 900ft. L.P. acetate	50p
5in. 1,200ft. D.P. Mylar	75p
5¾in. 1,200ft. L.P. acetate	62½p
5¾in. 1,200ft. L.P. Mylar	80p
5¾in. 1,800ft. D.P. Mylar	£1·12½
5¾in. 2,400ft. T.P. Mylar	£1·97½
7in. 1,200ft. Std. acetate	62½p
7in. 1,800ft. L.P. acetate	75p
7in. 1,800ft. L.P. Mylar	£1·00
7in. 2,400ft. D.P. Mylar	£1·25
7in. 3,600ft. T.P. Mylar	£2·25

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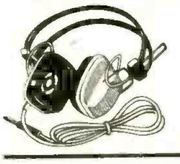
Top quality in plastic library boxes.
C60—60 min. 42½p; 3 for £1·22½
C90—90 min. 62½p; 3 for £1·80
C120—120 min. 75p; 3 for £2·17½
Casette Head Cleaner 56p All Post Extra.

HOSIDEN DH-02S STEREO HEADPHONES



Wonderful value and excellent performance combined. Adjustable headband. 8 ohm impedance. 20-12,000 cps. Complete with lead and stereo jack plug. ONLY £2·37½ P. & P. 12½p.

HOSIDEN DH04S
2-WAY STEREO HEADPHONES

Each headphone contains a 2½in. woofer and a ¾in. tweeter. Built in individual level controls. 25-18,000 c.p.s. 8Ω imp. with cable and stereo plug. £5·97½. P. & P. 12½p.

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G850	£5·12½
G800	£7·50
G800E	£11·97½
G800 Super E	£16·80

P. & P. 12½p any type.

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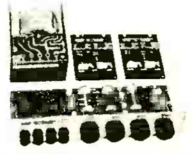
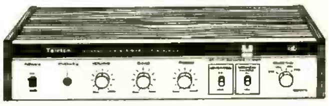
Project 60. Package Offers



2 × Z30 amplifier, stereo 60 pre-amp, PZ5 power supply. £19. Carr. 37½p. Or with PZ6 power supply, £21. Carr. 37½p. 2 × Z50 amplifier. stereo 60 pre-amp, PZ8 power supply. £21·50. Carr. 37½p. Transformer 4 PZ8, £2·97½ extra, Add to any of the above £4·87½ for active filter unit and £16 for a pair of Q16 speakers. PROJECT 60 FM TUNER £20·97½. Carr. 37½p. All other Sinclair products in stock; 2,000 amplifier £23. Carr. 37½p. 3,000 Amplifier £36. Carr. 37½p. Neoteric amplifier £46. Carr. 37½p.

TELETON SAQ-206 STEREO AMPLIFIER



Latest exciting release. Brand new model, beautifully styled with walnut case. 6 + 6 watts r.m.s. Switched inputs for mag, xtal, aux, tape. Incorporates volume, bass, treble and sliding balance control, scratch filter and loudness control. Rec. List £29·00. Our Price £19·97. Carr. 37p. Suggested system. SAQ 206 amplifier, SP25 III, plinth and cover, G800 cartridge, pair DJ 3 way speakers. Total Rec. List £81. Our Price £59·50. Carr. £1·50.

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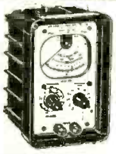
Our latest edition giving full details of a comprehensive range of HI-FI EQUIPMENT COMPONENTS, TEST EQUIPMENT and COMMUNICATIONS EQUIPMENT. FREE DISCOUNT COUPONS VALUE 50p. 248 pages, fully illustrated and detailing thousands of items at bargain prices.

SEND NOW! ONLY 37½p P & P 10p

RUSSIAN C1-16 DOUBLE BEAM OSCILLOSCOPE

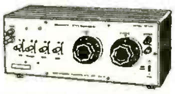
5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5 in. × 4 in. C.R.T. Calibrated triggered sweep from .2 μ/sec. to 100 milli-sec. per cm. Free running time base 50 c/s-1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. **£87** Carr. paid.



MARCONI CT44 TF956 AF ABSORPTION WATTMETER

1 μ/watt to 6 watts. **£20.** Carr. £1.

TE111 DECADE RESISTANCE ATTENUATOR



Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db × 10) + (1 db × 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db × 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new **£27·50** P. & P. 25p.

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR

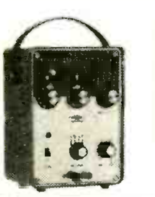
Sine 18-200,000 Hz; Square 18-50,000 Hz.

Output max. +10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case 7½ in. × 5in. × 2in.
Price **£17·50**
Carr. 17½p.

TE-16A TRANSISTORISED SIGNAL GENERATOR

5 Ranges 400 kHz-30 mHz. An inexpensive instrument for the handyman. Operates on 9 v. battery. Wide easy to read scale. 800 kHz modulation. 5¼ in. × 5¼ in. × 3¾ in. Complete with instructions and leads. **£7·97½** P. & P. 20p.

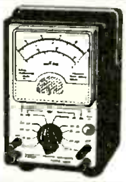
BELCO DA-20 SOLID STATE DECADE AUDIO OSCILLATOR



New high-quality portable instrument Sine 1 Hz to 100 KHz. Square 20 Hz to 20 KHz. Output max. +10 db (10 K ohms). Operation 220/240 v. A.C. Size 215 mm × 150 mm × 120 mm.

Price **£27·50**
Carr. 25p.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

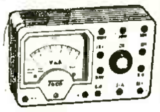


10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels −40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. **£17·50** Carr. 25p.

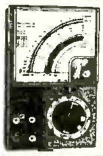
TE-65 VALVE VOLTMETER

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**. P. & P. 30p.
Additional Probes available; R.F. **£1·75** H.V. **£2·12½**.

MULTIMETERS for *EVERY* purpose!

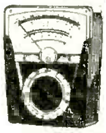


TECH PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K. **£1·97½** P. & P. 12½p.



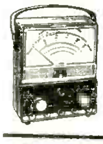
MODEL TE-200 20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000 V.D.C. 0/10/50/250/1,000 V.A.C. 0/50 μA/250 MA. 0/60K/6 meg. + 20 to + 62 db. **£3·75** P. & P. 15p

MODEL TE-80. 20,000 O.P.V. 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-50ƷA. 5/50/500mA. 0/6K/60K/600K/6 meg. **£4·87½** P. & P. 15p



MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30μA/3/30/300mA. 0/16K/160K/1.6M/16 Meg. **£5·50** P. & P. 15p

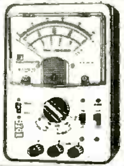
TMK MODEL TW-50K 46 ranges, mirror scale. 50K /Volt D.C. 5K /Volt A.C. D.C. Volts: .125, .25, 1.25, 2.5, 5, 10, 25, 50, 125, 250, 500, 1000V. A.C. Volts: 1.5. 3, 5, 10, 25, 50, 125, 250, 500, 1000V. D.C. Current: 25, 50μA, 2.5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance 10K, 100K, 1 MEG, 10 MEG. Decibels: –20 to +81.5 dB. **£8·87½** P. & P. 17½p



TE-900 20,000 Ω/VOLT GIANT MULTIMETER. Mirror scale and overload protection. 6 in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0/25/12.5/10/50/250/1,000/5,000 v. D.C. 0/50μA/0/10/100/500mA/10 amp. D.C. 02K/200K/20 MEG. OHM. **£15** P. & P. 25p

MODEL 5025 57 Ranges, Giant 5½ in. Meter, Polarity Reverse Switch. Sensitivity: 50K /Volt D.C. 5K /Volt A.C. D.C. Volts: .125, .25, 1.25, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.C. Current: 25, 50μA, 2.5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance: 2K, 10K, 100K, 1MEG, 10 MEG. Decibels: —20 to +85 dB **£12·50** P. & P. 17½p.

FTC-401 TRANSISTOR TESTER



Full capabilities for measuring A, B and 1CO. NPN or PNP. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads. **£6·97½**. P. & P. 15p.

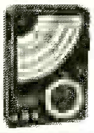
AVO CT471A MULTIMETER

Battery operated, fully transistorised. Sensitivity 100 MΩ/v. Measures A.C./D.C. voltages 12mV. to 1,200 V A.C./D.C. current 12μA. to 1.2 Amp. Resistance 12 ohm to 120 mΩ H.F., V.H.F., U.H.F. voltage with multiplier 4V. to 400V. up to 50 Mc/s., 40 mV. to 4V. up to 1,000 Mc/s. Offered in perfect condition. **£55** each. Carr. 50p.

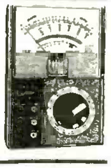
270° WIDE ANGLE 1mA METERS

MW1-6	60mm. square	£3·97½
MW1-8	80mm. square	£4·97½

P. & P. extra



HONOR TE.10A. 20 kΩ/Volt 5/25/50/250/500/2,500 v. D.C. 10/50/100/500/1,000 v. A.C. 0/50μA/2.5 mA/250 mA D.C. 0/6K/6 meg. ohm. –20 to + 22 dB. 10-0, 100 mfd. 0.100-0.1 mfd. **£3·47½**, P. & P. 15p.



MODEL TE-300 30,000 O.P.V. Mirror scale, overload protection 0/.6/3/15/60/300/1,200 V.D.C. 0/6/30/120/600/1,200 V.A.C. 0/30μA/6mA/6 OmA/300mA/600mA. 0/8K/80K/800K/8 meg. –20 to + 63 db. **£5·97½**, P. & P. 15p.

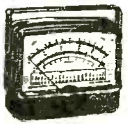
MODEL TE-12. 20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60μA/6/60/600 mA. 0/6K/600K/6Meg./60 Meg. Ω. 50 PF. .2 MFD. **£5·97½**. P. & P. 17½p.

MODEL 500 30,000 O.P.V. with overload protection, mirror scale. 0/.5/2.5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50μA/5/50/500 mA. 12 amp. D.C. 0/60/K/6 meg/60 meg Ω. **£8·87½**, Post paid.

MODEL TE-90 50,000 O.P.V. Mirror scale, overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200 v. D.C. .03/6/60/600 MA. D.C. 16K/160K/1.6/16 MEG. —20 to +63 dB. **£7·50**, P. & P. 15p.

TMK MODEL TW-20CB FEATURES RESETTABLE OVERLOAD BUTTON. Sensitivity: 20K Ω/Volt D.C. 5K Ω/Volt A.C.
D.C. Volts: 0-0.5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 0-2.5, 10, 50, 250, 1,000V. D.C. Currents: 0-0.05, 0.5, 5, 50, 500mA. - 10 amp. Resistance: 0-5K, 50K, 0-500K. 5 MEG. Decibels: –20 to + 52db. **£11·50**. P. & P, 17½p.

MODEL AS-100D. 100K Ω/Volt 5 in., mirror scale. Built-in meter protection 0/3/12/60/120/300/600 1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10μA/6/60/300MA/12 Amp. 0/2K/200K/2M/200M. –20 to + 17 dB. **£12·50**. P. & P. 17½p.



TMK LAB TESTER 100,000 O.P.V. 6½ in. Scale Buzzer Short Circuit Check. Sensitivity: 100,000 OPV D.C. 5 /Volt A.C. D.C. Volts: .5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 3, 10, 50, 250, 500, 1,000V. D.C. Current: 10, 100μA, 10, 100, 500mA, 2.5, 10 amp. Resistance: 1K, 10K, 100K, 10MEG, 100MEG. Decibels: —10 to +49 db. Plastic Case with carrying handle. Size 7½ × 6½ × 3¼. **£18·90**. P. & P. 25p.

SKYWOOD SW-500

50 K Ω/Volt. Mirror scale D.C. volts: 0.6/3/12/30/300/600. A.C. volts: 3/30/300/600. D.C. current: 20μA/6/60/600mA. Resistance: 10K/100K/1 Meg. Decibels: —20 to + 57 dB. **£7·50**, P. & P. 15p.

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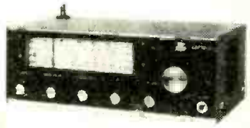
4 Bands covering 550kc/s - 30mc/s. B.F.O. Built in Speaker 220/240v AC. Brand new with instructions. **£15·75**, Carr. 37½p.

WS62 TRANSCEIVERS

Large quantity available for EXPORT! Excellent condition. Enquiries invited



UR-1A SOLID STATE COMMUNICATION RECEIVER

4 Bands covering 550kc/s - 30mc/s. FET, S Meter, Variable BFO for SSB, Built in Speaker. Bandspread, Sensitivity Control. 220/240v AC or 12v DC. 12¾″ × 4¾″ × 7″. Brand new with instructions. **£25**. Carr. 37½p.

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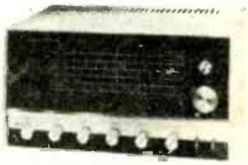
General coverage 150-400 kc/s, 550kc/s-30 mc/s. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, S Meter, Bandspread. RF Gain. 15″ × 9¾″ × 8½″. 18 lb. 220/240v AC or 12v DC. Brand new with instructions. **£45** Carriage 50p.

LAFAYETTE HA-800 SOLID STATE AMATEUR COMMUNICATION RECEIVER



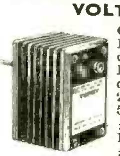
3.5 - 4, 7 - 7.3, 14 - 14.35, 21 - 21.45, 28 - 29.7, 50 - 54 mc/s. Dual conversion, 2 mech. filters, product detector, variable BFO, S Meter, 100kc/s calibrator. 220/240v AC or 12v DC. 15″ × 9¾″ × 8½″. 18 lb. Brand new with instructions. **£57·50**. Carr. Paid. (100kc/s Crystal £1·97½p extra).

FULL RANGE TRIOEQUIPMENT

EDDYSTONE V.H.F. RECEIVERS

770R. 19-165 Mc/s. excellent condition. **£150.**

SOLID STATE VARIABLE A.C. VOLTAGE REGULATORS



Compact and panel mounting. Ideal for control of lamps, drills, electrical appliances etc. Input 230/240 v. A.C. Output continuously variable from 20 v.-230 v. Model MR 2305 5 amp 68 × 46 × 43 mm. **£8·37½**. Model MR 2310 10 amp 90 × 68 × 60 mm. **£11·97½**. Postage 12½p.

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150 W.	£2·37½,	P. & P. 17½p
300 W.	£3·25,	P. & P. 22½p
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1,000 W.	£7·25,	P. & P. 37½p
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VOLTAGE STABILISER TRANSFORMERS. 180-260v. input. Output 230v. Available 150w or 225w. **£12·50**, Carr. 25p.

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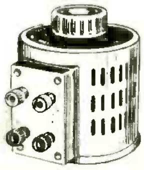
High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ¼in. dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. 72½p. P. & P. 7½p
50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. £1·05. P. & P. 7½p.
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. £1·37½. P. & P. 7½p.



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5 Amp ..	£9·75
8 Amp ..	£14·50
10 Amp ..	£18·50
12 Amp ..	£21·00
20 Amp ..	£37·00

MODEL S-260 B Panel Mounting

1 Amp	£5·50
2.5 Amp	£6·62½

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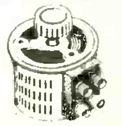
ALL MODELS
INPUT 230 VOLTS, 50/60 CYCLES
OUTPUT VARIABLE 0-260 VOLTS
Special discounts for quality



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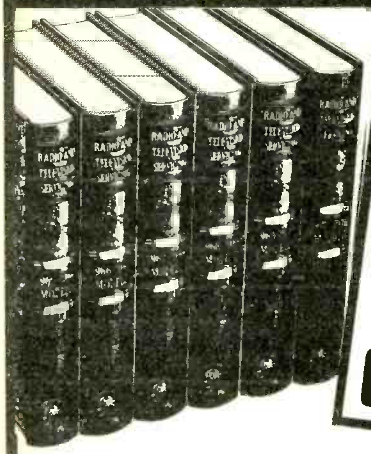

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6·4	25	6p
12·5	25	6p
25	25	6p
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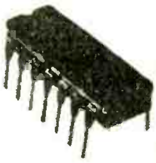

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6F23	0·72
6F24	0·68
6F25	0·65
6F26	0·29
6F28	0·70
6G6G	0·75
6H6GT	0·15
6J5G	0·19
6J6	0·18
6J7G	0·24
6J7GT	0·38
6K7G	0·10
6K7GT	0·23
6K8G	0·20
6L1	0·98
6L6GT	0·39
6L7GT	0·63
6L18	0·45
6L19	1·38
6LD20	0·48
6N7GT	0·40
6P15	0·24
6P28	1·25
6Q7G	0·30
6Q7GT	0·43
6R7G	0·35
6R7	0·55
6SA7GT	·35
6SC7GT	0·33
6SG7	0·33
6SH7	0·53
6SJ7GT	0·35
6SK7GT	·23
6SN7GT	·23
6SQ7	0·38
6U4GT	0·60
6U7G	0·53
6V6G	0·18
6V6GT	0·33
6X4	0·22
6X5GT	0·25
6Y6G	0·55
6Y7G	0·63
7B6	0·58
7B7	0·35
7C6	0·30
7F8	0·63
7H7	0·28
7R7	0·65
7V7	0·25
9BW6	0·50
9D7	0·78
10C1	1·25
10C2	0·50
10C14	0·33
10D1	0·50
10F1	0·75
10F9	0·45
10F18	0·35
10L14	0·37
10LD11	0·53
10PL12	0·35
10P13	0·65
10P14	1·10
10P18	0·33
12A6	0·63
12AC6	0·40
12AD6	0·40
12AE6	0·48
12AT6	0·23
12AT7	0·19
12AU6	0·24
12AU7	0·23
12AV6	0·28
12AX7	0·23
12AY7	0·68
12BA6	0·30
12BE6	0·30
12BH7	0·40
12E1	0·85
12J7GT	0·33
12K5	0·50
12K7GT	·34
12Q7GT	0·28
12SA7GT	0·40
12SC7	0·35
12SG7	0·23
12SH7	0·15
12SJ7	0·23
12SK7	0·24
12SQ7GT	0·50
14H7	0·48
18	0·63
19AQ5	0·24
19H1	2·00
20D1	0·65
20D4	1·02
20F2	0·70
20L1	0·98
20P1	0·88
20P3	0·90
20P4	0·93
20P5	1·00
25A6G	0·29
25L6G	0·29
25Y5	0·38
25Y5G	0·43
25Z4	0·30
25Z5	0·40
25Z6G	0·43
30C1	0·30
30C15	0·65
30C17	0·80
30C18	0·64
30F5	0·80
30FL1	0·64
30FL2	0·75
30FL12	0·80
30FL14	0·73
30L1	0·32
30L15	0·64
30L17	0·78
30P4MR	·98
30P12	0·69
30P16	0·33
30P18	0·33
30P19/30P4	0·60
30PL1	0·69
30PL12	0·37
30PL13	0·78
30PL14	0·75
30PL15	0·98
35A3	0·50
35A5	0·75
35D5	0·70
35L6GT	0·44
35W4	0·23
35Z3	0·50
35Z4GT	0·24
35Z5GT	0·30
50B5	0·35
50C5	0·32
50CD6G	2·17
50L6GT	0·45
72	0·33
77	0·53
85A2	0·43
85A3	0·40
90AG	3·38
90AV	3·38
90CG	1·70
90CV	1·68
90C1	0·80
150B2	0·58
150C2	0·30
301	1·00
302	0·83
303	0·75
305	0·83
306	0·65
807	0·59
956	0·10
1821	0·53
5763	0·50
6060	0·30
7193	0·53
7475	0·70
A1834	1·00
A2134	0·98
A3042	0·75
AC044	1·18
AC2PEN	98
AC2PENDD	0·98
AC6PEN	·38
ACPEN (7)	0·98
AC/TH1	·50
AC/TP	0·98
AL60	0·78
ARP3	0·35
ATP4	0·12
AZ1	0·40
AZ31	0·48
AZ41	0·53
B319	0·32
CL33	0·98
CV6	0·53
CV988	0·10
CY1C	0·53
CY31	0·38
D63	0·25
D77	0·12
DAC32	0·35
DAF91	0·22
DAF96	0·35
DCC90	1·00
DD4	0·53
DF33	0·39
DF91	0·14
DF96	0·35
DF97	0·63
DH63	0·30
DH76	0·28
DH77	0·20
DH81	0·58
DH101	1·25
DK32	0·37
DK40	0·55
DK91	0·28
DK92	0·43
DK96	0·37
DL33	0·35
DL92	0·29
DL94	0·32
DL96	0·37
DM70	0·30
DM71	0·38
DW4/350	0·38
DY86/7	0·29
DY802	0·48
E80F	1·20
E83F	1·20
E88CC	0·60
E180F	0·95
E182CC	1·13
E1148	0·53
EA50	0·18
EA76	0·88
EABC80	·33
EAC91	0·38
EAF42	0·50
EB34	0·20
EB41	0·50
EB91	0·12
EBC41	0·48
EBC81	0·33
EBC90	0·20
EBC91	0·30
EBF80	0·34
EBF83	0·40
EBF89	0·32
EBL21	0·60
EC53	0·63
EC54	0·50
EC70	0·24
EC86	0·63
EC88	0·60
EC92	0·35
ECC32	1·58
ECC33	1·58
ECC40	0·60
ECC81	0·19
ECC82	0·23
ECC83	0·23
ECC84	0·30
ECC85	0·28
ECC86	0·40
ECC88	0·35
ECC189	0·48
ECC804	0·58
ECC807	1·35
ECF80	0·33
ECF82	0·33
ECF86	0·65
ECF804	2·10
ECH21	0·63
ECH35	0·29
ECH42	0·64
ECH81	0·29
ECH83	0·40
ECH84	0·38
ECL80	0·35
ECL82	0·33
ECL83	0·52
ECL84	0·60
ECL85	0·55
ECL86	0·40
EF22	0·63
EF36	0·33
EF37A	0·35
EF39	0·40
EF40	0·50
EF41	0·50
EF42	0·33
EF54	0·98
EF73	0·33
EF80	0·23
EF83	0·48
EF85	0·29
EF86	0·32
EF89	0·25
EF91	0·17
EF92	0·13
EF97	0·55
EF98	0·65
EF183	0·30
EF184	0·30
EFP60	0·50
EH90	0·38
EK90	0·24
EL32	0·18
EL34	0·53
EL37	0·87
EL41	0·55
EL42	0·53
EL81	0·50
EL83	0·38
EL84	0·24
EL85	0·40
EL86	0·40
EL91	0·23
EL95	0·35
EM34	0·90
EM80	0·38
EM81	0·42
EM84	0·34
EM87	0·38
EY51	0·37
EY81	0·35
EY83	0·55
EY84	0·50
EY86/7	0·33
EY88	0·43
EY91	0·53
EZ35	0·25
EZ40	0·40
EZ41	0·43
EZ80	0·23
EZ81	0·24
EZ90	0·22
FW4/500	0·75
FW4/800	0·75
GZ30	0·35
GZ32	0·45
GZ33	0·70
GZ34	0·53
GZ37	0·75
HABC80	·45
HL13C	0·20
HL23DD	·40
HL41DD	·98
HL42DD	·50
HN309	1·37
HVR2	0·53
HVR2A	·53
IW3	0·38
IW4/350	0·38
IW4/500	0·38
KT2	0·25
KT8	1·73
KT41	0·98
KT44	1·00
KT63	0·25
KT66	0·83
KT74	0·63
KT76	0·63
KT88	1·70
KTW61	·63
KTW62	·63
KTW63	·50
L63	0·19
LN119	0·35
LN152	0·35
LN309	0·50
LN319	0·69
LN329	0·75
LN339	0·64
LZ319	0·30
LZ329	0·30
M8162	0·63
ME1400	·74
MHL4	0·75
MHLD6	·75
MU12/14	0·38
MX40	0·63
N78	2·02
N108	1·40
N119	0·33
N142	0·59
N152	0·48
N154	0·33
N308	0·98
N329	0·33
N339	1·25
N359	0·48
N379	0·33
N389	0·60
N709	0·24
P61	0·50
PABC80	·35
PC86	0·52
PC88	0·52
PC95	0·53
PC97	0·40
PC900	0·38
PCC84	0·32
PCC85	0·33
PCC88	0·49
PCC89	0·48
PCC189	0·49
PCC805	0·64
PCC806	0·78
PCE800	·64
PCF80	0·30
PCF82	0·33
PCF84	0·40
PCF86	0·50
PCF87	0·80
PCF200	0·67
PCF800	0·65
PCF801	0·35
PCF802	0·45
PCF805	0·64
PCF806	0·64
PCF808	0·73
PCF812	0·75
PCH200	·62
PCL82	0·37
PCL83	0·50
PCL84	0·38
PCL86	0·43
PCL88	0·75
PCL800	0·78
PCL801	0·69
PCL805/PCL85	0·45
PD500	1·44
PEN4DD	1·38
PEN45	0·35
PEN45DD	0·75
PEN46	0·20
PEN453DD	0·98
PENA4	0·98
PEN/DD 4020	0·88
PFL200	·59
PL33	0·38
PL36	0·48
PL81	0·48
PL81A	0·63
PL82	0·33
PL83	0·33
PL84	0·33
PL302	0·60
PL500	0·68
PL504	0·68
PL505	1·44
PL508	1·40
PL509	1·44
PL801	0·69
PL802	0·75
PM84	0·39
PX4	1·18
PX25	1·18
PY32/3	0·50
PY80	0·33
PY81	0·27
PY82	0·27
PY83	0·29
PY88	0·34
PY301	0·63
PY500	1·08
PY800	0·38
PY801	0·34
PZ30	0·48
QQVO3/10	1·20
QS75/20	·63
QS150/15	0·63
QVO4/7	·63
R10	0·75
R11	0·98
R16	1·75
R17	0·88
R18	0·50
R19	0·33
R20	0·59
R52	0·38
RG1/240A	1·98
RK34	0·38
SP13C	0·63
SP42	0·75
SP61	0·33
TH4B	0·50
TH233	0·98
TP2620	0·98
UABC80	·33
UAF42	0·52
UBC41	0·45
UBC81	0·40
UBF80	0·29
UBF89	0·34
UBL21	0·55
UC92	0·35
UCC84	0·40
UCC85	0·37
UCF80	0·42
UCH21	0·60
UCH42	0·63
UCH81	0·33
UCL82	0·35
UCL83	0·50
UF41	0·50
UF42	0·60
UF80	0·35
UF85	0·34
UF86	0·63
UF89	0·34
UL41	0·59
UL46	0·88
UL84	0·33
UM80	0·33
URIC	0·53
UU5	0·38
UU9	0·40
UU12	0·24
UY1N	0·50
UY21	0·55
UY41	0·38
UY85	0·29
U10	0·45
U12/14	0·38
U16	0·75
U17	0·35
U18/20	0·75
U19	1·73
U22	0·39
U25	0·65
U26	0·59
U31	0·30
U33	1·48
U35	0·83
U37	1·75
U45	0·78
U47	0·65
U49	0·59
U50	0·28
U76	0·24
U78	0·22
U107	0·92
U153	0·27
U191	0·63
U192	0·27
U193	0·34
U251	0·73
U281	0·40
U282	0·40
U291	0·50
U301	0·53
U329	0·73
U381	0·29
U403	0·33
U404	0·38
U801	0·95
U4020	0·38
VP2	0·53
VP2B	0·48
VP13C	0·35
VP23	0·40
VP41	0·38
VR75	1·20
VR105	0·33
VR150	0·33
VT61A	0·35
VT501	0·15
VU111	0·44
VU120	0·60
VU120A	·60
VU133	0·35
W76	0·34
W81M	0·68
W107	0·50
W729	0·60
XE3	5·00
XFY12	0·48
XH1·5	0·48
X41	0·50
X61	0·29
X65	0·50
X101	1·53
Z329	0·80
Z749	0·72
Z759	2·50

Transistors and diodes

1N1124	0·53
2N404	0·18
2N966	0·53
2N1756	0·50
2N2147	0·85
2N2297	0·23
2N2369A	0·22
2N2613	0·39
2N3053	0·33
2N3121	2·50
2N3703	0·19
2N3709	0·20
2N3866	1·00
2N3988	0·50
2S323	0·50
AA119	0·15
AA120	0·15
AA129	0·15
AAZ13	0·18
AC107	0·15
AC113	0·25
AC114	0·40
AC127	0·20
AC128	0·20
AC154	0·25
AC156	0·20
AC157	0·25
AC165	0·25
AC166	0·25
AC167	0·60
AC168	0·38
AC169	0·33
AC176	0·55
AC177	0·28
ACY17	0·25
ACY18	0·20
ACY19	0·19
ACY20	0·18
ACY21	0·19
ACY22	0·15
ACY28	0·18
AD140	0·38
AD149	0·50
AD161	0·45
AD162	0·45
ADT140	·63
AF102	0·90
AF106	0·50
AF114	0·25
AF115	0·15
AF117	0·20
AF119	0·23
AF121	0·30
AF124	0·25
AF126	0·18
AF139	0·65
AF178	0·68
AF180	0·48
AF181	0·70
AF186	0·55
AF239	0·38
ASY27	0·43
ASY28	0·33
ASY29	0·50
B1181	0·50
BA102	0·45
BA115	0·14
BA116	0·25
BA129	0·13
BA130	0·10
BCY10	0·45
BCY12	0·50
BCY33	0·20
BCY34	0·23
BCY38	0·23
BCY39	0·25
BC107	0·13
BC108	0·13
BC113	0·25
BC115	0·15
BC116	0·25
BC118	0·23
BCZ11	0·38
BD119	0·45
BF154	0·25
BF159	0·25
BF163	0·20
BF173	0·38
BF180	0·30
BF181	0·40
BF185	0·40
BFY50	0·23
BFY51	0·19
BFY52	0·20
BTX34/400	2·00
BY100	0·18
BY101	0·15
BY105	0·18
BY114	0·18
BY126	0·15
BY127	0·18
BYY23	1·00
BYZ10	0·25
BYZ11	0·25
BYZ12	0·25
BYZ13	0·25
BYZ15	1·75
CG12E	0·20
CG64H	0·20
FSY11A	·23
FSY28A	·23
GD4	0·32
GD5	0·28
GD6	0·28
GD8	0·20
GD9	0·20
GD10	0·20
GD11	0·20
GD12	0·20
GD14	0·50
GD15	0·40
GD16	0·20
GET111	·78
GET113	·20
GET116	·40
GET118	·20
GET119	·20
GET573	·38
GET587	0·43
GET872	·95
GET873	·15
GET882	·50
GET887	·23
GET889	·23
GET890	·23
GET896	·23
GET897	·23
GET898	·23
GEX13	0·18
GEX35	0·23
GEX36	0·50
GEX45	0·33
GEX55	0·75
GT3	0·25
M1	0·15
M3	0·15
MAT100	·39
MAT101	·43
MAT120	·39
MAT121	·43
OA5	0·28
OA9	0·13
OA10	0·43
OA47	0·10
OA70	0·15
OA73	0·15
OA79	0·09
OA81	0·09
OA85	0·08
OA86	0·20
OA90	0·13
OA91	0·09
OA95	0·09
OA200	0·09
OA202	0·10
OA210	0·48
OA211	0·68
OC19	1·25
OC22	0·38
OC23	0·38
OC24	0·38
OC25	0·38
OC26	0·25
OC28	0·60
OC29	0·63
OC35	0·32
OC36	0·43
OC38	0·43
OC41	0·50
OC42	0·63
OC43	1·18
OC44	0·10
OC45	0·13
OC46	0·15
OC65	1·13
OC70	0·13
OC71	0·13
OC72	0·13
OC74	0·23
OC75	0·13
OC76	0·15
OC77	0·27
OC78	0·15
OC78D	0·15
OC79	0·40
OC81	0·13
OC81D	0·13
OC82	0·13
OC82D	0·15
OC83	0·20
OC84	0·24
OC123	0·23
OC139	0·23
OC140	0·95
OC169	0·23
OC172	0·35
OC200	0·23
OC201	0·38
OC202	0·43
OC203	0·30
OC204	0·30
OC205	0·43
OC206	0·50
OC812	0·40
OCP71	1·65
ORP12	0·53
S6M1	0·25
SM1036	0·50
ST1276	0·50
SX1/6	0·18
U14706	0·25
XZ30	0·25
Y543	0·18
Y728	0·18
ZE12V7	·09

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LP15 (AC113, AC154. AC157, AA120). ·53

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1—OC44 and 2—OC45, ·43

1—OC82D and 2—OC82, ·48 Set of 3—OC83 0·65

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Wilkinsons

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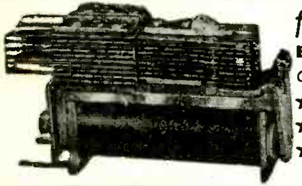

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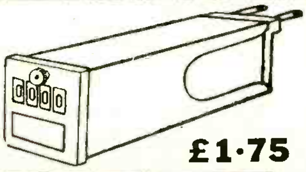

£1·75

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NGLEY HOUSE LO DON SURREY

: 01-684 0236 CO CROYDON

EX COMPUTER PRINTED CIRCUIT PANELS 2" × 4" packed with semiconductors and top quality resistors, capacitors, diodes, etc. Our price, 10 boards, 50p. P. & P. 7p. With a guaranteed minimum of 35 transistors. Transistor Data included.

SPECIAL BARGAIN PACK. 25 boards for £1. P. & P. 18p. With a guaranteed minimum of 85 transistors. Transistor Data included.

PANELS with 2 power transistors sim. to OC28 on each board plus components. 2 boards (4 × OC28) **50p.** P. & P. 5p.

9 OA5, 3 OA10, 3 Pot Cores, 26 Resistors, 14 Capacitors, 3 GET872, 3 GET872B, 1 GET875. All long leaded on panels 13" × 4". 4 for £1. P. & P. 25p.

12V 4A POWER SUPPLY

Extremely well made by FRAKO GmbH in W. Germany, with constant voltage mains transformer, tapped input from 115V to 240V. Full wave rectification and capacitor smoothing. Size 9"×6"×5", weight 11 lb. These units are brand new, unused and fully guaranteed. Maker's price believed to be around £80. Our Price £9·5. Carr. 50p.

250 MIXED RESISTORS ¼ and ½ Watt **62p**

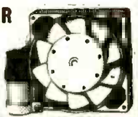
DIODES EX EQPT. SILICON

1 Amp 1,000 PIV 4 for **50p**

20 Amp 150 PIV 4 for **£1·00**

P. & P. 5p

EXTRACTOR/BLOWER FANS (Papst)



100 c.f.m. 4½" × 4½" × 2", 2800 r.p.m. 240V AC **£2·5** each. P. & P. 25p.

RELAY OFFER

Single Pole Changeover Silver Contacts 2" × 6" × 7". 2.5KΩ Coil operates on 25 to 50V. 8 for 50p. P. & P. 8p.

BUMPER BARGAIN PARCEL

We guarantee that this parcel contains at least 1,750 components. Short-leaded on panels, including a minimum of 350 transistors (mainly NPN and PNP germanium, audio and switching types—data supplied). The rest of the parcel is made up with: Resistors 5% or better (including some 1%) mainly metal oxide, carbon film, and composition types. Mainly ⅛ and ¼ watt . . . diodes, miniature silicon types OA90, OA91, OA95, 1S130, etc. . . . capacitors including tantalum, electrolytics, ceramics and polyesters . . . inductors, a selection of values . . . also the odd transformer, trim-pot, etc., etc. . . . These are all miniature, up to date, professional, top quality components. Don't miss this, one of our best offers yet! Price **£3·25.** P. & P. 33p—U.K. New Zealand £1 P. & P. Limited stocks only.

EX-COMPUTER POWER SUPPLIES

Reconditioned, fully tested and guaranteed. These very compact units are fully smoothed with a ripple better than 10mv. and regulation better than 1%. Over voltage protection on all except 24v. units. 120v.-130v. a.c. 50c/s input. Mains transformer to suit £3 extra if required.

We offer the following types:

6v.	8a.	**£10**
6v.	15a.	**£14**
12v.	20a.	**£16**
20v.	15a.	**£15**
30v.	7a.	**£12**
24v.	4a.	**£14**

Carriage 75p per unit.

150 High Stabs ⅛, ¼ and 1 Watt, 5% and Better **62p**

LARGE CAPACITY ELECTROLYTICS

4½"×2" dia. 10,000 mfd 30V
~~5,000 mfd 55V~~
16,000 mfd 12V

40p each P. & P. 6p

4½"×2" dia. 8,000 mfd 55V

50p each P. & P. 12p each

EXTENSION TELEPHONES

99p ea. P. & P. 25p

£1·75 for 2 P. & P. 50p

These phones are extensions and do not contain bells.

KEYTRONICS

MAILING ADDRESS
44 EARLS COURT ROAD, LONDON W.8
WAREHOUSE AND DISPATCH
01 478 8499

AUDIOTRINE A55 HIGH QUALITY STEREO SYSTEM

5 + 5 WATT OUTPUT

Garrard 5200 Changer with low mass pick-up arm and Stereo Cartridge. Controls: TREBLE, BASS, VOLUME STEREO BALANCE.

Operation on 200-250 v. A.C. mains. Output rating I.H.F.M.

Luxurious Teak Veneer Finished Cabinets. Transparent plastic (tinted) cover included for main unit. Silver finished facia plate and matching control knobs.

PAIR OF LOUDSPEAKER UNITS incorporating high flux 8in. × 5in. speaker. Size approx. 13 × 7½ × 8¾ ins.

PRICE COMPLETE ONLY £42 Carr. £1·25

Terms: Deposit £5.50 and 9 monthly payments £4.50 (Total £46).

A REALLY SURPRISING STANDARD OF QUALITY IS OBTAINED FROM THIS COMPACT LOW PRICED SYSTEM

FANE 807 HIGH FIDELITY LOUDSPEAKER

A full range 8in. 10 watt Unit for excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance at 30 c.p.s. Tweeter cone is fitted to extend high note response. Frequency range 25-15KHz. Impedance 3 Ω or 8-15 Ω. Cast Chassis.

REMARKABLE VALUE AT ONLY **£3·50**

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround or "L" indicates Roll Rubber surround. "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 8-15 ohms.

WHEN ORDERING PLEASE STATE IMPEDANCE

HF 801D	8″	8W	£2·71	HF 120D	12″	15W	£4·49
HF 102D	10″	10W	£3·40	HF 126	12″	15W	£5·25
HF 120	12″	15W	£3·99	HF 126D	12″	15W	£5·75

FANE ULTRA HIGH POWER LOUDSPEAKERS

All power ratings are R.M.S. continuous. 2 years' guarantee. High flux ceramic magnets Heavy cast chassis. ALL CARRIAGE FREE.

'POP' 100

18in. 100 watt 14,000 gauss 8/15Ω

£22·05

Dep.: £6 and 9 monthly payments £2 (Total £24).

'POP' 60

15in. 60 watt 14,000 gauss 8/15Ω

£12·90

Dep.: £3·30 and 9 monthly payments £1·30 (Total £15).

FOR BASS GUITAR OR ELECTRONIC ORGAN, ETC.

'POP' 50

12in. 50 watt 13,000 gauss 15Ω

£10·50

Dep.: £2 and 9 monthly payments £1·15 (Total £12·35). PAIR SUITABLE ALL PURPOSES.

FANE LOUDSPEAKERS 'POP' 25/2

Dual cone 15 Ω (for uses other than Bass Guitar or Electronic Organ. Carr. free. Or dep.: £1 and 9 monthly payments 75p (Total £7·75).

12in. 25watt **£6·75**

R.S.C. TA6 6 Watt High Fidelity Solid State Amplifier

200–250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, approx. 9½ × 2¾ × 5½in. Attractive brushed silver finish facia plate 10½ × 3¾in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. **£7·50** Carr. 40p

OR FACTORY BUILT with 12 months' g'tee. £9.45

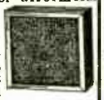
R.S.C. BATTERY/MAINS CONVERSION UNITS

Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s. is available.

Complete kit with diagram £3 or, READY FOR USE £3·50.

HIGH QUALITY LOUDSPEAKERS

In teak or afrormosia veneered cabinets.



L13 3 or 15 ohms. 13 × 8in. 8-10 Watt Model Gauss 10,000 lines, Carr. 40p **£5·25**

L12 12in. 20 Watt Model. Gauss 11,000 lines. Size 18 × 18 × 10 in. approx. 15 Ω. Carr. 45p. £9·50. Or dep £2 and 9 mthly pymts £1. (Total £11).

R.S.C. COLUMN SPEAKERS

Covered in Rexine and Vynair, ideal for vocalists and Public Address. 15 ohm matching.

TYPE C488, 30 watts. Fitted four 8in. high flux 8w. speakers. Or dep. £3 and 9 mthly pmts £2 (Total £21). Carr. 50p. **£17·75**

TYPE C4128, 50 watts. Fitted four 12in. 11,000 lines 15 watt Speakers. Or dep. £4 and 9 mthly. pymts. of £3 (Total £31). **£27·50** Carr. 75p

AUDIOTRINE HI-FI SPEAKER SYSTEMS

Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. Carr. 30p. **£5·75**

Or SENIOR 15 WATT inc. HF126 15,000 line Speaker £6·75. Carr. 35p.

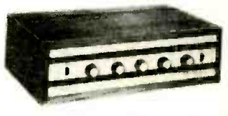
HI-FI LOUDSPEAKER ENCLOSURES

Teak or Afrormosia veneer finish. Modern design. Acoustically lined. All sizes approx. Carr. 25p extra.

JE8 Size 16 × 11 × 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker.	£4·75
SE8 For optimum performance with any 8in. Hi-Fi 'speaker. 22 × 15 × 9in. Ported	£5·75
SE10 For outstanding results with Hi-Fi 10in. speaker. 24 × 15 × 10in. Ported	£5·99
SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 × 16 × 10½in. Pressurised.	£6·99

TA12 MK III 6·5 + 6·5 WATT STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL

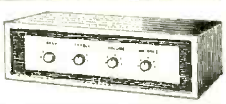


Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 20-20,000c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000c.p.s. Hum and noise —70dB ★ Sensitivities (1) 50 mV (2) 400 mV (3) 100 mV ★ Handsome finish Facia Plate and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. Carr. 40p. **£15·50**

FACTORY BUILT WITH 12 MTH GNTEE. £19·50. Or dep. £3 and 9 mnthly pymts. £2·05 (Total £21·45). Or in Teak veneer housing. £23. Or Dep. £3 and 9 mthly. pymts £2·55 (Total £25·95).

SELENIUM RECTIFIERS F.W. Bridged 6/12v. D.C. Output Input Max. 18v A.C. 1a., 25p; 2a., 35p; 3a., 50p; 4a., 65p; 6a., 80p

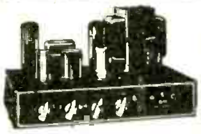
R.S.C. G66 6+6 WATT HIGH QUALITY STEREO AMPLIFIER



Individual/Ganged controls: Bass, Treble, Volume and Balance. Printed circuit construction employing 10 Transistors plus Diodes. Output rating I.H.F.M. Suitable for Crystal Pick-ups etc., and for loudspeaker output impedances of 3 to 15 ohms. For standard 200-250 v A.C. mains operation. Attractive silver finished metal facia plate and matching control knobs. Complete KIT of PARTS INCLUDING FULLY WIRED PRINTED CIRCUIT and comprehensive wiring diagram and instructions. **£9·99** No leaflet supplied for this unit. Or FACTORY BUILT in Teak veneered cabinet as illustrated £12.50. Carr. 40p. Or Deposit £2 and 9 monthly payments of £1.45 (Total £15.05).

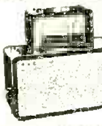
PACKAGE OFFER, SAVE APPROX. £4. Above G66 assembled in cabinet plus pair DORCHESTER LOUDSPEAKER UNITS. Or Deposit £5·25 and 9 monthly payments £2·85 (Total £30·90). **£27·50** Carr. £1

R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Hum level —70dB. Frequency response ±3dB 30-20,000 c/s. All high grade components. Valves EF86, EF86, ECC83, 807 .807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., A.C. For 3 & 15 Ω speakers. Complete Kit parts, wiring diagrams, instructions. **£15·75** Twin-handled perforated cover £1·75. Or factory built with EL34 output valves and 12 months' guarantee for £19·75. Tech. figs. apply to factory built units. Carr. 65p. TERMS: Deposit £4·00 and 9 monthly payments of £2·10 (Total £22·90). Send S.A.E. for leaflet.

RSC BASS-REGENT 50 watt AMPLIFIER



A powerful high quality, all purpose unit. For lead, rhythm, bass guitar, vocalists, gram., radio, tape. Peak output rating. Employing current valves and reliable components. FOUR JACK INPUTS and TWO VOLUME CONTROLS for simultaneous use of up to 4 pick-ups or 'mikes'. SEPARATE BASS AND TREBLE CONTROLS. OR SUPPLIED COMPLETE with matched twin loudspeaker unit as illustrated for £60. Carr. £1·50. Terms: Dep. £16 and 9 monthly payments £5·75 (Total £67·75).

ONLY £30 Carr. 90p

THE 'YORK' HIGH FIDELITY 3 'SPEAKER SYSTEM

Moderate size (approx. 25 × 14 × 10 in.). Range 30-20,000 c.p.s. Impedance 15 ohms. Performance comparable with units costing considerably more. Consists of (1) 12in. 15 watt Bass unit with cast chassis. Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker. (4) High efficiency tweeter. (5) Appropriate quantity acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions.

Complete kit **£22** Carr. 63p

REMARKABLE VALUE **HEAR IT AT ANY BRANCH**

INTEREST CHARGES REFUNDED

On Credit Sales settled in 3 months

R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250v. 50c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2¾ × 2¼in.

250v., 60mA, 6.3v. 2a.	90p
250-0-250v., 60mA, 6.3v. 2a.	95p

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v, 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	£1·25
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
300-0-300v. 130mA, 6.3v. 4a., c.t., 6.3v. 1a. For Mullard 510 Amplifier.	£2·40
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a.	£2·40
425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a.	£4·49
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a, 5v. 3a	£4·69
450-0-450v. 250mA. 6.3v. 4a., c.t., 5v. 3a.	£4·99

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v. 70mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·20
250-0-250v. 100mA, 6.3v. 3.5a.	£1·40
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	£1·45
350-0-350v. 80mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·50
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
300-0-300v. 130mA, 6.3v. 4a., 0-5-6.3v. 1a. Suitable for Mullard 510 Amplifier	£2·35
350-0-350v. 400mA., 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
350-0-350v. 150mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·35

FILAMENT or TRANSISTOR POWER PACK Types 6.3v. 1.5a. 45p; 6.3v. 2a. 49p; 6.3v. 3a. 69p; 6.3v. 6a, £1·15; 12v. 1a. 50p; 12v. 3a. or 24v. 1.5a. £1·20; 0-9-18v. 1½a. 99p; 0-12-25-42v. 2a. £1·60.

CHARGER TRANSFORMERS 0-9-15v. 1½a. 95p; 2½a. 99p; 3a. £1·10; 5a. £1·30; 6a. £1.49; 8a. £1·85.

AUTO (Step UP/Step DOWN) Transformers 0-110/120v. 200-230-250v. 50-80 watts 99p; 150 watts, £1·70; 250 watts £2·49; 500 watts £5·25.

OUTPUT TRANSFORMERS

Standard Pentode 5,000 Ω to 7,000 Ω to 3 Ω	45p
Push-Pull 8 watts EL84 to 3 Ω or 15 Ω	75p
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15 Ω	£1·25
Push-Pull EL84 to 3 or 15 Ω 10-12 watts	£1·20
Push-Pull Ultra Linear for Mullard 510, etc.	£1·99
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15 Ω	£1·80
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15 Ω	£2·99

SMOOTHING CHOKES 150mA, 7-10H. 250 Ω 65p; 100mA. 10H. 200 Ω 55p; 80mA. 10H. 350 Ω 45p; 60mA. 10H. 400 Ω 25p.

R.S.C. SUPER 30 Mk II HIGH FIDELITY STEREO AMPLIFIER

HIGH GRADE COMPONENTS. SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE

Employing Twin Printed Circuits. 200/250v. A.C. mains operation.

TRANSISTORS: 9 high-quality types per channel.

OUTPUT (Per channel): 10 Watts R.M.S. continuous into 15 Ω 15 Watts R.M.S. continuous into 3 Ω.

INPUT SENSITIVITIES: Mag. P.U. 4 m.v. Ceramic P.U. 35 m.v. Tape Amp. 400 m.v. Aux. 100 m.v. Mic. 5 m.v. Tape Head 2.5 m.v.

FREQUENCY RESPONSE: ±2dB. 10-20,000c.p.s.

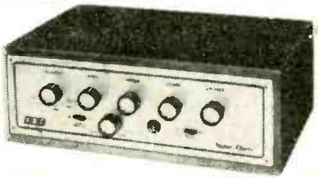
TREBLE CONTROL: +17 dB to —14 dB at 10 Kc/s.

BASS CONTROL: +17 dB to —15 dB at 50 c/s.

HUM LEVEL: —80 dB.

HARMONIC DISTORTION: 0.1% at 10 Watts 1,000 c.p.s.

CROSS TALK: 52 dB at 1,000 c.p.s.



CONTROLS: 5-position Input Selector, Bass, Treble, Vol., Bal., Stereo/Mono Sw., Tape Monitor Sw., Mains Sw.

INPUT SOCKETS: (1) P.U. (2) Tape Amp. (3) Radio. (4) Mic. or Tape Head. (Operation of Input Selector assures appropriate equalisation.)

CHASSIS: Strong Steel construction. Approx. 12 × 3 × 8in.

FACIA PLATE: Attractive design in rigid "Perspex" with silver background. Spun silver matching control knobs as available.

EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MIC. (Ceramic or Magnetic, Moving Coil, Ribbon or Crystal) **CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USE WITH FIRST-RATE ANCILLARY EQUIPMENT. COMPLETE KIT OF PARTS**, point to point wiring diagrams & detailed instructions supplied. **£23·25** Carr. 75p

UNIT FACTORY BUILT £30.50

Or deposit £4 and 9 mnthly payments £3·35 (Total £34·15).

Or in Teak or Afrormosia veneer housing as illustrated. Carr. 75p. **£33·75**

Terms: Deposit £4 and 9 monthly payments £3·75. (Total £37·75). Send S.A.E. for leaflet.

R.S.C. PLINTHS

Superior Solid Natural Wood Construction for Record Playing units. Cut for Garrard 1025 2025, 3000, AT60. SP25 etc. **£3·15**

Available with Transparent plastic cover. **£6·30**

RECORD PLAYING UNITS

MONEY SAVING UNITS Ready to plug into Amplifier.

RP23C Consisting of Garrard SP25 Mk. III fitted Goldring CS90 high compliance ceramic Stereo/Mono cartridge with diamond stylus. Mounted on plinth. Transparent plastic cover included Carr. 50p **£26·09**

RP6C Garrard 5200 Auto Unit fitted Stereo Cartridge. Plinth and Cover as RP2C. Carr. 50

OTHER TYPES wi
P.U. Cartridges r
or 'Roll over' trar
at lowest prices.

BRADFORD 10 North Parade (Half-day Wed.). Tel. 25349
BLACKPOOL (Agent) O & C Electronics 227 Church St.
BIRMINGHAM 30/31 Gt. Western Arcade. Tel.: 021-236 1279. Half-day Wed.
DERBY 26 Osmaston Rd. The Spot (Half-day Wed.). Tel. 41361
DARLINGTON 18 Priestgate (Half-day Wed.). Tel. 68043
EDINBURGH 133 Leith St. (Half-day Wed.). Tel. 556 5766
GLASGOW 326 Argyle St. (Half-day Tues.). Tel. CIty 4158
HULL 91 Paragon Street (Half-day Thurs.). Tel. 20505

R·S·C HI-FI CENTRES LTD.

MAIL ORDERS to: 106 Henconner Lane, Leeds 13
Terms C.W.O. or C.O.D. Postage 25p extra under £2. 30p extra over £2, or as stated. Trade supplied. S.A.E. with enquiries. Export enquiries welcomed.
Branches open ALL DAY Sats
MAIL ORDERS MUST NOT BE SENT TO SHOPS.

LEICESTER 32 High Street (Half-day Thurs.). Tel. 56420
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LIVERPOOL 73 Dale St. (Half-day Wed.). Tel. CENtral 3573
LONDON 238 Edgware Road, W.2 (Half-day Thurs.). Tel. PAD 1629
MANCHESTER 60A Oldham Street (Half-day Wed.) Tel. CENtral 2778
MIDDLESBROUGH 106 Newport Rd. (Half-day Wed.). Tel. 47096
NEWCASTLE UPON TYNE 41 Blackett Street (opp. Fenwicks Store) (Half-day Wed.). Tel. 21469
SHEFFIELD 13 Exchange Street (Castle Market Blds.) (Half-day Thurs.). Tel. 20716

BI-PRE-PAK
LIMITED

FULLY TESTED AND MARKED

AC107	15p	OC170	23p
AC126	13p	OC171	23p
AC127	17p	OC200	25p
AC128	13p	OC201	25p
AC176	25p	2G301	13p
ACY17	15p	2G302	13p
AF239	37p	2N1302-3	40p
AF186	50p	2N1304-5	25p
AF139	37p	2N1306-7	30p
BC154	25p	2N1308-9	35p
BC171 = BC107	13p	2N1389-FET	45p
BC172 = BC108	13p		
BF194	15p	**Power**	
BF274	15p	**Transistors**	
BFY50	20p	OC20	50p
BSY25	37p	OC23	30p
BSY26	13p	OC25	40p
BSY27	13p	OC26	25p
BSY28	13p	OC28	40p
BSY29	13p	OC35	25p
BSA95A	13p	OC36	37p
OC41	13p	AD149	30p
OC44	13p	2N3055	65p
OC45	13p	2S034	25p
OC71	13p	**Diodes**	
OC72	13p	AAY42	10p
OC81	13p	OA91	9p
OC81D	13p	OA79	9p
OC139	13p	OA81	9p
OC140	17p	IN914	7p

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PACKS OF YOUR OWN CHOICE UP TO THE VALUE OF 50p WITH ORDERS OVER £4

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DK96	11/6	EF800	20/-	PCC84	9/3	U20	13/6	6AB4	6/6	6F1	14/-	10D2	8/-	30FL14	15/6
DL92	7/6	EF804	20/-	PCC85	8/6	U25	15/-	6AF4A	9/6	6F5	8/-	10F1	18/-	30L1	7/-
DL94	7/6	EF811	15/-	PCC88	14/-	U26	15/-	6AG7	7/6	6F6G	5/-	10F9	10/-	30L15	17/-
DL96	9/3	EL34	10/6	PCC89	12/3	U31	9/-	6AH6	10/-	6F11	6/6	10F18	8/-	30L17	17/-
DM70	6/6	EL36	9/6	PCC189	12/3	U37	30/-	6AJ8	5/9	6F12	4/6	10L1	8/-	30P12	16/-
DY86/7	8/-	EL41	11/-	PCF80	10/3	U50	6/-	6AK5	6/-	6F13	7/-	10LD11	11/-	30P18	7/-
DY802	8/6	EL42	11/6	PCF82	10/6	U52	6/-	6AK6	11/6	6F14	12/-	10P13	11/-	30P19	15/-
E55L	55/-	EL81	10/-	PCF84	9/6	U76	5/-	6AL3	8/6	6F15	11/-	10P14	20/-	30PL1	15/6
E88CC	8/-	EL83	8/3	PCF86	12/3	U78	5/-	6AL5	3/3	6F18	8/-	12AB5	10/-	30PL13	18/-
E130L	90/-	EL84	7/9	PCF200/1	16/3	U191	15/-	6AM5	5/-	6F22	6/6	12AC6	7/6	30PL14	17/-
E180F	19/-	EL85	8/6	PCF801	12/3	U201	7/-	6AM6	4/6	6F23	15/6	12AD6	7/6	35A3	10/-
EABC80	10/6	EL86	8/6	PCF802	12/3	U281	8/-	6AQ5	6/6	6F24	13/6	12A15	8/-	35A5	11/-
EAF42	10/-	EL90	6/6	PCF805	13/-	U282	8/-	6AQ6	10/-	6F25	15/-	12AQ5	8/-	35B5	13/-
EBC33	11/-	EL91	5/-	PCF806	12/3	U301	11/6	6AR5	6/6	6F26	7/-	12AT6	5/-	35C5	7/-
EBC41	9/6	EL95	7/-	PCF808	18/6	U403	10/-	6AR6	6/6	6F28	14/-	12AU6	15/-	35D5	13/-
EBC81	6/6	EL360	23/-	PCH200	14/-	U404	7/6	6AS5	7/-	6F29	6/6	12AV6	6/-	35L6GT	9/6
EBC90	9/6	EL803	17/-	PCL82	10/3	U801	20/-	6AS7G	16/-	6F30	7/-	12AV7	9/-	35W4	5/-
EBF80	8/-	EL821	11/-	PCL83	12/3	UABC80	10/6	6AT6	9/-	6J4	9/6	12AX7	6/-	35Z3	11/-
EBF83	8/-	ELL80	15/-	PCL84	10/3	UBF89	8/-	6AU6	5/9	6J5GT	6/-	12AY7	13/6	35Z4G	5/-
EBF89	8/-	EM34	16/-	PCL85	10/6	UBC41	9/9	6AV6	6/-	6J7	8/6	12B4A	10/-	35Z5GT	7/6
EB91	5/3	EM71	12/6	PCL86	10/3	UCC85	9/3	6BA6	9/6	6K6GT	10/-	12BA6	6/6	50A5	13/-
EC53	10/-	EM80	8/-	PD500	30/6	UCH42	13/9	6BE6	12/-	6K7	6/6	12BA7	6/6	50B5	7/-
EC86	12/-	EM81	8/6	PFL200	14/9	UCH81	10/9	6BH6	8/6	6K8G	6/-	12BE6	6/6	50C5	7/-
EC88	12/-	EM84	7/6	PL36	12/9	UCL82	10/3	6BJ6	8/6	6K23	10/-	12BH7	6/6	50CD6G	35/-
EC90	6/-	EM87	11/-	PL38	18/-	UCL83	12/3	6BK7A	10/-	6K25	15/-	12BY7	10/-	50L6GT	8/-
EC92	6/6	EN91	6/6	PL81	10/3	UF41/2	11/-	6BL8	7/-	6L6GT	9/-	12K5	10/-	83A1	18/-
EC93	9/6	EY51	8/-	PL81A	12/6	UF80/5	7/6	6BN5	8/6	6L7	6/6	12K7GT	7/-	85A2	7/6
ECC81	8/-	EY80	9/-	PL82	7/3	UF89	8/3	6BN6	8/-	6L18	6/-	12Q7G	5/-	90AV	48/-
ECC82/3	8/6	EY81	8/-	PL83	10/3	UL41	11/6	6BQ5	5/-	6LD20	6/6	12SC7	5/-	90C1	12/-
ECC84/5	8/6	EY83	11/-	PL84	8/3	UL84	11/-	6BR7	15/-	6N7GT	7/-	12SG7	7/-	90CV	25/-
ECC88	11/-	EY86	8/-	PL500	16/6	UM80/4	9/-	6BR8	19/-	6P1	12/-	12SH7	5/-	807	9/6
ECF80/2	9/6	EY87	8/6	PL504	17/-	UY41	8/-	6BW6	16/6	6P25	21/-	12SJ7	5/-	811A	30/-
ECF86	11/-	EY88	8/6	PL505	29/-	UY85	6/9	6BW7	13/9	6P28	12/6	12SK7	8/-	812A	65/-
ECH35	13/6	EZ35	5/6	PL508	20/-	U25	15/-	6BX6	5/-	6Q7	7/6	12SL7GT	8/-	813	75/-
ECH42	13/3	EZ40	9/-	PL509	30/9	U26	15/-	6BZ6	6/6	6R7G	7/-	12SN7GT	8/-	866A	14/-
ECH81	10/3	EZ41	9/-	PL802	17/3	U191	14/6	6C4	6/-	6S2	8/-	12SQ7	8/-	5642	12/-
ECH83	8/-	EZ80	5/6	PL805	17/3	U193	8/3	6C5GT	7/-	6S4A	11/-	12SR7	6/6	6080	27/6
ECH84	9/6	EZ81	5/6	PY33	12/6	U301	17/-	6CD6G	28/-	6SA7	7/6	14S7	16/-	6146	30/-
ECL80	8/-	EZ90	5/-	PY80	6/6	W729	11/-	6CA4	5/6	6SG7	6/6	20D1	9/-	6146B	47/6
ECL82	9/9	G810C	100/-	PY81	8/3	Z759	24/6	6CA7	10/6	6SJ7	7/6	20L1	20/-	6267	6/6
ECL83	11/6	GY501	16/-	PY800	8/3	OA2	6/6	6CBC	5/6	6SK7	6/6	20P1	10/-	6360	25/-
ECL86	9/9	GZ30	7/6	PY801	8/3	OA3	9/-	6CD6GA	23/-	6SL7GT	6/6	20P3	12/-	6939	42/-
ECL L800	30/-	GZ31	6/-	PY92	7/-	OB2	6/6	6CG7	9/-	6SN7GT	6/-	20P4	20/-	7199	15/-
EF39	10/6	GZ32	9/6	PY83	10/-	OB3	10/-	6CH6	11/-	6SQ7	8/-	20P5	20/-	7360	36/-
EF80	8/-	GZ33	16/-	PY88	8/3	OC3	7/-	6CL6	10/-	6SR7	7/6	25C5	9/-	7586	25/-
EF83	10/-	GZ34	11/-	PY500	20/-	OD3	6/6	6CW4	12/6	6T8	6/6	25L6GT	7/6	9002	6/6
EF85	8/3	HK90	6/6	PZ30	16/-	3Q4	8/-	6CY5	8/-	6U4GT	12/6	25Z4G	6/-	9003	10/-

DE BANKS MAGNETIC RECORDING TAPES

POLYESTER Length	Spool Size in.	Price
Standard Play		
600 ft.	5	10/-
850 ft.	5¾	12/6
1200 ft.	7	14/-
Long Play		
210 ft.	3	5/6
450 ft.	4	8/6

POLYESTER Length	Spool Size in.	Price
900 ft.	5	14/-
1200 ft.	5¾	17/-
1800 ft.	7	20/-
Double Play		
1200 ft.	5	17/6
1800 ft.	5¾	22/-
2400 ft.	7	26/-

EMPTY TAPE REELS

3 in.	1/6
4 in.	1/10
5 in.	2/3
5¾ in.	2/6
7 in.	2/7

CASSETTES

Boxed in Plastic Library Packs

C60	10/6
C90	12/6
C120	17/6

P. & P. 1/6 on all orders.

DIODES & RECTIFIERS

IN461	2/-	AA119	2/-	BAY38	2/6	FST3/8	6/-
IN914	1/6	AA129	2/-	BY100	4/6	OA5	2/6
IN916	1/6	AAZ13	2/-	BY103	4/6	OA10	2/6
IN4007	4/6	AAZ15	2/6	BY122	7/6	OA9	2/-
IS010	3/-	AAZ17	2/6	BY124	2/-	OA47	1/6
IS021	4/-	BA100	3/-	BY126	4/-	OA70	1/6
IS025	5/-	BA102	4/6	BY127	4/6	OA73	2/-
IS44	2/-	BA110	6/6	BYX10	4/6	OA79	1/9
IS113	3/-	BA115	1/6	BYZ10	7/-	OA81	1/6
IS120	3/-	BA114	2/6	BYZ11	6/6	OA85	1/6
IS121	3/6	BAX13	2/6	BYZ12	6/-	OA90	1/6
IS130	2/6	BAX16	2/6	BYZ13	5/-	OA91	1/6
IS131	2/6	BAY18	3/6	BZY88 (Series)		OA95	1/6
IS132	3/-				6/6	OA200	2/-
IS940	1/6	BAY31	1/6	FST3/4	4/6	OA202	2/-

CATHODE RAY TUBES

New and Budget tubes made by the leading British manufacturers. Guaranteed for 2 years. In the event of failure under guarantee, replacement is made without the usual time wasting forms and postage expense.

Type		New £	Budget £
MW36–20			4/10/-
MW36–21			4/10/-
MW43–69Z	CRM171		
	CRM172	6/12/-	4/12/6
MW43–80Z	CRM173	6/12/-	4/12/6
AW43–80Z	CME1702	6/12/-	4/12/6
	CME1703	6/12/-	4/12/6
	CME1706	6/12/-	4/12/6
	C17AA	6/12/-	4/12/6
	C17AF	6/12/-	4/12/6
AW43–88	CME1705	6/12/-	4/12/6
AW47–90			
AW47–91	A47 14W	7/13/4	5/7/6
A47 14W	CME1901	7/13/4	5/7/6
	CME1902	7/13/4	5/7/6
	CME1903	7/13/4	5/7/6
	C19AH	7/13/4	5/7/6
A47 13W	CME1906	10/5/6	8/10/-
A47–11W	CME1905	8/17/3	7/-/-
A47–26W	CME1905	8/17/3	7/15/-
A47–26W/R	CME1913R	9/6/8	
A50–120W/R	CME2013	10/17/-	
AW53–80		8/18/8	6/5/-
AW53–88	CME2101	8/18/8	6/5/-
AW59–90			
AW59–91	CME2303	9/11/8	7/4/-
A59–15W	CME2301		
	CME2302		
	CME2303	9/11/8	7/4/-
A59–11W	CME2305		
A59–13W	CME2306	13/13/-	10/19/6
A59–16W	CME2306	13/13/-	10/19/6
A59–23W	CME2305	12/12/-	10/10/-
A59–23W/R		12/12/-	10/10/-
PORTABLE SET TUBES			
TSD217			6/15/-
TSD282			6/15/-
A28–14W		9/3/4	Not supplied
CME1601			7/15/-
CME1602			8/-/-

A discount of 10% is also given for the purchase of 3 or more *New* tubes at any one time.

All types of tubes in stock. Carriage and insurance 15/-.

TRANSISTORISED UHF TUNER UNITS NEW AND GUARANTEED FOR 3 MONTHS

Complete with Aerial Socket and wires for Radio and Allied TV sets but can be used for most makes.
Continuous Tuning, 90/-; Push Button, 100/-.

SERVICE AIDS

Switch Cleaner, 11/-; Switch Cleaner with Lubricant, 11/-; Freeza, 12/6. P. & p. 1/6 per item.

PLUGS

Jack Plugs and Sockets		Co-Axial Plugs	
Standard Plugs	3/10	Belling Lee (or similar type)	1/3
Standard Sockets	2/6	Add 5d. per doz. p. & p.	

STYLII

ACOS	Sapphire	Diamond
GP59	2/6	7/6
GP65	2/6	7/6
GP67	2/6	7/6
GP73-1	6/6	9/6
GP73-2	6/6	9/6
GP79	2/6	7/6
GP81-1	2/6	7/6
GP91-1	6/6	9/6
GP91-2	6/6	9/6
GP91-3	6/6	9/6
GP91-1Sc	6/6	9/6
GP91-3Sc	6/6	9/6
HGP37	2/6	7/6
B.S.R.		
BSR C1 (ST3)	6/6	9/6
BSR TC8H	2/6	7/6
BSR TC8M	2/6	7/6
BSR ST8	6/6	9/6
BSR ST9	6/6	9/6
BSR ST10	—	9/-
BSR X1M	6/6	9/6
BSR X1H	6/6	9/6
BSR X3M	6/6	9/6
BSR X3H	6/6	9/6
BSR X5H	6/6	9/6
BSR X4H	6/6	9/6
COLLARO		
Collaro Studio 'O'	2/6	7/6
Collaro-Ronett TX88	2/6	7/6
Collel SK1	2/6	7/6
Dual CDS2/CDS3 (DN2)	6/6	9/6
Dual CDS/320 (DN3)	6/6	9/6
ELAC KST9 (PE10)	6/6	9/6
ELAC KST9 (PE1B)	6/6	9/6
ER5MB	6/6	9/6
ER5MX	2/6	7/6
ER5 SB	6/6	9/6
ER60 Stereo	6/6	9/6

GARRARD	Sapphire	Diamond
EV26 Stereo	2/6	7/6
GC2	2/6	7/6
GC8	2/6	7/6
GCE12	2/6	7/6
GCS10/1	2/6	7/6
GCS10/2	2/6	7/6
S 1—2—3	6/6	9/6
TS1	6/6	9/6
TS2	6/6	9/6
TS3	6/6	9/6
GOLDRING		
CM50	2/6	7/6
CM60	2/6	7/6
MX1	2/6	7/6
MX2	2/6	7/6
Stereo CS80	2/6	7/6
PERPETUUM EBNER		
PE188	6/6	9/6
PHILIPS		
AG3016	2/6	7/6
AG3063	2/6	7/6
AG3306	6/6	9/6
AG3310/3306	6/6	9/6
AG3400	2/6	7/6
RONETTE BINOFLUID		
BF40	2/6	7/6
DC284	2/6	7/6
SONOTONE		
2T	6/6	9/6
3T	6/6	9/6
8T4A	6/6	9/6
9TA	6/6	9/6
9TA/HC	6/6	9/6
19T	2/6	7/6
20T	2/6	7/6

The Diamond Tip is .007 in. radius, thus making it compatible to play stereo records on mono equipment without damage to the record; and of course full stereo.
BRITISH MADE
EXPORT ENQUIRIES WELCOMED

CARTRIDGES

			Inc. P.T. each
ACOS			
GP79			12/6
GP91-1SC	- 1		21/-
	2- 11		17/9
	12- 49		15/6
	50-500		13/6
GP91-2SC			*As above*
GP91-3SC			*As above*
Suitable to replace TC8, etc.			
GP92			26/5
GP93-1			24/9
GP94-1			31/-
GP94-5			36/-
GP95			24/9
GP96			31/6
Acos 104	1- 10		41/10
	11- 25		39/9
	25- 50		38/3
	51-499		35/5
B.S.R.			
X3M		S/S	27/9
X3H		S/S	27/9
X5M		S/S	27/9
X5H		S/S	27/9
SX5M		S/S	36/3
SX5H		S/S	36/3
SX5M		D/S	39/11
SX5H		D/S	39/11
X4N		D/S	27/3
RONETTE			
105		S/S	19/10
106		S/S	19/10
DC400		S/S	14/-
DC400SC		S/S	14/-
105		D/S	22/4
106		D/S	22/4
DC400		D/S	16/9
DC400SC		D/S	16/9
SONOTONE			
8TA		D/S	25/-
9TA		D/S	35/10
9TAHC		D/S	35/10

GOLDRING

Model 850	£5.5.0	Model G800E	£15.0.0
Model G800	£7.7.0	Model G800 Super E	£19.10.0

ADD 5d. PER ITEM FOR POST AND PACKING FOR ORDERS UNDER 24 PIECES.

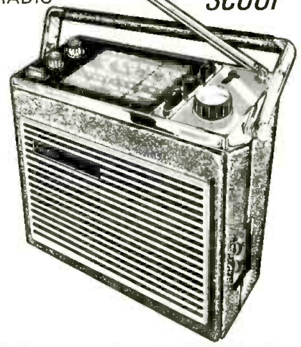
TERMS, CASH WITH ORDER ONLY. POST AND PACKING PAYABLE ON ORDERS UP TO £6, AFTER THAT, FREE EXCEPT C.R.T.'s.

Laskys

SONY TFM 8030L

HIGH PERFORMANCE 11 TRANSISTOR THREE WAVEBAND PORTABLE BATTERY MAINS RADIO

BARGAIN SCOOP



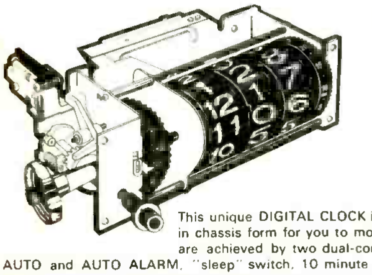
This is a really top performance, top quality solid state receiver packed with **SONY** know-how and backed by the outstanding reliability for which **SONY** are renowned. Now this outstanding set is available from Laskys at over 27% below the manufacturers list price making it without doubt the **NUMBER ONE SCOOP** of 1971! Just look at these outstanding features. Covers MW, LW and FM (VHF), 11 transistor circuit for high sensitivity and stability. Powerful output to 5" P.M. Dynamic speaker with rich clear tone quality. AFC for drift free VHF reception. Push button wave change selectors and tone control. Choice of three power sources—9V battery, household mains or car battery with suitable adaptors. Dial light for use in the dark. External jacks for earphone, tape recording, external power input and car aerial. Ultra modern styling and superb finish with padded leatherette covered cabinet for superior sound damping with chrome trim, strong carrying handle.

The **SONY TFM 8030L** will enliven your leisure hours anywhere, anytime with exciting sound, news, sport, music, etc. Technical specifications: Freq. range, FM 87-108 MHz, LW 150-285kHz MW 530-1,605kHz. Circuit: 11 transistors, 7 diodes and 2 thermistors. Aerial System: Directional telescopic for FM, internal ferrite bar for LW/MW Power Output: 1.85W max. Speaker PM Dynamic —4Ω imp. Power Source: 9v power pack battery (Every Ready PP9 or equiv.). AC mains with adaptor, car battery with adaptor. Size $9\frac{5}{8}$(W) x $8\frac{3}{16}$(H) x $3\frac{5}{8}$(D). Complete with earphone and battery.

MANUFACTURERS LIST PRICE £29.75
LASKYS SPECIAL OFFER PRICE £21.50
Post 35p

Optional Extras. SONY AC-90e AC adaptor **£4.00** DCC-126 stabilised car battery cord **£6.00.** Both post FREE if purchased with radio.

EXCLUSIVE DIGITAL CLOCK MECHANISM



- **Made especially for Lasky's by famous maker**
- **Mains operation**
- **12 hour alarm**
- **Auto "SLEEP" switch**
- **Hours, minutes and seconds read-off**
- **Forward and backward time adjustment**
- **Silent operation synchronous motor**
- **Shock and vibration proof**
- **Built in alarm buzzer**

This unique DIGITAL CLOCK is now available EXCLUSIVELY FROM LASKY'S in chassis form for you to mount in any housing that you choose. All settings are achieved by two dual-concentric controls at the front including: ON-OFF-AUTO and AUTO ALARM, "sleep" switch, 10 minute division "click" set alarm (up to 12 hour delay), time adjustment. Ultra simple mechanism and high quality manufacture guarantee reliable operation and long life.

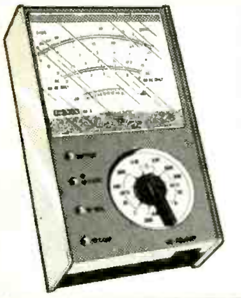
The sleep switch will automatically turn off any appliance—radio, TV, light, etc., at any pre-set time up to 60 min. and in conjunction with the AUTO setting will switch on the appliance again next morning.

The clock measures $4\frac{3}{4}$W x $1\frac{3}{4}$H x $3\frac{1}{8}$D (overall from front of drum to back of switch). SPEC: 210/240V AC, 50Hz operation; switch rating 250V, 3A. Complete with instructions. HUNDREDS OF APPLICATIONS. **COMPLETE WITH KNOBS**

LASKY'S PRICE £6.95 P & P 18p

SPECIAL QUOTATIONS FOR QUANTITIES

LASKY'S TM5 METER

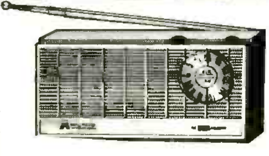


Another new look pocket multimeter from Lasky's providing top quality and value. The "slimline" impact resistant case—size $4\frac{3}{4}$in. x $2\frac{7}{8}$in. x $1\frac{1}{8}$in., fitted with extra large $2\frac{7}{8}$in. square meter. Readability is superior on all low ranges; making this an excellent instrument for servicing transistorised equipment. Recessed click stop selection switch. Ohms zero adjustment. Buff finish with crystal clear meter cover.

- **DC/V: 3-15-150-300-1,200 at 5K ohms/V**
- **AC/V: 6-30-300-600 at 2.5K ohms/V**
- **DC Current 0-300μA 0-300mA**
- **Resistance: 0-10K ohms, 0-1M ohms**
- **Decibels: –10dB to 16dP**
- **Complete with test leads, battery and instructions**

LASKY'S PRICE £2.95 P & P 13p

MIDLAND 10-406 AM/AIRCRAFT RADIO



The first pocket size receiver of its type allowing you to tune-in to the entire air communications band covered by 108-137 MHz in addition to full AM medium wave. Intermediate frequencies: AM 455 KHz: VHF 10.7 mc/s. Output power: 200mV $2\frac{1}{2}$in. P.D. 8 ohm speaker. A built in ferrite rod aerial is provided for AM reception. The 10-406 is finished in blue with chrome trim, chrome telescopic antena. Size $6\frac{5}{8}$ x $3\frac{5}{8}$ x $1\frac{7}{8}$in. complete with batteries, magnetic earphone, instructions and circuit.

LASKY'S PRICE £8.35 P & P 13p

207 EDGWARE ROAD, LONDON, W.2.
33 TOTTENHAM CT. RD, LONDON, W1P 9RB.
109 FLEET STREET, LONDON, E.C.4.
152/3 FLEET STREET, LONDON, E.C.4.
HIGH FIDELITY AUDIO CENTRE
42-45 TOTTENHAM CT. RD, LONDON, W1P 9RD.
MAIL ORDERS AND CORRESPONDENCE TO
3-15 CAVELL STREET, LONDON, E1 2BN

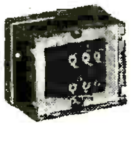
EX-STOCK TRANSFORMERS

★ A typical selection only is shown below. Please send for full lists.

★ Speedy production winding service offered.

MAINS ISOLATING SERIES

Primary 200-250 Volts Secondary 240 Volts Centre Tapped (120V) and Earth Shielded



Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Qty. 1-24 Np	Qty. 25-99 Np	P.P. each Np
61	100	5	12	10·2 × 8·9 × 8·3	2·28	2·12½	52
62	250	12	4	9·5 × 12·7 × 11·4	5·04½	4·66	67
63	500	27	0	17·1 × 11·4 × 15·9	9·73½	9·00½	•
92	1000	40	0	17·8 × 17·1 × 21·6	17·93½	16·58½	•
128	2000	63	0	24·1 × 21·6 × 15·2	29·66	27·43	•
129	3000	84	0	21·6 × 21·6 × 20·3	46·38	42·89½	•
190	6000	178	0	31·1 × 35·6 × 17·1	76·11	70·48	•

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	Qty. 1-24 Np	Qty. 25-99 Np	P.P. each Np
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	0·74	0·69	20
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·43½	1·32½	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	1·74	1·61	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	3·38	3·12½	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	5·02½	4·64½	67
84	1000	16	0	11·4 × 14·0 × 14·0	,, ,,	9·12	8·83½	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	13·22	12·22½	•
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	17·26	15·96	•
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	23·47	21·73	•

LOW VOLTAGE SERIES (ISOLATED)
PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	Amps. 24V	Weight lb	oz	Size cm.	Secondary Windings	Qty. 1-24 Np	Qty. 25-99 Np	P.P. each Np
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	0·74	0·69	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	0·87½	0·81	22
71	2	1	1	0	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·15½	1·06½	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	1·61½	1·49½	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	1·95	1·80½	42
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	2·56	2·37	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	3·95	3·15½	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	5·02½	4·69½	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	9·27½	8·58	82

LOW VOLTAGE MULTITAP SERIES (ISOLATED)
PRIMARY 200-250 VOLTS 30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	Qty. 1-24 Np	Qty. 25-99 Np	P.P. each Np
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-24-30V	0·87½	0·81	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·18	1·09½	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	1·59	1·46½	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·15½	1·95	42
21	4·0	6	0	10·2 × 9·5 × 8·6	,, ,,	2·56	2·37	52
117	6·0	7	8	12·1 × 9·5 × 10·2	,, ,,	3·79	3·50½	52
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	6·20½	5·73½	67

Ref. No.	Amps.	Weight lb	oz	Size cm.	50 VOLT RANGE	Qty. 1-24 Np	Qty. 25-99 Np	P.P. each Np
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·15½	1·06½	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	1·69	1·56½	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	2·33½	2·16	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	3·18	2·93½	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	4·20	3·88½	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	6·20½	5·73½	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	8·10	7·49	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	10·15	9·38½	97

Ref. No.	Amps.	Weight lb	oz	Size cm.	60 VOLT RANGE	Qty. 1-24 Np	Qty. 25-99 Np	P.P. each Np
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·18	1·09	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	1·64	1·51½	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	2·56	2·37	42
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	5·02½	4·64½	67
120	6·0	16	12	13·3 × 12·1 × 12·1	,, ,,	7·28	6·73	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	12·05	11·15	•

LEAD ACID BATTERY CHARGER TYPES
PRIMARY 200-250 VOLT FOR CHARGING 6 OR 12 VOLT BATTERIES

Ref. No.	Amps.	Weight lb	oz	Size cm.		Qty. 1-24 Np	Qty. 25-99 Np	P.P. each Np
45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifiers.	1·16½	1·07½	30
5	4·0	3	11	10·2 × 7·0 × 8·3		1·77	1·63½	42
86	6·0	5	12	10·2 × 8·9 × 8·3		2·66½	2·46½	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·04	2·81½	52
50	12·5	11	14	13·3 × 10·8 × 12·1		4·52	4·18	67

All ratings are continuous. Standard construction: Open with solder tags and wax impregnation. Enclosed styles to order.

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BI-PAK Order No.	Description	Price and Qty. 1-24	25-99	Prices 100 up
BP 00 = 7400	Quadruple 2-input NAND Gate	23p	20p	15p
BP 01 = 7401	Quadruple 2-input Positive NAND Gate (with open collector output)	23p	20p	15p
BP 02 = 7402	Quadruple 2-input Positive NOR Gates	23p	20p	15p
BP 03 = 7403	Quadruple 2-input Positive NAND Gates (with Open-Collector Output)	23p	20p	15p
BP 04 = 7404	Hex Inverters	23p	20p	15p
BP 10 = 7410	Triple 3-input Positive NAND Gates	23p	20p	15p
BP 13 = 7413	Dual 4-input Schmitt Trigger	35p	32p	29p
BP 20 = 7420	Dual 4-input Positive NAND Gates	23p	20p	15p
BP 30 = 7430	8-input Positive NAND Gates	23p	20p	15p
BP 40 = 7440	Dual 4-input Positive NAND Buffers	23p	20p	15p
BP 41 = 7441	BCD to decimal nixie driver	87p	77p	67p
BP 42 = 7442	BCD to decimal decoder (4-10 lines, 1 of 10)	87p	77p	67p
BP 47 = 7447	BCD-Seven-Segment Decoder/Drivers (15-V Outputs)	£1·40	£1·30	£1·20
BP 50 = 7450	Expandable dual 2-input AND-OR-INVERT	23p	20p	15p
BP 51 = 7451	Dual 2-wide 2-input AND-OR-INVERT GATES	23p	20p	15p
BP 53 = 7453	Quad 2-input Expandable AND-OR-INVERT	23p	20p	15p
BP 54 = 7454	4-wide 2-input AND-OR-INVERT Gates	23p	20p	15p
BP 60 = 7460	Dual 4-input Expander	23p	20p	15p
BP 70 = 7470	Single-phase J-K Flip-Flop	35p	32p	29p
BP 72 = 7472	Master-slave J-K Flip-Flop	35p	32p	29p
BP 73 = 7473	Dual Master slave J-K Flip-Flop	43p	40p	37p
BP 74 = 7474	Dual 0 type Flip-Flop	43p	40p	37p
BP 75 = 7475	Quad latch	47p	45p	43p
BP 76 = 7476	Dual J-K with pre-set and clear	47p	45p	43p
BP 80 = 7480	Gated Full Adders.	87p	77p	67p
BP 81 = 7481	16-bit read/write memory	£1·35	£1·25	£1·15
BP 82 = 7482	2-bit Binary Full Adders	£1·30	£1·20	£1·00
BP 83 = 7483	Quad Full Adder	87p	77p	67p
BP 86 = 7486	Quad 2 input Exclusive OR Gates	80p	70p	60p
BP 90 = 7490	BCD decade counter	87p	77p	67p
BP 91 = 7491	8-bit Shift Registers	£1·21	£1·00	87p
BP 92 = 7492	Divide-by-Twelve Counters	87p	77p	67p
BP 93 = 7493	4-bit Binary Counters	87p	77p	67p
BP 94 = 7494	Dual entry 4-bit shift register	87p	77p	67p
BP 95 = 7495	4-bit up-down shift register	87p	77p	67p
BP 96 = 7496	5-bit Parallel In parallel out Shift-Register	£1·10	£1·00	90p
BP100 = 74100	8-bit Bistable Latches	£1·75	£1·65	£1·55
BP118 = 74118	Hex Set-Reset Latches	£1·30	£1·20	£1·00
BP121 = 74121	Monostable Multivibrators	87p	77p	67p
BP141 = 74141	BCD-to-Decimal Decoder/Driver	87p	77p	67p
BP145 = 74145	BCD-to-Decimal Decoder/Drivers	£1·80	£1·70	£1·60
BP151 = 74151	8-bit Data Selectors (with Strobe)	£1·40	£1·30	£1·20
BP153 = 74153	Dual 4-Line-to-1-Line Data Selectors/Multiplexers	£1·40	£1·30	£1·20
BP191 = 74191	Binary Counter reversable	£3·50	£3·25	£3·00

Devices may be mixed to qualify for quantity price. Larger quantities—prices on application. (TTL 74 Series only.)

Data is available for the above series of I.C's in booklet form. PRICE 13p.

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Manufacturers' "Full outs"—out of spec. devices including functional units and part function but classed as out of spec. from the manufacturers' very rigid specifications. Ideal for learning about I.C's and experimental work.

PAK No.		PAK No.		PAK No.	
UIC00 = 12 × 7400N	50p	UIC42 = 5 × 7450N	50p	UIC80 = 5 × 7480N	50p
UIC01 = 12 × 7401N	50p	UIC50 = 12 × 7450N	50p	UIC82 = 5 × 7482N	50p
UIC02 = 12 × 7402N	50p	UIC51 = 12 × 7451N	50p	UIC83 = 5 × 7483N	50p
UIC03 = 12 × 7403N	50p	UIC60 = 12 × 7460N	50p	UIC86 = 5 × 7486N	50p
UIC04 = 12 × 7404N	50p	UIC70 = 8 × 7470N	50p	UIC90 = 5 × 7490N	50p
UIC05 = 12 × 7495N	50p	UIC72 = 8 × 7472N	50p	UIC92 = 5 × 7492N	50p
UIC10 = 12 × 7410N	50p	UIC73 = 8 × 7473N	50p	UIC93 = 5 × 7493N	50p
UIC20 = 12 × 7420N	50p	UIC74 = 8 × 7474N	50p	UIC94 = 5 × 7494N	50p
UIC40 = 12 × 7440N	50p	UIC75 = 8 × 7475N	50p	UIC95 = 5 × 7495N	50p
UIC41 = 5 × 7441AN	50p	UIC76 = 8 × 7476N	50p	UIC96 = 5 × 7496N	50p

UICX1 = 25 × Asst'd 74's £1·50

Packs cannot be split but 20 assorted pieces (our mix) is available as PAK UICX1. Every PAK carries our BI-PAK Satisfaction or money back GUARANTEE.

DTL 930 SERIES

Type No.	Function	Price 1-24	25-99	100 up
BP930	Expandable dual 4-input NAND	23p	20p	15p
BP932	Expandable dual 4-input NAND buffer	25p	23p	20p
BP933	Dual 4-input expander	25p	23p	20p
BP935	Expandable Hex Inverter	25p	23p	20p
BP936	Hex Inverter	25p	23p	20p
BP944	Dual 4-input NAND expandable buffer without pull-up	25p	23p	20p
BP945	Master-slave JK or RS	35p	32p	29p
BP946	Quad, 2-input NAND	23p	20p	15p
BP948	Master-slave JK or RS	35p	32p	29p
BP951	Monostable	90p	85p	80p
BP962	Triple 3-input NAND	23p	20p	15p
BP9093	Dual Master-slave JK with separate clock	80p	75p	70p
BP9094	Dual Master-slave JK with separate clock	80p	75p	70p
BP9097	Dual Master-slave JK with Common Clock	80p	75p	70p
BP9099	Dual Master-slave JK Common Clock	80p	75p	70p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only.)

DTL (Diode Transistor Logic) INTEGRATED CIRCUITS manufacturers "Fall outs"—out of spec devices including functional units and part functional but classed as out of spec from the manufacturers very rigid specifications. Ideal for learning about I.C's and experimental work.

Pak No.		Pak No.	
UIC930 = 12 × μA 930	50p	UIC948 = 8 × μA 948	50p
UIC932 = 12 × μA 932	50p	UIC951 = 5 × μA 951	50p
UIC933 = 12 × μA 933	50p	UIC961 = 12 × μA 961	50p
UIC935 = 12 × μA 935	50p	UIC9093 = 5 × μA 9093	50p
UIC936 = 12 × μA 936	50p	UIC9094 = 5 × μA 9094	50p
UIC944 = 12 × μA 944	50p	UIC9097 = 5 × μA 9097	50p
UIC945 = 8 × μA 945	50p	UIC9099 = 5 × μA 9099	50p
UIC946 = 12 × μA 946	50p	UIC × 9 25 Assorted 930 Series	£1·50

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Data Booklet available for the BP930 Series, PRICE 13p

LINEAR I.C's

Type No.	Case	Leads	Description	Price -124	25-99	100
BP201C—SL201C	TO-5	8	G.P. Amp	63p	53p	45p
BP701C—SL701C	TO-5	8	OP Amp.	63p	50p	45p
BP702C—SL702C	TO-5	8	OP Amp Direct O/P	63p	50p	45p
BP702—72702	D.I.L.	14	G.P. O.P. Amp (Wide Band)	53p	45p	40p
BP709—72709	D.I.L.	14	High Gain OP Amp	53p	45p	40p
BP709P—μA709C	TO-5	8	High Gain OP Amp	53p	45p	40p
BP741—72741	D.I.L.	14	High Gain OP. Amp (Protected	75p	60p	50p
μA703C—μA703C	TP-5	6	R.F.—IF Amp	43p	35p	27p
TAA263	TO-72	4	A.F. Amp	70p	60p	55p
TAAA293	TO-74	10	G.P. Amp	90p	75p	70p

"Q" PAKS QUALITY TESTED SEMICONDUCTORS

Pack No.	Qty. per pack	Description	Price
Q 1	20	Red spot trans. P.N.P.	50p
Q 2	16	White spot R.F. trans. P.N.P	50p
Q 3	4	OC 77 type trans.	50p
Q 4	6	Matched trans. OC44/45/81/81D	50p
Q 5	4	OC 75 transistors	50p
Q 6	4	OC 72 transistors	50p
Q 7	4	AC 128 trans. P.N.P. high gain	50p
Q 8	4	AC 126 trans. P.N.P.	50p
Q 9	7	OC 81 type trans.	50p
Q10	7	OC 71 type trans.	50p
Q11	2	AC 127/128 Comp. pairs PNP/NPN	50p
Q12	3	AF 116 type trans.	50p
Q13	3	AF 117 type trans.	50p
Q14	3	OC 171 H.F. type trans.	50p
Q15	5	2N2926 Sil. Epoxy trans.	50p
Q16	2	GET880 low noise Germ. trans.	50p
Q17	3	NPN 1 ST141 & 2 ST140	50p
Q18	4	Madt's 2 MAT 100 & 2 MAT 120	50p
Q19	3	Madt's 2 MAT 101 & 1 MAT 121	50p
Q20	4	OC 44 Germ. trans. A.F.	50p
Q21	3	AC 127 NPN Germ. trans.	50p
Q22	20	NKT trans. A.F. R.F. coded	50p
Q23	10	OA202 Sil. diodes sub-min.	50p
Q24	8	OA 81 diodes	50p
Q25	6	IN914 Sil. diodes 75PIV 75mA	50p
Q26	8	OA95 Germ. diodes sub-min. IN69	50p
Q27	2	10A 600PIV Sil. Rects. 1S425R	50p
Q28	2	Sil. power rects. BYZ 13	50p
Q29	4	Sil. trans. 2 × 2N696, 1 × 2N697, 1 × 2N698	50p
Q30	7	Sil. switch trans. 2N706 NPN	50p
Q31	6	Sil. switch trans. 2N708 NPN	50p
Q32	3	PNP Sil. trans. 2 × 2N1131, 1 × 2N1132	50p
Q33	3	Sil. NPN trans. 2N1711	50p
Q34	7	Sil. NPN trans. 2N2369, 500MHZ	50p
Q35	3	Sil. NPP TO-5 2 × 2N2904 & 1 × 2N295	50p
Q36	7	2N3646 TO-18 plastic 300MHZ NPN	50p
Q37	3	2N3053 NPN Sil. trans.	50p
Q38	7	PNP trans. 4 × 2N3703, 3 × 2N3702	50p 50p
Q39	7	NPN trans. 4 × 2N3704, 3 × 2N3705	50p
Q40	7	NPN amp. 4 × 2N3707, 3 × 2N3708	50p
Q41	3	Plastic NPN TO-18 2N3904	50p
Q42	6	NPN trans. 2N5172	50p
Q43	7	BC 107 NPN trans.	50p
Q44	7	NPN trans. 4 × BC108, 3 × BC109	50p
Q45	3	BC 113 NPN TO-18 trans.	50p
Q46	3	BC 115 NPN TO-5 trans.	50p
Q47	6	NPN high gain 3 × BC167, 3 × BC168	50p
Q48	4	BCY70 PNP trans. TO-18	50p
Q49	4	NPN trans. 2 × BFY51, 2 × BFY52	50p
Q50	7	BSY 28 NPN switch TO-18	50p
Q51	7	BSY 95A NPN trans. 300MHZ	50p
Q52	8	BY100 type sil. rect.	£1
Q53	25	Sil. & germ. trans. mixed all marked new	£1·50

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U1	120	Glass Sub-min. General Purpose Germanium Diodes	50p
U2	60	Mixed Germanium Transistors AF/RF	50p
U3	75	Germanium Gold Bonded Diodes sim. OA5, OA47	50p
U4	40	Germanium Transistors like OC81, AC128	50p
U5	60	200mA Sub-min. Sil. Diodes	50p
U6	30	Silicon Planar Transistors NPN sim. BSY95A, 2N706	50p
U7	16	Silicon Rectifiers Top-Hat 750mA up to 1,000V	50p
U8	50	Sil. Planar Diodes 250mA OA/200/202	50p
U9	20	Mixed Volts 1 watt Zener Diodes	50p
U11	30	PNP Silicon Planar Transistors TO-5 sim. 2N1132	50p
U13	30	PNP-NPN Sil. Transistors OC200 & 2S104	50p
U14	150	Mixed Silicon and Germanium Diodes	50p
U15	25	NPN Silicon Planar Transistors TO-5 sim. 2N697	50p
U16	10	3-amp Silicon Rectifiers Stud Type up to 1,000 PIV	50p
U17	30	Germanium PNP AF Transistors TO-5 like ACY17-22	50p
U18	8	6-Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	50p
U19	25	Silicon NPN Transistors like BC108	50p
U20	12	1·5 amp Silicon Rectifiers Top-Hat up to 1,000 PIV	50p
U21	30	AF Germanium alloy Transistors 2G300 Ser. & OC71	50p
U23	30	Madt's like MAT Series PNP Transistors	50p
U24	20	Germanium 1-amp Rectifiers GJM up to 300 PIV	50p
U25	25	300 Mc/s NPN Silicon Transistors 2N708, BSY27	50p
U26	30	Fast Switching Silicon Diodes like 1N914 Micro-min.	50p
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U29	10	1-amp SCR's TO-5 can up to 600 PIV CRS1/25-600	£1
U31	20	Sil. Planar NPN trans. low noise Amp 2N3707	50p
U32	25	Zener diodes 400mW D07 case mixed Volts, 3-18	50p
U33	15	Plastic case 1 amp Silicon Rectifiers 1N4000 series	50p
U34	30	Sil. PNP alloy trans. TO-5 BCY26, 2S302/4	50p
U35	25	Sil. Planar trans. PNP TO-18 2N2906	50p
U36	25	Sil. Planar NPN trans. TO-5 BFY50/51/52	50p
U37	30	Sil. alloy trans. SO-2 PNP, OC200 2S322	50p
U38	20	Fast Switching Sil. trans. NPN 400 Mc/s 2N3011	50p
U39	30	RF Germ. PNP trans. 2N1303/5 TO-5	50p
U40	10	Dual trans. 6 lead TO-5 2N2060	50p
U41	25	RF Germ. trans. TO-1 OC45 NKT72	50p
U42	10	VHF Germ. PNP trans. TO-1 NKT667 AF117	50p
U43	25	Sil. trans. Plastic TO-18 AF BC113-114	50p
U44	20	Sil. trans. Plastic TO-5 BC115-116	50p

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

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100	25p	33p	53p	58p	63p	£1·40
200	35p	37p	57p	61p	75p	£1·60
400	43p	47p	67p	75p	93p	£1·75
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ECC82	0·28
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EF85	0·32
EF86	0·31
EF89	0·26
EF91	0·15
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EF95	0·25
EF183	0·32
EF184	0·35
EFL200	0·77
EL34	0·51
EL41	0·57
EL42	0·52
EL84	0·23
EL85	0·36
EL86	0·40
EL90	0·30
EL95	0·35
EL500	0·85
EM31	0·25
EM80	0·40
EM84	0·35
EM87	0·55
EY51	0·40
EY86	0·35
EY81	0·35
EY88	0·40
EZ41	0·42
EZ80	0·25
EZ81	0·27
GZ34	0·52
KT66	1·60

KT88	1·75
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OA2	0·35
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PCC84	0·37
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PCC189	0·55
PCE800	0·75
PCF80	0·30
PCF82	0·33
PCF84	0·46
PCF86	0·57
PCF200	0·77
PCF201	0·77
PCF801	0·48
PCF802	0·48
PCF805	0·72
PCF806	0·65
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PCH200	0·70
PCL81	0·47
PCL82	0·37
PCL83	0·65
PCL84	0·42
PCL85	0·42
PCL86	0·42
PFL200	0·57
PL36	0·53
PL81	0·50
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PL83	0·42
PL84	0·35
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6SK7	0·35
6SL7GT	0·32
6SN7GT	0·35
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6SQ7GT	0·38
6V6G	0·17
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7H7	0·27
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9D6	0·37
11E2	1·50
12AT6	0·22
12AT7	0·20
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OC70	0·12
OC71	0·15
OC72	0·25
OC73	0·30
OC75	0·22
OC76	0·25
OC81	0·25
OC81D	0·20
OC81DM	0·20
OC82	0·25
OC82DM	0·15
OC83	0·22
OC83B	0·15
OC84	0·25
OC122	0·50
OC139	0·25
OC140	0·37
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2N3055	0·75
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82303	0·50
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3N128	0·87
3N139	1·75
3N140	0·97
3N154	0·95
3N159	1·45
6FR5	0·45
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10D1	0·16
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AC126	0·21
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AF127	0·17
AF139	0·37
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AFY19	1·12
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ASY28	0·27
ASY67	0·47
BAW19	0·27
BC107	0·15
BC108	0·15
BC113	0·30
BC118	0·37
BCY72	0·37
BF115	0·25
BF173	0·30
BF187	0·50
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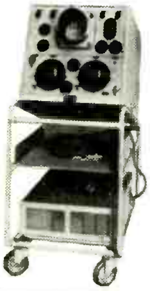

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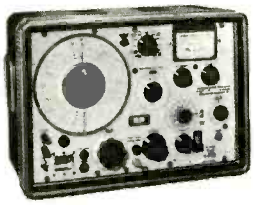

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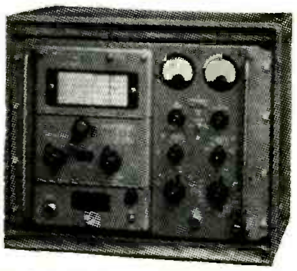

AM/FM SIGNAL GENERATOR TF 937 (CT 218) Frequency range 85kHz-30mHz. 8 bands. Main dial total 56 foot. Built in crystal calibrator 200kHz and 2mHz. RF output ·1μV to ·1V. Four internal mod. freq. FM deviation up to 9kHz. **£115.** Carriage £1/5/0.

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SIGNAL GENERATOR TS-403B/U (or URM-61A): (Hewlett Packard). A portable, self-contained, general-purpose test equipment designed for use with radio and radar receivers and for other applications requiring small amounts of RF power such as measuring standing-wave ratios, antenna and transmission line characteristics, conversion gain, etc. Both the output freq. and power are indicated on direct-reading dials. 115V, AC, 50 c/s. Freq.—1800-4000 Mc/s. CW, FM, Modulated Pulse—40-4000 pulses per sec. Pulse Width—0.5-10 microsecs. Timing—Undelayed or delayed from 3-300 microsecs from external or internal pulse. O/put—1 milliwatt max., 0 to —127 db variable. O/put Impedance—50 Ω. Price: **£120** each + £2 carr.

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TEST SET TS-147C: Combined signal generator, frequency meter and power meter for 8500-9600 Mc/s. CW or FM signals of known freq. and power or measurement of same. *Signal Generator:* O/put —7 to —85 dbm. Transmission—FM, PM, CW. Sweep Rate—0-6 Mc/s per microsec. Deviation—0-40 Mc/s per sec. Phase Range—3-50 microsec. Pulse Repetition Rate—to 4000 pulses per sec. RF Trigger for Sawtooth Sweep—5-500 watts peak. 0.2-6 microsec. duration, 0.5 microsec pulse rise time. Video Trigger for Sawtooth Sweep—Positive polarity, 10-50V peak. 0.5-20 microsec duration at 10% max. amplitude, less than 0.5 microsec rise time between 90% and 10% max. amplitude points. *Frequency Meter:* Freq. 8470-9360 Mc/s. Accuracy—+2.5 Mc/s per sec. absolute, + 1.0 Mc/s per sec. for freq. increments of less than 60 Mc/s relative, ±1.0 Mc/s per sec. at 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-418/URM49: Covers 400-1000 Mc/s range. CW, Pulse or AM emission. Power Range—0-120 dbm. Price: **£105** each + £1·25 carr.

TELEMETRY AUDIO OSCILLATOR TYPE 200T: (Hewlett Packard). Freq.— 250 c/s-100 Kc/s. 5 over-lapping bands. High stability. O/put 160 mw or 10V into 600 Ω Price: **£65** each + £1·25 carr.

SIGNAL GENERATOR TS-497B/URR: (Boonton). Freq. 2-400 Mc/s in 6 bands. Internal Mod. 400 or 1000 c/s per sec. External Mod. 50 to 10,000 c/s per sec. External PM. Percent Mod. 0-30 for sine wave. Am or Pulse Carrier. O/put Voltage 0.1-100,000 microvolts cont. variable. Impedance 50 Ω. Price: **£85** each + £1·50 carr.

FREQUENCY METER TS-74 (same TS-174): Heterodyne crystal controlled. Freq. 20-280 Mc/s. Accuracy .05%. Sensitivity 20 mV. Internal Mod. at 1000 c/s. Power Supply—batteries 6V and 135V. Complete with calibration book. (Manufactured for M.O.D. by Telemax. "As new" in cartons.) **£75** each. Fully stabilised Power Supply available at extra cost **£7·50** each. Carr £1·50.

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6K6GT	0·55
6K7	0·35
6K8G	0·35
6K8GT	0·50
6K23	0·55
6K25	0·75
6L6GT	0·45
6L7	0·40
6L18	0·45
6LD20	0·40
6N7GT	0·40
6P1	0·60
6P28	0·65
6Q7	0·40
6R7G	0·45

	£
6S2	0·40
6S4A	0·60
6SA7	0·40
6SC7	0·70
6SG7	0·35
6SH7	0·35
6SJ7	0·40
6SK7	0·35
6SL7GT	0·35
6SN7GT	0·35
6SQ7	0·40
6SR7	0·40
6SS7	0·20
6T8	0·35
6U4GT	0·60
6U8A	0·40
6V6GT	0·38
6X4	0·30
6X5GT	0·35
6X8	0·55
6Y6G	0·65
6Z4	0·35
7B5	0·75
7B6	0·70
7B7	0·45
7C5	0·85
7F8W	0·85
7Y4	0·60
7Z4	0·50
9BW6	0·50
10C2	0·50
10D1	0·50
10D2	0·40
10F1	0·90
10F9	0·50
10F18	0·45
10L1	0·45
10LD11	0·60
10P13	0·55
10P14	1·10
11D3	0·45
11D5	0·45
11E2	2·50
11E3	4·00
12AB5	0·60
12AC6	0·40
12AH7GT	0·30
12AL5	0·45
12AQ5	0·43
12AT6	0·30

	£
12AT7	0·33
12AU6	0.30
12AU7	0·30
12AV6	0·33
12AV7	0·50
12AX4GTB	0·55
12AX7	0·30
12AY7	0·70
12B4A	0·55
12BA6	0·35
12BA7	0·35
12BE6	0·35
12BH7	0·40
12BY7	0·55
12C8	0·35
12E1	1·35
12E14	3·57
12H6	0·30
12J5GT	0·25
12J7GT	0·45
12K5	0·55
12K7GT	0·35
12K8	0·50
12Q7G	0·30
12SC7	0·35
12SG7	0·35
12SH7	0·30
12SJ7	0·30
12SK7	0·45
12SN7GT	0·45
12SQ7	0·50
12SR7	0·35
12X4	0·45
14S7	0·80
20CV	3·15
20D1	0·45
20L1	1·10
20P1	0·50
20P3	0·60
20P4	1·10
20P5	1·20
25L6GT	0·45
25Z4G	0·30
25Z6GT	0·65
30A5	0·45
30AE3	0·40
30C1	0·30

	£
30C15	0·80
30C17	[illegible]
30C18	0·75
30F5	[illegible]
30FL1	0·70
30FL12	0·93
30FL14	0·75
30L1	0·40
30L15	0·85
30L17	0·80
30P12	0·80
30P19	0·80
30PL1	0·70
30PL13	0·93
30PL14	0·90
35A5	0·75
35B5	0·65
35C5	0·40
35D5	0·70
35L6GT	0·50
35W4	0·30
35Z3	0·60
35Z4G	0·30
35Z5GT	0·40
42	0·50
50A5	0·70
50B5	0·45
50C5	0·40
50CD6G	1·65
50EH5	0·80
50L6GT	0·50
52KU	0·40
53KU	0·70
75B1	0·50
75C1	0·45
80	0·50
83	1·10
85A2	0·40
85A3	0·50
90AG	2·40
90AV	2·50
90CM	0·60
90CG	1·25
90CV	1·25
108C1	0·35
150B2	0·60
150B3	0·60
150C4	0·60
305	0·65
310A	1·50
311A	2·00

	£
328A	2·00
[illegible]	1·15
329A	1·90
715A	2·50
715C	5·00
723A/B	7·00
725A	16·00
807	0·50
811A	1·60
813	3·75
829B	3·50
833A	17·00
837	0·85
866A	0·75
872A	3·00
884	0·60
889RA	50·00
927	3·00
931A	3·50
955	0·25
4378	1·40
4687	1·75
5544	6·50
5551A	16·00
5654	0·40
5670	0·50
5751	0·60
5763	0·70
5796	14·00
5814A	0·50
5894	5·50
6072	0·85
6080	1·50
6146	1·50
6146B	2·50
6293	3·25
6360	1·25
6870	2·50
6883	2·50
6939	2·15
7199	0·75
7586	1·25
7591A	1·00
7895	1·25
8005	7·00
9002	0·35
9003	0·50
A1834	0·80
A2293	1·20

	£
AC/HL/DD	0·50
AC/TH1	0·45
AX50	2·25
AZ31	0·55
C1K	4·50
CBL1	0·80
CBL31	0·90
CL4	0·60
CL33	1·00
CY31	0·35
DAF41	0·50
DAF91	0·25
DAF92	0·50
DAF96	0·42
DC90	0·45
DF91	0·25
DF92	0·20
DF96	0·42
DH76	0·35
DH81	0·60
DH101	0·55
DK40	0·55
DK91	0·35
DK92	0·50
DK96	0·42
DL66	1·25
DL68	0·65
DL69	1·75
DL91	0·27
DL92	0·35
DL93	0·35
DL94	0·45
DL95	0·40
DL96	0·42
DY86	0·33
DY87	0·35
DY802	0·50
E80CC	1·10
E80CF	1·50
E80L	0·95
E81L	1·15
E83F	1·10
E84L	0·50
E86C	0·90
E88C	1·15
E88CC	0·65
E88CC/01	1·90
E90CC	0·45
E91H	0·60
E130L	5·00

	£
E182CC	1·20
E186F	1·25
E188CC	0·90
E280F	2·10
E810F	2·90
EA50	0·20
EA52	4·50
EABC80	0·35
EAF42	0·55
EAF801	0·50
EB34	0·20
EB91	0·20
EBC33	0·50
EBC41	0·55
EBC81	0·30
EBC90	0·30
EBC91	0·30
EBF80	0·40
EBF83	0·40
EBF89	0·30
FBL31	1·50
EC53	0·50
EC86	0·60
EC88	0·60
EC90	0·33
EC92	0·35
EC93	0·50
EC8010	2·25
ECC34	0·40
ECC40	0·60
ECC70	0·85
ECC81	0·33
ECC82	0·30
ECC83	0·30
ECC84	0·30
ECC85	0·60
ECC86	0·60
ECC88	0·40
ECC89	0·50
ECC91	0·20
ECC189	0·60
ECF80	0·35
ECF82	0·35
ECF86	0·65
ECF804	1·50
ECH35	0·60
ECH42	0·70
ECH81	0·30
ECH83	0·40
ECH84	0·45
ECL80	0·40

	£
E180F	0·95
ECL81	0·45
ECL82	0·35
ECL83	0·65
ECL84	0·55
ECL85	0·55
ECL86	0·40
ECLL800	1·50
EF9	0·50
EF37A	0·60
EF39	0·40
EF40	0·50
EF41	0·65
EF42	0·70
EF80	0·25
EF83	0·55
EF85	0·35
EF86	0·30
EF89	0·28
EF91	0·33
EF92	0·40
EF93	0·25
EF94	0·25
EF95	0·30
EF96	0·22
EF97	0·65
EF98	0·65
EF183	0·30
EF184	0·35
EF800	1·00
EF804	1·25
EF811	0·75
EF812	0·80
EF814	0·75
EH90	0·40
EK32	0·45
EK90	0·30
EL5	0·55
EL33	1·25
EL34	0·50
EL35	0·40
EL36	0·50
EL37	1·25
EL41	0·55
EL42	0·58
EL81	0·55
EL83	0·42
EL84	0·25
EL85	0·43
EL86	0·40
EL90	0·35
EL91	0·32

	£
EL95	0·35
EL360	1·15
EL803	1·00
EL821	0·55
EL822	0·90
ELL80	0·75
EM34	0·90
EM71	0·75
EM80	0·40
EM81	0·60
EM84	0·35
EM85	1·00
EM87	0·55
EN10	4·00
EN11	3·50
EN32	1·50
EN91	0·35
EY51	0·40
EY80	0·45
EY81	0·40
EY83	0·55
EY84	0·55
EY86	0·40
EY87	0·43
EY88	0·43
EZ35	0·35
EZ40	0·45
EZ41	0·45
EZ80	0·25
EZ81	0·28
EZ90	0·30
FG17	4·50
FW4/500	0·75
FW4/800	0·75
GC10B	3·75
GN4	1·50
GR10M	1·50
GS10C	5·00
GS10D	5·75
GS10H	3·10
GS12D	7·00
GS47X	3·00
GU50	1·75
GY501	0·80
GZ30	0·40
GZ31	0·33
GZ32	0·48
GZ33	0·70
GZ34	0·60
HABC80	0·45

	£
HBC90	0·30
HBC91	0·33
HF93	0·35
HF94	0·30
HK90	0·35
HL23	0·40
HL23DD	0·40
HL42DD	0·50
HL92	0·40
HL94	0·45
KT8	2·00
KT36	1·00
KT44	0·50
KT45	2·00
KT66	1·70
KT71	0·50
KT76	0·40
KT88	1·75
KTW63	0·50
ME91	0·45
MH4	0·50
ML4	0·45
ML6	0·40
MSPEN/T	0·50
MT17	4·50
MU12/14	0·60
N78	1·15
NSP1	3·50
NSP2	4·00
PABC80	0·40
PC86	0·60
PC88	0·60
PC900	0·48
PCC84	0·40
PCC85	0·40
PCC88	0·55
PCC89	0·50
PCC189	0·55
PCC805	0·85
PCC806	0·80
PCE800	0·70
PCF80	0·30
PCF82	0·35
PCF84	0·50
PCF86	0·60
PCF87	0·85
PCF800	0·80

	£
PCF801	0·50
PCF802	0·50
PCF805	0·75
PCF806	0·70
PCF808	0·75
PCH200	0·70
PCL81	0·50
PCL82	0·35
PCL83	0·65
PCL84	0·45
PCL85	0·40
PCL86	0·45
PCL88	0·90
PCL800	0·93
PCL801	0·70
PCL805	0·50
PD500	1·50
PEN4DD	0·50
PEN45	0·40
PEN45DD	0·75
PEN46	0·40
PEN383	0·55
PEN384	0·60
PEN453DD	0·60
PF86	0·60
PF818	0·85
PFL200	0·70
PL33	0·35
PL36	0·55
PL81	0·50
PL82	0·45
PL83	0·45
PL84	0·40
PL302	0·80
PL504	0·80
PL508	0·90
PL509	1·30
PL801	0·80
PL802	0·75
PLL80	0·55
PM84	0·50
PX25	2·00
PY31	0·30
PY33	0·63
PY80	0·35
PY81	0·30
PY82	0·30
PY83	0·38
PY88	0·40
PY500	1·00
PY800	0·50
PY801	0·50
PZ30	0·35
QQV02-6	2·15
QQV03-10	1·25

	£
QQV05-20A	5·25
QQV06-40A	5·50
QS83/3	0·40
QV03-12	0·70
QY4-400A	16·00
R10	1·00
R18	0·55
RG3-250A	0·75
RL18	0·50
S130	1·75
S130P	1·75
SP2	0·50
SP4	0·50
SP41	0·45
SP61	0·55
TP22	0·60
TP25	0·40
TT21	2·65
TT22	2·80
U17	0·75
U18/20	0·75
U19	2·50
U20	0·75
U25	0·75
U26	0·75
U31	0·45
U37	1·50
U50	0·32
U52	0·33
U76	0·30
U78	0·30
U191	0·75
U201	0·35
U281	0·40
U282	0·40
U301	0·40
U403	0·50
U404	0·40
U801	1·00
UABC80	0·35
UAF41	0·50
UAF42	0·55
UB41	0·60
UBC41	0·50
UBC81	0·40
UBF80	0·40
UBF89	0·35
UBL1	0·50
UBL21	0·60
UC92	0·35
UCC85	0·40
UCF80	0·55
UCH21	0·60
UCH42	0·70
UCH43	0·75

	£
UCH81	0·35
UCL81	0·60
UCL82	0·35
UCL83	0·60
UF9	0·60
UF11	0·50
UF41	0·60
UF42	0·60
UF43	0·60
UF80	0·35
UF85	0·40
UF89	0·35
UL41	0·65
UL84	0·30
UM4	0·40
UM84	0·20
UU5	0·60
UY1N	0·50
UY11	0·65
UY41	0·45
UY82	0·50
UY85	0·30
VL8631	1·90
VP41	0·75
VP133	1·00
VR75/30	0·45
VR105/30	0·38
VR150/30	0·35
VU33	0·60
VU39A	0·60
VU111	0·80
VU120	0·80
VU133	0·60
W107	0·50
W729	0·60
X65	0·55
X66	0·55
X76M	0·50
XC11	0·75
XC12	0·35
XC12T	0·40
XC15	0·25
XC15T	0·40
XC23	0·90
XC25	0·35
XR1-1600	14·00
XR1-3200	6·50
Z329	0·85
Z520M	1·50
Z700U	0·75
Z700W	0·75
Z719	0·25
Z729	0·30
Z749	0·80
Z759	1·65
Z800U	1·75
Z801U	1·75
Z803U	0·90
Z900T	0·75

PLEASE NOTE THAT ALL PRICES ARE QUOTED IN DECIMAL CURRENCY.

PLEASE NOTE THAT VALVES LISTED ABOVE ARE NOT NECESSARILY OF U.K. ORIGIN

Head Office:
44a WESTBOURNE GROVE, LONDON, W.2
Tel.: 727 5641/2/3
Cables: **ZAERO LONDON**
Retail branch (personal callers only)
85 TOTTENHAM COURT RD., LONDON W.2. Tel: 580 8403

A.R.B. Approved for inspection and release of electronic valves, tubes, klystrons, etc.

WE WANT TO BUY:

SPECIAL PURPOSE VALVES. PLEASE OFFER US YOUR SURPLUS STOCK. MUST BE UNUSED.

TELEX 261306

APPOINTMENTS VACANT

DISPLAYED SITUATIONS VACANT AND WANTED: £8 per single col. inch.
LINE advertisements (run-on): 45p per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 25p.
SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to THURSDAY, 12 p.m., 8th APRIL, for the MAY issue, subject to space being available.

Straight talking electronics engineers

Listen to us for a few well-paid months, then with computer expertise added to your thorough understanding of general electronics, you'll be a well qualified Service Engineer Instructor.

We're looking for that rare ability to make others see exactly what you're getting at. We want people who know their stuff inside out—who can pass on practical information that trainees would otherwise take years of experience to acquire.

It will be your responsibility to make sure that when your pupils leave the Training Centre as computer service engineers, they're (almost) as good at their jobs as you are now at yours!

Some travelling will be involved in the UK, and possibly overseas, and during this time a salary premium is paid in addition to all normal expenses.

Most of you will be based at Letchworth in the pleasant Hertfordshire countryside, and only an hour's drive from London. Relocation expenses will be considered.

Please write, quoting ref WW666C to A. E. Turner, International Computers Limited, 85/91 Upper Richmond Road, Putney, London, SW15.

International Computers **ICL**

RADIO OPERATORS

There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1971 and subsequent years.

Specialist training courses lasting approximately 8 months are held at intervals. Applications are now invited for the course starting in September 1971.

Salary Scales

During training with free accommodation provided at the Training School:

Age 21	£848	per annum
,, 22	£906	,,
,, 23	£943	,,
,, 24	£981	,,
,, 25 or over	£1,023	,,

On successful completion of course:

Age 21	£1,073	per annum
,, 22	£1,140	,,
,, 23	£1,207	,,
,, 24	£1,274	,,
,, 25 (highest age point)	£1,351	,,

then by 6 annual increments to a maximum of £1,835 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must be United Kingdom residents, normally under 35 years of age at start of training course, and must have at least 2 years operating experience or PMG qualifications. Preference given to those who also have GCE 'O' level or similar qualification. Exceptionally well qualified candidates aged from 36-40 may also be considered.

Interviews will be arranged throughout 1971.

Application forms and further particulars from:

Recruitment Officer, Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 5AJ. **Tel: Cheltenham 21491 Ext 2270**

92

TEST TECHNICIAN

Required for Final Production Testing and Fault Finding of Digital Voltmeters, and analogue to digital converters.

Experience of similar work or of Digital Systems is essential. Qualifications to H.N.C. advantageous, although opportunities exist for completion of professional qualifications.

Full staff status including pension scheme and attractive salary.

Reply to: **Head of Test Section,**
Fenlow Electronics Ltd.,
Jessamy Road,
WEYBRIDGE, Surrey.
Tel: Weybridge 48177.

1075

Sea-going Radio Officers can now make sure of a shore job and good pay.

If you'd like a job ashore, at a United Kingdom Coast Station, the Post Office will start you off on £1,080—£1,360, depending on age, with annual rises up to £1,850. There are good prospects of promotion to higher posts, opportunities exist for overtime and you would receive additional remuneration for attendance during the late evenings, at night and on Saturday afternoons and Sundays.

You will need to be 21 or over, with a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General or the Ministry of Posts and Telecommunications, or a Radiocommunication Operator's General Certificate issued by the Ministry of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

Find out more by writing to:

The Inspector of Wireless Telegraphy,
I.M.T.R.
Wireless Telegraph Section (W.W.)
Union House,
St. Martins-le-Grand,
London,
EC1A 1AR.

Post Office Telecommunications

1084

ASSISTANT ENGINEER GRADE II (BROADCASTING) BOTSWANA

- ★ **Salary up to £2,387**
- ★ **Low taxation**
- ★ **Appointments grant £100 or £200 in certain circumstances**
- ★ **25% gratuity on basic salary**
- ★ **Contract 24 – 36 months**
- ★ **Subsidised accommodation**
- ★ **Education Allowances**

The Posts and Telecommunications Department requires an officer to undertake operational duties including the installation and maintenance of broadcasting equipment in transmitting stations and to assist with the training of junior engineering staff.

Candidates must possess the City and Guilds Intermediate Certificate (Telecommunications) or equivalent and have had five years relevant practical experience, (additional to any period of approved training) of technical broadcasting equipment including M.F. and H.F. transmitting equipment up to 10 KW.

During the postal strike please telephone the Crown Agents' Appointments Division (01-222 7730 Ext. 665) for full details and an application form, quoting reference M2K/690420/WF, or write to The Crown Agents, 'M' Division, 4 Millbank, London, S.W.1.

1102

ENGINEERS

SERVICE AREA PLANNING

The INDEPENDENT TELEVISION AUTHORITY is looking for engineers with a keen sense of responsibility and initiative to join a test team concerned with planning the expansion of our VHF colour television service.

It is expected that the men selected will be aged 23-35, qualified to H.N.C. level, have had experience in television, R.F. measurements or an associated field and feel they would like the opportunity of working throughout the United Kingdom enjoying an open air life. They should, in addition, be experienced drivers with a clean and current licence. The ability to climb aerial support structures would be an advantage. There are currently two vacant posts;

1. The more senior post for which candidates should have a good working knowledge of radio wave propagation and basic television principles. The job will also involve taking charge of a small team.

Salary—on a scale £2115-£2574.

2. For the junior post we would consider less experienced candidates who can show good potential.

Salary—on a scale £1623-£1965.

Although based at our Knightsbridge Headquarters the selected candidates will be expected to work in any part of the United Kingdom for periods generally not exceeding two to three weeks at a time.

If you are interested in either of these posts please write or telephone for an application form, quoting Ref. WW/1605, 1 or 2, to:

ITA

The Personnel Officer,
INDEPENDENT TELEVISION AUTHORITY,
70 Brompton Road, London, S.W.3.
Tel. 01-584 7011. Ext. 482.

Closing date for completed application forms: 31st March, 1971.

1083

CIRCUITRY DESIGNER

Experienced in design of analog and digital circuitry to join research team developing electronic music synthesisers. H.N.C. or graduate.

Write or 'phone: **ELECTRONIC MUSIC STUDIOS (LONDON) LTD**
49 Deodar Road, London S.W.15. Tel: 01-874 2363 1080

Data Line Officer

BOAC's world wide computer system requires expert control. We need a Data Line Officer to complete a team responsible for the operation of the terminal system. The appointed candidate will be based at London (Heathrow) Airport working on a rotating shift basis. He will occasionally be expected to travel to operational locations in North America and Europe.

Candidates should have qualified in electronics or data communications to H.N.C. standard or City & Guilds full certificate, and those with GPO line transmission experience will be given preference. Candidates qualified to O.N.C. standard will be considered only if they have appropriate experience.

Salary, including London Weighting, is in the range £1789 to £2179 per annum plus shift allowance of £383 per annum. Additional benefits include facilities for holiday air travel.

Please contact:

Selection Services, BOAC, Comet House (S Block 1st Floor), London (Heathrow) Airport, Hounslow, Middlesex. (Adjacent to Hatton Cross), or phone 01-759 5511 extn 2637 for an application form.

1099

BOAC

TEST ENGINEERS

This rapidly expanding company requires Test Engineers for test and alignment of transistorised V.H.F. Communications equipment.

Applicants should be familiar with V.H.F. techniques and capable of fault diagnosis.

Salaries offered will be commensurate with knowledge and experience. 38½ hour week, 3 weeks paid holiday. Non-contributory pension scheme. Ample opportunities for promotion.

Write or telephone

R. Trimmer, Chief Inspector,

DYMAR

Dymar Electronics Ltd.,
Colonial Way, Radlett Road,
Watford, Herts.
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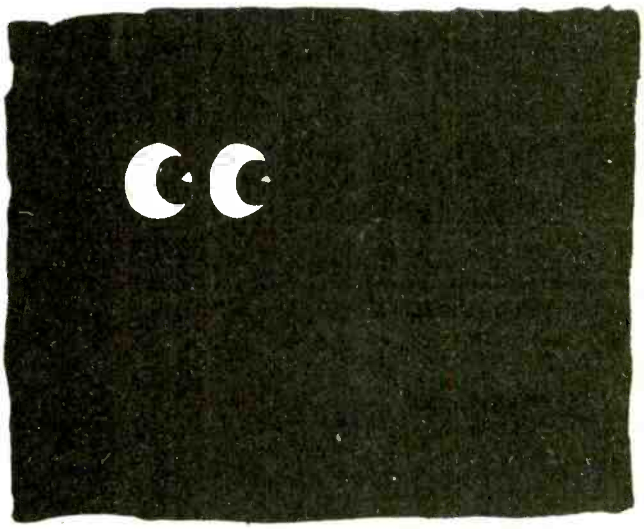

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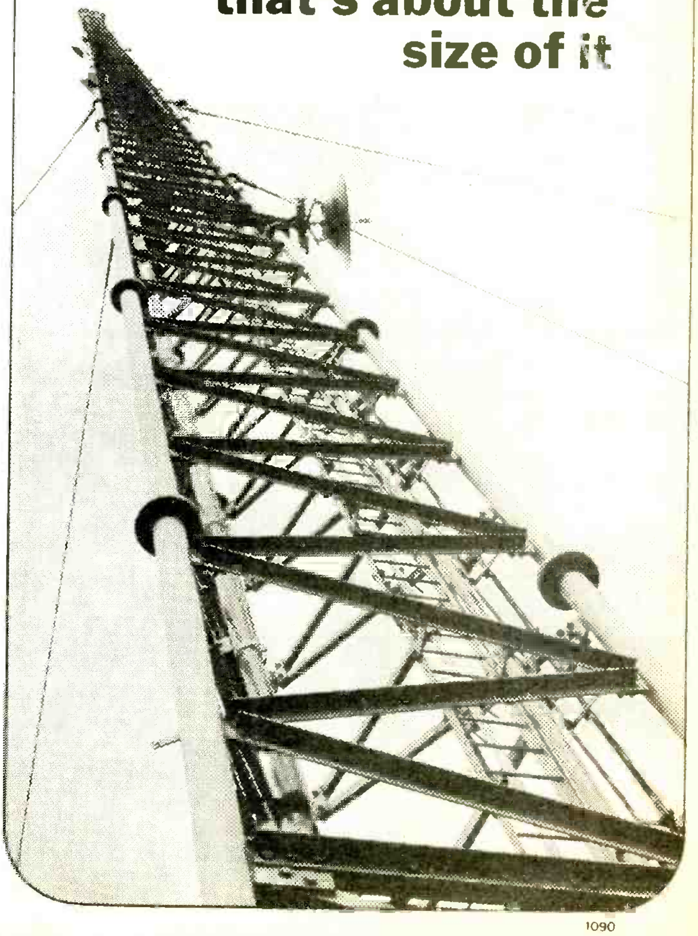

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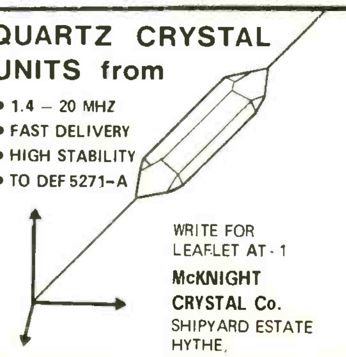

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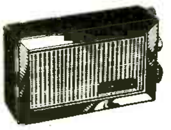

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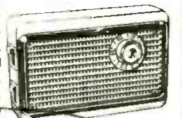

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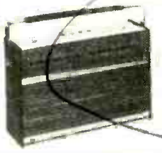

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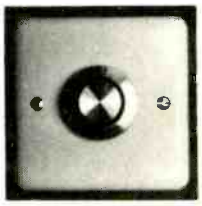

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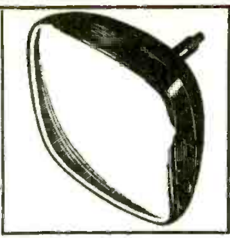

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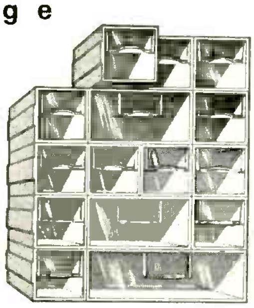

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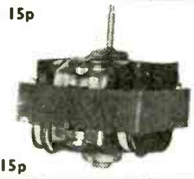

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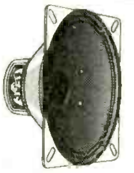

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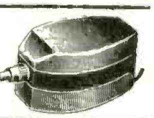

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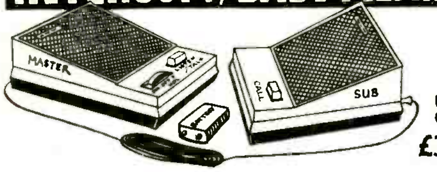

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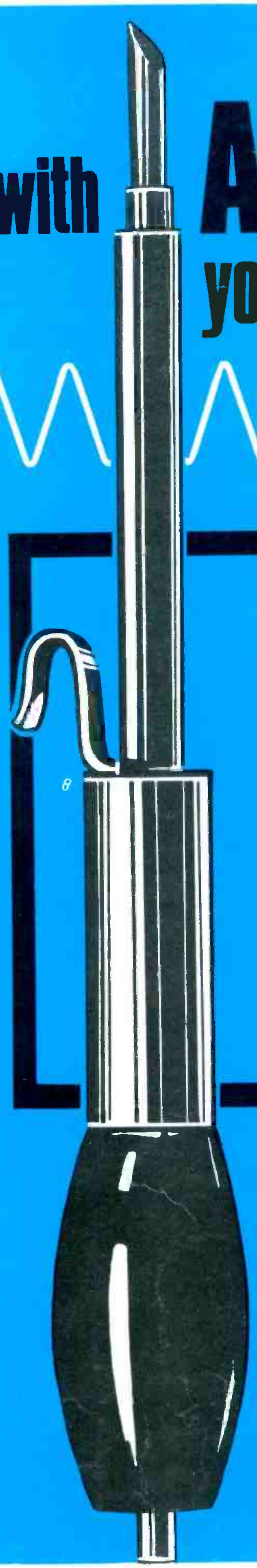

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