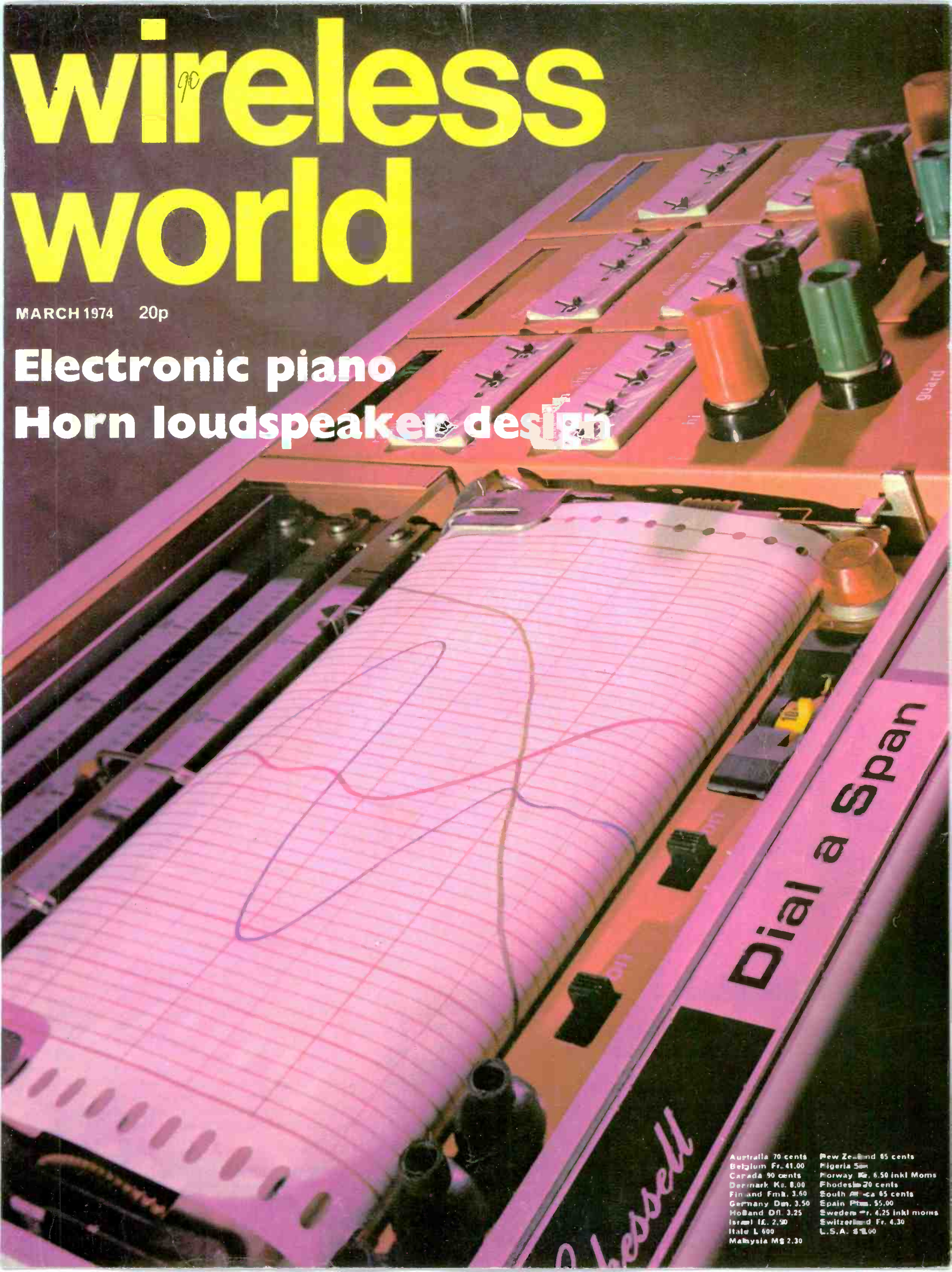
wireless world

MARCH 1974 20p

Electronic piano
Horn loudspeaker design



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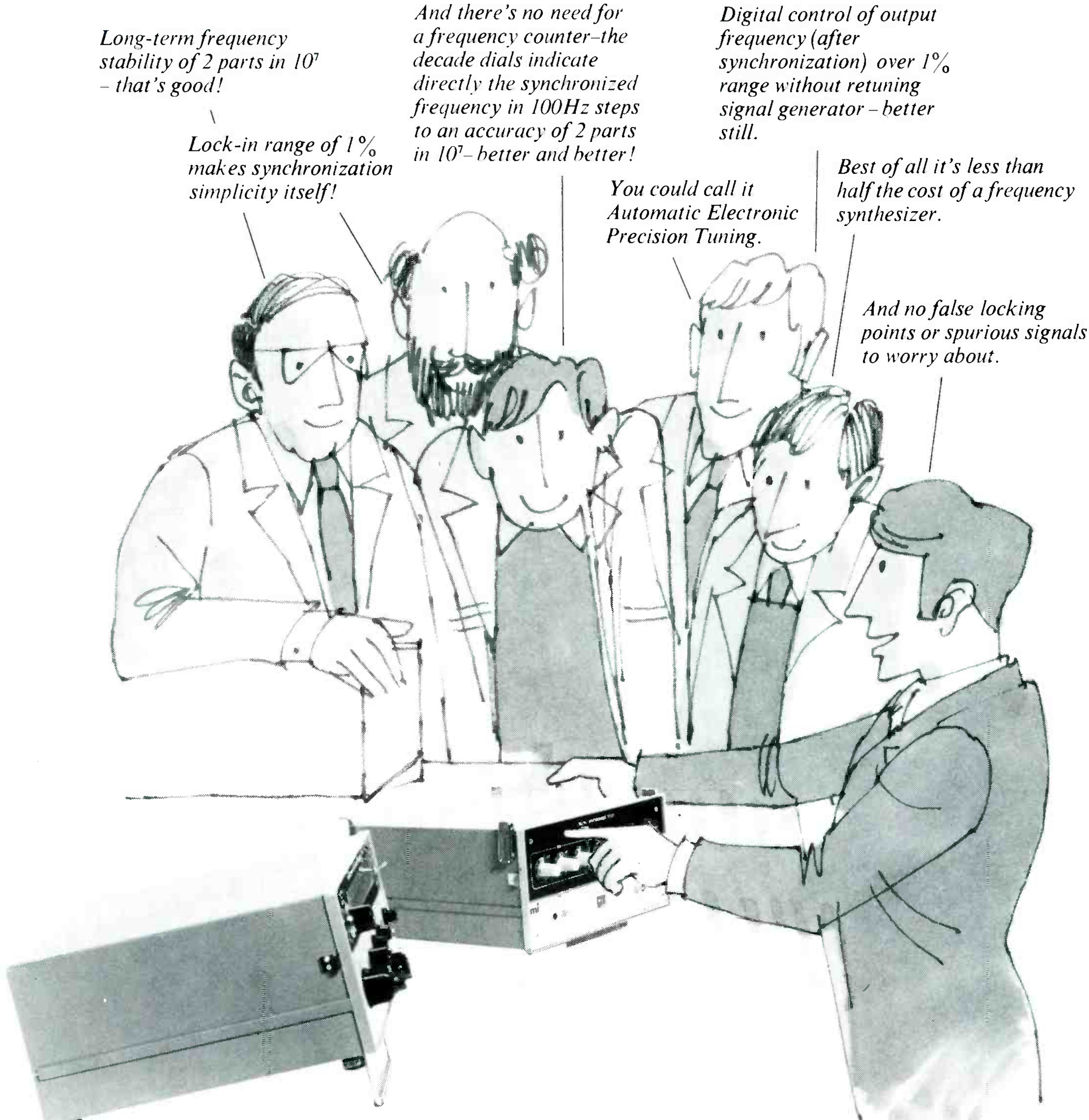


What is it?

It's the TF 2171 clip-on Digital Synchronizer– the first in a range of ancillary equipment designed to increase the usefulness of the TF 2015 – the signal generator that has a new performance/value standard. Together they give you:

- ✻ long-term frequency stability of 2 parts in 10^7.
- ✻ a simple method of frequency setting to an accuracy of 2 parts in 10^7 in 100Hz steps by means of 7 direct-reading decade dials.
- ✻ no false locking points and no spurious output signals.

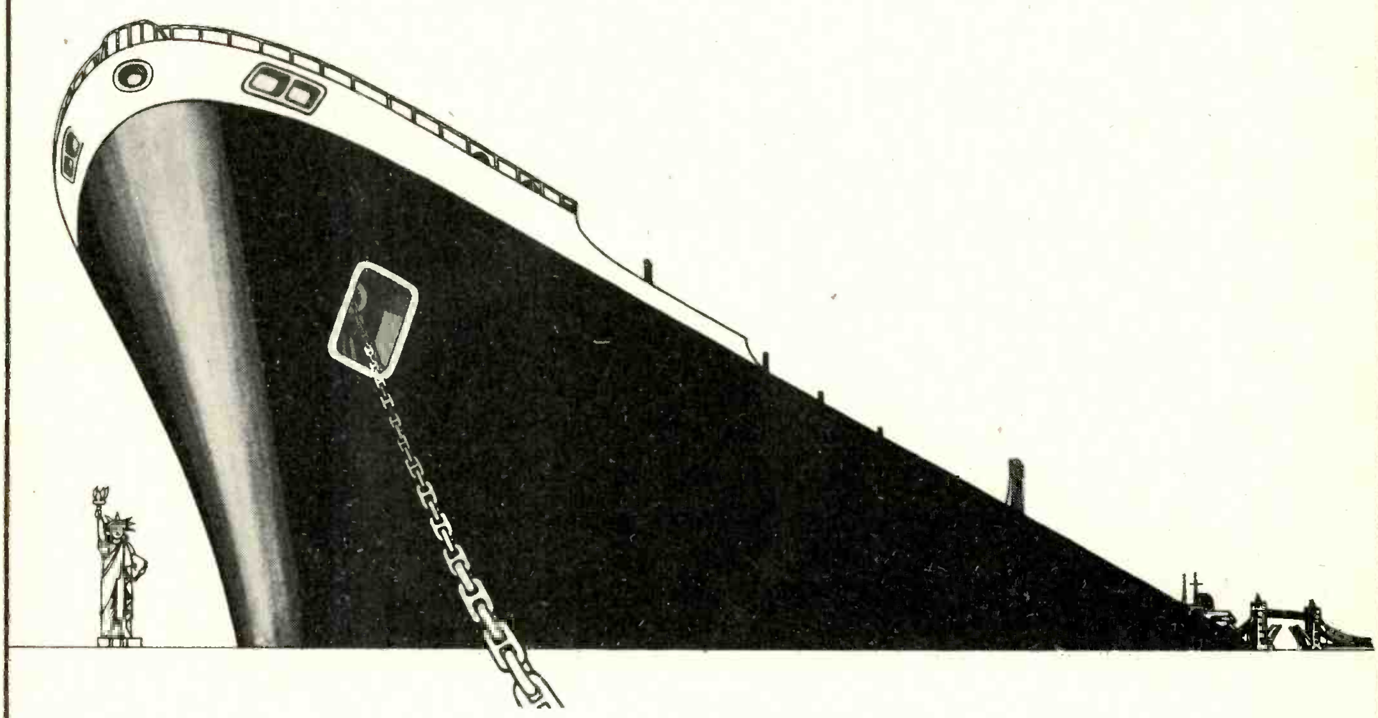
- ✻ all this is added to the TF 2015's exceptional performance: accurate 1 μV output over entire frequency range; attenuator accuracy of $\pm$ 1dB to 100MHz and $\pm$2dB to 520MHz, spurious radiation low enough to permit measurement at 0.1 μV level; 10-520MHz frequency coverage. Directly calibrated fm and am facilities.

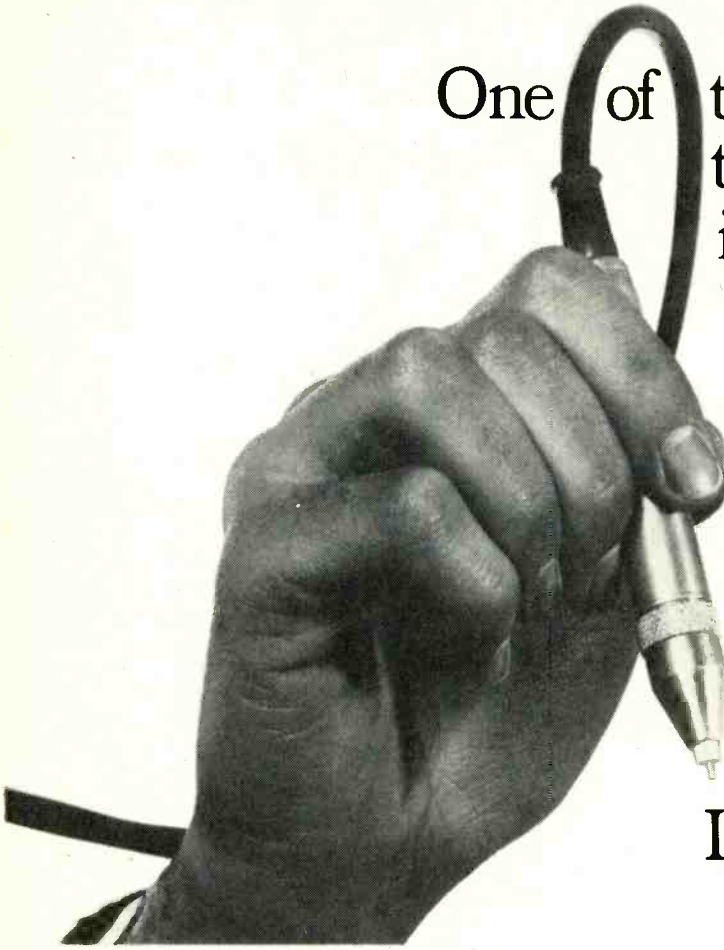
Add up these advantages, halve the cost of a synthesizer and you have the combined TF 2015 and TF 2171. If you are working with narrow band equipment–this combination has been designed for you. Ask us now for full descriptive literature.

mi

Marconi Instruments Ltd.,
Longacres, St. Albans,
Herts, AL4 OJN, England.
Telephone: St. Albans 59292. Telex: 23350
A GEC-Marconi Electronics Company.

WW—001 FOR FURTHER DETAILS



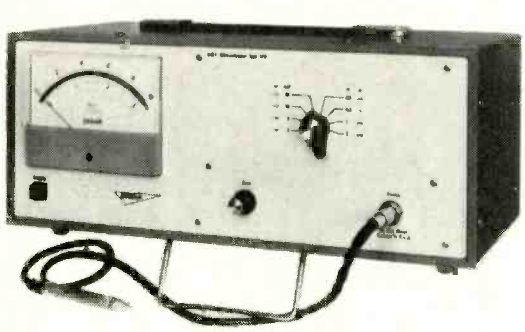


One of the many secrets of the Dymar 1711 is right here.

In the probe.

The Dymar 1711 is a VHF/UHF Millivoltmeter with a number of clever, and extremely useful, differences.

Take the compact, lightweight RF probe. This houses two high speed rectifying diodes in a full-wave circuit. The resulting low level DC voltage is amplified in a low noise chopper-stabilized DC amplifier. The rectifying characteristic of these diodes is such that below approximately 30mV they follow a square law. The result? True rms response.



Then there are the special linearising circuits used on each of the eight voltage ranges provided. These ensure completely linear readings between one-third fsd and full scale.

And, as you would expect from Dymar, the instrument is fully portable and provided with a comprehensive range of accessories.

Take a look at this brief spec.

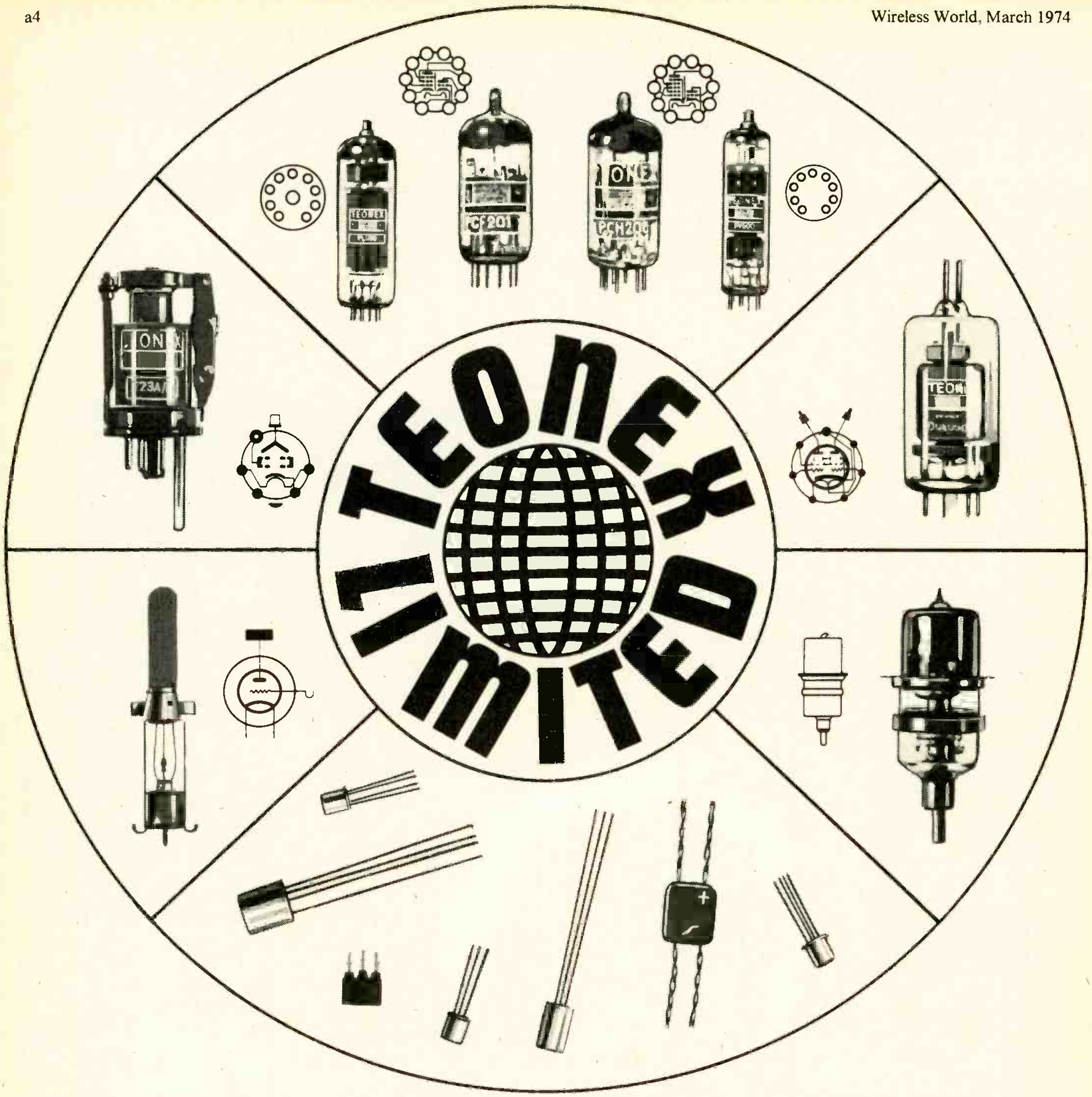
Frequency range:	50kHz to 850MHz
Voltage range:	1mV fsd to 3V
Minimum reading:	300μV
RMS response:	True below 30mV

Need to know more? Use the Reader Reply Service or contact Dymar direct.

DYMAR

the name in radiotelephones

DYMAR ELECTRONICS LIMITED,
Colonial Way, Radlett Road, Watford,
Herts. WD2 4LA. Tel: Watford 37321.
Telex: 923035. Cables: Dymar Watford.



Electronic valves (a comprehensive range) semi-conductors (a wide variety) integrated circuits...and now a comprehensive range of Hybrid Microcircuits. Prices on request.

Teonex offers more than 3,000 devices. They are competitively priced and they are superlative in performance because the company imposes strict quality control. Teonex concentrates entirely on export and now operates in more than sixty countries on Government or private contract. All popular types in the Teonex range are nearly always available for immediate delivery. Write now for technical specifications and prices: Teonex Limited, 2a Westbourne Grove Mews, London W11 2RY, England. Cables: Tosuply London W11. Telex: 262256

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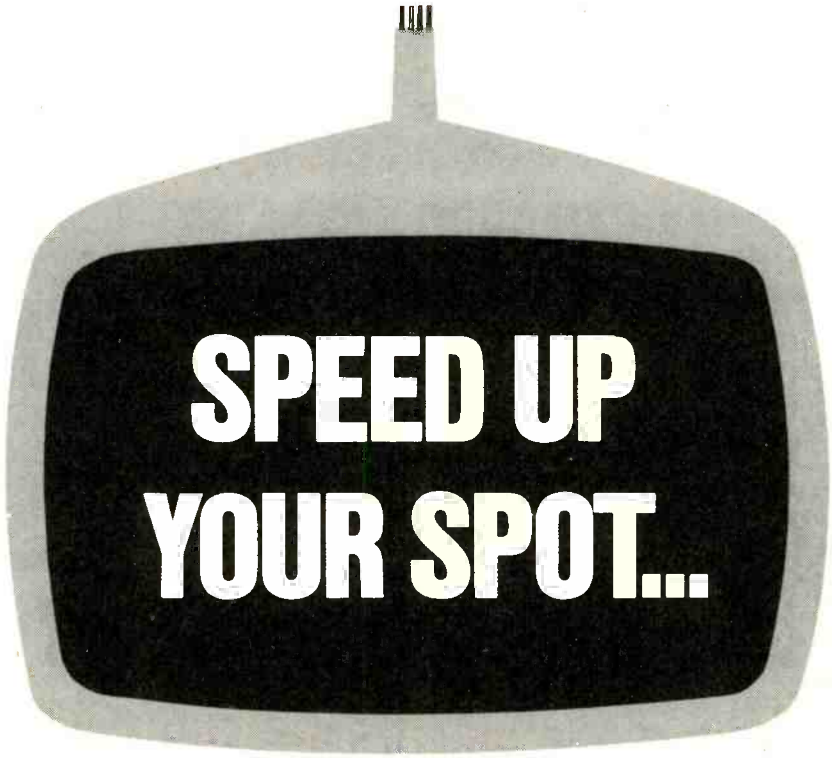

... AND SAVE POWER DRAIN, WEIGHT AND SPACE.

By introduction of new electron-optics in electrostatic deflection CRT's, THOMSON-CSF has overcome the limitations of current tubes: considerable increase of power drain of electromagnetic tubes for higher writing speeds, long gun and very high deflection voltages of conventional electrostatic tubes. While providing excellent resolution and brightness, this new generation of large screen electrostatic CRT's has spectacular advantages, due to unique performances: high deflection sensitivity, bandwidth and writing speed, short gun. The very high deflection sensitivity results in a considerable size and price reduction of power supplies and deflection amplifiers: for the same screen size, power consumption may be reduced by 100 and volume by 3. These tubes can be provided with internal graticule for large screen oscilloscopy or without graticule for high speed alphanumeric or graphic monitors.

Characteristics	Unit	TH 8100 TH 8201	OEE 1333	TH 8000
Useful screen dimensions	mm	180 x 130	255 x 190	255 x 190
Tube length	mm	360	450	450
Post-acceleration voltage	kV	20	20	25
Deflection sensitivity (min.)	V/cm	10	6	10
Deflexion linearity (max.)	%	2	1	2
Beam current (peak)	μA	30	30	50
Luminance (1)	cd/m^2	65	35	65
Line width	mm	0,4	0,5	0,4

(1) At 1 cm/μs and 50 Hz refresh rate

THOMSON-CSF

THOMSON-CSF ELECTRONIC TUBES LTD / BILTON HOUSE, UXBRIDGE ROAD, EALING / LONDON W5 2TT
TEL. (01) 579 5511 / TELEX : 25 659

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Germany - THOMSON-CSF Elektronenröhren GmbH / Am Leonhardsbrunn 10 / 6 FRANKFURT/MAIN / Tel. 70 20 99
Italy - THOMSON-CSF Tubi Elettronici SRL / Viale degli Ammiragli 71 ROMA / Tel. 63 80 143
Japan - THOMSON-CSF JAPAN K.K. / Kyosho Building / 1-9-3 Hirakawa-cho / Chiyoda-ku / TOKYO / T 102 / Tel. 03 264-6341
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U.S.A. - THOMSON-CSF Electron Tubes, Inc. / 50 Rockefeller Plaza / NEW YORK, N.Y. 10020 / Tel. (212) 489.0400

1945

SE Labs Dynamic

SM 2001 Digital Frequency Response Analyser (Transfer Function Analyser)

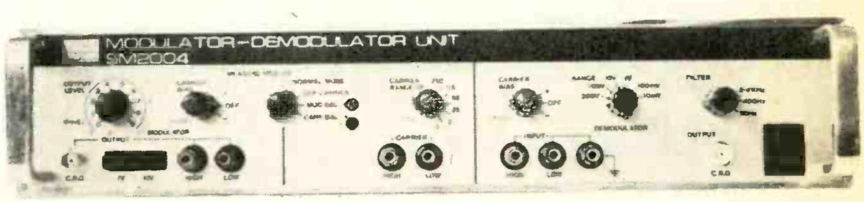
Four decade digital display in Cartesian, Polar or Log Polar form, from 0.00001 Hz to 1 kHz. Measurements in ratio or absolute terms. Remote programming for A.T.E. applications standard. Harmonic analysis capability. Suitcase format - easily portable. Fully floating and isolated input and output. Very high harmonic and noise rejection. Resolution to 0.1°. BCD output of all information standard.

SM 2003 Frequency Extension Unit

Extends the frequency range of SM 2001 up to 1 MHz. Also extends the harmonic measurement capability and reference synchronisation capability of the SM 2001/2 up to 1 MHz. Fully isolated input and output to the high frequency system under test.

SM 2004 Modulator Demodulator Unit

Provides for utilisation of SM 2001 with systems having modulated carrier input and/or output. Carrier frequency 50 Hz to 10 kHz. Modulation frequency 0 to 1kHz. Fully floating and isolated inputs and outputs.



SM 2002 Reference Synchronizer

An internal fitment for the SM 2001 F.R.A. to enable synchronisation from external signals. Will synchronise from virtually any wave form of almost any amplitude. Permits the use of SM 2001 on systems with mechanical or hydraulic inputs. Extends the use of SM 2001 to closed loop testing or part system testing and also to the measurement of the phase relationships between outputs of any two transducers or other sources.

Analysis

SM 272 Transfer Function Analyser

0.01Hz to 10kHz. Accuracy ± 1% (D version). Optional analogue or digital read out. Much better than 40dB noise rejection. Dynamic range greater than 25 x FSD. Sine, triangular and square outputs. DC offset capability. Cartesian or switchable cartesian/polar display (P version). 10 millivolts sensitivity. Fully isolated input and output. Independent R / Q expanders for small angle accuracy. Very low cost.

SM 2008 Computer Interface

A complete package of software and hardware to enable computer control of SM 2001 for any system or frequency change.

SM 2006 Two channel converter (Accessory for SM 2001)

Accepts two separate channels from any system or vibrating structure and computes the phase and amplitude relationship between them. Enables both channels to go into correlated input with high noise rejection.

Available Soon

SM 2007 Plotter Interface

This unit provides for coupling the SM 2001 frequency response analyser directly into any standard XY recorder. The resultant plots can be of Bode or Nyquist type. Three outputs are provided, 1. Log frequency, 2. A co-ordinate or amplitude. 3. jB. co-ordinate or phase angle. A dynamic range control and automatic pen-lift are further features.

SE Labs (EMI) Ltd

North Feltham Trading Estate, Feltham, Middlesex. Telephone: 01-890-1166 Telex 23995
Northern Sales Office, Bessell Lane, Stapleford, Nottingham. Telephone: Sandiacre 3255
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WW—005 FOR FURTHER DETAILS

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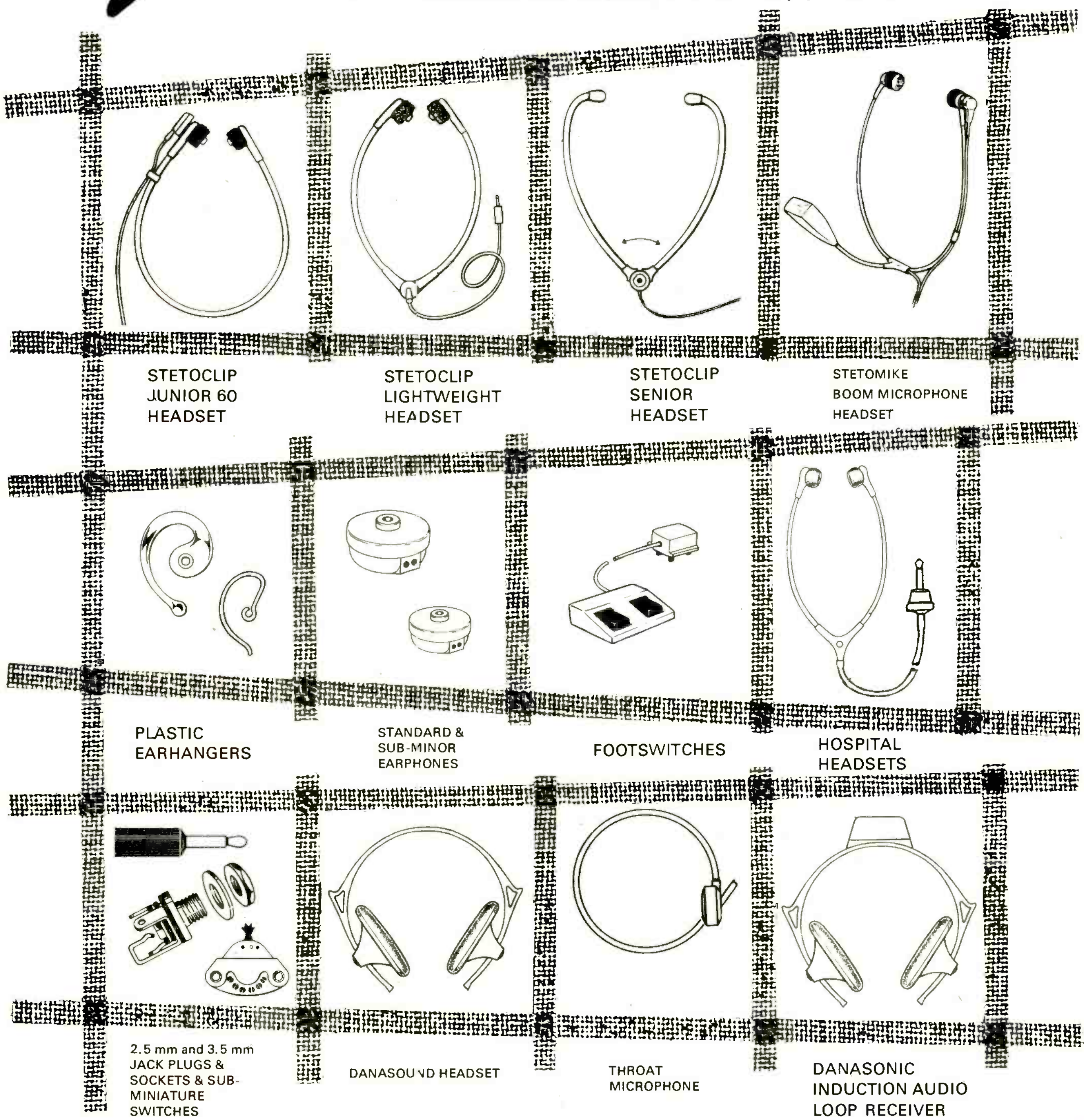

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QUAD 303

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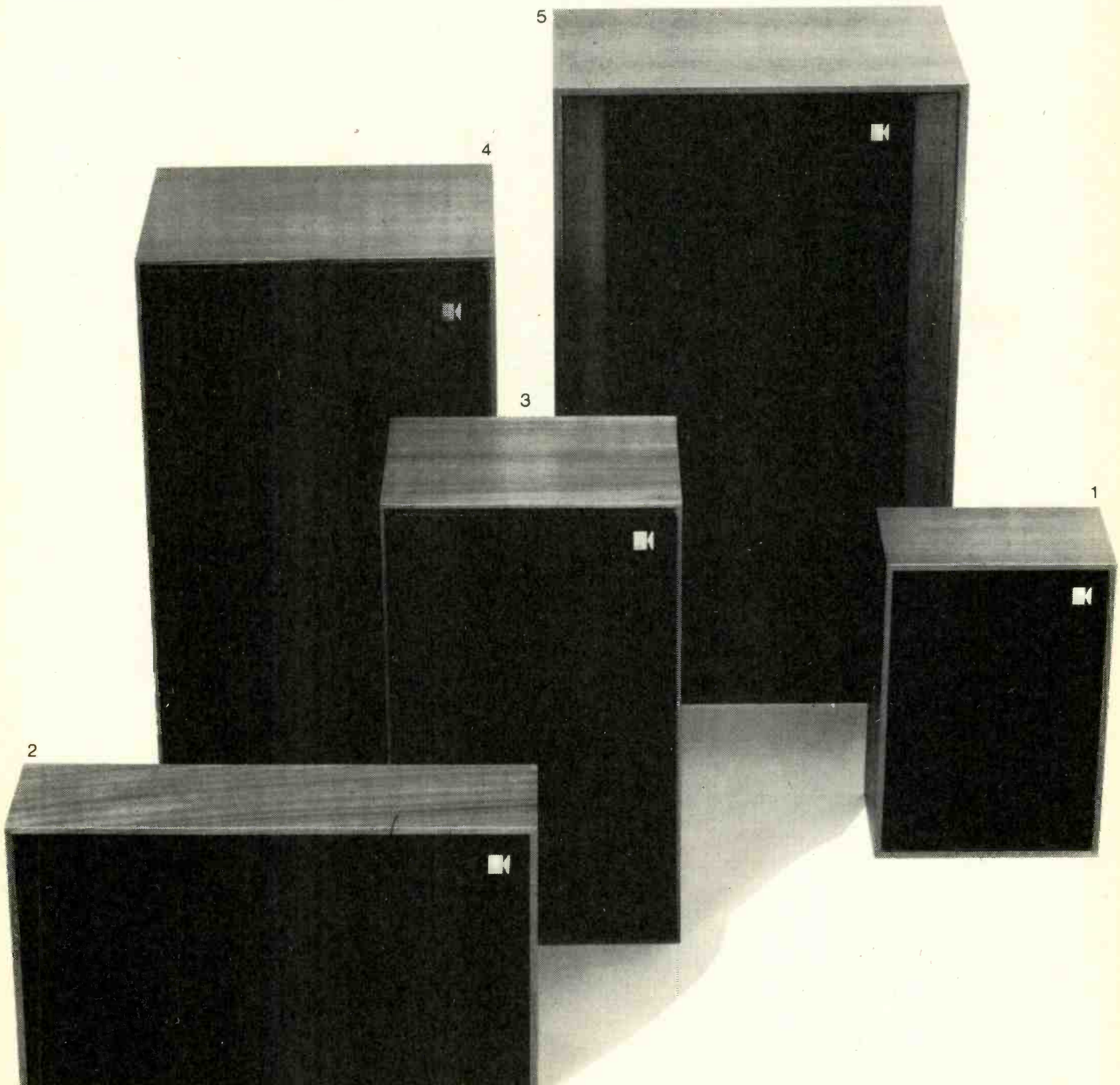
KEF believe that restricted space need not necessarily restrict performance – visit your KEF dealer and hear what we mean.

Full details of the Coda[1], Cantor[2], Chorale[3], Cadenza[4] and Concerto[5] will be sent on request.



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GOLD STAR
MAZDA

Introducing the new Martin Minidan & Microdan Speakers from Acos

The Microdan gives over 25 Watts from an enclosure which measures only 6½" x 6½" x 6½" and the Minidan gives 30 Watts from an enclosure measuring only 6⅞" x 6½" x 11¼".

Thanks to the Martin construction technique which gives an extremely rigid cabinet, these high outputs are available from 5" full range units which produce a very forward sound of high ambience and true fidelity. Their high quality performance combined with compact size make them ideally suited for siting even on the smallest bookshelf to give maximum flexibility from Hi Fi or quadraphonic installations regardless of space.

Complete the coupon for details of your nearest dealer.

ACOS

Acos for Sound Enjoyment

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Please send me your new Martin Speakers Leaflet giving details of the Minidan and Microdan.

Name: ____________________

Address: ____________________

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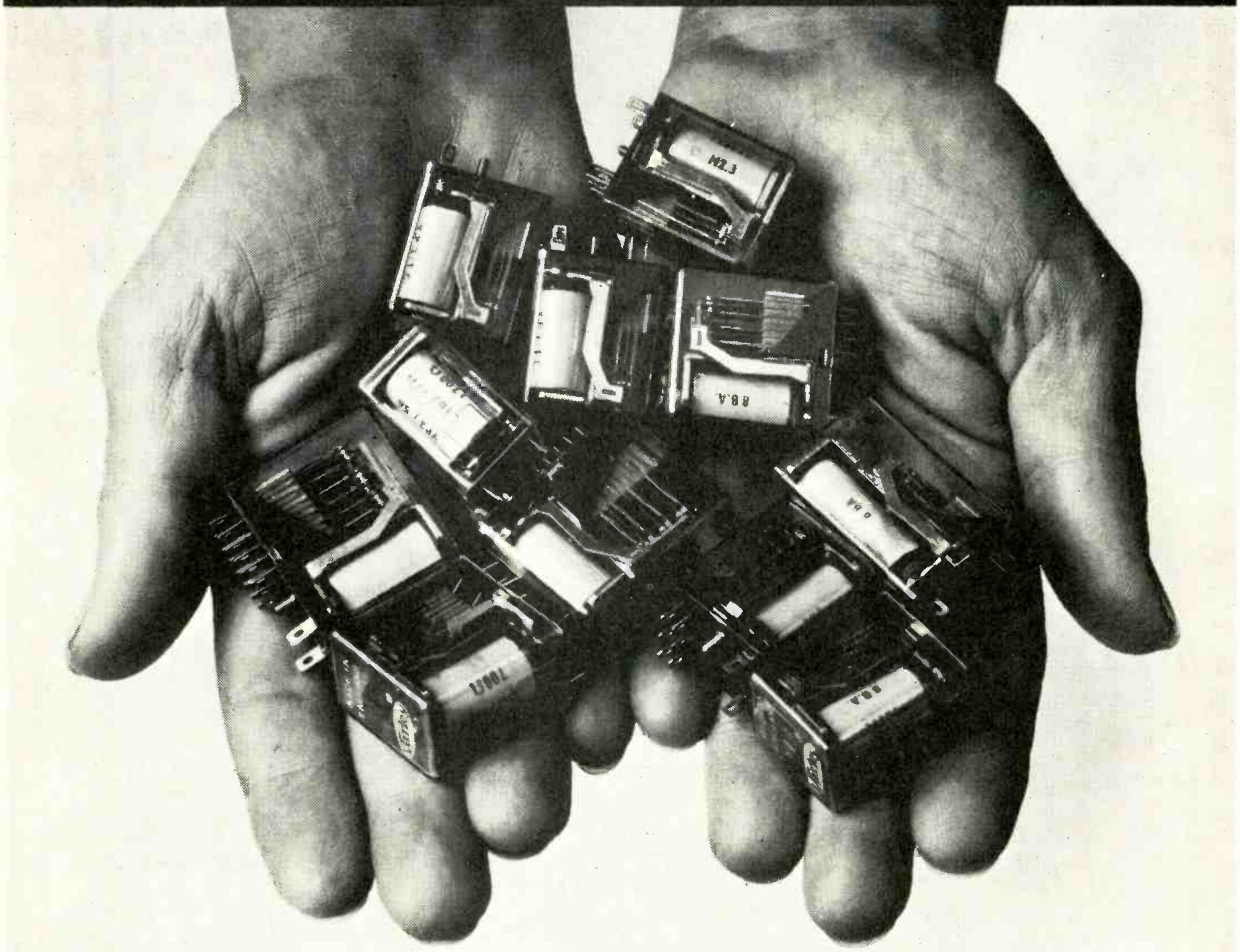

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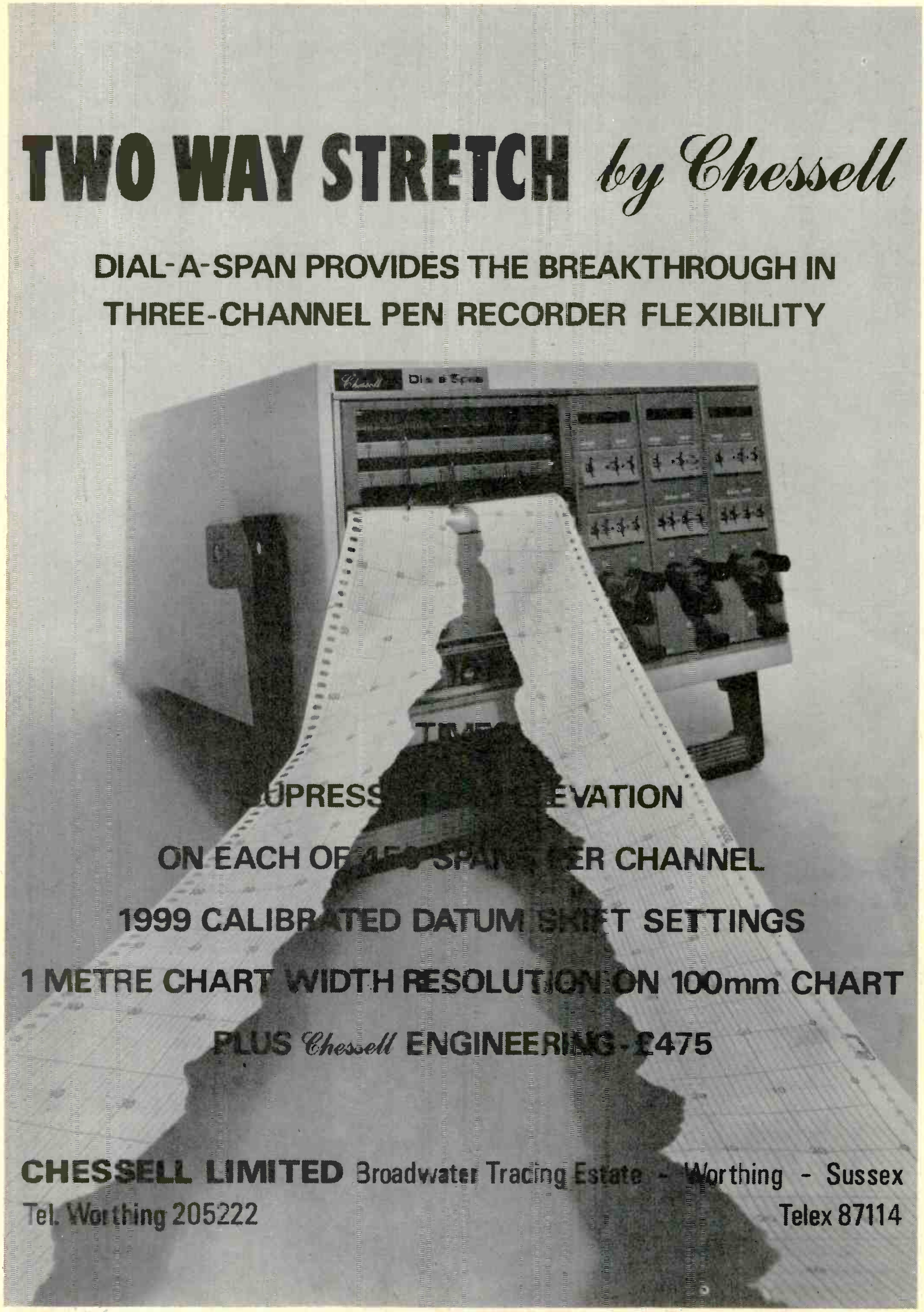
WW—024 FOR FURTHER DETAILS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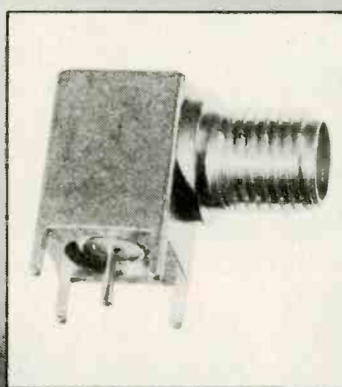
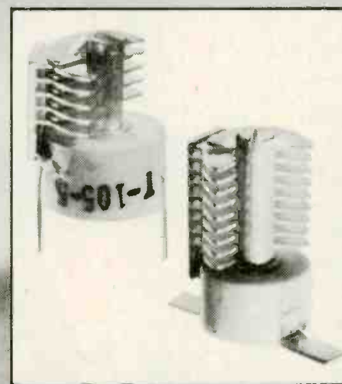
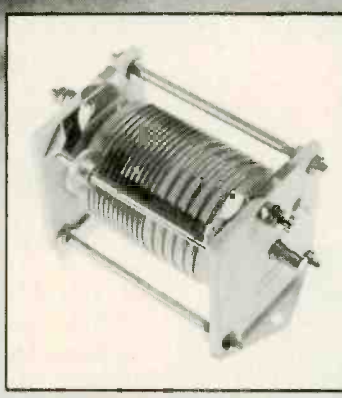


Coaxial connectors.
High quality miniature coaxial connectors with full SMA mating compatibility.



Airspace capacitors.
A wide range of miniature machined plate air variable capacitors offering extreme accuracy and high reliability.



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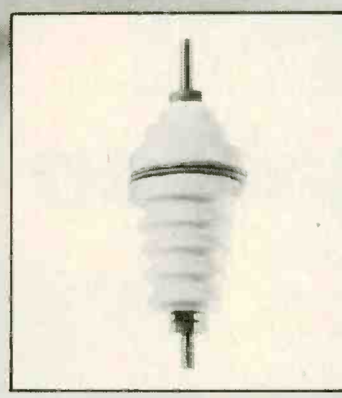

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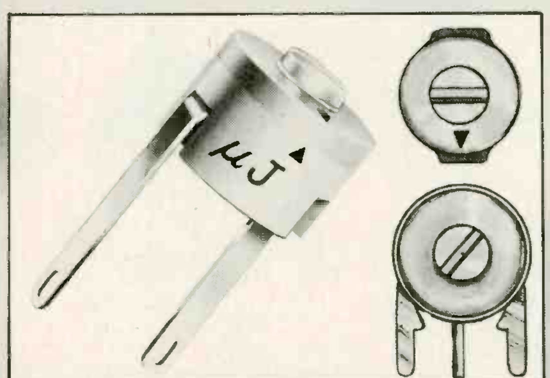
Through panel type.



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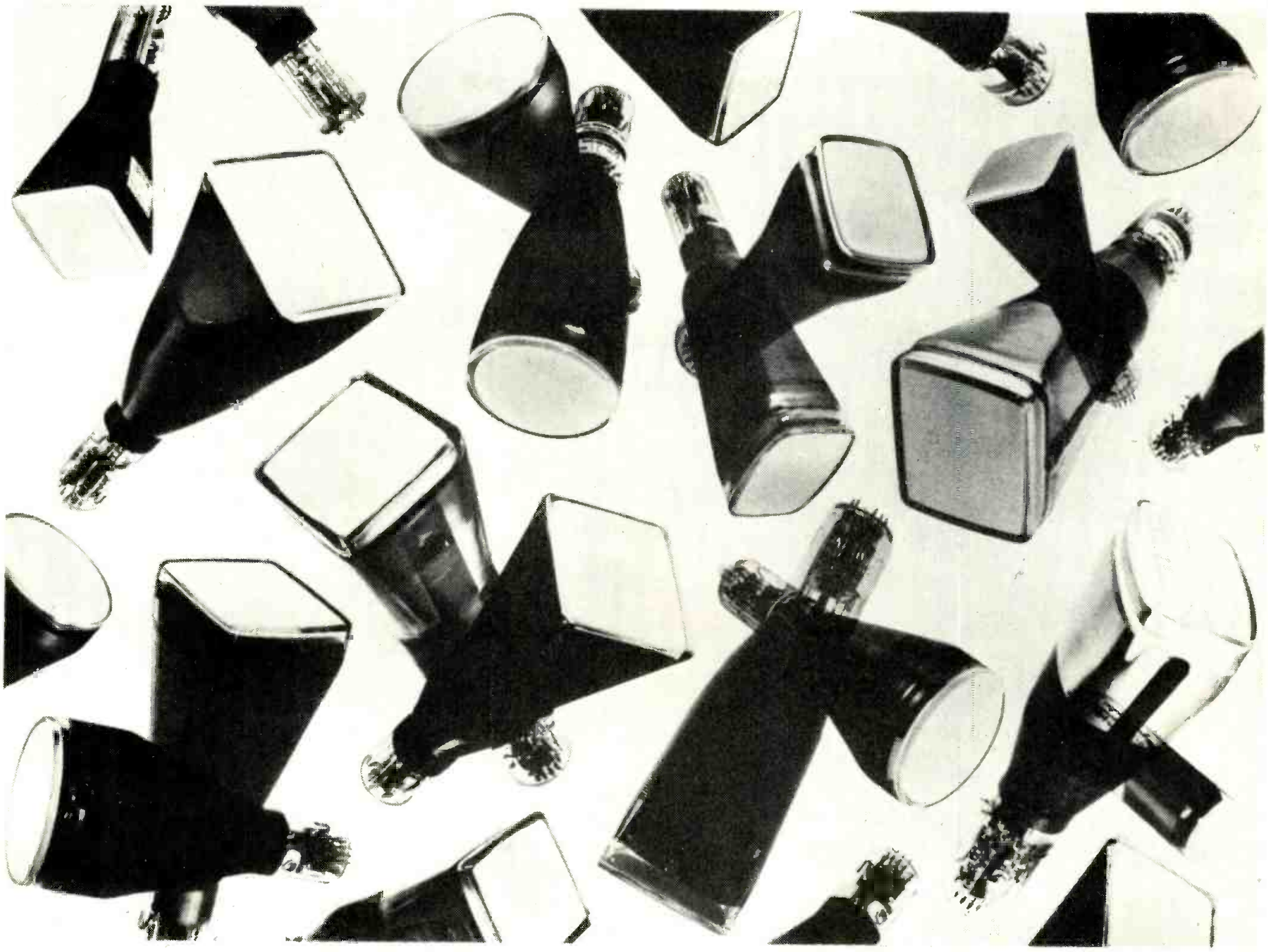

The many faces of BRIMAR

reveal the biggest current range of oscilloscope tubes in Europe.

Whenever it's a matter of designing or making an oscilloscope, remember one essential fact, Brimar have a complete range of tubes for operation up to 75/100MHz bandwidth. Many with ex-stock delivery.

The fact is: the current Brimar range of tubes is the largest in Europe — with as many as twenty-five different versions to choose from.

Brimar are continually revising and updating their range to meet the demands of the market. The latest additions are the D10-230 and D10-240 (4" compact flat faced tubes) and the D16-100 (XY plotter)

The quality of Brimar tubes is unquestionably good. Improve your scope — telephone or write for full or abridged data and prices 01-804 1201

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D10-210	D13-601	D14-210
D10-230	D13-610	D16-100
D10-240	D14-150	SE4D
D13-30	D14-170	SE5/2A
D13-33	D14-171	SE5F
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BRIMAR

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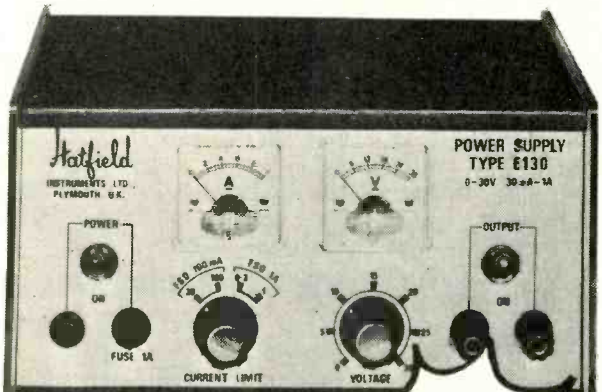

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from Hatfield

The 6130 variable d.c. power unit provides laboratories and test rooms with a new compact supply at an exceptionally low price. Among its many features are separate output and mains switching and individual voltage and current meter.

Price in Great Britain. **£29**

Output Voltage	0–30V continuously adjustable
Output Current	0–1 A with four current limit settings of 30mA, 100mA, 300mA. 1A Meter f.s.d. switched 100mA or 1A
Input Voltage	220–250V 50–60Hz with tappings for 230, 240V
Output Connections	Two insulated screw terminals (incorporating 4mm plug sockets) spaced 25mm (1·0") apart
Dimensions	190mm x 158mm x 152mm 7½" x 6¼" x 6"

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New Multi Range Collet Knobs and Accessories

NEW

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Four styles available which snap fit to knob tops.

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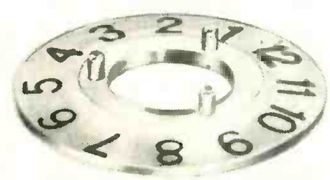
Four different types available in five sizes.



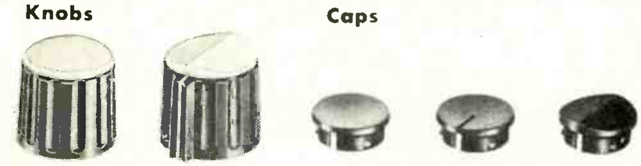
ACCESSORIES
Pointers, Dials, Stators, Nut covers, all snap fitting to the knobs.

A new and versatile range of twenty collet fixing control knobs, together with various snap on accessories illustrated below, manufactured in Switzerland to our rigorous standards and only available from the House of Bulgin.

There are four basic styles: Circular Knob, Circular Knob with line, Wing Knob and Wing Knob with line. They are available from stock in light grey and black as standard, with dark grey and red versions to special order. Each knob style is available 10, 15, 21, 28 and 36mm diameter with collets accepting ¼" ø shafts as standard. Other shaft sizes to special order.

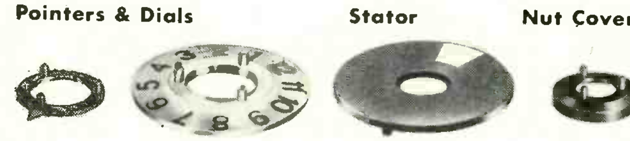
TYPICAL EXAMPLES OF THE KNOBS & A SELECTION OF THEIR ACCESSORIES.

Knobs **Caps**



Circular type with or without indicator line. | Wing type with or without indicator line. | Flat type, available plain or with curved arrow. | Flat with indicator line. | Peaked cap type.

Pointers & Dials **Stator** **Nut Covers**



Pointer, also arrow dials. | Transparent dials available with or without legending. | With fine or broad indicator band. | Plain or with indicator line, for 10 and 15mm sizes.

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TECHNICAL LITERATURE AVAILABLE ON REQUEST. QUOTE: WW/6/74

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*Declon speaker front material is a fully reticulated flexible polyester foam.

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24" x 16" £2.97 each inc. VAT
36" x 18" £4.75 each inc. VAT
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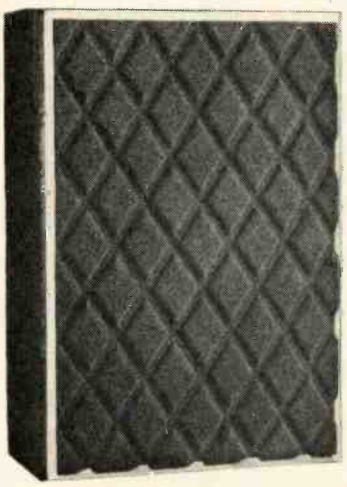

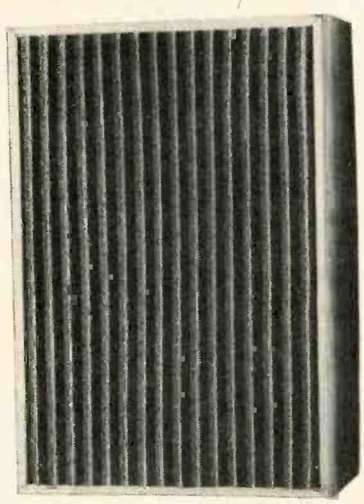

*Attractive designs and colours.
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Amplivox Minilite.
Untouched by human ear.
New Minilite weighs a mere 50g. Yet it combines maximum operating efficiency with absolute wearer comfort.
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Specified for Eurocontrol, Minilite is being widely used in air traffic control, aviation and communications control as well as other branches of industry. Minilite is, undoubtedly, the headset of the seventies. It's just one of the wide range of high-quality specialist products for civil and military use from Amplivox. No-one else offers so much for so little.
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Please send details of the Amplivox range of communications products:
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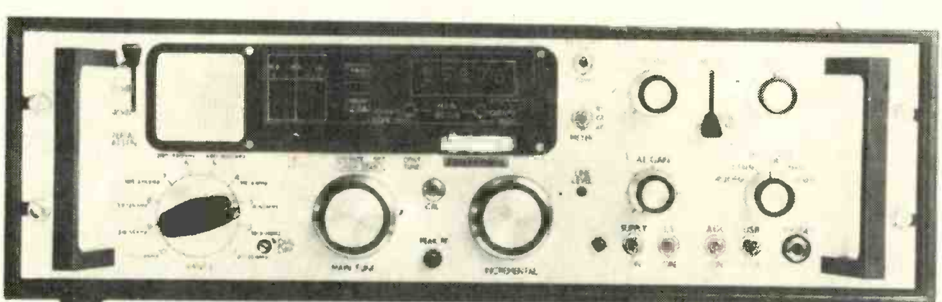
Now the EC958/7 High grade professional receiver



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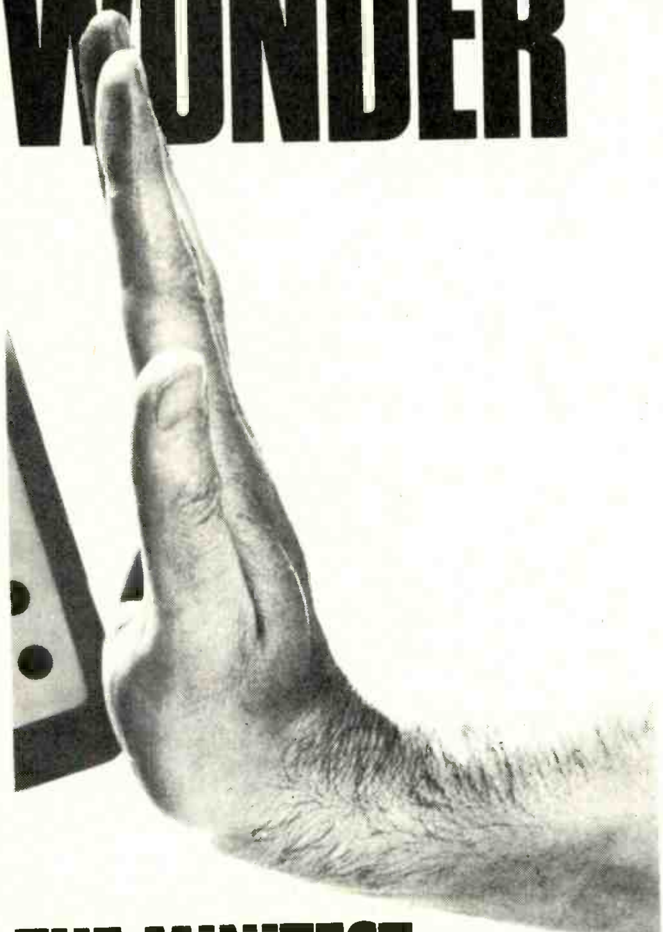
LITTLE WONDER



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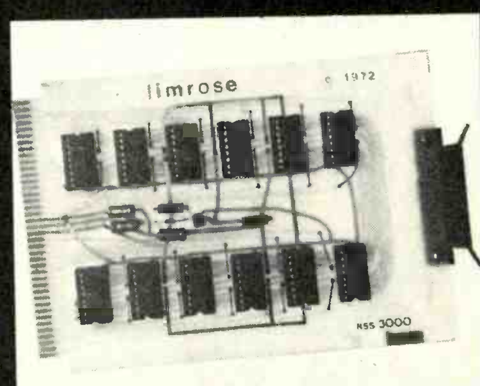

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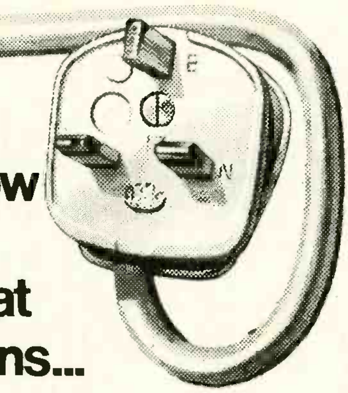

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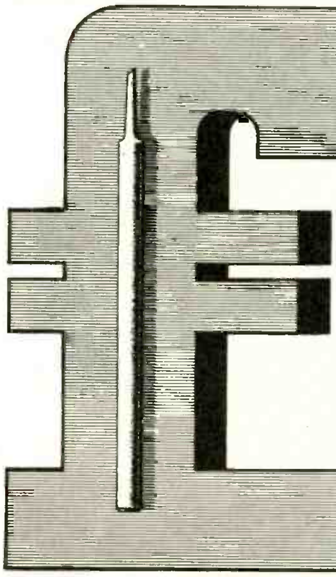

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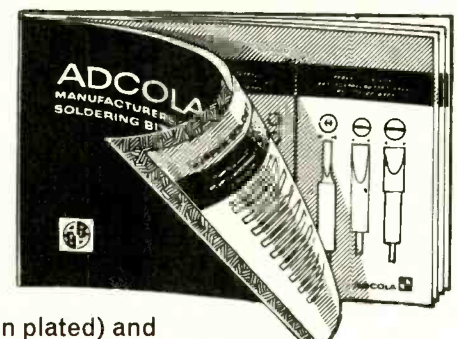

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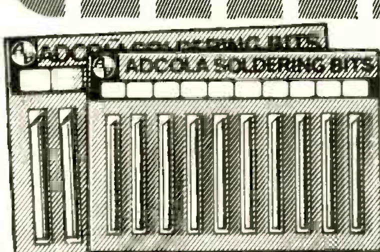

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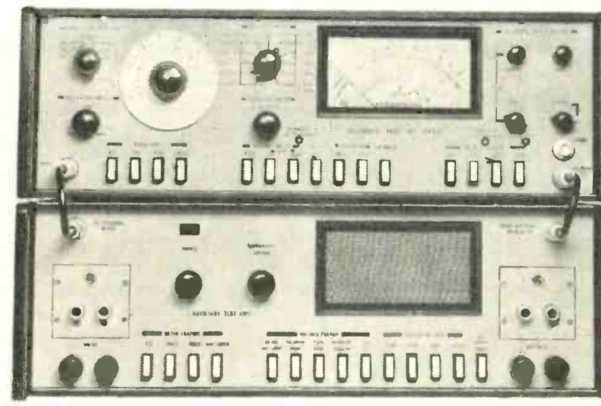

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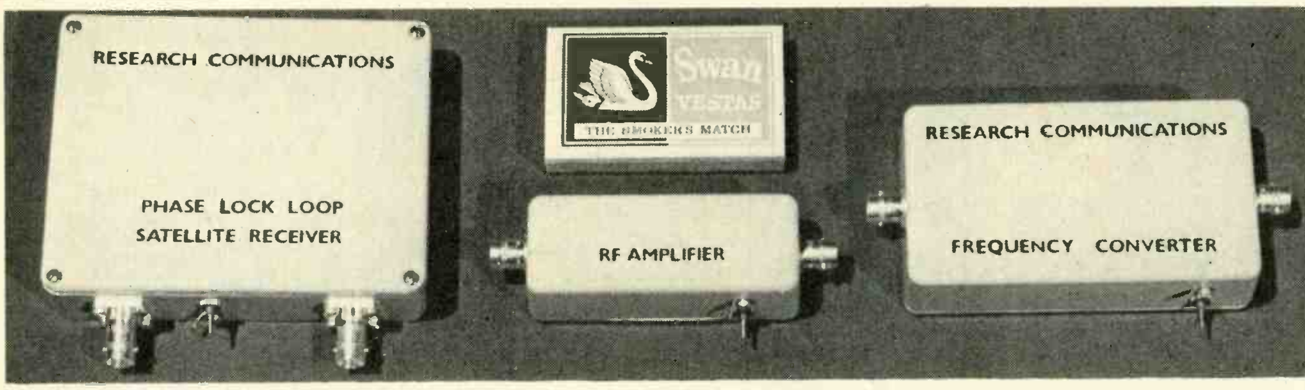

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1.5 dB. Noise Factor. High system gain. Automatic search and lock facility tunes receiver to satellite transmission in range without manual adjustment and enables several satellites to contribute to picture print-out without operator involvement over an extended period. Single channel or manual operation may also be selected. The unit is designed and rated for continuous duty monitoring service. The output drives facsimile picture equipment directly £280

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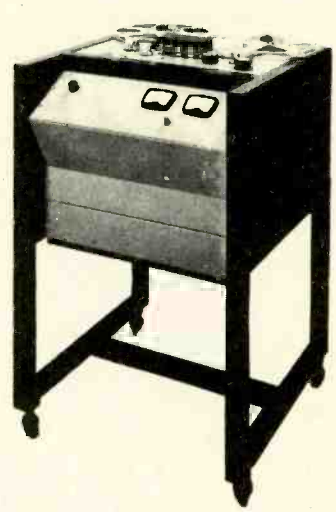

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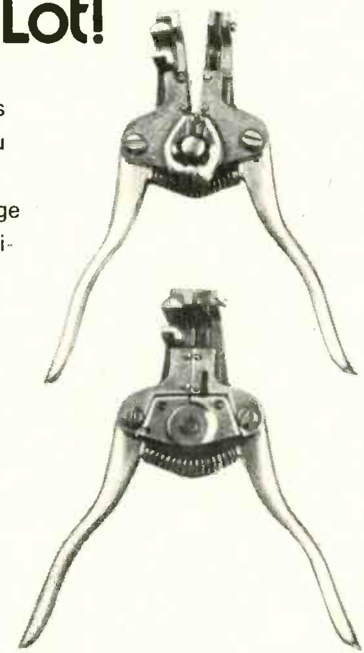

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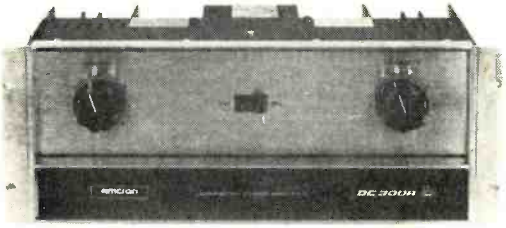

- ★ UP TO 500 WATTS RMS FROM ONE CHANNEL
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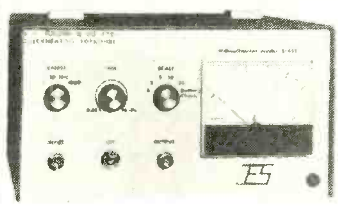

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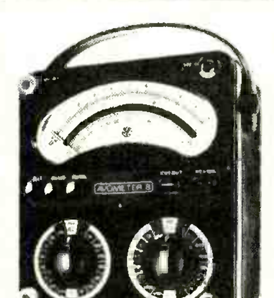

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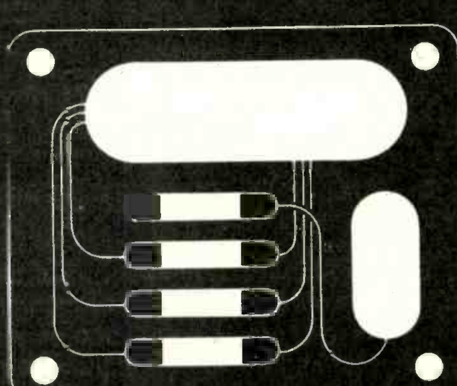
You name it. We've got it!

and lots and lots of others, too.



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WW—082 FOR FURTHER DETAILS

Infrared FILTERS

OCLI manufacture an extensive range of Infrared Filters covering the entire 1.0 to 30 micron spectral region.

Filters in these regions present an excellent solution to filtering out high-temperature radiation without appreciably limiting the signal from the source being observed. Moreover, they have proven capability over wide operating temperatures.

OCLI I. R. Filters are made to exact Customer specifications or a range can be supplied from stock.

Typical fields benefitting from OCLI I.R. Filters include:

- **GAS ANALYSERS/DETECTION SYSTEMS**
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- **POLLUTION DETECTION**
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- **INFRARED SPECTROSCOPY**
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- **SPACE RECONNAISSANCE**

Write for the new OCLI catalogue and price list of stock I.R. Filters.

OCLI OPTICAL COATINGS LTD.
Hillend Industrial Estate,
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OC-19D

WW—083 FOR FURTHER DETAILS

New 'one for all' Transistor/FET Tester for only £86*

RCA introduces the WT-524A, a new "one for all" tester for solid-state devices. With it, you can measure AC beta—up to 5,000—of any bipolar transistor, and Gm—up to 100,000 μmhos—of any field-effect transistor (FET). *And you'll do it with an accuracy of ±3%!* It also checks diodes, SCRs and triacs—and can do the job in-circuit or out.

The large, easy-to-read 6½" mirrored scale meter of the new WT-524A features special scales for I_C, I_{CBO}, I_{DSS}, I_{CEO}, and I_D currents. Each tester also includes two universal socket adapters and three colour-coded test leads.

Try the new WT-524A for yourself. You'll appreciate its quality, accuracy and ruggedness. To buy: order from any Authorised RCA Distributor or from:

***Excluding V.A.T.**

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Limited
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WW—088 FOR FURTHER DETAILS

Just released in complete electronic kit form...*

THE FORGESTONE 400

a high quality colour television receiver.

A really up-to-the-minute kit
with all these plus features . . . .

9 integrated circuits	Thick film resistor units
Ready-built and aligned IF module	Glass epoxy printed circuit panels
High quality components	Fully isolated power supply
Plugs and sockets for easy panel removal	Each module kit available separately
Full technical construction manual	LT supply regulators

*less cabinet which can be manufactured yourself from normal DIY sources.

Send for further details of the Forgestone 400 . . . the quality kit for the constructor of today.

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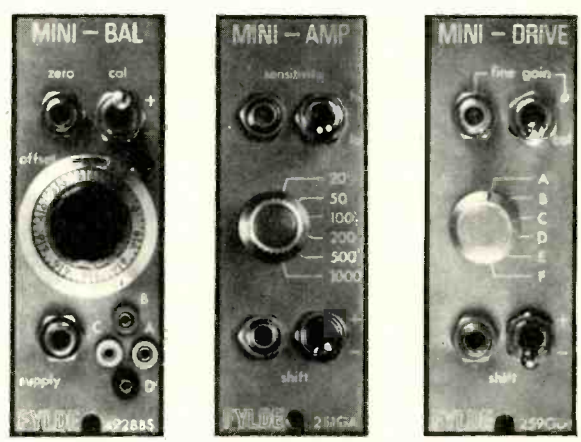
WW—089 FOR FURTHER DETAILS

Transducer and Recorder

amplifiers and systems



reliable high performance & practical controls
individually powered modules—mains or dc
option single cases and up to 17 modules
in standard 19" crates small size—low weight
—realistic prices.

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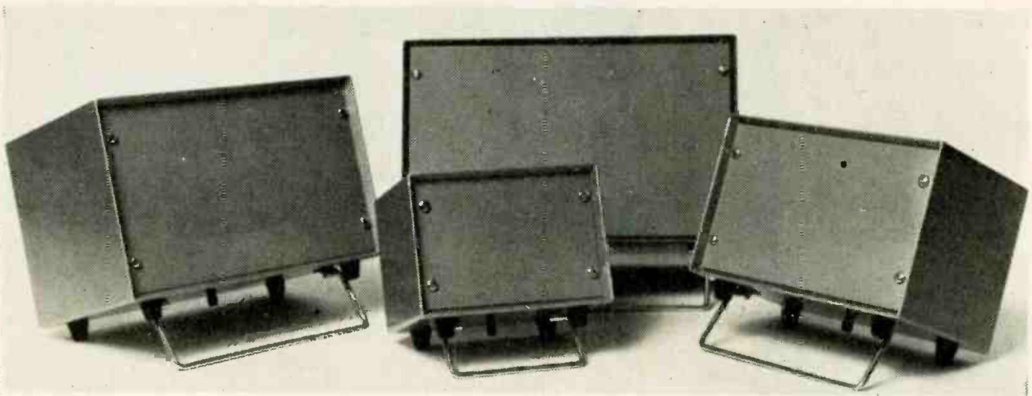
WW—090 FOR FURTHER DETAILS

NEW STANDARD CASES from OLSON

NEW SERVICE FROM STOCK — DESPATCHED BY RETURN OF POST



Cases made from 20swg. zinc coated m/s. Front & rear panels 16swg. aluminium. Cases finished in Olive green hammertone with front panels in light straw shade 384. All cases fitted with ventilated rear panels and a very attractive chrome plated retractable leg can be fitted as an optional extra.

TYPE	WIDTH	HEIGHT	DEPTH	FRONT PAN DIM.	PRICE	LEG EXTRA
21	6½"	4½"	4½"	6" x 4"	£2.95	70p
22	8½"	5½"	5½"	8" x 5"	£3.30	70p
23	10½"	6½"	6½"	10" x 6"	£3.95	75p
24	12½"	7½"	7½"	12" x 7"	£4.30	75p

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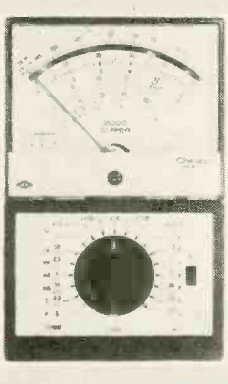
WW—051 FOR FURTHER DETAILS

THE FRUITS OF CHINAGLIA EXPERIENCE



The SUPER 2000
HIGH IMPEDANCE MULTIMETER

Suited to field, workshop and laboratory use, the SUPER 2000 is a high sensitivity portable multimeter with a Grade 1 movement, clear and simple to read mirror scale and tough simple-to-use case. It features:

- HIGH SENSITIVITY 50kΩ/V d.c. 10kΩ/a.c.
- WIDE RANGES 0.15V up to 1.5kV d.c., 2.5V up to 1.5kV a.c., 20μA up to 5.0A d.c., 250μA to 2.5A a.c. Resistance up to 100MΩ. Power −20dB up to +69dB.
- ACCURACY ± 2.5% a.c. and d.c.

Complete with case, leads and instructions.

£22.40
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WW—095 FOR FURTHER DETAILS

TRANSISTORS

Type	Price	Type	Price	Type	Price	Type	Price
AC107	0·35	BC159	0·15	BF185	0·26	OC170	0·25
AC117	0·24	BC167	0·15	BF194	0·15	OC171	0·30
AC126	0·25	BC168	0·13	BF195	0·15	R2008B	2·05
AC127	0·25	BC169	0·13	BF196	0·15	R2010B	2·10
AC128	0·25	BC170	0·15	BF197	0·17	TIS43	0·30
AC154	0·20	BC171	0·15	BF198	0·20	2N706	0·12
AC176	0·25	BC172	0·14	BF200	0·35	2N706A	0·15
AC187	0·25	BC176	0·16	BF222	1·08	2N916	0·20
AC193K	0·30	BC177	0·20	BF240	0·20	2N918	0·42
AC194K	0·32	BC178	0·20	BF241	0·20	2N1305	0·21
AD140	0·50	BC179	0·20	BF256	0·45	2N2646	0·53
AD142	0·52	BC186	0·25	BF257	0·49	2N2904	0·22
AD149	0·50	BC187	0·25	BF258	0·66	2N2904A	0·26
AD161	0·38	BC261	0·28	BF259	0·93	2N2905	0·23
AD162	0·38	BC262	0·26	BF263	0·70	2N2926G	0·13
AF114	0·25	BC263	0·25	BF337	0·35	2N2926Y	0·12
AF115	0·25	BC300	0·58	BFT43	0·55	2N3053	0·29
AF116	0·25	BC303	0·60	BFX29	0·30	2N3054	0·55
AF117	0·20	BC308	0·62	BFX30	0·35	2N3055	0·60
AF118	0·50	BC309	0·15	BFX84	0·25	2N3706	0·10
AF139	0·35	BC360	0·95	BFX85	0·26	2N3904	0·16
AF147	0·35	BD115	0·65	BFX88	0·24	2N3905	0·18
AF178	0·55	BD123	0·98	BFY50	0·25	2N3906	0·15
AF180	0·50	BD124	0·80	BFY51	0·23	2N4036	0·52
AF239	0·40	BD131	0·45	BFY52	0·23	2N4289	0·20
AL100	1·10	BD132	0·50	BFY90	0·70	2N4291	0·18
AL103	1·10	BD135	0·40	BPX25	1·65	2N4292	0·20
BC107	0·12	BD136	0·46	BPX29	1·60	2N5294	0·35
BC108	0·12	BD137	0·48	BPX52	1·75	2N5294	0·35
BC109	0·13	BD138	0·50	BRY39	0·40	2N5296	0·37
BC113	0·13	BD139	0·55	BSY54	0·50		
BC114	0·20	BD140	0·62	BT106	0·99		
BC115	0·20	BD234	0·75	BU105/02	1·95		
BC116	0·20	BDY20	0·99	BU108	3·25		
BC117	0·20	BF115	0·20	BU126	1·93		
BC125	0·22	BF121	0·25	BU204	1·98		
BC126	0·20	BF123	0·28	BU205	1·98		
BC132	0·15	BF125	0·25	BU207	3·00		
BC134	0·20	BF127	0·30	BU208	3·15		
BC135	0·15	BF158	0·25	MJE340	0·68		
BC136	0·20	BF159	0·27	MJE370	0·65		
BC137	0·20	BF160	0·22	MJE520	0·85		
BC138	0·20	BF161	0·45	MJE2955	1·20		
BC142	0·30	BF163	0·45	MJE3055	0·74		
BC143	0·35	BF167	0·25	MPF102	0·40		
BC147	0·13	BF173	0·25	OC28	0·65		
BC148	0·12	BF177	0·30	OC29	0·70		
BC149	0·14	BF178	0·33	OC36	0·55		
BC152	0·25	BF179	0·33	OC44	0·15		
BC153	0·20	BF180	0·35	OC45	0·15		
BC154	0·18	BF181	0·33	OC70	0·15		
BC157	0·15	BF183	0·44	OC71	0·15		
BC158	0·13	BF184	0·26	OC72	0·15		
				OC75	0·25		
				OC81	0·25		
				OC81D	0·30		

DIODES

Type	Price
AA119	0·09
AA129	0·20
AAZ13	0·30
BA100	0·15
BA102	0·25
BA1104	0·30
BA115	0·12
BA145	0·17
BA148	0·17
BA154	0·13
BA155	0·16
BA156	0·15
BA157	0·25
BAX13	0·06
BB105B	0·45
BB105G	0·35
BR100	0·50
BY100	0·15
BY126	0·16
BY127	0·17
BY133	0·23
BY140	1·40
BY164	0·55
BY176	1·00
OA47	0·07
OA81	0·10
OA90	0·08
OA91	0·07
IN914	0·07
IN916	0·10
IN4001	0·05
IN4002	0·06
IN4003	0·07
IN4004	0·08
IN4005	0·09
IN4148	0·05

ZENER DIODES

(400mW) **12p each** 3·0V—33V STANDARD VALUES

(1 WATT) **18p each** 3·3V—100V STANDARD VALUES

MINIATURE BRIDGE RECTIFIERS

V	2A	4A	6A
50V	0·36	0·45	0·52
100V	0·42	0·49	0·58
200V	0·44	0·54	0·64
400V	0·50	0·60	0·75

THYRISTORS AND TRIACS IN ISOLATED PLASTIC ENCAPSULATION

TRIACS WITH TRIGGER

VRM	100V	200V	400V	600V
1·6A	0·28	0·30	0·37	0·42
4A	0·39	0·45	0·76	·98
6A	0·44	0·50	0·85	1·00
8A	0·49	0·54	0·92	1·18
10A	0·55	0·61	1·02	1·32
16A	0·90	0·95	1·40	1·75

TRIACS WITHOUT TRIGGER

	100V	200V	400V	600V
1·6A	0·24	0·26	0·31	0·35
4A	0·37	0·43	0·73	0·94
6A	0·42	0·48	0·80	0·98
8A	0·46	0·51	0·88	1·12
10A	0·52	0·58	0·97	1·27
16A	0·87	0·88	1·32	1·75

THYRISTORS

	50V	100V	200V	400V	600V
1·6A	0·20	0·23	0·25	0·35	0·45
4A	0·26	0·30	0·38	0·60	0·75
6A	0·29	0·33	0·42	0·68	0·80
8A	0·32	0·38	0·47	0·75	0·90
10A	0·36	0·42	0·51	0·84	1·00
16A	0·45	0·53	0·66	1·05	1·25

PLEASE INCLUDE 10% FOR V.A.T. (U.K. ONLY)
P. & P. (UK ONLY) £0·07 PER ORDER
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THIS MONTH'S SPECIAL OFFERS

Miniature mains transformers: primary 240V, secondary 12-0-0-12V at 150mA. Dimensions: Width 46mm. Height 38mm. Depth 32mm. Mounting hole spacing 54mm. **£1·05.**

PAL Chroma Delay Line Type DLIE **£1·65.**

EAST CORNWALL COMPONENTS

P.O. BOX 4, SALTASH, CORNWALL

WW—101 FOR FURTHER DETAILS

★ **BRITISH MADE**
★ **EX-STOCK DELIVERY**

★ SIX DECADES
★ SCALE FACTOR & REF LEVEL (adjustable)
★ 1nA to 1mA OPERATING RANGE (std)
★ TRUE LOGARITHMIC FUNCTION
★ SCALE FACTOR SLOPE 1v per DECADE
★ REF. LEVEL 0 Volts OUT for 1μA IN
★ ACCURACY ± 0.25 db
★ BUILT IN AMPLIFIER
★ ANTI-LOG MODULE AVAILABLE

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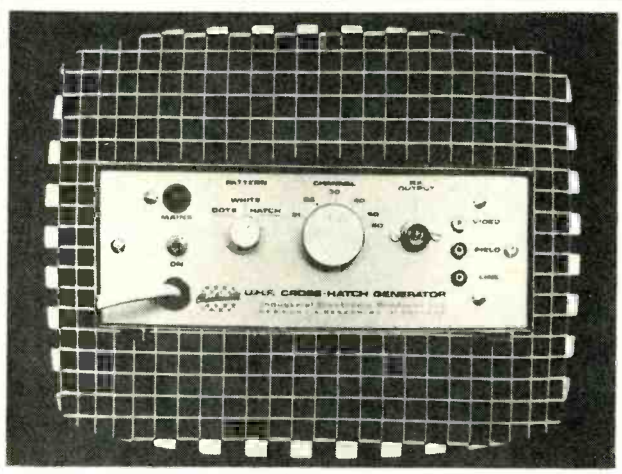
WW—102 FOR FURTHER DETAILS



CHECKMATE PROFESSIONAL TEST PATTERN GENERATOR

The unique test card edge enables the completely accurate picture alignment of colour and monochrome receivers without the need of a broadcast test pattern. The crystal derived patterns and waveforms make extensive use of digital i.c. logic. The stable and reliable 625 line high resolution patterns are crosshatch dot and white field. Full 2:1 interlace with complete synchronising and blanking waveforms. Continuous tuning over all channels in each band. B.N.C. video outputs into 75 ohms available for CCTV use on all models. Compact—8 × 3 × 6ins. Light weight—3½lbs.

Model CCH-1 UHF Bands IV & V	£69·00
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Telephone: Headley 487
Telegrams: MANORENG, NEWBURY.

WW—103 FOR FURTHER DETAILS

NEW DESIGN

ACTIVE FILTER CROSSOVER

FOR YOUR TOP FLIGHT SPEAKER SYSTEM

AS FEATURED IN WIRELESS WORLD Dec 1973

An essential and critical component in a high quality speaker system is the crossover unit conventionally comprising of a series of passive networks which unfortunately, through introducing reactive impedances between the amplifier and the speakers, result in the loss of the advantage of high amplifier damping factor and renders the speakers prone to overshoots and resonances. An elegant solution to this problem, described by D. C. Read in *Wireless World*, involves the use of a series of active filters splitting the output of the pre-amplifier into three channels, of closely defined bandwidth, each of which is fed to the appropriate speaker by its own power amplifier. A design for a suitable 20 Watt amplifier, based on a proven Texas circuit, was also described by Mr. Read. The printed circuit boards for this has been designed such that three amplifiers may be stacked and mounted together on a common heat sink to achieve a conveniently compact module.

ACTIVE FILTER

Pack
1 Fibreglass PCB (accomodates all filters for one channel) 1·05
2 Set of pre-sets, solid tantalum capacitors, 2% metal oxide resistors, 2% polystyrene capacitors 4·20
3 Set of semiconductors 2·65

2 off each pack required for stereo system

SUITABLE ALSO FOR FEEDING ANY OF OUR HIGH POWER DESIGNS

READ/TEXAS 20w amp.

Pack
1 Fibreglass PCB ·70
2 Set of resistors, capacitors pre-sets (not including O/P coupling capacitors) 1·10
3 Set of semiconductors 2·40

6 off each pack required for stereo system

4 Special heat sink assembly for set of three amplifiers ·85
5 Set of 3 O/P coupling capacitors 1·00

2 off packs 4, 5 required for stereo system

POWER SUPPLY

FOR 20W/CHANNEL STEREO SYSTEM

Pack
1 Fibreglass PCB 50
2 Set of rectifiers, zener diode, capacitors, fuses, fuse holders 2·60
3 Torodial transformer 4·95

ENQUIRIES WELCOME
For quality sets of speakers

PRE-RELEASE OFFER!

UNTIL APRIL 22nd
(Orders received after April 22nd subject to 10% VAT)

WE PAY YOUR VAT

Applies to goods advertised on this page only

POWERTRAN

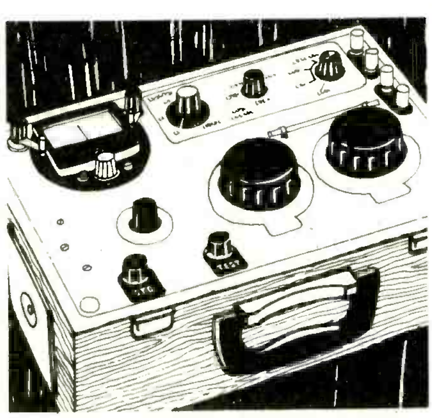
AVAILABLE FROM APRIL 23rd 1974. ORDERS DESPATCHED IN STRICT ROTATION FROM THAT DATE

SEE FOLLOWING PAGE

WW—106 FOR FURTHER DETAILS

If you want the Cambridge Pot. phone Dover 202620

That's the 'phone number of Sullivan, manufacturers of the original Cambridge workshop pot that's designed for the testing and calibration of thermocouples and associated indicators and controllers.
It's completely portable. And now, fitted with the 3334 solid state dc detector, its rugged construction coupled with its ability to maintain its accuracy, makes it a must for either workshop or laboratory. And it weighs just 6.12 kg. You'll find the price is really competitive too.



Get in touch today for further detailed specification. Just telephone the number above or write to the address below.

Sullivan

H. W. Sullivan Limited, Dover, Kent.
Tel: Dover (STD 0304) 202620
Telex: 96283

THORN Thorn Measurement Control and Automation Division.

WW—107 FOR FURTHER DETAILS

Hi Fi News Linsley-Hood 75W Amplifier

DESIGNER APPROVED KIT

★ **75 WATTS PER CHANNEL**
★ **BANDWIDTH (3dB) 3HZ-40KHZ**
★ **DISTORTION LESS THAN 0.01%**
★ **UNCONDITIONAL STABILITY**

FREE TEAK CASE with full kits

KIT PRICE only

£56.60 POST FREE (U.K.)

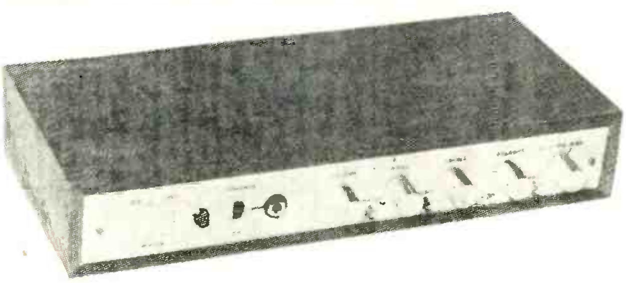
Full circuit description in handbook

Pack		Price
1	Fibre glass printed circuit board for power amp.	£0.75
2	Set of resistors, capacitors, pre-sets for power amp.	£1.50
3	Set of semiconductors for power amp. (highest voltage version).	£5.50
4	Pair of 2 drilled, finned heat sinks.	£0.80
5	Fibre glass printed circuit board for pre-amp.	£1.10
6	Set of low noise resistors, capacitors, pre-sets for pre-amp.	£2.70
7	Set of low noise, high gain semiconductors for pre-amp.	£2.10
8	Set of potentiometers (including mains switch).	£1.55
9	Set of 4 push button switches, rotary mode switch.	£3.10
10	Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V, secondaries: 33-0-33 V 24-0-24 V.	£9.15
11	Fibre glass printed circuit board for power supply.	£0.55
12	Set of resistors, capacitors, secondary fuses, semiconductors for power supply.	£3.50
13	Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, interconnecting cable, control knobs	£3.25
14	Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£6.30
15	Handbook.	£0.30
16	Teak cabinet.	£7.35
	2 each of packs 1-7 inclusive are required for complete stereo system.	
3a	Set of semiconductors for Power Amp. (30W version).	£3.40
3b	Set of semiconductors for Power Amp. (50W version).	£5.30

Toroidal T20 + 20

★ **WITH TOROIDAL TRANSFORMER**
★ **20 WATTS PER CHANNEL**

Developed from the famous Practical Wireless TEXAN.



FREE TEAK CASE and HANDBOOK with full kits

KIT PRICE only £28.25 POST FREE (U.K.)

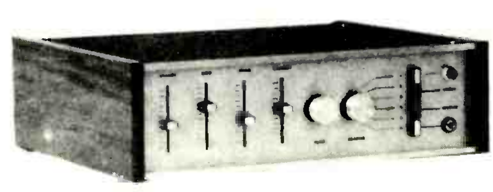
Pack		Price
1	Set of all low noise resistors	£0.80
2	Set of all small capacitors	£1.50
3	Set of 4 power supply capacitors	£1.40
4	Set of miscellaneous parts including DIN sockets, fuses, fuse holders, control knobs etc.	£1.90
5	Set of slide and pushbutton switches	£0.90
6	Set of potentiometers and selector switch	£1.45
7	Set of all semiconductors	£8.25
8	Special Toroidal Transformer	£4.95
9	Fibre Glass P.C. Panel	£2.50
10	Complete chassis work, hardware and brackets	£4.20
11	Preformed cable/leads	£0.40
12	Handbook	£0.25
13	Teak Cabinet	£2.75

COMPONENT PACKS FOR W.W. AMPLIFIER DESIGNS

30W BAILEY	
Pk. 1 F/Glass PCB	£0.65
Pk. 2 Resistors, capacitors, pots	£1.75
Pk. 3 Semiconductor set	£4.70
30W BLOMLEY	
Pk. 1 F/Glass PCB	£0.70
Pk. 2 Resistors, capacitors, pots	£2.15
Pk. 3 Semiconductor set	£5.60
20W LINSLEY-HOOD	
Pk. 1 F/Glass PCB	£0.70
Pk. 2 Resistors, capacitors, pots	£2.40
Pk. 3 Semiconductor set	£3.35
60V REGULATED POWER SUPPLY	
Pk. 1 F/Glass PCB	£0.65
Pk. 2 Resistors, capacitors, pots	£1.40
Pk. 3 Semiconductor set	£3.10
BAILEY-BURROWS PRE-AMP	
Pk. 1 F/Glass PCB	£1.60
Pk. 2 Resistors, capacitors, pre-sets, transistors	£4.95
Pk. 3R Rotary potentiometer set	£1.60

For further details on the above and other designs including 100W amplifier and Stuart Tape Recorder write for FREE LIST.

METALWORK SYSTEM FOR WIRELESS WORLD AMPLIFIERS



Designed to house Bailey, Blomley or Linsley-Hood Class AB amplifiers with simple or regulated power supplies and Bailey Burrows pre-amp. Options of standard or hum reducing toroidal mains transformer. Also rotary control version. Details in price list.

For FREE LIST write NOW!

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2N1613	0.20	2N4062	0.11	BCY72	0.13	MPSU05	0.60	TIP34A	1.50
2N1711	0.25	2N4302	0.60	BD529	0.85	MPSU55	0.70	TIP41A	0.74
2N2926G	0.10	2N5087	0.42	BD530	0.85	SN72721P	0.58	TIP42A	0.90
2N3053	0.15	2N5210	0.54	BDY56	1.60	SN72748P	0.58	TIP3055	0.60
2N3055	0.45	2N5457	0.45	BF257	0.40	TIP29A	0.50	IB08T20	0.50
2N3442	1.20	2N5459	0.45	BF259	0.47	TIP30A	0.60	IB40K20	1.40
2N3702	0.11	2N5830	0.30	BFR39	0.25	TIP29C	0.71	IN914	0.07
2N3703	0.10	40361	0.40	BFR79	0.25	TIP30C	0.78	IN916	0.07
2N3704	0.10	40362	0.45	BFY50	0.20	TIP31A	0.60	IS920	0.10
2N3705	0.10	BC107	0.10	BFY51	0.20	TIP32A	0.70	5B05	1.20
2N3706	0.09	BC108	0.10	BFY52	0.20				
2N3707	0.10	BC109	0.10	MJ481	1.20				
2N3708	0.07	BC125	0.15	MJ491	1.30				
2N3709	0.09	BC126	0.15	MJE521	0.60				
2N3710	0.09	BC182K	0.10	MPSA05	0.30				
2N3711	0.09	BC212K	0.12	MPSA12	0.55				
2N3819	0.23	BC182L	0.10	MPSA14	0.35				
2N3904	0.17	BC184L	0.11	MPSA55	0.35				
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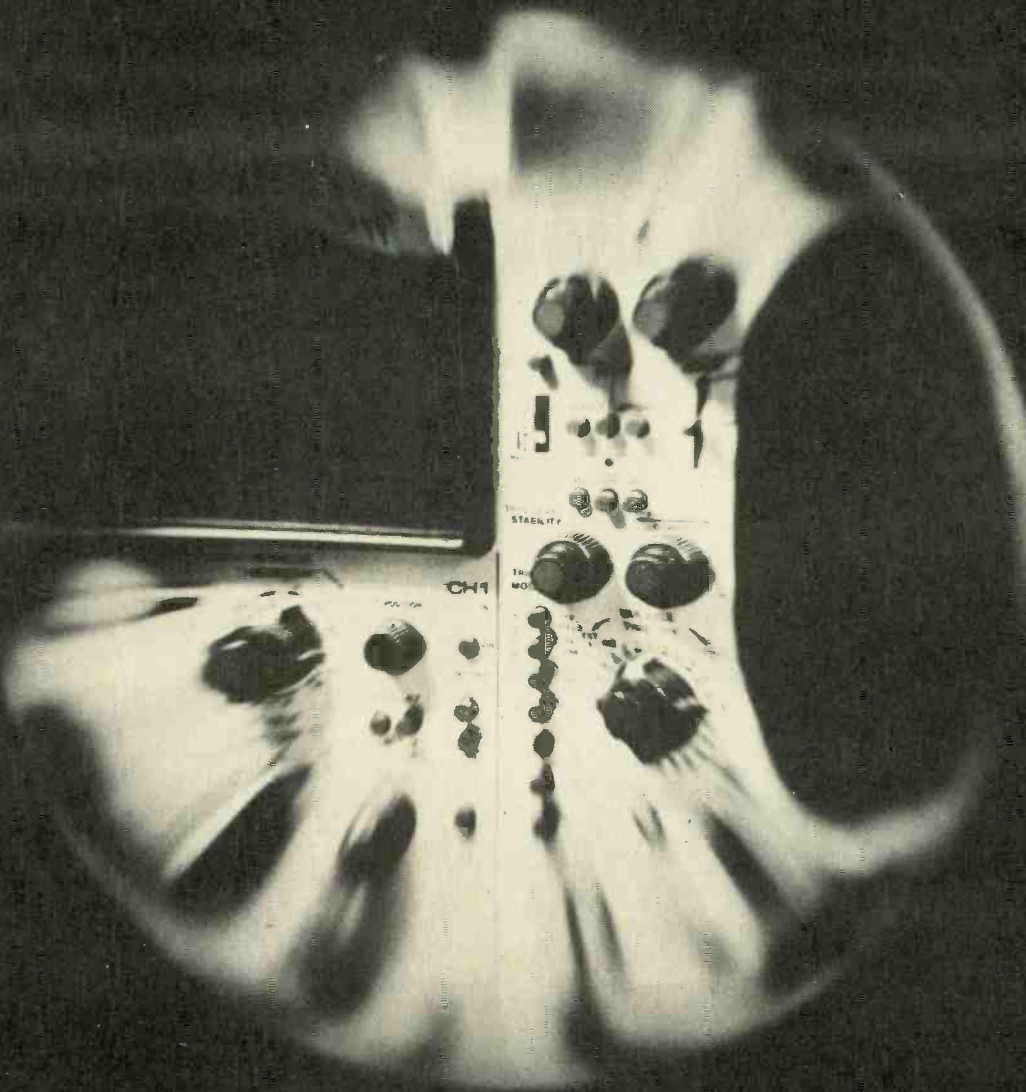

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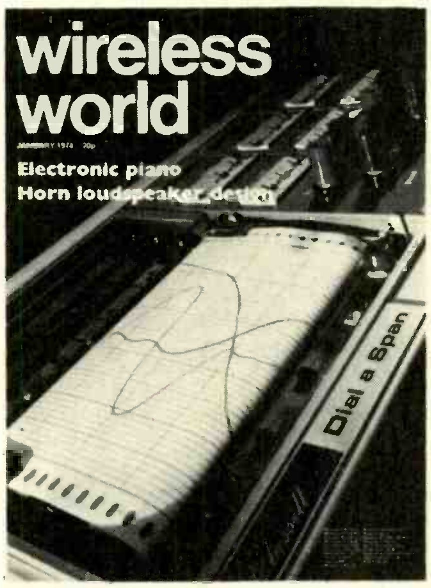
Electronics, Television, Radio, Audio

MARCH 1974 Vol 80 No 1459

SIXTY-THIRD YEAR OF PUBLICATION



The cover picture shows overlapping traces on a three-pen recorder made by Chessell Ltd. Thumb-wheel selectors provide 450 sensitivities and 1999 datum shift settings.

Contents

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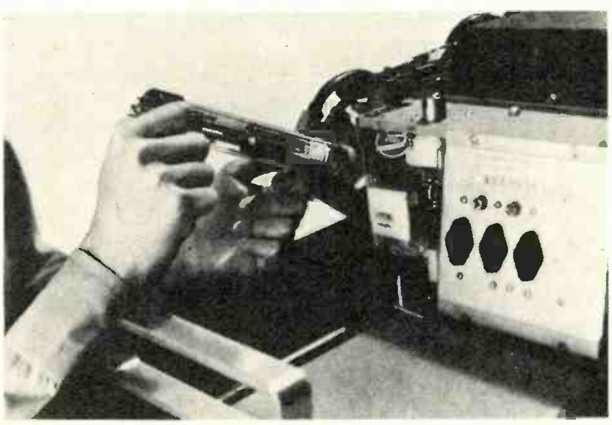

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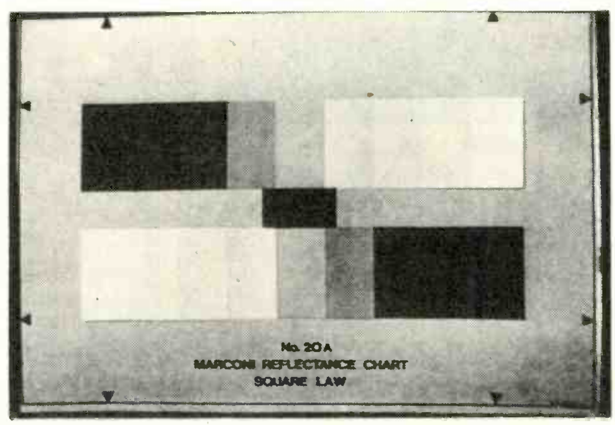

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P8001 P8001 B P8001 G P8001 L P8001 R	Monochrome Blue channel Green channel Luminance channel Red channel	30mm diameter, separate mesh
P8003	Red channel	30mm diameter, separate mesh with extended red response
P8005 P8005B P8005G P8005L P8005R	Monochrome Blue channel Green channel Luminance channel Red channel	30mm diameter, separate mesh with light bias
P8008	Monochrome	30mm diameter
P8021 P8021 B P8021 G P8021 L P8021 R	Monochrome Blue channel Green channel Luminance channel Red channel	Mechanically interchangeable with 1-inch separate mesh vidicons

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Social Responsibility in Communications

"Men themselves make their history but in a given environment which conditions them" wrote Friedrich Engels in the 19th century. In the present century the "given environment" is increasingly being shaped by technologists. Electronics and communications engineers in particular are changing that part of the environment which most strongly conditions the humanity of man — the available means for using symbols and messages. The invention of printing led to one cultural revolution. Telecommunications, broadcasting and audio-visual records are resulting in a new cultural revolution, according to a recent book "Communications Technology and Social Policy"*. If this is so, electronics and communications people bear an immense responsibility — in providing the means for influencing man's most central notions of his own existence, values, priorities and relationships. Are they in fact conscious of this responsibility?

The book draws attention to the variety of ways in which broadcasting, among other forms of communication, is being extended and modified, not merely by the provision of more channels but by cable distribution, satellite transmitters and cassette and disc records. One paper argues that this proliferation of communication "outlets" will lead to the "deprofessionalization" of broadcasting organizations — a process comparable with what has been occurring for some time in the church. "There will be little room for the professional elitism that thrived in the situation when the broadcaster not only could presume he knew what was best for the public but was also encouraged to do so by those interested in keeping control over popular culture" say the authors Gurevitch and Elliott. In another paper Dennis Gabor (the inventor of holography) suggests that the increase of programme choice will probably produce a cleavage in the public: "The educated will choose more and more cultural features, the culturally deprived even more pornography and violence. The technologist could no more than enlarge the choice". Throughout the book the communications engineer appears as a shadowy figure apparently with no will of his own, a mere instrument by which technological change manifests itself.

Of course the technologist can shelter behind the consideration that his job is only to provide the means of communication, not to control the uses to which they are put. From a blinkered point of view this is true. From a wider point of view, if the technologist makes a living (or perhaps a profit) from co-operating in providing and developing the means of communication, either through public corporations or through the commercial system, he is in partnership with the users and therefore has a social responsibility whether he likes it or not. So far, unlike some scientists (*viz.* the British Society for Social Responsibility in Science) he has not been very vocal about this involvement. We invite him to have his say through this journal.

* An international collection of 36 papers by technologists, social scientists, educators, communications experts and the like, published by John Wiley & Sons Ltd., Chichester, Sussex, price £9.00.

PROJECT

Project is a new venture for Wireless World and originated with our belief that the future of electronics lies with the young, and secondly from the knowledge that the journal has been used on innumerable occasions, by schools, colleges, universities and industrial training centres, to provide tutorial material unobtainable elsewhere.

These columns will contain news, information, projects and product information specifically relating to educational electronics and electronics in education. Much will be of interest to the young and the beginner and is intended to be so, but more importantly it will be written with all the authority and experience of Wireless World behind it.

Finally Project is intended as a point of contact between industry and educationists with an electronics interest. We would welcome news, articles, reports and letters for possible use in the journal.

Future Project features will include a report on Link, the scheme which puts voluntary industrial advisers in touch with schools; university radio and television stations; an article describing the radio astronomy project at the Gypsy Hill College at Kingston-upon-Thames and some fascinating new experimental projects for readers to undertake.

The Value of School Projects

by E. R. Laithwaite, D.Sc., Ph.D., F.I.E.E., F.I.E.E.E.

Professor of Heavy Electrical Engineering, Imperial College, London

While the rate of increase of technical and scientific knowledge continues itself to increase with time, the Physics syllabus of an Examining Board stays remarkably stable. I know that many parents are surprised to find that the "A" level Physics paper contains questions on the same topics that were contained in the syllabus when they themselves took the examination, perhaps 25 years ago. Some solid-state electronics will probably have been added, and a dusting of particle physics, just to prevent the Board from appearing decadent, but in the main the same method of teaching is pursued and the pupils, one fears, are subjected to the same set of so-called "experiments", in which the result is never in doubt before the first reading is taken.

I have discovered the basic reasons for this conservative outlook, partly by being Chairman of the Advisory Committee for Physics for one of the Examining Boards for several years, and partly by being a member of the Schools Science and Technology Committee. One of the activities of that Committee was to set out on a fact-finding exercise to discover why school science and electronics teaching was not keeping pace with the demands of a modern technological society.

At first, I thought that the Advisory Committees of Examining Boards had a free hand to change the syllabus which was entirely in their care, I was told fairly quickly that certain changes in syllabus which I proposed "would never get past the Schools Council". I deduced that the Schools Council was an overlord to all the Boards, which was why the standards of "O" level or "A" level exams were much the same whatever the Board.

Not a bit of it! Every Examining Board, I discovered through the S.S.T.C., was a private company and therefore a law unto itself. Like other commercial enterprises, the one thing every Board feared was losing customers, and the easiest way to lose customers was to change the syllabus — why? — because the average, grossly underpaid school teacher had long ago lost enthusiasm for his subject and could not be bothered to learn new material. No, I am being unfair, even to the *average* teacher. If only a minority of lazy science teachers existed, they would be the ones who would write angry letters to the Board threatening to change to another Board if the syllabus were changed. This undoubtedly was cause number *one.*

The second cause too, I soon unearthed. I was very quickly told that I could not introduce new material (such as the magnetic circuit concept) which involved a new approach to an old topic "for", I was told, "there are no readily available, cheap text books which the teacher can use." I had to agree that this was a strong argument. I reported my findings to the S.S.T.C. who promptly sent for a sample of publishers who, when asked if they would welcome the opportunity to publish books containing new science teaching methods, gave us a unanimous "no", for the simple reason that "there was no syllabus which demanded it, so the book would not sell". — Stalemate!

The third reason came to light when I wanted my committee to delete permanent magnetism, as being too difficult for school children. The chief examiner hesitated to doubt my wisdom in this but told me gently that if we deleted the magnetometer, in particular, "there would be nothing to set for the practical exam". His counsel was wise, as I found out all too soon. Set a practical question which requires a rubber band and out of perhaps 400 schools will come questions as to what its dimensions should be, its maximum tension, and "where can we buy them?" (or in dire cases with *what* can we buy them?). But magnetometers present no problem — *all* schools have magnetometers!

The school project is likely to be afflicted similarly for the same reason as just outlined, for school apparatus accounts do not run to buying much new apparatus. At universities, of course, things are better, but the emphasis here is on theory at its highest level and a few years ago no less a place than the Massachusetts Institute of Technology scrapped its electrical machine laboratory in the belief that tomorrow's engineers could learn all they needed from Generalized Machine Theory, which was extremely fashionable at the time. The only thing wrong with Generalized Machine Theory and all its kind is that they represent the ultimate in "organization" of a subject and without, of course, admitting it, they do so in the belief that all the knowledge in their particular subject is now acquired. This stifles any hopes of fostering curiosity and imagination among students of all ages. They become acclimatized to the idea, among others, that nearly all can be explained by theory and that if their experiments, such as they are, disagree with the theory, they must repeat the experiments until they get them "right".

The answer to all this, I am sure, lies with the interesting project, however simple, provided it has the necessary air of mystery to make it exciting. If only we could convince our students that when their measurements failed to confirm the existing theory they may be standing on the threshold of a new era in science, all their laboratory work would take on a new look. First perhaps we should design experiments specifically to discredit theory which has been simplified to make it palatable. The extension of theory just to the point of personal ability exists at all levels of academic achievement. It is still fashionable in engineering departments of universities to take a known problem to which a known solution exists to a reasonable degree of accuracy, and re-specify the data in such a way that the solution is now only possible using the most up-to-date computing machine available, for just as long as the department can afford. A paper is then published on the results, on the strength of which the postgraduate student hopes for higher honours.

The problem of encouraging inventiveness and of teaching the next generation the facts about science begins at school, and therefore should be tackled at school. In sixth form applied mathematics the "good book" says that the frictional force between bodies which are in contact, but moving relative to each other, is μR where R is the normal reaction between the bodies and μ is the "coefficient of friction" which is constant. This leads at once to the idea that if a body is placed on a horizontal plane which is thereafter tilted to greater and greater angles, slipping will occur at a given angle, irrespective of the mass of the body. This angle is known as the "angle of friction", thereby implying that it is a constant for any given pair of surfaces.

So cut blocks of metal, the first of which has dimensions $2 \times 2 \times \frac{1}{2}$in, the second $1 \times 1 \times \frac{1}{4}$in, the third $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{8}$in and so on down to perhaps $\frac{1}{8} \times \frac{1}{8} \times \frac{1}{32}$in. Place these blocks with one of their large faces in contact with a flat piece of glass or plastic sheet and begin to tilt slowly. According to the theory all should begin to slide together. In practice, the first attempts suggest that they are likely to move off in any old order, but after each block has been carefully polished and the glass cleaned with spirit, the blocks will be found to start off in strict order of size, largest first. The student is then encouraged to seek out his own better theory which will fit more practical situations than the simpler one. We have to confess that at school level certainly, and at higher levels in lesser degree, we teach physical subjects to just the right level to make good examination questions!

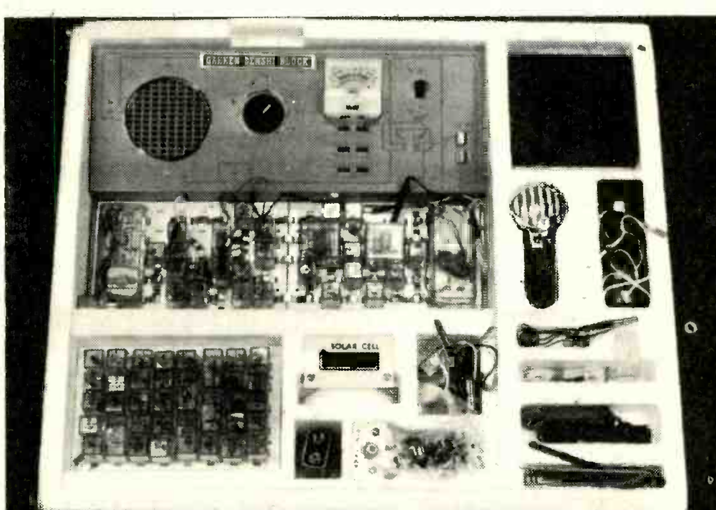
There are however some encouraging signs. My own speciality in engineering is "linear motors". No sooner had I become a director of a company which manufactures these articles than I was asked to put my mind to the task of designing a kit of parts to operate with a linear motor and provide as much scope for variation of experiment as there is scope for creating models in Meccano. What they wanted could be described as an "electromagnetic construction kit". This is happily now available and I hope will encourage specialists in other subjects to produce similar apparatus.

But note how the pressure to do this came from industry and not the teaching world. Industry knows that only in this way can it hope to avoid the shock which, at present, generally occurs when schooldays (where life is simple and "correct") end and industry or commerce (where life is complex and *always* incorrect!) begins. The Schools Science and Technology Committee was, however, very conscious of the value of project work in schools and early in its existence the Committee took under its wing the excellent work being carried out at Loughborough by Geoffrey Harrison and his colleagues which was initiated by the Schools Council under the title "Project Technology". The S.S.T.C. were sufficiently impressed by certain facets, notably the publications distributed to schools, that when Schools Council money ran out, they arranged for continuation of these facets to be financed through the Standing Conference on Schools' Science and Technology — a body set up specifically as the result of S.S.T.C. activity. Among the other works of the S.C.S.S.T. is that of setting up "local centres" where industry and schoolteachers may meet, exchange views, be lectured at, but perhaps most of all, where surplus raw materials from local firms can be distributed to local schools for the widening of project scope within school laboratories.

School projects could be described as "coming face-to-face with Nature" and as such are a "must" at this time. One word of caution only would I venture. "Man shall not live by bread alone" says the Bible, and school science cannot live by projects alone. Complementary to the more formal teaching they must always be and not a substitute for it, nor an end itself. The greatest asset of school projects is the way in which they can creep up on a child and persuade him to become first a little curious, then definitely interested and perhaps finally fanatical about a subject which, if introduced through the more usual teaching channels, he would find entirely unpalatable.

More and more we need women in the engineering professions and again the school project can be the start of it. It is the opinion of most members of S-S.T.C. that most children really make their minds about their future careers between the ages of 10 and 13. It is here that we must teach girls especially that technology did more than invent the atom bomb and is therefore not all bad. It is here perhaps most of all that the school project must be geared to make its impact.

An educational electronic kit, one of a series priced from £6 to £26 available from Electronikits, 408 St. John's Street, London E.C.1. WW 390 for further details.



PROJECT

An F.E.T. Curve Tracer

by L. G. Cuthbert

Although the junction field effect transistor is not part of any A level Physics syllabus, there are several advantages in spending a short time teaching its basic circuit properties. In cases where the triode valve is taught as the main electronic device a study of the f.e.t. could well follow this as it has many valve-like properties, yet gives students the chance of using a modern electronic circuit element. However, many schools are now using the bipolar transistor at A level and here the f.e.t. could well be studied first since it is a much simpler device to use, thus enabling students to grasp basic concepts without being put off by complications.

To study the characteristics of the circuit properties of a device it is not necessary to know why or how it works, only what it does. Therefore, the f.e.t. will be treated as a "black box" with three terminals and the characteristics show the relationships between the voltages and currents at the terminals.

The symbol for an n-channel j.f.e.t. (there is also a p-type where all the polarities are reversed) is shown (Fig. 1). For normal circuit operation the voltages applied to the terminals are:

- source—connected to earth
- drain—to a positive voltage
- gate—to a negative voltage. This is very important as the f.e.t. may be destroyed if the gate is made positive.

The gate acts as a control terminal and controls the amount of current that can flow between drain and source. As the gate is made more negative, less current flows until eventually no current at all will pass from drain to source. The f.e.t. is a useful device because a small change in gate voltage can produce a fairly large voltage change in a resistor connected to the drain, thus acting as an amplifier. (Fig. 2)

by Ohm's law

$$V_{out} = V_{DD} - I_D R_D$$

change in $V_{out} = \Delta V_{out}$

$$= R_D \Delta I_D$$

amplification is $R_D \Delta I_D / \Delta V_G$

Quantitative information about the effect of gate voltage on drain current is given by the transfer and output characteristics. These are very similar to the pentode valve curves and in fact the same small signal equivalent circuits can be used for both f.e.t. and pentode, although the symbols used are different.

The f.e.t. is therefore a very simple device to teach and experiments based on valves can be easily modified to use an f.e.t., thus giving the advantage that pupils are not investigating an obsolete device. In the current second year Applied Electronics course at Queen Mary College, circuit concepts are discussed initially with f.e.ts and then extended to bipolar transistors.

The most useful of the two characteristics shown in Fig. 3 is the output one and it is also the more impressive when displayed on an oscilloscope. Thus, for simplicity, the project described in these notes will concentrate only on displaying the output curves although it is quite possible to modify the system to display the transfer characteristic or, for that matter, the curves for a bipolar transistor.

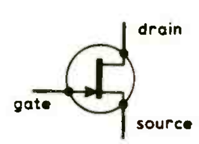


Fig. 1. The symbol for an n-type j.f.e.t.

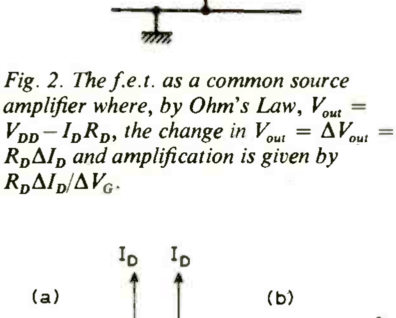


Fig. 2. The f.e.t. as a common source amplifier where, by Ohm's Law, $V_{out} = V_{DD} - I_D R_D$, the change in $V_{out} = \Delta V_{out} = R_D \Delta I_D$ and amplification is given by $R_D \Delta I_D / \Delta V_G$.

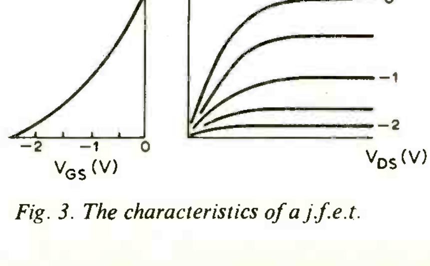


Fig. 3. The characteristics of a j.f.e.t.

The curve tracer as a system

The output characteristic is a plot of drain current against drain-source voltage for different (equal increment) values of gate voltage. Thus the basic system for displaying these curves needs to be as shown in Fig. 4. However, there are several points that affect the system and lead to simplification in some parts and a more complicated design in others.

1. The drive ramp need not be a linear function of time since the plot is of current against voltage. A highly non-linear ramp does, however, mean that the oscilloscope beam will take significantly different times to cover the same distance on the screen, thus making the brightness of the trace vary.

2. The gate voltage must not be greater than zero. To avoid inadvertent damage to the transistor protection should be provided to prevent V_G becoming positive.

3. The maximum drain current of many f.e.ts is about 10mA which is within the maximum current capability of a general purpose integrated circuit operational amplifier. This is helpful because the amplifier suggested is short circuit protected (i.e. its output can be shorted to earth or the power supply without damage) and this is a very useful asset for a project being built by students. If a discrete component amplifier were used, separate protection would have to be provided.

4. In the real world nothing ever happens instantaneously so that the ramp and staircase waveforms have the form shown in Fig. 5(a). If the gate waveform is triggered by the falling edge of the ramp waveform it will be changing during the flyback of the ramp voltage and may still be changing during the start of the next cycle and therefore not only would the flyback of the oscilloscope trace follow a different path but the start of the next trace could be distorted. Admittedly the flyback trace will be faint because it occurs much faster but it still, un-

fortunately, is visible. This can be improved by using an "intermediate" triggering waveform (Fig. 5(b)) so that the gate voltage is held constant over the whole of one ramp and the flyback and then the beam is held at the origin while the gate voltage is changed. A further benefit is that the origin is brightened, since the trace is kept there for a relatively long period, thus emphasising its position.

A block diagram of the complete system, taking account of these points, is shown in Fig. 6. The drain current is determined by measuring the voltage developed across a small resistor in series with the drain. Since the drain voltage is measured at the drain terminal, the small resistor has no effect on this measurement, but the potential drop across it will very slightly reduce the voltage at the drain

Details of the circuit, construction, setting-up and sources of component supply will appear in the next issue of *Wireless World*.

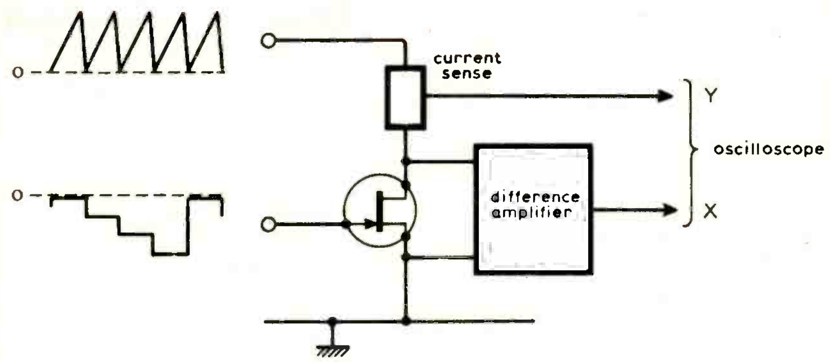


Fig. 4. Basic curve tracer system.

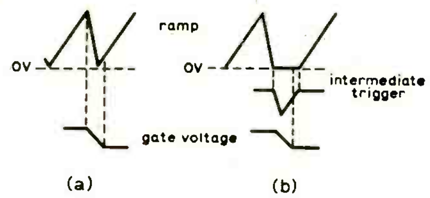


Fig. 5. Elimination of the flyback trace using an intermediate trigger. The time scale is exaggerated for clarity.

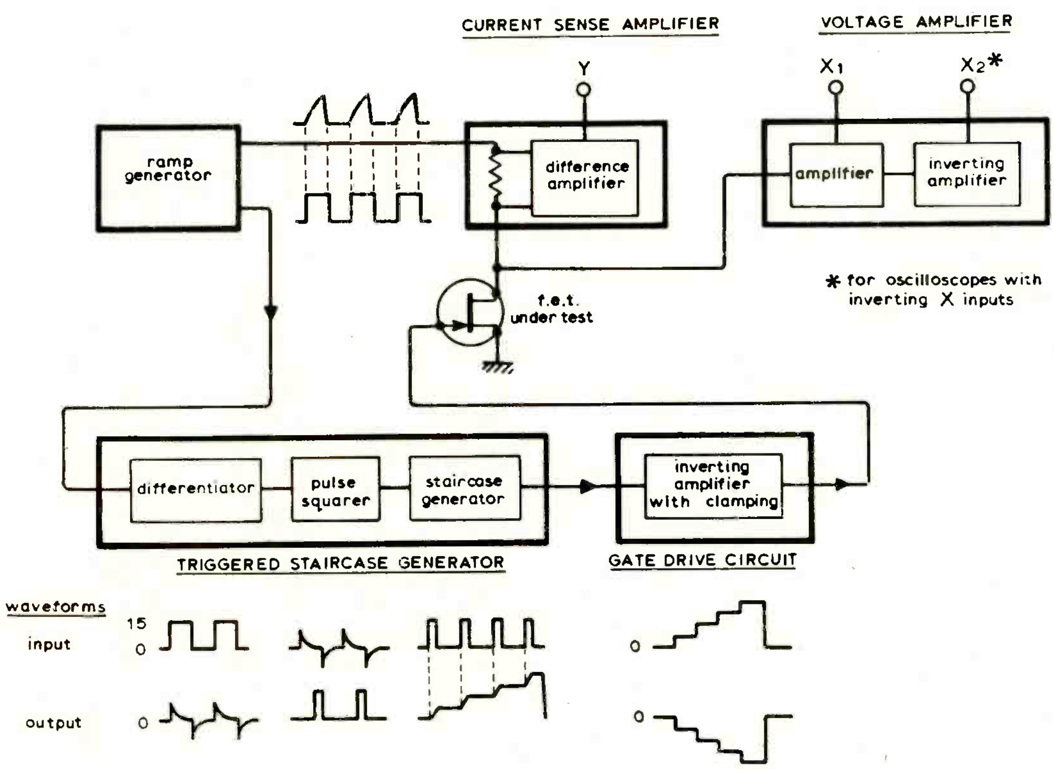


Fig. 6. Block diagram of the curve tracer.

News of the Month

Component shortage — broken promises

Component buyers are being fed too many delivery promises and not enough facts on the realities of product availability. This was the essence of a statement made by buyers at a recent meeting held by AFDEC, the distributors' association. Although accepting that distributors have no option other than to accept delivery information supplied by their principals, they believe that the situation is sufficiently serious to merit a far more militant stand by distributors against principals supplying either worthless or no information.

A significant factor in the current shortage situation is the amount of "double ordering" which has taken place to safeguard supplies. Distributors can plan to meet almost any eventuality, but they need two basic contributions from buyers. The first is a firm statement of requirements over as long a period as possible. The second is a reduction in the time now being taken to settle accounts enabling distributors to maintain stocks at a high level.

AFDEC suggested that, if buyers decide to be honest about their "double ordering", distributors can then reasonably increase demands upon principals without having to face the problems of suddenly carrying vast stocks of products for which orders have suddenly been cancelled.

On a practical point, both buyers and distributors expressed concern about the lack of information from manufacturers on the handling of certain new products. A prime example is the m.o.s. circuit which was introduced with very little warning about the sensitivity of such devices. It was suggested that suitable markings on both the packaging and the devices themselves might overcome some of the handling difficulties still being experienced in this area.

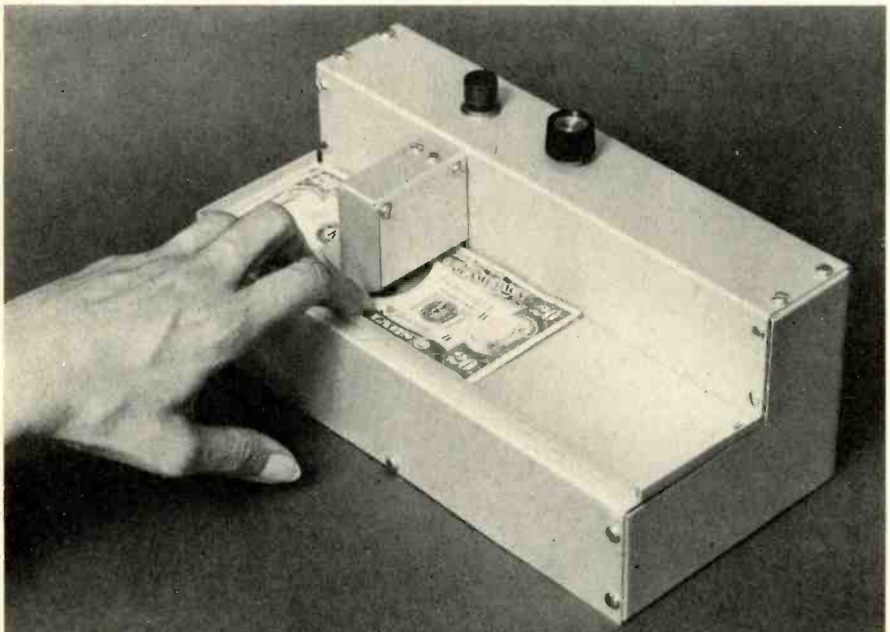
Radiopaging market opens

Redifon Telecommunications have received a licence to manufacture and sell in the U.K. a pocket radiopager developed by the Martin Marietta Aerospace Company of Orlando, Florida. The product will be marketed under the name "Redipage". The system has a computer located at a central telephone exchange controlling a network of unattended transmitters sited throughout the required area. A caller wishing to contact the user of the pager will dial a ten-digit number from any telephone.

An experimental public system has been in operation by the Post Office in the Reading area (see News of the Month, "Radiopaging by telephone", Feb. 1973, p.58) and its success is currently being evaluated.

The Redipage system is based on high speed digital transmissions, each transmitter being allocated one time slot out of a sequence of eight in an eight second transmission cycle. By this means, degradation of the service by mutual transmitter interference is completely eliminated.

Installation of the pagers is expanding rapidly in the U.S. and Martin Marietta have recently announced an order for a central computer controlled system and an initial 10,000 pagers in New York City.



Paper money identifier for blind persons. See news item.

Reformation for broadcasting

Siemens has developed a radio receiver system for the reception of transmissions made using the independent sideband (i.s.b.) system[1], suggested by the Hamburg Institute for Radio Engineering. I.s.b. modulation is a variant of s.s.b. modulation, offering the same advantages as the latter in suppression of interference and reduction of distortion due to fading and inefficient band utilization, but also enables a broadcasting station to double its number of programme channels. The system allows the transmission of two independent programmes over the two sidebands of a carrier. The advantages of i.s.b. can thus be used to prevent the increasing mutual interference between a.m. broadcasting stations, which is devaluing their prime advantage of long range.

I.s.b. modulation is incompatible with present radio sets on m.w. and l.w. and Siemens has made two suggestions for an i.s.b. receiver, the two designs differing only in the method used for suppressing the unwanted sideband. The first version uses phase-compensated carrier regeneration, produces sideband suppression of 40dB and is compatible with d.s.b., s.s.b. and i.s.b. modulation. The second version includes two i.f. filters with consequent higher i.f. selectivity, which means fewer filters in the a.f. section. The second system is also fully compatible.

1. Langer, E., "AM Broadcasting System Reform, a New Chance for European Radio Setmakers", *Siemens Components Report*, Vol. VIII No.5, Nov. 1973, pp.108-111.

Dot-scan television system

A closed-circuit television system using a pseudo-randomly scanned matrix of dots to produce the display has been developed by Mullard Research Laboratories and the MEL Equipment Co.

The system was developed for the Royal Aircraft Establishment, who need to simulate different types of scan in their examination of new matrix-type and mechanical systems. It is possible, for instance, to simulate the effect of a sensor using an array of infra-red devices, or to investigate the appearance of multiple-interlaced displays. Areas of different resolution may be displayed on the same scan.

Electrostatic deflection is used in

camera and display, and the spot is allowed 262,000 possible positions in a 512 × 512 matrix. A digital pattern generator controls the spot position, being applied to camera and display with a delay to allow for the propagation time of the video information. Speed of deflection of the spot is such that it can move between any two positions in less than 200ns. Movement of the spot is programmed by the use of cards and two 49-word digital stores, which may be controlled by computer.

Mobile recording for Island

Island Studios have begun the operation of a 24-track mobile recording unit in the U.K. The 3M company supplied the recorder, model M79 whose control panel can be detached and used remotely at a distance up to 30ft away from the console. The mixing desk (30 inputs, 24 outputs) was produced by Helios Electronics. Complete with kitchen and fridge, sleeping accommodation, heating and air conditioning, the 32ft long, 8ft wide vehicle cost £75,000. Let's hope that the present materials shortage in the recording industry does not damage the justification of this cost.

Money identifier for the blind

A reliable paper money identifier to aid blind business persons has been developed from NASA technology. The device identifies paper money by its sound "signature". As a bank-note passes under a light source, a photo-transistor measures changes in the note's light patterns. These changes are converted into beeping sounds by an oscillator. Since each denomination of paper money has a different pattern, a different series of tones is given off. These differences are easily identified after about three hours' practice. NASA technology which led to development of the device stems from a technique for the semi-automatic inspection of microfilm records first reported in 1969. The Marchak Engineering and Manufacturing Co., Austin, Texas, produces the device commercially. A photograph of the device is shown opposite.

Static problem eliminated

A static eliminator bar manufactured by 3M United Kingdom is in use at the EMI record pressing factory. At the plant, records are produced on injection moulding machines. A hot plastic copy is taken from the highly-polished metal master disc, is then partially cooled, trimmed and ejected for packing into sleeves. Despite rigorous precautions, a high static charge was generated as the pressings separated from the metal master. By fitting the bar near the rotary trimmer, static charge dust and dirt particles from the trimming process are removed.

The model 201 anti-static bar is a self powered, compact device, with no moving parts or wires, that causes localized ionization of the air, producing a conductive path to drain off any charges on an adjacent surface. The bars emit nuclear energy from radioisotopes of polonium 210 which is safely contained in tiny ceramic beads. The source emits positively charged alpha particles which ionize the surrounding air molecules.

Roadside emergency Help Box

A system for roadside emergencies called the Help Box has been evaluated in the U.S. which uses a radio transmitter instead of the more usual landline-connected roadside telephone. The unit has been developed by the American District Telegraph Company of New York.

The stranded motorist cannot speak to anyone, but several advantages are claimed for the system. Pulling down a vertical cover to the horizontal exposes a choice of four buttons to press—fire, ambulance, police and car trouble. The appropriate button is pushed and the lid closed. Moving the lid generates electromagnetically enough electricity to power the transmitter for 2.5secs, during which time the Help Box sends a tone coded message to a central receiving point. The transmitted signal contains information on the box location and the service required.

All boxes use the same v.h.f. or u.h.f. frequency, the chances of two boxes transmitting at the same instant being very small. The central console can accommodate up to 9,999 box codes.

The system seems ideal for roads carrying heavy traffic which, unlike motorways which have a landline emergency call-box service installed when the road is built, do not have a roadside emergency service. The ADT non-battery radio system is claimed to be vandal proof and cheaper to install and maintain than line systems, due mainly to the absence of cable laying costs. A further application could be in protecting residential and shopping areas against crime.

Enquiries should be sent to the U.K. division, Electric Protection Services, 26 Old Bailey, London EC4M 7HL.

Impression of the observation and communications tower, Toronto, Canada, which when completed will be 1805ft high — the tallest self supporting structure in the world.

Cross-channel phone hop — stage two

The first sod has been cut on the Tolsford Hill, near Folkestone, site for a new Post Office radio tower which will greatly enlarge Britain's busiest single international telephone link — a 30-mile microwave radio "hop" across the English Channel to France.

The radio mast already standing on Tolsford Hill has been strengthened to take more aerials. This is the first step in a two-stage programme — the second will be the setting-up of the new tower — which will enlarge the route's call-carrying capacity under major Post Office plans to keep pace with rapidly increasing demand for communications with Europe. It will be ready for service in 1975, when the old mast will be taken down.

This route, from the Tolsford Hill microwave station to its French counterpart at Fiennes, near Loos, handles calls to and from France — people in Britain make nearly four million calls there a year — and carries many international calls routed across France to other countries, principally Italy, Switzerland, Spain, Greece and Yugoslavia.

Britain's international telecommunication services are doubling every five years. Communications with the Continent account for the biggest slice of the Post Office's international telephone traffic. Of the 25 million oversea calls from Britain last year, 20 million were to mainland Europe. By 1975, 77 million telephone calls a year will be flowing between Britain and the Continent.

The new tower will be 64m (210 ft) high, with six galleries, triangular in plan, spaced at 6m (30 ft) intervals.

Electronic piano design

Simple touch-sensitive piano using ready-made keyboard — 1

by G. Cowie, B.Sc.

The instrument described is a simple touch-sensitive electronic piano which is small and portable. The circuitry is designed on a modular basis using i.cs extensively and is not difficult to construct. It generates tones by an oscillator-divider system, the tones being keyed by individual touch-sensitive key circuits. Costing around £70 to build, the design is believed to be the most cost-effective available, in terms of what it is intended to do, and a commercial instrument with this touch-sensitive feature would seem to cost at least £300.

This design was built to fill a real need; if there had been an acceptable instrument on the market I would have bought it instead of spending three months and £50 in making one. I was learning to play the piano and wanted an instrument of my own for practice. As I live in furnished flats, moving frequently, a full-sized upright just was not practicable. The alternatives were a "mini" piano or an electronic piano. I ruled out the first on finding that second-hand instruments were surprisingly expensive because of the demand; moreover they were not portable enough.

This left electronic pianos. I looked at several but they cost a lot of money and I did not like them. The trouble is that they all have the same artificial keying action in which pressing the key beyond a certain point suddenly generates a note of fixed loudness. On the cheaper instruments the note cannot be held after the key is released.

I wanted an instrument which behaved just like a string piano, even if it did not sound much like one. The prototype is quite true to my original intentions: if you play loud the sound comes out loud, if you play very softly the sound hardly comes out at all. In playing a chord, one can make some notes loud and others soft at the same time. There is a "loud" pedal which can be used to sustain notes after the key is released, and the sound dies away just as in a real piano.

The low notes have long decay time constants, and the high notes have very short time constants. The tone is a bit like that of an electric piano, a harpsichord, and an electric guitar. Most listeners find the tone pleasant; it is much less harsh than that of a real piano. In any case to imitate a grand piano perfectly would be very difficult. Most important of all, the instrument is about the size of a large suitcase and light enough to be carried by one person.

The essential feature of the design is that the volume of sound generated depends on how fast the key is pushed down, a feature not then available to my knowledge on any other electronic piano. This feature is what makes a pianoforte what it is, and its importance was impressed on me by a musician friend with whom I discussed the project. In simple terms, the effect is to add a new dimension, that of loudness, to the sound. Although I made no attempt to vary the tone along with the volume, the characteristics of the human ear and of the power amplifier cause such an effect with my instrument. I find the instrument sufficiently interesting to play that I have not found it necessary to add tone-shaping circuits though this could be done quite easily. The only extra is a swell pedal which is useful for increasing the dynamic range. Functionally, the instrument is much the same as a string piano, except that there is no "soft" pedal. Purists may argue that the key action is not the same as that of a real piano. Strictly speaking this is so, but the art of playing the electronic piano is so similar to the art of playing a real one that there is no difficulty in changing from one to the other.

To produce an electronic imitation of a real piano would be an ambitious undertaking, and potentially an uneconomic one. If the imitation is to be useful by reason of its small bulk and competitive cost then compromises are necessary. The sound that a piano makes has a complex harmonic content. This is not an insuperable difficulty in itself, but the harmonic content varies according to the loudness with which the note is struck, and with time; it is also different for notes of different pitches. Loudness of course varies with time, with a fast attack and slow decay. As if this weren't enough to contend with, most of the notes employ two or three strings which do not vibrate in perfect unison.

The keys of a piano have a characteristic feel when pressed down by the finger: there is a constant resisting force caused by the weight of parts on the inner end of the key, a reactive component caused by the inertia of the fast-moving hammer, and a small amount of friction. The harder one tries to play, the greater the reactive part of the opposing force becomes. From the musician's point of view this characteristic of the piano is most desirable, as it makes it easier to exploit the touch-sensitive loudness which is inherent in the piano. The faster the key goes down, the faster the hammer moves, the harder the hammer hits the strings, the louder the sound. Music tutors exhort one to think of the key speed rather than the pressure. Technically this makes sense as only the final speed of the hammer matters and it is easier to accelerate it by a smooth pressure than by jabbing the key (and the music sounds better). In this piano design, each key is linked to its own timing circuit so that sound output depends on the average velocity with which a key is pushed down.

Various electronic pianos are on the market. Those priced competitively with respect to conventional uprights seem to adopt similar solutions to the problems outlined above. Keyboards are similar to those used in electronic organs, with the same touch, and most of the instruments are not touch-sensitive at all. One infers that the acoustic waveforms are square waves treated by low-pass filters, and by high-pass filters for special effects. All have the right sort of fast attack, slow decay as this is very easy to effect for square waves. Again by inference the frequency generation is done by oscillators and dividers as in electronic organs.

Design considerations

After preliminary thought and discussion, I decided that my electronic piano would be touch-sensitive, have a sustain pedal, use square-waves as the working waveform, and have twelve master oscillators, using t.t.l. 7493 integrated-circuit frequency dividers to generate the lower pitches. On seeing ready-made organ keyboards and keyswitches I decided to use these and, as five octaves is a standard size, that the little-used top and bottom octaves of the conventional 88-note piano keyboard could be dispensed with. This simplifies the work considerably and makes the finished instrument significantly smaller and lighter.

The essential features of electronic key circuit are shown in Fig. 1. The key position must be determined electrically, to control an envelope shaper whose output is used to modulate the amplitude of a continuous-pitch waveform. Tone is determined by the pitch waveform, and attack and decay are determined by the envelope. As the piano is to be touch sensitive then the initial height of the envelope must be variable.

A number of envelope waveforms are shown in the Fig. 2. These show a note played and released, a note played and sustained, and notes repeated without and with sustain. Generally, electrical key contacts are used to signal the states "up", "down" and "moving" and this can be done by a single contact moving between two busbars. But I found that the simplest and cheapest system must use more contacts to simplify the electronics. An electronic piano must have an electronic switch to block the pitch signal when it is not required; in my circuit a diode is used.

Table 1. Fundamental frequencies for C-C keyboard

Octave section	C	B	A	A	G	G	F	F	E	D	D	C
1 (osc. freq.)	2093	1975	1865	1760	1661	1568	1480	1397	1318	1244.4	1174	1108
2 (1st div.)	1046.4	987.7	923.3	880.0	830.6	783.8	739.8	698.4	659.2	622.2	587.2	554.2
3 (2nd div.)	523.2	493.8	466.2	440.0	415.3	391.9	369.9	349.2	329.6	311.1	293.6	277.1
4 (3rd div.)	261.6	246.9	233.1	220.0	207.6	196.0	185.0	174.6	164.8	155.6	146.8	138.6
5 (4th div.)	130.8	123.4	116.5	110.0	103.8	98.0	92.5	87.3	82.4	77.8	73.4	69.3
6 (5th div.)	65.4	*61.7*	*58.2*	*55.0*	*51.9*	*49.0*	*46.2*	*43.6*				

N.B. For modified C-C keyboard (see text) or an F-F keyboard, range is 43.6Hz to 1397Hz.

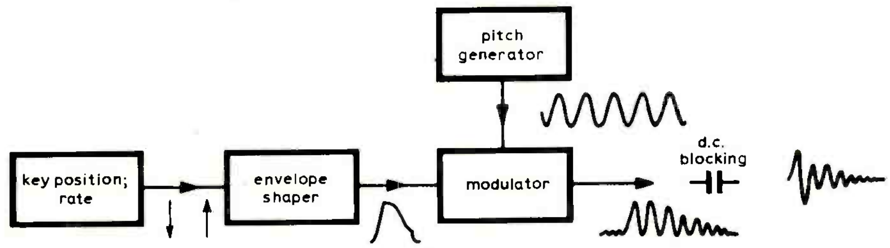


Fig. 1. Key switching and rate information provides an envelope that modulates signals from a pitch generator (c.w. oscillator).

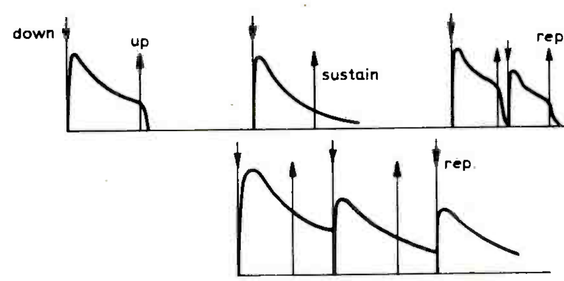


Fig. 2. These envelope waveforms are determined by switches actuated by keys and the sustain pedal. Diagrams show single and repeated notes with and without sustain action.

Twelve oscillators generate the twelve pitches for an octave, and the pitches for lower octaves are obtained by dividing by 2, 4, 8, 16 (Table 1).

The oscillators use operational amplifiers instead of *LC* circuits — it is cheaper to buy op-amps than to buy special coils. Also, the op-amp circuit is easier to design and can be tuned by a cheap pre-set potentiometer. A detailed discussion of this type of oscillator is given in *Electronic Engineering*, Nov.1971, page 54. Complex m.o.s. microcircuits are now available which will produce the twelve top-octave frequencies when driven by a radio-frequency master oscillator. Thus all the key pitches are synchronized with the master oscillator and the organ or piano never needs retuning. Such a device would add about £3 to the cost of the project and a suitable (optional) module will be described in part 3 of this article.

Regulated supplies of +5 and −5 volts are provided as a regulated 5-volt supply was needed in any case for the t.t.l. divider circuits. The advantages of integrated-circuit frequency dividers over discrete dividers in cost, time, space etc are such as to make them the only choice. About half of the piano circuitry is inside the divider i.c. packages.

I devoted much thought to making the key circuits as simple as possible. As there are sixty-one key circuits, elimination of even one component could save hours of work and pounds of hard cash. Wood was the obvious choice of material for the case.. The case is styled after my own conception of how an electronic piano should look, and has no lid as this wasn't essential and would not fit into the design. There is more room at the rear of the case than is strictly necessary; this was deliberate in that making the case too big would cause nothing like as much trouble as making it too small.

Circuit Description

Fig. 3 is a schematic diagram of the complete circuitry which is too complex to be drawn in full. Under the keyboard

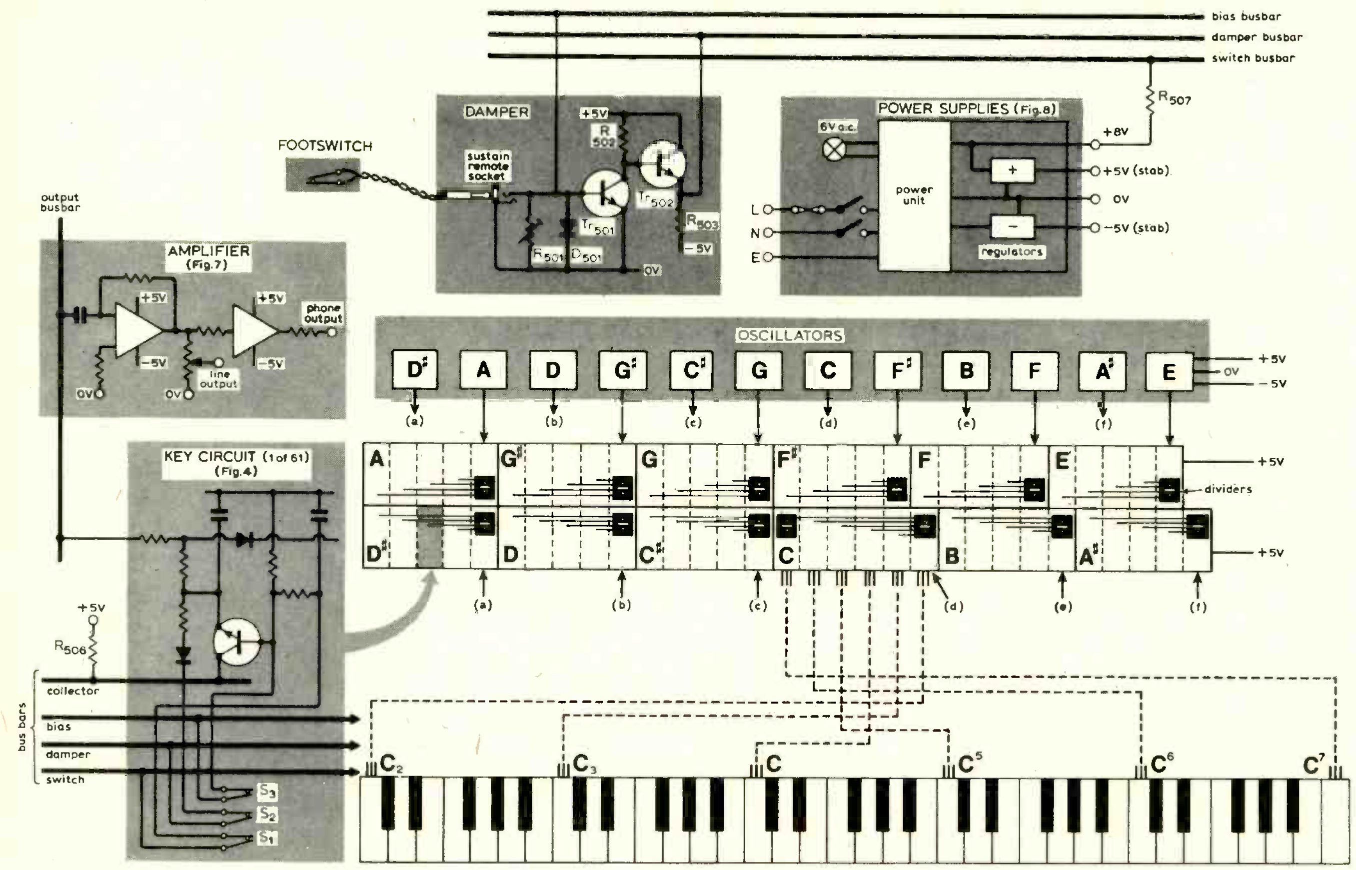


Fig. 3. Time between S_2 and S_1, S_3 opening as the key is pressed determines loudness of sound, achieved with the key circuit. Twelve RC oscillators feed 12 dividers (shown above keyboard in diagram), giving 60 of the 61 tones for modulation by the key circuits. For a five-octave keyboard 61 tones are actually required, the additional tone (C^7) being provided by a 13th divider, as the i.cs will only divide by a maximum of 16. Outputs from the key circuits are mixed in the amplifier via the output busbar. Three of the busbars run alongside the keyboard so that three keyswitch leads can be directly soldered to them.

are 61 sets of three normally-closed gold-plated wire switches, one set being shown. One pole of each switch is connected to one of three busbars which run under the keyboard. The other poles are wired to a key circuit, which is one of a letter-group of five as there are five octaves; and there are twelve letter-groups. There is a sixth note C for which an extra key circuit and an extra divider to give ÷ 32 provided.

Each letter-group of key circuits is fed with signals from an oscillator and frequency divider. The key circuit for one note is drawn in full to show the interconnections.

To each of the 61 keyswitches six connections are made. Three of these are common busbars (bias, damper, switch), and the other three are bias, damper, and switch signal lines and all go to one key circuit, linking the key to the electronics.

The power supply feeds +5 volts to the oscillators, frequency dividers, summing preamplifier and output amplifier and, via a resistor, to the collector bus which feeds all 61 key circuits. It also feeds an unregulated +8-volt supply to the switch bus, and −5 volts to the oscillators and amplifiers.

The output bus is a virtual earth line fed from all 61 key circuits. The bias and damper buses are controlled by the sustain pedal.

Key circuits

Though the key circuits appear simple (Fig. 4), each has three sections which are more or less analagous to parts of a string piano. Components C_1, R_1, R_2, S_1, S_2, form a velocity-measuring circuit which gives the piano its touch-sensitive property. The charge in C_1, when the key is depressed, represents hammer velocity. Transistor Tr_1 provides isolation between the input and output sections of the circuit — the equivalent in a real piano is a device allowing the hammer to fall back. Capacitor C_2 has a charge representing the vibrational energy of a string. Components D_2, S_3, R_3 form the damper circuit, which may be disabled to give a sustain action. Diode D_1 blocks the pitch signal when the circuit is on standby and, when the circuit is active, forms a chopper and output circuit with R_4 and R_5. The discharge times of capacitors C_2 vary to imitate the peculiarity of the string piano whereby bass notes die away more slowly than the treble.

Velocity section. Standby operation is as follows: current flows from the switch busbar, which is at about +8V, through S_1, R_1, S_2, to the bias busbar at about +0.7V, so that Tr_1 is just cut off. Capacitor C_2 is charged to about +0.4 V. When the key is partway depressed, contacts S_1 and S_3 open, and C_1 discharges toward +0.7V, with a time constant of 18ms. (This is a critical time constant that influences the playing properties of the instrument.) When the key is almost fully depressed, S_2 opens and the remaining charge in C_1 passes through R_1 into the base of Tr_1, which conducts heavily, causing a corresponding charge to appear in C_2. If R_2 were not included in the circuit, then S_2 having opened, a capacitance of C_1 times the gain of Tr_1 would be added to C_2; R_2 ensures that C_1 always discharges faster than C_2.

When the key is released, S_2 closes first, S_3 closes discharging C_2, and S_1 closes, recharging C_1 from the other 60 capacitors in parallel. The resulting current surge does not damage the contacts as they will handle up to 2A at low voltages, and the power factor of the capacitors is very poor. All the contacts have so far survived 21 months of use. The action of the circuit is such that when the key is pressed very swiftly, C_1 loses potential by only a volt or so, and a potential of nearly five volts appears on C_2. When the key is pressed very lightly, C_1 discharges almost to the bias voltage, so that a very small charge is delivered to C_2.

Envelope section. Capacitor C_2, having been charged, begins to discharge in pulses through R_4, D_1 and the 7493 i.c. (Fig 5) with a time constant $2R_4\ C_2$. A square chopped signal appears across R_4 and is taken out via R_5; the amplitude of the signal being C_2 voltage minus D_1 volt drop. The t.t.l. divider outputs have two transistors in a sort of class B arrangement so source; in the piano circuit this is a nuisance and is blocked by D_1. In the low state it acts as a current sink to ground. The voltage applied to the output must not exceed 5V.

This diode chopper was chosen because it is the simplest modulating circuit with a precisely definable output and a low feed-through of pitch signal in the off state. The impedance of this section is low to reduce the effect of D_1 leakage and capacitance in its off state. Hence C_2 must be relatively large. The impedance of the velocity section is relatively high to minimize standing currents, hence a current amplifier Tr_1 is necessary.

Damper section: When the key is released, S_3 closes, discharging C_2 through R_3 and D_2. The value of R_3 is made large enough to avoid a key click. A sustain action is effected by raising the potential of the damper bus so that no current can flow into it through D_2, and so C_2 discharges through the chopper, irrespective of the key position. Normally, R_3, D_2 drain some leakage current from C_2. The sustain allows capacitors C_2 in circuits on standby to charge up slightly via Tr_1 until D_1 begins to conduct. To suppress this chorus effect, the bias busbar potential is reduced.

Resistor R_4 varies from 1kΩ (top C) to 15kΩ (low C) — Table 3 lists values.

Oscillator circuits

The 12 oscillators use operational amplifiers in a precision relaxation oscillator circuit (Fig. 5). The output of the op-amp switches between nearly the positive and negative supply voltages. When the output has just gone positive, the negative input voltage starts to change positively as charges. When it reaches the positive input voltage, $V_0R_1/(R_1 + R_2)$, the invering action causes the output to fall negatively, almost instantaneously. The circuit has a bridge configuration which almost eliminates the effect of load and supply voltage. At the instant of switching a differential voltage of $2V_0R_1/(R_1 + R_2)$ exists at the amplifier inputs, which limits the ratio R_1/R_2 that can be used at the chosen supply voltage with 709 series op-amps (but not 741 types). Sources of drift in the circuit include offset voltage and bias current changes.

Supplies of +5V, −5V were chosen to simplify the power supply and buffer circuits. This has rendered the oscillators more sensitive to ripple and one-sided supply voltage changes. Frequency depends on the values of R_{201}, R_{202}, R_{203}, R_{204}, and C_{201}, and is set by R_{203} (Fig. 6). High-stability components are required.

A buffer circuit R_{205}, Tr_{201} is incorporated as the load of the divider input and the discharge current from the top-octave key circuits may be as much as 6.6mA, which is more than the op-amp can be guaranteed to drive. The 7493 i.c. divides the oscillator frequency by 16 and has outputs for 2, 4, 8, divisors also. It changes state for an input transition from high to low, and has two reset inputs, one of which must be grounded for operation as a divider or counter. The outputs will sink more than 16mA ample for driving the key circuits. Eleven of the oscillator and divider circuits are as shown, but for C an overall divisor of 32 is required and so the output ÷16 is wired to the input of another divider stage whose output then feeds low C.

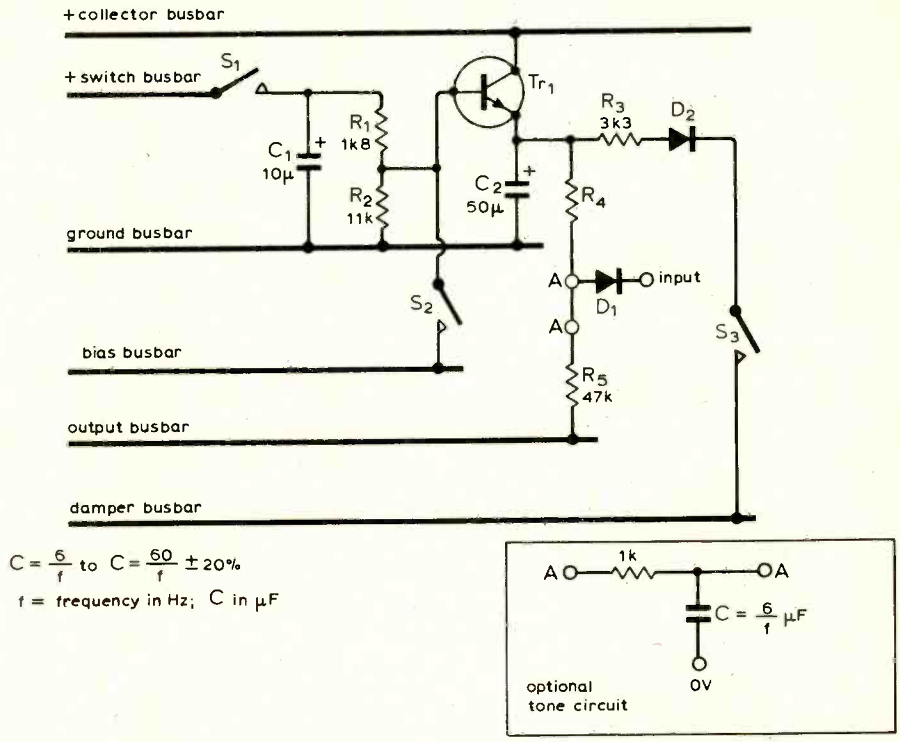
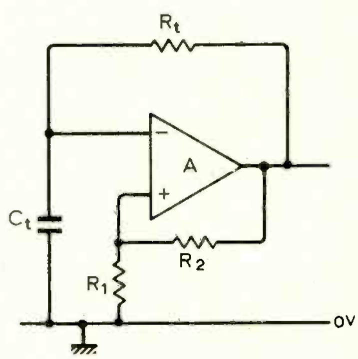


Fig. 4. Key circuit (one of 61) acts as envelope shaper and modulates input from the dividers to feed amplifier via busbar. The three busbars wired to the three switches run alongside keyboard switches. Optional tone circuit was used on the bottom twelve keys of the author's design to make low tones less harsh.

Table 2. Oscillator resistance values

Pitch	Frequency (Hz)	Nom. tuning R (kΩ)	Use (kΩ)
C♯	1108	36.5	33 + 4.7
D	1174	34	33 + 4.7
D♯	1244.4	32	30 + 4.7
E	1318	30	27 + 4.7
F	1397	28	27 + 4.7
F♯	1480	27	24 + 4.7
G	1568	25	24 + 3.3
G♯	1661	24	22 + 3.3
A	1760	23	22 + 3.3
A♯	1865	21	20 + 3.3
B	1975	20	18 + 3.3
C	2093	19	18 + 3.3



half period $\approx 2C_tR_t \frac{R_1}{R_1+R_2}$

$f \approx \frac{1}{4C_t\ R_t + R_1(R_1+R_2)}$

Fig. 5. Relaxation oscillator uses bridge configuration to keep effects of load and supply voltage changes to a minimum.

Summing preamplifier

The summing circuit is a standard op-amp arrangement. Capacitor C_{401} (Fig. 7) blocks the d.c. component of the output, i.e. the C_2 voltages which would be summed to about 25V. Resistor R_{401} is not mounted on the board but at a suitable point among the key circuits, thereby using the differential inputs to minimize pickup of unwanted signals. The headphone amplifier likewise is a fairly standard discrete-component op-amp with complementary emitter-follower output. It can be readily altered to drive various loads.

Table 3. Decay time constant resistor values (R_4 in Fig. 4). (61 resistors needed.)

Note	Octave section 1	2	3	4	5	6
C, B, A♯, A	1k	1.8k	3.3k	5.6k	10k	18k (low C)
G♯, G, F♯, F	1.2k (top F)	2.2k	3.9k	6.8k	12k	18k (low F)
E, D♯, D, C♯	1.5k	2.7k	4.7k	8.2k	15k	—

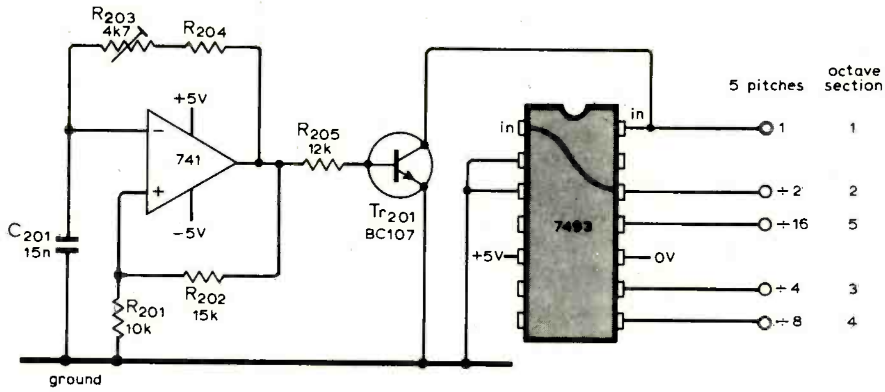


Fig. 6. One of 12 RC oscillators which feed the 12 dividers, giving five octave-related tones for each of 12 notes.

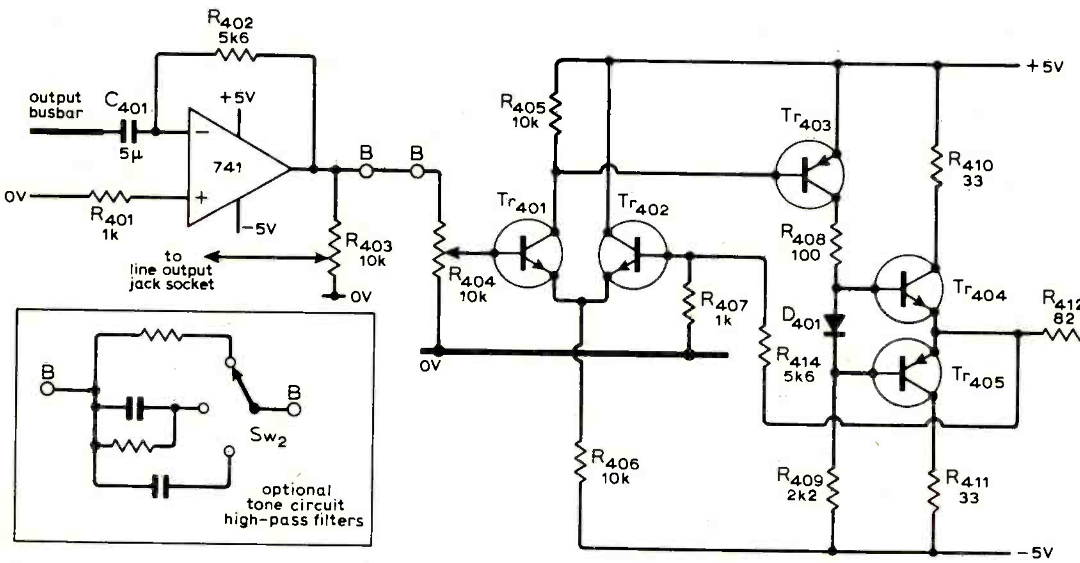


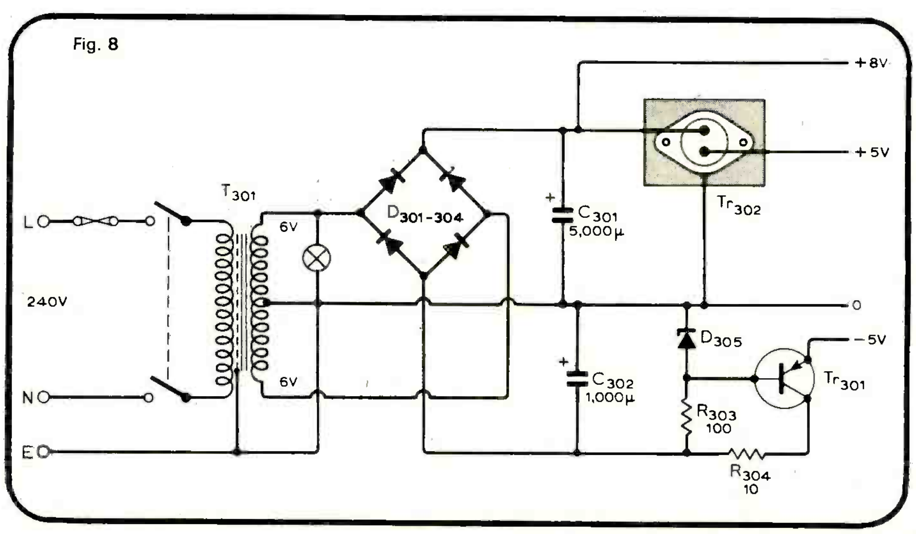
Fig. 7. Amplifier accepts inputs from 61 key circuits via output busbar. Discrete-component amplifier can be omitted if headphone operation is not needed.

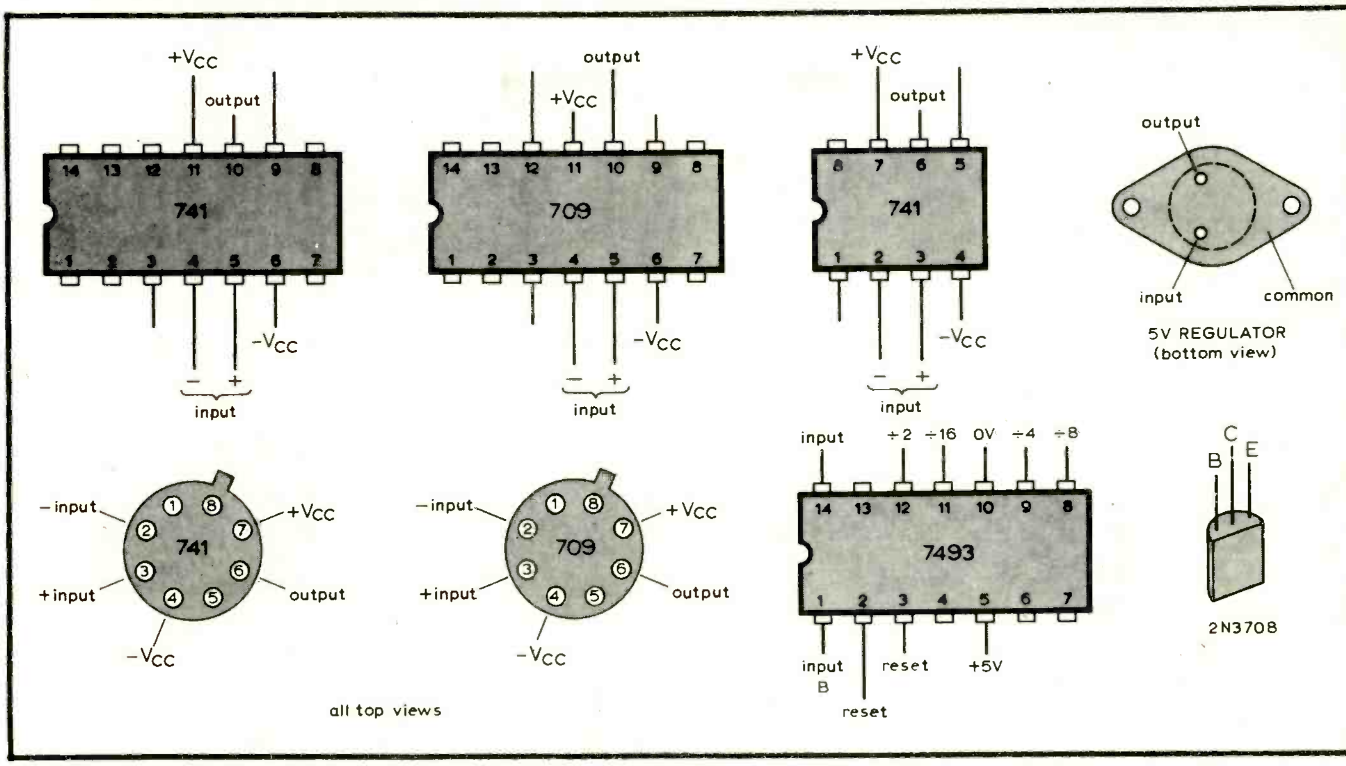
Power supply

The power supply unit (this page) provides regulated voltages of +5V at 600mA −5V at 50mA, an unregulated +8V at 250mA, and a low-voltage a.c. to light an indicator lamp. The twin full-wave rectifier arrangement produces two "raw" d.c. supplies with a minimal voltage loss across diodes. A simple discrete-component regulator is used for the negative line, and an integrated regulator is used for the positive supply to maximize reliability. The t.t.l. divider circuits may be ruined if a regulator failure causes their supply voltage to exceed 7V. Regulated supplies assist in maintaining the frequency stability of the oscillators.

Busbar lines

A number of wires feed signals and power to all parts of the piano circuitry (Fig. 3.) These wires are for the +5V regulated power line, the −5V regulated line, ground potential, the switch bus fed via a resistor from the unregulated





+ supply, the output bus, the bias bus and the damper bus.

The bias bus is returned to ground via a rectifier diode and trimming potentiometer in parallel, so that the bus voltage may be finely adjusted. When the sustain pedal is pressed, thus closing a remote switch, the bias voltage is reduced, cutting off Tr_{501} whose base is connected to the bias bus. An emitter-follower Tr_{502} is used to control the damper bus, whose potential is 0.7V below that of Tr_{501} collector. Therefore when the sustain pedal is depressed, the damper bus potential rises by 5V to +4.3V.

Keyboard

The keyboard used in the prototype is a five-octave plastics-keyed C-C electronic organ keyboard of Italian origin, supplied by Elvins Electronics. Other keyboards may be obtained, e.g. from Harmonics Ltd and from Kimber-Allen, and if these are used some of the cabinet dimensions may have to be altered.

For musical reasons it is most preferable that the keyboard be F-F with low F at 43Hz. I believe that such keyboards may now be obtained to order. With a C-C keyboard, one has the option of modifying it to F-F by cutting away the bottom five notes and re-attaching them at the top of the keyboard.

Converting the C-C keyboard. Unhook the springs from the bottom ends and poke out the pivot wire. Put the keys aside in order. Cut the frame flush with low F and cut off the top C mountings also. Rearrange the C-E portion at the top of the keyboard with the top C (now top F) above it, and repair the saw cuts with sheet metal and self-tapping screws, being sure to get the key spacing exactly right. Replace the keys on the board, threading the pivot wire from the bottom end. A similar operation can be performed on the Kimber-Allen keyboard. If you are at all doubtful about cutting up the keyboard, it would be better to order the F-F version. As the pitch of the mountings varies over an octave, it is not possible to simply shunt the keys down the board.

Constructional details will be continued in a subsequent article.

Parts summary

Power supply (Fig. 8)
Panel fuseholder and 0.5A fuse
Illuminated push-on, push-off switch (0.5A, 250V)
6.3 plus 6.3-V, 1.5-A transformer, or 9-0-9V, 1A (Osmabet)
Bridge rectifier for 30V, 2A
Capacitors — 1000 and 5000μF 16V
100μF 6V
Resistors — 10 and 100Ω, ½-watt
Regulator 5V, 600mA (RS Components)
BZY88-C5V6 zener diode
BCY38 transistor
Three-way mains panel socket (Bulgin)

Oscillators and dividers (Fig. 6)
709 or 741 op-amps (twelve)
2N3708 or BC107 transistors (twelve)
Capacitors — 15nF 5% polystyrene (twelve)
Resistors — 10k, 15k 18k, 30kΩ, 2%
20k, 22k, 24k, 27k, 33kΩ, 2% (two each)
12kΩ 20% (twelve)
preset pots (pref. w.w.) 3.3k, 4.7kΩ (six each)
7493 i.c. dividers (thirteen)

Preamplifier (Fig. 7)
741 op-amp
Capacitor 50μF 6V
Resistors — 1k, 5.6kΩ, 10%
— 10k preset carbon pot

Headphone amplifier (Fig. 7)
2N3708 or BC107 — Tr_{401}, Tr_{402}
OC203 — Tr_{403}
2N3703 — Tr_{404}
2N3705 — Tr_{405}
OA200 silicon diode
Resistors — 8.2, 33 (two), 82, 100Ω, 10% ½-watt
1k, 2.2k, 5.6k, 10kΩ (two), 10%
10k preset carbon pot

Busbar terminations (Fig. 3)
Resistors — 3Ω, 5W (R_{506})
3 or 18Ω, 5W (R_{507})
1kΩ (R_{503})
22Ω variable (R_{501})
1A silicon diode (D_{501})
2N3703 or 2N3903 (Tr_{501}, TR_{502})

Key circuits (Fig. 4)
Capacitors — 10μF 10V (sixty one)
50μF 6V (sixty one)
Resistors — 1k (R_1), 10 or 11k (R_2), 3.3kΩ (R_3) ⅛-watt, 5% (sixty one each)
see Table 3 for R_4 values (sixty eight needed)
47kΩ (R_5), ⅛-watt 5% (sixty one)
BFY50, BFY51, BFY52 or 2N697 (sixty one)
OA200 (D_1, D_2) silicon diode

Hardware
Keyswitches gold-plated type (sixty two) and keyboard from Elvins Electronics at 8 Putney Bridge Road, London SW18 1HU. Alternative keyboards from Harmonics Ltd, PO Box 32, Chiselhurst, Kent BR7 5RU. Alan Douglas, 4 Lees Barn Road, Radcliffe-on-Trent, Notts.
Veroboard 17 x 5 x 0.1in (three)
Vero pins (200)
Vero track cutter and pin inserter
Edge connector, 16-way 0.1-in pitch (two)
Flex — 10/0.1mm 50 metres p.v.c. ins. (two)
16/0.2mm 5m } p.v.c. ins.
24/0.2mm 3m } assorted colours
Tinned copper wire — 22 s.w.g. 3m
20 s.w.g. 1m
Jack sockets and plugs
Tagstrip — 6-way (two) and 12-way
Pushbutton switch (to stand 100lb load)
¼-in grommets
Cable clamps

1974 Conferences & Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON
Mar. 25-27 West Centre Hotel
Coil Winding International '74
(Electromation Exhibitions Ltd, Cleveland House, 344a Holdenhurst Road, Bournemouth, Hants)
Mar. 29-31 Post House Hotel
Sonex '74
(British Audio Promotions Ltd., 31 Soho Sq., London W1V 5DG)
May 19-23 Bloomsbury Centre and Hotel Russell
IREDA Radio Show 1974
(Victor Brand Associates, 256 Wimbledon Park Road, London, SW19)
July 1-5 Savoy Place
Precision Electromagnetic Measurements
(The 1974 CPEM Secretariat, c/o The Conference Dept., I.E.E., Savoy Place, London WC2R 0BL)
July 9-12 Imperial College
1974 URSI Symposium on Electromagnetic Wave Theory
(Conference Dept., I.E.E., Savoy Place, London WC2R 0BL)
July 12-14 Goldsmith College
The History of Electrical Engineering
(I.E.E., Savoy Place, London WC2R 0BL)
July 15-19 City University
1974 Frontiers in Education
(Conference Dept., I.E.E., Savoy Place, London WC2R 0BL)
July 23-31 Imperial College
8th International Congress on Acoustics
(International Congress on Acoustics, 47 Belgrave Square, London SW1X 8QX)
July 23-26 Savoy Place
Circuit Theory and Design
(Conference Dept., I.E.E., Savoy Place, London WC2R 0BL)
Sept. 23-27 Grosvenor House
International Broadcasting Convention
(International Broadcasting Convention, I.E.E., Savoy Place, London WC2R 0BL)
Sept. 24-26 Brunel University
Minicomputer Forum
(Online, Brunel University, Uxbridge, Middlesex)
Oct. 22-24 Savoy Place
Linear Electric Machines
(Conference Dept., I.E.E., Savoy Place, London WC2R 0BL)
Nov. 26 & 27 Savoy Place
Plastics in Telecommunications
(The Plastics Institute, 11 Hobart Place, London SW1W 0HL)
Dec. 3-5 Savoy Place
Power Electronics — Power Semiconductors and their Applications
(Conference Dept., I.E.E., Savoy Place, London WC2R 0BL)

BRIGHTON
May 7-9 Metropole Convention Centre
Electrical Insulation Conference
(Electrical and Electronic Insulation Association, 8 Leicester St., London WC2H 7BN)
June 4-7 Metropole Convention Centre
Communications '74
(ETV Cybernetics Ltd, 109 Kingsway, London WC2B 6UP)
Aug. 27-29 University of Sussex
Control of New Forms of Guided Land Transport
(Conference Dept., I.E.E., Savoy Place, London WC2R 0BL)
Nov. 5-8 Metropole Convention Centre
Automatic Testing 74
(Network, 84 High Street, Newport Pagnell, Bucks MK16 8EG)

COVENTRY
May 14 & 15 Lanchester Polytechnic
Physiological Measurement
(Departments of Electrical Engineering and Biological Studies, Lanchester Polytechnic, Priory Street, Coventry CV1 5FB)

EDINBURGH
Sept. 10-14 University of Edinburgh
Ferroelectricity
(Dr H. Montgomery, Physics Dept., The University, Kings Buildings, Mayfield Road, Edinburgh EH9 3JZ)

GUILDFORD
Apr. 8 & 9 University of Surrey
Leaky Feeder Radio Communication Systems
(Miss A. J. Perkins, Dept. of Electronic & Electrical Engineering, University of Surrey, Guildford, Surrey)

HATFIELD
July 15-26 Hatfield Polytechnic
Vacation school on Signal Processing in Modern Telecommunication Systems
(Divisional Secretary (Electronics), I.E.E., Savoy Place, London WC2R 0BL)

LANCASTER
Aug. 1 & 2 University of Lancaster
Microwave Acoustics
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX)

LIVERPOOL
Apr. 17-19 University of Liverpool
Negative Ions
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX)
Sept. 18 & 19 University of Liverpool
Electrostatics: Fundamentals, Application and Hazards
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX)

MANCHESTER
Apr. 3-4 UMIST
Metal Semiconductor Contacts
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX)

NOTTINGHAM
Sept. 9-14 University of Nottingham
Magnetic Resonance and Related Phenomena
(Professor E. R. Andrew, Dept. of Physics, The University, University Park, Nottingham NG7 2RD)

Sept. 16-19 University of Nottingham
European Solid State Device Research Conference (ESSDERC 1974)
(The Institute of Physics, 47 Belgrave Sq., London SW1X 8QX)

OXFORD
Apr. 1-4 University of Oxford
Vacation school on Functional Analysis for Engineers
(Secretary, Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, quoting the reference LS/CA)

SOUTHAMPTON
Apr. 8-11 University of Southampton
Computer Aided Design
(Conference Dept., I.E.E., Savoy Place, London WC2R 0BL)
Apr. 8-11 University of Southampton
CADEX '74
(Electronic Engineering Association, 8 Leicester Street, London WC2H 7BN)

SWANSEA
Mar. 26-29 University College
Atomic and Molecular Physics
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX)

July 8-11 University College
Aviation Electronics
(Symposium Secretary, SERT, 8-10 Charing Cross Road, London WC2H 0HP)

OVERSEAS (March-May)
Mar. 26-29 Copenhagen
AES Convention
(Robert Sorensen, Kinovox, Industrievej 9, 3540 Lynge, Denmark)

Apr. 1-5 Liege
Radio Communication in Mines, Roads and Tunnels
(Institut National des Industries Extractives, Rue de Chera, B-4000 Liege, Belgium)

Apr. 1-6 Paris
International Electronic Components Exhibition
(S.D.S.A., 14 rue de Presles, 75740 Paris Cedex 15, France)

Apr. 2-4 Las Vegas
Reliability Physics
(J. Vaccaro, Rome Air Development Ctr., RBRP, Griffiss AFB, N.Y. 13441, U.S.A.)

Apr. 2-5 Montreux
Electro-optics
(Mack-Brooks Exhibitions Ltd, 62-64 Victoria Street, St. Albans, Herts A11 3XT)

Apr. 16-18 New York City
Optical and Acoustical Micro-electronics
(Polytechnic Institute of Brooklyn, Microwave Research Institute, 333 Jay Street, Brooklyn, New York 11201, U.S.A.)

Apr. 21-24 San Francisco
Circuits and Systems Theory
(Dr. S. P. Chan, Dept. of Electrical Engineering and Computer Science, University of Santa Clara, Santa Clara, California 95053, U.S.A.)

Apr. 21-26 Los Angeles
SMPTE Spring Conference
(Society of Motion Picture & Television Engineers, 862 Scarsdale Ave., Scarsdale, N.Y. 10583, U.S.A.)

Apr. 22-26 Amsterdam
Eurocon '74
G. Gaikhorst, c/o F.M.E., Nassaulaan 13, The Hague, Netherlands.

Apr. 29-May 1 Orlando
Southeastcon '74
(Claude E. Jones, Mail Point 417, Martin Marietta Corporation, P. O. Box 5837, Orlando, Florida 32805, U.S.A.)

May 14-17 Toronto
Intermag
(International Magnetics Conference, Box 82, Coopersburg, Penna. 18036, U.S.A.)

May 20-23 Ottawa
Subscriber Loops and Services
(Mrs. Jean Higgerty, Bell-Northern Research, P.O. Box 3511, Station C, Ottawa, Canada K1Y 4H7)
May 20-24 Davos
Biotelemetry
(International Society on Biotelemetry, Swiss Federal Institutes of Technology, Lausanne EPFL, Switzerland)
May 21-23 Rosemont, Ill.
Coil Winding Chicago '74
(Coil Winding International Exhibitions (Norglebe Ltd), Cleveland House, 344a Holdenhurst Road, Bournemouth BH8 8BE, Hants, England)
May 29-31 Atlantic City
Frequency Control
(U.S. Army Electronics Technology & Devices Lab. (Ecom), Fort Monmouth, N.J., U.S.A.)

Letters to the Editor

Noise measurement and dB

Discussion in recent issues on the performance of feedback amplifiers in respect of distortion and, more especially, of noise has been most interesting but, to my mind, rather confusing and inconclusive.

Letters and articles by, among others, Messrs J. Linsley Hood, H. P. Walker, J. Stuart, J. Fison and E. F. Taylor indicate a certain amount of mutual misunderstanding and a possibly misplaced reliance upon theoretical predictions based upon rather abstract mathematical exercises. As a one-time practising design engineer, I sometimes feel that if I read one more self-confident prediction invoking Boltzmann's Constant I shall run screaming.

May I suggest that many readers, myself emphatically included, would be most interested and directly assisted in their work by a lengthy article — or, more probably, a short series — giving in a factual way the results of *measurement* of noise produced by a variety of circuits and of individual types of components both active and passive, and more especially dealing with the construction and use of apparatus for noise measurement which would lie within the capacity of the individual constructor and technician?

I have met, here and there, a tendency to regard such measurements as impossible for anyone not backed by an array of expensive and complex commercial equipment and a formidable budget. I doubt that this is true, and it tends to restrict practical testing into too few channels. Further, it leads to unquestioning acceptance of pronouncements from well-equipped authorities, when personal tests could be more rewarding. It has been my experience over many years that the engineer who too easily accepts, without experimental check, the calculated results of the theoreticians is in serious danger of knowing for a fact something that just is not so.

Arising from the foregoing, may I make a request? Could some of your contributors refrain from the growing practice of treating the decibel as an absolute electrical unit, rather than as the ratio — well or ill-defined — which it actually is? For example, a writer discussing the matching of tuners to amplifiers derives a simple formula and continues " . . . where X is the signal strength in dB . . . ". There we part company and I retire from the struggle for comprehension, murmuring "dB referred to *what*?". Signals, including unwanted ones like noise and hum, should surely be expressed in volts, amperes, or fractions thereof; most of us are probably capable of converting to dB referred to some other signal or quantity if that seems helpful.

F. G. Canning,
Portsea,
Australia.

Hi-fi equipment standards

In your November 1973 issue the drafts for the coming British hi-fi standard have been compared to the German hi-fi standard DIN 45500. On this occasion DIN 45500 has been typed "mid-fi". This cannot be accepted without response.

Reading and judging the DIN hi-fi standard without knowledge of the methods of measurement and their conditions will lead to erroneous assumptions. DIN 45500 has been worked on and established during the years 1963 to 1966 and partially revised in 1972. The original purpose of the standard was and is to give the consumer (who pays) the means of comparing and judging what hi-fi equipment he buys. This means furnishing the consumer with data he can use and compare. It does not mean establishing a standard with levels as high as can be achieved by the present state of the art. This has remained unchanged. The DIN values are absolute minimum values and must be met, without any exceptions or tolerances whatsoever, in all points by all units of hi-fi equipment of a certain series. Furthermore, if a manufacturer claims better specifications than DIN for his product, such better specifications must be measured according to DIN 45500 and must also be fulfilled by all units of the series. Consequently in design always the rule of "worst case condition" applies. The addition of all tolerances in construction material, e.g. semiconductors, capacitors, is included in the definition "worst case condition". It must not be overlooked that DIN furnishes two criteria: minimum requirements *and* uniform measuring methods. The latter is deemed a necessity for making competition transparent. When designing an amplifier under application of today's technology and consideration of the "worst case condition" with the goal of observing the 1% t.h.d. limit set forth by DIN, the product finally manufactured will then display a t.h.d. of 0.15% or better. It would be highly unfair to the consumer to make him pay more money for an amplifier processing programme material and driving loudspeakers having, as a rule, a t.h.d. considerably higher.

The matter is different when looking into signal-to-noise ratio. Everyone having to do with high fidelity knows that one of the most unpleasant experiences is the hiss accompanying a stereo broadcast. Please permit me to quote in comparison the relevant figures as demanded by DIN 45500 and the BSI standards draft for radio tuners. On first sight the figures for weighted and unweighted signal-to-noise ratio appear to be the same. In reality there are considerable differences, explained by the following facts: In the BSI standard the noise levels are related to a deviation of 22.5 kHz, whereas in DIN a deviation of 40 kHz is set as a measuring condition. This makes the British standard stricter by 5 dB. The BSI provides for measuring conditions according to IEC publication 268/3. Up to the present, in Germany measuring conditions are set forth in DIN 45405. This standard demands, for weighted signal-to-noise ratio, the application of a weighting curve which raises frequencies around 5000 Hz up to 8 dB from zero. The measuring instrument for this purpose must have a quasi peak-to-peak indication. The peak-to-peak indication and the weighting curve according to DIN 45405 result in a measurement 10 dB lower than if measured according to IEC 268/1, clause 7.2, 7.3 and 7.5, i.e. this particular DIN condition of measurement is 10 dB stricter than BSI (IEC). BSI and DIN provide for a weighted signal-to-noise ratio of 54 dB. If measuring methods according to IEC were applied, DIN would have to quote 59 dB on account of the different measuring methods as outlined above. A figure of 54 dB obtained by measurement according to BSI would directly correspond to a figure of 49 dB measured according to DIN. The figures make evident the influence of the different measuring methods. In contrast to DIN, the BSI standards draft does not differentiate between mono and stereo operation. It furnishes only conditions for mono operation. However, with f.m. reception the problem is not hiss on mono reception but hiss on stereo reception. This is the reason why DIN provides for an antenna level of 3.3 nW for both conditions, whilst BSI puts down 0.39 nW for mono only. A possible conclusion would be to propose for a future IEC standard a figure of 60 dB for weighted signal-to-noise ratio measured according to IEC (also BSI) and an unweighted signal-to-noise ratio figure between 46 and 48 dB (IEC/BSI), applying to mono *and* stereo reception.

Similar conditions exist with the signal-to-noise ratio figures for amplifiers. The BSI draft provides that the total noise output power shall not exceed 1µ W. DIN provides for an unweighted signal-to-noise ratio of 50 dB related to an output power of 50 mW per channel, measured at a position of the gain control which produces 50 mW output power with the signal sources 5 mV for low impedance pickup heads and 500 mV for tuners, tape-recorders, etc.; inputs (for measurements) being terminated for high impedance inputs with 47 kΩ in parallel with 250 pF and for magnetic pickups with 2.2 kΩ. Also, this unweighted signal-to-noise ratio has to be measured with an instrument with quasi peak-to-peak indication according to the measuring methods described in DIN 45405. Comparison: BSI indicates 1µ W.

This equals 2 mV applied to a 4-ohm speaker. This 2 mV amounts to a signal-to-noise ratio of 47 dB related to a signal of 50 mW, measured according to IEC 268.1, clause 7.3. The same measurement according to DIN results in a figure of 38 dB for unweighted signal-to-noise ratio, as well as weighted signal-to-noise ratio. This means that the DIN method of measurement is so much stricter that a measuring figure unfavourable by 9 dB shows, compared to BSI, where actually the same condition exists. Also, here it should be considered establishing an unweighted signal-to-noise ratio of 55 to 56 dB. Measuring conditions: Volume control adjusted to between the position 50 mW and the position for rated power, always produced by an input reference signal for high impedance inputs of 500 mV and for magnetic pickup inputs of 5 mV; inputs (for measurements) being terminated as described above. All measurements according to IEC 268.

Measurements and tests made by independent and neutral German hi-fi magazines and test institutes reveal very often that equipment by well-known manufacturers around the world show testing results below or just achieving the moderate respective minimum figures set forth by DIN 45500.

The British draft for the future IEC standard shows that it is made by people knowing their business. It is correct that in some points the BSI draft sets forth stricter conditions. It is clear that today DIN 45500 can be made stricter in some points without making the product dearer. Admittedly the designing audio engineer very likely has to put in some more brain-work to meet such stricter standards.

The hope is justified that in the near future the international experts will arrive at a universal standard for hi-fi equipment, enabling the consumer (who pays) to judge a piece of hi-fi equipment from any country simply by comparing figures meaning the same. This will certainly promote the cause of hi-fi.

Heinrich Fischelmayer,
Zirndorf,
W. Germany.

Editor's note: Mr Fischelmayer is the chairman of the working group on household hi-fi audio equipment in the German Standards Institute (DIN).

Frequency shifter for howl suppression

The method advocated by M. Hartley Jones in "Frequency shifter for howl suppression" (July 1973 issue) is doubtless effective for speech, but whether it is acceptable for music is perhaps a subjective matter. A less obtrusive and less elaborate method is the use of tunable tone filter(s) of adjustable bandwidth, many designs of which are outlined in *W.W.* Circards — Series 1; use of the twin-T filter for a particular application is also described in "Designing a low-frequency active notch filter", N.B. Rowe, *Electronic Engng.*, April, 1972. Ready-built active filters are already on the market. In many halls it is observed that tendency to howling occurs chiefly at a particular frequency, so that the availability of even one such filter may enable gain to be usefully advanced at other frequencies without noticeable distortion.

K. J. Young,
Derby.

Using c.m.o.s. devices

I was interested in the recent correspondence on the problems of handling c.m.o.s. and f.e.t. devices. I wonder what percentage are damaged beyond repair *before* being wired into apparatus.

Recently I was in a component shop in the Edgware Road, London, area when I heard mention of "f.e.t.". I was intrigued to observe the assistant produce some from a plastic tray with pins separated (no sign of a keeper) and lay them on a glass counter and finally pack them into a plastic bag!

I couldn't but wonder whether any of them survived!

In the light of such an experience, the idea of using special soldering irons and conducting benches seems ludicrous. Or *is* it? Whilst I have had my share of defunct f.e.t. devices, I am now wondering whether it was, indeed, my fault . . .

Ronald G. Young,
Peacehaven,
Sussex.

Model railway control system

Most model locomotives are driven through a worm drive which is non-reversible. This prevents the loco from coasting when the power is removed as at (f) in Fig.1 of P. Cowan's article in the November issue. The addition of a large flywheel to the motor shaft helps to some extent but it is usually difficult to find room inside the cramped loco body.

Mr Cowan suggests improving the conventional motor by "sawing out the armature slot". If this is done the armature collapses into small pieces. If he means sawing out the armature "tunnel" to take a ring-field magnet then how does he propose to retain the bearing plates at either end? My advice is leave well alone!

The Hornby ring-field motor is far too large to use as a replacement motor and is also not very reliable. Stalled current can be as high as 2A with some of these motors, giving a power dissipation of 12W for Tr_{28} and Tr_{31}, double the 6W suggested.

Another problem concerns the total current given in Fig.2. This is just over 3A (with the loco running normally, I assume). As a scale modeller the rail section I use is 0.9mm × 1.8mm nickel silver with a large "groove" down each side — in fact an exact scale version of 95lb bullhead rail. The cross-sectional area of this rail is less than 1.5mm^2 and even for copper the quoted working current is less than 2.5A.

Regarding coaches, where do you put the electronics? The inside is detailed with seats and passengers and all the underframe details are there, leaving no room for a heatsink and transistors. Also, no self-respecting railway modeller — as opposed to those who "play trains" — uses Trix coaches as they are to a different scale from the locos.

Finally price! I have about 15 locos and 35 coaches at present (in varying stages of construction) and my layout requires 3 main controllers. The total cost for the separate units for each item would be prohibitive if I could find room in each loco for two pieces of electronic circuitry, a motor and drive and an earpiece without displacing the crew and cab fittings.

I feel that this system is not a viable proposition for the serious model enthusiast who can achieve the same, if not better, results for a much lower cost by other electronic circuits.

R. A. Ganderton,
Dunstable,
Beds.

One-off printed circuit boards

While developing distributed circuit u.h.f. amplifiers, I found that necessary modifications could be easily and quickly made by covering the copper clad board with Sellotape or Fablon, then cutting round the required circuit shape with a scalpel and peeling the areas to be etched.

Using this method, lines as narrow as 250 μm are possible, even using boards with 20 μm of copper. The masking is unaffected by most common etching solutions and the circuit can be drawn on the mask using a fine pointed fibre tip pen.

I wonder why manufacturers do not produce copper clad board already masked. It would protect the copper from dirt and oxidation, which makes etching more difficult, and provide a surface for easy and clear marking out of mechanical as well as electrical details.

The method is of course equally applicable to conventional circuit boards.

M. R. Yeo,
UWIST,
Cardiff.

Surround-sound with headphones

While I and a small group of tape recording friends were pleased to see Sennheiser's recordings specially made for headphone listening brought to the attention of readers (Nov. issue, p.544) we feel too much emphasis has been placed on the dummy head, as though it alone were the reason for the success of the recordings. The dummy head may be very impressive, it may even give a subtle improvement, but we find that the biggest improvement is made by the position of the microphones.

To recap on the main objection usually raised against headphone listening: two sounds of equal loudness produced from two separate sources, provided that they are in phase, will appear as one central sound. If the two sound sources are a pair of headphones, the point between the two is, of course, inside the head. Stereo sound, recorded so that the main difference in position of sounds is achieved by the polar diagram of the microphones feeding a different level to each channel, will just swing the sound from side to side inside the head. This will happen if the recordist makes the mistake of trying to position the microphones as nearly as possible in the same place. Of course, when listening via loudspeakers, the sound "over there" is quite acceptable. Surprisingly it is possible to move the sound outside of the headphones, without the complication of a dummy head or the doubtful dependence on fortuitous interpretation by the listener.

The transformation of the headphone stereo sound requires moving the microphones from the "crossed heads" arrangement to, well, "crossed tails" comes to mind as a suitable expression, so that the transducer elements in the microphones are spaced at 150mm or so. To maintain the "image" the same way round, the microphone leads must reverse channels. It is, of course, easier to position the microphones on their mounting bracket pointing away from each other, and the cables, now sprouting from the microphones near the upright of the stand, can be led away more tidily than when the microphone heads are crossed. It is also interesting to note that, because of the physical size of microphones, it is not practical to bring the two transducers into one place in any case, and this results in a variety of positions with a common variation one above the other, and although it is possible to listen with one's head over to one side, it is not possible to maintain the horizontal polar pattern achieved by the vertically mounted microphones!

So, by the simple expedient of moving the microphones, the sound for the headphone listener has been opened out at least as much as is done by adding a derived difference signal rear channel through several good quality loudspeakers to straight loudspeaker stereo; and whereas the sound over such a loudspeaker system does not properly convey position (although usually an improvement over stereo alone) the two channels on the headphones give accurate 360 degree information to the listener. It would seem that the small but critical time difference, perceived when listening to live sounds, in the arrival of sound at each ear, can in fact be recorded by correctly positioned microphones. This time difference can be included in the loudness difference established by the two microphones and, when presented to each ear without loudness or time difference distortion, the spatial effect is very close to reality. Sounds from the rear appear to come quite solidly from the rear, even if they are being heard for the first time, and it is rather worrying to find that the spatial effect including the sense of "behind" is actually increased with S.T.C. 4033A microphones switched to "ribbon", even though they can be used as cardioid. This aspect of the performance does not at first make sense if one is thinking from the point of view of simulating the human ear with the microphones, but of course David Hafler has shown that ribbon or "figure of eight" polar diagrams for the microphones will increase the difference signal for side emanating sounds, since the rear of the ribbon is out of phase with the front. It would seem reasonable to suggest that the brain can detect a phase difference between two sounds presented simultaneously, giving us a preference for this information when it is available. This difference signal is not the reason for the sound moving to the outside of the headphones, and relatively inexpensive microphones such as the A.K.G. D19 still give an excellent result.

The success of recordings made in this manner seems to indicate that more attention could be given to the relationship between the microphone spacing and the loudspeaker spacing, so that the time difference that would have been heard several feet behind the microphones is preserved by the recording and played back over the loudspeakers, even though an anomaly will always exist for sound coming from behind the microphones for replay in this manner. This line of thought can be projected further into an explanation for the improvement of stereo with a derived difference rear channel, based on the fact that loudspeakers spaced several feet apart cannot reproduce the sound field of two microphones mounted fairly close together, even though small differences in the microphone position are inaudible. The difference channel, in all its various guises, has an output which coincides with some point along the centre line of the main left and right loudspeakers, and thus, far from increasing the apparent sound *source,* it has in effect reduced the difference in the sound from the two main loudspeakers, as perceived by the listener, until the position they appear to be in is much more like the position of the two microphones on one stand. Therefore there appears to be an important relationship between the time interval heard by the listener's two ears and the instantaneous phase of the signal. If this can be understood, it may well be a bigger step forward than quadraphony.

John C. Tugwell,
Southend,
Essex.

Radiating coaxial cables

We have read with interest your correspondence relating to the use of radiating coaxial cables in communication systems (Sept. and Nov. issues 1973).

Mr Avery refers to the attenuation of "loose braid" (*sic*) cables in v.h.f. and u.h.f. systems under conditions of contamination by dirt and moisture. As manufacturers of radiating cables using both types of coupling mechanism, i.e. holes (apertured tape outer conductors) and reduced cover ("open") braids, we have carried out extensive tests on both types of cable and have found no evidence to support the contention that the latter types are susceptible to the effects of adverse environmental conditions.

From tests of attenuation carried out at v.h.f. and u.h.f. we have found that open braid cables laid on the ground, against wall surfaces, covered with wet mud, and immersed in water, exhibit no change in linear attenuation as compared with cables suspended in air clear of external objects. With our apertured tape cable a small increase can be observed at u.h.f. with the cable immersed in water.

Our experimental evidence is supported by the satisfactory performance of working installations, in particular systems operating in NCB mines where braided radiating coaxial cables have been extensively used, in some cases under very adverse conditions.

We are, of course, referring to braided cables specifically designed for this service, where the braid design has been developed to achieve the necessary balance between radiation and linear attenuation, an important requirement in long systems. The open weave cables referred to by Mr Goddard, presumably television downlead type cables having braids with optical cover of the order of 60%, are not designed for these applications.

J. L. Goldberg and A. J. Willis,
BICC Ltd,
Helsby, Cheshire.

Soldering-iron leakage

To-day soldering iron manufacturers make quite a big issue about the leakage to earth of their soldering irons, claiming that this can damage transistors and similar devices. This I am sure is perfectly true. What I would like to know is what is the maximum permissible leakage at which an iron can safely be used on transistors. The reason is that I shall then be able, when I am offered a soldering iron, to ask the manufacturers if it measures up to this particular specification.

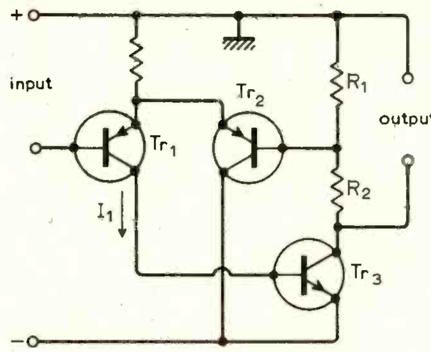
I think, to-day, any iron that does not meet this requirement is only suitable for soldering kettles!

A. Sproxton,
Home Radio (Components) Ltd,
Mitcham,
Surrey.

Thank you all readers who have written enquiring about the absence of the January and February issues (see announcement on p.30). It's nice to know we have been missed!

Editor

Circuit Ideas

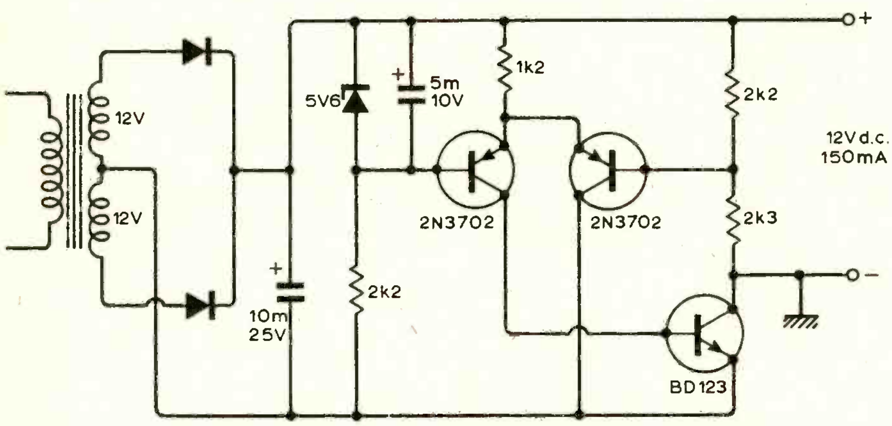


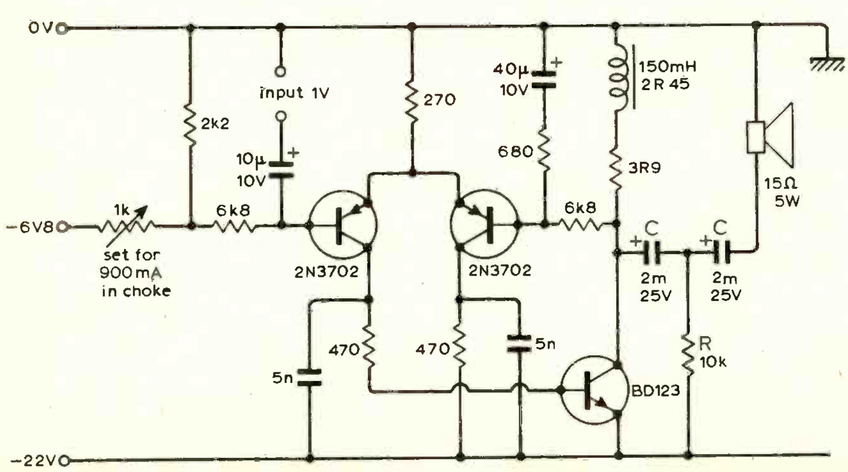
Novel 5-watt class A amplifier uses three-transistor feedback circuit

There are seemingly endless ways of making a feedback loop using two or three transistors. One configuration which has proved valuable is shown on the right. A fraction $R_1/(R_1+R_2)$ of the output p.d. is compared with the input in the long-tailed-pair Tr_1 and Tr_2 and the resulting current I_1 controls the current source Tr_3. In one application (below) a cheap voltage stabilizer was produced, in which the output p.d. is little less than the unstabilized p.d. and in which the ripple is low (usually incompatible requirements).

In another application the circuit was used to make a 5-W a.f. amplifier operating in class A. The usual emitter resistor (bottom) is now combined with the choke d.c. resistance in the collector circuit where it continues to provide d.c. stability with less nuisance value. The peculiar arrangement of *C*, *C* and *R* feeding the loudspeaker keeps the feed capacitors properly polarized as the output p.d. swings above and below zero level. A single capacitor could be used instead if the loudspeaker were returned to the negative supply, but power supply ripple would then find its way into the feedback loop.

R. H. Pearson
North East London Polytechnic

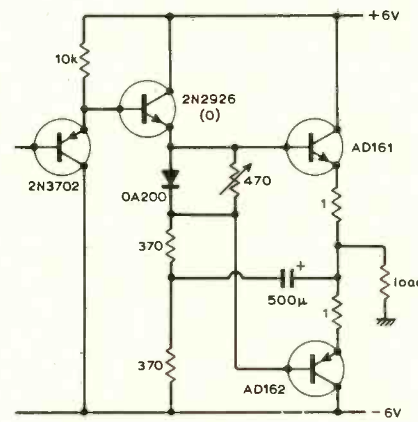




Deflection coil driver for slow-scan television

The circuit shown was developed for use in the line timebase amplifier of a slow-scan television system operating at 4Hz. The most unusual feature is the use of an emitter follower in the driver stage. This together with the first transistor was needed to match the output impedance of the unijunction oscillator used to provide the sawtooth waveform: such a circuit gives a large output voltage at high impedance. The amplifier drives the deflection coils of an old 17-in television tube, which have a resistance of about 5Ω. The diode and variable resistance provide slight forward bias for the output pair; the capacitor applies part of the base input to their emitters, enabling them to provide some voltage gain.

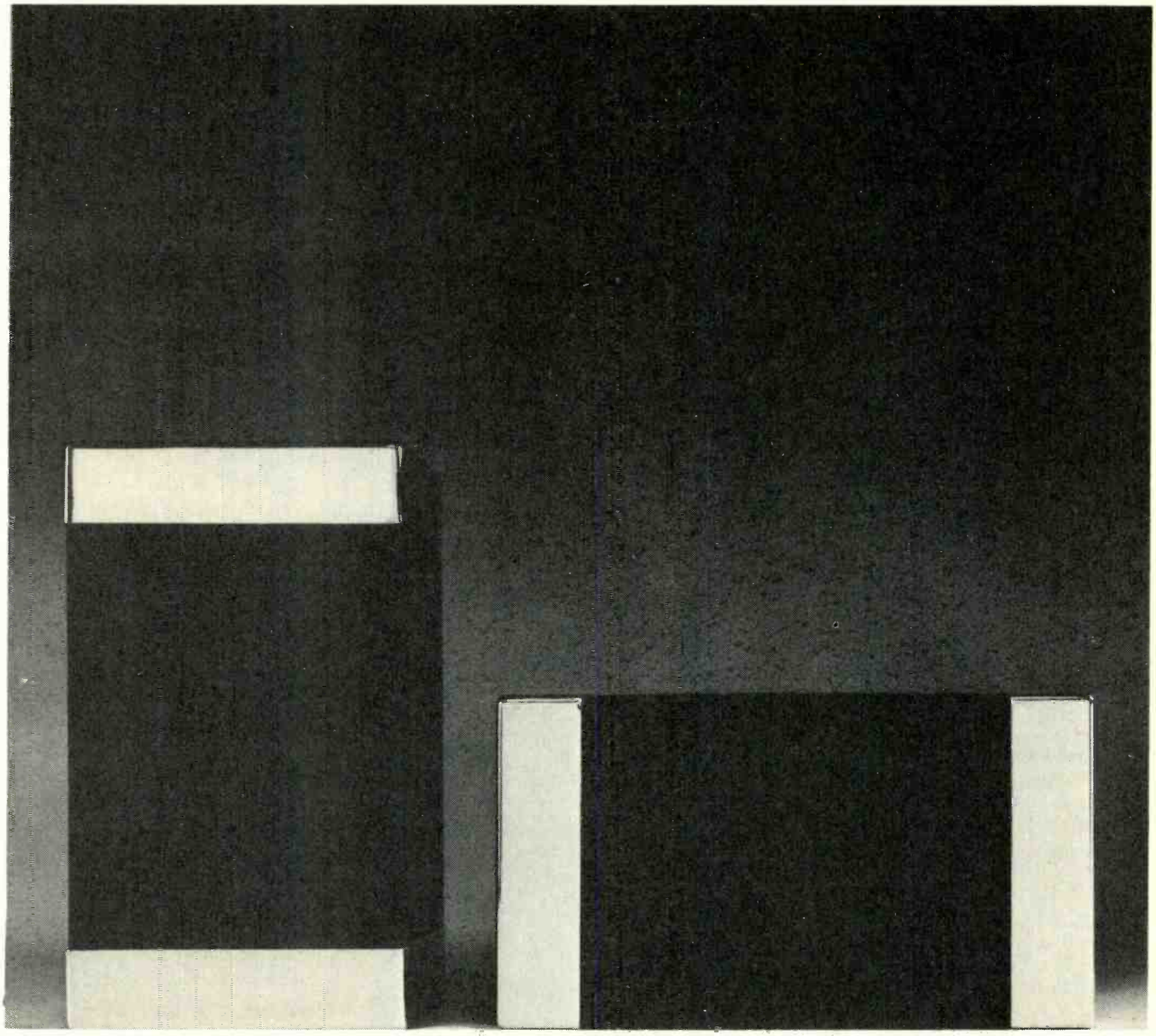
M. Hadley
Sutton Coldfield



Aerial seal of approval

Shown here is the new motif which is to be used by members of the British Aerial Standards Council. It will be seen on packaging and point of sale material going out to dealers as soon as existing stocks of packaging material have passed through the production pipelines.

The B.A.S.C. hopes that its "radiation pattern" symbol will quickly become a familiar sight in all places where television aerials are sold as ". . . the sign of a good aerial".



The Ultimate Draws a Little Closer

How can the qualities of the new Gale GS401A be conveyed? Not in words, certainly. To assess this new speaker, there's nothing for it but to go along to a dealer. He will tell you first that the GS401A carries a *seven* year guarantee. Then, when you've admired the handsome exterior created by Jon Bannenberg in matt black and chrome, we suggest you use some test equipment. All you have to do is take a good pair of ears. This delicate apparatus will tell you that, for a speaker only 23¼ x 13 x 10¾ inches, the GS401A combines an unusually high power handling with breathtaking clarity. You will also need a favourite record. Preferably the one you use to impress your friends with the quality of your existing equipment. The one with prominent percussion and a wide dynamic range. We have only one serious anxiety. With the GS401A being the breakthrough it is, we worry that you simply won't believe the evidence of your ears. At the time of going to press, the Gale GS401A can be seen at the following franchised dealers only.

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Thomas Heinitz Music in the Home 35 Moscow Road London W2
Henry's Radio Limited 354 Edgware Road London W2
REW (Audio Visual) Co Centre Point London WC1
Studio 99 81 Fairfax Road London NW6
Audio Systems 23 South Street Dorking Surrey
Audio Impressions Ltd 32 High Street South Dunstable Beds
Complete Audio Systems 32 Grove Road Eastbourne Sussex
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Guildford Hi Fi 270 Upper High Street Guildford Surrey
Audio Systems 28 Queens Parade Queen Street Horsham Sussex
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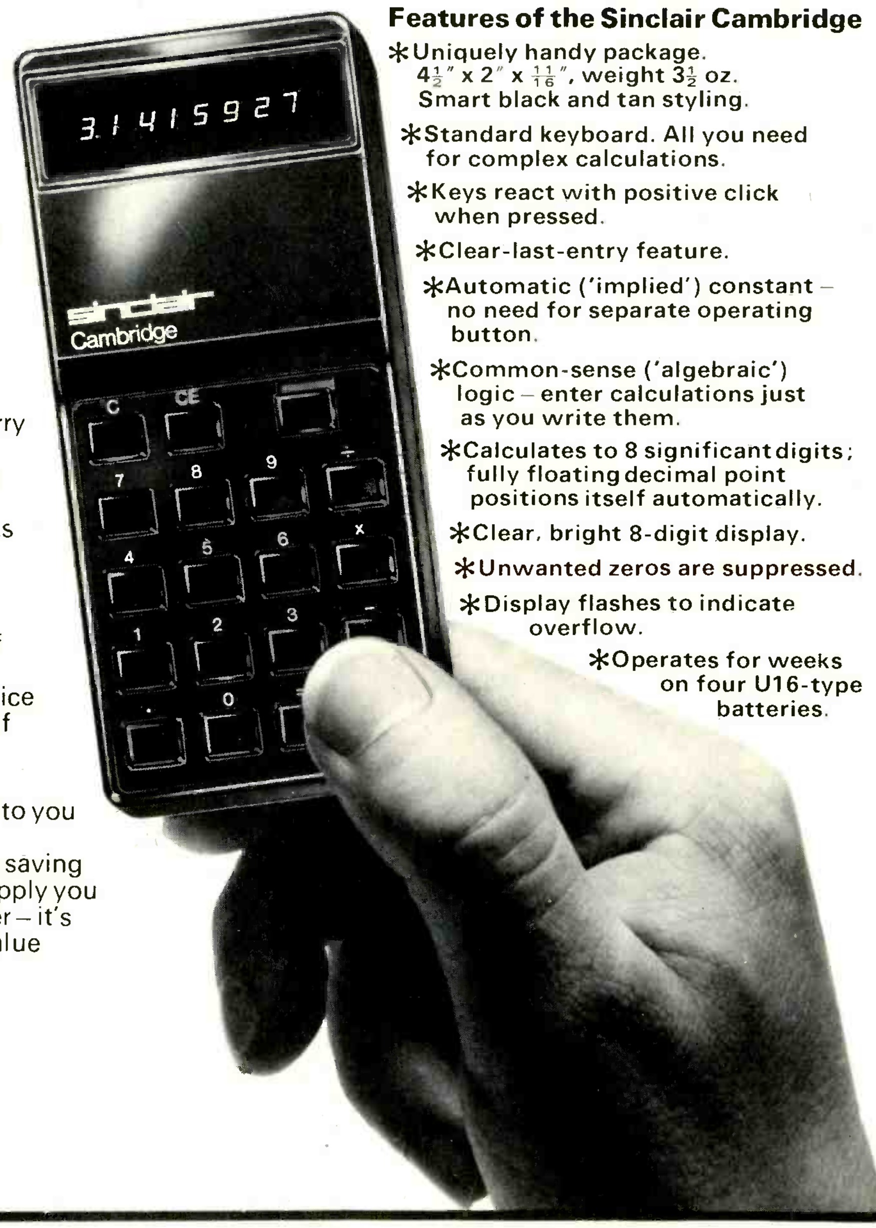

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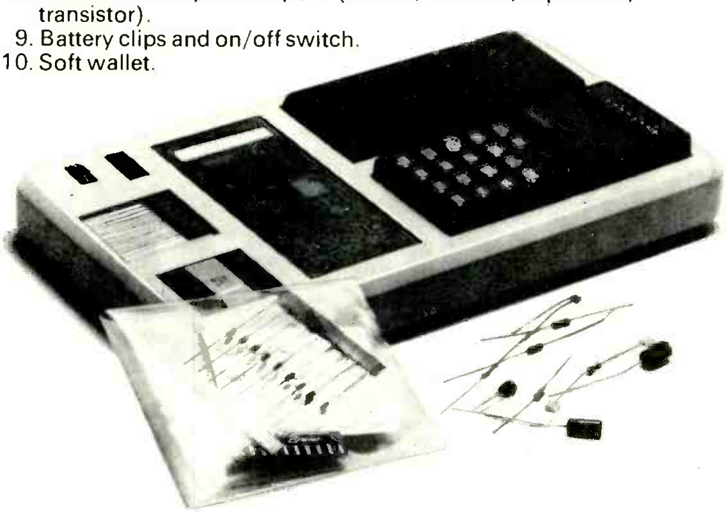

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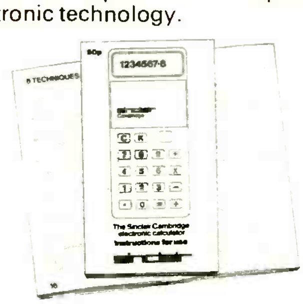

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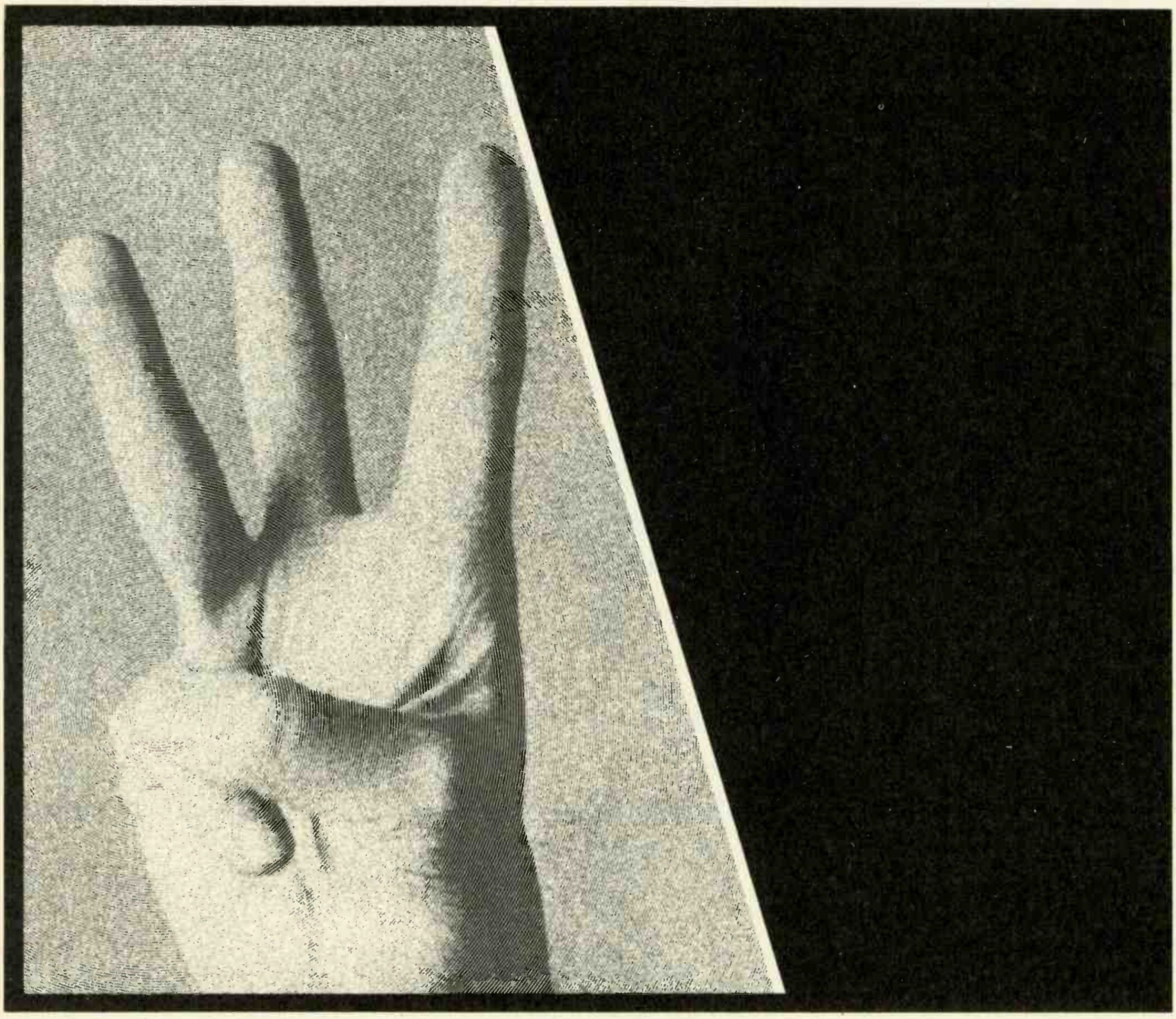


Horn loudspeaker design

Three articles summarizing the development of design theories and concluded with two systems for construction

by J. Dinsdale, M.A., M.Sc.
Cranfield Unit for Precision Engineering

After a period in the infancy of the gramophone when it was universally employed, the horn loudspeaker has fallen from popularity, due probably to its relatively large size, complexity of manufacture and hence high cost. Although full-range horn systems are used today only by a small number of enthusiasts, most experts are unanimous in acclaiming their virtues as loudspeaker enclosures, especially their high degree of realism and "presence". These articles examine briefly the history of the exponential horn loudspeaker and discuss the theory of horn-loading and the technical requirements of a good design. Comprehensive data are included for a wide range of horns, together with outline designs for a large and a small horn, suitable for domestic use.

The ideal exponential horn consists of a straight circular tube whose cross-sectional area increases logarithmically along its length from a small throat (at which is mounted the loudspeaker) to a large mouth. Extreme bass notes demand a mouth of very large area (20 to 30 sq. ft) and a horn at least 20ft in length, whereas extreme treble notes require a horn with dimensions of only a few inches. For this reason most wide-range horn systems will incorporate a number of separate loudspeakers, each with its individual horn of appropriate length and mouth area. To accommodate these horn combinations within a cabinet of reasonable size, the bass and middle horns are generally of square cross-section and are "folded" into a complicated pattern. Unfortunately, the inevitable restrictions and compromises introduced by these departures from a straight axis and circular section can cause serious variations in the frequency response, and much of the art of horn design is concerned with achieving a product of reasonable overall size and cost, without sacrificing any of the astonishing realism which is obtainable from the ideal horn.

The efficiency of a horn system will be typically between 30 and 50%, a figure to be compared with 2 or 3% for a bass-reflex enclosure and less than 1% for a totally-enclosed box.

The principal reasons for the evident lack of popularity of the horn probably lie in its dimensions and cost. The overall size of a bass horn, even when folded into a cabinet of reasonable shape, will be larger than a bass-reflex or infinite baffle enclosure of comparable specification. But although one reads occasionally of straight horns up to 20ft long, excellent results may be obtained from horns of more moderate dimensions; for example a complete horn system may be folded into an attractive cabinet of volume only 6 cu. ft, a not unreasonable size for domestic listening. The cost of horn enclosures is often considered to be prohibitive, and it is true that there is considerably more work in constructing a folded horn than in other enclosures; furthermore, this is work best performed by craftsmen and not easily adapted to "production-line" methods. Nevertheless, the building of a folded horn is by no means outside the capability of a competent do-it-yourself enthusiast, and it is to these individuals that the practical designs will be directed.

Although the early acoustical gramophones or phonographs employed horns of one type or another to couple the diaphragm to the listening room, and the early electrical reproducers of the 1920s and '30s also used horns, thereafter the horn suffered a setback from which it has never recovered. Certainly, a few companies market horn loudspeaker enclosures, and the occasional articles in the technical press[1,2] stir up a passing interest, but unless one resorts to the masterly academic treatises by Olson[3] or Beranek,[4] or reverts to pre-1940 publications, there is very little information available for the enthusiast who wishes to both design and construct a horn. Recent experience gained by Telfer and others[5,6] has reinforced the author's opinion that there are many audio enthusiasts who would be interested in constructing a horn enclosure.

After a brief historical survey, these articles examine the theory behind the horn-loaded loudspeaker enclosure and explain the basic points to consider when designing horns. The various compromises adopted by different workers are discussed, especially in the area of folding techniques, and the effects of these compromises on audio quality are studied. Finally, outline designs for two domestic horns are given: a "no-compromise" horn to suit the most fastidious (and enthusiastic) listener, and a "mini-horn" which provides a more limited performance for those with smaller living rooms (and bank balances), and which, while no more obtrusive than most commercial loudspeaker cabinets, will provide extremely clear and natural reproduction.

Background

It has been known for many thousands of years that when sound is passed through a tube with a small throat and a large mouth, it experiences an apparent amplification, and from Biblical times man has used rams' and similar naturally occurring horns both as musical instruments and as megaphones. Thomas Edison attached a tin horn to his primitive phonograph in 1877 to couple the minute vibrations of the diaphragm to the air load in the listening area, and to the majority, the term "gramophone horn" conjures up an image of the early gramophones or phonographs designed between about 1890 and 1912, all of which utilised an external horn.

A variety of expansion contours were employed for these early horns, mainly straight conical horns in the earliest machines, but the later gramophones of this period employed large flaring horns with either straight or curved axes depending on the overall length of the horn and the general design of the complete equipment. An analysis of these early horns, carried out in the light of modern acoustic knowledge, reveals a lack of understanding at that time of the operation of the horn as an acoustic transformer. This is surprising since Lord Rayleigh had analysed the "transmission of acoustic waves in pipes of varying cross-section" in Articles 265 and 280 of his classic treatise "Theory of Sound", published in 1878.[7]

Lord Rayleigh gave the analysis in Art.281 for the passage of sound through a conical pipe, and he also made the interesting statement that "when the section of a pipe is variable, the problem of the vibrations of air within it cannot be generally solved". For some years after publication, Lord Rayleigh's results were purely of academic interest, but more general interest was aroused about the turn of the century by the early gramophones, most of which used external conical horns, as in the early HMV "dog" models.

After 1912, a number of manufacturers introduced internal horns with a degree of folding to enable cabinets of reasonable size to be used, and these models held the consumer market during the following 12 years, on account of their compactness and suitability as pieces of furniture. (Even in those early days, the enthusiast must have had problems in persuading his wife to provide house-room for a large unfolded external horn.)

In the early 1920s a number of designers carried out theoretical analyses based initially on the work of Lord Rayleigh, but extending the work to be more applicable to the full audio range at domestic listening levels. Among these early analyses must be mentioned the work in America by A. G. Webster[8] in 1920, by C. R. Hanna and J. Slepian[9] in 1924 and by P. B. Flanders[10] in 1927. In Britain independent analyses were carried out by P. Wilson in 1926 writing in *The Gramophone* magazine and later with A. G. Webb in "Modern Gramophones and Electrical Reproducers", and also by P. G. A. H. Voigt[12] in 1927.

All of these analyses, except the last, were based on an exponential contour, and were derived from a statement in Art.265 of Rayleigh's treatise. Webster had worked out an approximate theory for other types of horn and had deduced that the exponential was the optimum contour. All these analyses made the assumptions that (a) the cross-section is circular, (b) the axis is straight, and (c) all wavefronts are plane.

However, while it may be reasonable to assume plane wavefronts at the throat of the horn, it is clear that the wavefront at the mouth will be curved (as if a balloon were emerging from the horn, being inflated at the same time). Wilson, who had independently derived the analysis of the exponential horn in 1926 working from Rayleigh's treatise, later published a modified form on the assumption that the wavefront would assume a spherical shape always cutting the contour of the horn and its axis at right angles.

This assumption, that the curvature of the wavefront would gradually increase from zero (the initial flat wavefront at the throat), satisfies also the condition specified by Hanna and Slepian and later by I. B. Crandall[13] that the wavefront as it emerges from the open end will be equivalent to that provided by a spherical surface, as opposed to that produced by a flat piston. Voigt, however, had commenced his analysis on the assumption that wavefronts within the horn will be spherical and of the *same* radius throughout their progression through the horn. This assumption leads to a tractrix curve for the horn contour, and both theoretical considerations and very careful listening tests by the author and others tend to support the claims of the tractrix as the optimum horn contour. The mathematical basis of the exponential and tractrix curves is discussed in a later section of this article.

During the 1920s, 30s and 40s a large number of experimenters investigated methods of folding horns into small enclosures for domestic gramophone reproducers, and the records of the Patents Office bear witness to the ingenuity of man at overcoming conflicting conditions in the search for perfect sound reproduction.. These designs for folded horns enjoyed a greater or lesser degree of success according to a number of factors including the performance of the loudspeaker motor. Nevertheless, it must be repeated that they were almost invariably of square or rectangular cross-section, and the axis was no longer straight and thus any resemblance between their actual performance and theoretical considerations was to some extent coincidental.

The advent of the moving coil loudspeaker in 1927 and electrical amplification stimulated further advances in the design of horns, which, because they now no longer had to be connected to the acoustical tone-arm, were freed of many of the earlier constraints. Many loudspeaker motor units were designed specifically for horn loading, and it was not until World War II that interest in the horn lapsed in favour of the bass reflex, infinite baffle and other types of loading systems which, although they had the peripheral advantages of smaller physical size, greater ease of design and manufacture and hence lower cost, were decidedly inferior in terms of musical realism.

During this time the designs of Voigt in Britain and of Klipsch[14-18] in America continued to attract considerable support, especially the ingenious method evolved by the latter in adapting a doubly-bifurcated bass horn design to utilize the acoustic advantages inherent in corner positioning, a design which has now become a classic. Others at this time were experimenting with horn-loaded loudspeakers, notably J. Enoch and N. Mordaunt (whose design was subsequently incorporated in the Tannoy "Autograph" and "GRF" enclosures). Lowther (using a modern version of Voigt's high-flux motor unit) and J. Rogers (whose horn-loaded mid-frequency ribbon is still regarded by many as the ultimate in sound reproduction in this range) and one must not overlook the contributions of H. J. Crabbe[19] and R. Baldock[20] in more recent times.

However, it must be emphasised that the multiple reflections, absorptions, resonances and changes of direction inherent in folded horns, together with the uncertainty of function of non-circular sections must inevitably alter the performance of such horns from that of the straight, circular-section horn on which the design may have been based.

Recent years have seen a minor resurgence in the popularity of the horn, caused perhaps by the search for "perfect sound reproduction", and there are many who hope that this trend will continue.

A very readable account of the early history of the horn loudspeaker has been given recently by P. and G. L. Wilson.[21]

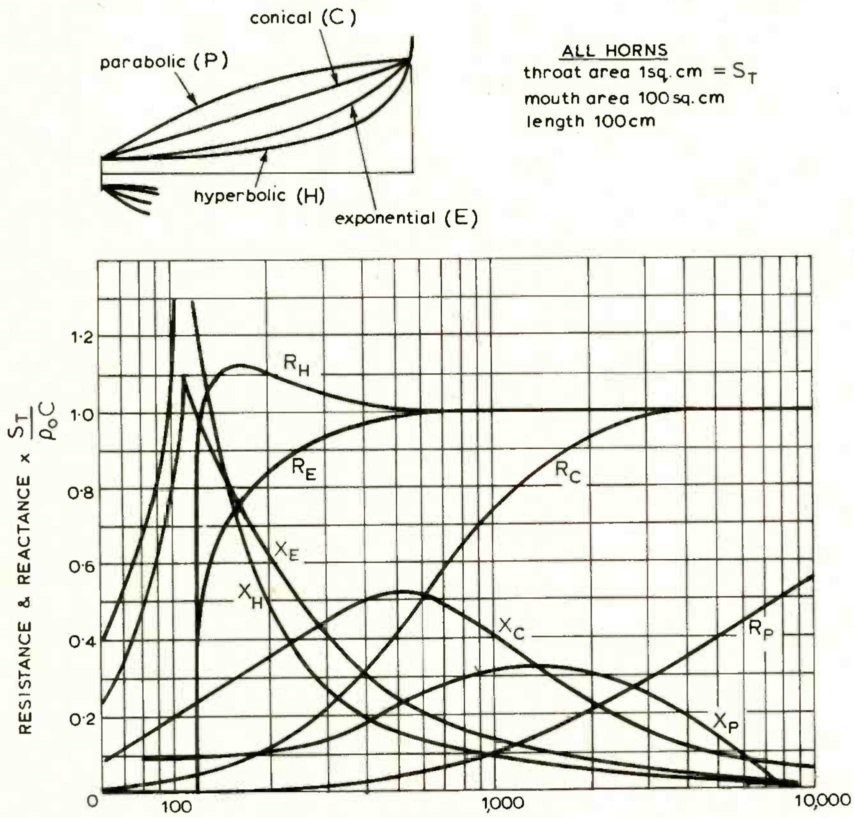


Fig. 1. Acoustical resistance and reactance against frequency at the throats of a series of infinite horns of different contour.

General theoretical principles

The following section deals principally with the exponential contour, which is the basic expansion curve used in most high quality horn loudspeakers, and the tractix, which has a more complicated formula, but with a dominant exponential component—indeed the two curves are virtually identical from the throat to about midway down the horn.

Determination of flare contour

The theory of the conical horn was originally worked out by Lord Rayleigh, but the first serious attempts to establish a practical working formula for the exponential horn were not made until 1919 and the years following. The basic formulae for the transmission of sound waves through horns have been given in modern terms by V. Salmon[22] and others. Beranek[4] has plotted the acoustical resistance and reactance against frequency at the throats of a series of infinite horns of different contour with identical cross-sectional areas at the throat and at a given point along the axis of the horn, and the resulting curves are shown in Fig. 1. For optimum loading of the loudspeaker motor, it may be shown that the impedance presented by the throat of the horn should be entirely resistive and of constant value throughout the working frequency range, i.e. the sound transmission should be of unity "power factor". Examination of the curves in Fig. 1 shows that the exponential and hyperbolic contours satisfy this condition most closely.

However, a further condition to be satisfied is that of minimum distortion at the throat of the horn, caused by "air overload". When a sound wave is propagated in air, a series of harmonics will be produced, thereby distorting the waveform. This occurs because if equal positive and negative changes in pressure are impressed upon a mass of air, the resulting changes in volume will not be equal; the volume change due to an increase in pressure is less than that due to an equal decrease in pressure. The rapid expansion and compression of air caused by the propagation of sound waves takes place adiabatically, i.e. there is no net transfer of heat, and the pressure and volume are related by the formula pV^γ = constant, where

p = pressure
V = volume
γ = adiabatic gas constant (approx. 1.4 for air under normal room conditions)

This curve has been plotted in Fig. 2, together with a superimposed large sinusoidal change in pressure to illustrate the corresponding distorted change in volume.

If the horn were a long cylindrical pipe, distortion would increase the further the wave progressed towards the mouth. However, in the case of a flaring horn, the amplitude of the pressure wave decreases as the wave travels away from the throat, so for minimum distortion the horn should flare out rapidly to reduce the pressure amplitude as early as possible after the sound wave has left the throat. From this viewpoint it is apparent that the parabolic and conical contours will generate the least distortion due to air overload, and that distortion will be highest for the hyperbolic horn, because the sound wave must travel a further distance before the pressure reduces significantly.

Further inspection of Fig. 1 shows that the acoustical resistance of the hyperbolic horn lies within 10% of its limiting value over a larger part of its working frequency range than that of the exponential horn, and for that reason the hyperbolic horn provides rather better loading conditions to the loudspeaker motor. However, in view of the considerably higher air-overload distortion of the hyperbolic horn, the exponential or one of its derivatives is generally chosen as a satisfactory compromise between the hyperbolic and conical contours.

In cases where the advantages of a long

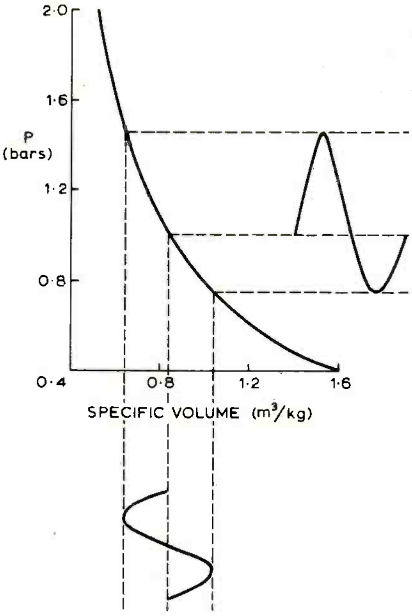


Fig. 2. Adiabatic pressure/volume relationship for air.

slow flare rate are required without the attendant high air-overload distortion, Olson[3] has shown that a horn can be made up of a series of manifold exponential sections, commencing with a very short stub of high flare rate at the throat (to minimize distortion) which leads into a longer section of lower flare rate and thence to the main horn of very low flare rate. Klipsch has referred to this technique as the "rubber throat" in his paper on corner horn design.[14] The mouth acoustical impedance of each exponential section is designed to match the throat impedance of the preceding section, right along the chain. Practically any acoustical impedance relationship with frequency may be obtained by this technique, but the procedure is complicated, and the additional effort cannot generally be justified for domestic horns.

Determination of mouth area

The acoustical resistance and reactance of the exponential horn have been plotted on a normalized scale in Fig. 3, which shows that the acoustic impedance is entirely reactive below a frequency given by

$$f_c = \frac{mc}{4\pi}$$

where c = speed of sound; m = flare constant which appears in the basic exponential horn formula

$$S_x = S_T e^{mx}$$

where S_x is the area at distance x from throat; S_T is the area at the throat.

The frequency f_c, known as the cut-off frequency, is the lowest frequency at which the horn will transmit acoustical power, and thus the flare constant defines the lower frequency of transmission by a given horn. The flare constant may be calculated for any given cut-off frequency, and the horn profile may then be constructed. The above statement refers strictly only to horns of infinite length. In horns, as in cylindrical tubes, wavefronts of sounds whose wavelength is large compared with the mouth diameter tend to be reflected back into the horn where they interfere with successive wavefronts. Just as the loading of the loudspeaker motor by the throat of the horn must be largely resistive over the working frequency range for the smooth efficient transfer of acoustical energy, so must be the loading presented to the mouth of the horn by the surrounding air. Beranek has shown[4] that for the radiation impedance of the mouth to be mainly resistive, the relationship $C/\lambda > 1$ must hold, where C is the circumference of the mouth of the horn and λ is the wavelength of the lowest note to be transmitted. If the mouth of the horn is not circular, it will behave in a similar way for equal mouth areas, i.e. if $C = 2\pi r_m > \lambda_C$ is the limiting condition

and $$S_m = \pi r_m^2 > \frac{\lambda^2 c}{4\pi} \quad r_m > \frac{\lambda_C}{2\pi}$$

where λ_C = cut-off wavelength; r_m = mouth radius; S_m = mouth area.

Thus a horn of square section may be employed provided the mouth area exceeds $\frac{\lambda_C^2}{4\pi}$. Hanna and Slepian had examined from

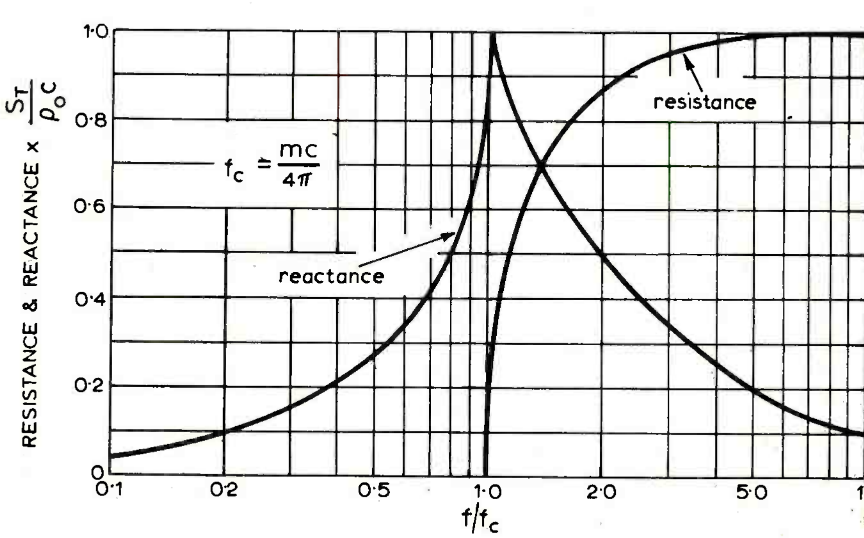


Fig. 3. Acoustical resistance and reactance of an exponential horn.

a different standpoint the behaviour of wavefronts at the mouth of the horn, and deduced that reflection was a minimum when the slope of the profile was 45° (i.e. included angle of 90°). This will be so where the mouth circumference equals the cut-off wavelength of the horn. It also illustrates the importance of distinguishing between the values of flare constant used for calculating exponential increase in area, and in plotting the profile of the actual horn. Fig. 4 (after Olson) illustrates the effect of foreshortening the horn to a length less than the ideal. When the mouth circumference becomes less than the cut-off wavelength, reflections at the mouth cause objectionable peaks and troughs in the frequency response at frequencies near to cut-off, and if, in a given design, the mouth dimensions are restricted, it is generally preferable to increase the cut-off frequency to a value which allows the correct mouth area to be adopted, rather than to accept the uneven bass response illustrated in Fig. 4.

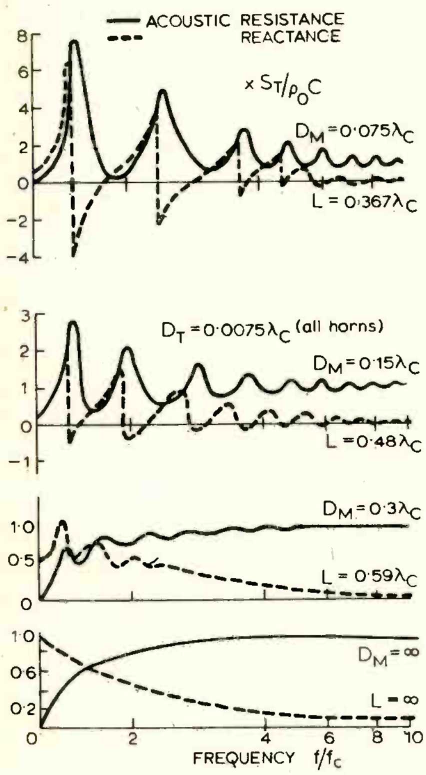


Fig. 4. Performance of foreshortened horns. Reflections at the mouth cause peaks and troughs in the frequency response near to cut-off.

Plane and curved wavefronts

Hitherto, the assumption has been made that successive wavefronts remain plane throughout their propagation through the horn. However, along a straight circular section horn the wavefront must be normal to the axis, and also normal to the walls. (If the wavefront were either approaching or receding from the walls, energy would be either absorbed or supplied; alternatively, the composite wavefront resulting from the original wavefront and its reflection will itself be normal to the walls.) Thus wavefronts transmitted along a cylindrical tube will be plane, while wavefronts transmitted down a conical horn will be spherical. It is therefore clear that the wavefront emerging from an exponential horn will possess a degree of curvature, and that the conventional calculations made on the assumption of the exponential increase of plane wavefronts will be in error (in practice, the actual cut-off frequency will be somewhat altered from that derived theoretically, and the profile errors of the horn are not excessive).

The correct approach to the design of a horn in which the areas of successive wavefronts expand according to a true exponential law is not certain, since any horn profile chosen will *per se* determine the contour of the wavefronts within it, and in general this contour will be different to that originally assumed. Wilson[11] decided to assume spherical wavefronts of increasing curvature from zero (plane wavefronts) at the throat of the horn, and on this basis he calculated a modified contour which lies just inside and very close to the true exponential. Fortuitously, if a papier mâché horn is made on a solid former designed to a true exponential contour, the shrinkage of the papier mâché when drying converts the horn very closely to Wilson's modified form. Nevertheless, the prime assumption has been made that wavefronts are spherical and of changing curvature, and it is by no means certain that this is the case.

The tractrix contour

Voigt, in his 1927 patent, had proceeded on the more elementary assumption that the wavefronts within the horn must be spherical and of the same radius throughout their propagation through the horn. He based this assumption on the reasoning that if the curvature increases from plane waves (zero curvature) at the throat to a certain curvature at the mouth, then a point on the axis must travel at a faster rate than a point at the wall. Since the entire wavefront must travel at the speed of sound (assumed to be constant throughout the horn) the wavefront has no alternative but to be spherical and of constant radius. This requires that the horn contour should be the tractrix.

The tractrix is the involute of the catenary (the curve adopted by a uniform heavy chain suspended between two points at the same level) and is the curve traced out by a load being dragged along by a man moving in a straight line not passing through the load. It is not the "pure pursuit" curve traced by a missile which always travels towards an escaping target, as is often mistakenly supposed. The length of a tractrix horn of mouth circumference λ_C, may be expressed as the cut-off wavelength

$$x = \frac{\lambda}{2\pi}\log_e \frac{\dfrac{\lambda}{2\pi} + \sqrt{\left(\dfrac{\lambda}{2\pi}\right)^2 - y^2}}{y} - \sqrt{\left(\frac{\lambda}{2\pi}\right)^2 - y^2}$$

where y is the radius

cf. the equivalent exponential,

$$x = \frac{\lambda}{2\pi}\log_e\left(\frac{\lambda}{2\pi y}\right)$$

Both these curves are shown in Fig. 5.

It will be seen that the tractrix has a dominant exponential term which becomes less significant towards the mouth; in fact for the first 50% of their length the exponential and tractrix contours for a given cut-off frequency and throat area are virtually identical, but thereafter the tractrix flares at an increasingly greater rate until it attains its fully developed mouth at 180° included angle. In view of the complex nature of the formula, the best way to construct a tractrix is by graphical means, as shown in Fig. 6. The curve thus derived may be used to provide ordinates for the tractrix horn, after some smoothing of the slight discontinuities inherent in the graphical construction.

Whereas the tractrix terminates when the angle between the horn and the axis is 90° (180° included angle), the true exponential goes on to infinity in both directions. The

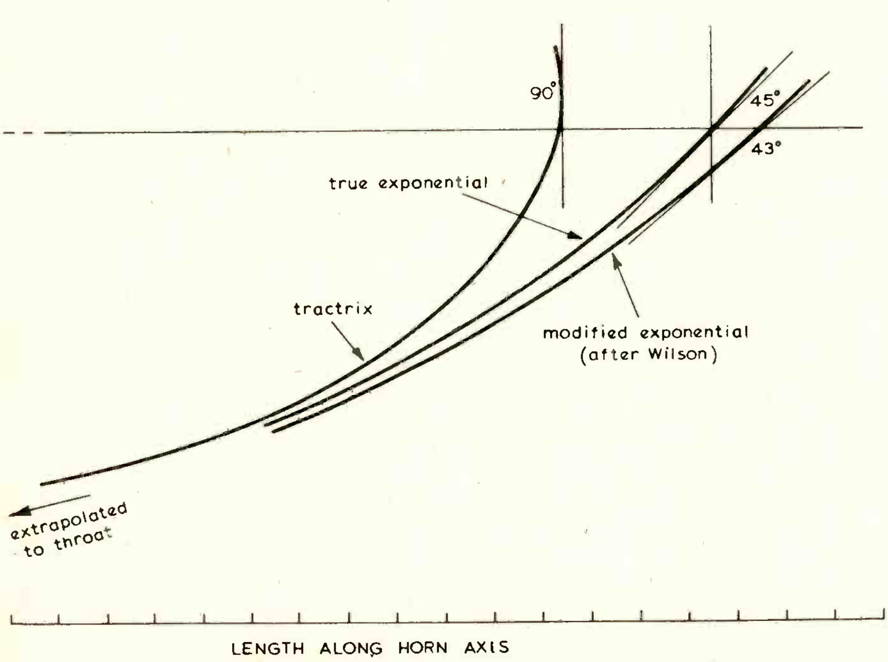
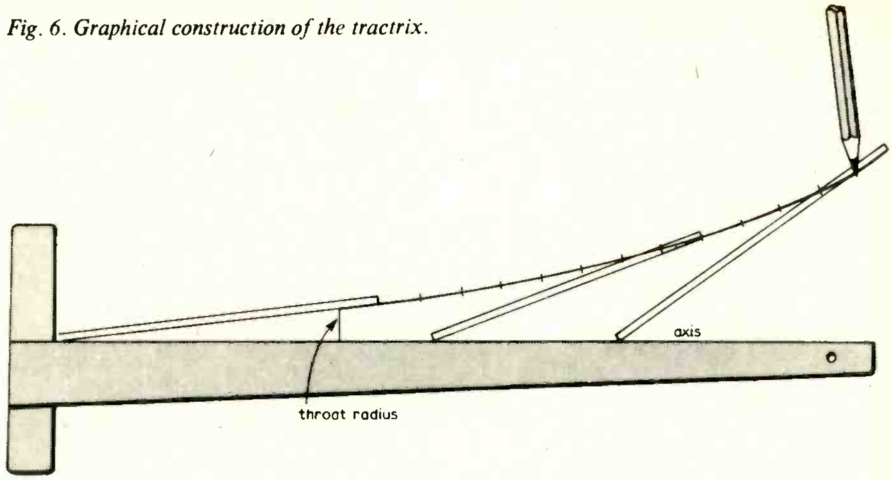


Fig. 5. Comparison of the exponential and tractrix contours.

tractrix horn for given throat and mouth dimensions is thus shorter than the equivalent exponential. It has been suggested that with the full tractrix terminating in a mouth of 180° included angle, the sound appears to originate from a point just inside the mouth, where the included angle is only 90°. There is thus some evidence that the tractrix may be terminated prematurely at this point, and if this is done, the mouth perimeter will be 90% of the wavelength at cut-off, as shown in Fig. 5, which compares the true and modified exponentials and the tractrix contours.

Fig. 6. Graphical construction of the tractrix.



Using a straight edge of length equal to the final mouth radius, the tractrix curve is constructed of a series of tangents, length not greater than $\frac{1}{10}$ the mouth radius, starting at the throat.

Efficiency

The efficiency of an exponential horn loudspeaker is determined by a large number of parameters, and a comprehensive treatment has been provided by Olson.[3] Typical efficiencies of bass horns can be as high as 50%, while mid-frequency and treble horns can have efficiencies of over 10%, and these figures compare very favourably with bass-reflex enclosures (efficiency 2 to 5%) and infinite baffles (efficiency generally less than 1%). The extremely high efficiency of the horn is not necessarily of value in enabling amplifiers of lower output power to be used. Indeed, some class B output stages may produce a higher distortion level in horns because they need only be operated within the first 10% of their capability, at which low levels the effects of crossover distortion are more pronounced.

The principal advantage conferred by the horn's high efficiency is that for a given loudness the amplitude of movement of the loudspeaker motor is appreciably less than with other enclosures. The effects of non-linearities in the magnetic field and suspension are therefore greatly reduced, and there is less tendency for "break-up" of the cone to occur. Thus the relatively high distortion products normally produced by the loudspeaker motor will be minimized, and, provided the horn itself does not introduce distortion, extremely high quality sound can be radiated.

A further advantage resulting from this reduction in amplitude of movement of the cone is that a form of inter-modulation distortion, caused by variation of the volume of the cavity between the loudspeaker cone and the throat of the horn, may be reduced to negligible proportions.

Tuning the throat cavity

The cavity, which must inevitably exist between the loudspeaker diaphragm and the throat of the horn, plays an important function in the design of horn systems, since it can be used to limit the maximum frequency to be transmitted. Although the lower frequency limit may be set with some precision by the flare rate of the horn, in conjunction with the mouth area, the upper frequency limit is ill-defined, being determined by a combination of (a) unequal path lengths between different parts of the diaphragm and the throat of the horn, (b) internal cross reflections and diffraction effects within the horn, especially when the horn is folded, (c) the high frequency characteristics of the motor unit itself, and (d) the effective low-pass filter characteristic presented by the cavity between diaphragm and throat.

It may be shown that a cavity of fixed volume behaves as an acoustic reactance of value

$$\frac{S_D{}^2\rho c^2}{2\pi f V}$$

where S_D = area of diaphragm, V = volume of cavity, ρ = density of air, c = speed of sound, f = frequency.

When the cavity is placed between the diaphragm and throat, it behaves as a "shunt capacitance" across the throat itself, and thus by choosing the correct parameters, the cavity/throat combination acts as a low-pass filter at a frequency which may be set by making the cavity impedance equal to the throat impedance at the desired frequency,

i.e. $$\frac{S_D{}^2\rho c^2}{2\pi f V} = \frac{\rho c S_D{}^2}{S_T}$$

where S_T = throat area, f = desired upper frequency limit, whence

$$V = \frac{cS_T}{2\pi f}$$

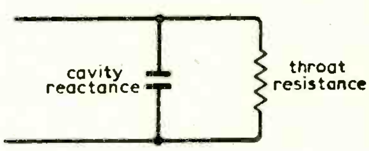
The volume of the cavity may therefore be calculated to provide high-frequency roll-off at a point before the poorly-defined effects (a) to (c) stated above become significant (Fig. 7).

A further benefit resulting from the use of a cavity tuned to prevent mid and high frequencies from entering a bass horn at the rear of a loudspeaker is that the efficiency of transmission of these frequencies by the opposite side of the loudspeaker is greatly increased, thus improving the performance of a mid/high frequency horn mounted at the front of the loudspeaker.

The considerations affecting the practical determination of the upper and lower frequency limits of a particular horn will be considered in more detail.

Loading the rear of the loudspeaker motor

Mention has already been made of distortion resulting from the non-linear expansion/compression characteristics of air. This effect is accentuated when a loudspeaker is horn-loaded on one side only, because the



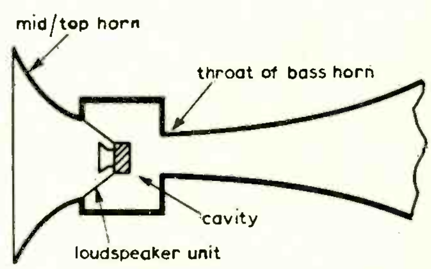


Fig. 7. Effect of the throat cavity in limiting high frequency performance.

constant resistance characteristic of the throat acts only against excursions of the cone in the forward direction; when the cone moves back it is against a far lower load and hence the excursion will be larger. The ideal way of eliminating this distortion is to load both sides of the loudspeaker by equal horns, or to employ a bass horn for loading the rear of the cone and a middle/top frequency horn to load the front. The design of the mini-horn, to be described, utilizes this feature.

An alternative solution favoured by many designers is to load the rear of the loudspeaker by a sealed compression chamber, the effect of which is to provide a loading similar to the horn. The compression chamber thus reduces the effects of non-linearity due to uneven loading on each side of the loudspeaker diaphragm, and also presents a better resistive load to the diaphragm because a closed chamber on the opposite side of the diaphragm to the horn itself acts as an "inductive" reactance which tends to balance the "capacitive" reactance presented by the mass reactance of the throat impedance at low frequencies.

Klipsch states[14] that the volume of this cavity is given by the throat area multiplied by the speed of sound divided by 2π times the cut-off frequency. This is readily shown as follows:

The air chamber reactance is given by

$$\frac{S_D{}^2\rho c^2}{2\pi f_c V}$$

where S_D = diaphragm area, V = volume of air chamber.

The throat reactance at cut-off is

$$\frac{\rho c S_D{}^2}{S_T}$$

where S_T = throat area.

Equating these,

$$V = \frac{cS_T}{2\pi f_c}$$

However, some observers claim that the use of a compression chamber detracts from the realism of the reproduced sound, and advocate either double horn-loading or a combination of horn-loading with direct-radiation from the other side of the diaphragm; in other words, the most realistic reproduction occurs when both sides of the diaphragm are allowed to radiate.

Summary

In summarizing this section, it is clear that there is no universal formula applicable to any aspect of horn design. The reason for mentioning the alternative approaches and for providing a comprehensive list of references is to stimulate others to experiment in those areas where to a large extent results must be evaluated subjectively by very careful comparative listening tests *a posteriori*.

To quote Wilson:[21] "It cannot legitimately be assumed that a horn incorporated in a cabinet has the precise characteristics of any particular type of straight horn, whether exponential, hyperbolic, catenary or tractrix, even though their dimensions have been used as guides in its construction. The multiple changes of direction, coupled with reflections and absorptions and internal resonances, are always such as to destroy any legitimate comparison. Every internal (horn) enclosure construction must be judged on its merits as revealed by measurement and by listening tests."

(*To be continued*)

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GENERAL INFORMATION

A catalogue which uses no words and which is, therefore, international, is obtainable from Keyswitch Relays Limited, Bendon Valley, Garratt Lane, Wandsworth, London SW18 4LZ.........WW401

Technical and sales information on miniature switches (including illuminated types), circuit breakers, rotary stud switches and audible indicators (annunciators) is presented in a new catalogue from Highland Electronics Limited, 33-41 Dallington, Street, London EC1V 0BD WW402

Electroforming techniques and new nickel alloy production methods are among the subjects discussed in Issue 38 of *Inco Nickel*, published by International Nickel Limited, Thames House, Millbank, London SW1P 4QF...............................WW403

We have received the new Antiference catalogue, which contains descriptions of a full range of radio and television aerials, and folders on a new range of fringe-area v.h.f. aerials and improved folded dipole ranges. Antiference Limited, Aylesbury, Bucks. WW404

A wall-chart showing a range of lever-operated, magnetic and inductive limit switches is obtainable from Herbert Controls and Instruments Limited, Spring Road, Letchworth, Hertfordshire. WW405

Issue No.98 of the Tin Research Institute review *Tin and its Uses* contains articles on solderable finishes, plastic plating, long-life soldering bits and hot tinning. The publication can be obtained from the Tin Research Institute, Fraser Road, Greenford, Middx., in English, French, German, Italian, Spanish and Japanese editions. WW406

A catalogue describing panels, socket boards, connectors and racks has been sent to us by Tekmar Electronics Ltd., 102 High Street, Harrow-on-the-Hill, Middx., HA1 3LP. Power supplies and crystal oscillators are also included in this Dual-in-line Socket Board and Packaging Hardware catalogue, ...WW407

Lasky's have produced their 1974 catalogue, which contains information on a range of audio, television and communications equipment, together with a selection of test equipment. Lasky's, Audiotronic House, The Hyde, London NW9 6JJ.............WW435

Public address equipment, including amplifiers, microphones, mixers, speakers and accessories is described in a new brochure from Eagle International, Precision Centre, Heather Park Drive, Wembley, Middlesex WW436

The latest issue of the RS Components catalogue is now available, additions being miniature l.e.ds, an i.c. timer and a 5W audio amplifier i.c. among many others. RS Components Ltd, P.O. Box 427, 13-17 Epworth Street, London EC2P 2HA...............WW437

EQUIPMENT

We have received a leaflet on the Bloodhound detector for gas, smoke and combustible vapours from P. H. Electronics, Sandwich Industrial Estate, Sandwich, Kent CT13 9LN. WW408

Information on a range of digital frequency meters, including one 32MHz instrument which performs this function only and is very simple to use, is contained in leaflets published by Radio Control Specialists Limited, National Works, Bath Road, Hounslow, TW4 7EE. WW409

The third issue of *OMR News*, devoted to products and their applications in the field of optical mark recognition data-capture techniques has just been published by Data Recognition Limited, Loverock Road, Battle Farm Estate, Reading Berks. RG3 1DX. WW410

High-voltage d.c. insulation testers and fault locators are described in a catalogue sent to us by Hipotronics, Inc., Route 22 — Brewster, New York.....WW411

Varactor-tuned solid-state oscillators operating in the range 0.2 to 20GHz are the subject of a catalogue published by Watkins-Johnson International, Shirley Avenue, Windsor, Berkshire. WW412

The PEP400 series of scan converters and image storage units is described in a leaflet published by Princeton Electronic Products, Inc., P.O. Box 101, North Brunswick, New Jersey 08902. ..WW413

We have received from CAI Limited, 95A High St., Rickmansworth, Hertfordshire, a booklet on their minicomputer — the Naked Mini — which is a complete computer on one printed-circuit board. It is also available in a cased version. WW414

A new catalogue available from Eagle International, Precision Centre, Heather Park Drive, Wembley HA0 1SU describes their full range of audio equipment and specifications...WW434

A range of digital panel meters for the measurement of voltage, current, temperature and time and for counting events is presented in a leaflet produced by Newport Laboratories Inc. The equipment is distributed by Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks.......................................WW430

Voltage dividers, attenuators and decade boxes are the subject of a new brochure sent to us by Danbridge (U.K.) Ltd, Sherwood House, High Street, Crowthorne, Berks...WW431

APPLICATION NOTES

A brochure, obtainable from Penny and Giles Limited, Mudeford, Christchurch, Hampshire, gives design information on the use of zener barriers with intrinsically safe equipment installed in hazardous atmospheres. WW415

A manual on the application of Accuride telescopic drawer slides has been published by the Accuride Division of Imhof-Bedco Limited, Colne Way Trading Estate, By-Pass, Watford, Herts, WD2 4NE. WW416

An application note entitled "Numeric and Alphanumeric Display using the ZM1251 Dot Matrix Display Tube" is obtainable from Computer Electronics Division, Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD. Requests for copies should be on company letter-heads and should quote reference TP1341. ....WW417

Microwave Landing Aid

Flexible Doppler system which could replace ILS as an aeronautical navaid

This year the Royal Aircraft Establishment will be starting feasibility studies of a microwave landing aid which could eventually replace ILS (Instrument Landing System) as the principal aircraft landing aid of the world's airports. The new aid, known as MLS (Microwave Landing System), will provide positional information for aircraft by means of the Doppler frequency shift principle, the frequency shift being produced by relative movement between a moving source of radio waves on the ground and a receiver in the aircraft.

This microwave Doppler system has already been proposed by U.K. authorities to the International Civil Aviation Organization (ICAO). Now, an agreement between Plessey Radar, the Ministry of Defence, the Civil Aviation Authority and the Department of Trade and Industry will enable the system to be further developed and submitted complete to ICAO with the support of flight trials. Plessey are building experimental equipment for the studies with Standard Telecommunication Laboratories as sub-contractors.

Aviation people have been aware of shortcomings in ILS for a good many years. First of all there is its inflexibility: aircraft must fly in straight paths down fixed radio beams generated by "localizer" (azimuth) "glideslope" (elevation) and "marker" beacons. Another problem is that ILS cannot be employed on all runways at an airport because it uses ground reflections to form the radio beams, and these, therefore, are vulnerable to irregularities of the site. The "localizer" propagation path in particular is vulnerable to noise caused by re-radiation from fixed and moving objects (e.g. airport buildings and aircraft taking-off) and by locally generated interference. Such problems could be mitigated by the use of narrower radio beams, but at the v.h.f. and u.h.f. used this would require very large aerial arrays. ILS uses broad beams and obtains the required precision by interpolation from the cross-over of the beams. This confines the region of proportional guidance to a narrow sector and so prevents ILS from providing the aircraft approach procedures envisaged for the future, for example, glideslopes arranged for noise abatement, approaches for STOL and VTOL aircraft, curved approaches for traffic sequencing, and "missed approach" guidance.

Alternatives to ILS have been under consideration for some years. For example in May 1967 we reported on "Correlation Protected I.L.S."[1] and in May 1972 on the interferometric system MADGE (Microwave Aircraft Digital Guidance Equipment)[2] both of which work at microwave frequencies. The first has fallen by the wayside, while the second is intended mainly for military airfields. A further microwave system, now being considered at the same time as MLS, uses narrow radio beams which are scanned either mechanically or electronically across the required space in azimuth and elevation. These beams have to be encoded to indicate their instantaneous pointing angle.

The main advantages of the Doppler MLS, as well as of the scanning beam system, over ILS are greater flexibility of

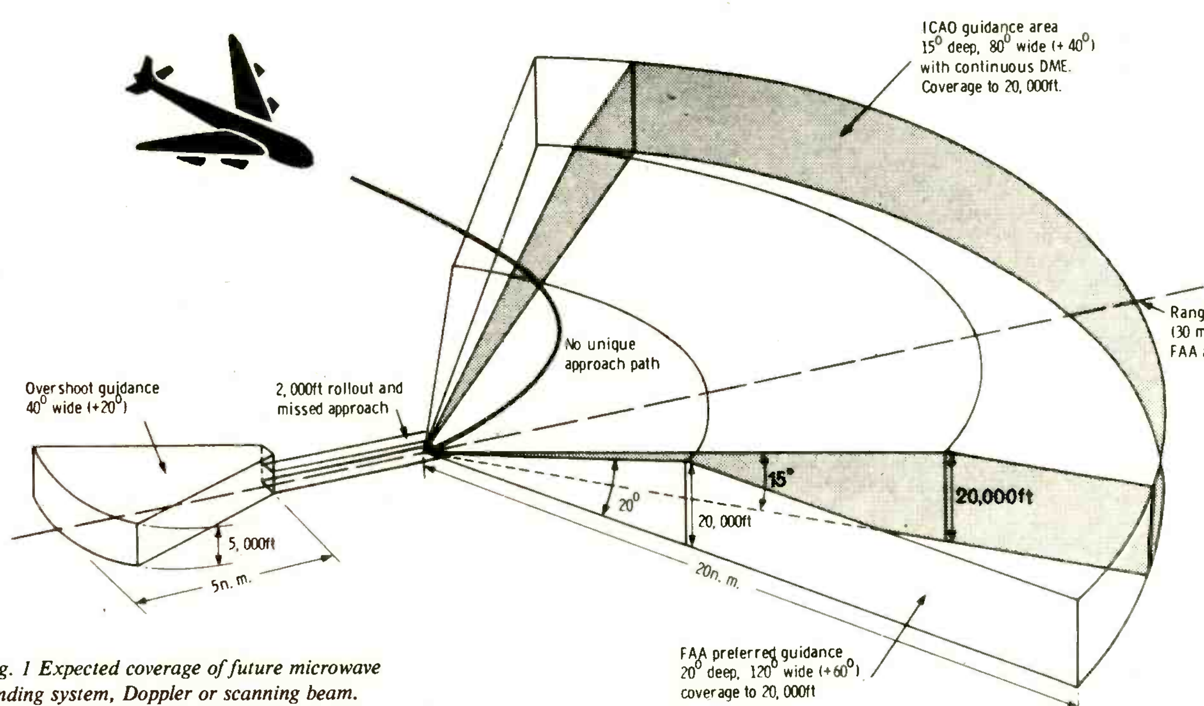

Fig. 1 Expected coverage of future microwave landing system, Doppler or scanning beam. (FAA stands for the American Federal Aviation Agency.)

operation and freedom of siting. They will handle aircraft descending in curved approach paths over a wide range of angles in both azimuth and elevation as shown in Fig.1. This wider operational coverage will also facilitate the landing of STOL and VTOL, private and business aircraft, and will provide landing and "missed approach" guidance in all-weather operations for new generations of aircraft.

The path finding principle of the Doppler system is based on a ground transmitter (in the frequency range 5000-5250MHz) which provides a linearly moving radiating source. In fact the linear movement is simulated by switching a source of radiation, element by element, along a multi-element antenna array. When the source reaches the end of the array it is returned to the beginning, starting again and giving a scanning action. This is provided for both azimuth and elevation. The azimuth array, for example, is approximately 7.5m long (about 120 wavelengths) and has 64 elements with a nominal spacing of 1.86 wavelengths. Referring to Fig.2, when the radiating source is approaching the aircraft receiver from the left, as a result of the Doppler shift the received frequency is higher than that of the transmitted frequency; when it reaches the position shown the received frequency equals the transmitted frequency, and when the source is receding from the receiver, to the right, the received frequency, as a result of the Doppler shift, is lower than the transmitted frequency. The Doppler shift frequency, which we shall call f_D, is actually proportional to both the relative velocity of source and receiver, which we shall call V, and the wavelength of the source which we shall call λ. In Fig. 3, for example, the Doppler frequency as measured in the aircraft receiver is given by $f_D = (V/\lambda)\sin\theta$.

In the receiver f_D is measured, while V and θ. are known, so it is possible to obtain $\sin\theta$. and hence the angular position of the aircraft in relation to the ground antenna array. Because of the scanning action of the radiating source the energy spectrum of the transmitted signal consists of a number of lines. The envelope of this spectrum as received in the aircraft exhibits a strong peak at a particular f_D and this provides part of the information to define the angular position of the receiver as explained. The width of this peak is an inverse function of the array aperture and represents the beam width of the array. The received signal, after detection, is "decoded" by a tracking filter followed by a zero crossing counter which gives a digital measure of f_D. The tracking filter eliminates the effects of multi-path signals which are outside the main beam. The Doppler frequency information is finally converted into parameters acceptable to the aircraft's navigation system. These include outputs in digital and analogue form for absolute approach angles, offset from demanded angles and various "flags" and warnings.

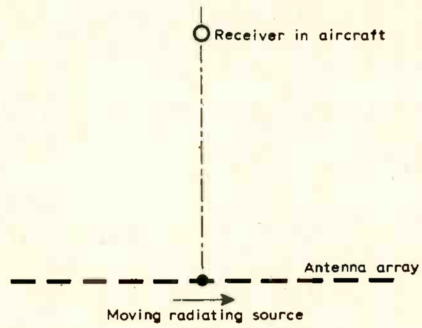

Fig 2 Basic illustration of Doppler effect resulting from a linearly moving radiating source on the ground.

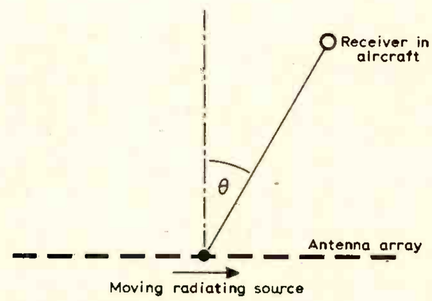

Fig. 3 Doppler frequency f_D depends on the relative velocity of moving source and airborne receiver, the wavelength of the radiating source and the angular relationship between the airborne receiver and the antenna array.

Of course a complication is introduced by the fact that the airborne equipment is moving as well as the ground radiating source. Unless special steps were taken the accuracy of the Doppler frequency measurement would be affected by the Doppler shift arising from the receiver movement. This problem is overcome by radiating from the ground a second signal, called a reference signal, from a fixed source on the antenna array and at a frequency offset by a small increment from the scanning frequency. Thus the airborne receiver's movement affects both the main signal and the reference signal equally. The receiver in fact detects a beat frequency between the two, and this can be achieved with high accuracy because the uncertainty regarding the transmitted frequency is removed and narrow band processing can be used.

There are 200 channels available for the system in the allocated 5 GHz frequency band, each 600kHz wide. In a channel, the spectrum space is divided into four sub-channels: one for forward azimuth transmission, using frequency division multiplex, centred at 540kHz above the lower channel edge; one for elevation at 290kHz also using f.d.m.; one at 415kHz for data transmission again using f.d.m.; and one at 120kHz, using t.d.m., providing a back azimuth service and auxiliary signals for azimuth and elevation.

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Sixty Years Ago

Viewing the beginnings of commercial radio communications from sixty years on, one gains the impression that even such an unbelievable development as "wireless" still found an entrenched body of opinion which regarded the technique as an interesting toy. This impression is lent weight by the news items and articles which appeared in *Wireless World* with the purpose of bringing to the attention of readers the sea rescues and commercial and military benefits conferred by the use of radio. One would have hardly thought, for instance, that the value of wireless in bringing help to distressed ships needed much comment, and yet in January 1913 there was lengthy reporting on the performance of the Marconi system in the *Volturo*, which burnt in mid-Atlantic.

At the less disastrous end of the traffic stream, readers were offered proof that wireless had come to stay based on the new-found facility with which bananas could be scheduled to arrive at Covent Garden in prime condition. The wireless was used to call assistance in the event of breakdown in the banana ship, thereby avoiding the effects of delay on "this delicious and nutritious fruit".

We have previously remarked (September 1973) on the severe tone adopted by the editor of the 1913 letters column. To redress the balance, we give the following extract from a page of advice by "our irresponsible expert". "Amateur (Tooting). — Carborundum is used in the Marconi crystal receiver. It has been found that this substance resists mildew very well and is not easily bent. It acts by virtue of its high resistance. The current finds such difficulty in passing through one way that it does not think it worth while to go back again. The current is thus rectified and produces a tick in the telephones. The Fleming valve acts in a similar way by making things hot for the current. We hope this is clear".

Telephoning at 6,000 words a minute

The first step towards providing a service in mid-1975 for the transmission of digital information over telephone circuits at a rate of 4,800 bits/s for the cost of a telephone call has been taken by the Post Office. The new Datel 4800 service will carry the equivalent of about 6,000 words per minute. The Post Office has placed a contract with Plessey Telecommunications Research for the design and development of a modem to operate at this data transmission rate. Prototypes should be delivered in 1974.

The highest rate of transmission available so far is provided by the Datel 2400 service at 2,400 bits/s.

Audibility of phase distortion

Pulse testing of all-pass phase shift networks, loudspeakers and human heads

by Benjamin B. Bauer
CBS Laboratories

The intense interest aroused in scientific circles by matrix quadraphony has resulted in a careful scrutiny of all its components, most important among them being all-pass phase-shift networks (or "psi-networks" as we like to call them). After presentation of our paper on quadraphony at the Audio Engineering Society Meeting in Rotterdam[1], a discussion was held about wave-shape changes that had been observed in testing psi-networks with square waves. We acknowledged the existence of these changes, but replied that at no time had we noticed audible distortion with psi networks (the results of psychoacoustic testing in which such networks were randomly introduced in paired comparisons being governed strictly by chance [2]), and concluded by stating that square waves did not seem to be useful for testing psi networks (or, for that matter, loudspeakers). This paper expands our views on this subject.

As every electronics engineer knows, psi networks have been used in audio communications for many years without the slightest perceptible ill effect. Traditionally, they have been utilized for production of single sideband modulation; an important application in modern a.m. and f.m. broadcasting technology is for "symmetricizing" speech waves to increase the modulation index — a psi network sold in the U.S.A. under the trade name "Symmetrapeak" is commonly used for this purpose. Also, a widely employed scheme for producing monophonic records from, and for compatible broadcasting of, stereophonic programs utilizes differential psi networks in the two channels of the stereophonic source.

Prior to the introduction of the SQ system by CBS, the action of psi networks was carefully reviewed at our laboratories using music, speech, square waves, triangular waves, and Gaussian noise sources. These were applied to loudspeakers with the psi network in and out of the circuit. At no time have any of our listeners been able to detect the slightest audible difference. These experiments, naturally, did not prove that some all-pass networks might not be capable of altering the quality of sound — they simply meant that the psi networks we designed had not produced such alterations. I presume that similar tests have been performed by Mr Itoh of Sansui[3] and by Drs Cooper and Shiga of Nippon/Columbia[4] with their systems of matrix quadraphony which also use psi networks. Additionally, one should mention the work of Dr Manfred P. Schroeder, who studied psi networks and established criteria for their audible performance[5].

Impulse testing of psi networks

Let us take a typical psi network of the type used for matrix encoding and study its impulse characteristics. As an example, we selected a 10-pole network used in an SQ encoder, with straight-line phase shift

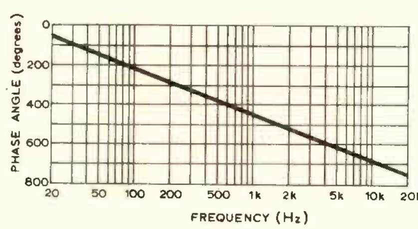

Fig. 1 Typical phase shift function, psi (f) of psi network used in SQ encoders.

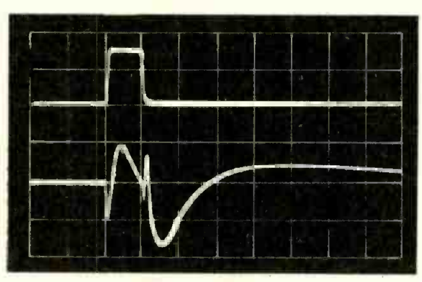

Fig. 2 The response of the psi network of Fig. 1 (lower trace) to a 1ms rectangular pulse (upper trace).

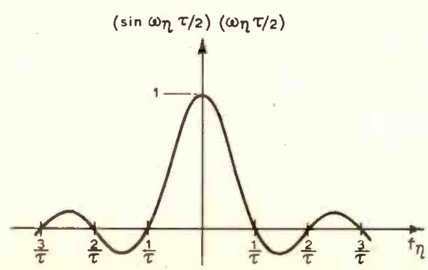

Fig. 3 The plot of $(\sin \omega_\eta \tau/2)/(\omega_\eta \tau/2)$

versus log-frequency characteristic from 20-20,000 Hz, shown in Fig. 1. The sine-wave response of this network is flat within 0.25 dB over the audible range and its harmonic and intermodulation distortions are virtually unmeasurable. However, if a rectangular wave, e.g., of 1ms duration, is applied to it, the output has little resemblance to the input, as seen in Fig. 2. The alteration of shape obviously is caused by differential phase delays.

We know, of course, through the use of the Fourier transform, that a single rectangular pulse may be represented in the frequency domain by a continuum from minus to plus infinity with amplitude distribution following the law $(\sin \omega_\eta \tau/2)/\omega_\eta \tau/2)$ shown in Fig. 3, where ω_η is the angular frequency, $2\pi f\eta$, and τ is the pulse length in seconds, or by an equivalent line structure in the event of periodically generated pulses. With a 1ms-wide pulse, the nulls occur at 1 kHz intervals. Any presumption that such a continuum can fairly be used for visual assessment of the performance of a psi network used for conventional speech and music clearly is unwarranted, especially since the presence or absence of the network does not perceptibly influence the audible quality of sound.

Nevertheless, visual inspection of the effect of psi networks upon pulses is, at times, desirable as when one wishes to measure system overload capability or time delay. Some years ago, while developing tests for loudspeakers, similar consideration led us to search for a pulse which would fairly represent the reaction of an acoustical system to transient signals. Reviewing the available signals, one finds at one extreme the delta pulse of infinitesimal duration which is equivalent, in the frequency domain, to a uniform cophase amplitude distribution extending from minus to plus infinity; and at the other, a continuous sine wave signal extending from minus to plus infinity in the time domain, equivalent to a single line-frequency. Either extreme is obviously uninformative. A limited-frequency continuum appealed to us as a reasonable compromise since the delay characteristics of the waves within such a packet would be more or less uniform. In the time domain the limited-bandwidth pulse resembles a bell-shaped amplitude-modulated sine wave, not unlike the shape of the transient sounds of some musical instruments.

An easy way to obtain the desired function is to pass a 100 μs or shorter pulse through a 1/3-octave bandpass filter. Fig. 4 shows what happens when such a test signal produced through a filter with a mid-frequency of 1000 Hz (top curve), is passed through the psi network (bottom curve). We note that the packet of waves passes through the network with practically no change in the shape of the envelope, albeit the phase relationship at midpoint, predictable from the curve in Fig 1, is modulo 360°, or 450° — 360° = 90°.

Impulse performance of loudspeakers

Since we commonly use loudspeakers to judge sound quality, the performance of loudspeakers with impulsive sounds becomes a matter of interest. Fig 5 shows the response of a high-quality monitor loudspeaker to the 1μs rectangular pulse. A small microphone with flat frequency response placed approximately 18in from the loudspeaker grille picks up the reproduced pulse. The time delay, (1 μ per division), clearly corresponds to the transit time from the loudspeaker to the microphone, plus a small delay within the loudspeaker proper. The reproduced pulse is quite similar to that exhibited by the psi networks but with some added perturbations.

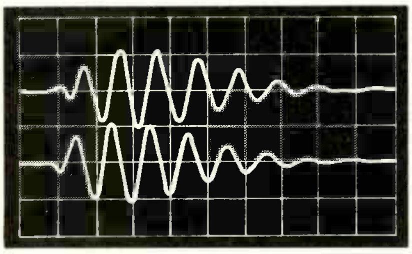

Fig. 4 A bandpass-filtered delta pulse (lower trace) with the bandpass-filtered delta pulse passed through the psi network (upper trace).

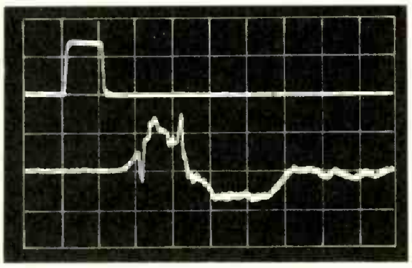

Fig. 5 The response of a high quality loudspeaker (lower trace) to a lms rectangular pulse (upper trace).

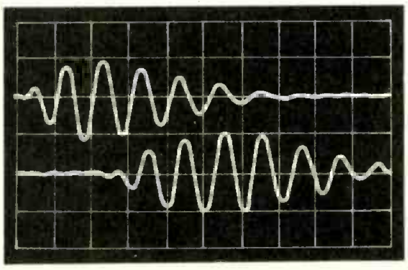

Fig. 6 The bandpass-filtered delta pulse (upper trace) compared with the response of a high quality loudspeaker to the same pulse (lower trace).

By applying the 1000-Hz centred 1/3-octave filtered packet of waves to the loudspeaker, the result shown in Fig 6 becomes similar to that obtained with the psi network, except that the envelope delay corresponding to the microphone-speaker distance again is noted. The response curve of this particular loudspeaker exhibits a slight hangover, suggesting a somewhat underdamped condition. In CBS Laboratories' high fidelity components testing programme, such 1/3-octave band-limited pulses are regularly used for loudspeaker testing[6]. Comparing the shapes of the input and output pulses allows us to study such diverse factors as magnetic dissymmetries, mechanical nonlinearities, acoustical reflections, etc. which otherwise would be difficult to detect.

Having established that psi networks and loudspeakers share similarities with respect to impulsive sounds, one is led to conjecture whether there might not exist an opportunity for improving the performance of both classes of devices. Here we open the door to a debate which probably will continue for a long time to the delight of hi-fi enthusiasts and magazine editors alike.

Will the ultimate perfection of psi networks and loudspeakers, if it were theoretically possible, lead to significant improvements in fidelity? Even to conjecture about this question requires that we define what is meant by audible fidelity in the reproduction of impulsive sounds. Some years ago we measured the interaural delays caused by the human head as a function of frequency and azimuth of sound arrival[7]. The delays were calculated from phase measurements at the ear canal entrances at low frequency, but high-frequency measurements were difficult to perform because of rapid phase changes caused by minuscule head motions, also exhibiting inconsistencies which probably were related to differences between phase and group velocities. Later we attempted to use acoustical pulses with the thought of obtaining group delay characteristics. The results were similar to those exhibited by the psi networks and loudspeakers. Thus, even if one were able to design these latter components to transmit visually unaltered rectangular pulses, the diffraction around the head might prevent the audible effect of such change from being significant, except possibly at very low frequencies.

Conclusion

In conclusion, careful auditing of speech, music, impulsive repetitive sounds and Gaussian noises reproduced with and without psi networks through high quality loudspeakers convinced us that the types of networks we use are not a cause of discernible changes in quality. With respect to distortions occasionally reported by some observers, one is tempted to wonder if an unrelated factor such as a change in frequency response, amplifier overload, etc., might not in fact have been the assignable cause. The phase shifts or time delays exhibited by our psi networks simply have turned out to be inaudible.

Presumably, we should be grateful to Messrs. G. S. Ohm and H. L. F. Helmholtz who discovered that phase does not influence timbre[8], even if a number of distinguished investigators have described subsequent experiments designed to demonstrate that phase changes can result in alterations of timbre[9]. Shroeder[10] maintains that small or no subjective changes will be produced by variations of phase spectrum which leave the envelope of the stimulus invariant. The latter condition is attained with the impulse we used in testing psi networks as demonstrated by Figs 4 and 6, and which we believe fairly represents the impulsive sounds of speech and music. But even the timbre of square waves is unaltered with our psi networks, we conjecture, because loudspeakers and human heads introduce similar differential delays in the path of the signal. Evidently more research into this problem is needed.

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Simple f.m. modulator/ demodulator for a magnetic tape recorder

by B. D. Jordan
Institute for Advanced Studies, Dublin

This unit offers an extension of the facilities of a domestic tape recorder to permit its use as an intrumentation recorder employing f.m. principles. The design involves no modification of the tape recorder and thus allows a wide field of application with various makes and types of machines.

Magnetic tape as a medium for recording v.l.f. signals or signal levels, suffers at least two serious limitations when using direct recording methods. First, the frequency response rarely extends below about 50Hz and, second, amplitude instability occurs, caused mainly by surface inhomogenieties in the tape. For the purposes of handling analogue data, where the d.c. component of the signal must be preserved, it is necessary to incorporate some form of signal modulation into the recording process. Most of the commercially available instrumentation tape recorders employ f.m. modulation and many of these have specifications that include a frequency response of d.c. to 2MHz as well as a great many other facilities that may not be required.

The instrument described was designed to provide a tape recorder with f.m. modulation giving a frequency response of d.c.–800Hz for recording v.l.f. phenomena and utilizing a domestic recorder at a tape speed of 9.1cm/sec. At this tape speed the tape recorder has a frequency response of about 50Hz–6.0kHz. The carrier frequency was chosen to lie in the midband region, i.e. 3kHz so that amplitude variations in the tape recorder output would not be excessive within the expected range of frequencies to be handled. In order to minimize the effect of wow and flutter due to the transport system, a reasonably large depth of modulation is desirable. A frequency deviation of about $\pm 30\%$ of the carrier was found to be satisfactory.

An integrated phase locked loop, Signetics type NE565, was used as both modulator and demodulator. Fig. 1 illustrates the principle of the phase locked loop. An f.m. signal, f_s, is fed to a phase comparator whose reference is the output of a voltage controlled oscillator, f_o. The phase comparator is a balanced multiplier which produces the sum, (f_s+f_o) and difference (f_s-f_o) frequencies of the input f.m. signal and the voltage controlled oscillator output. When the loop is in lock, the v.c.o. duplicates the input frequencies so that $f_s-f_o=0$, and the output of the phase comparator contains a d.c. component which is proportional to the phase difference between the input signal and the v.c.o. output. A low pass filter removes the sum frequency component and the remaining d.c. voltage is amplified and used to control the v.c.o. frequency in such a manner as to maintain $f_s=f_o$. It is this controlling or error voltage which constitutes the demodulated signal.

The modulator

One of the outstanding features of the NE565 is the high linearity and wide dynamic range of the v.c.o. These characteristics make the device particularly attractive as a modulator. For this purpose the loop can be opened by disconnecting the v.c.o. output from the phase comparator reference input. The modulating signal can then be applied directly to the v.c.o. input, or if required, advantage can be taken of the high gain d.c. amplifier, by applying the modulating signal to the signal input of the phase comparator. The reference input should be returned to earth in this mode of operation. The low pass filter can be omitted by disconnecting C_2.

The Fig. 2 shows the complete circuit. The v.c.o. is a relaxation type of oscillator the free running frequency, f_o being determined by the external capacitor, C_1, and the charging current controlled by R_1. The frequency f_o can be calculated from the expression

$$f_o = \frac{1}{4R_1C_1}$$

C_1 can be any value, but R_1 has an optimum value of about 4kΩ so as to maintain minimum linearity error. So for our system, with f_o = 3kHz, C_1 = .021μF. The conversion factor K for the v.c.o. is given by

$$K = \frac{50f_o}{V_{cc}} \text{ radians/sec/volt}$$

In our case f_o = 3kHz and V_{cc} = 6V. K = 2kHz per volt. Therefore in order to limit the depth of modulation to $\pm 30\%$ ($\pm$900Hz maximum frequency deviation), the control voltage at the v.c.o. input must not exceed 0.9V peak to peak. The gain of the d.c. amplifier can be varied by means of the feedback resistor R_2. Thus the depth of modulation can be fixed for a given input by means of R_2.

Demodulator

In this mode of operation the phase locked loop is closed by reconnecting the v.c.o. output to the phase comparator reference input. The low pass filter is formed by connecting C_2 between pin 7 and the power rail.

The capture range, f_c of the p.l.l. (i.e. that range of frequencies about f_o over which the loop can acquire lock) is given by

$$f_c = \frac{1}{\pi}\sqrt{\frac{32\pi f_o}{\tau V_{cc}}}$$

τ is the time constant of the l.p. filter formed by C_2 and an internal resistance of 3.6kΩ. The tracking range f_t of the p.l.l. is that range of frequencies about f_o over which the v.c.o. once having acquired lock, will maintain lock with the input signal and is given by

$$f_t = \frac{8f_o}{V_{cc}}$$

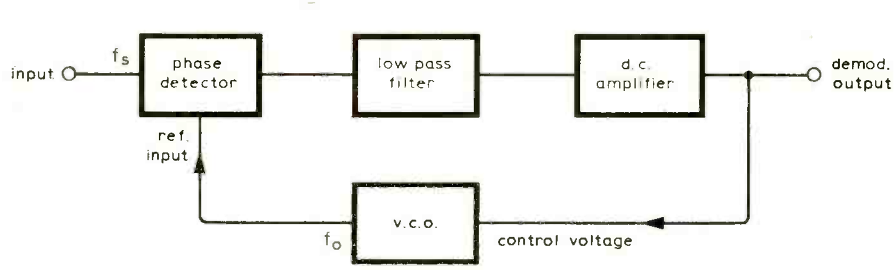

Fig. 1. Block diagram of the phase lock loop.

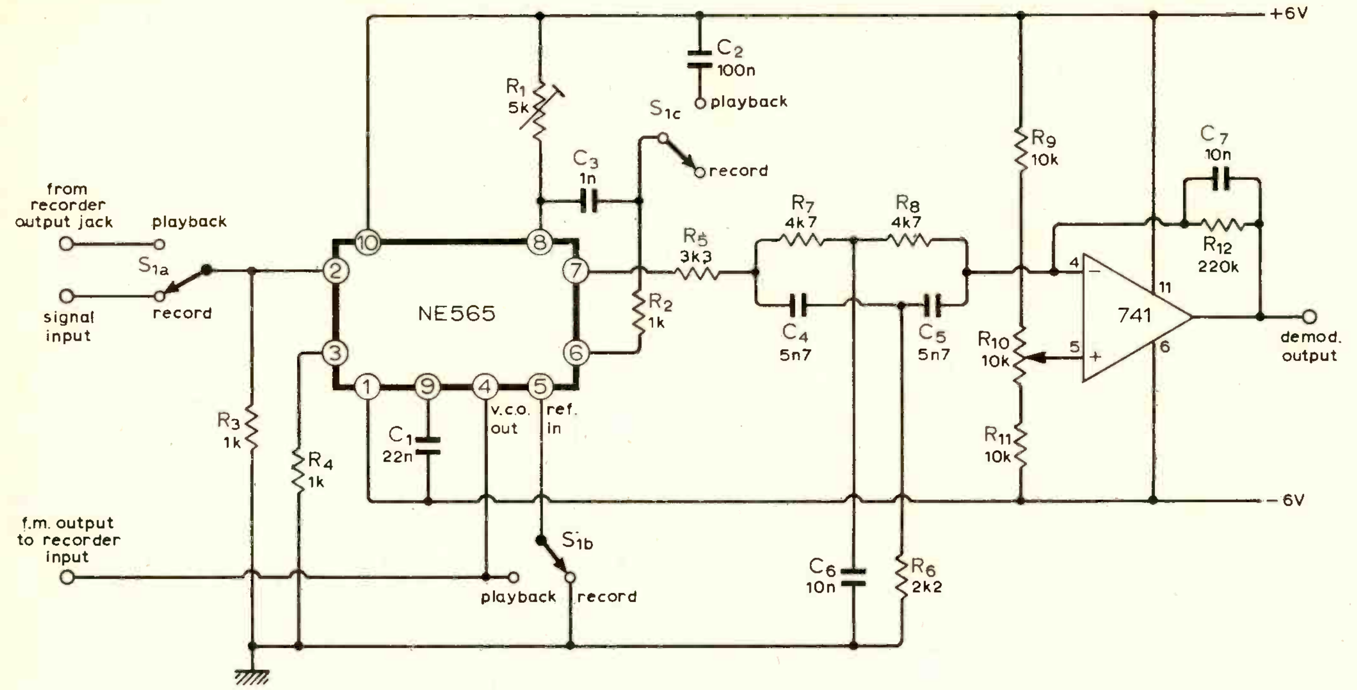

Fig. 2. The complete modulator/demodulator circuit.

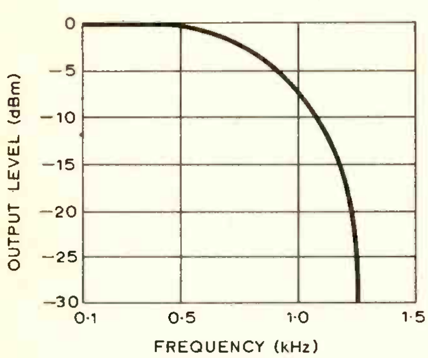

Fig. 3. The system frequency response.

To eliminate the residual unwanted sum frequency component present in the demodulated output, a balanced *T* filter is incorporated in the output. This was found to be most effective when tuned to $2f_o$. This is followed by a low pass active filter which has a cut-off frequency at 800Hz. Because the demodulator of the p.l.l. output is referenced to the positive power rail there is always a standing d.c. potential of about 0.125 V_{cc} below the positive power rail. This can be cancelled out by means of the level shifting facility incorporated in the active filter.

Performance and testing

The system was tested using an Akai Model XV tape-recorder at a tape speed of 9.1cm/sec and a carrier frequency of 3kHz. Fig. 3 shows the frequency response of the system. This test was made by recording an f.m. signal produced by applying tones of 5mV peak to peak from 1.0Hz to 1.5kHz to the input. This recording was then played back and the demodulated signals were measured with an oscilloscope. A d.c. test was made by applying d.c. levels from −5mV to +5mV to the input. On playback the linearity error of the reproduced levels was less than 0.5%.

A two-channel system was constructed on a printed circuit board and mounted together with power supply in an instrument case measuring 10 × 7 × 6in. No special layout precautions were found to be necessary. The system was incorporated in a 2-channel d.c. photometer.

WE'RE BACK!

Apologies to readers and advertisers for the absence of January and February issues of Wireless World. This was due to severe difficulties in the printing industry. However, we are back with this enlarged March issue which we are confident is up to our normal standard. It includes all the regular features plus the two special articles on an electronic piano and on horn loudspeaker design announced in our December 1973 issue and in press advertisements.

The present issue has a slightly smaller page size than normal—about half an inch shorter. This was made necessary by a change of printing arrangements and problems of paper supply. It does not, however, mean that there is any less reading matter on a page. We shall revert to our normal page size as soon as possible.

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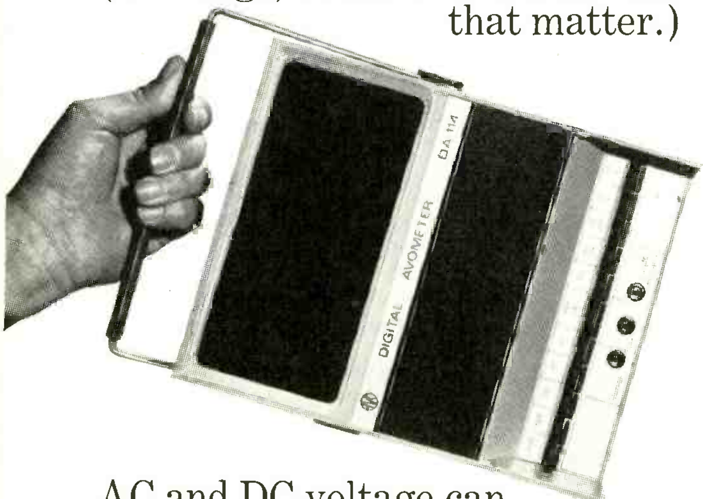

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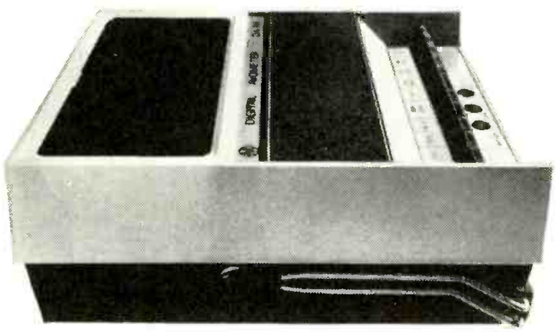

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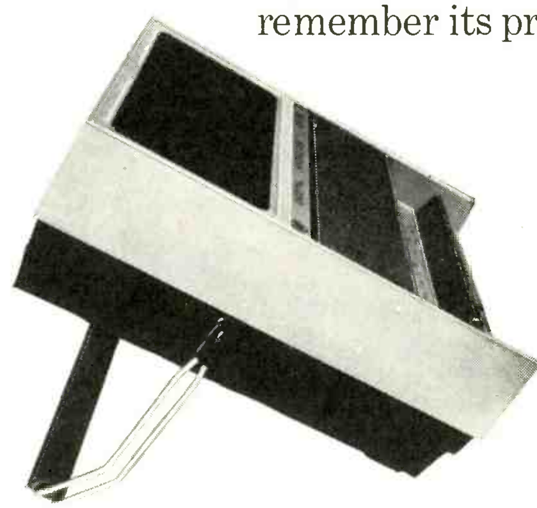

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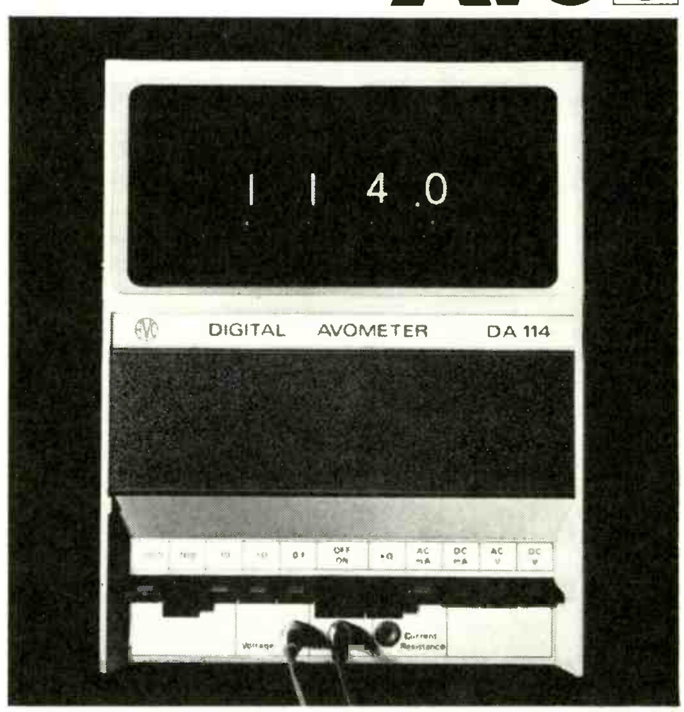

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Multimeters

A survey of analogue and digital multi-function meters currently on the U.K. market

by Brian Sexton

The application of a voltage across a resistance produces a current — a well-known phenomenon rationalized some time ago by a Dr Ohm, who presented the results of his researches to the world in the form of his familiar Law. Simple though the law is, it is still the basis of the circuit. Whatever one's interest in electronics, at some point one needs to know voltage, current or resistance. The instrument used to determine these quantities is usually an analogue or digital multimeter — a short-hand expression meaning an instrument capable of measuring at least voltage and current, and usually resistance.

The analogue, or moving-pointer instrument was the sole method of measurement until a few years ago, when digital techniques became common in all branches of the art. It is not proposed to go into the "analogue versus digital" argument here — both types of meter have their advantages. The overwhelming advantage of a digital meter is its reading accuracy; a pointer instrument can be reliably read to within around 1% of full-scale, whereas a digital display presents no problem in this respect. (One assumes that the measuring accuracy is sensibly related to the reading accuracy.) This feature is, of course, gained at the expense of complexity and digital meters cost, at the very least, twice as much as a good-quality analogue meter. On the other hand, the much simpler pointer instrument will be a perfectly suitable meter for the great majority of work, the electronic variety, using amplifiers to increase sensitivity and input impedance, increasing its usefulness to compare with that of some digital equipment.

The analogue multimeter is a fairly straightforward instrument, its specifications being readily understood. Digital multimeters, in contrast, use a different type of circuit altogether, the requirements of a moving-coil meter display and a digital readout being totally divorced. The circuitry and operation of digital meters have brought a host of "digital" terms to specifications and to clear up any confusion that may exist, it is proposed to deal briefly with the commoner terminology.

Analogue-to-digital converters

Although self-explanatory, the a.-to-d. converter is the heart of a digital meter and merits some attention. By means of this circuit, the input analogue (voltage, current or resistance) is converted into one of several forms of digital representation, which can be indicated by a digital display. It takes many forms, but the commonest is the dual-slope integrator, a method of conversion pioneered by Solartron. In this circuit, the input signal determines the slope, in one direction, of a Miller (Blumlein) integrator, the slope in the other direction being dictated by a very precise reference voltage. During the known time interval that the integrator is under the control of the input, pulses are gated to a counter and displayed to represent the input. The integration in both directions reduces the effect of amplifier drifts and clock frequency variations, the accuracy of the result depending chiefly on the precision of the reference voltage. The time interval during which the input controls the integrator is held to one complete cycle of the mains waveform, i.e. 20ms, so that any 50Hz or harmonics thereof picked up at the input are effectively cancelled in the integrator.

Several other methods of conversion are in use, but the system described accounts for the majority of instruments at present in use.

Autoranging

Some of the more elaborate instruments are automatic to the fullest extent in that they will select the range providing maximum resolution when the input is connected and will display the sign of the measured quantity. Less expensive equipment often displays the sign and indicates when the input exceeds the selected range limit. A further aid to ease of operation is afforded by "leading zero suppression", which simply means that display elements reading zero to the left of the first significant figure are suppressed. For instance, 001.8 would become 1.8.

Display

The cold-cathode numerical indicator tube is still the most used type of display, although light-emitting diode (l.e.d.) arrays are coming into greater prominence of late. The dot-matrix l.e.d. display possesses the advantage that the failure of one diode does not result in the complete loss of one digit.

Flicker on digital indicators is not now a problem. Several years ago, when t.t.l. latched bistables became available cheaply, the stored display was adopted, wherein the last reading is displayed until a new one is obtained, with no rapid counting being visible. Liquid crystals are also coming into favour.

Resolution

Digital meters are often described as, say, 3½-digit instruments. This somewhat bizarre designation refers to the way in which a two-fold increase in the range can be obtained by the use of an indicator tube which shows either "0" or "1" for the most significant digit. The normal range limit would be set at perhaps 0999mV: with the addition of the "half" digit it becomes 1999mV, the additional electronics being much simpler than for a full digit. The value of the least significant digit is the resolution.

Outputs

It is fairly common practice to provide the displayed reading as an output in binary-coded decimal form, particularly when the instrument is to be used as part of a data-collecting system. The outputs may also be used to drive a printer.

A.c. measurements

Some instruments, analogue or digital, are called "true-r.m.s. meters". In many voltmeters, sinusoidal inputs are rectified, the resulting signal applied to the measuring circuits corresponding to the average value of the sinusoid, although the display is calibrated to read r.m.s. So long as the input remains sinusoidal, this trick is valid, but any departure from this shape causes an error in the reading. Consequently, some manufacturers either introduce correction circuitry or use special a.c. to d.c. converters, providing an output corresponding to the r.m.s. value of any shape of input waveform.

In the short directory which follows, only salient performance figures are given; space does not allow more detailed description.

For the same reason, only one or two instruments from each manufacturer have been included. Prices given are exclusive of v.a.t., which is charged at 10%.

Advance Electronics Ltd, Raynham Road, Bishop's Stortford, Herts.
The DMM2 digital instrument provides for the measurement of alternating and direct voltage and current, and resistance in 17 ranges. Functions are selected by push-button, and the $3\frac{1}{2}$-digit neon-tube display has an automatically-positioned decimal point. Overrange and reverse polarity indicators are provided. Power is obtained from a.c. mains, external 12V d.c. or a rechargeable battery pack.

Ranges

V d.c./a.c.	200mV 2V 20V 200V 1kV
Resolution d.c./a.c.	100μV 1mV 10mV 100mV 1V
Accuracy d.c.	±0.1% to ±0.2% of reading ±0.1% to ±0.15% f.s.
Accuracy a.c.	±0.3% to ±0.4% of reading ±0.15% to ±0.2% f.s.
Input *R* d.c.	10M
Input *Z* a.c.	(1MΩ and 150pF) to (10MΩ and 40pF)
I d.c./a.c.	200μA
Resolution d.c./a.c.	100nA
Accuracy d.c.	±0.3% reading ±0.2% f.s.
Accuracy a.c.	±0.5% reading ±0.5% f.s.
R	200Ω 2kΩ 20kΩ 200kΩ 2MΩ
Resolution	100mΩ 1Ω 10Ω 100Ω 1kΩ
Accuracy	±0.3% to ±0.4% reading ±0.15% f.s.
Price	£99

WW500 for further details

Avo Ltd, Archcliffe Road, Dover, Kent. CT16 9EN.
Little needs to be said about the well known Avo 8. The Mark 5 version is more accurate (1% of f.s.d. on all d.c. ranges, and 2% of f.s.d. on all a.c. ranges). It has a new movement and new cut-out. An interesting point is that the d.c. sensitivity remains unchanged. Apparently, so many thousands of service and instruction manuals relate their test voltage readings to the Model 8 sensitivity of 20,000Ω/V that it has been retained to avoid misleading results. The price is £40.30.

The Avometer Type DA114 digital meter is a $3\frac{1}{2}$-digit instrument with automatic zero drift cancellation, a built-in operational check and a calibration facility. DA114M is mains-powered, the rechargeable battery/mains model being designated DA114B. Overrange and polarity reversal are indicated.

Ranges

V d.c./a.c.	100mV 1V 10V 100V 1kV
Resolution d.c./a.c.	100μV 1mV 10mV 100mV 1V
Input *R* d.c.	Between 10MΩ and better than 1000MΩ
Input *Z* a.c.	1MΩ in parallel with not more than 20pF
Accuracy d.c.	±(0.1% to 0.2%) of reading ±1 digit
Accuracy a.c.	±1% of full range, or ±1% of reading on overrange
I d.c./a.c.	100μA 1mA 10mA 100mA 1A
Resolution	0.1 1 10 100 1k
Accuracy d.c.	±(0.3% to 0.5%) of reading ±1 digit
Accuracy a.c.	±0.3% rdg ±1% full range, or ±1.3% of reading on overrange
R	100Ω 1kΩ 10kΩ 100kΩ 1MΩ
Resolution	0.1Ω 1Ω 10Ω 100Ω 1kΩ
Accuracy	±0.5% rdg ±1 digit
Price	(DA114M) £103.50, (DA114B) £135.

WW501 for further details

Bach-Simpson (U.K) Ltd, Trenant Industrial Estate, Wadebridge, Cornwall, PL27 6HD.
Overload protection is strongly featured in the new 260-6P analogue multimeter. The various protective devices include, fuse, varistor and a transistor switch with overload circuit breaker. The instrument has 27 ranges of resistance, alternating and direct voltage and current measurement. These ranges can be extended by a series of 10 plug-in units which enable the basic instrument to be used for various functions including transistor testing, temperature testing and milliohm measurement. An optional plug-in unit provides alternating current measuring facilities up to 250A.

Ranges

V d.c.	250mV 1V 2.5V 10V 50V 250V 500V 1kV
Input *R*	20,000Ω/V
Accuracy	±2% f.s.d.
V a.c.	2.5V 10V 50V 250V 500V 1kV
Input *Z*	5,000Ω/V
Accuracy	±3% f.s.d.
I d.c.	50μA 1mA 10mA 100mA 500mA 10A
Accuracy	±2% f.s.d.
R	2kΩ 200kΩ 20MΩ
Price	£34.50

WW502 for further details

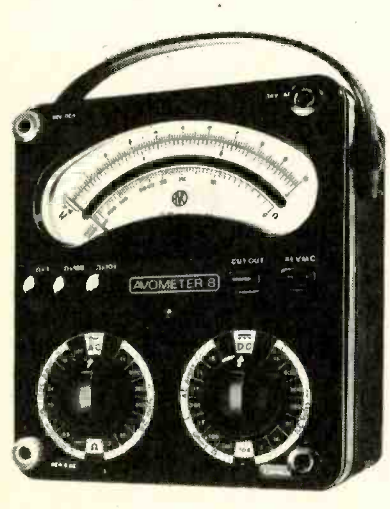
G. & E. Bradley Ltd, Electral House, Neasden Lane, London N.W.10.
The Type 196 four-digit multimeter measures resistance and alternating and direct voltage within the frequency range 20Hz to 100kHz. Overrange facilities on all functions extend each range by 50%. The maximum reading is 1500V d.c. and 15MΩ but is limited to 1200V r.m.s. on the maximum *V* a.c. range. The overrange condition is indicated by a "1" digit incorporated in the polarity indicating tube. Fully guarded input circuits give a common-mode rejection on d.c. ranges of more than 140dB at 50 to 60Hz and d.c. Common and series mode rejection is better than −60dB on a.c. and mains frequency series-mode noise rejection is better than −60dB on d.c. ranges. Five neon display tubes are used for readout with polarity indicated automatically. Sampling rate is 10 times per second irrespective of mode selected and hold facilities are provided.

Ranges

V d.c.	100mV 1V 10V 100V 1kV
Resolution	10μV 100μV 1mV 10mV 100mV
Input *Z*	10GΩ 10GΩ 10GΩ 10MΩ 10MΩ
Accuracy	±0.01% of reading ±1 digit
V a.c.	1V 10V 100V 1kV
Resolution	100μV 1mV 10mV 100mV
Input *Z*	1MΩ shunted by less than 50pF (all ranges)
Accuracy	±(0.1% to 0.4%) of reading ±1 digit (depends on range and frequency)
R	100Ω 1kΩ 10kΩ 100kΩ 1MΩ 10MΩ
Resolution	0.01Ω 0.1Ω 1Ω 10Ω 100Ω 1kΩ
Accuracy	±0.1% of reading ±1 digit
Price	£395

WW503 for further details

Cosmocord Ltd, Eleanor Cross Road, Waltham Cross, Hertfordshire EN8 7NX.
The model 12 battery-powered analogue multimeter has a slide switch for range selection and a colour coded scale to facilitate reading. In addition to voltage, current and resistance ranges, the instrument has



Avometer 8, Mark 5

Digital Avometer DA114

Bach-Simpson 260-6P multimeter

two transistor checking ranges "LI" and "LV" (low current and voltage) which enable the impedance of junctions to be determined at different current levels.

Ranges

V d.c.	0.25V	2.5V	10V	50V	250V	1kV
Input *R*	20 kΩ/V					
V a.c.	—	—	10V	50V	250V	1kV
Input *Z*	5kΩ/V					
I d.c.	50μA	25 mA	250 mA			
R	3 kΩ	30 kΩ	300 kΩ	3MΩ		
"LI"	52 mA	5.2 mA	520μA	52μA		
"LV"	1.5V	1.5V	1.5V	1.5V		
dB	−20 to +22dB	−6 to +36 dB	+20 to +50dB			
Price £7						

WW504 for further details

Dana Electronics Ltd, Collingdon Street, Luton, Beds.

The 4300 digital multimeter has 4-digit plug-in l.e.d. readout with +100% overranging and leading-zero suppression, the intensity of the display being automatically adjusted to suit prevailing ambient light conditions. The instrument can be powered by either mains or battery. When battery-powered, a switch position provides for digital readout of battery voltage; a chart on the battery case converts battery voltage to the approximate unused battery time remaining, and automatic shut-off at battery voltage recharge level prevents battery damage and the possibility of incorrect readings.

Ranges

V d.c./a.c.	0.1V (d.c. only) 1V 10V 100V 1kV
Resolution	0.01% of range (10μV on 0.1V d.c. and 100μV on 1V a.c.)
Input *R* d.c.	1GΩ (0.1V and 1V ranges) 10MΩ (other ranges)
Input *Z* a.c.	1MΩ shunted by 100pF
Accuracy d.c./a.c.	Range, temperature and time dependent
I d.c./a.c.	100μA 1mA 10mA 100mA 1A
Accuracy d.c./a.c.	Range, temperature and time dependent
Resolution	10nA on 100μ A range
R	1kΩ 10kΩ 100kΩ 1MΩ 10MΩ
Resolution	0.01% of range (0.1Ω on 1kΩ range max.)
Accuracy	Range, temperature and time dependent
Price	£299

The 5800A is a five-digit instrument capable of measuring direct and true r.m.s. values of alternating voltage, the ratio between two alternating voltages, two direct voltages between resistance and direct voltage or direct and alternating voltage, and will perform four-wire resistance measurements, or direct and alternating voltage, all but direct voltage and ratio determination requiring the addition of ancillary units.

Ranges

V d.c.	1V 10V 100V 1000V
Resolution	10μV 100μV 1mV 10mV
Input resistance	1GΩ 10GΩ 10MΩ 10MΩ
Accuracy	±0.008% of reading +0.002% f.s. (long term)
Ratio	mV, V d.c., ohms or V a.c. to V d.c.
Price	£1,595

WW505 for further details

Eagle International, Precision Centre, Heather Park Drive, Wembley, HA0 1SU.

The company's current catalogue contains details of some 13 analogue multimeters ranging in price from £4 to £50. At the top end of the price range, the K200 f.e.t. voltohmeter has a claimed input resistance of 10MΩ on both d.c. and a.c. voltage ranges. Frequency response is 20Hz to 3MHz ±1 dB.

Ranges

V d.c./a.c.	0.3V	1V	3V	10V	30V	100V	300V	1kV
I d.c./a.c.	30μA	300μA	1mA	3mA	10mA	30mA	100mA	300mA
R	500Ω	5kΩ	50kΩ	500kΩ	5MΩ	500MΩ		
Price	£46.70							

WW506 for further details

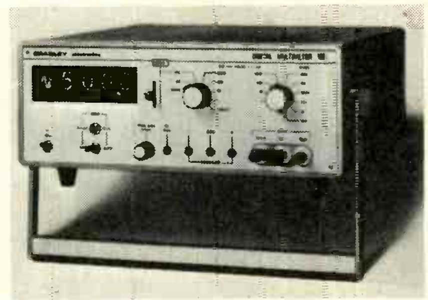
Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire, LS22 4DH.

The company produces a digital measuring system which favours individual modules for separate parameters rather than a combined instrument. Three mainframes (for 3, 4 and 6 digit display units) are used to accept plug-in measurement modules covering direct and alternating voltage, resistance, capacitance, frequency, counting and timing. A feature of the DCV100 d.c. voltmeter module is its ability to discriminate between a.c. and d.c. signals. This is accomplished by input filtering, a photo-chopper stabilized operational amplifier and a precision gate. The mainframe costs between £125 and £199, depending on the number of digits and other facilities.

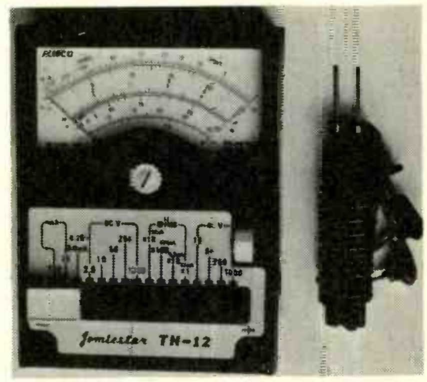
Ranges

V d.c.	99.9mV 0.999V 9.99V 99.9V 999V
Resolution	100μV max. or 0.1% f.s.d.
Input *R*	10MΩ ± 1%
Accuracy	0.1% of reading ± 1 digit
Price	£75

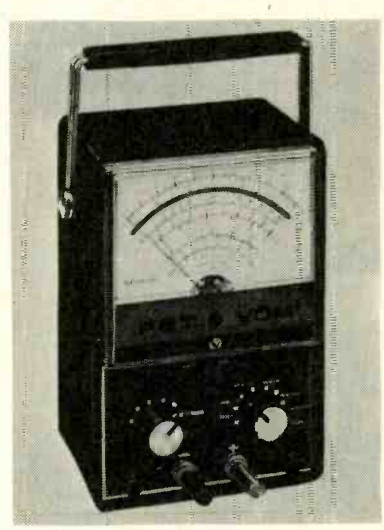
Bradley 196 digital multimeter



Cosmocord 12 analogue multimeter



Eagle International K200 electronic multimeter



Farnell DCV100 d.c. voltmeter module and mainframe

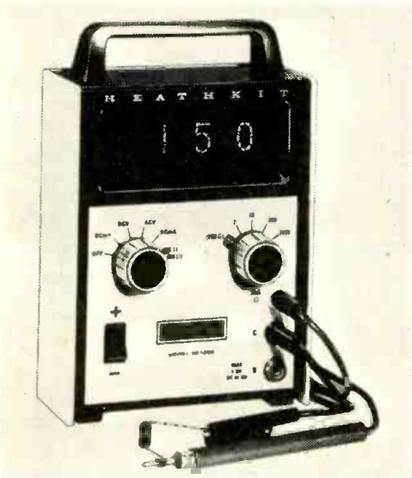
Farnell DOM100 ohmmeter module

Fenlow 801 digital multimeter

The DOM 100 ohms module provides for the measurement of resistance from 999mΩ to 1GΩ full-scale. The measuring circuit is a self-balancing bridge with a front-panel lamp to indicate when the bridge comes to balance. Remote sensing terminals are provided for lead resistance compensation. The resistance of inductive windings can be measured and the power applied to components being measured is less than 1mW.

	Ranges
R	999mΩ to 999MΩ (in 10 decade ranges)
Accuracy	
(Less than 1Ω)	±0.2% of reading ±1 digit
(1Ω to 10MΩ)	±0.1% of reading ±1 digit
10MΩ to 100MΩ	±0.2% of reading ±2 digits
100MΩ to 1GΩ	±0.5% of reading ±1 digit
Price	£110

WW507 for further details (DCV100)
WW508 for further details (DOM100)



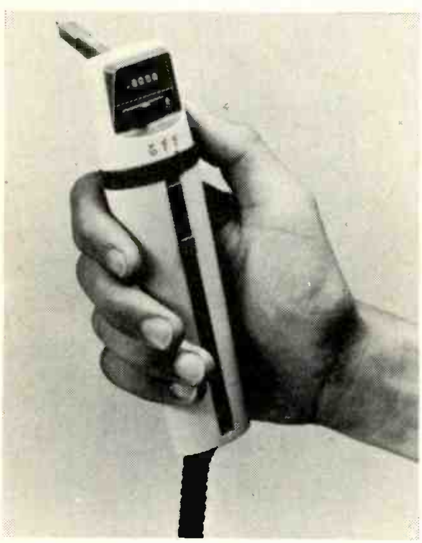
Heathkit IM-1202 digital multimeter

Fenlow Agents: Bryans Southern Instruments Ltd, Willow Lane, Mitcham, Surrey, CR4 4UL.

The Fenlow model 801 has an auto zero facility which allows the instrument to be ready for use within 30 seconds of switching on. Voltage, current and resistance are covered and readout from the $3\frac{1}{2}$-digit storage display is by seven-segment fluorescent tubes. On d.c. ranges, series mode rejection is 80dB and common mode rejection is 126dB. These figures are maintained during ±2% mains frequency variation.

	Ranges					
V d.c./a.c.	200mV	2V	20V	200V	1200V	
Resolution	100μV	1mV	10mV	100mV	1V	
Input *R* d.c.	1GΩ	10GΩ	10MΩ	10MΩ	10MΩ	
Input *Z* a.c.	(as d.c. but with 100pF on 20V, 200V, 1200V ranges)					
Accuracy d.c.	±(0.1% of reading +0.5% f.s.)					
a.c.	±(0.5% of reading +0.1% f.s.)					
I d.c./a.c.	200μA	2mA	20mA	200mA	2A	
Resolution	100nA	1μA	10μA	100μA	1mA	
Accuracy d.c.	±(0.3% of reading +0.05% f.s.)					
a.c.	±(1% of reading +0.1% of f.s.)					
R	200Ω	2kΩ	20kΩ	200kΩ	2MΩ	20MΩ
Resolution	100mΩ	1Ω	10Ω	100Ω	1kΩ	10kΩ
Accuracy	±(0.2% of reading +0.05% f.s.)					
Price	**£114**					

WW509 for further details



Hewlett Packard HP970A digital multimeter

Hartmann & Braun (U.K.) Ltd, Moulton Park, Northampton, NN3 1TF.

A wide range of instruments are available from this company. Many are perhaps more suitable for power engineering applications such as the interesting Elavi which measures alternating current and voltage, active current I cos ø, cos ø, sin ø frequency and resistance. Among the lighter current instruments is the Elavitron 1 electronic multimeter with analogue readout. The instrument presents a resistance of 200kΩ/V in the ranges between 1V and 100V.

Elavitron 1	Ranges							
V d.c./a.c.	0.3V	1V	3V	10V	30V	100V	300V	1kV
I d.c./a.c.	0.1mA	1mA	10mA	30mA	100mA	300mA	1A	3A
R	1kΩ	100kΩ	10MΩ					
Price	**£37**							

WW510 for further details

Heathkit: Heath (Gloucester) Ltd, Gloucester, GL2 6EE.

This kit company has several multi-function meters available. Usually the buyer has the alternative of an assembled version, but the new IM-1202 digital multimeter is offered in kit form only. The instrument has ranges for the measurement of resistance, d.c./a.c. voltage and current. Frequency range is 25Hz to 10kHz. Cold cathode tubes are used for readout and a pseudo memory ensures a non-blinking display.

	Ranges				
V. d.c.	2V	20V	200V	1 kV	
Resolution	10mV (lowest range only)				
Input *R*	1MΩ				
Accuracy	1% ±1 digit				
V a.c.	2V	20V	200V	700V	
Resolution	10mV (lowest range only)				
Input *Z*	1MΩ				
Accuracy	$1\frac{1}{2}$% ±1 digit				
I a.c.	2mA	20mA	200mA	2A	
Resolution	10μA (lowest range only)				
Accuracy	$1\frac{1}{2}$% ±1 digit				
I a. c.	2mA	20mA	200mA	2A	
Resolution	10μA (lowest range only)				
Accuracy	$1\frac{1}{2}$% ±1 digit				
R	200Ω	2kΩ	20kΩ	200kΩ	2mΩ
Resolution	1Ω (lowest range only)				
Accuracy	2% ±1 digit				
Price	**£39.60**				

WW511 for further details

Hewlett Packard 3490A digital multimeter

Hewlett Packard Ltd, 224 Bath Road, Slough, Bucks, SL1 4DS.

The 3490A multimeter is a five digit integrating instrument which uses a dual slope integrating technique. The basic instrument measures d.c. voltages, a.c. voltages (20Hz to 250kHz) and resistance. Ohm measurements can be made using the four-wire conversion technique to eliminate errors due to test lead resistances. Ranging is automatic on all functions. Sixteen frontpanel self tests are designed to assist calibration and fault finding. Each test interrogates an internal parameter and displays the results on the frontpanel. Results are compared with proper values given on a pull-out instruction card. Among the tests are a series of logic tests and measurement of the reference voltage. The display is of the dot-matrix type. Extra optional facilities are available, for instance, the provision of a ratio measurement mode and a sample/hold option.

Ranges

V d.c.	0.1V 1V 10V 100V 1kV
Input *R*	more than 2 x $10^{10}\Omega$ on 0.1V to 10V ranges; 10MΩ ±0.15% on 100V and 1kV ranges
Accuracy (24 hours)	±(0.005% of reading +0.001% of range) on 0.1V range; ±(0.004% of reading + 0.001% of range) on 1V to 1kV ranges
V a.c.	1V 10V 100V 1kV
Input *Z*	2MΩ ±1% parallel with 65pF
Accuracy (24 hours)	±(0.24% of reading + 0,05% of range) between 20 to 50Hz
Price	**£761**

The HP970A is a digital multimeter designed to be held in the hand. It is self-contained, using a rechargeable battery pack, and presents the readings on a miniature l.e.d. dot-matrix display at the forward end of the unit. The display can be inverted electronically. Ranging is automatic, as is the indication of polarity and placing of the decimal point, which maintains units of volts and kilohms.

Ranges

V d.c.	0.1V 1V 10V 100V 1kV
Input *R*	10MΩ ±5%
Accuracy	±(0.7% of reading +0.2% of range)
V a.c.	0.1V 1V 10V 100V 1kV
Input *Z*	10MΩ ±5% with less than 30pF
Accuracy	±(2% of reading + 0.5% of range) 45Hz to 1kHz
R	1kΩ 10kΩ 100kΩ 1MΩ 10MΩ
Accuracy	±(1.5% of reading + 0.2% of range)
Price	£137.50

WW512 for further details (3490A)
WW513 for further details (HP970A)

Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks.

The company has recently announced the Model 190 a.c./d.c. digital multimeter which has 5½ digit resolution and 0.005% basic accuracy. Features include 100% overranging, 1GΩ input resistance and built-in binary-coded decimal outputs. Measurement ranges cover four of a.c., four of d.c. and five of resistance. The a.c. and d.c. voltage measurements cover 8 decades, from 10μV per digit to 1000V full scale in four ranges. Resistance measurements cover 9 decades from 1kΩ to 20MΩ full scale (10mΩ to 100Ω per digit). A useful feature, when simultaneous data readings must be recorded from several instruments, is the output hold control which can be used to retain data in the display and the digital output. Model 190 costs £399.
WW513 for further details

Levell Electronics Ltd, Park Road, High Barnet, Herts.

The TM9BP is an electronic analogue multimeter providing measurement facilities from 3V or 3pA full-scale, and resistance to 1GΩ. All ranges (including resistance) are linear and have large overload ratings. Features include high input impedance and high a.c. rejection on voltage ranges, low voltage drop on the current ranges (10^{-3}V at 1nA, 0.1V at 1mA) and low test voltage (3mV at f.s.d.) on the linear resistance ranges. Power consumption is low, resulting in a very small warm-up drift and a life of 1000 hours from a self contained battery. The d.c. amplifier has 100% series negative feedback applied on the 1V range, high stability metal film resistors attenuating the negative feedback for ranges below 1V. A recorder output is included and switch selects centre zero or left zero.

Ranges

V d.c./a.c.	3μV 10μV 30μV . . . . same intervals to . . . . 1 kV
Accuracy	±1% ±1% f.s.d. up to 100 M rising to ±10% at 1 G
Input *Z*	>1 MΩ/μV up to 10 mV; >10 GΩ from 30 mV to 1V; 100 MΩ above
I d.c./a.c.	3 pA 10 pA 30 pA . . . same interval multiples to . . . 1A
Accuracy	±2% ±1% f.s.d. ±0.3 pA
R	3Ω 10Ω 30Ω . . . same interval multiples to . . . 1 GΩ
Accuracy	±1% ±1% f.s.d. up to 100 MΩ rising to ±10% at 1 GΩ
Price	***£93***

WW514 for further details

Linstead Electronics, Roslyn Works, Roslyn Road, London N15 5JB.

The company market a range of instruments for industrial measurement, laboratories, universities, technical colleges and schools. The M2B is a d.c./a.c. analogue millivoltmeter providing 20 ranges from 1.2mV (120mV d.c.) to 400V full scale, d.c. or a.c. within a frequency range from 10Hz to 500kHz. A decibel scale is also provided for plotting amplifier response, transfer functions, etc.

Ranges

V d.c.	120 mV 400 mV 1.2V 4V 12V 40V 120V 400V
Input *R*	Varies from 2 MΩ at 30 mV to 7.5 MΩ at 400 mV. Other ranges 10 MΩ
Accuracy	±(2½% + 2½% f.s.d.)
v.a.c.	1.2 mV 4 mV 12 mV 40mV . . . then as for V d.c. ranges
Input *Z*	10 MΩ
Accuracy	±(2½% + 2½% f.s.d.)
Price	***£35***

WW516 for further details

Marconi Instruments Ltd, St. Albans, Herts.

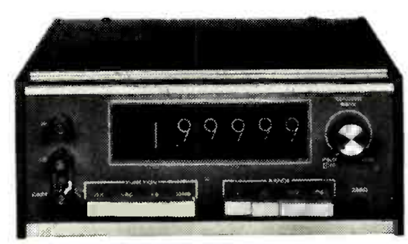
The TF2670 3½-digit multimeter is suitable for test room and laboratory measurements of voltage, current and resistance. Decimal point position is indicated automatically by lamps switched by the range selectors. Range overload and reversed polarity conditions are shown by warning indicators. The a-d system uses the dual integration technique, the reference voltage being derived from a low drift Zener with a low temperature coefficient so that the instrument is largely insensitive to moderate variation in ambient temperature. Counting and storage functions are performed by a single large scale integrated circuit. The instrument can be powered by mains, external direct voltage supply or by a rechargeable battery box attachment.

Ranges

V d.c.	200 mV	2V	20V	200V	1 kV
Resolution	100 μV	1 mV	10 mV	100 mV	1V
Input *R*	10 MΩ all ranges				
Accuracy	Varies from ±0.1% to 2% of reading and ±0.1% to 0.15% f.s.d.				
V a.c.	200 mV	2V	20V	200V	1 kV
Resolution	100 μV	1 mV	10 mV	100 mV	1V
Input *Z*	1 MΩ and 40-150 pF				
Accuracy	Varies from ±0.3% to 0.4% of reading and ±0.15% to 0.2% f.s.d.				
I d.c.	200 μA	2 mA	20 mA	200 mA	2A
Resolution	100 nA	1 μA	10 μA	100 μA	1 mA
Accuracy	±0.3% of reading ±0.2% f.s.d. all ranges				
I a.c.	200 μA	2 mA	20 mA	200 mA	2A
Resolution	100 nA	1 μA	10 μA	100 μA	1 mA
Accuracy	Varies from ±0.3% to 0.7% of reading and ±0.3% to 0.5% f.s.d.				
R	200Ω	2 kΩ	20 kΩ	200 kΩ	2 MΩ
Resolution	100 mΩ	1Ω	10Ω	100Ω	1 kΩ
Accuracy	±0.4% of reading ±0.15% f.s.d. on 200Ω range. Other ranges ±0.3% of reading ±0.15% f.s.d.				
Price	***£99***				

WW517 for further details

Keithley 190 digital multimeter



Linstead M2B electronic d.c./ a.c. voltmeter

Neuberger

Agents: Kandem Electrical Ltd, 711 & 715 Fulham Road, London SW6 5UN.

The PKD4 set of measuring and testing instruments is a somewhat unusual approach to multi-function measurements. It consists of a basic moving coil indicator which accepts adaptors in the form of plug-in modules. Up to 12 different modules are separately available, covering d.c./a.c. voltage, d.c./a.c. current, resistance, a multi-range d.c. amplifier, a transistorised a.c. voltmeter and static and dynamic testers for n-p-n and p-n-p transistors. The meter has two linear scales, 0 to 10 and 0 to 30 (for a.c. and d.c. measurements) and a third non linear scale marked in ohms and decibels. Adaptors are colour coded for quick identification and the ranges of PA2 (*V* d.c.), PA3 (*I* d.c.), PA4 (*V* a.c. and *I* a.c.) and PA5 (resistance) modules are as follows.

Ranges

PA2	
V d.c.	60 mV 150 mV 300 mV 1V 3V 10V 30V 100V 300V 1 kV 3 kV
Input *R*	20 kΩ/V
Accuracy	1%
PA3	
I d.c.	100μA 300μA 1 mA 3 mA 10 mA 30 mA 100 mA 300 mA 1A 3A 6A
Accuracy	1%
PA4	
V a.c.	3V 10V 30V 100V 300V 1 kV
Input ***Z***	333Ω/V (on 3V and 10V ranges) 2 kΩ/V (remaining ranges)
Accuracy	1%
I a.c.	3 mA 30 mA 300 mA 1A 6A
PA5	
R	1 kΩ 100 kΩ 10 MΩ
Accuracy	1%
Price	*£220*

WW518 for further details

Pye Unicam Ltd, York Street, Cambridge CB1 2PX

Released only in January 1974, the 4-digit (max.9999) PM2424 digital multimeter measures resistance, d.c. and a.c. (40 Hz to 50 kHz) voltage and current with automatic ranging. Ranging time per range is 200 ms to 330 ms. Dual slope a-d conversion is used, and sampling rate is 3 to 5 samples/sec.

Ranges

V d.c.	1V 10V 100V 1 kV
Resolution	100μV 1mV 10mV 100mV
Input *R*	More than 1GΩ on 1V and 10V ranges. 10 MΩ above.
Accuracy	±0.01% reading ±0.01% f.s. ±1 digit
V a.c.	1V 10V 100V 500V
Resolution	100μV 1 mV 10 mV 50 mV
Input *Z*	1 MΩ in parallel with 10 pF (all ranges)
Accuracy	Depends on range and frequency
I d.c.	1 mA 10 mA 100 mA 1A
Resolution	100 nA 1μA 10μA 100μA
Accuracy	±0.2% reading ±0.01% f.s. ±1 digit on all ranges except 1A where it is ±0.3% reading ±0.01% f.s. ±1 digit
I a.c.	1 mA 10 mA 100 mA 1A
Resolution	100 nA 1μA 10μA 100μA
Accuracy	±0.5% reading ±0.2% f.s. ±1 digit on all ranges except 1A where it is ±0.7% reading ±0.2% f.s. ±1 digit
R	1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ
Resolution	100 mΩ 1Ω 10Ω 100Ω 1 kΩ
Accuracy	Depends on range
Price	Not released

WW519 for further details

Racal Instruments, 26 Broad Street, Wokingham, Berks

Model 314A is a general purpose electronic voltmeter for measuring alternating voltage (25 mV to 300V), direct voltage (±5 mV to ±300V) and resistance (100Ω to 1 GΩ). An optional a.c. high voltage probe is available. The instrument is N.A.T.O. approved.

The 9070 Digital Universal Meter measures alternating or direct voltages from 100μV to 1.1 kV together with a.c. and d.c. current and resistance, and costs £211.

WW520 for further details

RCA Ltd, Sunbury-on-Thames, Middlesex TW16 7HW.

The WV38A analogue multimeter measures resistance, direct current, d.c. and a.c. voltages and audio signals in dB units. Extra low 0.25V and 1V d.c. ranges are included. Frequency response (reference 1kHz) of the a.c. voltmeter is within 0.5dB from 10Hz to 50kHz from 2.5 to 50V full-scale.

Ranges

V d.c.	0.25V 1V 2.5V 10V 50V 250V 1 kV 5 kV
Input *R*	20 kΩ/V
Accuracy	±3% f.s.d.
V a.c.	2.5V 10V 50V 250V 1 kV 5 kV
Input *Z*	5 kΩ/V
Accuracy	±5% f.s.d.
I d.c.	50μA 1 mA 10 mA 100 mA 500 mA 10A
Accuracy	±3%
R	R×1 R×100 R×10,000
Price	£32.50.

WW521 for further details

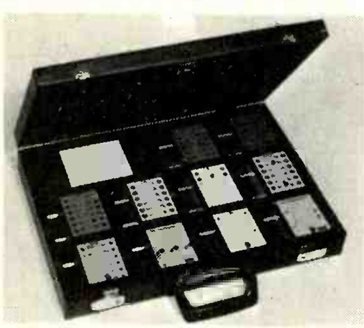
Salford Electrical Instruments Ltd., Peel Works, Barton Lane, Eccles, Manchester M30 0HL

The Super 50 Mark 2 Selectest multi-range meter has three scales with a mirror inset and knife edge pointer to eliminate parallax errors. Current and voltage scales are 0 to 100 with 100 divisions and 0 to 25 with 50 divisions. The third scale, 0 to 1000 ohms, covers all three resistance ranges. The outer scale is 6 in (152 mm) long. Ranges are selected by two rotary, electrically-interlocked, multi-position switches capable of continuous rotation in either direction. The 2.5 kV ranges in the following table are on separate terminals.

Ranges

V d.c.	250 mV 2.5V 10V 25V 100V 250V 1 kV 2.5 kV
Input *R*	20 kΩ/V
Accuracy	±1.5% (I.E.C. Class 1.5)
V a.c.	2.5V 10V 25V 100V 250V 1 kV 2.5 kV
Input *Z*	2 kΩ/V
Accuracy	±2.5% (I.E.C. Class 2.5) f.s.d. at 50 Hz
I d.c.	50μA 250μA 1 mA 10 mA 100 mA 1A 2.5A 10A
Accuracy	±1% (I.E.C. Class 1.0)
I a.c.	25 mA 100 mA 250 mA 1A 2.5A 10A
Accuracy	±2.5% f.s.d. (I.E. C. Class 2.5) at 50 Hz
R	2 kΩ 200 kΩ 20MΩ
Accuracy	±3% (zero to mid scale reading) ±5% (mid scale to ⅔ f.s. d.) ±10% (⅔ f.s.d. to f.s.d.)
Price	Approximately £37.

WW522 for further details



Neuberger PKD4 multi-function modular measuring set

Racal 9070 digital multimeter

Pye PM2424 digital multimeter

Sanwa

Agents: Quality Electronics Ltd, 47/49 High Street, Kingston-upon-Thames, KT1 1 LP.

The 460-ED is an analogue multimeter with a 10μA meter movement giving a d.c. sensitivity of 100 kΩ/V. Frequency coverage on ranges of 30V a.c. and below is 50 Hz to 100 kHz, and 10 kHz for other a.c. voltage ranges. At the inherent 100 kΩ/V sensitivity, the instrument measures up to 300V d.c. Above this, a high voltage probe is available to measure up to 30 kV at a sensitivity of 16.6 kΩ/V.

Ranges

V d.c.	0.3V	3V	12V	30V	120V	300V	
Input *R*	100 kΩ/V						
Accuracy	±2%						
V a.c.	3V	12V	30V	120V	300V	1.2 kV	
Input *Z*	5 kΩ/V						
Accuracy	±3%						
I d.c.	12μA	0.3 mA	3 mA	30 mA	300 mA	1.2A	12A
Accuracy	±2%						
I a.c.	1.2A	12A					
Accuracy	±3%						
R	5 kΩ	50 kΩ	500 kΩ	50 MΩ			
Price	£29.72						

WW523 for further details

Sinclair Radionics Ltd, London Road, St Ives, Huntingdonshire. PE17 4HJ.

The Sinclair DM1 3½ digit multimeter is suitable for d.c. measurements ranging from 1 mV to 1 kV and 1 nA to 1A and a.c. measurements ranging from 1 mV to 1 kV and 1μA to 1A. Accuracy varies from 0.4% on the d.c. voltage scale to 1% on the a.c. voltage scale. Full scale error amounts to ±2 digits. The instrument is priced in the region of £49, and when launched in December 1972 was claimed to be the first digital multimeter to be directly price competitive with professional quality analogue meters.

Ranges

V d.c.	1V	10V	100V	1000V
Resolution	1mV	10mV	100mV	1V
Input resistance	1GΩ			
Accuracy	±0.5% of reading			
V a.c.				
Accuracy	± 1% of reading			
I d.c.	1μA to 1A			
Max.res.	1nA			
I a.c.	1mA to 1A			
Max.res.	1μ A			
R	1kΩ to 1MΩ			
Max.res.	1Ω			

WW524 for further details

The Solartron Electronic Group Ltd, Farnborough, Hampshire.

When using the fully automatic 7040 digital multimeter, the user selects the function, subsequent operations being fully automatic. The instrument itself samples the input, selects the correct range, illuminates the unit indicator and decimal point as appropriate and displays the measured value together with its polarity. Leading zero suppression is applied. Common mode noise and series (normal) mode noise rejection are achieved by the use of a fully floating input stage with good isolation and integration over an integral number of mains cycles. The integration period is 100 ms, giving high rejection of 50 Hz, 60 Hz and 400 Hz without the use of filters.

Ranges

V d.c.	100 mV	1V	10V	100V	1 kV
Resolution	10μV	100μV	1 mV	10 mV	100 mV
Input *R*	1 GΩ	1 GΩ	1 GΩ	10 MΩ	10MΩ
Accuracy	± (0.02% to 0.03%) reading ±1 to 2 digits				
V a.c.	100 mV	1V	10V	100V	700V
Resolution	10μV	100μV	1 mV	10 mV	100 mV
Input *Z*	1 MΩ with less than 100 pF (all ranges)				
Accuracy	±0.2% reading ±2 to 10 digits				
I d.c.	10μA	100μA	1 mA		
Resolution	1 nA	10 nA	100 nA		
Accuracy	±0.05% reading ±1 to 3 digits				
R	1 kΩ	10 kΩ	100 kΩ	1 MΩ	10 MΩ
Resolution	100 mΩ	1Ω	10Ω	100Ω	1 kΩ
Accuracy	±0.05% reading ± 1 to 3 digits				
Price	£195				

WW526 for further details

Smiths Industries Ltd, Industrial Instrument Division, Waterloo Road, Cricklewood, London. NW2 7UR.

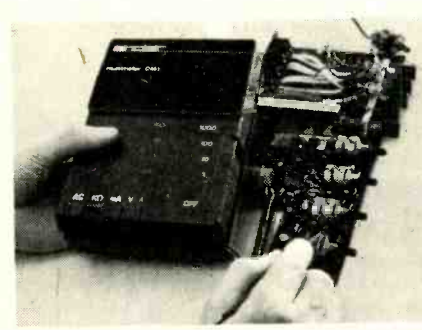
Multimeter 3 is a portable instrument designed around a 24-position rotary switch. A.c. and d.c. ranges are identical except for additional low d.c. voltage and current ranges. Volts, resistance and current ranges are selected by push button. Unidirectional components such as electrolytic capacitors and semiconductors can be tested without the need to reverse leads or terminals — press buttons select the polarity of test voltage and meter movement. A safety cut-out which operates within 5 ms to 10 ms reacts to the rise time of the applied signal, not the movement of the pointer, breaking the circuit before the pointer reaches full scale. The cut-out is equally sensitive in the forward or reverse direction.

Ranges

V d.c.	0.1V	0.3V	1V	3V	10V	30V	100V	300V	1 kV
Input *R*	31.6 kΩ/V								
Accuracy	± 1% f.s.d.								
V a.c.	0.3V	1V	3V	10V	30V	100V	300V	1 kV	
Input *Z*	5 kΩ/V								
Accuracy	±1.5% f.s.d. (25 Hz to 1 kHz)								
I d.c.	30μA 0.1 mA 0.3 mA. . .in same multiples to. . .10A								
Accuracy	±1% f.s.d.								
I. a.c.	0.3 mA . . . and then same ranges as I d.c. to . . . 10A								
Accuracy	±1% f.s.d. (25 Hz to 1 kHz)								
R	500Ω	50 kΩ	500 kΩ	5 MΩ	50 MΩ				
Price	£38.50								

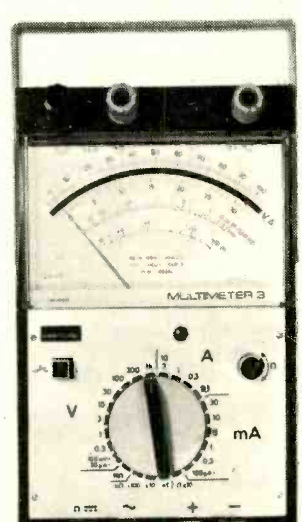
WW525 for further details

Salford Super 50 Mark 2 Selectest multimeter



Sinclair DM1 digital multimeter

Smiths Multimeter 3



Tekelec-Airtronic Agents: REL Equipment & Components Ltd, Croft House, Bancroft, Hitchin, Herts SG5 1BU.

A d.c. multimeter with a 3½-digit display, the TE923 possesses voltage, current and resistance ranges. Grounded or floating operation (500V) is provided for and the input can be offset by up to ±50µV. An analogue output of 1V is available and an optional digital output is possible. A further option is the TE380, which provides an alarm signal when the reading is either within or outside two preset limits.

Ranges

V d.c.	100µV to 1kV f.s.
Resolution	0.1µV to 1V
Input R	100kΩ to 100MΩ
Accuracy	±0.1% reading, ±1 digit
I d.c.	100nA to 1A
Resolution	0.1nA to 1mA
Accuracy	**± 0.2% reading**, ±1 digit
R	100Ω to 1GΩ
Resolution	0.1Ω to 1MΩ
Accuracy	Range dependent
Price	Not available

WW530 for further details

Wessex Electronics Ltd, Stover Trading Estate, Yate, Bristol, BS17 5QP.

The California Instruments 8300 offers frequency measurement up to 1MHz in addition to handling alternating and direct voltage and current, and resistance. A l.e.d. dot-matrix display is used and a comprehensive printer output is provided.

Ranges

V d.c.	100mV	1V	10V	100V	1000V (50% overrange on highest ranges)
Resolution	10µV	100µV	1mV	10mV	100mV
Z_{in}	1000MΩ			10MΩ	10MΩ
Accuracy	±0.01% of reading ±0.01% f.s.				
V a.c.	100mV	1V	10V	100V	1000V (50% overrange on highest ranges)
Resolution	10µV	100µV	1mV	10mV	100mV
Z_{in}	Less than 0.5% loading of 1kΩ source up to 10kHz				
Accuracy	±0.45% of reading ±0.05% f.s.				
I a.c. *I d.c.*	100mV	1V	10V	100V	1000V
Accuracy (d.c.)	±0.03% of reading ±0.02% f.s.				
(a.c.)	±0.7% of reading ±0.05% f.s.				
R	100Ω	1kΩ	10kΩ	100kΩ	1MΩ
Resolution	10mΩ	100mΩ	1Ω	10Ω	100Ω
Accuracy	±0.02% of reading ±0.02% f.s.				
Frequency	1kHz	10kHz	100kHz	1MHz	
Z_{in}	Less than 0.5% loading of 1kΩ source up to 10kHz				
Accuracy	±0.01% reading ±0.01% f.s.				
Price	£850				

WW527 for further details

West Hyde Developments Ltd, Ryfield Crescent, Northwood Hills, Northwood, Middlesex. HA6 1NN.

Imported from Italy, the TS140 analogue multimeter is somewhat unusual in that it does not employ a selector switch for its 50 ranges. Instead, insertion of the test lead plugs is arranged to operate internal switches. It is claimed that the method possesses long term mechanical reliability. In addition to the voltage, current and resistance ranges listed in the following table, the instrument measures reactance, frequency and capacitance. Accessories are available for measurement of light (0 to 20,000 lux), heat (−25°C to +250°C) and e.h.t. up to 25 kV d.c.

Ranges

V d.c.	0.1V	1V	3V	10V	30V	100V	300V	1 kV
Input *R*	20 kΩ/V							
V a.c.	1.5V	15V	50V	150V	500V	1500V	2.5/5 kV	
Input *Z*	4 kΩ/V							
I d.c.	50µA	500µA	5 mA	50 mA	500 mA	5A		
I a.c.	250µA	50 mA	500 mA	5A				
R	1 kΩ	10 kΩ	100 kΩ	1 MΩ	10 MΩ			
Price	£15.50							

WW528 for further details

Z & I Aero Services Ltd, 44A Westbourne Grove, London, W2 5SF.

Imported from U.S.S.R., multimeter Type U4323 has *V*, *I* and *R* facilities plus an oscillator output which produces a 1kHz square wave, and a 465 kHz sine wave modulated by 1 kHz square wave.

Ranges

V d.c.	0.5V	2.5V	10V	50V	250V	500V	1 kV
Input *R*	20 kΩ/V						
V a.c.	2.5V	10V	15V	250V	500V	1 kV	
I d.c.	0.05 mA	0.5 mA	5 mA	50 mA	500 mA		
R	1 kΩ	10 kΩ	100 kΩ	1 MΩ			
Accuracy	5% f.s.d.						
Price	£7						

WW529 for further details

Active filters for loudspeakers

Addition and correction

Values for the capacitors C_3 and C_4 shown in Fig. 4 of the article published in the December 1973 issue should be

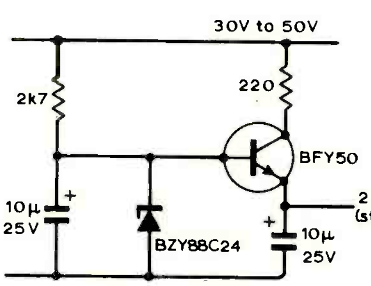
C_4	h.f.	10µF
C_3	h.f.	10µF
C_4	m.f.	25µF
C_3	m.f.	25µF
C_4	l.f.	50µF
C_3	l.f.	150µF

Components are shown on the active filter card for a power supply regulator not included in the circuit diagram. It is recommended that the transistor mounted above the 2k2 pot on the power amplifier circuit board is a plastic 2N3904 which can be clipped under the output transistor heat sinks. The lead marked "to (−ve) of l.s. & coupling C" on the power amplifier layout (Fig. 6) should read "to (−ve) of l.s. coupling C". Cut off frequencies, for the 12dB/octave filters should be $1/2\pi\sqrt{R_1R_2C_1C_2}$.

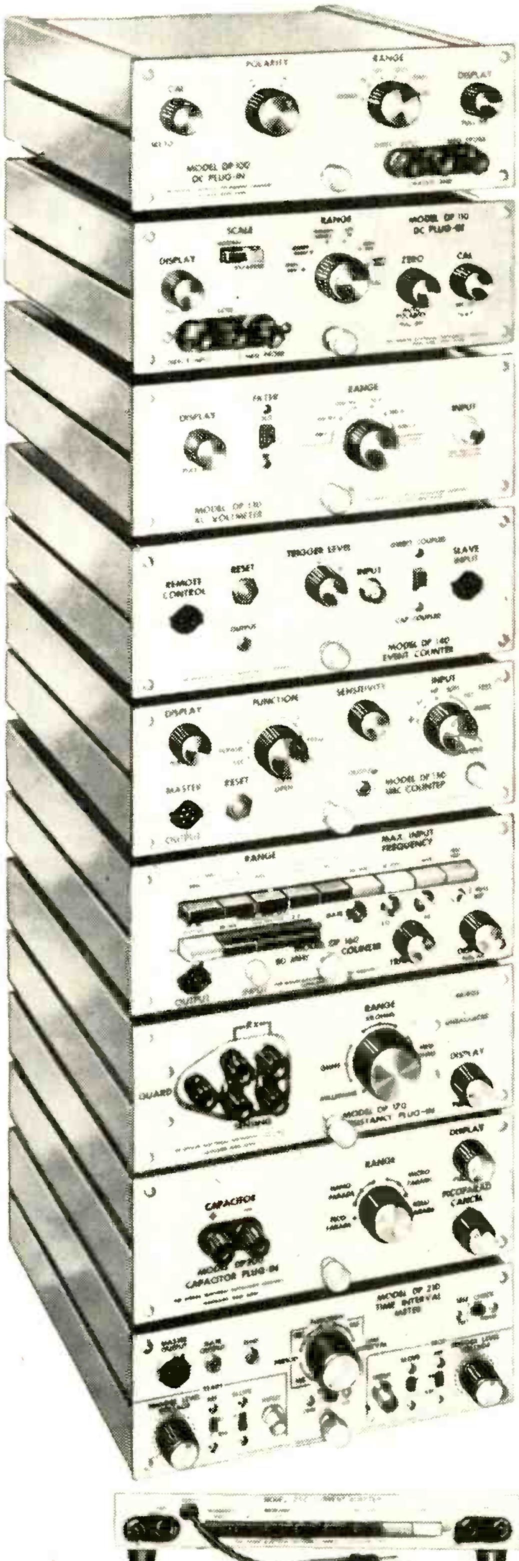
Listening tests conducted by the author, comparing the active design with a passive network, produced the following comments from him:

"Convinced theoretically that the active filter approach is better, I needed assurance that it sounded better. With the help of many discerning friends, listening tests were carried out. A remote push-button was used to compare reproduction through active or passive filters. Nobody was told whether the active filter was in circuit when the button was pressed or released, but without exception all preferred the sound produced via the active filter. The remarks made were: 'It is less harsh, the sound is clearer, the cymbal comes through cleanly, the piano notes have no overhang,' etc. The difference is small, but it is unmistakeably there. The advantages are particularly apparent on certain types of music which contains plucked bass, piano and percussion instruments—that is, pieces with high transient energy. With some other types of music, it was admittedly hard to tell which was which."

Components of the "on-board" power supply regulator.



No half measure!



D.C. VOLTS
100 μV to 1000V

D.C. VOLTS
1 μV to 1000V

A.C. VOLTS
10 μV to 1000V

EVENTS TO
1 MILLION COUNTS
PER SECOND

FREQUENCY
to 8MHz

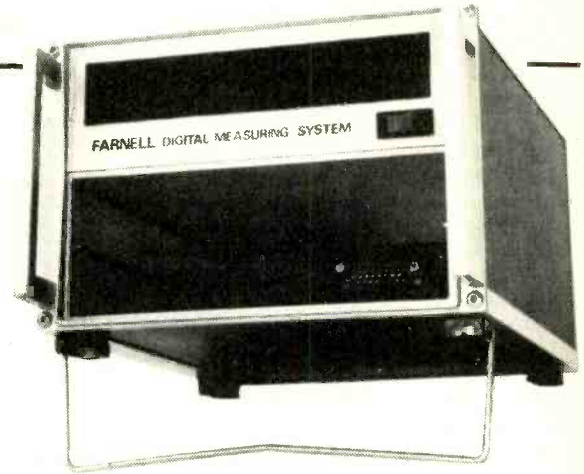
FREQUENCY
to 100 MHz

RESISTANCE
.001Ω to 1,000MΩ

CAPACITANCE
1pF to 10,000μF

TIME INTERVALS
0.01mS to 1
MILLION SECONDS

D.C. CURRENT
0.1nA to 10A



The Farnell Digital Measuring System provides a wider range of measurement than is generally possible with digital multimeters.

There's a choice of 3, 4 or 6 digit main frames and any module may be used with any frame. The module slips into the main frame on runners and is secured by a locking shaft. Simply and quickly in this way, the instrument is converted to measure voltage, frequency, period, events, resistance, capacitance etc.

An obvious choice when equipping a new laboratory because the display section and power supplies are bought just once —in the main frame. Additional functions are obtained at far less cost than complete single purpose digital instruments by purchasing the required modules.

To obtain a 16 page brochure describing this equipment contact:-

Farnell

FARNELL INSTRUMENTS LIMITED,
TELECOMMUNICATIONS DIVISION,
SANDBECK WAY, WETHERBY, YORKSHIRE.
TELEPHONE 0937 3541 · TELEX 557294

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LOW COST RC OSCILLATORS

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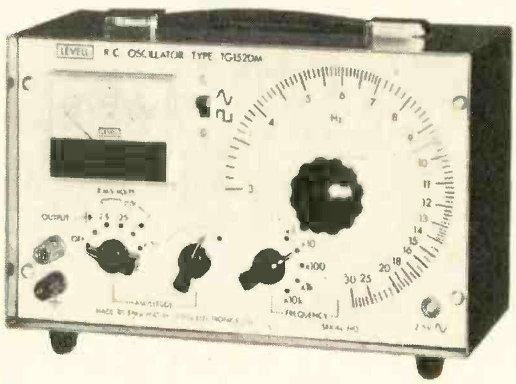
SEE US ON STAND No. 645 AT THE I.E.A. EXHIBITION

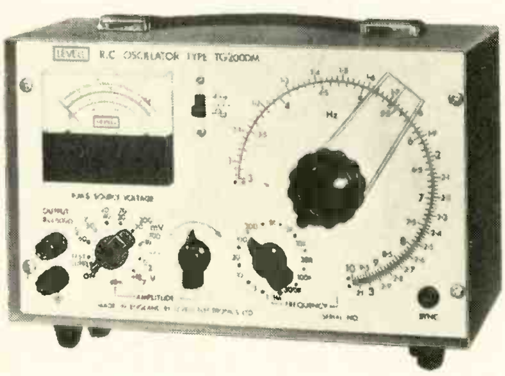
ANALOGUE



FREQUENCY	3Hz to 300kHz in 5 ranges.
ACCURACY	±2% ±0.1 Hz up to 100kHz, increasing to ±3% at 300kHz.
SINE OUTPUT	2.5V r.m.s. down to < 200μV.
DISTORTION	< 0.2% from 50Hz to 50kHz.
SQUARE OUTPUT	2.5V peak down to < 200μV.
SYNC. OUTPUT	2.5V r.m.s. sine.
METER SCALES	0/2.5V & −10/+10dB on TG152DM.
SIZE & WEIGHT	7" high x 10¼" wide x 5½" deep. 8 lbs.

TG152D Without meter. **£46**

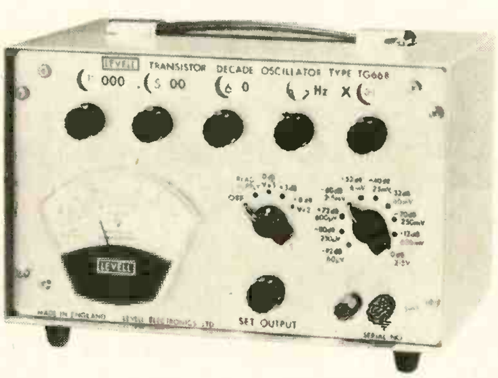
TG152DM With meter. **£56**



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

TG200	TG200D	TG200M	TG200DM
Sine O/P	Sine & Sq. O/P.	Sine O/P +meter.	Sine & Sq.O/P + meter.
£55	**£58**	**£65**	**£68**

DIGITAL



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Television Broadcasting from Satellites

Conclusion of a two-part series describing 12GHz satellite TV receiver design

by D. B. Spencer, Ph.D and K. G. Freeman, B.Sc., A.Inst.P., M.I.E.R.E.

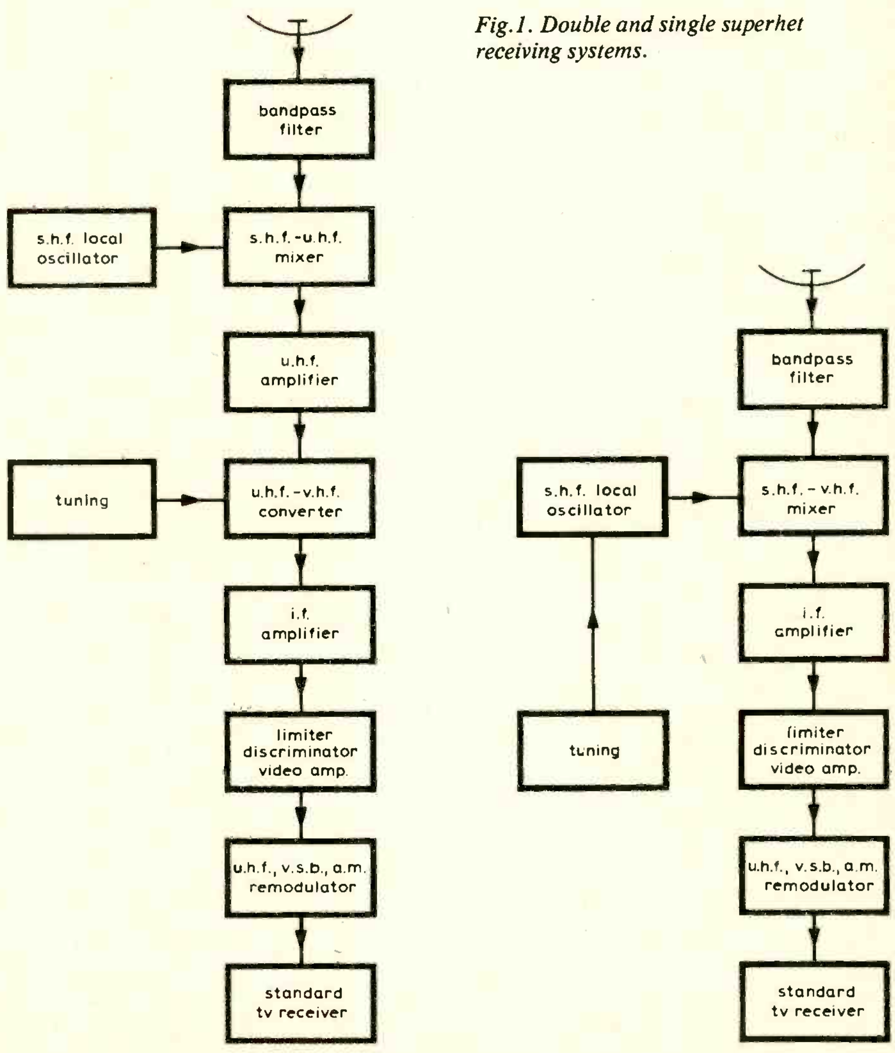
It was concluded in our previous article that broadcasting of television signals from a geostationary satellite is feasible at both u.h.f. and s.h.f. Transmission in the u.h.f. band which has been allocated to satellite broadcasting (620-780MHz), will probably be chosen by the developing countries, whereas developed countries which have an existing u.h.f. terrestrial television service will probably use the s.h.f. allocation (11.7-12.5GHz for Region 1, Europe, U.S.S.R. and Africa). Considerations of the transmitter power requirements and channel allocation problems led to the conclusion that such systems would almost certainly use wideband frequency modulation. Possible f.m. 12GHz receiver designs and microwave technologies will now be considered and these will be illustrated by reference to experimental receivers which have been constructed. Although u.h.f. receiver design will not be discussed specifically, the i.f. processing circuits (amplification, limiting and demodulation) together with a.f.c. techniques are of general application. The tuner required for the u.h.f. system will be similar to that used as the second converter of the s.h.f. double superhet receiver.

Receiver design problems

Apart from cost, which as with all consumer products is of prime importance, a number of important factors affect the design of 12GHz f.m. satellite television broadcast receivers. Either direct reception of the signals in the home or some form of community reception could be used. In both cases the need would initially be for a converter capable of providing a u.h.f. (or possibly v.h.f.) a.m. signal suitable for feeding the standard television receiver which is already in most homes. In the long term specially designed receivers can be envisaged to which the input may be at video or as f.m. at a v.h.f. or u.h.f. intermediate frequency.

Future trends such as the use of several receivers in one home, video tape recorders and also possible local cable TV must be borne in mind. It is also necessary to take into account the possible development of a system of data transmission within the existing broadcast signal, such as that proposed by the B.B.C./I.B.A. [2, 3]. The domestic television receiver may also be called upon to act as the visual display unit of a domestic data link system. All of these factors may affect the packaging of the parts of the satellite broadcast receiver. Since part of the receiver will probably be near the aerial there would be a need to supply power, and in some cases, a tuning and a.f.c. voltage, up to this unit. The most convenient and elegant solution would be to use the existing u.h.f. television down-lead for these signals together with the satellite signal.

Although 800MHz of bandspace has been allocated at 12GHz to countries in Region 1 it is likely that transmissions to any particular country will be grouped within only part of this band. This eases the constraints on receiver design. We have assumed for this study that all programmes to any one country will be within 400MHz of bandspace. Assuming a 30MHz channel spacing this allows a gap of 90MHz between each programme which should be more than adequate in order to provide adjacent channel rejection.



a) double superhet b) single superhet

Fig.1. Double and single superhet receiving systems.

There are two principal types of receiver suitable for s.h.f. satellite broadcast reception; these are the single and double superhet. In the single superhet design the incoming s.h.f. signal is converted to an intermediate frequency which allows amplification, limiting and demodulation to be accomplished directly. The double superhet consists of two converter stages. The first converts the s.h.f. to a lower frequency at which it is amplified and passed to a second mixer which produces the required intermediate frequency. Two types of double superhet can be considered. In one, the first local oscillator is fixed and a broadband first i.f. amplifier is employed which passes all the required satellite signals. The second oscillator is then tuned to provide reception of the required programme. The alternative form of double superhet has a tunable first local oscillator and a narrow-band first i.f. amplifier which passes only the required programme. A fixed second local oscillator in the second mixer provides the necessary second i.f.

Due to the restricted space available here it is impossible to go into the various advantages of the two types of double superhet in detail. However, if the problems of local oscillator re-radiation, image rejection and cost are considered it seems probable that the first local oscillator will be fixed in frequency and the second tuned.

Fig. 1 shows possible double and single superhet designs. In the case of the double superhet the incoming 12GHz signals are mixed with an s.h.f. local oscillator. The resultant u.h.f. signals are passed through an amplifier to a second mixer where they are mixed with a tunable u.h.f. oscillator to produce a v.h.f. i.f. This frequency modulated signal is amplified and limited before being demodulated to produce a video output (with 6MHz inter-carrier f.m. sound). A u.h.f. a.m. modulator then produces a signal which is suitable for insertion into the aerial socket of a standard television set. An a.f.c. signal derived from the frequency discriminator controls the frequency of either local oscillator. The single superhet receiver produces a low i.f. directly from the 12GHz incoming signal; this is then processed as indicated above.

A problem which is common to both single and double superhet designs is the rejection of the image frequency. (A mixer produces an output for signals spaced at the i.f. away both above and below the local oscillator frequency. Only one of these signals is wanted, the other is known as the image frequency.) In the case of a 30MHz bandwidth f.m. television signal a protection of approximately 30dB is required against an interfering signal whether it be co-channel or image channel interference. Image channel protection is provided by a combination of the contributions from the receiver selectivity, receiver directivity and the position and directivity of the interfering transmitter. Sufficient first image rejection can be provided reasonably easily with the double superhet design since the high first i.f. places the image frequency bands well away from the wanted signal. This is indicated in Fig. 2a. The first i.f. lies between 500 and 900MHz and, if a low local oscillator is assumed, the image band lies between 10.4 and 10.8GHz. The design of a band-pass filter which will pass only the wanted signals is relatively simple. Selectivity must also be provided before the second mixer to reject the second image; this should be achievable using existing techniques.

In the single superhet design a v.h.f. i.f. has to be chosen as low cost amplification, limiting and discrimination circuits would otherwise not be possible. This makes image rejection more difficult. Fig. 2b shows the variations of the signal, local oscillator and image frequencies for a similar tuning range to that assumed for the double superhet. An i.f. of 70MHz has been assumed for the purpose of illustration together with a 30MHz signal bandwidth. The signal frequency range is 11.8-12.2GHz and if a low local oscillator is assumed this varies between 11.745GHz and 12.145GHz (see Fig. 2c). An image frequency band from 11.69GHz to 12.09GHz must be rejected.

It is apparent that the selectivity demanded before a conventional mixer calls for a high-Q tunable s.h.f. filter. This must have a bandwidth of 70MHz and 110MHz away from the band edge it must have some 30dB of attenuation. A filter based upon a Yttrium Iron Garnet (YIG) device may provide a suitable solution. At the present time, however, such filters are rather expensive, lossy and also temperature dependent. (A YIG filter consists basically of a small sphere of magnetic material (Yttrium Iron Garnet) which exhibits a gyromagnetic resonance effect. The sphere is positioned in a circuit so that it will couple power between the input and output only at its resonant frequency. The frequency at which this occurs depends upon the magnetic field in which the sphere is situated and this can be varied to provide tuning.)

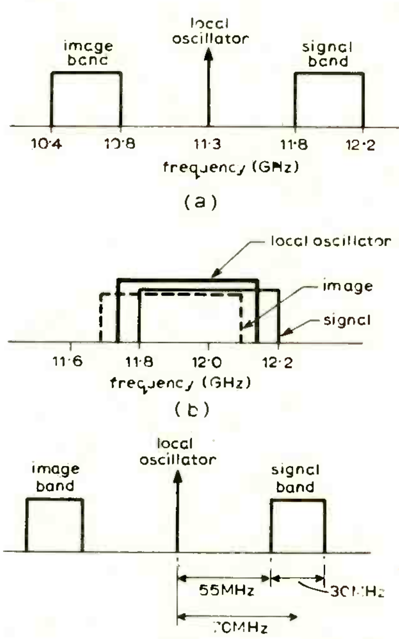


Fig.2. Diagrams showing the relationship of the signal, image and local oscillator bands in (a) double superhet (b) single superhet (c) indication of the final image filtering problem.

Perhaps a more elegant solution to the problem of image rejection could be the image rejection mixer. This should be amenable to mass production techniques and it will be considered in more detail later.

Another problem which may have to be solved in the receiver design is that of the prevention of excessive local oscillator power radiation. This again can more easily be solved in the double superhet design where the local oscillator frequency is fixed and sufficiently far removed from the required signal band so that a filter is readily made. In fact this filter could also provide image band rejection. In the case of the single superhet, a filter solution is difficult. An attractive approach might be the inclusion of a non-reciprocal device, such as an isolator, before the mixer. This would pass signals from the aerial but attenuate the local oscillator signal from the mixer. However, it is possible that by suitable allocation of frequencies the local oscillator frequency can be made to lie between channels and be relatively untroublesome.

Receiver aerial

The aerial must be considered as an integral part of the receiving system. Its supply and fixing may well prove to contribute a significant proportion of the overall system cost. For individual (domestic) reception the aerial required would probably be a 75cm diameter parabolic dish or an aerial of similar performance. This would have a beamwidth of about 2°. A community receiver aerial might well be twice the size of an individual receiving aerial with a subsequent smaller acceptance angle. In both cases they would have to be mounted to withstand all weathers, whilst maintaining a high positional accuracy. As the satellite transmitter would be in an equatorial orbit, it would have to point approximately South with an elevation angle varying from, for example, 23° in Northern Scotland to 33° in Southern England. The surface profile of a parabolic aerial would have to be accurate to the order of 2mm.

As large numbers of aerials would eventually be required it may be possible to produce them, at a reasonable cost, using a plastic moulding technique. A conductive coating would have to be added to provide a reflecting surface. Similar techniques may be feasible for the construction of the aerial feeder and this could incorporate a bandpass filter.

Microwave front end

Since even a short length of low-cost s.h.f. feeder will incur significant signal attenuation and installation costs, the microwave portion of the receiver will be located at or near the aerial. It will comprise a mixer with local oscillator followed by some low noise i.f. amplification. Because of the exposed position of this "head-unit" it will have to be designed to withstand all the rigours of the climate.

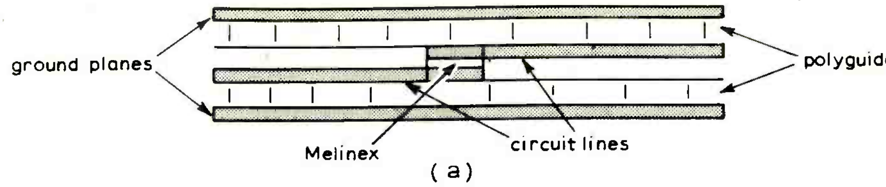
The mixer may well be constructed using a strip-line technique as this should be compatible with high volume, low cost production. Two such techniques are currently in general use, known as "Tri-plate" and "Microstrip"; they have both been described recently in *Wireless World*[3]. Tri-plate consists of a sandwich construction of ground plane, dielectric, circuit lines, dielectric and a second ground plane. Microstrip consists of a single ground plane and dielectric upon which are laid the circuit lines. Tri-plate and Microstrip are illustrated in Fig. 3. For our early experimental work with Tri-plate we used 1.5mm irradiated polyolefin as a dielectric which was backed with copper ground planes (this material is generally known as polyguide). Our later work concentrated on the Microstrip technology, in which the circuits consisted of an alumina substrate with gold ground plane and circuit lines.

All the experimental mixers were of the balanced variety as these are easier to make using strip-line techniques than the apparently simpler single-ended type. The fact that a balanced mixer rejects local oscillator amplitude noise comes as an unnecessary bonus as the i.f. signal limiter will do this anyway.

Some means must be found to apply signal and local oscillator voltages across the mixer diodes. At microwave frequencies this is achieved by means of hybrid rings, which are shown in suitable forms for Tri-plate and Microstrip circuits in Fig. 4(a) and 4(b) respectively. In the Tri-plate version a signal applied to port (1) is divided equally between ports (3) and (4), the two signals being in phase.

A signal applied to port (2) is similarly divided between ports (3) and (4) but in this case there is a 180° difference between the two outputs. In the Microstrip hybrid-ring a signal applied to either port (1) or port (2) is divided between ports (3) and (4). The outputs are of equal amplitude but differ by 90° in phase in each case. A mixer is constructed by taking ports (3) and (4) to a pair of diodes and applying signal and local oscillator voltages to ports (1) and (2).

The microwave mixer requires a local oscillator power of the order of 10mW in the region of 11.5GHz. This can be obtained directly from one of a number of semiconductor two terminal bulk effect devices. Perhaps the best known, and certainly the most widely used, are the avalanche diode and the Gunn device. The avalanche oscillator requires a supply of some 60V and produces more power than is necessary. A Gunn oscillator on the other hand needs only an 8V supply and it produces the right amount of power.



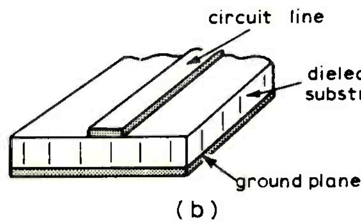


Fig.3. Schematic diagram of (a) a section of triplate showing a series capacitor and (b) microstrip.

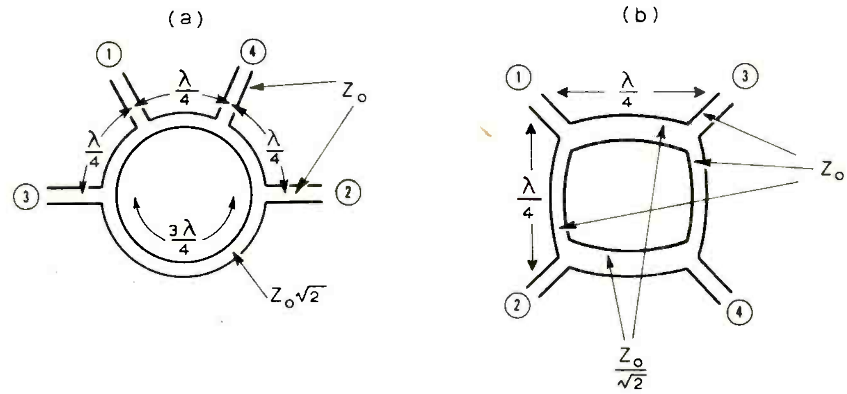


Fig.4. Hybrid ring suitable for (a) triplate construction and in (b) microstrip construction.

The local oscillator may be fixed tuned in the case of the double superhet but it must be electronically tunable if the single superhet approach is adopted. (Electronic tuning is possible by the addition of a varactor diode to the resonant circuit of the oscillator.) The temperature stability of Gunn oscillators is generally poor — typically of the order of 1MHz/°C. As the oscillator would be exposed to wide temperature variations, mounted as it is near the aerial, large frequency variations would occur. Fortunately it appears that the application of a.f.c. using the existing wideband frequency discriminator, together with some temperature compensation, would probably provide adequate frequency stability. Although our experimental receivers used varactor tuned Gunn oscillators, it is interesting to note that experimental transistors have already been made which will oscillate at 12GHz.

A typical 12GHz mixer followed by a low noise i.f. amplifier will have a noise figure of the order of 9dB, whether it be the single superhet 12GHz/v.h.f. mixer or the first mixer of the double superhet. This noise figure could be improved by several decibels if the mixer were preceded by a low-noise s.h.f. amplifier. Even with current progress in microwave transistor development, the realization of such an amplifier at a reasonable cost in the near future seems unlikely, but it may well be available by the time that a 12GHz service is implemented.

The output from the head unit will be either a v.h.f. or u.h.f. f.m. signal. This has to be taken to the remainder of the satellite broadcast receiver which will probably be adjacent to the TV set. How this may be accomplished and how power can be fed to the head unit (adjacent to the aerial) depends to a certain extent upon the design of the receiver. These problems will be dealt with in more detail as we go on to consider the double and single superhet designs in more detail.

Double superhet

From several points of view the most attractive receiver design appears to be the double superhet which has a fixed s.h.f. oscillator and a tunable u.h.f. oscillator. In a practical receiver a head unit would provide wideband conversion of the received signals to the u.h.f. band together with a broadband low-noise u.h.f. amplifier. The amplifier would prevent cable losses in the u.h.f. downlead and subsequent stages from degrading the system noise performance. Drift in the frequency of the fixed tuned s.h.f. local oscillator due to ambient temperature changes could be compensated for by the application of a.f.c. to the second local oscillator.

D.c. power has to be fed to the head-unit to drive the local oscillator and the low-noise i.f. amplifier. There are two principal ways in which this can be obtained. The first being directly from the mains electrical supply via a power unit situated perhaps in the attic or loft. The alternative and perhaps the more attractive solution would be to derive this power from the portion of the receiver adjacent to the TV set and feed it up the cable which is used to bring the u.h.f. signals down from the head-unit. If the cable which exists in many homes, from the terrestrial TV aerial system to the TV set, could also be used for the satellite signals then this would prove economical as well as aesthetically pleasing. Problems, however, occur such as possible interference between the satellite u.h.f. f.m. intermediate frequency signals and the terrestrial u.h.f. a.m. signals.

The u.h.f. f.m. intermediate frequency signal from the head unit must be further processed to arrive at a signal which is compatible with a television receiver. A second mixer is necessary to convert the u.h.f. signal down to a v.h.f. signal which may be more easily amplified, limited and demodulated. As the v.h.f. processing circuits are generally applicable to both double and single superhet designs these will be considered later after a discussion of the single superhet.

An important advantage of the double superhet is that a single head-unit could provide a number of outlets in a home, allowing several programmes to be received simultaneously. As a result of this the double superhet approach could also form the basis for a community distribution system. Distribution could be made at u.h.f. as f.m. signals, or these signals could be demodulated and then remodulated onto a u.h.f. carrier as amplitude modulation in a form compatible with a conventional TV set.

Single superhet

The single superhet receiver design is shown in Fig. 1(b). In order that extensive use may be made of integrated circuit techniques a low i.f. must be chosen. As has been discussed earlier this makes the problems of oscillator radiation and image rejection more difficult to solve.

A possible solution to the problem of image rejection is the image rejection mixer[5], which is shown in schematic form in Fig. 5. In this the incoming signal is split and fed in quadrature to two balanced mixers. The i.f. outputs from the mixers are combined in quadrature giving cancellation of the image signal components. An experimental, microstrip, image-rejection mixer uses a tri-plate, meander line hybrid to produce the necessary 90° of phase change at the i.f. A wireline hybrid (basically a screened lead which contains a pair of balanced conductors) is also suitable and has been used in an experimental receiver. The image rejection which is achieveable is typically of the order of 24dB.

A disadvantage with the single superhet design is the need to tune the s.h.f. local oscillator for channel selection. This can be achieved electronically by the addition of a varactor (variable capacitance diode) into the tuned circuit of the oscillator. However, this may result in a degraded performance as the varactor will lower the circuit Q making the oscillator more temperature sensitive and increasing the f.m. noise.

To avoid an increased system noise figure due to loss in the down lead, and also to provide a signal sufficiently large so that it will not be degraded by stray terrestrial transmitter pick up, amplification would also be provided at the i.f. in the head unit. The head unit must be supplied with power and a tuning voltage together probably with an a.f.c. signal, preferably all via the coaxial signal downlead cable. This is possible using fairly simple circuit techniques. It might be thought possible to use an existing u.h.f./v.h.f. downlead cable on a shared basis with u.h.f. terrestrial transmissions. However, this is unlikely, as although v.h.f. 405-line TV transmissions may well have closed down by the advent of satellite broadcasting these frequencies may well be re-allocated to terrestrial broadcasting.

With the single superhet approach only one satellite programme can be received in the home at any time. A single superhet receiver is, therefore, not particularly suited to a community system as this would have to have as many s.h.f./v.h.f. mixers as there were programme choices. These mixers would have to be preceded by a low noise amplifier and probably a large receiving aerial to make up for the signal loss due to the power splitting between the multiple mixers. Although the single superhet may upon initial examination appear to be the simplest solution it is thus seen to hold real disadvantages when compared to the double superhet.

I.F. signal processing

The requirements for i.f. selectivity, amplification and f.m. demodulation are, in general, similar for both the double and single superhet designs. However, the double superhet will need a second mixer to convert the u.h.f. first i.f. down to a v.h.f. second i.f. It will require a tunable local oscillator and sufficient selectivity in order to reject the second image. These are similar problems to those encountered with conventional u.h.f. TV tuners. A low noise u.h.f. amplifier will be included in the head-unit and if this has sufficient gain the noise figure of the u.h.f. converter will not be important.

The choice of the final i.f. will be a compromise between the desire to use i.c. techniques and the need to achieve adequate selectivity and, for the double superhet, adequate second image rejection. At present, an i.f. centred in the range 30-80MHz is probably optimum. If full use is to be made of the available frequency allocation then it would be split into a series of adjacent channels as shown in Fig. 6. If the final i.f. centre frequency is an integral number of half channel widths (b.w./2) then the image channels occupy one full frequency channel,

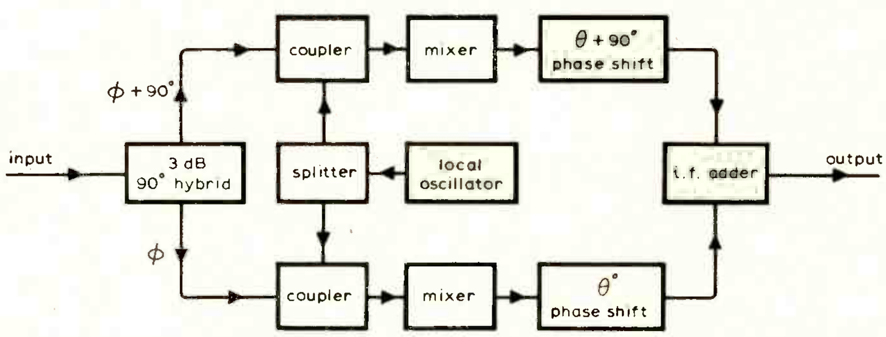


Fig.5. Outline of the image rejection mixer.

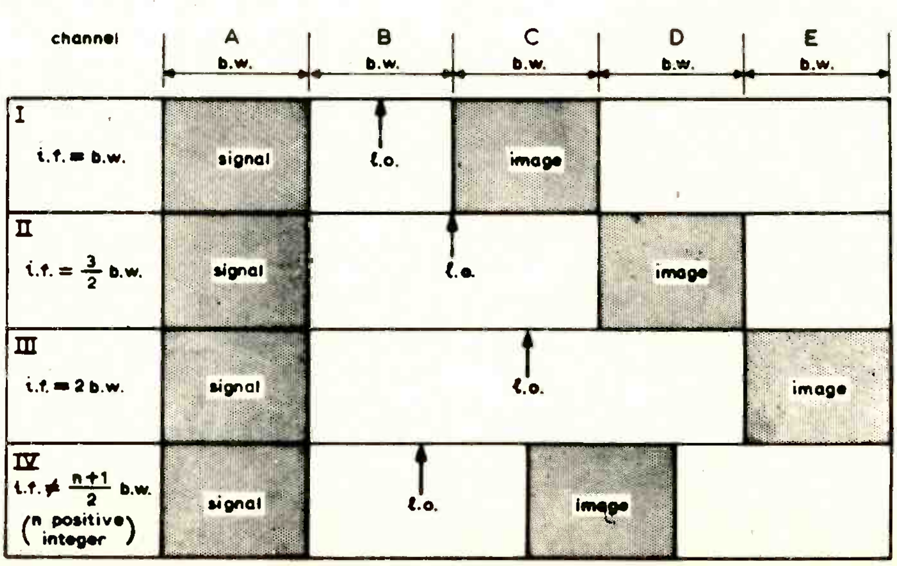


Fig.6. Allocation of the image channel for various intermediate frequencies.

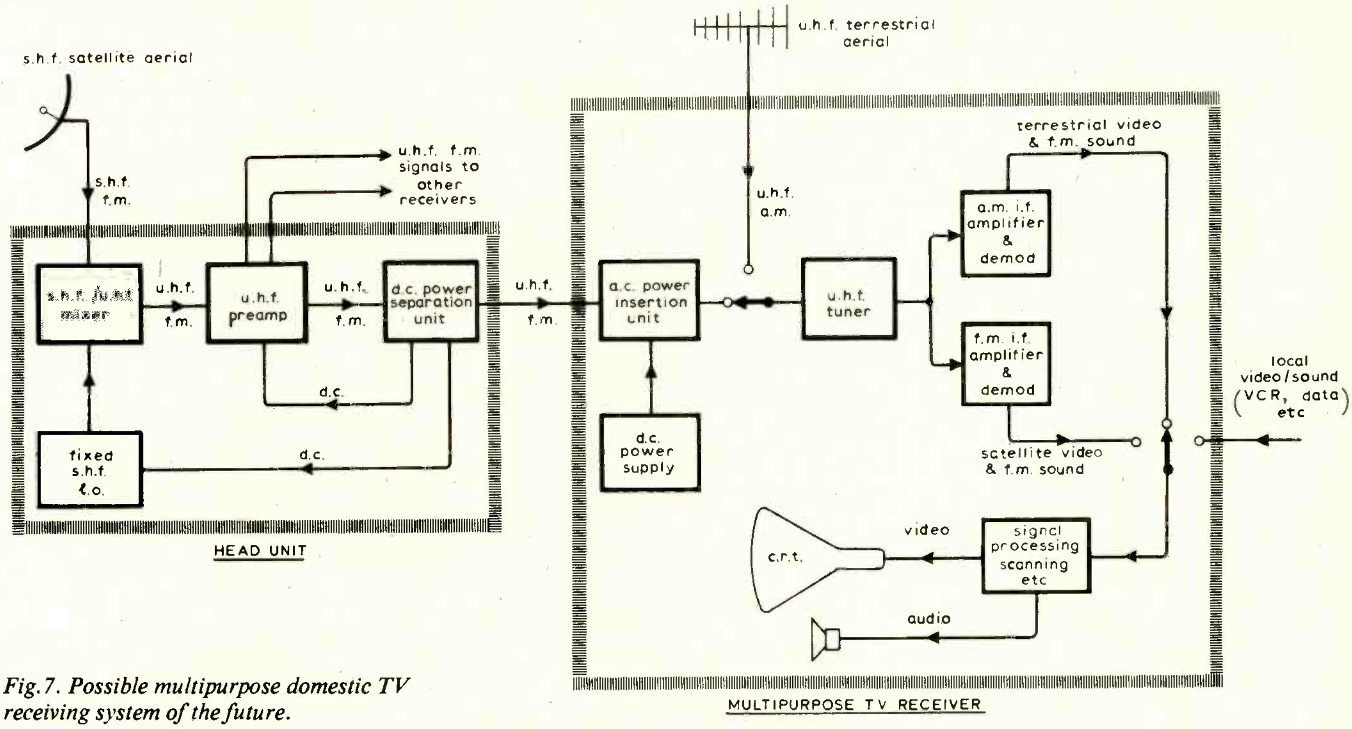


Fig. 7. Possible multipurpose domestic TV receiving system of the future.

otherwise they occupy parts of two frequency channels. For a given image protection the second situation makes allocation of service areas to give continuous coverage of the earth's surface more difficult.

Although this constraint upon the choice of the final i.f. could well apply to the single superhet it is unlikely to apply to the double superhet as sufficient image rejection can probably be provided by the selectivity of the second mixer. If local oscillator radiation is a problem with the single superhet design, choice of the i.f. to be $(2n+1)$, b.w./2, where n is again an integer, will cause this to fall at channel boundaries and it should be relatively untroublesome. In the case of the double superhet sufficient local oscillator radiation protection could probably be obtained in a band-pass filter before the first mixer and this could also provide first image rejection.

The i.f. response must provide acceptable phase and amplitude response within its passband consistent with adequate adjacent channel rejection, to permit efficient use of the available bandspace. The relationship, for example, between signal bandwidth and the filter bandwidth and response must be considered with reference to the differential phase and gain distortions in the demodulated signal. It is possible that in time new developments such as acoustic surface wave filters may prove to be an attractive solution to the filter problem as these could have constant amplitude and group delay response in band and rapid roll-off at the band-edge. It is clear that receiver design problems must be considered before fixing the signal parameters and channel allocations.

Apart from the low-noise input for the single superhet the i.f. amplifier can be integrated as can be the whole of the double superhet second i.f. As signal strengths over the service area will not vary by more than a few dBs the limiter has only to work over a small dynamic range and this too can be integrated.

A variety of techniques are available for the demodulation of an f.m. signal: these can be grouped into three fundamental classifications as slope, phase shift, and pulse counting discriminators. The slope discriminator makes use of the amplitude versus frequency response of one resonant circuit or alternatively two resonant circuits which have slightly different resonance frequencies. The phase shift discriminator relies on the phase versus frequency characteristic of a resonant circuit or transmission line. A pulse counting discriminator is based upon the generation of a pulse of constant area each time the signal crosses the zero axis; these pulses are than integrated to provide the original modulation. During the course of our experimental work we have tried several different types of broadband f.m. discriminators but the most successful to date appears to be the pulse count discriminator. This type should be amenable to complete integration as it does not rely upon inductors or transmission lines. Our latest experimental, discrete, discriminator has an output voltage versus input frequency characteristic which is linear to well over 100MHz.

Automatic frequency control

Automatic frequency control will almost certainly be required to cope with oscillator drift. The wideband frequency discriminator used for signal demodulation can also form part of the a.f.c. circuit to provide a wide catching and holding range. The a.f.c. circuit must have low d.c. drift and the i.f. signal frequency corresponding to black level on the picture must be maintained constant by some form of line gating technique. (The d.c. content of a video signal is not constant with time and without such a gating circuit wider i.f. and discriminator bandwidths would be needed.)

Receiver packaging and interfacing

The problems of packaging the 12GHz receiving system into a head unit and a unit adjacent to, or in, the domestic television set is interrelated with the problem of taking a signal into the television set. As the chassis of present television receivers is connected directly to the mains supply these problems are complicated by the need to consider the safety requirements.

If we consider a present day standard television receiver then the satellite receiver must generate a u.h.f. a.m. signal by remodulation if it is to be completely compatible. Due to problems which may occur in certain sets which use a.f.c. controlled tuners, a vestigial side-band signal may be necessary. Where a slight modification of the standard receiver is possible other techniques may be used. For example, we have successfully coupled the video and sound sub-carrier signals directly into a U.K. receiver which has a single video detector. An opto-electronic coupler was used to provide suitable isolation of the input leads from the receiver chassis. Opto-couplers are now available which provide adequate isolation and have bandwidths extending to several megahertz.

Unfortunately the present trend in television receiver design is towards the use of synchronous demodulation using i.c. techniques which make direct entry at video more difficult. However the growing need for inputs from other sources such as video tape recorders etc., may well change this situation.

In the long term most of the satellite broadcast receiver might be incorporated in a dual or multi-purpose television receiver. The signal from the 12GHz head unit could then enter the receiver as a u.h.f. or v.h.f. f.m. signal. One possible system, in which a single head unit could be used to drive a number of receivers, is outlined in Figure 7.

Obviously other configurations can also be envisaged. It is therefore likely that the domestic television receiver will ultimately be rather different from its present form. However, it should be emphasized that if 12GHz f.m. satellite television broadcasting is introduced it will supplement the existing services, not replace them. There is therefore no question of present day receivers being made obsolete and one would expect that for many years after the inception of a satellite service, converters would be available which would provide signals compatible with conventional u.h.f a.m. receivers.

Conclusions

With the present pace of technological progress and the various needs which exist for the expansion of television broadcasting it seems likely that within the next decade we may see the use of satellite television broadcasting direct to the home, or at least to community receiving systems, in at least one country in the world. We have therefore attempted in these two articles to look at some of the problems which may be encountered, together with certain aspects of possible receiver design.

Developing countries with no existing u.h.f. (or even v.h.f.) terrestrial service are likely to adopt the u.h.f. allocation (620-780MHz) for satellite broadcasting. On the other hand, developed countries with existing v.h.f. and u.h.f. terrestrial services which require more channels will be obliged to choose the s.h.f. allocation (11.7-12.5GHz for Europe). In either case it is almost certain that wideband frequency modulation will be employed. As far as the U.K. is concerned it should be emphasized that although satellite broadcasting at 12GHz will be technically feasible within a few years it is unlikely to be used for at least a decade and probably longer. Sufficient v.h.f. and u.h.f. bandspace is available in this country for the provision of up to six terrestrial television channels provided that the present v.h.f. transmission can be phased out.

Because the success of satellite broadcasting will depend crucially upon the availability of sufficiently cheap receivers we have concentrated upon the problem of receiver design — particularly in relation to the use of the new 12GHz band. Although we have made only passing reference to the necessary advances in satellite, power source and transmitter technology — especially the development of high power sources at 12GHz — these are obviously no less important.

With regard to the reception of 12GHz it seems likely, particularly in the early stages when costs may be higher, that there would be a strong preference in urban areas to adopt community reception. The growing desire to avoid the pollution of housing estates by a proliferation of aerials would be a factor in favour of this. However, in rural areas, individual receivers would be necessary because of the high cost of community systems in such situations. Moreover, even in urban areas there would ultimately be some demand for individual reception. Thus although the majority of the population might be able to receive their signals via a community system a truly national service would require a broadcasting system capable of individual reception. Because this may have implications for the choice of broadcast parameters we have therefore concentrated upon the problems of designing individual 12GHz receivers. In any case, the design of a community system can be regarded as a logical extension of an individual one.

Although some development of microwave components for cheap mass-production will obviously be necessary, current studies indicate that suitable devices capable of meeting the receiver requirements already exist. Of the two principal designs discussed the double superhet appears to offer significant advantages over the single superhet, particularly in the case of a community system or a multiple outlet home system. With either approach the i.f. processing circuits can make extensive use of integrated circuit techniques for amplification limiting and demodulation with resultant cost advantages. In our view, therefore, given sufficient impetus, satellite television broadcasting to the home at 12GHz is technically capable of realization. Whether it will indeed become a reality depends upon other factors, beyond the scope of these articles.

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Checking peak inverse ratings

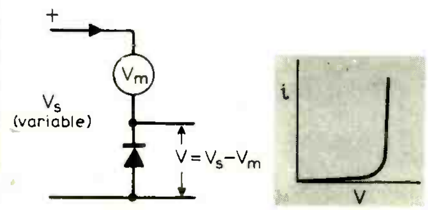
by J. M. Osborne
Westminster School

It is sometimes necessary to find the breakdown voltage of a semiconductor device, either because it is unknown or to determine how far above the manufacturers rating one can go with an individual item.

It is possible to determine this non-destructively with no more than a high resistance voltmeter and a variable voltage supply. The voltmeter serves as a current limiter as well as measuring both leakage current and (by subtraction) the applied voltage. The procedure is to connect the voltmeter in series with the device and apply the variable voltage supply. The voltmeter will read zero so long as there is no leakage current. As the variable voltage supply is raised there comes a point where the voltmeter reading starts to rise. Let us suppose that the meter is a 10kΩ per volt on the 1 kV range. If it reads 50 V then the leakage current is 5 microamps. Suppose that the supply voltage is 750 V; then the voltage across the device is 700 V which may be taken as the breakdown voltage. If the device was a silicon rectifier, it should be safe to run it in a circuit with p.i.v. of 600 V although the manufacturuer's safe rating for this type number might only be 400 V.

Likewise the collector-base rating of a germanium power transistor can be determined. With germanium devices the leakage is much greater; the point to take is that at which the voltage across the device ceases to rise significantly, i.e. the voltmeter reading increases in step with the supply voltage above this point. Suppose the voltmeter reading increased from 10 to 20 V while the supply increased from 50 to 62 V; this indicates that the leakage current increases from 10 to 20 microamps as the voltage across the collector-base rises from 40 to 42 V. One could install the transistor with some confidence in a circuit with a 35-V rail.

The voltmeter can be used to measure the voltage of the variable voltage supply, if it is not metered. This is of course much more cumbersome. If the supply has a high internal resistance, e.g. a high resistance potentiometer across a high voltage supply, then allowance might have to be made for the current taken by the voltmeter by loading the supply with a resistance drawing, say, 1 mA.



Current i is determined by interpreting the V_m reading in microamps. A 10,000 ohm per volt meter has a full scale deflection of 100 microamps on all voltage ranges.

Wideband amplifiers

Introducing wideband techniques; circuits and their performance are discussed in detail in series 12 of Circards

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

Paisley College of Technology

Wideband amplifiers are extensively used in instrumentation and communication systems where the signals to be handled may be of an analogue or a digital nature. Such amplifiers are required to provide fairly equal amplification of a large range of frequencies with a lower frequency limit of zero or nearly zero. The high-frequency behaviour of the active devices must be considered in conjunction with the passive network elements to design an amplifier with required characteristics.

Many different circuit models are available for such devices, but not all are necessarily useful. Consider, for example, the bipolar junction transistor models shown in Fig. 1. The three versions of the intrinsic low-frequency equivalent circuit shown in (a), (b) and (c) are highly-idealized models that focus attention on the basic active properties of the device. The low-frequency T and h-parameter models shown in (d) and (e) are more useful, but are unsatisfactory for predicting amplifier performance in the region of its upper cut-off frequency.

Models that are useful for high-frequency design must provide a more realistic representation of the transistor as a network element. The high-frequency model one chooses is often determined by availability of data, personal preferences and experience or whether the parameters of interest are readily determined by measurement. Fig. 2(a) shows the hybrid equivalent circuit which is a reasonable compromise between accuracy and complexity and which may be reduced to simpler forms for low-frequency and high-frequency calculations.

In high-frequency transistors, r_{ce} and $r_{b'c}$ are often sufficiently large to be neglected, the former being much larger than the load impedance and the latter much greater than the reactance of $C_{b'c}$ at high frequencies. The simplified form of Fig. 2(b) is often sufficiently accurate for assessing high-frequency performance and this may be reduced to that shown in Fig. 2(c), where C_{in} consists of $C_{b'e}$ in parallel with the Miller effect equivalent of $C_{b'c}$. The base spreading resistance $r_{bb'}$ and the product $g_m r_{b'e}$ may normally be assumed to be independent of the operating point, g_m increasing and $r_{b'e}$ decreasing as I_E increases. The value of $C_{b'e}$ increases with I_E and the depletion-layer capacitance $C_{b'e}$ varies as $1/(V_{CB})^{\frac{1}{2}}$ to $1/(V_{CB})^{\frac{1}{3}}$.

To obtain a wide bandwidth with the simple cascade of common-emitter stages shown in Fig. 3, the collector coupling re-

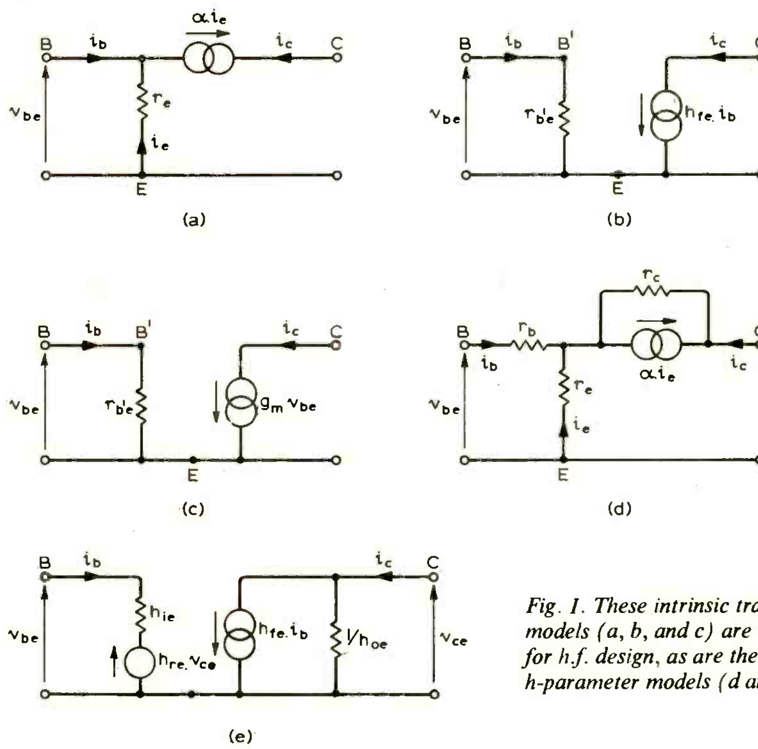
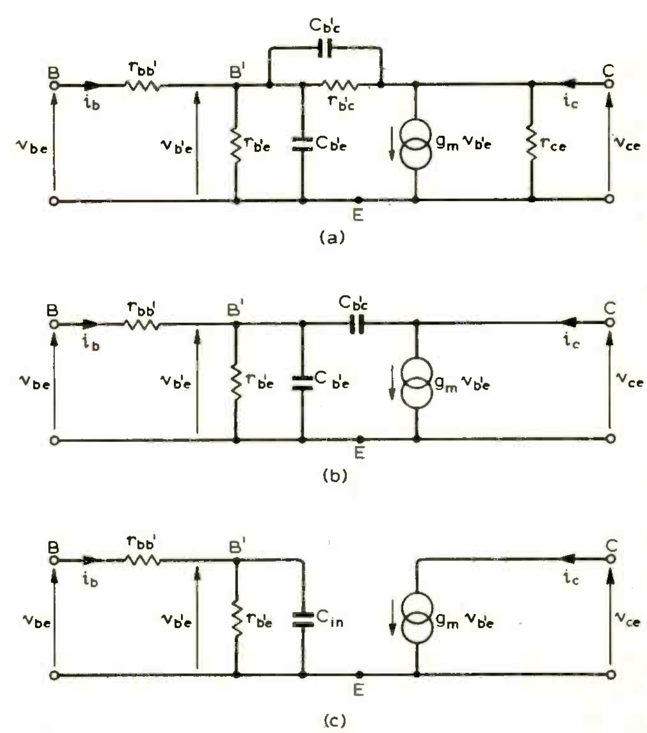


Fig. 1. These intrinsic transistor models (a, b, and c) are unsatisfactory for h.f. design, as are the T and h-parameter models (d and e).

Fig. 2. The hybrid equivalent circuit (a) is a reasonable compromise between accuracy and complexity, and may be simplified for h.f. work to (b) and even (c).



sistors must be made small compared with the input impedance of the following stage, the capacitive component of which causes the gain to fall at high frequencies. Further reduction of R_C to exchange gain for bandwidth is limited by the presence of $R_{bb'}$. Also, if the gain per stage is reduced, more stages must be cascaded to achieve a desired amplifier gain and it becomes increasingly difficult to maintain the overall bandwidth which shrinks as the number of cascaded stages increases. The gain-bandwidth product of the transistors (f_T) attains a maximum value at a particular value of emitter current, which is often small. Adjusting the emitter current of each stage to its optimum value may result in a small signal-handling capability if significant distortion is to be avoided.

Several techniques are available for improving the achievable stage gain-bandwidth product, the simplest of which is the inclusion of an inductor to compensate for the falling response due to transistor input capacitance. The stages in Figs. 4(a) and 4(b) are said to be shunt-peaked and series-peaked respectively, the latter being far less effective in improving gain-bandwidth product. The effect of the shunt-peaking inductor is illustrated in Fig. 5 and by correct design the stage bandwidth, for a given gain, can be improved by a factor of about two without lifting the high-frequency gain above its low-frequency value. Too large a value of L results in overcompensation which produces overshoot and ringing in the transient response. Amplifiers using a number of these stages in cascade may suffer from instability and prove difficult to align.

This problem may be alleviated by making the effective load on each transistor resistive. Referring to Fig. 6, this can be achieved by considering L and R_C to be in parallel with the series equivalent of the CR input network, making R_C equal to the equivalent series input resistance and designing L to produce the same short-circuit time constant for each of the parallel branches. A disadvantage of this constant-resistance cascade is that it is no longer possible to vary a network element to adjust amplifier gain or bandwidth, which must be attempted by variation of the transistor parameters, e.g. by adjusting the individual collector currents. The foregoing techniques have the disadvantage that all the cascaded stages interact, any change in the design of one stage normally requiring changes in the others.

As the input capacitance, including that due to Miller effect, plays an important part in limiting the achievable bandwidth, a design approach that attempts to eliminate the effects of internal feedback is useful. The cascode amplifier shown in Fig. 7 employs this technique and it may be considered as a common-emitter common-base cascade. The common-base stage has a very low input impedance, so the common-emitter stage has a current gain approaching h_{fe} and a very small voltage swing at its collector, resulting in a large reduction of the internal feedback between collector and base. The bandwidth of the common-emitter stage approaches f_β and as that of the common-base stage is much larger, the cascode pro-

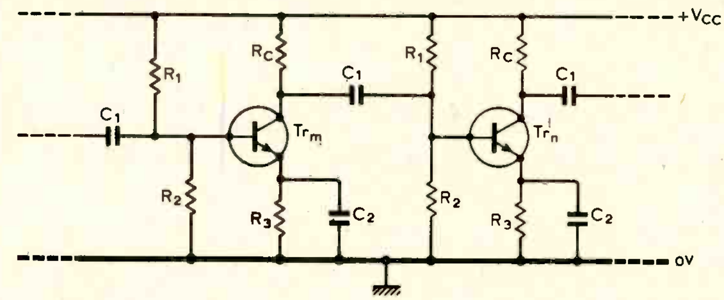


Fig. 3. Reducing R_c and increasing the number of stages can reduce overall bandwidth and give poor signal handling.

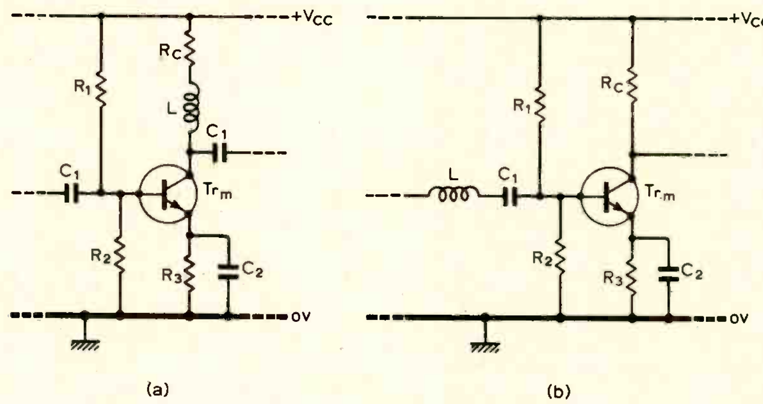


Fig. 4. Simplest way of improving bandwidth is to add shunt (a) or series (b) compensation. Effect of shunt peaking—the most effective—is shown in Fig. 5.

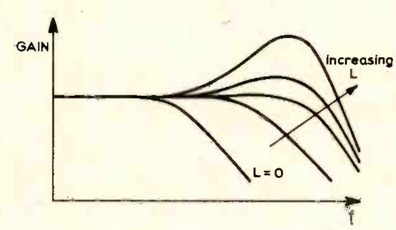


Fig. 5. Too large a value of L in Fig. 4(a) results in overshoot and ringing.

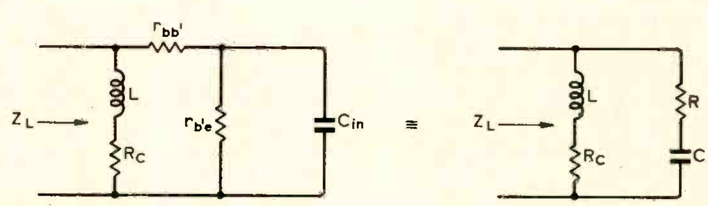


Fig. 6. To avoid instability in cascaded circuits of Fig. 4(a), the transistor load can be made resistive.

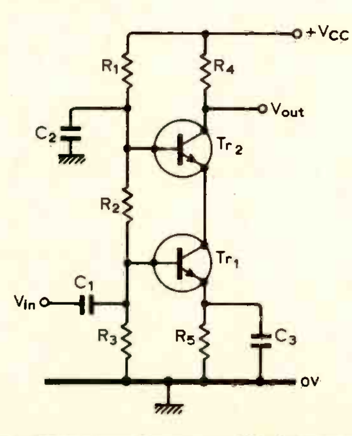


Fig. 7. Cascode circuit minimizes effect of internal feedback.

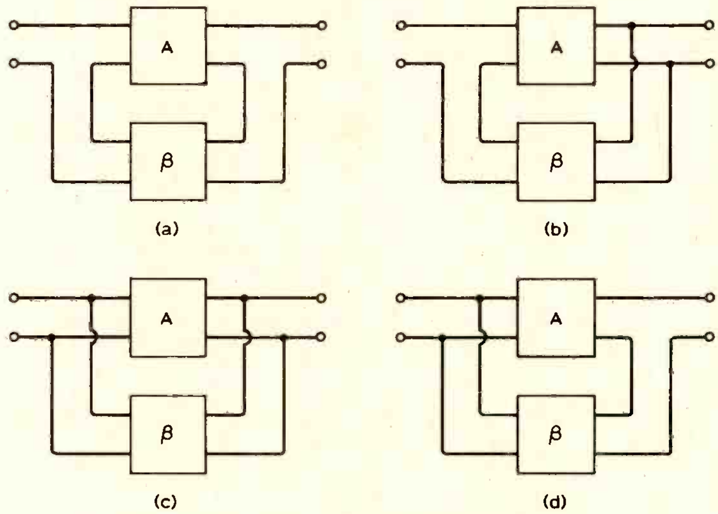


Fig. 8. Four basic ways of increasing bandwidth using negative feedback.

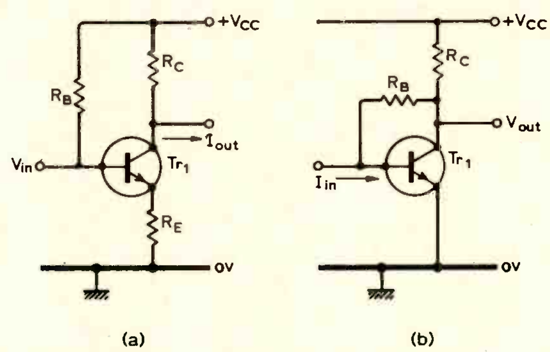


Fig. 9. Series and shunt feedback applied to a single stage.

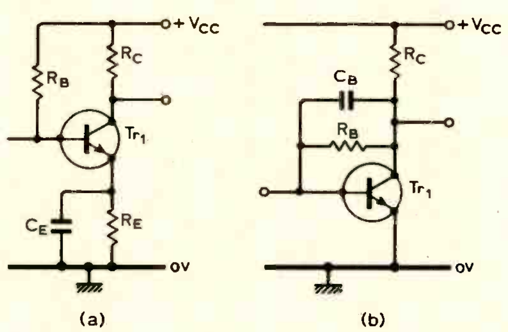


Fig. 10. Peaking capacitors improve h.f. response of Fig. 9.

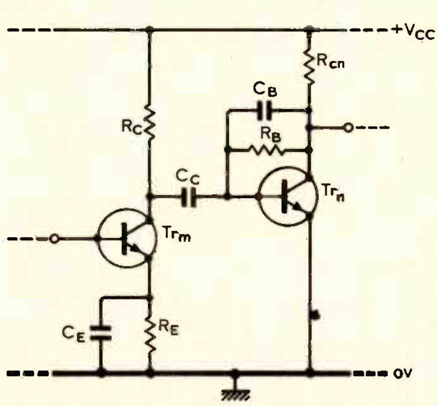


Fig. 11. Deliberate mismatching of impedances can improve stability.

vides the voltage gain and current gain of a common-emitter stage with a wider bandwidth than that obtainable with a simple common-emitter amplifier.

Satisfactory design of wideband amplifiers usually requires the interaction between individual stages or elementary building blocks to be negligible, or definable, the mid-band gain to be stable and input and output impedances to be adjustable to desired values. Use of feedback in the design allows these criteria to be approached without undue concern for the variations in transistor parameters and permits bandwidth to be extended at the expense of gain in a controllable manner. While the reduction in gain is a disadvantage it is not an expensive price to pay, bearing in mind the benefits obtained and the relatively low cost of adding extra feedback stages to meet the overall gain requirement.

Another disadvantage of feedback is the increased possibility of oscillation, which may be avoidable at the design stage by using a sufficiently accurate circuit model. In a multi-stage amplifier designed for the highest possible bandwidth before the application of feedback, the cut-off frequencies of all stages will normally be similar. Hence there is a near certainty that the combined phase shift can reach 180° while the magnitude of the gain is well in excess of unity. To remove this possibility, by deliberately setting one of the cut-off frequencies much lower than the others, negates the original requirement for maximum pre-feedback bandwidth. General-purpose operational amplifiers, such as the 741-type, have internal stages with high cut-off frequencies, but a dominant lag at about 10Hz has to be introduced to cope with the possibility of 100% feedback.

Four basic feedback configurations may be used to create elementary building blocks. Fig. 8 shows these configurations which may be described in terms of the method in which the feedback is derived and applied. Thus, (a) is series-derived series-applied, (b) is shunt-derived series-applied, (c) is shunt-derived shunt-applied and (d) is series-derived shunt-applied. Alternative descriptions of these configurations are in common usage e.g. (a) transimpedance feedback, series-series or simply series, (b) voltage-ratio feedback or series-shunt, (c) transadmittance feedback, shunt-shunt or simply shunt, and (d) current-ratio feedback or shunt-series. Other descriptions include the use of the terms current feedback or voltage feedback. In the former case the signal fed back is proportional to the output current but may itself be a current or a voltage. With voltage feedback the fed-back signal is proportional to the output voltage. All four arrangements have the property of increased bandwidth and reduced gain compared with the open-loop values. The input and output impedances become modified as shown in the table, shunt derivation (application) reducing the output (input) impedance and series derivation (application) increasing the output (input) impedance.

The two types of single-stage feedback, series and shunt, are shown in Fig. 9. In Fig. 9(a) the load impedance should be low and the input supplied from a voltage source

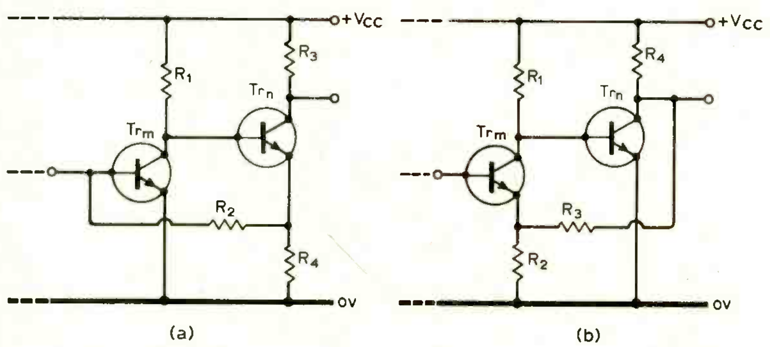


Fig. 12. Widely differing input and output impedances make two-stage feedback circuits useful for cascading.

whereas in Fig. 9(b) the load impedance should be high and the amplifier input should be from a current source. The high-frequency response of these elementary blocks may be improved by the addition of peaking capacitors as shown in Fig. 10.

Source and load impedance requirements for stable gain with single-stage feedback can be met by purposely creating a large mismatch between cascaded stages, i.e. by alternating series and shunt feedback stages as shown in Fig. 11. With this arrangement gain-bandwidth product is high, low-frequency gain may be determined with reasonable accuracy by multiplication of individual stage gains, and there is little interaction between stages. Feedback applied to two stages can offer similar merits, Figs. 12(a) and 12(b) showing series-derived shunt-applied and shunt-derived series-applied configurations respectively. Both networks have widely differing input and output impedances and are therefore attractive as basic building blocks for cascaded stages.

Although discrete devices may be used in a multistage realization, the availability of integrated-circuit transistor arrays, containing about five transistors with parameters inherently reasonably matched, are very attractive for many designs. Integrated circuits are available in the form of a long-tailed pair which can be operated as single-ended or differential-input wideband amplifiers by the addition of external passive components that allow a high degree of flexibility in the selection of gain, bandwidth and signal-handling capability.

Other integrated circuit versions provide emitter-follower input and output transistors to make the input and output impedances high and low respectively. Integrated wideband power amplifiers can be obtained providing bandwidths up to about 8MHz and outputs of about 14V pk-pk. Integrated circuits containing pairs of cascode amplifiers and some with gating facilities are also very useful as wideband amplifiers. Modern integrated-circuit logic gates designed for high-speed switching applications may also be usefully employed as low-cost wideband amplifiers by setting the quiescent conditions in a linear part of the transfer characteristic and employing feedback to define the gain.

Feedback type	Z_{out}	Z_{in}
Fig. 8(a)	increases	increases
Fig. 8(b)	decreases	increases
Fig. 8(c)	decreases	decreases
Fig. 8(d)	increases	decreases

How to get Circards

Order a subscription by sending £9 (U.K. price; £10.50 elsewhere) for a series of ten sets to:

Circards
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Dorset House
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Specify which set your order should start with if not the current one. One set costs £1 U.K. and £1.15 elsewhere, postage included.

Cheques should be made payable to I.P.C. Business Press Ltd.

Topics covered in Circards are
1 active filters
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5 audio circuits (equalizers, tone control, filters)
6 constant-current circuits
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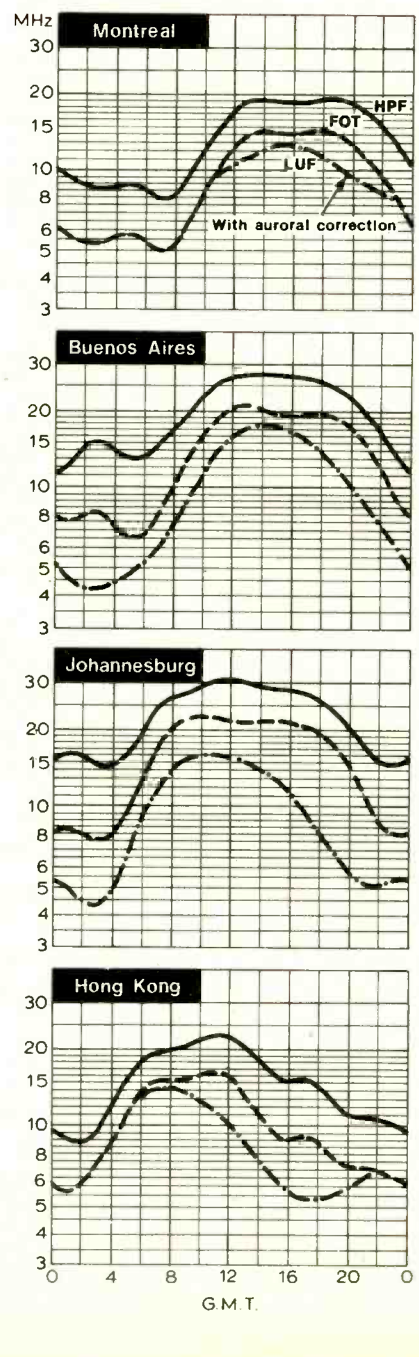
8 astable circuits
9 optoelectronics: devices and uses
10 micropower circuits
11 basic logic gates
12 wideband amplifiers

Subsequent issues will cover alarm circuits. digital counters, pulse modulators. Introductory articles in *Wireless World* indicate availability of Circards, which are normally ready for despatch on the 14th of the month, and the Circard concept was outlined in the October 1972 issue, pages 469/70.

H.F. Predictions for March

The charts are based on a predicted Solar Index of 17, a considerable change since February 1973 when the measured value was 47. The Solar Index used here is known as IF2 which towards sunspot minimum is generally numerically the same as the more commonly used index of 12 month smoothed sunspot numbers known as R12. However, unlike sunspot numbers it is possible for IF2 to have low negative values at sunspot minimum and this may well be the case at the end of this year. Predicted disturbed days are March 8th to 18th.



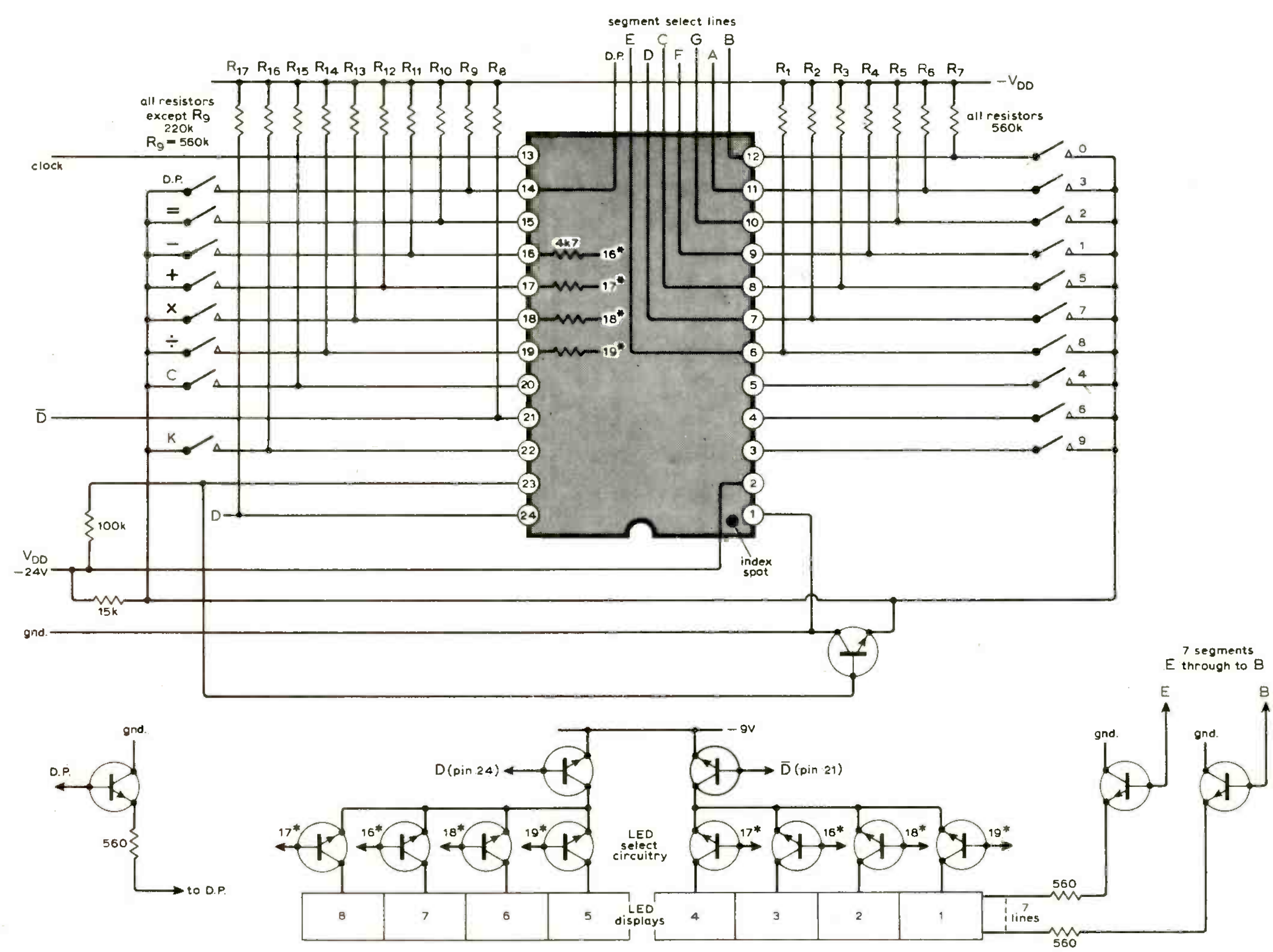
Electronic calculator components offer

"Custom built" calculating systems economically feasible for Wireless World readers

Over the past two years the great advances that have been made in m.o.s. l.s.i technology and solid-state display technology have brought about a "calculator revolution". There is now a proliferation of low-cost instruments of varying degrees of calculating power and there are several kits available. While these undoubtedly cater for the majority of users (and pockets), we have been aware for some time now that there are certain individuals whose needs have not been met. These are people — whose involvement with electronics may be professional or amateur — who wish to construct a calculator for a "dedicated" application, say, in a laboratory, or to a personal design which might incorporate other equipment.

While the prices of ready-made models and kits have fallen rapidly, the one-off prices of the essential components, the m.o.s. integrated circuit and the displays, have not reflected this in any way. These components are often difficult to obtain at the one-off level. The reasons for this are understandable since the high design and development costs of complex m.o.s. circuits have to be paid for as quickly as possible by their application to equipment with a high volume of production. It is only economic sense for an m.o.s. manufacturer to think (and price) at quantity levels of hundreds of thousands, and the one-off quantity and price simply has no relevance to him. The one-off price of one well known series of calculator chips is still quoted as £29.00 although they are incorporated in finished machines costing very little more and even less.

One manufacturer who has seriously considered the one-off market is General Instrument Microelectronics. In April 1973 this firm dramatically reduced the one-off prices of its C500 series of devices and the first type in the series, the C500



Wiring diagram for using the C500 i.c. and eight l.e.d. displays. (D.P. stands for decimal point.)

8-digit integrated circuit, came down by about half to £13.70. As a result of this *Wireless World* has been able to make arrangements with Semicomps Ltd for the supply of a "package" of components (*not* a complete kit), consisting of one 8-digit calculator i.c. and eight 7-segment l.e.d. alpha-numeric displays, at an advantageous price (see panel).

The calculator i.c. Housed in a 24-lead dual-in-line ceramic package, the C500 m.o.s. integrated circuit provides all the electronics needed to perform the arithmetic functions of a four-function calculator. Arithmetic operations are performed algebraically* and the device can handle chain calculations. The "constant" facility operates on all four functions. This feature enables a partial result to be stored by simply pressing a K contact at any time. Thus, for example, a result can be made a divisor without the need to re-enter it. The i.c. can be used as a simple up/down counter by entering 1 as a constant and actuating the + or − inputs. Raising to a power is achieved by entering the number as a constant and actuating the × function the required number of times.

The decimal point is fully floating, which, apart from convenience, can make a significant increase in the accuracy of the result after chain calculations.

The need for overflow or underflow indication is eliminated by the fact that during computation the exponent of all numbers from $1.0000000 \times 10^{-20}$ to 9.9999999×10^{79} is retained. Dividing by powers of 10 will retrieve the decimal point.

A useful simplification is that a "clear" (C) contact can perform three different functions. Operation followed by the entry of a number clears the calculator. Operation followed by the actuation of a "function" contact clears the previous entry only. Thirdly, operation followed by the actuation of a "constant" (K) contact clears a constant and allows a chain calculation to proceed where it is no longer needed.

The number of pins on the i.c. (24) has been kept low for a chip of such complexity by a system of multiplexing. As can be seen from the diagram, certain pins are used for both inputs and outputs. The i.c. generates a strobe pulse at pin 23 which is fed to all keyboard contacts used with the i.c. If any contact is closed during this pulse then the appropriate input is entered. The strobe pulse occupies only a very small proportion of the clock period, the rest being used to actuate the display. Keyboard contact bounce protection is incorporated, enabling very simple keyboards to be used. Simple spring-loaded push switches would prove satisfactory.

Construction of a versatile calculator is relatively simple and requires only a clock generator of 80 to 100Hz, 18 low-cost plastic n-p-n transistors (e.g. ZTX300) and 27 resistors.

The l.e.d. display. This device, type MAN 3 made by Monsanto, is of flat pack construction and has staggered leads which facilitate interconnection.

Details of the Offer

1 — eight-digit calculator i.c. (General Instrument Microelectronics, Type C500), plus

8 — seven-segment l.e.d. alpha-numeric displays (Monsanto, Type MAN3).

Data sheets are supplied.

Price for the "package" offer: £14.00 plus 10% VAT. (In this arrangement individual items cannot be supplied separately.) Not a limited offer.

Orders with cash to: Semicomps Ltd., 5C Northfield Industrial Estate, Beresford Avenue, Wembley, Middx., HA0 1SD.

Purchasers are advised to observe standard m.o.s. device handling precautions as discussed in recent *Wireless World* correspondence (Oct., Nov., Dec. Letters). The C500 device should not be removed from its black conductive foam packing until it is finally required for assembly.

* Positive values produce no sign on the display whereas negative values produce a minus symbol to the left of the most significant digit.

Announcements

Weir Electronics Ltd, producer of power supplies, has announced the formation of a wholly owned subsidiary, **Weir Electronic Instruments Ltd**, Durban Road, Bognor Regis, Sussex, for the manufacture and marketing of a range of low-cost instruments. It is intended that the first series of low priced laboratory instruments will be introduced early in 1974.

Surrey Electronics, 24 The High Street, Merstham, Redhill, Surrey RH1 3EA, are providing circuit boards and kits for the Hartley Jones **"Frequency Shifter for 'Howl' Suppression"** described in the July 1973 issue of *Wireless World*.

Lowther Acoustics Ltd, Lowther House, St. Mark's Road, Bromley, Kent, have recently moved their manufacturing division to larger premises in Maidstone. The company state that they will be offering a 24-hour reconditioning service on their loudspeakers including diaphragm replacement.

Bach-Simpson (U.K.) Ltd have announced the appointment of Electroplan Ltd, P.O. Box 19, Orchard Road, Royston, Herts, SG8 5HH, as distributors in the U.K. for their model 260-6p taut band multimeter and its range of accessories. The agreement covers all small quantity orders.

Under a recent agreement between Spin Physics Inc. and SE Labs (EMI) Ltd, North Feltham Trading Estate, Feltham, Middlesex, **analogue tape recorder** users may obtain replacement headstacks for most standard wideband analogue recording systems including Ampex, Bell & Howell, Hewlett Packard, Leach, Winston, Mincom and SE Labs. These replacement headstacks are tipped with a four-element magnetic alloy, "Spinalloy", claimed to have twice the life of Sendust.

HY-Q Antennas Ltd, Moulton Park Industrial Estate, Northampton is offering v.h.f. and u.h.f. aerials in the range up to 1.5GHz. A 48-hours guaranteed delivery service is offered to customers.

Competition results from West Hyde Developments: 1st A. Barr, Lefney Products; 2nd B. F. Martin, Mullard Research Laboratories.

"Hi-Fidelity '74" will be held at the Heathrow Hotel, Bath Road from 27th to 31st March inclusive. The first two days are for trade only and the new exhibition will run concurrent with the annual Sonex show. Organizers of Hi-Fidelity '74 are Pyser Britex (Swift) Ltd.

Orders for over £200,000 worth of v.h.f. **radio alarm equipment** have been awarded to the Mobile Radio division of GEC-Marconi Electronics by the Home Office. The units consist of portable intruder alarms, feeding decoder displays at a central point via existing v.h.f. radio systems.

Applications for the 1974 **Hudswell Research Awards** must reach the Institution of Electrical Engineers before March 31, 1974. The awards are to support research in electrical and electronic science and engineering by members of any I.E.E. class who are registered as U.K. research students.

The Institution of Electrical Engineers is to organize a vacation school on **"L.f. and d.c. electrical measurement practice"**, which will be held at the University of Lancaster between the 7th and 9th of July, 1974. Co-sponsors of the school will be the British Calibration Service, the Institution of Electronic and Radio Engineers and the Institute of Electrical and Electronic Engineers. Theory and techniques of measurement up to 100kHz will be covered at a level suited to professional engineers.

Professor Sir Hermann Bondi, K.C.B., F.R.S., F.R.A.S., chief scientific adviser to the Ministry of Defence, will deliver the Twelfth Annual Lecture of the I.E.E. Electronics Division at Savoy Place at 5.30 p.m. on 13th February 1974. The title of his lecture will be **"Electronics and human beings"**.

About People

Royal Society

At the Anniversary Meeting of the Royal Society on November 30, **Sir Martin Ryle, F.R.S.** was awarded the Royal Medal. Sir Martin is well-known for his work in radio astronomy, in particular for the development of interferometry aerial arrays, which have made possible the correlation of many radio sources with visible objects. The radio catalogues which have been produced as one result of this work are now standard references. One of Sir Martin's greatest contributions has been the building up of a laboratory at Cambridge in which outstanding work has been possible.

The Mullard Medal was awarded to **Professor C. W. Oatley, O.B.E., F.R.S.,** emeritus professor of electrical engineering at Cambridge in recognition of his contribution to the development of the scanning electron microscope, which has been used to study the performance of semiconductor devices when voltages are applied and to display magnetic domain structures, among many contributions to physical and biological science.

Royal Television Society

Huw Wheldon, O.B.E., M.C., B.Sc. (Econ), who is managing director of BBC Television, has been elected a vice-president of the Royal Television Society. Mr. Wheldon has been closely associated with the programme side of television, notably with the "Monitor" arts review and later as assistant head of Talks (General) and as head of Documentary Programmes. In 1963, he was awarded the Television Society's Silver Medal.

The Institution of Electrical Engineers

George Millington, M.A., B.Sc., F.I.E.E. has been awarded the 1974 Faraday Medal for his theoretical studies of radio wave propagation. The medal is awarded without regard to nationality, country of residence or Institution membership.

Wilfred Bennett Lewis, C.B.E., F.R.S.C., Ph.D., F.R.S. has been elected to Honorary Fellowship of the Institution in recognition of his contributions to the development of wartime radar and of nuclear energy.

The Rt. Hon. the Lord Penney of East Hendred, O.M., K.B.E., M.A., Ph.D., D.Sc., F.R.S. has been elected Honorary Fellow for his work in the advancement of technological education and in the development of nuclear energy.

Motional feedback in loudspeakers

"There is no new thing under the sun", Solomon, Eccles., Ch. 1, verse 9

by H. D. Harwood, B.Sc.
B.B.C. Research Department

This article was written as a result of reading the account in *Wireless World* [1] of a commercial embodiment of motional feedback in loudspeakers. This is a subject which has exercised the minds of loudspeaker designers for some time, but it may not be appreciated by all readers for just how long. In my card index, which is selective, not comprehensive, the earliest mention of this subject is a patent No. 231,972, awarded to P. G. A. H. Voigt as early as Jan. 29th, 1924. It may shake many persons, who thought that negative feedback came in with Black and Nyquist ten years later, to realise that the principles and advantages of feedback were appreciated, at least by some persons, as long ago as that, and indicates that what Black and Nyquist did was to place a matter of general knowledge on a formal and sound theoretical basis rather than to originate it, which is what I had been taught. Perhaps our academic readers could supply even earlier references to the use of negative feedback in circuits, but it is remarkable that not only were the advantages of feedback already known at this date but also that it should be applied to as intractable a subject as a loudspeaker.

Voigt used a bridge circuit to extract the motional impedance from the loudspeaker terminals and applied the corresponding feedback to a grid. It was therefore velocity feedback and although it would damp out the primary resonance, would give a 6dB/octave bass cut. On the other hand, he was aware of the effects on distortion as he quotes "... circuits where by the change of impedance with change of frequency of the loudspeaker or equivalent circuit is caused to alter the reaction into the grid circuit in such a manner as to compensate for the distortion of the said loudspeaker".

The next reference I have is to a patent by A. F. Sykes, No. 272,622, dated March 20th, 1926. He describes the use of an auxiliary coil or even a microphone to sense the loudspeaker output and refers to a separate coil mounted on the centre pole piece so that the e.m.f. directly induced into his pick-up coil is cancelled. This again would yield velocity feedback.

Then comes a patent by M. Trouton, No. 320,713, dated Aug. 10th, 1928. He uses capacitive pick-up elements to give a feedback signal which is compared either with the displacement of a very light dummy transducer or with the original signal. He seems to be the first to recognise the need for transposing the signals to give feedback proportional either to velocity or acceleration.

These three cases are mentioned in detail to give an idea of the thoughts on the subject prior to Black and Nyquist's classical papers on feedback. The use of an accelerometer for sensing the cone motion is not mentioned until later.

To obtain a uniform frequency response in the bass, the acceleration of the cone should be held constant, but it does not matter in essence whether the means of obtaining the feedback gives a signal proportional to amplitude, velocity or acceleration as it is simple to derive one from the others. There are, however, certain disadvantages in obtaining the feedback in particular ways.

Voigt's method of using the motional impedance is very attractive but falls down in several ways. The first is the need for compensating the change in resistance of the voice coil as it warms up under the influence of programme, and the compensation must have the same time constant as that of the voice coil without consuming appreciable amounts of power. Furthermore, if the frequency range extends beyond a few hundred hertz the complex variation with frequency of the inductive part of the voice coil impedance must also be taken into account, as it does not behave as a simple inductance owing to the solid iron core. Finally and fundamentally almost impossible to deal with, is the limited length of uniform magnetic flux between the pole pieces. When the amplitude (at low frequencies) of the voice coil exceeds the magnetic field length the average flux cut by the coil decreases. This causes the back e.m.f. to be reduced and, as has been shown[2], the amplitude of the cone is therefore *increased* contrary to what one would expect. The falling off in back e.m.f. and therefore feedback will, however, cause the driving voltage also to be increased, thus compounding the non-linearity.

The moving coil method of Sykes does not need the temperature compensation of the previous item but to avoid magnetic non-linearity effects the magnetic field length available to the pick-up coil must exceed the maximum excursion likely to be used. This involves a rather bulky and expensive additional magnet assembly and, together with the need for accurate compensation of the unwanted directly induced voltage, rules it out on economic grounds.

The electrostatic method of Trouton is relatively simple, but with the large amplitudes involved a considerable spacing between electrodes would be necessary. Even then a push-pull type of pick-up would probably be needed to obtain a linear signal; this would also obviate the need for accurate alignment of the cone relative to the pick-up points.

This leaves us with the accelerometer method which has the advantage of giving directly the signal desired, provided the relatively heavy mass can be coupled to the cone or voice coil former without the intervening struts resonating in the frequency range of interest or without undue loss of sensitivity.

Having now decided on one or other of the means of pick-up the next step is to limit the frequency range over which feedback can usefully be applied to that over which the cone behaves as a simple piston, as it is only the motion of the voice coil which is sampled and cone break-up is not at all controlled by it. This places an upper limit which depends on the cone design and the feedback as to be rapidly* removed above this frequency without causing conditions of instability or creating a rise in output near the cross-over frequency. A similar problem arises in the bass where it is desirable to restrict the frequency range, because of limitations in amplitude. Depending on the cone size and therefore the directivity, it may be also advisable to increase the feedback with rising frequency to compensate for the otherwise rising frequency response and this increases the problem of a rapid crossover.

Finally, having solved all the technical problems in applying the feedback, the question arises as to what we really have gained.

The first facile answer is, of course, an extended bass response. In fact, this extended response could more easily, and

* The average slope cannot exceed 10dB/octave for reasons of stability.

more cheaply, have been obtained by means of a passive equaliser connected ahead of the power amplifier. It should be made clear at this point that using feedback has not essentially changed the loudspeaker unit one iota, so that if equalisation, by any means, is applied to the bass to the tune of, say, 10dB, then 10dB extra power has to be applied to the voice coil. Now this may not matter at low power levels, but if a 10 watt amplifier is needed for the mid-band and it is expected to radiate the same sound pressure in the bass, an amplifier capable of supplying 100 watts will be necessary, and of course the voice coil too must be capable of taking it without burning out. This fact of life applies whether the equalisation is provided by means of feedback or by a simple circuit, and is probably the reason why a 40 watt amplifier is provided with the 8in unit in the article previously mentioned. Some amelioration is provided by the fact that the peak programme spectrum falls off in the bass[3], but it still remains that the same power has to be applied whether feedback is used or simple equalisation.

The next point is that if feedback is used a closed cabinet must also be used, for the loading imposed upon the cone by a vented cabinet implies that a constant acceleration from the cone is no longer wanted and the advantages of this loading on the cone motion are therefore not available to the designer.

It must be conceded that waveform distortion can be considerably reduced. Hence non-linearity due to a small closed cabinet, short magnetic field or non-linear suspension can all be reduced to very small proportions. However, in a good conventional design none of these factors need to be a cause of *audible* distortion and it is largely a question of economics as to whether money is best spent on producing a good design of this type or on providing a cheaper unit using feedback with the necessary accompaniment of having to always buy an associated amplifier with the loudspeaker.

At the moment it is an open question, but with a growing tendency for power amplifiers to be built into loudspeaker cabinets, the day may come when such an attachment is commonplace, although at present it is generally supplied with those more expensive units which have least need of feedback.

To conclude, the use of feedback over a loudspeaker unit is as old as feedback itself, but possesses no magical properties. The market place will decide whether it is the best way of achieving its object.

References

1. "Motional Feedback Loudspeaker", *Wireless World*, Vol. 79, Sept. 1973, pp. 425, 426.
2. Harwood, H. D., "New BBC Monitoring Loudspeaker,", *Wireless World*, March, April, May, 1968, see Fig. 12.
3. Harwood, H. D., "Loudspeaker Distortion Associated with Low-frequency Signals", *Jour. Audio Eng. Soc.*, November 1972, Vol. 20, No. 9, see p. 721.

New Products

Recorder module

A low noise, high sensitivity module, claimed to be more versatile than any other recorder amplifier available, has been developed by Oxford Instruments for their '3000 series' single- or two-pen potentiometric recorders.

The new module offers a range of input facilities including × 20 f.s.d. zero offset. Twenty separate input ranges are provided from 50V to 100V f.s.d. with continuously variable sensitivity adjustment.

Other special features include: voltage and current adjustment for source impedance correction, electrical zero adjustment and reverse polarity switch. Oxford Instruments, Osney Mead, Oxford OX2 0DX.

WW 301 for further details

18mm vidicon tube

The Electron Tube Division of EMI Electronics Ltd has introduced an 18mm vidicon, type 9831.

It is designed to operate in standard 18mm scan and focus coil assemblies and is primarily intended as a direct replacement in existing compact television cameras. Features include a low wattage heater, separate mesh construction and improved processing of the target layers offering better shading characteristics and sensitivity. The tubes are produced to very close limits and are individually tested immediately prior to despatching to the customer.

With this type of vidicon, EMI claim that the size and weight of the associated scanning assembly can be considerably reduced. Specialized formats will include non-browning faceplate versions for use in fields of nuclear radiation. A version with a fibre optic faceplate, for direct coupling to an intensifier, eliminates the need for an intermediary coupling lens, providing a much higher light transmission. An ultra-violet sensitive target layer will be available for use in microscopy and for inspection of items which are surrounded by intense red heat. Because this has negligible dark current, it permits the signal current to be integrated over a period of time and enables the tube to be used for low-light scientific purposes. EMI Electronics Ltd, 243 Blyth Road, Hayes, Middlesex.

WW 303 for further details

WW 301

Swept function generator

The Model 750 function generator with internal sweep from Clarke-Hess Communications Research Corporation offers all standard function generator outputs plus an adjustable wide range ramp generator, together with tone burst, external f.m., and phase lock synchronization capabilities. In addition to providing sine, square, or triangular outputs over the dial controllable range from 1Hz to 2MHz, the Model 750 can supply swept frequencies from below 1/10th of the lowest dial setting up to twice the upper dial setting. For example, on the 20kHz range, the output may be swept from below 10Hz to above 40kHz. Overall operation is thus possible from 1 millihertz to 4MHz. The internal ramp (sweep) generator is variable in frequency from 1kHz down to 1 millihertz (periods from 1ms to 1000s) in four ranges. Three sweep width ranges allow reasonably accurate variation of the sweep width from twice the dial setting down to less than 1% of the dial setting. The internal sweep may free run, single shot, or be triggered from an external source. The rear panel contains sync. and tone burst input sockets, the ×1 range low frequency expand switch, and the sweep trigger input. The ramp generator supplies 0

WW 304

to 5V from a 600Ω impedance. The main generator provides two 50Ω outputs separated in level by 30dB, the high output supplying up to 20V p.-p. into an open circuit. Price £298 plus v.a.t. Lysons Instruments Ltd, Hoddesdon, Herts.
WW304 for further details

Adjustable video delay unit

Matthey announce the introduction of the UN360 adjustable video delay unit. Fitted with BNC connections as standard, the unit has a range of delays from 10ns to 325ns in 5ns steps by switches, and a fine trim of ±4ns by screw adjustment. This unit can therefore be used for delaying signals up to and beyond 360° of phase at colour sub carrier in either PAL or SECAM, or N.T.S.C. systems. The response of amplitude/frequency is controlled to within 0.2dB ripple up to 5.5MHz to preserve transmission quality video signals.

The unit can also be used in series with the Silver Star video delay units (separate data sheet available), having fixed delays of 50ns, 200ns, 500ns, or 1000ns. The UN360 can be used as a timing tool, a temporary delay line, or a permanent delay installation. Matthey Printed Products Ltd, William Clowes Street, Burslem, Stoke-on-Trent ST6 3AT.
WW306 for further details

60MHz oscilloscope

Tektronix has introduced a series of general purpose oscilloscopes designated the 5400 series. A range of measurement capabilities are provided by 17 plug-in units. For the full 60MHz bandwidth with the optional c.r.t. digital readout facility, the basic units are the 5403 three plug-in mainframe, D40 non-storage display module, 5A48 dual-trace amplifier, and 5B42 delayed-sweep time base. The 5A48 provides 5mV/div sensitivity at 60MHz and 1mV/div at 25MHz. Two 5A48 dual trace amplifiers can be used together for four-trace displays. The 5B42 time base features sweep rates up to 0.1μs/div and a ×10 magnifier gives a fastest sweep rate of 10ns/div. Fifteen other plug-ins (without c.r.t. readout capability) include a dual-trace sampling unit covering up to 1GHz at 1mV/div sensitivity, a differential amplifier offering 10μV/div sensitivity and a 100,000:1 common mode rejection ratio, a differential comparator amplifier with measurement accuracy up to 0.2% — and many others. By using two 5A14N four-trace amplifiers, up to eight traces can be displayed with a bandwidth of 1MHz. Since the 5403 mainframe has three plug-in compartments, multi-function capabilities can be arranged by selection from the present total of 17 plug-in units, and more of these units are to be announced soon. Modular construction enables the 5403 oscilloscope to be converted conveniently from cabinet to standard $5\frac{1}{4}$ in rackmount configuration. The price of the 5403 mainframe with D40 display unit and c.r.t. readout facility, is £631.90 (£443.60 without readout). The prices of the 5A48 dual trace amplifier and 5B42 time base are £242.20 and £309.30 respectively. (All prices exclusive of v.a.t.) Tektronix U.K. Ltd, P.O. Box 69, Beaverton House, Harpenden, Herts.
WW313 for further details

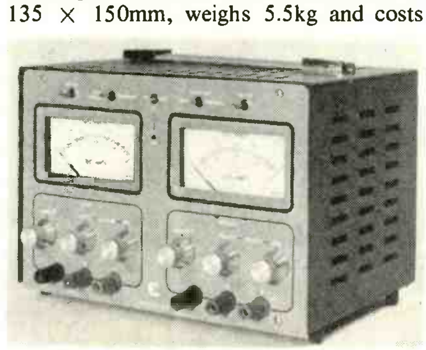
WW 313

Lab power supply

Just introduced by Coutant Electronics are two twin-output, continuously-variable power supplies in the L Series of laboratory units. Designated the LQT 100 and LQT 200, the former offers two 0–30V outputs at 1A, while the latter provides two 0–15V outputs at 2A.

Each metered unit may be used in a constant current or constant voltage mode, and their outputs can be switched in series or parallel, as well as in a master or slave configuration — particularly useful for differential operational amplifier circuits where common tracking is employed.

The type LQT also has the following principal specifications: mains regulation 0.01% +1mV, constant voltage (c.v.), or +1mA constant current (c.c.); load regulation 0.03% +3mV (c.v.) or +3mA (c.c.); ripple voltage 0.005% + 0.5mV pk–pk; ripple current 0.01% + 1mA pk–pk; transient response less than 10μs; operating temperature range +10 to +45°C; and temperature coefficient 0.02% per °C. Each unit measures 185 × 135 × 150mm, weighs 5.5kg and costs £79. Coutant Electronics Ltd, 3 Trafford Road, Reading, RG1 8JR.
WW302 for further details



WW 302

Universal measuring bridge

Avo Ltd announce the introduction of the Universal Measuring Bridge Type B150 Mark 2. This model incorporates not only all the popular features of the earlier model but also greatly improved sensitivity. This improved sensitivity now enables the full range of resistance measurement available to be determined under d.c. conditions using only the 9V internal battery supply.

Capacitance may be measured up to 1199μF, inductance up to 119.9H, and resistance up to 11.99MΩ at a frequency of 1000Hz using the internal oscillator, or at frequencies between 20Hz and 30kHz using an external source. To facilitate the testing of electrolytic capacitors, provision is made for the connection of an external polarising voltage of up to 350V.

Mechanical digital in-line display of the measured value is retained. When the bridge is balanced the digits and range symbols, indicating the component value, are displayed automatically. This presentation of the component value is claimed to provide maximum reading accuracy, as all multiplying factors are eliminated.

This battery operated bridge has a carrying handle for portability and a fold-away stand on the base allowing the instrument to be inclined at a convenient angle if required. Avo Ltd, Avocet House, Archcliffe Road, Dover, Kent.
WW312 for further details

Capacitor design kit

A hybrid circuit capacitor engineering design kit has been introduced by Union Carbide U.K. Ltd. The kit comprises 280 Kemet tantalum and ceramic chip capacitors together with technical literature. It is priced at £45.

The tantalum chip portion of the kit contains 80 T400 series capacitors in 20 different CV ratings and 10 case sizes. The ceramic chip portion contains 200 capacitors in both BX and NPO dielectric and in six popular case sizes. All chips feature a copper barrier layer that enables them

WW 312

to withstand the severe temperatures associated with solder reflow circuit assembly techniques. The tantalum chips will withstand assembly temperatures of 300°C for 20 minutes. Union Carbide U.K. Ltd, 8 Grafton Street, London W1A 2LR.
WW 308 for further details

Digital controlled current source

A dual-range, digitally-programmable current source, the Hewlett-Packard Model 6145A, provides current outputs from −9.999 to +9.999mA at compliance voltages up to 100V d.c. In the times-one range (±9.999 milliamperes), resolution is 1μA, accuracy is 1μA, and programming speed is 300μs. An active guard circuit eliminates internal leakage currents so that output voltage can be measured without drawing current from the load.

The 6145A can be programmed from a remote four-digit 8421-b.c.d. source, or locally using front-panel thumbwheel switches.

The Model 6145A can be programmed by computers, programmable calculators, or other digital sources. It satisfies all requirements for system use with:

- Optically isolated digital inputs and outputs that eliminate ground loops.
- Internal storage of all digital input data that eliminates the need to refresh the supply.
- Flexible interface circuitry that ensures compatibility with many programming sources.
- Programmable voltage limiting that protects the supply and the load. The voltage limit can be programmed to any of eight discrete levels. A separate "clear" line programmes the minimum voltage limit.
- Feedback signals to co-ordinate the transfer of output data and tell the computer if an overvoltage condition has occurred.
- External analogue input to provide the ability to modulate the programmed output current with a.c.

Programmed inputs to the Model 6145A include 16 bits for current magnitude, 1 bit for sign, 3 bits for voltage limit, 1 bit for voltage "clear" and 1 bit for range.

The Model 6145A digital current source costs £1450. An interface kit is available for interfacing the current source with Hewlett-Packard computers. It consists of a plug-in computer/output card, interconnecting cables and driver software. Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks, SL1 4DS.
WW310 for further details

Marine radiotelephone

EMI Marine has introduced a marine radiotelephone which incorporates all 57 v.h.f. international channels with the addition of 10 private channels when required. Naval and military communications are covered by the equipment, which has full Post Office approval and has been environmentally tested.

The radiotelephone features data controlled frequency selection, a method of digital frequency synthesis needing only four crystals aided by a miniature computer to control the 134 frequencies required — a technique which previously has been limited to satellite and military communications. Designated the AP759, and offering full duplex, semi-duplex and simplex operation, the equipment is manufactured by A.P. Radiotelephone, Copenhagen.

Dual-watch facilities are included as standard. This means that two pre-selected channels may be constantly monitored, with one-second intervals between switching. When a message is received, the system automatically "locks on" to that channel and holds it until the message has been completed. It then reverts to the monitoring mode. The skipper can override the system manually if required.

Another feature of the AP759 is that the standard single unit (which is complete in itself as an international radiotelephone) may be simply converted into a 4-station system, for inclusion in different areas of the vessel, i.e. skipper's cabin, navigator's area, communications room, bridge, etc. Each station has access to the full 57 + 10 channel unit as described, with any station being the master station, which can override the other three. Full indication is given by four coloured lights on each station control panel as to which station is in use at any time.

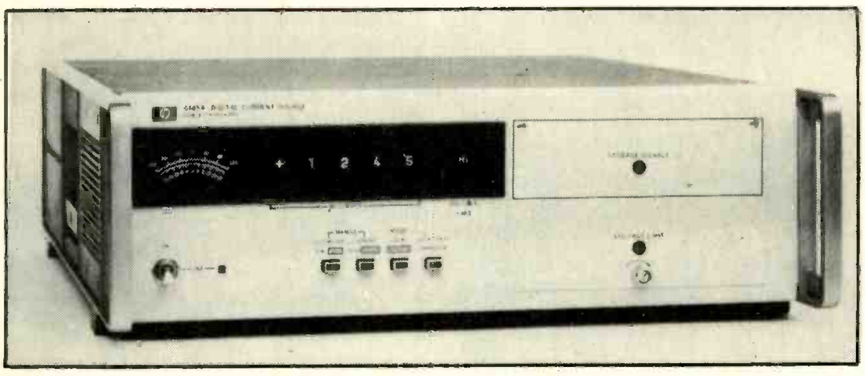
The radiotelephone units are compactly designed, measuring 132 × 380 × 165mm and have facilities for two extra handsets, and two extension speakers. Distances between individual stations can be up to 200 feet and operating supplies are either 12 or 24V d.c. (completely isolated) or ships' voltages of 100 d.c. or 230 a.c. Price £695 for a complete single system. EMI Marine, Cramptons Road, Sevenoaks, Kent.
WW311 for further details

Scientific calculator

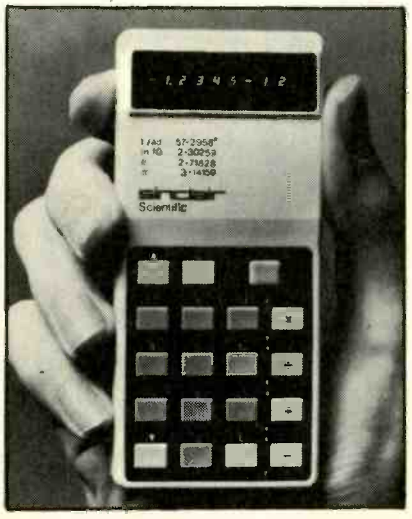
Sinclair Radionics have launched their scientific pocket calculator at the Consumer Electronics Show in Chicago. The 12-function Sinclair Scientific is similar to the recently introduced Cambridge, but has an "upper and lower case" keyboard enabling all twelve functions to be obtained using only four function keys.

Apart from the normal operators, plus, minus, divide, multiply, the following additional functions are provided: $\log_{10}$, antilog_{10}, sine, cosine, tan, arcsin, arccos and arctan. Post fixed operators provide full flow calculation facility on all functions.

The entry and result are displayed as a five-digit mantissa and a signed two-digit exponent ranging from 10^{-99} to 10^{99}. The calculator chip was the result of new algorithms for transcendental function devised by Clive Sinclair and special programming techniques by Nigel Searle. This enabled the use of a fairly conventional calculator chip which is, however, exclusive to Sinclair. Price will be £49 plus v.a.t. and first supplies are expected for the U.K. and Europe by the end of March. Sinclair Radionics Ltd, London Road, St. Ives, Huntingdonshire PE17 4HJ.
WW 391 for further details



WW 310



WW.391

Solid State Devices

Each section under the title of Solid State is devoted to the new semiconductor products offered by one manufacturer or distributor. The type number and device title is given in bold type, followed by a brief description of features or application. The section is terminated with reader reply card numbers associated with the device numbers of types.

L120, L121 s.c.r. and triac controls. These i.cs by SGS-Ates are complete control systems for thyristors and triacs, using phase control (L120) or burst control (L121). Both units can be operated from a.c. mains or d.c. and generate pulse for direct application to the control element gate. The outputs are short-circuit protected. The circuits are in 16-pin dual-in-line packs and operate between 0°C to 70°C.

BF679/BF680 u.h.f. pair. The two devices are p-n-p silicon planar transistors in one SOT-37 package and are designed to act as r.f. amplifier and mixer/oscillator in varicap-tuned television front-ends. They are pin-compatible with germanium equivalents. The units possess a noise figure of 3.5dB at 3mA and 800MHz and can operate at a junction temperature of 150°C and 24V supply.

BF479 u.h.f. transistor. Designed for use in p-i-n diode tuner, the BF479 operates at high collector currents, giving a noise figure of 4dB at 10mA and 800MHz. See article in August 1973 issue, pp 375-7.

L129/130/131. These are three voltage regulators in the three-lead SOT-32 plastic package, offering load regulation of better than 1% of 60dB ripple rejection and overload/short circuit protection. Output voltage of L129 is 5V for 7.5V to 20V input, L130 gives 12V for an input of 14.5 to 27V and L131 puts out 15V for 17.5 to 27V. Currents are 850, 720 and 600mA respectively. The only external component needed is an output capacitor.

M24 static r.o.m. is a 4096 bit static read only memory in the silicon-gate technology. The memory is organized in 512 words of 8 bits. The unit is t.t.l. compatible and the outputs can from ORed. Access time is 500ns.

M250 rhythm generator. This device is arranged as a r.o.m., having an internal decoder to select one of 32 rows, which allows 12 rhythms, driving eight outputs to be programmed.

TDA1200 radio chip. An integrated circuit providing a complete f.m. i.f. amplifier up to the detector. Included in the system are squelch, a.f.c. and delayed a.g.c., stereo switching, tuning meter drive and a supply regulator. The circuit is in 16-pin dual-in-line form. SGS-Ates Planar House, Walton St., Aylesbury, Bucks.

WW 317 L120, L121
WW 318 BF 679/BF680
WW 319 BF479
WW320 L129/130/131
WW 321 M24
WW 322 M250
WW323 TDA1200

XR-2567 tone decoder. This is a twin version of the Exar XR-567 tone decoder, and includes a voltage regulator in 16-pin ceramic d.i.p. The unit is intended for frequency decoding in multiple tone communication systems, the centre frequencies extending from 0.01Hz to 500kHz. The outputs, which are logic compatible, can sink up to 100mA at 26V.

LM354A audio amplifier. This 4W amplifier by EEP is an integrated unit intended for use in television receivers and can tolerate a range of supply voltages from 6 to 24V. The unit features a directly-coupled input and high input impedance and requires a minimum of external components. A 14-lead d.i.p. is used with an integral heat-sink.

LH300 Series voltage regulators. These units were designed by EEP to power m.o.s. integrated circuits and require neither external components nor adjustment. Each unit will supply up to 1A and output voltages are fixed at 12V (LH312), 15V (LH315) and 24V (LH324).

CY2035 Series d-a converters. Using thin-film resistor networks and low-drift operational amplifiers, these Cycon units have a short settling time and low linearity drift (0.0005%/°C). The output range is selectable and both ends of the range can be adjusted. Versions available are CY2035 (8-bit), CY2135 (10-bit) and CY2235 (12-bit) and the units take the form of an encapsulated module with pins on 0.1in. centres.

COM 2502 receiver/transmitter. A m.o.s./l.s.i. module by Standard Microsystems which performs functions associated with asynchronous data communication. Word length, parity mode and number of stop bits are programmable and notable among the other features are double buffering, start bit verification, input protection and tri-state outputs. The COM 2601 is similar but is intended for synchronous operation.

KR2376-XX keyboard encoder r.o.m. This circuit will encode keyboard closures from an 11 × 8 matrix to a 1-but code. Data and strobe tin-state outputs interface directly with t.t.l., d.t.l. and m.o.s. logic.

CY1010/1011 instrument amplifiers. These are two Cycon bipolar input op-amps which are small enough to be sited near remote transducers to reduce noise pick-up. Common-mode rejection is as high as 140dB, voltage offset drift is 1 V/°C and input bias current 30 A. The input and output are both differential. The price of the CY1010 is £13.20, and that of the close tolerance CY1011 is £21.45. The units measure 1.52 × 1.15 × 0.61 in. Rastra Electronics Ltd, 275-281 King Street, Hammersmith, London W6 9NF.

WW324 XR-2567
WW325 LM 354A
WW326 LH 300
WW327 CY2035
WW328 COM 2502
WW329 KR2376-XX
WW330 CY1010/CY1011

LM/122/222/322 timers. This is a wide-range timer (microseconds to hours) with a built-in voltage regulator providing immunity to supply variations between 4.5 and 40V. The output drive is from a "floating" transistor, which makes for ease of interfacing, and is provided with a reverse circuit to give an "on" or "off" output during the timed interval. The devices are to be had in TO-5, flat-pack or d.i.p. form and operate between −55°C and +125°C (LM122) or −25°C and +85°C (LM2229.

LM555 timer. This device is intended for precision timing, pulse generation, delay generation, pulse position modulation or ramp generation. It requires a minimum of two external components and the output which is t.t.l. compatible, can source or sink 200mA. The 555 is available in a metal-can version or in dual-in-line form. Stability is better than 0.005% per degree centigrade.

LM139A/239A/339A quad comparators. The packages each contain four separate voltage comparators with voltage offsets of less than 2mV. The units were designed to use single power supplies, although the split type of supply can be used. The range of permissible common-mode voltages includes ground, even when a single rail is in use. LM139A will interface with t.t.l. and c.m.o.s., while the LM339A, when used with dual supplies, will interface with m.o.s. logic. The output is in the form of an open collector transistor, many of which can be ORed together.

74C160/161/162/163 c.m.o.s. counters. A series of binary (161/163) and decade counters with synchronous or asynchronous clear and internal look ahead carry. The circuits are endowed with all the advantages of c.m.o.s. (high noise immunity, wide supply tolerance, etc.), and are available in 54C, 64C and 74C versions. National Semiconductor (UK) Ltd, The Precinct, Broxbourne, Herts.

WW350 LM122 timer series
WW351 LM555 timer
WW352 LM139A quad comparator
WW353 74C160 series counters

GPL 120/121/122 l.e.ds. Three gallium phosphide yellow light-emitting diodes are announced by Plessey. The GPL120, which is encapsulated in clear plastic, produces an intensity of 4.7 millicandelas at 20mA, and can be pulsed at 1A for much higher intensities. The devices differ in the material used for encapsulation. Plessey Optoelectronics and Microwave Unit, Wood Burcote Way, Towcester, Northamptonshire.

WW333

World of Amateur Radio

More repeaters . . . more licences

For almost 18 months GB3PI near Cambridge has been the only amateur repeater station in the U.K. But the MPT has now agreed to authorize a second 144 MHz repeater, GB3BC, covering the Bristol Channel area from a site near Pontypool. In addition applications for three more f.m. repeaters are being considered; one would be in the Malvern hills; the second at the Crystal Palace in south London; and the third probably near Alton, Hants. The southern counties station is being prepared by the 50-strong U.K. FM Group (Southern) and, if authorised will be either at the Four Marks water tower near Alton (650 ft a.s.l.) or at Hannington; it would be based on a Storno CQF600 25-watt solid-state unit, accessed by 1750 Hz tone burst, and including emergency shut-down systems which can be operated manually or over a radio link.

The combined total of Class A and Class B licences now exceeds 19,000: 14,866 Class A; 4272 Class B — plus 253 amateur TV and 4176 mobile licences. This is just a shade less than the total in West Germany where there are over 20,000 amateurs including 900 issued to non-Germans. In the past five years the number of British Class A licences has risen by about 1500 (+ 12%); Class B by about 3000 (+ 230%). Reciprocal licences in the G5AAA series for overseas amateurs visiting Britain are now being issued for periods of six instead of three months.

American incentive licensing has significantly increased the number of amateurs holding the privileged extra and advanced licences; during the period 1967 to 1972 extra class licences rose by 148%, advanced class by 59%, while technician class decreased by 12% and conditional class by 20%.

New band plans for v.h.f.

As a result of recommendations of the v.h.f. managers of the national societies making up the I.A.R.U. Region 1 Bureau, new band plans for the 144, 432 and part of the 1296 MHz bands will be introduced from February 1, 1974 and are intended to apply voluntarily to amateurs throughout western Europe.

For British amateurs perhaps the most radical change is the abandonment of the long-established U.K. system of geographical zoning on the grounds that this releases a wider spectrum of frequencies for general use. Other important changes include the moving of s.s.b. operation lower in the bands and the suggestion that local operation be confined to the higher frequency parts of each band.

In general each band will follow a similar pattern not unlike that used on h.f. bands. The lowest 150 kHz of each band will be reserved for c.w.; then will come s.s.b. with no fixed upper edge but merging into the sections intended for longer distance contacts on other phone modes; local operation and f.m. repeaters are placed towards the higher frequency ends of the bands, with the exception of 145.845 to 146 MHz which is allotted to space satellites.

Segments are reserved for moonbounce (first 10 kHz); random meteor scatter (144.1 and 432.1 MHz); rtty (long distance) 144.6, 432.6, 1296.6 MHz; rtty (local) 145.3, 433.3 and 1297.3 MHz; mobile calling 145.5 MHz. Beacons will be moved to 144.15 MHz $\pm$ 25 kHz and immediately below 432.05 and 1296.05 MHz; repeater inputs 145 to 145.225 MHz, with 600 kHz spacing to provide outputs between 145.6 to 145.825 MHz. Local operation should be above 145 and 433 MHz.

The launching of a new band plan, involving the recommendation that many thousands of amateurs should voluntarily change crystal frequencies and should use different frequencies for local and long-distance working, is clearly an ambitious undertaking. One result may be to encourage more use of variable frequency techniques and single-channel working. It will be interesting to see how quickly and how effectively the new plans come into general use.

Tvi and reverse-tvi

Some 1242 ($1\frac{3}{4}$%) of the 69,270 radio and television interference complaints investigated by the Post Office during 1972 were ascribed to amateur transmitters; this compares with 1027 in 1971, 1161 in 1970, 1442 in 1969 and 1151 in 1968. An unwelcome feature is the doubling in interference to u.h.f. television: 348 complaints compared with 173 in 1971 and 65 in 1970. Many amateurs had hoped that with the coming of three-channel u.h.f. television, television interference (tvi) would rapidly fade into history, but it is clear that many present-day tv receivers do not cope well with strong local signals even when these are far removed in frequency from the tv stations. But Band I still accounts for about half of all tvi complaints.

Amateurs will also note with interest an MPT comment that radiation from tv receiver timebases causing interference to long and medium-wave radio reception has increased significantly "owing to mains-borne r.f. voltages from the semiconductor controlled power supply units of some large screen colour tv receivers". Certainly in the London suburbs there now seems a higher than ever level of timebase interference extending up through the h.f. bands. Against this the amateur can claim no protection unless it is at a level that affects the reception of local broadcasting stations.

Death of "Paragon Paul"

A direct link with the original spanning of the Atlantic by amateur signals has vanished with the death at the age of 84 of Paul ("Paragon Paul") Godley, formerly 2ZE. In November 1921, as a leading American amateur, he came to Britain for the Transatlantic Tests, bringing with him a ten-valve Armstrong "supersonic heterodyne" receiver. He first set up station at Wembley but was discouraged by the high noise levels and departed for Scotland. There in a tent at Ardrossan on the wind-swept west coast he erected an 850 ft Beverage aerial and — fighting off the depressing effects of a heavy cold and the flickering oil lamps — succeeded during the Tests in receiving one Canadian and 27 American amateurs. The first call he logged was 1AAW which seems to have been a pirate station, and the first positive identification of an American station was actually made by the British station 2KW of Sale (Messrs W. R. Burne & Co).

In a lecture to the Wireless Society of London he reported the rapid progress of amateur radio in the United States and said: "One has far greater hopes of being able to travel greater distances on the shorter wavelengths than on higher wavelengths". But it is doubtful whether these words made much impression on the British amateurs who were then fighting hard to retain their allocation at 1000 metres, threatened by complaints of interference to Croydon Airport.

In brief

Pye Telecommunications Contest Group, operating portable in Wales on the 70, 144, 432 and 1296 MHz bands, won the 1973 R.S.G.B. VHF National Field Day . . . . M. P. Hawkins of Chelmsford was the victor in the 1973 National DF Final, successfully finding three carefully concealed 1.8 MHz transmitters 7, $4\frac{1}{2}$ and 10 miles from the starting point, in a period of 2 hours 18 minutes . . . . Over 1800 different amateurs used the Oscar 6 satellite in its first year in orbit, about 1000 of them outside the United States . . . . The GB3GEC beacon located on the premises of the M-O Valve Company for a number of years has closed down . . . . "If you choose a band segment of 100 kHz in the h.f. spectrum, within that segment you can accommodate 1000 c.w. signals, or 333 narrow-shift rtty, or 100 wide-band rtty, or 33 s.s.b. signals, 16 d.s.b., 16 n.b.f.m. or 3 wideband f.m. signals" — A. Prose Walker, W4BW of the F.C.C.

PAT HAWKER, G3VA

RS3

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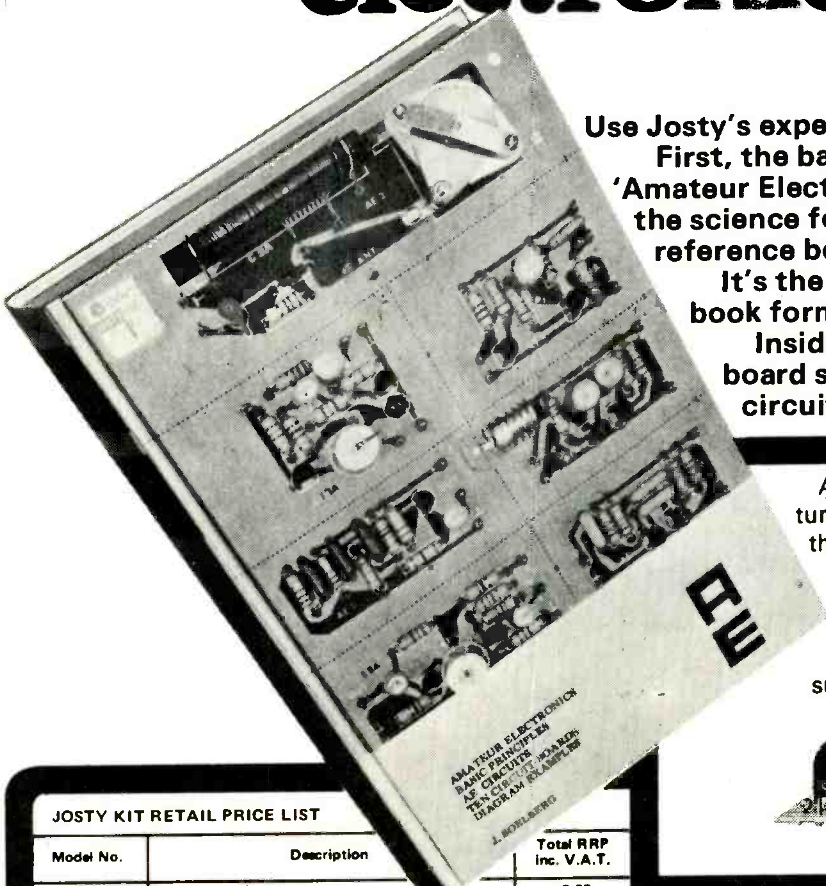

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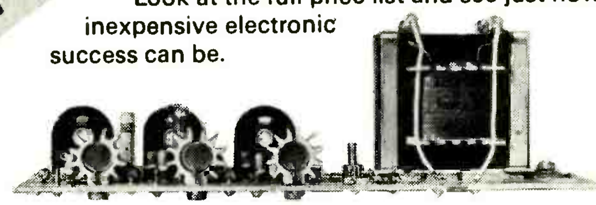

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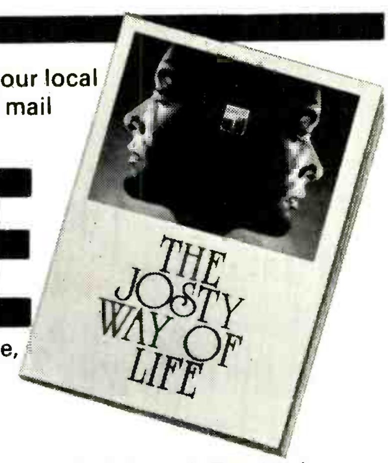

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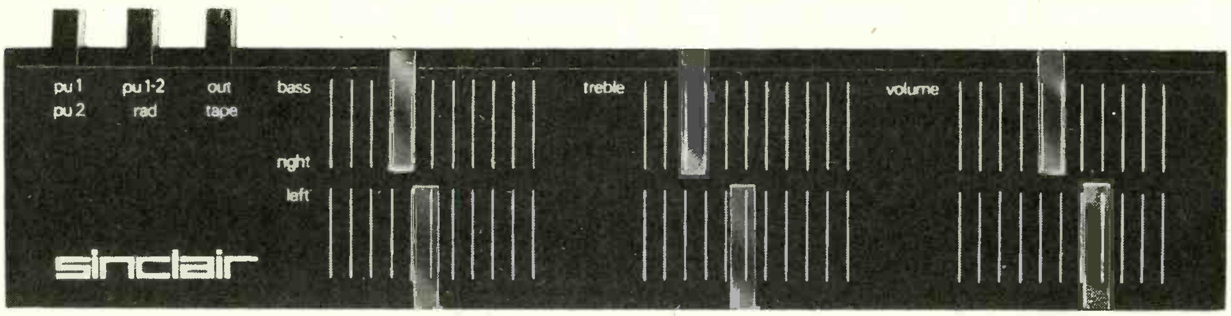
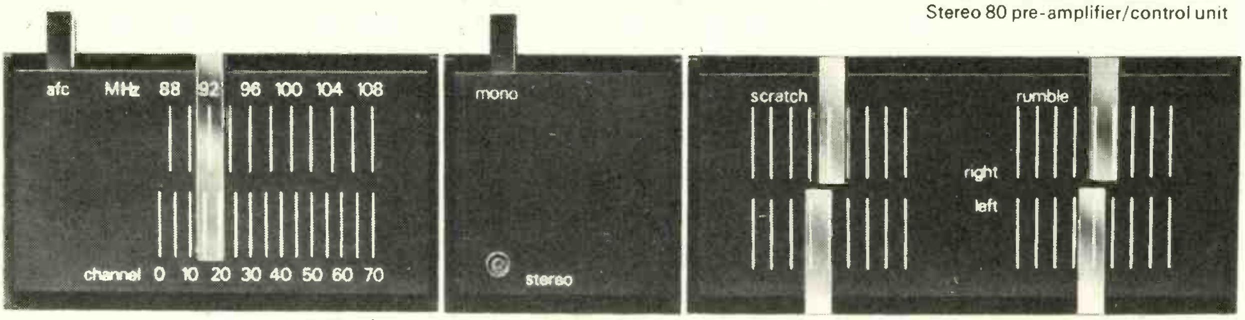


Stereo 80 pre-amplifier/control unit



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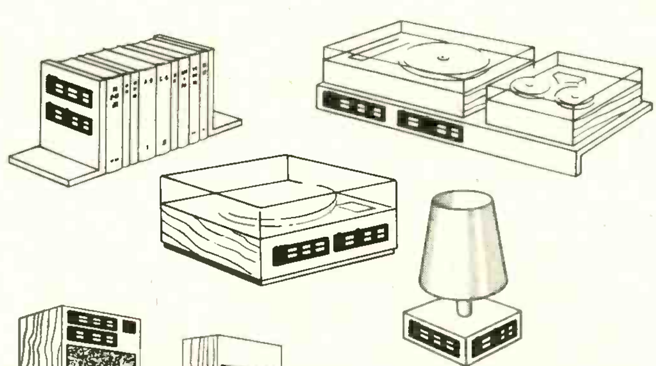

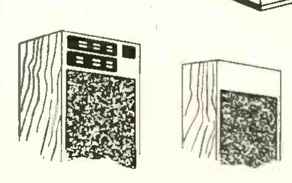

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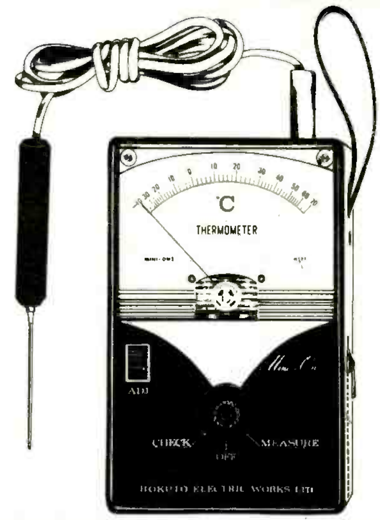

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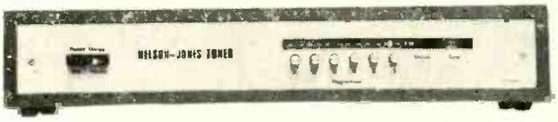

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MOSFET Front end for excellent cross modulation performance and low noise.
3 GANG Tuning for high selectivity
VARICAP tuning diodes in back to back configuation fo low distortion.
CERAMIC IF filters for defined IF response.
INTEGRATED circuit IF amplifiers for reliability and excellent limiting/AM rejection.

PHASE LOCKED Stereo decoder with Stereo mute, see below.
LED fine tuning indicators.
PUSH BUTTON tuning (with AFC disable) over the whole FM band.
IC STABILISED and S/C protected power supply.
CABINET veneered inside and out.

The Nelson-Jones Tuner has all of these features and many more, and more importantly the design is fully **proven** not just with a few prototypes but with many thousands of working tuners spread across the world.

Basic tuner module prices start as low as **£10·79**, with **complete** kits starting at **£23·95** (mono) + PP 50p. and of course all components are available separately.

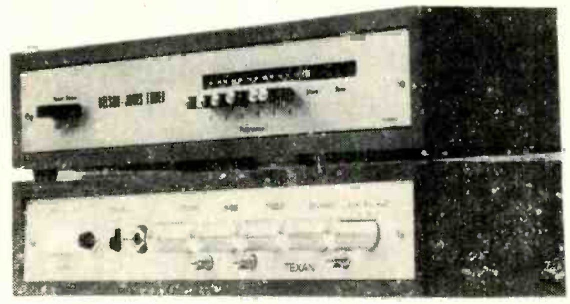
Our low cost **alignment service** is available to customers without access to a signal generator.

Please send large SAE for our latest price lists which detail all of the many options and special low prices for complete kits. All our other products remain available.

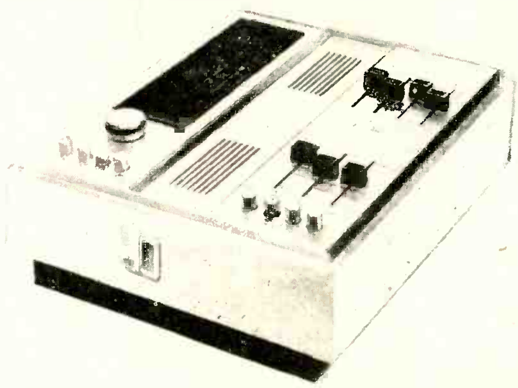
PORTUS AND HAYWOOD PHASE LOCKED DECODER (W.W. Sept. '70). Still the lowest distortion P.L. decoder available. THD typically 0.05% (at Nelson-Jones Tuner O/P level)! Supplied complete with Red LED.

Price **£5.50** when bought with a **complete** N-J tuner kit or **£7.68** if bought separately (P.P. 19p.)

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



TEXAN AMPLIFIER. We have designed the tuner case and metalwork to match the Texan amplifier (see photograph). Complete designer approved Texan kits are available at **£28·50** plus p.p 50p including Teak Sleeve.



THE RONDO QUADRAPHONIC SYSTEM (20 WATTS/CHANNEL)

Complete designer approved kits for this outstanding Quadraphonic Sound System ('P.E.' Sep. '73, etc.) with the following features:—

★ SWITCHING FACILITIES AND MODULES FOR SQ, QS AND CD4.
★ COMPLETE LOUDSPEAKER ENCLOSURE DESIGN.
★ MODULAR BUILT IN-AM/FM RADIO.
★ INDIVIDUAL KITS MAY BE INCORPORATED IN EXISTING EQUIPMENT.
★ LOW COST, FULLY ENGINEERED, INTEGRAL DESIGN.
★ KITS AVAILABLE AS PUBLISHED—SEE BELOW.
★ COMPLETE LOUDSPEAKER SYSTEMS AVAILABLE

CBS SQ* MATRIX DECODER *TM CBS INC.	Complete Kit	£8·00	Post Free Incl. CBS Licence Fee	VAT Extra
PREAMPLIFIER BOARD	Complete Kit	£3·00	Post Free	VAT Extra
MASTER VOL./TONE/BALANCE BOARD	Complete Kit	£8·50	Post Free	VAT Extra
POWER AMP. BOARD AND HEATSINK STEREO PAIR	Complete Kit per Board	£7·50	Post Free	VAT Extra
POWER SUPPLY BOARD	Complete	£5·00	Post Free	VAT Extra
MAIN SMOOTHING CAPACITORS (TWO REQD)	Per Pair	£1·50	Post Free	VAT Extra
MAINS TRANSFORMER	Complete Kit	£6·25	Post Free	VAT Extra
CHASSIS—PUNCHED and DRILLED WITH SCREENS	Complete Kit	£3·25	Post Free	VAT Extra
QUAD SELECTOR SWITCH		£1·30	Post Free	VAT Extra
WOODEN CASE		£1·75	Post Free	VAT Extra
HARDWARE PACK		£2·00	Post Free	VAT Extra
CONTROL SECTION FACIA		£3·50	Post Free	VAT Extra

THE COMPLETE P.E. RONDO SYSTEM IS AVAILABLE AS PUBLISHED.

PLEASE PHONE OR WRITE FOR FULL DETAILS

ACCESS

You can order these goods by Telephone on Access. Simply quote your Access Number.

OPTO-DEVICES

Panel mounting LED's.

RED	1-9	29p	10-24	23p
GREEN	1-9	59p	10-24	49p

7 Seg LED's

0·325" RH Dec Point.
Common Anode 1-4 £2·00; 5-24 £1·80.
Common Cathode 1-4 £2·C0; 5-24 £1·80.
7447 Dec Driver £1·30 (C.A.)

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

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LINEAR 202 10+10 Watt AMPLIFIER £29·95 (List Price £39·93) Carr. 45p

FANE ULTRA HIGH POWER LOUDSPEAKERS

Power Rating R.M.S. continuous. 2 years guarantee. Carr. free

12" 'POP' 50 50 Watts **£12·75** 15 Ω 13,000 Gauss
Or Dep. £1·71 and 8 monthly payments £1·71 (Total £15·39) Pair suitable for all purposes

15" 'POP' 60 60 Watts **£15·75** 8/15 Ω 14,000 Gauss
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SUITABLE FOR BASS GUITAR, ELECTRONIC ORGAN, etc.

R.S.C. G66 MkII 6+6 WATT STEREO AMPLIFIER

High Quality Output. Rating I.H.F.M. Ind. Ganged Controls Bass, Treble, Vol and Balance. Solid state constr. employing 10 Trans. plus diodes. Range 20-20,000Hz. Bass control ± 12 dB. Treble ± 13 dB. Selector switch P.U. or Tape/Radio. Output for 3-15 ohm speakers. Standard 200-250v. 50 Hz mains operation. Attractive Black/Silver metal face plate and matching knobs.

FACTORY BUILT in Teak Veneered Cabinet. **£16·50**
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COMPLETE KIT OF PARTS inc. fully wired printed circuit **£12·75**

FANE SPEAKERS 'POP' 25/2

12" 25 WATT **£8·75** Dual Cone 15 ohms NOT for Bass Guitar. Or Dep. £1·15 and 8 monthly payments £1·15 (Total £10·35)

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250v., 60mA, 6.3v. 2a.	£1·10
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250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	£1·55
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300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 130mA, 6.3v. 4a., c.t., 6.3v 1a. For Mullard 510 Amplifier	£2·95
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a.	£2·95
425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a.	£5·45
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a, 5v. 3a	£5·60
450-0-450v. 250mA. 6.3v. 4a., c.t., 5v. 3a.	£6·00

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v 70mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·49
250-0-250v. 100mA, 6.3v. 3.5a.	£1·71
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	£1·75
350-0-350v. 80mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·81
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
300-0-300v. 130mA, 6.3v. 4a. c.t. 6·3v. 1a. Suitable for Mullard 510 Amplifier	£2·85
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£2·45
350-0-350v 150mA, 6.3v. 4a., 0-5-6.3v. 3a.	£2·85

FILAMENT or TRANSISTOR POWER PACK Types 6.3v. 1.5a. 55p; 6.3v. 2a. 60p; 6.3v. 3a. 85p; 6.3v. 6a. £1·45; 12v. 1a. 61p; 0-9-18v. 1½a. £1·25; 0-12-25-42v. 2a. £1·95; 12v. 3a. or 24v. 1.5a. £1·50;

CHARGER TRANSFORMERS 0-9-15v. 1½a. £1·10; 2½a., £1·25; 3a., £1·40; 5a., £1·60; 6a., £1·85; 8a., £2·20.

AUTO (Step UP/Step DOWN) Transformers 0-110/120v., 200-230-250v. 50-80 watts £1·25; 150w., £2·10; 250w., £3·00; 500w., £6·40

OUTPUT TRANSFORMERS

Standard Pentode 5,000 Ω to 7,000 Ω to 3 Ω	55p
Push-Pull 8 watts EL84 to 3 Ω or 15 Ω	95p
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15 Ω	£1·55
Push-Pull EL84 to 3 or 15 Ω 10-12 watts	£1·50
Push-Pull Ultra Linear for Mullard 510, etc	£2·45
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15 Ω	£2·20
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R.S.C. BM1 battery eliminator completely replaces 1·5v. and 90v. Radio batteries where normal 200-250v. AC mains is available. Ready for use Post 30p **£4·15**

HI-FI SPEAKER ENCLOSURES

Teak veneer finish. Pleasing design. Acoustically lined. All sizes approx.
JE8 16×11×9 in. Pressurised. Excellent results with 8 in. Hi-Fi Speaker. **£5·50**
SE8 for optimum results with any 8 in. Hi-Fi Speaker. 19×10½×9 in. **£6·50**
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FANE 807T HIGH FIDELITY SPEAKER 8" 10 WATT

A full range unit to provide excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance of 30 Hz. Tweeter cone extends high note response. Frequency range 25-15,000 Hz Imp. 3 or 8/15 Ω (state requirement.) LIST PRICE £4·99 **£3·99**

MODEL 803T 8" 15w. with parasitic Tweeter. Response 25 Hz to 15 KHz. Gauss 13,000 Imp 3 or 8-15 Ω LIST £6·99 **£5·50**

AUDIO FIDELITY FR1 SPEAKER KIT

Response 30Hz-15kHz Imp. 8-15Ω. Rating 15 watts. 8" Bass Unit, Pressure Tweeter, Cross-over, etc.

£11 ea. SPECIAL OFFER £14·95 pr. Carr. 45p

HIGH FIDELITY SPEAKERS

AUDIOTRINE RANGE

Heavy construction. Highly efficient ceramic magnets. Plastiflex cone surrounds. "D" indicates Tweeter cone providing frequency range up to 15 KHz. Exceptional performance at low cost.

HF 808T	8"	10W	£2·98
HF 102D	10"	10W	£3·30
HF 120	12"	15W	£4·95
HF 120D	12"	15W	£5·50
HF 126	12"	15W	£6·35
HF 126D	12"	15W	£6·85

Please state impedance required. 3 or 8-15 ohm.

HI-FI SPEAKER SYSTEMS

Audiotrine 121K. 12 in. 15 watt. 11,000 Gauss bass unit. Cross-over unit and Tweeter. Smooth response and wide frequency range ensure realistic sound reproduction. Carr. 33p **£6·50**

Audiotrine 125K with extra sensitive 15,000 Gauss 12 in. speaker. Carr. 39p **£7·65**

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210028 RCA	9 TRACK	303462 RCA	7 TRACK
259019 RCA	7 TRACK	1215872 TYPE 1301	7 TRACK
257124 RCA	8 TRACK	5007821 POTTER	7 TRACK
282812 RCA	8 TRACK	19467 EPSYLON	8 TRACK
303489 RCA	7 TRACK	76815/948 BURROUGHES	9 TRACK
73927 RCA	7 TRACK	652623DRI 12/101	12 TRACK
303464 RCA	7 TRACK	L651922 DRI FR3000	16 TRACK

TRANSISTORS & DIODES

2N1547	75p	AC128	20p	OA5	20p
2N1545	50p	AF115	25p	OA10	25p
2N1542	50p	AF116	25p	RAS508AF 800PIV	50p
2N1557	50p	AF117	25p	RAS310AF 1000v Av. 1.5a 2 for	50p
2N1908	£6·00	OC35	40p	STC Wire ended 400PIV 1a 4 for	50p
2N3054	40p	OC42	40p	IN3193	13p
2N3055	45p	OC71	12p	IN3194	14p
2N985	£1·05	CV7006/OC72	20p	IN3255	20p
2N1046	£4·50	OC75	25p		
2N5322	50p	OC77	45p		
2N4427	52p	OC83	25p		
2N3375	£3.46	2N356/OC139	25p		
AC126	20p	Get110	20p		
AC127	25p	2G106/2N711B	43p		

RCA PHOTOMULTIPLIER C31005B Checked and tested ...... £37·50

BRIDGE RECTIFIERS 1B40KO5 50v 4a 95p

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GEX541B1P1	£3·50
GEX541D2P1	£3·50
GEX541NB1P1F	£6·00
GEX541HP3F	£6·00
SX751N1B1P1F	£6·00

INTEGRATED CIRCUITS

MC3544	£1·10
MC353G	£2·00
MC358AG	£5·00
MC365G	£5·00
CA3020	93p
CA3021	£1·15
CA3028A	97p
CA3038A	£2·14
CA3055	£1·24
CA3085	78p
CD4035AE	£1·91
CD4017AE	£3·86
CD4047AD	£3.86

THYRISTORS

GE2N1774 200v. 5a.	£1·20
CR1-021C 20v. 1a.	25p
CR10-101B 100v. 10a.	£1·00
CR10-021 10a.	£1·00
CR10-40B 10a.	£1·00
CR10-051 10a.	£1·00
CR10-017 10a.	£1·00
BTX 92 1200R 16a 1200v.	£2·85
STC 3/40 400v. 3a.	50p

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Edwards High Vacuum "Speedivac" model VSK1B range 25·760 torr contact ratings 250v. 5a. volume 4·2 cu. cm. max. working pressure 15lb/sq. in. gauge net weight 17 ozs. .... £6·20
Belling Delay hand reset L415 .... £1·10
Stackpole min. rocker 125v. 10a. 250v. 5a. 20p
Tippalite Rocker 12v 60p
Securex 5000 press button 250v. ac. .. £1·20

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Veeder Root Mech. Reset 4 dig. 50p
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STABILIZED POWER SUPPLIES

Advance PM47 0-15v. £18.50

RELAYS

Varley Min. 700 Ω 12v. 50p
Siemens Min. 12/15v. 50p
Magnetic Dev. Type 596E .... £2·00
BR Type M51 240v. 65p

KEYBOARDS

ICT Numerical .... £3·50 carr. 35p
ICL Alpha Verifier (PN7035130) .... £27·50 carr. £1·00

ELECTROACOUSTIC UNIT

6 watt (peak) Amplifier 240v. AC. with inputs for Radio, Tape Recorder, freq. response 80-12,500Hz, bass and treble controls, 2 speakers. Dimensions 265 x 235 x 580 mm. Net weight 10Kg. Ideal for education seminars etc. £12·00 incl. carr.

CONNECTORS

McMurdo Red Range. Plug RP24 .... 56p
McMurdo Red Range. SKT RS32 .... 90p
Eng. Elect. Edge. 36 way 0·2 inch .... £1·00
Sylvania Edge. 48 way 0·2 inch .... pair £1·40
Ultra Gold-plated Contacts. 0·1 inch Type 10M 54631263C 38 way .... pair £2·00
20 way .... pair £1·60

CAPACITORS

Daly Electrolytic 9000 uf 40v. **50p**; Wego paper 4µf 400v 60p; Dubilier Metallised Paper Type 426 100uf 150v. DC **50p**; R.I.C. type 1297 1.8uf 440v. AC **35p**. TCC Visconol 0·1uf 1500v. DC **50p**.

MOTORS

GEC fractional 1/12 hp 230/250v 1ph 50c 2850rpm .... £3·50 carr. 67p
E.E. ⅓hp 230v. 50c 1ph 50c. 1440rpm complete with cap 80/100uf 275v. ... £13·00 carr. £1·00
3 phase 2HP motor 60/50c. 1800/1500 RPM, 208/220/440v. .... £21.50 Incl. Carriage

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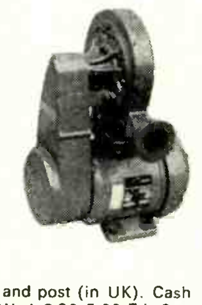
Airmax Type M1/Y3954 (3 blades) Cast Aluminium alloy impeller & casing (corresponds to current type 3965 7½") 230v. 1ph 50c 2900rpm Class "A" insulation 425cfm free air weight 9½lbs. incl. p.p. **£21·00**.

Woods Aerofoil short casing type "S" 2700rpm 220/250v 1ph 50c 6" plastic impeller incl. p.p. **£11·50**.

Woods Aerofoil Code 7.5 280K 200/250v. 1·0a 1ph 50c 2700rpm 7½" impeller 14 blades incl p.p. **£13·50**.

Service Electric Hi-Velocity Fans, suitable for Gas combustion Systems. Steam exhausting, Pneumatic conveying, Cooling Electronic equipment, Air blast for Oil burners. **Secomak** Model 365 (corresponds to 575) Airblast Fan, 440v 3ph 50c 0·75hp 2850rpm. continuous 160cfm 12 in w.g. nett weight 44lb, price incl. carr. **£41.00**. **Secomak** model 350 250v 1ph 50c 0·166hp, 2800 rpm continuous 50cfm 2 in. w.g. net weight 34lbs, price incl. carr. **£26·00**.



Air Controls type VBL4 200/250v 1ph 50c. 110cfm free air weight 7½lbs price incl. p.p. **£14·50**.

Type VBL5 200/250v 1ph 50c. 172 cfm free air. Weight 10½lbs, price incl. p.p. **£18·50**.

William Allday Alcosa Two Stage Vacuum Pump Model HSPOB 8hg up to 29 in. mercury rpm 1420. E.E. 3 phase induction, motor ⅓hp cont. 220/250v. 380/440v. **£21·00** incl. carr.

Gast MFG. Vacuum pump 0522-P702-R26X. Motor 110/120v. A.C. 1 ph. 60c 1725 rpm. Class E. 10cuft to 10in Mercury in 2 mins maintains vacuum. 635mm Mercury. Or as compressor 10psi int. or 15 psi cont. **£25·00** incl. carr.

Where p.p. not advised add 10p per £ handling and post (in UK). Cash with order. Personal callers welcome. Open Mon.-Wed. 9.30-5.00 Fri.-Sat. 9.30-5.00. Free Car Park adj. **PRICES SHOWN ARE EXCLUSIVE OF V.A.T.**

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WW—134 FOR FURTHER DETAILS

YATES ELECTRONICS

(FLITWICK) LTD.
DEPT. WW ELSTOW STORAGE DEPOT
KEMPSTON HARDWICK
BEDFORD

C.W.O PLEASE. POST AND PACKING PLEASE ADD 10p TO ORDERS UNDER £2.

Catalogue which contains data sheets for most of the components listed will be sent free on request. 10p stamp appreciated.

CALLERS WELCOME
MON.-SAT. 9 a.m.-5 p.m.

PLEASE ADD 10% V.A.T.

RESISTORS

½W Iskra high stability carbon film—very low noise—capless construction. ½W Mullard CR25 carbon film—very small body size 7·5 x 2·5 mm. ½W 2% ELECTROSIL TR5.

Power watts	Tolerance	Range	Values available	Price 1–99	Price 100+
½	5%	4·7Ω–2·2MΩ	E24	1p	0·8p
½	10%	3·3MΩ–10MΩ	E12	1p	0·8p
½	2%	10Ω–1MΩ	E24	3·5p	3p
⅛	10%	1Ω–3·9Ω	E12	1p	0·8p
⅛	5%	4·7Ω–1MΩ	E12	1p	0·8p
4	10%	1Ω–10Ω	E12	6p	5·5p

Quantity price applies for any selection. Ignore fractions on total order.

DEVELOPMENT PACK

0·5 watt 5% Iskra resistors 5 off each value 4·7Ω to 1MΩ.
E12 pack 325 resistors **£2·40**. E24 pack 650 resistors **£4·70**.

POTENTIOMETERS

Carbon track 5kΩ to 2MΩ, log or linear (log ¼W, lin ½W).
Single, **12p**. Dual gang (stereo), **40p**. Single D.P. switch, **24p**.

SKELETON PRESET POTENTIOMETERS

Linear: 100, 250, 500Ω and decades to 5MΩ. Horizontal or vertical P.C. mounting (0·1 matrix).
Sub-miniature 0·1W, **5p** each. Miniature 0·25W, **7p** each.

TRANSISTORS

AC107	15p	AF126	20p	BF115	25p	OC42	12p	2N3707	12p
AC126	12p	AF139	32p	BF173	20p	OC44	12p	2N3708	10p
AC127	15p	AF178	32p	BF177	28p	OC45	12p	2N3709	11p
AC128	15p	AF180	40p	BF178	32p	OC70	12p	2N3710	11p
AC131	12p	AF181	40p	BF179	32p	OC71	12p	2N3711	11p
AC132	12p	BC107	12p	BF180	32p	OC72	12p	2N3819	32p
AC176	15p	BC108	12p	BF181	32p	OC81	12p	2N4062	12p
AC187	22p	BC109	12p	BF194	14p	OC82D	12p	2N4286	20p
AC188	22p	BC147	12p	BF195	14p	2N2646	60p	2N4289	20p
AD140	50p	BC148	12p	BF197	15p	2N2904	20p	40360	35p
AD149	45p	BC149	12p	BF200	32p	2N2926	10p	40361	35p
AD161	33p	BC157	14p	BF750	20p	2N3054	58p	40362	40p
AD162	36p	BC158	14p	BF751	20p	2N3055	60p	40408	40p
AF114	20p	BC159	14p	BF752	20p	2N3702	13p	ZTX108	15p
AF115	20p	BC187	22p	BU7105	225p	2N3703	12p	ZTX300	15p
AF116	20p	BD131	75p	OC26	45p	2N3704	13p	ZTX302	20p
AF117	20p	BD132	75p	OC28	50p	2N3705	12p	ZTX500	15p
AF118	38p	BD133	75p	OC35	50p	2N3706	11p	ZTX503	20p

ZENER DIODES

400mW 5% 3·3V to 30V, **12p**.

WIRE WOUND POTS

3W, 10, 25, 50Ω and decades to 100kΩ, **35p**.

DIODES

RECTIFIER

BY127	1250V	1A	12p
1N4001	50V	1A	7p
1N4002	100V	1A	8p
1N4004	400V	1A	8p
1N4006	800V	1A	10p
1N4007	1000V	1A	12p

SIGNAL

OA85	7p
OA90	5p
OA91	5p
OA202	7p
1N4148	5p
BA114	8p

BRUSHED ALUMINIUM PANELS

12in x 6in, **25p**; 12in x 2½in, **10p**; 9in x 2in, **7p**

SLIDER POTENTIOMETERS

86mm x 9mm x 16mm, length of track 59mm.
SINGLE 10K, 25K, 100K log. or lin. **40p.**
DUAL GANG, 10K + 10K etc. log. or lin. **60p.**
KNOB FOR ABOVE, **12p.**
FRONT PANEL, **65p.**
18 Gauge panel 12in x 4in with slots cut for use with slider pots. Grey or matt black finish complete with fixings for 4 pots.

THYRISTORS

2N5060 50V 0·8A	30p
2N5064 200V 0·8A	47p
106F 50V 4A	40p
106D 400V 4A	65p

MULLARD POLYESTER CAPACITORS C296 SERIES

400V: 0·001µF, 0·0015µF, 0·0022µF, 0·0033µF, 0·0047µF, **2½p.** 0·0068µF, 0·01µF, 0·015µF, 0·022µF, 0·033µF, **3p.** 0·047µF, 0·068µF, 0·1µF, **4p.** 0·15µF, **6p.** 0·22µF, **7½p.** 0·33µF, **11p.** 0·47µF, **13p.**
160V: 0·01µF, 0·015µF, 0·022µF, 0·033µF, 0·047µF, 0·068µF, **3p.** 0·1µF, **3½p.** 0·15µF, **4½p.** 0·22µF, **5p.** 0·33µF, **6p.** 0·47µF, **7½p.** 0·68µF, **11p.** 1·0µF, **13p.**

MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. mounting: 0·01µF, 0·015µF, 0·022µF, **3p.** 0·033µF, 0·047µF, 0·068µF, **3½p.** 0·1µF, **4p.** 0·15µF, 0·22µF, **5p.** 0·33µF, **6½p.** 0·47µF, **8½p.** 0·68µF, **11p.** 1·0µF, **13p.** 1·5µF, **20p.** 2·2µF, **24p.**

MYLAR FILM CAPACITORS 100V

0·001µF, 0·002µF, 0·005µF, 0·01µF, 0·02µF, **2½p.** 0·04µF, 0·05µF, 0·068µF, 0·1µF, **3½p.**

CERAMIC DISC CAPACITORS

100pF to 10,000pF, **2p** each.

ELECTROLYTIC CAPACITORS—MULLARD O15/6/7

(µF/v) 1/63, 1·5/63, 2·2/63, 3·3/63, 4·7/63, 6·8/40, 6·8/63, 10/25, 10/63, 15/16, 15/40, 15/63, 22/10, 22/25, 22/63, 33/6·3, 33/16, 33/40, 47/4, 47/10, 47/25, 47/40, 68/6·3, 68/16, 100/4, 100/10, 100/25, 150/6·3, 150/16, 220/4, 220/6·3, 220/16, 330/4, **6p.** 47/63, 100/40, 150/25, 220/25, 330/10, 470/6·3, **7p.** 68/63, 150/40, 220/40, 330/16, 1000/4, **10p.** 470/10, 680/6·3, **11p.** 100/63, 150/63, 220/63, 1000/10, **12p.** 470/25, 680/16, 1500/6·3, **13p.** 470/40, 680/25, 1000/16, 1500/10, 2200/6·3, **18p.** 330/63, 680/40, 1000/25, 1500/16, 2200/10, 3300/6·3, 4700/4, **21p.**

SOLID TANTALUM BEAD CAPACITORS 12p

0·1µF	35V	2·2µF	35V	22µF	16V
0·22µF	35V	4·7µF	35V	33µF	10V
0·47µF	35V	6·8µF	25V	47µF	6·3V
1·0µF	35V	10µF	25V	100µF	3V

VEROBOARD

	0·1	0·15
2½ x 3¾	22p	16p
2½ x 5	24p	24p
3¾ x 3¾	24p	24p
3¾ x 5	27p	27p
17 x 2½	75p	57½p
17 x 3¾	100p	78p
17 x 5 (plain)	—	82p
17 x 3¾ (plain)	—	60p
17 x 2½ (plain)	—	42p
2½ x 5 (plain)	—	12p
2½ x 3¾ (plain)	—	11p
Pin insertion tool	52p	52p
Spot face cutter	42p	42p
Pkt. 50 pins	20p	20p

JACK PLUGS AND SOCKETS

Standard screened	18p	2·5mm insulated	8p
Standard insulated	12p	3·5mm insulated	8p
Stereo screened	35p	3·5mm screened	13p
Standard socket	15p	2·5mm socket	8p
Stereo socket	18p	3·5mm socket	8p

D.I.N. PLUGS AND SOCKETS

2 pin, 3 pin, 5 pin 180°, 5 pin 240°, 6 pin
Plug 12p. Socket 8p.
4 way screened cable, **15p**/metre.
6 way screened cable, **22p**/metre.

BATTERY ELIMINATOR £1·50

9V mains power supply. Same size as PP9 battery.

LARGE (CAN) ELECTROLYTICS

1600µF	64V	74p	2500µF	64V	80p	4500µF	16V	50p
2500µF	40V	74p	2800µF	100V	£2·60	4500µF	25V	£1·68
2500µF	50V	58p	3200µF	16V	50p	5000µF	50V	£1·10

HIGH VOLTAGE TUBULAR CAPACITORS—1,000 VOLT

0·01µF	10p	0·047µF	13p	0·22µF	20p
0·022µF	12p	0·1µF	13p	0·47µF	22p

POLYSTYRENE CAPACITORS 160V 2½%

10pF to 1,000pF E12 Series Values, **4p** each.

SMOKE AND COMBUSTIBLE GAS DETECTOR—GDI

The GDI is the world's first semiconductor that can convert a concentration of gas or smoke into an electrical signal. The sensor decreases its electrical resistance when it absorbs deoxidizing or combustible gases such as hydrogen, carbon monoxide, methane, propane, alcohol, North Sea gas, as well as carbon-dust containing air or smoke. This decrease is usually large enough to be utilized without amplification. Full details and circuits are supplied with each detector.
Detector GDI, **£2.** Kit of parts for detectors including GDI and P.C. board but excluding case. Mains operated detector **£5·20.** 12 or 24V battery operated audible alarm **£7·30.** As above for PP9 battery, **£6·40.**

PRINTED BOARD MARKER 97p

Draw the planned circuit on to a copper laminate board with the P.C. Pen, allow to dry, and immerse the board in the etchant. On removal the circuit remains in high relief.

TRANSFORMERS

All have 240V Primary

MT 30/2	0—12—15—20—24—30V	2A	£2·85
MT 50/½	0—19—25—33—40—50V	½A	£1·90
MT 50/1	0—19—25—33—40—50V	1A	£2·55
MT 50/2	0—19—25—33—40—50V	2A	£3·50
MT 60/½	0—24—30—40—48—60V	½A	£2·10
MT 60/1	0—24—30—40—48—60V	1A	£2·80
MT 60/2	0—24—30—40—48—60V	2A	£3·80

HEAT SINKS—REDPOINT

2W **24p** 4W **45p** TO5 Clip **5p** TO1 Single **5p**
3W **36p** 6W **60p** TO18 Clip **5p** TO1 Double **8p**

METERS £1·90

1½" Scale 500uA. 1mA. 10mA. 100mA.

WAVECHANGE SWITCH 23p

1p—12W, 3p—4W, 2p—6W, 4p—3W.

ROTARY MAINS SWITCH 32p

DP. 2A.

THERMISTORS

VA 1005	15p
VA 1026	15p
VA 1033	15p
VA 1055S	15p
VA 1066S	15p
VA 1077	15p
R 53	£1·35

LINEAR ICs

709 14 pin DIL	40p
741 8 pin DIL	40p
741 14 pin DIL	38p
723 14 pin DIL	95p
747 14 pin DIL	85p
748 8 pin DIL	45p
DIL Sockets 14 pin and 16 pin	16p

ALUMINIUM BOXES

AB7	2¾"×5½"×1½"	50p	AB14	7"×5"×2½"	84p
AB8	4"×4"×1½"	50p	AB15	8"×6"×3"	108p
AB9	4"×2¾"×1½"	50p	AB16	10"×7"×3"	122p
AB10	4"×5¼"×1½"	50p	AB17	10"×4½"×3"	108p
AB11	4"×2½"×2"	60p	AB18	12"×5"×3"	120p
AB12	3"×2"×1"	44p	AB19	12"×8"×3"	160p

BULGIN MAINS CONNECTORS

3 PIN 1½A	CHASSIS PLUG	10p
	LINE SOCKET	13p
3 PIN 3A	CHASSIS PLUG	10p
	LINE SOCKET	14p
3 PIN 5A	CHASSIS PLUG	16p
	LINE SOCKET	18p
3 PIN 1½A	CHASSIS SOCKET	18p
	LINE PLUG	13p
3 PIN 3A	CHASSIS SOCKET	21p
	LINE PLUG	23p
2 PIN 5A	LINE PLUG	20p

C. T. ELECTRONICS

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20 TONS OF ELECTRONIC EQUIPMENT

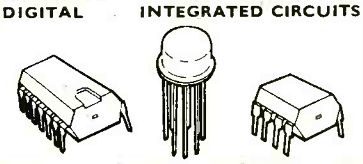
Resistors ★ Relays ★ Capacitors ★ Switches ★ Transformers Meters ★ Potentiometers ★ Component Panels ★ Semiconductors Cable ★ Values ★ Etc. ★ Etc. ★ Etc.

Regret no lists available. Personal callers only. Cash and Carry only.

semiconductors

AC107	35p	BCY33	45p	MJE370	75p	OC77	40p	ZTX504	50p	2N2907	30p		
AC125	25p	BCY34	45p	MJE371	80p	OC81	25p	ZTX531	30p	2N2926G	13p		
AC126	25p	BCY38	60p	MJE520	60p	OC83	25p	ZTX550	30p	2N3053	25p		
AC127	25p	BCY39	85p	MJE521	75p	OC84	25p	1N914	8p	2N3054	60p		
AC128	25p	BCY55	£1·20	MJE2955	£1·95	OC139	40p	1N916	8p	2N3055	65p		
AC176	25p	BCY70	22p	MJE3055	85p	OC140	25p	1N4001	7p	2N3232	70p		
AC187	25p	BCY71	20p	MM1613	43p	OC170	25p	1N4002	8p	2N3440	60p		
AC188	30p	BCY72	20p	MM1712	60p	OC171	25p	1N4003	9p	2N3702	14p		
AD140	55p	BD121	75p	MPF102	43p	OC200	50p	1N4004	10p	2N3703	12p		
AD149	65p	BD123	75p	MPF103		OC201	60p	1N4005	12p	2N3704	12p		
AD161	44p	BD124	75p	(2N5457)	35p	OC202	75p	1N4006	13p	2N3705	12p		
AD162	44p	BD131	75p	MPF104		OC205	80p	1N4007	14p	2N3706	12p		
AF114	25p	BD132	75p	(2N5458)	40p	TIP29A	50p	1N4148	7p	2N3707	12p		
AF115	25p	BD153	75p	MPF105		TIP30A	60p	2N696	30p	2N3708	12p		
AF116	25p	BD156	75p	(2N5459)	40p	TIP31A	65p	2N697	25p	2N3709	14p		
AF117	25p	BDY11	£1·40	NKT135	35p	TIP32A	75p	2N698	25p	2N3771	£2·80		
AF118	50p	BF152	20p	NKT222	25p	TIP33A	£1·05	2N706	12p	2N3772	£3·00		
AF172	30p	BF194	14p	NKT401	75p	TIP34A	£1·55	2N706A	15p	2N3773	£3·40		
BA102	30p	BF195	15p	NKT404	80p	TIP35A	£3·35	2N708	15p	2N3819	35p		
BA112	60p	BF196	15p	NKT773	25p	TIP36A	£3·65	2N930	20p	2N3820	55p		
BA114	18p	BFX29	30p	NKT774	25p	TIP41A	75p	2N1132	25p	2N3866	85p		
BC107	14p	BFX84	30p	OA5	25p	TIP42A	95p	2N1302	20p	2N3904	22p		
BC108	14p	BFX85	30p	OA10	50p	TIP29B	60p	2N1303	20p	2N3905	22p		
BC109	14p	BFX86	30p	OA47	10p	TIP30B	70p	2N1304	25p	2N4058	12p		
BC109C	16p	BFX87	30p	OA70	12p	TIP31B	75p	2N1305	25p	2N4059	12p		
BC147	12p	BFX88	30p	OA81	10p	TIP32B	85p	2N1306	25p	2N4060	12p		
BC148	12p	BFY44	50p	OA90	10p	TIP33B	£1·20	2N1307	35p	2N4061	14p		
BC149	12p	BFY50	25p	OA91	10p	TIP34B	£1·75	2N1308	35p	2N4126	17p		
BC157	14p	BFY51	25p	OA200	10p	TIP35B	£2·90	2N1309	35p	2N4286	15p		
BC158	14p	BFY52	25p	OA202	10p	TIP36B	£3·80	2N1613	25p	2N4287	15p		
BC159	14p	BFY53	25p	OA210	35p	TIP29C	75p	2N1711	25p	2N4288	15p		
BC169C	15p	BFY90	60p	OA211	35p	TIP30C	85p	2N2160	65p	2N4289	15p		
BC182	13p	BSW63	60p	OC16	90p	TIP31C	90p	2N2217	25p	2N4290	15p		
BC183	13p	BSW68	75p	OC19	85p	TIP32C	£1·10	2N2218	30p	2N4444	£1·90		
BC184	13p	BSY95A	12p	OC22	55p	TIP33C	£1·35	2N2219	35p	2N4871	35p		
BC212	15p	BY127	20p	OC26	65p	TIP34C	£2·00	2N2222	25p	2N5191	96p		
BC213	15p	BY164	60p	OC28	65p	TIP35C	£3·25	2N2222A	25p	2N5194	£1·10		
BC214	15p	IS103	15p	OC35	60p	TIP36C	£4·25	2N2398	70p	40360	50p		
BC238	14p	MJ340	50p	OC44	20p	TIS50	40p	2N2646	50p	40361	50p		
BC239	14p	MJ481	95p	OC45	20p	ZTX107	15p	2N2846	£1·50	40362	55p		
BCY30	40p	MJ2801	£1·20	OC71	17p	ZTX300	15p	2N2904	30p				
BCY31	55p	MJ2901	£2·20	OC75	25p	ZTX500	16p	2N2905	45p				
BCY32	95p	MJE340	50p	OC76	25p	ZTX501	20p	2N2906	25p				

DIGITAL INTEGRATED CIRCUITS



SN7400	28p	SN7412	42p	SN7433	70p	SN7451	25p	SN74104	£1·45	SN74166	£4·00
SN7401	38p	SN7413	60p	SN7437	70p	SN7454	28p	SN74105	£1·45	SN74167	£6·25
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SN7403	28p	SN7417	40p	SN7440	35p	SN7470	30p	SN74110	80p	SN74174	£2·00
SN7404	40p	SN7420	20p	SN7441	75p	SN7472	30p	SN74118	£1·00	SN74175	£1·35
SN7405	40p	SN7422	48p	SN7442	79p	SN7473	57p	SN74119	£1·90	SN74176	£1·60
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SN7407	56p	SN7425	48p	SN7445	£2·00	SN7475	96p	SN74122	£1·35	SN74180	£1·55
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SN7411	24p	SN7432	48p	SN7450	25p	SN7482	40p	SN74150	£3·35	SN74185	£2·40
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						SN7486	45p	SN74154	£2·00	SN74192	£2·00
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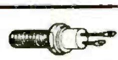
						SN7491	£1·20	SN74156	£1·55	SN74194	£2·50
						SN7492	75p	SN74157	£1·80	SN74195	£1·85
						SN7493	75p	SN74160	£2·60	SN74196	£1·50
						SN7494	80p	SN74161	£2·60	SN74197	£1·50
						SN7495	80p	SN74162	£3·40	SN74198	£4·60
						SN7496	£1·00	SN74163	£3·40	SN74199	£4·60
						SN7497	£6·25	SN74164	£2·75		
						SN74100	£2·50	SN74165	£4·00		

S.C.R.



CRS1/05	40p
CRS1/10	56p
CRS1/20	60p
CRS1/40	65p
CRS1/60	90p
CRS3/10	62p
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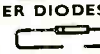
CRS16/600	£1·60
C106B	45p
C106D	70p
40669	90p
TIC44	35p
2N4444	£1·90

BRIDGE RECTIFIERS

W02 1A. 200V.	38p
BY164 1·4A. 200V.	57p
MDA952/2 6A. 100V.	80p

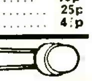
ZENER DIODES



BZY88 series 400mW.

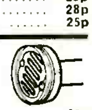
3.3-33V. 5%	15p
1.5 Watt range	25p
10 Watt range	4?p

L.E.D.



TIL209	28p
HP5082	28p
MA2082R	25p

L.D.R.



ORP 12 .... 60p

TRIACS

TXL228B 8A 400V.	90p
SC40D	£1·40
SC40E	£1·65
SC45D	£1·70
SC45E	£2·10
SC50D	£2·42
SC50E	£2·70
DIAC	25p

3A 200V Rec. Diode...... 25p

LINEAR OP. AMPS

LM309K 5V. 1A. Voltage Reg.	£2·10
LM723C 2-37V. 150mA Voltage Reg.	£1·05
MFC4000 250mW Audio	60p
TBA800 5 Watt Audio	£1·50
709C OP. Amp D.I.L./T099	45p
741C Op. Amp 8/14 D.I.L./ T099	55p
748C Op. Amp D.I.L.	75p
747C Dual Op. Amp.	£1·20
ZN414 Radio I.C.	£1·25
TAD100 Radio I.C. Inc. Filter	£1·90
CA3014	£1·55
CA3018	£1·00
CA3028	£1·20
CA3036	£1·00
CA3046	95p
CA3048	£2·35
CA3075	£1·60
CA3090Q	£4·85
MC1303L	£2·20

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1035. D.B.	CD643.1.
1049 Mk. 3A. D.B.	CD711S.2.
1049 Mk. 4. D.B. **EMI**	WM2.
Solartron	WM3B.
AD557.	WM7.
CD513.2.	WM8.
CD523 S.2.	WM16.
CD643.	WM18.
	WM26.

All prices and details on application, phone 01-994 6275. Inspection welcome—call at warehouse.

V.A.T.

Unless otherwise stated all prices are **EXCLUSIVE** of V.A.T. Please add 10% to all orders. Carriage: orders under £5 + 20p. Over £5 post free.

AUDIO ACCESSORY SHOP

17 TURNHAM GREEN TERRACE, CHISWICK, W.4

VALVE AMPLIFIERS

5 Watt	£12·50	50 Watt	£36·25
15 Watt	£24·50	150 Watt	£75·90
30 Watt	£29·50	500 Watt	£124·50

TRANSISTOR AMPLIFIERS

FAL Phase 50W .... £39·93 | FAL Phase 100W. .... £69·95

DISCO CONSOLES

FAL Disco Mk. 2 .... £82·99 FAL Power Disco .... £123·75 (with 70W. rms. Amp.)

HEAVY DUTY LOUDSPEAKERS

★ SPECIAL OFFER PRICE ★

Decca 8in 10 watt Hi-Fi speaker, plus matching tweeter £7·50 complete

Suitable 2 way Xover ...... £1·21

DISCO LIGHTING

Sound-Light Module	£7·90
3 Channel Sound-Light	£22·50
Oil Wheel 6 in. dia.	£5·25
Suitable ½ rpm Motor	£1·00
Strobe 4 Joule	£25·00
Single Flash Box (100W Red. Blue, Gn., Yel.)	£7·50
Triple Flash Box	£16·25
150W Projector plus Wheel	£25

TEAK VENEERED SPEAKER CABINETS

For 8×5in. Speaker	Size: 7¾×11¾×5¼	£3·50
8in.+Tweeter	9¼×13¼×5¾	£5·00
13×8in.	10½×17×6	£5·75
13×8in.+Tweeter	12×18¼×8¾	£7·50
12in×Tweeter	15¾×18×8¾	£9·00

ALSO: Audio Connecting Leads, Tape, Cassettes, Stereo Systems, Mixers, Mic. Stands, Speaker Cloth, Turntables, Plynths, Covers, etc., etc.

REXINE COVERED SPEAKER CABINETS

Suitable for P.A. or DISCO use; takes 12in. speaker unit. Size approx. 18×18×8in. £9·00.

SPEAKER CLOTH

Available in Black or Green; Approx. width 54in. £1·75 yd.

HEADPHONES

Type H-202 Features: Mono/stereo switch, Volume controls on each channel. Freq. response: 20-20,000Hz. Impedance 4-16 ohms. £4·50.

SGS EA1000 3W AMPLIFIER MODULE £2·45. Handbook 10p

Solidev 15W Class B Audio Amp thick film Circuit £3·65p. Handbook 15p.

TBA 800 5W Audio I.C. £1·50. Data 10p.

UA041 5W Amplifier Module £3·75

ELECTRONIC COMPONENTS BARGAIN COMPONENT PACKS

Pack No.

1 500 Carbon resistors, ¼, ½, 1, 2 watt.
2 100 Electrolytic Condensers.
3 250 Ceramic, Polystyrene, Silver Mica, etc., Condensers.
4 250 Polyester, Polycarbonate, Paper, etc., Condensers.
5 25 Potentiometers, assorted.
6 250 High-stab. 1%, 2%, 5% resistors.
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8 1lb Assorted nuts, bolts, washers, spacers, etc.
9 25 Assorted switches, rotary, lever, micro, toggle, etc.
10 50 Preset Potentiometers.
13 30 Unmarked OC71 Transistors.
14 25 Unmarked 250mW. Zener Diode. 4·7V, 5·1V, 6·2V, 7·5V, 9·1V, 10V. Measured and tested. Please state voltages required.
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ALL COMPONENTS NEW AND UNUSED

£1 + 25p p.p. per pack, **£5** for 5 packs p/free.

★★SPECIAL OFFERS★★

MINIATURE MAINS TRANSFORMER. PRI. 240V. SEC. 12V. 100mA. Manuf.: Hinchley Size: 36 × 45 × 40mm. F.C. 53mm.

Price: 1-65p. 100-60p. ea. 1000-50p. ea. 10,000-40p. ea.

3 CORE PVC INSULATED MAINS CABLE GREY ML6650. 3 × 7/0·2mm.

Price: 100m.-£4·50 1000m.-£35 10,000m.-£330

0·47mfd. 50V. MYLAR FILM CAPACITOR Size: 1in × 0·35in × 0·65in P.C. Mount.

Price: 100-6·8p. ea. 1,000-5p. ea. 10,000-4·3p. ea.

POWER SUPPLY. 12V, 6·5A. Stabilised Power Supply. Contains 18 5V. 8·5A. sec. Transformer, 4×4000µF 25V. Mullard capacitors, 2×2N3055 on 2 Redpoint heatsinks, 12A., 120V. Bridge rectifier, stabilised p.c.b circuit diagram. The parts alone are worth the asking price of **£13** each inc. carriage.

240V. A.C. SOLENOID. Reversible operation; twin coil. Size: approx. 2¾×1½×1¾in. 90p each.

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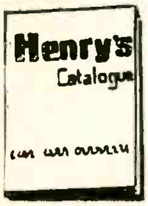
U.K's LARGEST RANGE OF ELECTRONIC COMPONENTS AND EQUIPMENT AT BARGAIN PRICES

Latest Catalogue price 55p post paid. Complete with Discount Vouchers



BUILD THE TEXAN

20 + 20WATT IC STEREO AMPLIFIER

As featured by *Practical Wireless* 1972

Now built and used by thousands of satisfied customers. Features slim design overall size in cabinet 15¼"×2¼"×3⅜ 6-IC's, 10 transistors, stabilisers Gardners low field transformer. Fibre Glass PC Panel, complete chassis work. Now available built and tested as well as in kit form. HIGH QUALITY AND STABILITY ARE PREDOMINATE FEATURES — DEVELOPED BY TEXAS ENGINEERS FOR PERFORMANCE, RELIABILITY AND EASE OF CONSTRUCTION. FACILITIES.

On/off switch indicator, headphones socket, separate treble, bass, volume and balance controls, scratch and rumble filters, mono/stereo switch, input selector; Mag. P.U., Radio Tuner, Aux. Can be altered for Mic., Tape, Tape-head, etc. Constructional details Ref. No. 21 **30p.** Distributed by Henry's throughout UK.

FREE — Teak cabinet with complete kit.

Kit Price £28·50 (+VAT+50p carr/packing) or built and tested **£35·00** (+VAT+50p carr/packing), as illustrated.

BUILD THE NEW HENELEC

STEREO FM TUNER

A completely new high stability stereo FM tuner. Features variable capacity diode tuning, stabiliser power supply, IC Decoder, high gain low noise. IF stages, LED indicators. Tuning meter, AFC, eas to construct and use. Mains operated. Slim modern design with fibre glass PC, teak cabinet etc. Available as a kit to build or ready built. Overall size 8" x 2¾"×6⅜". Produced to give high performance with a realistic price. (Parts list and constructional details Ref. No. 5 30p.) Henry's are sole distributors UK and Europe.

Kit price

£21·00 (+VAT)

OR BUILT AND TESTED £24·95 (+VAT)

EARN YOURSELF EASY MONEY, WITH PORTABLE DISCO EQUIPMENT

DISCO MINI A complete portable disco, fitted mixer/preamp, 2 decks all facilities	£98·50
As above but with **Slider Controls**	£118·50
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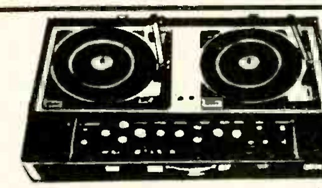
R100 100 watt mixer/amplifier	£57·50
DISCO AMP 100 watt mixer/amplifier	£73·00
NORTHCOURT	
400, 40 watt Mixer Amplifier	£37·50
800, 80 watt Mixer Amplifier	£43·00
DISCO MIXER/PREAMPLIFIERS (OP for up to 6-100 watt amplifiers)	
SDLI (rotary controls)	£49·50
SDLII (slider controls)	£58·50
DISCO VOX (slider controls) the complete disco preamp	£72·00
DJ100 100 watt power amplifier for above	£49·50
DJ30L Mk II 3 channel 3kw sound to light	£36·00
DJ30L Mk III Slider Controls	£45·50
DJ DISCLITE As 30L/II +Variable speed flashes	£54·00
DIMAMATIC 1 kW adjustable speed auto dimmer	£25·00



Carlsbro Reverberation Unit	£44·00
Disco anti-feedback microphone	£11·95
Colt 150 watt liquid wheel projector	£23·50
150 watt QI liquid wheel projector	£50·00
150 watt QI cassette wheel projector	£50·00
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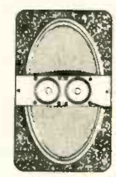
LOW COST HI-FI SPEAKERS



SPECIAL OFFER

EMI 13" x 8"—full range speakers (post 20p each or 30p pair)

*150TC—8 ohms Twin Cone 10 watt **£2·20** each or **£4·00** pair.

*450 10 watt C/o Twin Tweeters 3, 8 or 15 ohms **£3·85** each.

EW 15 watt 8 ohms C/o Tweeter **£5·25** each.

350 20 watt C/o Tweeters 8 or 15 ohms **£7·80** ea.

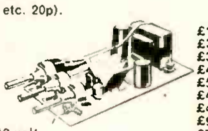
* Polished wood cabinet **£4·60** post 35p.

SPEAKER KITS (carr. etc. 35p)

20-2	8"	30 watt	£24·50 pair
20-3	8"	40 watt	£35·95 pair
LINTON 2		20 watt	£18·30 pair
GLENDALE 3		30 watt	£32·95 pair
DOVEDALE 3		50 watt	£51·50 pair
KEF KK2			£20·40 each
KEF KK3			£32·00 each

MINIATURE AMPLIFIERS

AMPLIFIERS (carr. etc. 20p).



4-300, 0·3 watt 9 volt	£1·75
104, 1 watt 9 volt	£3·10
304, 3 watt 9 volt	£3·95
555, 3 watt 12 volt	£4·10
E1208, 5 watt 12 volt	£5·10
608, 10 watt 24 volt	£4·95
410, 10 watt 28 volt	£4·95
E1206, 30 watt 45 volt	£9·75
E1210, 2½ + 2½ watts 12 volt	£7·75
RE500, 5 watt IC mains operated Amplifier with controls	£6·30
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SAC13, 15 + 15 watt Stereo with controls	£14·95
PROJECT 605 KIT	£19·95
PROJECT 805	£26·95
SP40-5 2Z40/Stereo 80/P25	£25·00
SP40-6 2Z40/Stereo 80/P26	£27·75
SP60 2Z60/Stereo 80/P28	£30·45

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Stereo Pre-Amplifier	£11·95
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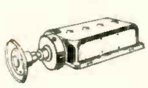
Z60 25 watt Amplifier	£6·95
PZ5 Mod. for 1 on 2 Z40	£4·98
PZ6 Mod. (S Tab) 1 on 2 Z40	£7·98
PZ8 Mod. (S Tab) 1 on 2 Z60	£7·98
TRANSFORMER FOR PZ8	£3·95
NEW FM TUNER	£11·95
STEREO DECOOER	£7·45

All items post paid.

SPECIAL PURCHASES



UHF TV TUNERS CHANNELS 21 TO 64

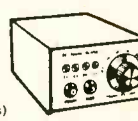
Brand new transistorised geared tuners for 625 line Receiver IF output. £2·50 post 20p.

FIBRE OPTICS

0·01 diam. Mono Filament **£1·50** per 25 metre reel.
0·13 diam. 64 Fibres Sheathed. **£1·00** per metre.
SPRAYS 15mm. diam. Mares Tails. **£9·50**

All types offered subject to availability. Price correct at time of proof. E. & O. E. Subject to change without notice. 10% VAT to be added to all orders. Export Supplied.

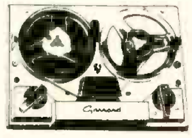
POWER SUPPLIES FOR EVERY PURPOSE



(All cased unless stated chassis)

470C 6/7½/9 volt 300 MA (includes Multi-Adaptor for Tape Recorders, etc.)	£2·15 post 20p
Car Lighter Voltage Adaptors 300mA (State voltage 6v, 7½v, 9v)	£1·95 ea. post 25p
SC202 3/6/7½/9 volt 400mA	£3·65 carr. 30p
HC244R Stabilised version	£4·90 carr. 30p
P500 9 volt 500mA	£3·20 post 20p
P11 24 volt 500mA (chassis)	£2·90 post 20p
P15 26/28 volt 1 amp (chassis)	£2·90 post 20p
P1080 12v 1 amp (chassis)	£4·50 post 20p
P1081 45v 0·9 amp (chassis)	£7·50 post 20p
P12 4½-12 volt 0·4-1 amp	£7·15 post 30p
SE101A 3/6/9/12 volt 1 amp (Stab.)	£12·50 post 25p
RP164 6/7½/9/12 1 amp (Stab.)	£12·95 post 30p

GARRARD BATTERY TAPE DECK



GARRARD 2 speed 9 volt tape decks. Fitted record/play and oscillator/Erase heads. Wind and rewind controls. Takes up to 4" spools. Brand new complete with head circuits. £9·50 carr. 30p.

TOP QUALITY SLIDER CONTROLS

60mm stroke high quality controls complete with knobs (post, etc., 15p any quantity).
Singles Log and Lin 5K, 10K, 22K, 50K, 100K, 250K, 500K, 1 Meg, **45p** each.
Ganged Log and Lin 10K, 22K, 50K, 100K, 250K, **85p** each. (Quantity discounts available.) Complete with knobs.

MARRIOT TAPE HEADS

4 TRACK MONO or 2 TRACK STEREO. '17' High Impedance **£2·00.** '18' Medium Impedance **£2·00.** R730/E73 2 track mono Record/Erase, low imp, **75p** pair. Erase Heads for '17' and '18' **75p.** '63' 2 track mono, Hi imp, **£1·75.** '43' Erase Head for '63' **75p.** (Post etc., 15p any quantity.)

TEST EQUIPMENT MULTIMETERS

(carr. etc. 30p)

111-2	20K/V Slimline	£5·95
	20K/Volt Slimline deluxe with case	£6·75
TLH33D	2K/Volt Robust with case	£7·50
U437	10K/Volt Steel case. AC up to 40KHz	£4·95
U4324	20K/Volt with AC current ranges	£8·00
AF105	50K/Volt	£11·95
U4313	20K/Volt AC current. Steel case	£10·50
U4341	Plus Built in transistor tester	£10·50
Model 500	30K/Volt	£9·95

OTHER EQUIPMENT

SE250B	Pocket Signal Injector 2·10 carr. 15p
SE500	Pocket Signal Tracer 1·70 carr. 15p
TE15	Grid Dip meter 440kHz-280mHz 15·00 carr. 30p
TE40	AC Millivoltmeter 1·2mHz 18·95 carr. 35p
TE65	28 Range valve voltmeter 19·95 carr. 40p
TE20D	120kHz-500mHz RF Generator 17·95 carr. 40p
TE22D	20Hz-200kHz Audio Generator 18·95 carr. 40p
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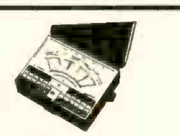
SE400	Volts/ohms/R-C sub./RF field/RF gen. 14·75 carr. 20p

NEW REVOLUTIONARY SUPER TESTER 680R

The complete testing system



Volts AC=11 ranges from 2V to 2500V
Volts DC=13 ranges from 100mV to 2KV
Amp DC=12 ranges from 500A to 10A
Amp AC=10 ranges from 200µA to 5A
Ohms=6 ranges from one tenth of Ohm to 100MΩ
Reactance=1 range from 0 to 10MΩ
Capacity=6 ranges from 0 to 500pF and from 0 to 0·5µF and from 0 to 50·000pF
Frequency=2 ranges from 0 to 500Hz and from 0 to 5000Hz
Output Voltage=9 ranges 10V to 2500V
Decibels=10 ranges from −24 to +70dB

PRICE **£18.50**

ACCESSORIES

Transistor tester	11·00
Electronic voltmeter	18·00
Ampclamp	11·95
Temperature probe	11·95
Guass meter	11·95
Signal Injector	5·95
Phase Sequence	5·95
EHT Probe	5·95
Shunts 25/50/100A	4·50 each

EXCLUSIVE DECCA KELLY SPEAKERS

12 watt speaker Tweeter systems. 8in. Bass/Midrobe and Melinex Domed HF radiator plus crossover **£12·50 per pair** of systems (carr./pkg. 40p) or built into veneered cabinets, size 18×12×6½in. **£19·50 pair** (carr. £1).

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(Any one type except where quantity discounts show) Min. Order £1.00 please, Post 10p.

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VERY IMPORTANT. ONLY branded I.C's are to the FULL manufacturers specifications. ALL others are not. Henry's sell *only* branded Integrated Circuits . . . From **TEXAS . . . I.T.T. . . . FAIRCHILD . . . SIGNETICS.** So why buy alternatives or under spec. devices when you can purchase the genuine article from us—ex stock . . . need we say more!

Type	1/11 £p	12/29 £p	30/99 £p	Type	1/11 £p	12/29 £p	30/99 £p	Type	1/11 £p	12/29 £p	30/99 £p
SN7400N	0·20	0·18	0·16	SN7448N	1·50	1·27	1·13	SN74141N	1·00	0·90	0·80
SN7401N	0·20	0·18	0·16	SN7450N	0·20	0·18	0·16	SN74142N	2·88	2·88	2·52
SN7401AN	0·38	0·38	0·33	SN7451N	0·20	0·18	0·16	SN74145N	1·44	1·44	1·26
SN7402N	0·20	0·18	0·16	SN7453N	0·20	0·18	0·16	SN74147N	2·30	2·30	1·83
SN7403N	0·20	0·18	0·16	SN7454N	0·20	0·18	0·16	SN74148N	2·01	2·01	1·63
SN7403AN	0·38	0·38	0·33	SN7460N	0·20	0·18	0·16	SN74150N	2·30	2·30	2·01
SN7404N	0·24	0·21	0·18	SN7470N	0·33	0·30	0·27	SN74151N	1·15	1·15	1·00
SN7405N	0·20	0·18	0·16	SN7472N	0·38	0·38	0·34	SN74153N	1·09	1·09	0·95
SN7405AN	0·44	0·44	0·38	SN7473N	0·44	0·41	0·37	SN74154N	2·30	2·30	2·01
SN7406N	0·40	0·38	0·35	SN7474N	0·48	0·48	0·42	SN74155N	1·15	1·15	1·00
SN7407N	0·40	0·38	0·35	SN7475N	0·59	0·55	0·51	SN74156N	1·09	1·09	1·00
SN7408N	0·25	0·22	0·19	SN7476N	0·45	0·36	0·32	SN74157N	1·09	1·09	0·95
SN7409N	0·33	0·33	0·28	SN7480N	0·80	0·70	0·50	SN74159N	2·44	2·44	2·14
SN7409AN	0·44	0·44	0·38	SN7481N	1·25	1·10	0·95	SN74160N	1·58	1·58	1·38
SN7410N	0·20	0·18	0·16	SN7482N	0·87	0·80	0·72	SN74161N	1·58	1·58	1·38
SN7411N	0·25	0·23	0·21	SN7483N	1·20	1·10	1·00	SN74162N	1·58	1·58	1·38
SN7412N	0·28	0·28	0·25	SN7485N	1·87	1·87	1·63	SN74163N	1·58	1·58	1·38
SN7412AN	0·38	0·38	0·33	SN7486N	0·50	0·50	0·44	SN74164N	2·01	2·01	1·76
SN7413N	0·30	0·27	0·25	SN7489N	4·32	4·32	3·78	SN74165N	2·01	2·01	1·76
SN7414N	0·72	0·72	0·63	SN7490N	0·75	0·70	0·63	SN74166N	2·16	2·16	1·89
SN7416N	0·30	0·27	0·25	SN7491AN	1·10	1·00	0·90	SN74167N	4·10	4·10	3·59
SN7417N	0·30	0·27	0·25	SN7492N	0·75	0·70	0·63	SN74170N	2·88	2·88	2·52
SN7420N	0·20	0·18	0·16	SN7493N	0·75	0·70	0·63	SN74172N	5·76	5·76	5·04
SN7422N	0·28	0·28	0·25	SN7494N	0·85	0·80	0·75	SN74173N	1·66	1·66	1·45
SN7422AN	0·38	0·38	0·33	SN7495N	0·85	0·80	0·75	SN74174N	1·80	1·80	1·57
SN7423N	0·37	0·34	0·32	SN7496N	1·00	0·90	0·80	SN74175N	1·29	1·29	1·13
SN7425N	0·37	0·37	0·32	SN74100N	2·16	1·89	1·89	SN74176N	1·44	1·44	1·26
SN7427N	0·37	0·37	0·32	SN74104N	0·60	0·53	0·45	SN74177N	1·44	1·44	1·26
SN7428N	0·43	0·43	0·37	SN74105N	0·60	0·53	0·45	SN74180N	1·44	1·44	1·26
SN7430N	0·20	0·18	0·16	SN74107N	0·51	0·51	0·45	SN74181N	5·18	5·18	4·53
SN7432N	0·37	0·37	0·32	SN74110N	0·57	0·57	0·50	SN74182N	1·44	1·44	1·26
SN7433N	0·43	0·43	0·38	SN74111N	0·86	0·86	0·75	SN74184N	2·16	2·16	1·89
SN7433AN	0·57	0·57	0·50	SN74116N	2·16	2·16	1·89	SN74185AN	2·16	2·16	1·89
SN7437N	0·43	0·43	0·37	SN74118N	1·00	0·90	0·83	SN74188N	6·48	6·48	5·67
SN7438N	0·43	0·43	0·37	SN74119N	1·92	1·92	1·68	SN74190N	2·30	2·30	2·01
SN7438AN	0·57	0·57	0·50	SN74120N	1·05	1·05	0·92	SN74191N	2·30	2·30	2·01
SN7440N	0·20	0·18	0·16	SN74121N	0·57	0·57	0·50	SN74192N	2·30	2·30	2·01
SN7441AN	0·85	0·79	0·73	SN74122N	0·80	0·80	0·70	SN74193N	2·30	2·30	2·01
SN7442N	0·85	0·79	0·73	SN74123N	1·44	1·44	1·26	SN74194N	1·72	1·72	1·51
SN7443N	1·50	1·27	1·13	SN74125N	0·69	0·69	0·60	SN74195N	1·44	1·44	1·26
SN7444N	1·50	1·27	1·13	SN74126N	0·69	0·69	0·60	SN74196N	1·58	1·58	1·38
SN7445N	2·16	2·16	1·89	SN74132N	0·72	0·72	0·63	SN74197N	1·58	1·58	1·38
SN7446N	2·16	2·16	1·89	SN74136N	0·63	0·63	0·55	SN74198N	3·16	3·16	2·77
SN7447AN	1·80	1·80	1·57					SN74199N	2·88	2·88	2·52

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CRS 1/10AF	100v	30p
CRS 1/20AF	200v	35p
CRS 1/40AF	400v	45p
CRS 1/60AF	600v	55p
THREE AMP (T048)		
CRS 3/05AF	50v	40p
CRS 3/10AF	100v	40p
CRS 3/20AF	200v	45p
CRS 3/40AF	400v	55p
CRS 3/60AF	600v	65p
FIVE AMP		
CRS 5/400	400v	60p
SEVEN AMP (T048)		
CRS 7/100	100v	60p
CRS 7/200	200v	67p
CRS 7/400	400v	85p
CRS 7/600	600v	95p
SIXTEEN AMP (T043)		
CRS 16/100	100v	70p
CRS 16/200	200v	75p
CRS 16/400	400v	85p
CRS 16/600	600v	£1·10

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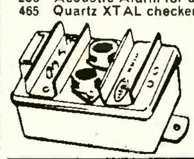

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B05/10	100v	22p
B05/20	200v	23p
B05/40	400v	25p
B05/60	600v	27p

⅓H x ⅓L x 3/16" dia.

1 AMP P.I.V.

B1/05	50v	25p
B1/10	100v	25p
B1/20	200v	28p
B1/60	600v	30p

⅓H x ⅓L x 3/16" dia.

1 AMP P.I.V.

W005	50v	29p
W01	100v	30p
W02	200v	32p
W06	600v	35p

⅜ x ⅜" Tubular

2 AMPS P.I.V.

B2/05	50v	35p
B2/10	100v	40p
B2/20	200v	45p
B2/60	600v	50p
B2/100	1000v	55p

½H x ½L x 3/16" dia.

4 AMPS P.I.V.

B4/100	100v	55p
B4/200	200v	59p
B4/400	400v	65p
B4/600	600v	75p
B4/800	800v	£1·00

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6 AMPS P.I.V.

B6/05	50v	65p
B6/10	100v	70p
B6/20	200v	80p
B6/40	400v	90p
B6/6x0	600v	£1·00

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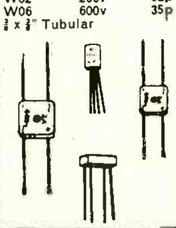

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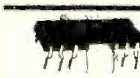

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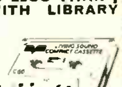

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UF89	0·35	6AB7	0·45	6H6M	0·25	9D6	0·40	30P12	0·95	8020	3·75
UL41	0·60	6AC7	0·45	6Y4WA	1·00	11E2	4·80	30P19	0·95	9001	0·30
UL84	0·40	6AH6	0·60	6Y5	0·55	12AT6	0·35	30PL1	0·80	9002	0·50
UY41	0·45	6AK5	0·35	6Y5GT	0·40	12AT7	0·35	30FL13	1·00	9003	0·55
UY85	0·35	6AK8	0·38	6Y6	0·25	12AU7	0·33	30PL14	1·00	9004	0·25
VR105/30	0·40	6AL5	0·20	6Y7G	0·30	12AV6	0·50	35L6GT	0·50	9006	0·25

VAT 10% EXTRA

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DG7-5	7·50
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K305	11·00
K308	14·50
K337	14·50
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WL417A	1·35
3J/92/E	35·00
5C22	22·00
725A	22·50

TRANSISTORS, ZENER DIODES

TRANSISTORS											
AC107	0·35	AF127	0·30	BF115	0·25	CRS25/025	0·75	OAZ200	0·50	OC76	0·25
AC113	0·15	AF139	0·30	BF167	0·25	GET115	0·75	OAZ201	0·45	OC77	0·45
AC126	0·20	AF178	0·48	BF173	0·25	GET116	0·85	OC16	1·00	OC78	0·25
AC127	0·20	AF180	0·48	BF177	0·20	GEX66	1·50	OC22	1·00	OC78D	0·25
AC128	0·20	AF181	0·48	BF180	0·35	NKT222	0·30	OC25	0·40	OC81	0·20
AC132	0·25	AF186	0·40	BF200	0·30	NKT401	0·75	OC26	0·35	OC81D	0·20
AC176	0·20	AFZ12	1·00	BFY51	0·20	OA5	0·60	OC28	0·65	OC81DM	0·20
AC187	0·25	ASY26	0·25	BFY52	0·20	OA10	0·40	OC29	0·65	OC82	0·25
AC188	0·25	ASY28	0·25	BFY90	0·75	OA70	0·10	OC35	0·50	OC82DM	0·30
ACY17	0·35	BC107	0·10	BSY29	0·30	OA71	0·10	OC36	0·65	OC83	0·25
ACY28	0·35	BC108	0·10	BYZ13	0·35	OA73	0·15	OC44	0·17	OC84	0·25
AD139	0·40	BC113	0·16	BYZ16	0·60	OA74	0·15	OC45	0·12	OC122	1·00
AD149	0·50	BC118	0·20	CRS1/10	0·30	OA79	0·10	OC70	0·12	OC139	0·25
AD161	0·35	BC182A	0·11	CRS1/20	0·40	OA81	0·08	OC71	0·12	OC140	0·65
AD162	0·35	BC212A	0·13	CRS1/40	0·48	OA91	0·07	OC72	0·20	OC141	0·60
AF118	0·25	BCY72	0·15	CRS3/40AF	0·50	OA200	0·07	OC73	0·30	OC170	0·25
		BD136	0·45			OA202	0·10	OC75	0·25	OC171	0·30
										OC200	0·40
										OC201	0·75
										OC202	0·90

	£		£
OC203	0·55	2N1308	0·27
OC204	0·65	2N1309	0·28
OC205	1·00	2N2147	0·75
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ORP93	1·10	2N3053	0·20
RAS310AF	0·35	2N2989	4·00
		2N2904	0·20
ORP12	0·55	2N3054	0·45
ORP60	0·50	2N3055	0·55
ORP61	0·45	2N3646	0·30
ORP90	0·95	2N3730	0·65
SD94	0·21	2N3731	0·70
V405A	0·25	2N3819	0·25
ZR11	0·50	2S303	0·70
ZR21	0·30	2S304	0·80
ZR22	0·25	2S307	1·60
ZT20	1·00	2S703	0·75
ZT83	0·80	40594	0·65
ZT84	1·00	40595	0·75
ZT91	2·00	40636	1·00
ZT202	0·50	40669	0·90
ZT203	0·50		
ZTX302	0·20		
1N823A	0·65	**ZENER DIODES**	
1N4785	0·75		
2N918	0·37	10W/1V	0·45
2N987	0·43	10W/2V	0·45
2N1304	0·22	10W/6·2V	0·45
2N1305	0·22	10W/7·5V	0·45
2N1306	0·25	10W/11V	0·45
2N1307	0·25	10W/15V	0·45

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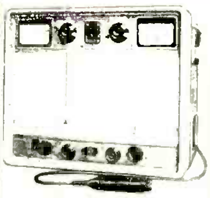

MARCONI TF 867 SIGNAL GENERATOR
Range: 15KHz to 30MHz. Output 0.4µV to 4V at 13 or 75 ohms. Impedance with termination (supplied). Built in crystal check facility with handbook. **£138** including carr.

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TF 526B OSCILLATOR AND DETECTOR UNIT £50·00.

TF 1226B, TF1225A, TF 577A. WHITE NOISE TEST SET £185·00. Full spec. on request.

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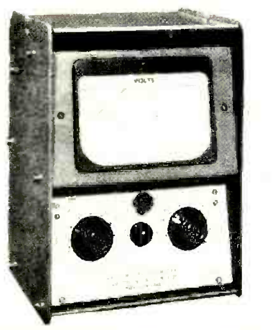

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A precision HF/VHF signal generator embodying facilities seldom found or contained in one instrument, namely outputs of **CW/AM/PM and swept carrier,** in the frequency range **10 to 440 MHz.** Some of the features of the instrument are: **AUTOMATIC FREQUENCY STABILISATION** (locks output signal to selected frequency), **AUTOMATIC LEVEL CONTROL** (holds output constant ±1db **INTERPOLATION OSCILLATION** (for precise tuning between crystal check points) **MARKERS** (for S.F.M.)
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TF 801D/1/S SIGNAL GENERATOR. Range 10-485 MHz in five ranges. R.F. output 0·1 µV-IV source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator. 50Ω output impedance. Internal modulation at 1 kHz at up to 90% depth, also external sine and pulse modulation. Built-in 5MHz crystal calibrator. Separate R.F. and mod. meters. P.O.A.

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571A—60MHz, separate P.S.U. **£150** complete.
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PLUG-IN UNITS
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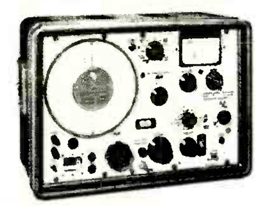

TF144H SIGNAL GEN. Freq. range 10 KHz-72 MHz. R.F. output 2µV to 2V at 50 ohms 400 and 1000 Hz internal mod. Limited qty.

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TRANSMITTERS:
BC 610 Hallicrafters.
RCA ET 4336 also modified version of increased output to 700w.
COLLINS TYPE 231D 4/5kw., 10 channel, autotone and manual tuning. All above complete installation and spare parts.
TRANSCEIVERS
19, 19HP, 38, 62.
C-13 TRANSMITTERS

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ELECTROVALUE

CATALOGUE 7

An A to Z guide to component buying

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Very wide range of types is shown together with grouped and tabulated specifications for each one. Outlines are illustrated, and there is a full range of supporting hardware. Also near-equivalent tables are given.

I.C.s
Here too a wide range of TTL types are shown, together with linear and special-purpose types such as touch switches, etc. Over 60 circuit and connection diagrams as well as much other useful information is included.

MINITRON DIGITAL INDICATORS
3015F Seven segment filament, compatible with standard logic modules. 0–9 and decimal point; 9mm characters in 16 lead DIL. **£1·20**
Suitable BCD decoder driver **£1·15**
3015G showing + or – & 1 & dec. pt. **£1·20**

POLYESTER CAPACITORS C.280
Radial leads for P.C.B. mounting. Working voltage 250V d.c.
0·01, 0·015, 0·022, 0·033, 0·047 ea. **3p**
0·068, 0·1, 0·15 ea. **4p**
0·22, **5p**; 0·33, **7p**; 0·47, **8p**; 0·68, **11p**; 1·0, **14p**; 1·5, **21p**; 2·2, **24p**

SILVERED MICA CAPACITORS
Working voltage 500V d.c.
Values in pFs—2·2 to 820 in 32 stages ea. **6p**
1000, 1500 **7p**; 1800 **8p**; 2200 **10p**; 2700, 3600 **12p**; 4700, 5000 **15p**; 6800 **20p**; 8200, 10,000 **25p**

CERAMIC DISC
1000pF/500, 2000/500, 5000/500, 0·01mF/50, 0·02mF/50, 0·1mF/3—each **2p**; 0·05mF/50V—**3p**

CERAMIC PLAIN
In a range of 26 values from 22 to 6800pF/50V d.c., each **2p**

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JP.20 DUAL GANG Log/antilog 10K, 22K, 47K, 1 megohm only ea. **48p**
JP.20 DUAL GANG antilog 10K only **48p**
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Control knobs, blk/wht/red/yel/grn/blue/dk. grey/lt grey ea. **7p**

RESISTORS

Code	Watts	Ohms	1 to 9	10 to 99	100 up (see note below)
C	1/20	82–220K	9	8	7·5
C	1/3	4·7–470K	1·3	1·1	0·9 nett
C	1/2	4·7–10M	1·3	1·1	0·9 nett
C	3/4	4·7–10M	1·5	1·2	0·9 nett
C	1	4·7–10M	3·2	2·5	1·9 Nett
MO	1/2	10–1M	4	3·3	2·3 nett
WW	1	0·22–3·9	9	9	8
WW	3	1–10K	7	7	6
WW	7	1–10K	9	9	8 nett

Codes:
C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.
Values: All E12 except C $\frac{1}{3}$W, C $\frac{3}{4}$W, and MO $\frac{1}{2}$W.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.
Tolerances:
5% except WW 10% ±0·05Ω and MO $\frac{1}{2}$W 2%.
Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.) Prices for 100 up in units of 100 only.

ZENER DIODES
Full range E24 values: 400mW: 2·7V to 36V, **14p** each; 1W: 6·8V to 82V, **21p** each; 1·5W: 4·7V to 75V, **48p** each. Clip to increase 1·5W rating to 3 watts (type 266F), **5p.**

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Copper clad 0·1 matrix—2·5 x 3·75 ins. **24p**; 3·75 x 3·75 ins.—**27p**; 2·5 x 5 ins.—**27p**; 3·75 x 5 ins.—**30p.**
Copper clad 0·15 in. matrix 2·5 x 3·75 ins.—**16p**; 3·75 x 3·75 ins.—**27p**; 2·5 x 5 ins.—**27p**; 3·75 x 5 ins.—**33p.**
Vero spot face cutter (any matrix) **43p.**
0·040 pins (for 0·1 matrix) per 100—**30p.**
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ELECTROLYTIC CAPACITORS

Axial Lead

µF	3V	6·3V	10V	16V	25V	40V	63V	100V
0·47	—	—	—	—	—	—	11p	8p
1·0	—	—	—	—	—	11p	—	8p
2·2	—	—	—	—	11p	—	8p	9p
4·7	—	—	—	11p	—	8p	9p	8p
10	—	—	—	—	8p	9p	8p	8p
22	—	—	8p	—	9p	8p	8p	10p
47	8p		9p	8p	9p	8p	10p	13p
100	9p	8p	8p	8p	9p	10p	12p	19p
220	8p	8p	9p	10p	10p	11p	17p	28p
470	9p	10p	10p	11p	13p	17p	24p	45p
1,000	11p	13p	13p	17p	20p	25p	41p	—
2,200	15p	18p	23p	26p	37p	41p	—	—
4,700	26p	30p	39p	44p	58p	—	—	—
10,000	42p	46p	—	—	—	—	—	—

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*Items with asterisk are Moving Iron type, all others are Moving Coil

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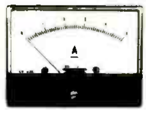

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100-0-100uA	£3.30
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5mA	£3.20
10mA	£3.20
50mA	£3.20
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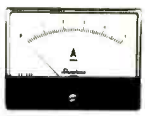

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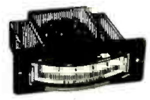


50uA	£4.15
100uA	£3.95
200uA	£3.75
500uA	£3.50
50-0-50uA	£3.95
100-0-100uA	£3.85
1mA	£3.50
300V AC	£3.50
VU Meter	£4.25

MODEL ED107 EDUCATIONAL METER
Size: 100 x 90 x 150mm including terminals

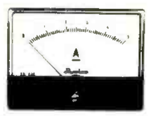
A range of high quality moving coil instruments ideal for school experiments and other bench applications. 3" mirror scale. The meter movement is easily accessible to demonstrate internal working.

50uA	£7.60
100uA	£7.05
50-0-50uA	£7.05
1A DC*	£6.55
5A DC	£6.55
5V DC	£6.55
10V DC	£6.55
15V DC	£6.55
20V DC	£6.55
50V DC	£6.55
300V DC	£6.55
500mA/5A DC	£7.70
5V/50V DC	£7.70
5V/15V DC	£7.70
1A/15A DC	£7.70

CLEAR PLASTIC MODEL 85P
Size: 120 x 110mm

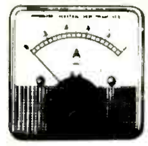
50uA	£4.85
100uA	£4.70
200uA	£4.45
500uA	£4.30
50-0-50uA	£4.70
100-0-100uA	£4.45
500-0-500uA	£4.30
1mA	£4.30
1-0-1mA	£4.30
5mA	£4.30
10mA	£4.30
50mA	£4.30
100mA	£4.30
500mA	£4.30
1A DC	£4.30
5A DC	£4.30
15A DC	£4.30
30A DC	£4.35
10V DC	£4.30
20V DC	£4.30
50V DC	£4.30
150V DC	£4.30
300V DC	£4.30
15V AC	£4.35
300V AC	£4.35
S Meter 1mA	£4.30
VU Meter	£5.00
1A AC	* £4.30
5A AC	* £4.30
10A AC	* £4.30
20A AC	* £4.30
30A AC	* £4.30

CLEAR PLASTIC MODEL SD830
Size: 110 x 83mm



50uA	£3.75
100uA	£3.70
200uA	£3.65
500uA	£3.45
50-0-50uA	£3.75
100-0-100uA	£3.70
1mA	£3.40
5mA	£3.40
10mA	£3.40
50mA	£3.40
100mA	£3.40
500mA	£3.40
1A DC	£3.40
5A DC	£3.40
10A DC	£3.40
5V DC	£3.40
10V DC	£3.40
20V DC	£3.40
50V DC	£3.40
300V DC	£3.40
15V AC	£3.65
300V AC	£3.65
VU Meter	£3.85

CLEAR PLASTIC MODEL 45P
Size: 50 x 50mm

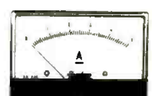


50uA	£3.00
100uA	£2.85
200uA	£2.75
500uA	£2.70
50-0-50uA	£2.90
100-0-100uA	£2.75
500-0-500uA	£2.65
1mA	£2.65
5mA	£2.65
10mA	£2.65
50mA	£2.65
100mA	£2.65
500mA	£2.65
1A DC	£2.65
5A DC	£2.65
10V DC	£2.65
20V DC	£2.65
50V DC	£2.65
300V DC	£2.65
15V AC	£2.70
300V AC	£2.70
S Meter 1mA	£2.75
VU Meter	£3.00
1A AC	* £2.65
5A AC	* £2.65
10A AC	* £2.65
20A AC	* £2.65
30A AC	* £2.65

CLEAR PLASTIC MODEL 38P
Size: 42 x 42mm

50uA	£2.80
100uA	£2.70
200uA	£2.65
500uA	£2.50
50-0-50uA	£2.75
100-0-100uA	£2.65
500-0-500uA	£2.50
1mA	£2.50
1-0-1mA	£2.50
2mA	£2.50
5mA	£2.50
10mA	£2.50
20mA	£2.50
50mA	£2.50
100mA	£2.50
150mA	£2.50
200mA	£2.50
300mA	£2.50
500mA	£2.50
750mA	£2.50
1A DC	£2.50
2A DC	£2.50
5A DC	£2.50
10A DC	£2.50
15A DC	£2.50
20A DC	£2.50
3V DC	£2.50
10V DC	£2.50
15V DC	£2.50
20V DC	£2.50
50V DC	£2.50
100V DC	£2.50
150V DC	£2.50
300V DC	£2.50
500V DC	£2.50
750V DC	£2.50
15V AC	£2.55
50V AC	£2.55
150V AC	£2.65
300V AC	£2.55
500V AC	£2.55
S Meter 1mA	£2.55
VU Meter	£2.90

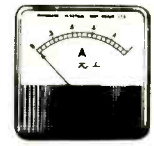
CLEAR PLASTIC MODEL SD460
Size: 59 x 46mm



50uA	£3.10
100uA	£3.05
200uA	£3.00
500uA	£2.80
50-0-50uA	£3.10
100-0-100uA	£3.05
1mA	£2.85
5mA	£2.85
10mA	£2.85
50mA	£2.85
100mA	£2.85
500mA	£2.85
1A DC	£2.85
5A DC	£2.85
10A DC	£2.85
5V DC	£2.85
10V DC	£2.85
50V DC	£2.85
300V DC	£2.85
15V AC	£3.00
300V AC	£3.00
VU Meter	£3.20

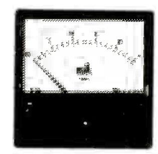
POSTAGE & PACKING 15p

CLEAR PLASTIC MODEL 65P
Size: 86 x 78mm



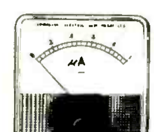
50uA	£4.10
100uA	£3.45
200uA	£3.35
500uA	£3.05
50-0-50uA	£3.45
100-0-100uA	£3.40
500-0-500uA	£2.85
1mA	£2.85
5mA	£2.85
10mA	£2.85
50mA	£2.85
100mA	£2.85
500mA	£2.85
1A DC	£2.85
5A DC	£2.85
10A DC	£2.85
15A DC	£2.85
20A DC	£2.85
30A DC	£3.10
50A DC	£3.20
5V DC	£2.85
10V DC	£2.85
20V DC	£2.85
50V DC	£2.85
150V DC	£2.85
300V DC	£2.85
15V AC	£3.10
50V AC	£3.10
150V AC	£3.10
300V AC	£3.10
500V AC	£3.10
S Meter 1mA	£3.15
VU Meter	£4.10
1A AC	* £2.85
5A AC	* £2.85
10A AC	* £2.85
20A AC	* £2.85
30A AC	* £2.85
50mA AC	* £2.85
100mA AC	* £2.85
200mA AC	* £2.85
500mA AC	* £2.85

BAKELITE MODEL S80 Enlarged Window
Size: 80 x 80mm



50uA	£3.85
100uA	£3.75
500uA	£3.35
50-0-50uA	£3.75
100-0-100uA	£3.65
1mA	£3.00
1A DC	£3.30
5A DC	£3.30
20V DC	£3.30
50V DC	£3.30
300V DC	£3.30
300V AC	£3.30
VU Meter	£4.05

CLEAR PLASTIC MODEL 52P
Size: 60 x 60mm



50uA	£3.85
100uA	£3.30
500uA	£2.90
50-0-50uA	£3.35
100-0-100uA	£3.25
1mA	£2.75
5mA	£2.75
10mA	£2.75
50mA	£2.75
100mA	£2.75
500mA	£2.75
1A DC	£2.75
5A DC	£2.75
10V DC	£2.75
20V DC	£2.75
50V DC	£2.75
300V DC	£2.75
15V AC	£2.85
300V AC	£2.85
S Meter 1mA	£2.85
VU Meter	£3.95
1A AC	* £2.75
5A AC	* £2.75
10A AC	* £2.75
20A AC	* £2.75
30A AC	* £2.75

BAKELITE MODEL 65 Size: 80 x 80mm

25uA	£5.05
50uA	£3.90
100uA	£3.30
500uA	£3.00
50-0-50uA	£3.35
100-0-100uA	£3.30
500-0-500uA	£2.85
1mA	£2.85
1-0-1mA	£2.85
5mA	£2.85
10mA	£2.65
50mA	£2.85
100mA	£2.85
500mA	£2.85
1A DC	£2.85
2A DC	£2.85
5A DC	£2.85
15A DC	£2.85
30A DC	£2.85
50A DC	£2.85
5V DC	£2.85
10V DC	£2.85
20V DC	£2.85
50V DC	£2.85
150V DC	£2.85
300V DC	£2.85
30V AC	* £2.85
50V AC	* £2.85
150V AC	* £2.85
300V AC	* £2.85
500V AC	£2.85
VU Meter	£4.00
1A AC	* £2.85
5A AC	* £2.85
10A AC	* £2.85
20A AC	* £2.85
30A AC	* £2.85
50A AC	* £2.85
500mA AC	£2.85
50mV DC	£3.20
100mV DC	£3.20

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing. ¼" diameter shafts. Bulk quantities available.

25 WATT 10/25/50/100/250/500/1000 Ohms **£1.15** P&P 10p

50 WATT 10/25/50/100/250/500/1000/2500/5000 Ohms. **£1.62** P&P 10p

100 WATT 1/5/10/25/50/100/250/500/1000/2500 Ohms **£2.34** P&P 15p

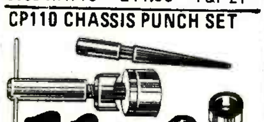
ALL PRICES EXCLUDE VAT

Also see previous page

AUTO TRANSFORMERS
0/115/250V. Step up or step down. Fully shrouded.

80 WATTS	£2.75	P&P 18p
150 WATTS	£3.50	P&P 18p
300 WATTS	£4.50	P&P 23p
500 WATTS	£6.95	P&P 33p
1000 WATTS	£9.50	P&P 38p
1500 WATTS	£12.50	P&P 43p
2250 WATTS	£20.95	P&P 50p
5000 WATTS	£44.95	P&P £1

CP110 CHASSIS PUNCH SET



Carefully machined top grade steel. Contains 1/2", 5/8", 3/4", 1" and 1 1/8" punches complete with gripper and accessories.

OUR PRICE £3.00 P&P 40p

YAMABISHI VARIABLE VOLTAGE TRANSFORMERS
Excellent quality at low cost. Input: 230V 50/60Hz. Output 0–260V.

MODEL S260 BENCH MOUNTING

		P&P
1A	£10.50	30p
2.5A	£12.00	35p
5A	£17.50	37p
8A	£30.35	50p
10A	£33.75	75p
12A	£29.50	75p
20A	£85.00	125p
25A	£95.00	130p
40A	£120.00	150p

MODEL S260B PANEL MOUNTING

1A	£10.00	30p
2.5A	£12.00	35p

BVD5 Vernier TUNING DIAL

App. 7:1 ratio planetary drive vernier dial. Log scale 0–180 degrees. Blank scales 1–5. Dial size 128 x 76mm. Overall size 190 x 117 x 41mm. deep including knob and coupling. ¼" diam. shaft

OUR PRICE £1.62 P&P 15p

2 TRANSISTOR RADIO KIT

No Soldering required. All connections made with spring clips. Kit includes all parts and wire including ear-piece. Will receive all normal broadcasts on Medium Wave 535–1605kHz. Operates from standard 9V battery or Solar Cell included.

OUR PRICE £1.30 P&P 30p

SWR METER Model SWR3

Handy SWR meter for transmitter antenna alignment, with built-in field strength meter. Accuracy 5%, Impedence 52' Indicator 100uA DC. Full scale 5 section collapsible antenna. Size 145 x 50 x 60mm.

OUR PRICE £4.25 P&P 25p

SUPER VALUE TOP QUALITY TRIO equipment

TRIO JR599 RECEIVER

Nine wave-bands covering 1.8–29.7 MHz, 144–146MHz and 10MHz WWV SSB, CW, AM and FM. AF output is more than 1 watt. S Meter. Squelch control. BFO. Variable AF and RF controls. 4–16 ohm output and jack for phones. Power requirement 100/240V AC, 12/14V DC. Size: 270 x 140 x 310mm.

Our Price £132.50 CARR. PAID

TRIO 9R59DS RECEIVER

Four bands covering 550kHz to 30 MHz continuous and electrical band-spread on 10, 15, 20, 40, and 80 mtrs. 8 valve plus 7 diode circuit. 4 to 8 ohm output and phone jack. SSB–CW, ANL, variable BFO. S Meter and separate band spread dial. IF frequency 445kHz, audio output 1½ watt. Variable RF and AF gain controls. 115/250V AC, with instructions.

Our Price £42.50 CARR. PAID

TRIO TR2200 TRANSCEIVER

Fully transistorised portable VHF transceiver Will transmit and receive on six channels between 144–146MHz. 1 watt transmitter. 12V DC internal or external supply. Built-in charger for Ni-Cad cells. Power/volume switch, squelch control, channel selector, mic. socket, earphone/external speaker socket. Complete with microphone and 144.48, 144.72 & 145.32 crystals. Size: 134 x 58 x 180mm.

OUR PRICE £79.50 Carr.paid

BELTEK W5400 CAR TRANSCEIVER

Solid state mobile transceiver for 12 volt DC neg. Transmits and receives on any 12 of 28 channels between 144 and 146MHz. Power output 10W and 1W switchable. Controls: On/off/volume, squelch and channel selector. Internal 3" speaker. Complete with dynamic mic. PTT switch, three sets of crystals for 144.48, 144.6 and 145MHz, mounting bracket and instructions. Size: 150 x 70 x 220mm.

OUR PRICE £75.00 P&P 50p

WALKIE TALKIES

SKYFON 100mW

OUR PRICE £24.95 per pair

P302 Two Channel 300mW

OUR PRICE £52.50 per pair

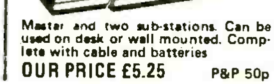
P1003 Three Channel 1 Watt

OUR PRICE £71.25 per pair

P&P 50p per pair

NB. Licence required for use in UK

KE630 3 Station INTERCOM



Master and two sub-stations. Can be used on desk or wall mounted. Complete with cable and batteries

OUR PRICE £5.25 P&P 50p

LASKYS

INCORPORATING LASKYS RADIO AND G. W. SMITH & CO. (RADIO).

LH02S STEREO HEADPHONES

Light weight headphones with padded ear pieces. 4/16 ohms 20–20,000Hz. Complete with 6' lead and plug.
OUR PRICE £1.97 P&P 30p

TE1018 Deluxe Mono High Impedence Headset.

Sensitive magnetic headset with soft ear pads. Impedence 2,600 ohms (600 ohms DC). Frequency response: 200–4,000Hz.
OUR PRICE £2.25 P&P 30p

DH02S STEREO HEADPHONES

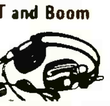
Wonderful value and excellent performance combined. Adjustable head band. Impedence 8 ohms. 20–12,000Hz. Complete with lead and plug.
OUR PRICE £2.25 P&P 30p

TE1035 Stereo HEADPHONES

Low cost with excellent response. Foam rubber earcups. Adjustable headband. 8 ohms impedence. Frequency response 25Hz–18kHz. Complete with cable and stereo jack plug.
OUR PRICE £2.60 P&P 30p

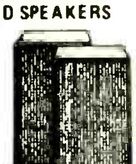
SH80V MONO/STEREO HEADPHONES

Volume control for each channel. 4/16 ohms impedence. Frequency response 20Hz–18kHz. Complete with 10ft. coiled lead and jack plug
OUR PRICE £4.97 P&P 30p

BH001 HEADSET and Boom Microphone

Moving coil. Ideal for language teaching, communications etc. Headphone impedence 16 ohms. Microphone impedence 200 ohms.
OUR PRICE £5.95 P&P 30p

SPECIAL BARGAIN!!
PHONIC 10 Two Way Speakers

Matched pair of compact book-shelf speakers of unique design. Incorporating a 2" high frequency unit & 6" woofer. 8 ohms impedence. Size: 348 x 228 x 110mm.
OUR PRICE £8.85 Pair P&P 50p

SPECIAL BARGAIN !!
STEREOSOUND SPEAKERS

Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size: 368 x 229 x 190mm. 8 ohms. 8 watts RMS, 16 watts peak. Complete with Din lead.
OUR PRICE £12.95 P&P 50p

AUDIOTRONIC CRITERION SPEAKERS

High quality three way speaker system offering a performance better than more expensive units. Teak finished with dark fronts. Frequency response: 40Hz–20kHz. 8 ohms impedence. Maximum power 20 watts. Size: 476 x 232 x 232mm.
OUR PRICE £27.50 Pr. P&P £1

HIGH QUALITY CONSTRUCTION KITS

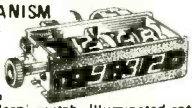
JOSTY KIT

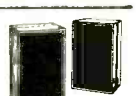
WE ARE APPOINTED STOCKISTS AT ALL BRANCHES

All kits are complete with comprehensive easy to follow instructions and covered by full guarantee.
Post and Packing 15p per kit.

AE1 100mW output stage	£1.65
AE2 Pre-amplifier	£1.26
AE3 Diode receiver	£2.00
AE4 Flasher	£1.09
AE5 Astable multi-vibrator	£1.05
AE6 Monostable multi-vibrator	£1.02
AE7 RC generator	£1.06
AE8 Bass filter	99p
AE9 Treble filter	99p
AE10 CCIR filter	99p
AF20 Mono amplifier	£4.80
AF25 Mixer	£3.60
AF30 Mono pre-amplifier	£2.61
AF35 Emitter amplifier	£2.27
AF80 0.5W mic. amplifier	£4.22
AF305 Intercom	£9.52
AF310 Mono amplifier	£5.91
AT5 Automatic light control	£2.58
AT25 Window wiper robot	£5.82
AT30 Photo cell switch unit	£5.70
AT50 400W triac light dimmer/speed control	£4.80
AT56 2,200W triac light dimmer/speed control	£6.90
AT60 1 channel light control	£7.80
AT65 3 channel light control	£14.55
GP304 Circuit board	£4.94
GP310 Stereo pre-amplifier for use with 2 x AF310	£21.27
GP312 Circuit board	£11.45
GU330 Tremolo unit	£7.50
HF61 Diode detector	£3.32
HF65 FM transmitter	£2.70
HF75 FM receiver	£2.87
HF310 FM tuner	£15.81
HF325 Deluxe FM tuner	£24.12
HF330 Decoder (HF310/325)	£9.96
HF380 lw/vhf aerial amplifier	£4.94
HF395 broadband aerial amp.	£1.77
LF380 Quadraphonic device	£11.36
M160 Multi-vibrator	£1.71
M191 VU Meter	£4.55
M192 Stereo balance meter	£4.97
M1302 Transistor tester	£8.45
NT10 Stabilised power supply 100mA, 9V	£6.15
NT300 Stabilised p. supply	£12.51
NT305 Voltage converter	£4.50
NT315 Power supply 240V AC to4,5/15V DC, 500mA	£9.57

Amateur Electronics by Josty-Kit, the professional book for the amateur—covers the subject from basic principals to advanced electronic techniques. Complete with circuit board for AE1 to AE10 above.
OUR PRICE £3.30 (No VAT)
P&P 25p plus VAT.

DT55G DIGITAL CLOCK MECHANISM

Features 24 hour alarm setting, on/off and auto alarm 'sleep' switch. Illuminated rotary dial with hours, minutes and seconds. Automatically turns off radio, TV, light etc. and with auto-switching will turn on again when required. 240V AC operation. Switch rating 250V–3 Amp.
OUR PRICE £5.95 P&P 30p

SPECIAL BARGAIN! FERGUSON 3406 HI-FI SPEAKERS

High quality 2 way speaker systems. 25 Watts. 4–8 ohms. 40Hz–18kHz. Size: 560 x 340 x 255mm. approx. Wood grain finish with black fronts.
OUR PRICE £26.95 PR. P&P £1

RUH6 Reflex Horn Speaker

Built-in driver unit. Impedence 16 ohms. Power rating 10W. Response 380–7000Hz. Size app. 6" x 6". Weather and shock protected.
OUR PRICE £4.97 P&P 30p

RECORD DECKS P&P 50p

BSR McDONALD	
C114 Mini	£3.95
C129 Mono	£5.50
C137	£7.00
510/TPD	£12.55
610	£11.35
610/TPD	£16.65
710	£22.70
810	£28.30
MP60	£8.90
MP60/ADC K8	£11.50
MP60/TPD	£14.20
HT70	£12.50
HT70/ADC K7E	£15.95
HT70/TPD	£17.80
CONNOISSEUR	
BD1 Kit	£10.20
BD1 Chassis	£12.50
BD2/SAU2/Chassis	£25.50
BD2/SAU2/Plinth/Cover	£32.25
GARRARD	
1025T Stereo	£4.95
2025TC Less cartridge	£6.35
2025TC/KS40A	£6.95
SP25 Mk3	£9.25
SP25 Mk3/G800	£10.95
SP25 Mk4	£10.90
SP25 Mk4/M75–6	£13.90
86SB	£20.00
SL65B	£11.15
SL72B	£17.75
SL95B	£28.00
GOLDRING	
G101 Mk2/P/C	£22.50
GL72	£25.45
GL72P	£33.75
GL75	£32.20
GL75P	£41.65
GL78	£34.60
GL78/P/C	£56.25
GL85/P/C	£72.00

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210/SC7M	£7.95
C129	£9.50
MP60/G800	£19.50
MP60/TPD/ADC K8	£16.80
MP60/M44–7	£17.50
HT70/TPD/ADC K7E	£21.25
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2025TC/9TA-HC/D	£11.35
SP25 Mk3/G800	£18.15
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SP25 Mk3/M44–7	£17.80
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SP25 Mk4/G800	£19.95
SP25 Mk4/AMC50E (M55E)	£21.30
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GL75/G800	£40.90
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CR90	£5.32	£10.46	£25.22

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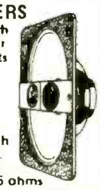
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All silicon, transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery. INPUTS: 5mV and 100mV. OUTPUT: 50mV per channel.
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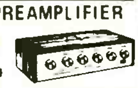
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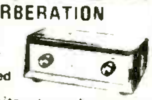
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071 15472	16	4700	3·9 amps	1oz	17p
071 15682	16	6800	5·8 amps	1½oz	22p
071 14113	10	11000 + 11000	10·6 amps	3oz	37p
072 14173	10	16500 + 16500	13·4 amps	4oz	49p
072 15752	16	7500 + 7500	10·5 amps	3oz	37p
072 15113	16	11000 + 11000	13·8 amps	4½oz	49p
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104 90003	20	39000	16oz	30p
102 16802	25	8000	7oz	25p
104 90001	45	20000	16oz	50p

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Ref. No.	Capacity	Voltage	Price
H8/2	2·2µf	25v	4p
H8/2A	3·3µf	25v	4p
H8/3	3µf	50v	4p
H8/3A	4µf	50v	4p
H8/4	4·7µf	25v	4p
H8/4A	5µf	64v	4p
H8/5	5µf	10v	4p
H8/5A	5µf	150v	4p
H8/6A	10µf	10v	4p
H8/7	10µf	70v	4p
H8/8	16µf	35v	4p
H8/8A	16µf	16v	4p
H8/9	20µf	6v	2p
H8/9A	20µf	70v	4p
H8/10	22µf	50v	4p
H8/10A	22µf	100v	4p
H8/11	25µf	12v	4p
H8/12	32µf	15v	4p
H8/12A	30µf	10v	4p
H8/13A	32µf	50v	4p
H8/14	40µf	25v	5p
H8/14A	40µf	16v	4p
H8/15	47µf	50v	4p
H8/15A	40µf	35v	4p
H7/1	50µf	6v	3p
H7/1A	50µf	10v	4p
H7/2A	64µf	2·5v	2p

Ref. No.	Capacity	Voltage	Price
H7/3A	64µf	25v	4p
H7/4	64µf	15v	4p
H7/4A	64µf	35v	5p
H7/5	80µf	16v	4p
H7/7	100µf	25v	4p
H7/8	125µf	16v	5p
H7/8A	100µf	35v	8p
H7/9	100µf	63v	6p
H7/9A	125µf	4v	4p
H7/10	125µf	25v	6p
H7/10A	160µf	2·5v	3p
H7/11	160µf	25v	6p
H7/11A	150µf	16v	5p
H7/13A	200µf	25v	8p
H7/14	220µf	50v	10p
H7/15	220µf	25v	5p
H7/15A	220µf	35v	10p
H6/1A	250µf	4v	3p
H6/3A	320µf	2·5v	3p
H6/4	320µf	10v	4p
H6/4A	330µf	16v	5p
H6/5	330µf	25v	10p
H6/5A	330µf	35v	15p
H6/8	470µf	25v	10p
H6/8A	470µf	35v	20p
H6/9A	400µf	40v	20p
H6/13A	1000µf	25v	16p

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Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

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75mm × 100mm	33p
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150mm × 200mm	£1·32
250mm × 200mm	£2·20

SILICON P.N.P.

Type	*Voltage*	*Frequency*	*Price*
BCY 71	45	200 MHz	12p
BFS 92	100	70 MHz	20p
BFS 95	40	70 MHz	17p
BFX 12	25	210 MHz	10p
2N 2906	60	200 MHz	15p
2N 3702	40	100 MHz	11p
2N 3703	50	100 MHz	12p

SILICON N.P.N.

BC 108	30	150 MHz	10p
BC 109	30	150 MHz	10p
BF 179	225	125 MHz	40p
BF 180	30	625 MHz	25p
BFW 58	80	80 MHz	15p
BFX 43	30	500 MHz	20p
BFX 86	40	50 MHz	17p
BFY 53	30	50 MHz	10p
2N 697	60	40 MHz	12p
2N 709	15	900 MHz	30p
2N 718	60	60 MHz	12p
2N 753	25	250 MHz	12p
2N 744	20	300 MHz	12p
2N 1613	75	60 MHz	17p
2N 2220	60	250 MHz	15p

SILICON N.P.N.

Type	*Voltage*	*Frequency*	*Price*
2N 3053	60	100 MHz	17p
2N 3707	30		12p
2N 5179	20	900 MHz	40p
GERMANIUM P.N.P.			
ACY 44	50	1 MHz	10p
ADY 26	80	75 watts	£1
AF 124	20	75 MHz	20p
AFY 19	32	350 MHz	20p
ASY 32	25	5 MHz	10p
ASZ 21	15	450 MHz	20p
GET 113	32		10p
GET 120	32	2 watts	10p
OC 123	50	1 MHz	10p
OCP 70	Light-sensitive		20p
2N 1307	30	10 MHz	15p
2N 1309	30	15 MHz	15p
2N 443	60	150 watts	£1
HIGH FREQUENCY, POWER			
BFR 64	40	1,200 MHz	£1
BLY 89A	35	650 MHz	£5
BLY 93A	60	500 MHz	£5
BLY 218	36	1,200 MHz	£2
2N 709	15	800 MHz	15p
2N 3926	36	250 MHz	£1

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CL 8450	ditto	9·35 GHz	£40
CL 8470	ditto	9·35 GHz	£40
BXY 27	Varacter Diode. "S" Band. Cut-off	70 GHz	£1
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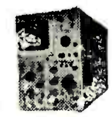

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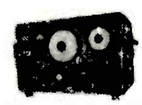

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MARCONI TEST EQUIPMENT. All items have been calibrated, reconditioned and guaranteed.

Wave Analyser **TF455E.** Frequency range 20Hz. **£105.**

TF893 Audio Wattmeter. Range 20Hz-35KHz. Power range 20uW-10W. Impedance 2·5 Ω to 20K Ω in 48 steps. Direct calibration in Watts and dbm. Price **£30.**

MARCONI TF340 AF power meters. As above but limited to 6 Watts. **£25** each.

MARCONI Sensitive Voltmeter type TF2600. As new. 1mV—300 Volt. Full-scale deflection. 12 ranges, with dbm markings. A modern instrument. Only **£50.**

TF2162 MF attenuator. DC-1MHz. O-111db attenuation in ·1db steps. Impedance 600 ohms unbalanced. Price **£50.**

TF2163 U.H.F. Attenuator. DC-1 GHz. 0-142db in 1db steps. Z, 50 ohms. Max. power input 0·5W. As new Price **£75.**

TF801D/1 A.M. Signal Generator up to 470MHz.

TF1041B Voltmeter. 300mV-300V. 20Hz-1500MHz. **£45.**

MARCONI DOUBLE PULSE GENERATOR TF1400/S. With secondary P.G. Type 6600/1. As new condition. **£105.**

OA1094AHF Spectrum Analyser 100KHz-30MHz. As new.

TF1417 Counter, Frequency Meter 7 digits. Plus range extension unit TF1434/2 to 220MHz. As new.

ADVANCE DVM4 Digital voltmeter. AC/DC. Brand new **£65·**

PO type, 316, Jack Plugs. Complete with leads. Good condition. Price **£2** for ten.

DIGITAL MEASUEMENTS DM2003 Digital voltmeter. AC/DC to 1KV. Direct readout. New price over £350 each. Our price, in full working condition is **£75·00.**

ADVANCE type TC1A Timer-counter. Solid-state. 6 digit readout. Manual or auto. (electronic) stop/start. As frequency meter —1Hz—1MHz, or timer with all facilities. Brand new with handbook, leads, etc. Special offer **£65.**

R216 V.H.F. AM/FM Communications receivers. Coverage 19-157MHz. Film scale dial 2 frequency crystal calibrator. Plus all other facilities. Complete with A.C. power supply connecting lead. Supplied in full working order in excellent secondhand condition.

PLEASE ADD 10% V.A.T. TO THE TOTAL AMOUNT WHEN ORDERING. INCORRECT AMOUNTS WILL CAUSE DELAY IN DESPATCH. THANK YOU.

BI-PRE-PAK

SUPPLIERS OF SEMI-CONDUCTORS TO THE WORLD

Telephone Corner

COMPLETE TELEPHONES
NORMAL HOUSEHOLD TYPE AS SUPPLIED TO THE POST OFFICE EX. G.P.O.

Only £1·05
P & P 45p EACH

TELEPHONE DIALS
Standard Post Office type. Guaranteed in working order.
Only 27 1/2 p P & P 16½p EACH

Ex GPO Push-button Intercom Telephones

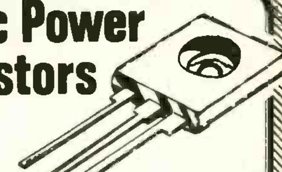
Exactly as internal telephone systems still in everyday use where automatic internal exchanges have not yet taken over. Available in 5, 10 or 15 ways. Complete with circuits and instructions. Necessary 24 pair cable 22p per yard. Price of each instrument is independent of the number of ways.

£2.75 P & P 38½p per instrument

Cable can be sent by Parcel Post. Post and Packing per 50 yds: 73½p

EXTENSION TELEPHONES
71½p each p.p. 27½p. £1.37½ for 2 p.p. 55p. These phones are extensions and do not contain bells.

Plastic Power Transistors



NOW IN TWO RANGES
These are 40W and 90W Silicon Plastic Power Transistors of the very latest design, available in NPN or PNP at the most shatteringly low prices of all time. We have been selling these successfully in quantity to all parts of the world and we are proud to offer them under our Tested and Guaranteed terms.

RANGE 1 VCE. Min. 15 HFE. Min. 15	1-12	13-25	26-50
40 Watt	22p	20p	18p
90 Watt	26½p	24½p	22p
RANGE 2VCE. Min. 40			
RANGE 2VCE. Min. 40 HFE. Min. 40			
40 Watt	33p	31p	29p
90 Watt	38½p	36½p	33p

Complementary pairs matched for gain at 3 amps. 11p extra per pair. Please state NPN or PNP on order.

LM380 AUDIO I.C.
as featured in *Practical Wireless*, December issue, complete with application data **£1.10.**

INTEGRATED CIRCUITS
We stock a large range of I.Cs at very competitive prices (from 11p each). These are all listed in our FREE Catalogue, see coupon below.

METRICATION CHARTS now available
This fantastically detailed conversion calculator carries thousands of classified references between metric and British (and U.S.A.) measurements of length, area, volume, liquid measure, weights etc.
Pocket Size **15p.** Wall Chart **18p.**

LOW COST DUAL IN LINE I.C. SOCKETS
14 pin type at **16½p** each
16 pin type at **18p** each
Now new low profile type.

BOOKS
We have a large selection of Reference and Technical Books in stock.

BUMPER BUNDLES
These parcels contain all types of surplus electronic components, printed panels, switches, potentiometers, transistors and diodes, etc.

2 LBS in weight for £1·10
Post and Packing 27½p.

Tested and Guaranteed Paks

B79	4	1N4007 Sil. Rec. diodes. 1,000 PIV lamp plastic	55p
B81	10	Reed Switches 1" long ⅛" dia. High speed P.O. type	55p
B99	200	Mixed Capacitors. Approx. quantity, counted by weight. P & P 15p.	55p
H4	250	Mixed Resistors. Approx. quantity, counted by weight P & P 15p.	55p
H35	100	Mixed Diodes, Germ. Gold bonded etc. Marked and Unmarked	55p
H38	30	Short lead Transistors. NPN Silicon Planar types	55p
H39	6	Integrated circuits, 4 Gates BMC 962, 2 Flip Flops BMC 945	55p
H41	2	Power Transistors Comp. Pair BD 131/132	55p
H63	4	2N3055 Type NPN Sil. power transistors. Below spec. devices	55p

A Cross Hatch Generator £3·85 post paid

A complete kit of parts including Printed Circuit Board. A four position switch gives X-hatch, Dots, Vertical or Horizontal lines. Integrated Circuit design for easy construction and realibility. A project in the Sept. '72 edition of Television.

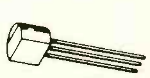
New Paks

Tested, Guaranteed

H64	4	3819 N Channel FET's ZN3819 in plastic case	55p
H65	4	40361 Type NPN Sil. transistors TO-5 can comp. to H66	55p
H66	4	40362 Type PNP Sil. transistors TO-5 can comp. to H65	55p

Untested, Unmarked

H67	10	3819 N Channel FET's plastic case type	55p



Unmarked Untested Paks

B1	50	Germanium Transistors PNP, AF and RF.	55p
B66	150	Germanium Diodes Min. glass type	55p
B84	100	Silicon Diodes DO-7 glass Equiv. to OA200, OA202	55p
B86	100	Sil. Diodes sub. min. IN914 and IN916 types	55p
H16	15	Experimenters Pak of Integrated Circuits, Data supplied	55p
H46	40	NPN Silicon Trans. 2N3707-11 range, low noise amp.	55p
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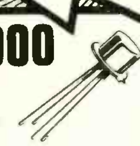
Over 1,000,000 Transistors in stock



We hold a very large range of fully marked, tested and guaranteed Transistors, Diodes and Rectifiers at very competitive prices. Please send for Free Catalogue.

Our very popular 4p Transistors

FULLY TESTED & GUARANTEED
TYPE "A" PNP Silicon alloy, TO-5 can.
TYPE "B" PNP Silicon, plastic encapsulation.
TYPE "E" PNP Germanium AF or RF.
TYPE "F" NPN Silicon plastic encapsulation.
TYPE "G" NPN Silicon, similar ZTX300 range.
TYPE "H" PNP Silicon, similar ZTX500 range.

Various Types
8 RELAYS FOR £1·10 Post & Packing 27½p

Our famous P1 Pak

is still leading in value

Full of Short Lead Semiconductors & Electronic Components, approx. 170. We guarantee at least 30 really high quality factory marked Transistors PNP & NPN and a host of Diodes & Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.
11p P & P on this Pak.

Please ask for Pak P.1. only 55p

Make a rev counter for your car

The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a linear and accurate rev. counter for any car with nomal coil ignition system.

£1·10 each

High-speed magnetic counters

4 digit (non reset) 24v or 48v (state which) 4 X 1 X 1". 33p p.p. 5p.

Please send me the FREE Bi-Pre-Pak Catalogue.

ALL PRICES INCLUDE 10% VAT

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SERVICE TRADING CO

MATSUNAGA VARIABLE VOLTAGE TRANSFORMERS
INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.

BRAND NEW. All types.

0·5 KVA	(Max. 2½ Amp)	£10·00
1 KVA	(Max. 5 Amp)	£14·70
2 KVA	(Max. 10 Amp)	£28·10
3 KVA	(Max. 15 Amp)	£31·25
4 KVA	(Max. 20 Amp)	£72·50
	(Max. 37·5 Amp)	£102·50

Carriage extra

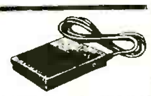
L.T. TRANSFORMERS
All primaries 220-240 volts.

Type No.	Sec. Taps	Price	Post
1	30, 32, 34, 36 v. at 5 amps	£6·90	45p
2	30, 40, 50 v. at 5 amps	£8·85	60p
3	10, 17, 18 v. at 10 amps	£6·25	50p
4	6, 12 v. at 20 amps	£8·15	60p
5	17, 18, 20 v. at 20 amps	£9·15	60p
6	6, 12, 20 v. at 20 amps	£8·65	60p
7	24 v. at 10 amps	£6·65	50p
8	4, 6, 24, 32 v. at 12 amps	£9·00	60p
9	6 and 12 v. at 10 amps	£4·75	40p

VOLTAGE CHANGING TRANSFORMER
M.f. to highest W.D. spec. Auto wound, and tapped 0-130, 160-200-250 at least 2KVA. Can also be used as 230-240V. input, 115V. out for U.S.A. equipment, or reverse to obtain 240V. from 115V. The ideal transformer for making up solid state constant voltage unit, by use of taps the following voltages may be obtained: 30-40-50-70-90 Volts at 10 amps. Weight 40 lbs., length 260 mm., height 190 mm., width 230 mm. In original maker's wooden case, **£8·00**, carr. **£1**.

240 V A.C. SOLENOID OPERATED FLUID VALVE


Rated 1 p.s.i. will handle up to 7 p.s.i. Forged brass body, stainless steel core and spring. ½ in. b.s.p. inlet/outlet. Precision made. British mfg. PRICE: **£1·75**. Post **25p**. Special quotation for quantity. NEW in original packing.

FOOT SWITCH


Suitable for Motors, Drills, etc., etc. 5 amp. 250 Volt. Price **75p**. Post **15p**.

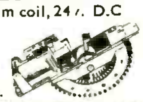
VENNER TIME SWITCH TYPE MSQP


200/250 Volt 2-ON/2-OFF every 24 hours at any manually pre-set time. 20 amp contacts. Fitted die-cast case. Tested and in good condition **£4·75** Post **25p**.

METERS NEW! 2½in. FLUSH ROUND

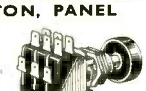

available as D.C. Amps 1, 5, 10, 15, 20 or A.C. Amps 1, 5, 10, 15, 20. Both types **£2·00**. Post **15p**. **VOLTMETER 0-300V.** A.C. **£2·00**. Post **15p**.

50 in 1 ELECTRONIC PROJECT KIT
50 easy to build Projects. No soldering, no special tools required. The Kit includes Speaker, meter, Relay, Transformer, plus a host of other components and a 56-page instruction leaflet. Some examples of the 50 possible Projects are: Sound level Meter, 2 Transistor Radio, Amplifier etc. etc. Price **£7·75** post **25p**.

UNISELECTOR SWITCHES—NEW


4 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C operation **£6·90**. Post **30p**.
6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. **£7.90**. Post **30p**.
8 BANK 25 WAY FULL WIPER 24 v. D.C. operation **£9·50**. Post **40p**.

GENERAL ELECTRIC POWER-GLAS TRIACS
10 amp. Glass passivated plastic Triac. Latest device from U.S.A. Long term reliability. Type SC 146D 10 amp. 400PIV **£1·00**. Post **5p**. Type SC 146E 10 amp. 500PIV. **£1·30**. Post **5p**. (Inclusive of data and application sheet) suitable Diac **18p**.

'HONEYWELL' PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY


Each bank comprises of a change-over rated at 10 amps 240 volt A.C. Black knob 1 in. dia. Fixing hole ⅜ in. Prices: 1-bank **30p**, 2-bank **40p**, 3-bank **50p**. (Illustrated) inc. P. & P. Special quotes for quantities.

24 VOLT DC SOLENOIDS
Unit containing: 1 heavy duty solenoid approx. 25 lb. pull at 1 in. travel. 2 solenoids of approx. 1 lb. pull at ¼ in. travel. 6 solenoids of approx. 4 oz. pull at ¼ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price: **£2·50**. Post **60p**. **ABSOLUTE BARGAIN.**

High Visibility Panel Mounting LED'S
·25 inch mounting, ·16 inch lens. Typical parameters 2 volt 20 M. amp. all types. Supplied complete with snap in mountings and data. Red 4 for **£1·00**, Green 3 for **£1·00**, Yellow 3 for **£1·00**. Post 5p. (Min. order **£1·00**.)

STROBE! STROBE! STROBE!
FOUR EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES, SOLID STATE TIMING + TRIGGERING CIRCUITS, PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.

EXPERIMENTERS "ECONOMY" KIT
Adjustable 1 to 30 Flash per sec. All electronic components including Xenon Tube + instructions **£6·30**. Post **40p**.

INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. Adjustable 1-80 f.p.s., approx. ¼ output of Hy-Lygth. Price **£12·00**. Post **50p**.

HY-LIGHT STROBE
Designed for use in large rooms, halls and utilizes a silica tube, printed circuit. Speed adjustable 1-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. Price **£12·00**. Post **50p**.

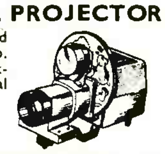
'SUPER' HY-LIGHT KIT
Approx. 4 times the light output of our well proven Hy-Lyght strobe.
Variable speed from 1-13 flash per sec.
Reactor control circuit producing an intense white light. **ONLY £20·00**. Post **75p**.

ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE for the Super Hy-Lyght Kit including reflector. **£7·00**. Post **60p**.

FOR HY-LYGHT STROBE Incl. reflector, **£5·75**. Post **25p**.

7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price **55p**. Post **15p**.

RAINBOW STROBE FOUR LIGHT CONTROL MODULE
Will operate four of our Hy-Lyght or Super Hy-Lyght Strobes in either 1, 2, 3, 4 sequence; 2 + ; or all together. Thoroughly tested and reliable. Complete with full connection instructions. Price: **£18·00**. Post **50p**. Send S.A.E. for details.

COLOUR WHEEL PROJECTOR


Complete with oil filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. **£18·50**. Post **50p**.

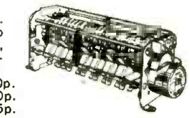
1 R.P.M. MOTOR and COLOUR WHEEL
200/240 volt A.C. 1 r.p.m. synchronous motor, 2 watt, A/clock. Spindle 10 mm. long, 3 mm. dia. Motor only 20 mm. deep. Fixing centres 44 mm. 6 inch colour wheel as used for Disco lighting effects, etc. PRICE motor and wheel **£5·60**. Post **40p**. (Motor not available separately).
6 INCH COLOUR WHEEL ONLY. Price **£4·50**. Post **30p**.

AUTO FADE COLOUR BLEND MODULE
Will control up to 750W. of lighting. Automatic fade-up, fade-down at a manually pre-selected timing, which may be varied between 1 second to 1 minute. Based on 10 amp. triac for maximum reliability. Ready built with switch and Time Control, on 4½" × 5" glass P.C. board. Three modules or more can be sequenced to obtain fantastic colour blending effects. Price **£12·50**. Post 30p. Per module. (Send S.A.E. for further details.)

BIG BLACK LIGHT


400 Watt. Mercury vapour ultra violet lamp. Extremely compact and powerful source of u.v. Innumerable industrial applications also ideal for stage, display, discos etc. P.F. ballast is essential with these bulbs. Price of matched ballast and bulb **£16·00**. Post **£1**. Spare bulb **£7·00**. Post **40p**.

BLACK LIGHT FLUORESCENT U.V. TUBES
4ft. 40 watt. Price **£5·50**. Post **30p**. **2ft. 20 watt £4·25**. Post 25p. (For use in stan bi-pin fittings.) **MINI 12in. 8 watt £1·60**. Post 15p. **9in. 6 watt £1·30**. Post 15p. Complete ballast unit and holders for either 9" or 12" tube. **£1·70**. Post 25p. (9in. x 12in. measures approx.).

PROGRAMME TIMERS


230/240 Volt A.C. 15 RPM Motors. Each cam operates a c/o micro switch. Ideal for lighting effects, animated displays etc. Ex equipment tested.

4 cam model	£2·50	post 30p.
6 cam model	£3·25	post 30p.
12 cam model	£4·00	post 35p.

VAT All prices are subject to 10% VAT. (10p in the £)

To all orders add 10% VAT to total value of goods including carriage/packaging.

RELAYS
SIEMENS PLESSEY, etc.
MINIATURE RELAYS

1	2	3	4	1	2	3	4
52	4-6	6M	60p*	700	15-35	2c/oHD	70p*
58	5-9	6 c/o	80p	700	6-12	1c/oHD	50p*
150	4-9	2 c/o	70p*	700	20-30	6 c/o	80p
185	8-12	6 M	60p*	2500	36-45	6 M	60p*
308	9-14	4 c/o	75p*	2400	30-48	4 c/o	60p
410	10-18	4 c/o	70p*	5800	24-26	2 c/o	60p
700	16-24	4M2B	60p*	9000	40-70	2 c/o	60p*
700	16-24	4 c/o	80p*	15k	85-110	6 M	60p

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*including Base)

6 VOLT D.C. 1 make con. **35p**. Post 5p.

9 VOLT D.C. RELAY
3 c/o 5 amp contacts. 70 ohm coil **75p**. Post 5p.

12 VOLT D.C. RELAY
3 c/o 5 amp contacts 20 ohm coil **75p**. Post 5p.

24 VOLT D.C. 3 c/o 600 ohm coil **75p**. Post 5p.

100 VOLT A.C.
2 c/o sealed type, octal base **£1·00**. Post 10p.

24 VOLT A.C.
Mfg. by ITT. 2 h.d. c/o contacts. **55p**. Post 5p.

240 VOLT A.C. RELAY
240V. A.C. heavy duty c/o contacts. Octal plug in base. (Similar to illustration below.) Price **75p**. Post **5p**.

HEAVY DUTY SEALED RELAYS

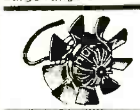

230/240 Volt 2 c/o 20 amp contacts.
110 Volt 2 c/o 20 amp contacts.
Either type **£1·25**. Post **10p**.

CLARE-ELLIOT Type RP 7641 G8
Miniature relay. 675 ohm coil. 24 volt D.C. 2 c/o. **70p**. Post Paid.

DRY REED RELAYS


M.f.g. by ERG 12 volt D.C. encapsulated.
Single c/o **65p**. Post Paid.
Two c/o **85p**. Post Paid.

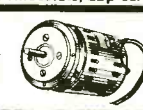
STC 280 ohm coil 6/12 V D.C. 3 make contacts metal shrouded **60p**. Post Paid.
Large range of other types available.

BLOWER UNIT


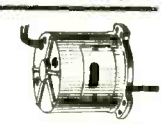
200-240 Volt A.C. **BLOWER UNIT**
Precision German built. Dynamically balanced, quiet, continuously rated, reversible motor. Consumption 60mA. Size 120mm. dia. x 60mm. deep. Price **£3·00**. Post **30p**.

POWER RHEOSTATS

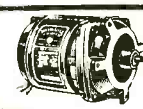

New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10/25/50/100/250/300/500/1k ohm **£1·15** Post 10p.
50 WATT 1/5/10/25/50/100/250/500/1k/1·5k/ ohm **£1·60**. Post 10p.
100 WATT 1/5/10/25/50/100/250/500/1k/1·5k/2·5k/3·5k/5k ohm **£2·35**. Post 15p.
Black Silver Skirted knob calibrated in Nos. 1-9. 1¼ in. dia brass bush. Ideal for above Rheostats, 22p ea.

AEI A.C. MOTOR


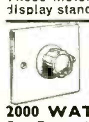
Smooth running, powerful, continuously rated, reversible motor. 230/250V. A.C., 50 cycle 1/50th H.P., 0·25 amp. 900 r.p.m. **£3·50**. Post **30p**.

230V/240V COMPACT SYNCHRONOUS GEARED MOTORS


Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox. 2 RPH, 3 RPH, 6 RPH, 12 RPH. Price **90p**. Post **10p**.

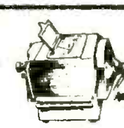
BODINE TYPE N.C.I. GEARED MOTOR


(Type J) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle ·38 amp. **(Type 2) 28 r.p.m.** torque 20 lb. in **Reversible** 1/80th h.p. 50 cycle ·28 amp.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for 230/240v **A.C. input**.
Price, either type **£4·84** Post **50p**. or less transformer **£2·75**. Post 40p.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines, etc, etc.

600 WATT DIMMER SWITCH


Easily fitted. Fully guaranteed by makers. Will control up to 600 watts of all lights except fluorescent at mains voltage. Complete with simple instructions. **£2·75**. Post **25p**.

2000 WATT POWER CONTROL
For Power tools, Heating, Lighting etc. Incorporating 13amp. outlet and mains lead. **£8·00** Post **27p**.

INSULATION TESTERS (NEW)


Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8 in., W. 4 in., H. 6 in., weight 6 lb.
500 VOLTS, 500 megohms **£28·00**. Post 60p.
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GENERATORS

MARCONI TF867 STANDARD SIGNAL GENERATOR

Carrier Frequency. Range: 15Kc/s-30Mc/s in 11 bands. Calibration Accuracy: ± 1%. Stability: After warm up the drift in a 10-minute period is, typically, less than 0·005% for carrier frequencies up to 3·2Mc/s and less than 0·01% from 3·2-2·30Mc/s. Output Voltage: 0·4µV-4V. Impedance: 75 ohms nominal for outputs from 2-4 v. 75 ohms for outputs from 4µV-2V. 13 ohms for outputs from 0·4µV-0·4V.
Accuracy: below 3Mc/s ±0·25dB ot ±0·1µV. 3-10Mc/s ±0·5dB or 00·2µV. 10-30Mc/s ±1·0dB or ±0·5µV.
Power Supply: 100-125V, 200-250V 40-100c/s. Dimensions: 18 in. high × 21 in. wide × 14½ in. deep. **Price £145**

DOUBLE PULSE GENERATOR TYPE TF 1400/S
10 c/s-100 Kc/s. Complete with TM 6600. Pulse adjustable between 1·5 µsec. before and up to 3,000 µsec. **PRICE £145·00**

MARCONI A.M. SIGNAL GENERATOR TYPE TF801D
10-485Mc/s in five ranges. Output 0·1µV-1 Volt E.M.F. External Sine A.D. Frequency 30c/s-50Kc/s. **P.O.A.**

PHILIPS SQUARE WAVE GENERATOR MODEL GM2314 Range 15 c/s-200 Kc/s. Duration of square wave pulses between 0·75 µsec and 40 m/sec. Square wave voltage 10V **PRICE £75·00**

AMPLITUDE MODULATOR TF1102
100Kc/s-300Mc/s Sine-wave from 20 c/s-15 Kc/s and 20 x/s-500Mc/s **£35·00**

MARCONI Type TF987/1 NOISE GENERATOR
1-200 Mc/s ± 0·5DB **£20·00**

MARCONI TF2092 NOISE GENERATOR £295·00

MARCONI VHF SIGNAL GENERATOR TF 1145
450-1900 Mc/s **£295·00**

PHILIPS VIDEO GENERATOR GM2887 £95·00

HEWLETT PACKARD SIGNAL GENERATOR 608B
10-400 mc in five bands. Output voltage 0·1 mV-0·8 Volt 50 ohm. **£165.**

MARCONI H.F. CIRCUIT MAGNIFICATION METER TF886A
A direct reading Q Meter 15-170 Mc/s Magnification 60-7200 Q **£45·00**

MARCONI DISTORTION FACTOR METER TF142F
100 c/s-8 Kc/s 0·05%-50% Measures all spurious components up to 30Kc/s **£35·00**

MARCONI PULSE GENERATOR TF675E
Repetition Frequency 50c/s-50Kc/s 0·15-40µSec **£35·00**

MARCONI WIDE RANGE R.C. OSCILLATOR TF1370
Sine-waves 10c/s-Mc/s, square waves 10c/s-100Kc/s Directo outputs up to 31·6V. Attenuator with three impedances. **£120·00**

HETERODYNE UNIT TF1221
2Kc/s-100Mc/s **£45·00**

WAYNE-KERR NOISE GENERATOR
A portable instrument for measuring the noise factor of radio receiving equipment, metric radar receivers, and radar wide-band i.f. amplifiers in the band 15KHz-160MHz. **£115**

MARCONI Type TF144H STANDARD SIGNAL GENERATOR

Frequency range: 10kHz-72MHz. Crystal Check: 400kHz and 2MHz crystals. Stability: 0.002% in 10 minute interval. FULL SPECIFICATION AVAILABLE ON REQUEST **£225**

MARCONI TYPE TF801A SIGNAL GENERATOR
Frequency range: 10MHz to 310MHz. O/P voltage: 0-100 db relative to 200 mV into 75ohm IV CW O/P available. Internal modulation: 400Hz, 1kHz and 5kHz to 80% sine or square. **£45·00**

ADVANCE TYPE D1/D SIGNAL GENERATOR
Frequency range: 10MHz-300MHz. O/P voltage: 1V-10mV. **£25·00**

ROHDE & SCHWARZ SIGNAL GENERATOR
BN4105 30-300 Mc ± 1% Output 3 Volt. **£350·00.**

HEWLETT PACKARD 8690 SWEEP GENERATOR
plus 8693B Plug-in. 3·7-8·3 GHz. **£1,695·00.**

MARCONI TF995A/2M
AM/FM Generator. **£325·00.**

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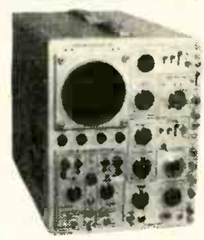
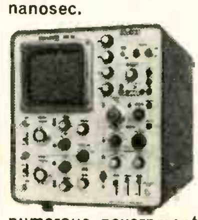
TEKTRONIX



524AD		£125
535A	DC-30 Meg Main Frame	£205
545	,, With CA time base	£225
545A	,,	£295

HEWLETT PACKARD 185B
Sampling Oscilloscope DC-1000 Meg complete with 187C Dual Trace AMP has 350 microsec. Rise time (1000 MC). **£395**

COSSOR CDU 110
Dual Channel Transistorised DC-25 MHz at 5mV/cm. 0·2 microsec. −0·5 ± 3% 5X Magnification extends sweep speed to 40 nanosec./cm. Sweep delay 180 nanosec. **£249·50**



COSSOR CDU 120
Dual Channel fully transistorised 50 mV/cm to 10V DC-60 MHz. Rise time 6 nanosec. 1 mV/cm at 25 MHz. 0·1 microsec. **£349·50**

COSSOR CDU 150
Rugged Transistorised fully portable Dual Channel DC-35 MHz at 5mV/cm. As used by numerous government departments (c/f CT531) **£375**

COSSOR. The very latest Cossor 4000 Dual beam. 55 MHz at 50mV/cm Trigger. SCOOP—ONE ONLY **£395**

TEKTRONIX 526 COLOUR TV VECTORSCOPE M00158M PAL £495.

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TEKTRONIX STORAGE OSCILLOSCOPE TYPE 564 including 3A6 and 3B1 plug-ins. **£475**

SYNCHROVERTER SWITCH TYPE G1280 BY ELLIOTT **PRICE £3.**

DC AMPLIFIER BY ASTRODATA 885-235 **£49.**

SAUNDERS OSCILLATOR CLC 7-12K/mc/s **£25.**

MUIRHEAD D880A 2 Phase Decade Oscillator **£75.**

ALPHANUMERIC NIXIE TUBES B7971
Has the ability to display all letters of the alphabet and numerals 0 thru 9 in a single tube. Readability in high ambient light 200 footlamberts brightness. Supply voltage 170 VDC, numeral height 2.5 inches. **PRICE 99p** P & P 16p.

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

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DYNAMCO 71 OSCILLOSCOPE

½ PRICE

* Fully Transistorised * Dua Channel * Sweep Delay * Rang DC-30 MHz * Sensitivity 1mV

The 71 Display Unit contains the cathode ray tube an controls, power supplies, calibrator, vertical and horizonta main deflection amplifiers and unblanking amplifier for th 71 series of oscilloscopes.

On either side of the Display Unit may be plugged th vertical and horizontal deflection units.

The design of the 71 display unit allows its use as a sel contained oscilloscope with or without plug-in units.

Waveform: Approximately Squarewave. **Amplitudes** 50mV, 500mV and 5V. **Accuracy:** ±2%. **Repetition Rate** 1kHz ± 2%. **Rise Time:** <1µs. **Fall Times:** <5µs. **Outpu Impedance:** 50mV, 500mV : 50Ω. 5V : 500Ω. **Current Out put:** 10mA 1kHz squarewave available at loop on front panel ± 2%.

1X2 DELAYED SWEEP TIMEBASE
The type 1X2 is a timebase module used to provide normal an delayed sweeps. The module contains two timebases, on of which 'A', is intended for a main sweep, the other 'B', fo delaying the start of timebase 'A'. Fine delay is achieved b using a comparator circuit controlled by a calibrated 10 tur knob.

During delayed operation, pulse location is simplified b the use of a Bright-up Strobe ('B' intensified by 'A'). To var the 'hold off' period for maximum repetition rates, the 'B timebase has a variable velocity control with two calibrate positions (X1 and X5).

CALIBRATED SWEEP RATES
0.2µs in 19 calibrated steps. Uncalibrated variations betwee steps 0.5secs (5 second sweep).

SWEEP RATES
10µs/division to 10ms. Fine control extends the sweep rate t 50ms (0.5 second sweep).
Accuracy: 5% on all calibrated ranges.

MAGNIFIER
X1 and X10 extends the fastest sweep rate to 20µs.

1Y2 DUAL CHANNEL AMPLIFIER
The 1Y2 is a wide band, dual channel amplifier. It features two identical wide-band preamplifiers, each with its own inpu selector and attenuator, which may be electronically switchd to provide single or dual trace displays. In addition the two channels may be combined algebraically.

A balanced helical wound delay line provides 160ns o signal delay

Unrepeatable offer— limited quantity only!

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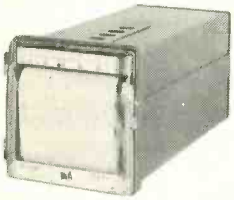


MINIATURE PEN RECORDER

Provides permanent record of DC currents up to 1mA. Eminently suitable for use where space is limited. Separate time marker pen provided. Chart width 80mm. Chart length 40ft. Chart speeds: Slow 20-60-180 mm/hour. Fast 600-1800-5400 mm/hour. Dimensions 120x120x285mm. Weight 7.7 lbs. (3.5 Kg). Price complete with accessories

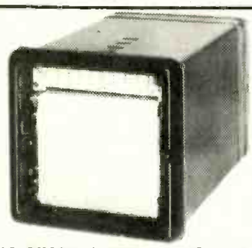
£39.00

NEW HIGH SPEED PEN RECORDERS 3 MODELS AVAILABLE:

SINGLE CHANNEL **£180** : THREE CHANNEL **£310** : FIVE CHANNEL **£385**

Frequency range DC to 100Hz. Recording presented in curvilinear coordinates by means of ink on paper. Built-in solid state amplifier (one per channel) provides 8 calibrated sensitivity steps. Two marker pens are provided; one of these can be connected to internal time marker oscillator providing 1 second pulses. This pen can also be used as a process marker to mark a desired event on the chart. Second marker pen can be used as 'zero' (reference) line marker or as another event marker. Full range of chart speeds is immediately available by means of push button control.

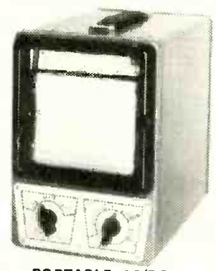
SPECIFICATION. Basic error 4%. Frequency response from DC to 100Hz, 2 db. Calibrated sensitivity V/cm: 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5. Width of each recording channel 40mm. Chart speeds mm/sec: 1, 2, 5, 10, 25, 50, 125, 250. Internal calibrating voltage: 40mV. Chart length: 50 meters. Voltage: 220/250. **COMPLEMENT OF ACCESSORIES AVAILABLE.**



10 CHANNEL EVENT RECORDER

Designed for recording sequences of up to ten different operations, e.g. sequence of machine tool operation; switching sequences, etc. Record is presented in the form of square "pulses". When energised, pen moves by approximately 4mm. to the right of zero line. Response time 100 milliseconds. Chart width 110mm. Chart length 50ft. Inv. capacity 72 hours. Chart speeds 20-60-180-600-1800-5400 mm/hour. Size 160x160x255mm. Weight 9 lbs. Price complete with accessories

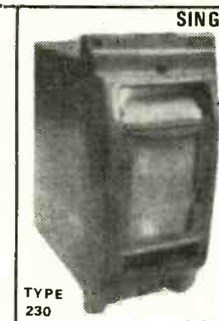
£52.00



PORTABLE AC/DC RECORDING VOLTAMMETER

Fitted with separate zero-marking pen. Accuracy 1.5% DC, 2.5% AC. Measurements ranges — AC and DC: 5-15-150-250-500mA 1.5-5 Amps 5-15-50-150-250-500V. DC only 150mV. Frequency range 45 to 1000 c/s. Chart width 100mm. Chart speeds 20-60-180-600-1800-5400 mm/hour. Weight 22 lbs. Price complete with accessories

£78.00



TYPE 230

SINGLE PEN RECORDER

A most versatile pen recorder producing a trace on a curvilinear 3 in. strip chart. Two synchronous speeds: 1 in. and 6 in. per hour. Fitted with high and low alarm contacts operated by the moving coil. Basic movement 1mA DC coil resistance 400 ohms. Fitted with rectifier to allow operation on AC effective coil impedance at 50Hz 1800 ohms.

Power supply required: 230V 50Hz.

Applications: Ideal for recording relatively slow changing phenomena such as:

Temperature: Gas or Liquid Flow Rates, Sound Levels, Speed variations, Power Demand, Rainfall, humidity, etc.

PRICE £25.00

Clockwork version also available £29.50

These two items are newly reconditioned only.

MINIATURISED STRIP CHART RECORDER

Indicates the magnitude of applied currents or voltages by a continuous distortion-free line on pressure sensitive paper. Moving coil movement, scale calibrated 0-1 milliamp d.c. Internal resistance 100 ohms. Chart drive motor 240V 50Hz. Chart speed 1" per hour. Complete with handbook.

Price £25.00

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obtainable only from Electronic Brokers Ltd.

11" OSCILLOSCOPE Type 0 271

This oscilloscope has a 11" screen, is fully transistorized, and its dimensions allow mounting on standard rack.

It can be equipped with a series of plug-in units which make it highly versatile at a very convenient cost. Dual-trace, time axis logarithmic and differential amplifiers, plug-in units are provided, as well as other plug-in units for interesting and special applications. Since it incorporates the Z-axis modulator, it can be used for display of swept curves, in conjunction with any type of sweep-marker generator, ensuring high stability and deflection linearity.

Vertical amplifier (with plug-in type CV 271-A)

Bandwidth: DC to 10kHz within 3 dB DC to 10kHz within 3 dB. Sensitivity: 1mV/pp to 10Vpp in 5 ranges. Input Impedence: 0.5 MOhm, with approx. 30 pF.

Horizontal amplifier.

Bandwidth: 10Hz to 1kHz Sensivity: 50 mVpp max. adjustable. Mains frequency scanning: phase-adjustable, approx. 180°. Z axis: suppression by-25Vp negative.

£120.00

Plug-in Type A, B, C, D, E, F, P.O.A.

OSCILLATOR FM Mod OF 272

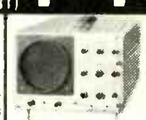
Built with modern concepts, this oscillator has been developed to meet all the requirements for the calibration of any FM receiver. It can be used in conjunction with an AM oscillator, for testing on production lines, or for teaching purposes.

It is provided with good frequency resolution and stability, an efficient output attenuator and has particular built-in features which keep the irradiation field at a practically negligible level.

Simplicity of construction and stability of the characteristics are combined in the circuits used. Thus an instrument has been developed which, whilst priced as a normal service oscillator, has many of the characteristics of a signal generator. Solid state.

RF frequency range: from 85 ÷ 110 MHz. IF frequency range: from 9.5 ÷ 12 MHz. Frequency accuracy: within ± 1%. Max output signal: 0.1V ± 3dB (open circuit). Attenuator: continuous, 0 ÷ 100 dB approx. indication. Output impedance: 75 Ohm constant. FM modulation: frequency 400Hz ± 5% F adjustable until ± 100KHz, about. Sweep frequency: 50Hz (Meius) Δ F adjustable until about ± 500KHz.

£139.50



LARGE WAVEBAND OSCILLOSCOPE Mod 0 373

A very reliable oscilloscope, with a flat screen tube, developed for all applications where the specific function of the trigger is not of primary importance. Completely solid state (40 semiconductors) except for the input and Y terminal for reasons of security and economy. All power supplies are stabilised, including the voltage to the tube. It has a mumetal screen. Recommended mainly for teaching purposes and for servicing or production lines of televisions.

Vertical Amplifier Bandwidth: DC to 10MHz within 3 dB. Deflection Sensitivity: 20 mVpp/cm for all the range. Input Attenuator: from 20 mVpp/cm to 10 Vpp/cm in 9 ranges. Risetime: about 35 nS. Input Impedance: 1 Mohm with about 30 pF. Internal Calibration: for sensitivity control Y. **Horizontal Amplifier** Bandwidth from DC to 0.5MHz. Deflection Sensitivity: 100 mVpp/cm — adjustable. X Deflection Line Voltage: phase adjust. within 180° approx. Time Base (uncalibrated): from 1μS/cm to 10mS/cm. Synchronization: automatic internal and mains external, minum. 100 mVpp. Z Axis: 20 v negative blank the intensity.

Synchronization: automatic ± internal and mains external, minim. 100 mVpp. Z Axis: 20v negative blank the intensity.

£169.50

SWEEP MARKER GENERATOR Mod SM 972

This generator has been specially developed for the design and testing of active and passive network within the frequency range 5-800 MHz; by excluding the sweep, it can be used as a normal non-modulated-generator.

It has a good output stability and linearity of amplitude and is particularly suitable for the observation of the curve of passing wavebands from some tenth of KHz up to hundreds of MHz.

Quartz signal markers placed at intervals of 1, 5, 10 and 50 MHz (which can be included singly up to their total number) make it possible to locate frequencies with accuracy and ease. It is recommended that the 11" Oscilloscope 271 be coupled with this generator for a better performance.

Appropriate outputs allow remote control and programming of the instrument through a keyboard so as to facilitate its use on production lines. Solid state.

Sweep range: 5 ÷ 400MHz and 400 ÷ 800MHz Δ F variable from few KHz until all the range. Sweep frequency: 50 Hz (meius). Output signal: 1 Vpp-75 Ohm. External attenuator: adjustable continuously 0 ÷ 80 dB. Ampl/freq linearity: within ± 1 dB for A total Δ F. Markers: quartz, adjustable in amplitude. Karkers presentation: Birdy type. Markers interval: 1-5-10-50 MHz as like it.

£525.00

RCL BRIDGE Type P 966 **£245**

AM-FM GENERATOR Type AF 1065 **£259.50**

OUTPUT POWER METER Type MU 964 **£129**

TV SWEEP MARKER GENERATOR Type VU 167 **£259.50**

WOW AND FLUTTER METER Type WF 971 **£295**

DISTORTION METER Type D566 B **£319**

LF SIGNAL GENERATOR Type G 1165 B **£229**

DUAL TRACE OSCILLOSCOPE Type O 371 **£369**

MODULATED OSCILLATOR Type OM 866

Up-to-date radio receivers possess such a high degree of sensitivity that, even in radio-service shops, a fairly high-performance oscillator is required, so as to permit the output signal to be attenuated also at high frequencies, which is the condition for avoiding saturation of the input stage in transistorized radio receivers.

This oscillator is provided with a buffer-modulator stage to prevent possible spurious modulations. An accurate shielding of the oscillator stage, and an enlarged frequency range for calibration of intermediate-frequency stages, are further features which complete the rational design of this instrument.

Frequency range: from 150KHz to 46MHz in 6 ranges. FM expanded range: 430-530 KHz. Frequency accuracy: better than 1%; IF range 0.1%. Internal modulation: 400 Hz; fixed 30%. External modulation: from 20 Hz to 15 KHz. Max. RF output: 0.2V ± 3 dB. Attenuator: continuous, linear and in steps. Output impedance: 75 Ohm constant. VF output voltage: 2 V approx.

£85.00

SWEEP MARKER GENERATOR Mod IF 1271

Developed exclusively for production use, this instrument allows a rapid and accurate calibration of intermediate TV frequency stages with the possibility of inserting, singly or simultaneously, a total of 8 quartz markers either of standard frequency or frequencies chosen according to the different production systems, including the colour under-carrier.

Its solid state construction makes it extremely reliable, a fundamental requirement of an instrument used on production lines.

Frequency control range: 36.15 MHz (or 43 MHz). Width of the sweep: about 12 MHz. Sweep linearity: within 1 dB. Sweep frequency: 50 Hz (meius). Output signal: 0.4 Vp 75 Ohm. Attenuator: adjustable continuously from 0 ÷ 80 dB. Regulation sweep phase: max. 180°, about. Quartz marker: max no.8, to be precised. Markers inclusion: single switch. Marker type: best over Y axis oscilloscope. Marker amplitude: adjustable.

£585.00

SOUND GENERATOR Mod GS 1171B

This instrument is of great help in the production of televisions for a rapid and definitive calibration of the sound circuits, rendering superfluous the use of the emitter for a final test. It is a fequency modulated generator with a 1:10,000 stability, more than sufficient for its purpose, with the possiblity of frequency tests which bring the short term stability within 50 Hz on 5.5 MHz. It can be supplied, on request, for any other frequency in the 4-12 MHz range. It is completely solid state and offers high reliability.

Central range frequency: 5.5 MHz (other frequencies on request). Frequency deviation: ± 25 KHz. Frequency stability: within ± 250 Hz (with possibility of control). Linearity: with 1 dB. Modulation frequency: 400 Hz. Output signal: 1 Vp. about on 75 Ohm. Attenuator: Continuously adjustable from 0 ÷ 80 dB.

£549.00

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THE REVOLUTIONARY SUPERTESTER 680R

FOUR INTERNATIONAL PATENTS — SENSITIVITY 20,000 Ohms per Volt
10 FIELDS OF MEASUREMENT AND 80 RANGES. ACCURACY 1% in D.C. 2% in A.C.

OUTSTANDING FEATURES:

20,000 Ohm per Volt sensitivity ● Fully screened against external magnetic fields ● Scale width and small case dimensions (128 x 95 x 32mm) ● Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading ● Simplicity and ease of use and readability ● Full ranges of accessories ● 1000 times overload ● Printed circuit board is removable without de-soldering ● More ranges than any other meter. VOLTS A.C. = 11 ranges: 2–10–50–250–1000–2500. Volts and **4–20–100–500** and **2000** Volts. VOLTS D.C. = 13 ranges: 100mV–2V–10–50–200–500-1000 Volts **200** mV-**4V-20-100-400** and **2000** Volts AMP D.C. = 12 ranges: 50µA-500µA-5 mA-50 mA-500 mA-50 Amp and **100µA-1 mA-10 mA-100 mA-1 Amp** and **10 Amp.** AMP. A.C. = 10 ranges: 250µA-2.5 mA-25 mA-250 mA-2.5 Amp and **500µA-5mA-50 mA-500 mA-5 Amp.** OHMS REACTANCE = 6 ranges: **x1-x10-x100-x1000-x0,000** and **Low Ohms.** DETECTOR = 1 range: from 0 to 10 Megaohms. FREQUENCY = 2 ranges: from 0 to 500 and from 0 to 5000 Hz. V. OUTPUT VOLTAGE = 9 ranges: 10-50-250-1000-2500 V and **20-100-500-2000** Volts. DECIBELS = 10 ranges: from –24 to +70 db. CAPACITY = 6 ranges: from 0 to 50,000 and from 0 to 500,000 pF using the mains and from 0 to 20, from 0 to 200, from 0 to 2,000 and from 0 to 20,000 Micro farad using the incorporated 3 Volts battery.

Bold figures indicate depress button.

£18.50 with shockproof case

ALL I.C.E. EQUIPMENT POST FREE

ACCESSORIES TO CONVERT THE SUPERTESTER 680R TO THE FOLLOWING:

Amperclamp

For measuring a.c. currents from 250mA to 500 amps. **£11.95**

Signal Injector

Producing 1KHz and 500 KHz signals for circuit testing. **£5.95**

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For transistors and diodes. **£11.00.**

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For measuring magnetic field strengths. **£11.95**

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To indicate the phase sequence of a 3 phase supply. **£5.95.**

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Covering the range –50 to +200°C **£11.95**

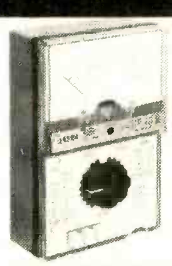
OTHER ACCESSORIES AVAILABLE

SHUNTS D.C. 25, 50 and 100 amps **£4.50** each.
CURRENT TRANSFORMERS A.C. 25 and 100 amps. **£7.00** each.
E.H.T. PROBE Extends D.C. voltage to 25,000v. **£5.95.**

Electronic Voltmeter

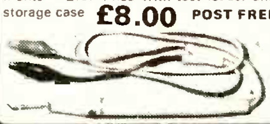
Input resistance of 11Mohms for d.c. and 1.6Mohms shunted by 10pF for a.c. **£18.00**

METERS, PROBES, ETC.



AC/DC MULTIMETER

With taut band suspension movement. Sensitivity 20,000 ohms per volt on DC and 4,000 ohms per volt on AC.
Technical Data:
0.06-0.6-6-60-600mA-3 Amps DC. 0 3-3-30-300mA-3 Amps AC. 0.6-1.2-3-12-30-60-120-600 DC. 1200 Volts. 3-6-15-60-150-1300-600-900 Volts AC. 45 to 20,000 Hz.
500Ω, 5-50-600kΩ resistance. Decibel range –10 to +12dB. Accuracy (% of F.S.D.):—DC and resistance measurements +2.5. Price with test leads, and storage case **£8.00 POST FREE**



AMPERTEST 690 NEW CLAMP TYPE AMMETER

With unique self-locking meter system retains reading until released, enabling engineer to obtain accurate results after testing inaccessible places etc.

Designed for use in one hand, measures without breaking the circuit. It has six current ranges from 3A to 600A f.s.d. with the first division at 100mA. a 10-to-1 current rransformer supplied with the instrument provides ranges from 300mA to 60A f.s.d. with the first division at 10mA. Two a.c. voltage ranges of 250V and 600V f.s.d. are provided.

£39.50 POST FREE
inc. leather case

MODEL 300 LOGIC PROBE

A compact easy-to-operate logic probe. As a light-emitting diode is used the unit actuates with low power. It does not affect the circuit under test because of high input impedance. Up to as high a frequency as 12 MHz.

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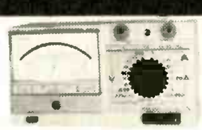

AC/DC MULTIMETER

With taut suspension movement and full coverage of AC and DC current and voltage ranges.
The instrument incorporates all facilities needed for field and laboratory measurements. Knife edge pointer and 86mm long mirror scale allow the high inherent accuracy of the instrument to be utilized in full. The movements and circuits are fully protected by transistorized triggering circuit.
Scale length: 86mm. D.C. current ranges: 50µA, 0.5, 1, 5, 10, 50, 250mA 1, 5 Amps. A.C. current ranges: 0.25, 0.5, 1, 5, 10, 50 250mA, 1, 5 Amps. D.C. voltage ranges: 100mV, 0.5, 2.5, 10, 25, 50, 100, 250, 500, 1000V. A.C. voltage ranges: 0.5, 2.5, 10, 25, 50, 100, 250, 500, 1000V. Transmission level: –5 to +10db. Resistance ranges 0.5, 200 ; mid-scale reading 13 10Ω-3kΩ ; mid-scale reading 200Ω, 100Ω 30kΩ ; mid-scale reading 2000Ω, 1kΩ-300kΩ mid-scale reading 20kΩ. Accuracy, % of F.S.O.: D.C. ranges — 1.5 A.C. ranges — 2.5. Sensivity: D.C. Ranges, 20,000Ω/V. A.C. ranges, 4,000Ω/V for all ranges except 2.5V and 10V. 1000Ω/V for 10V range 200Ω/V for 2.5V range. Batteries required: 2 dry cells 1.5V for automatic cut-out 1 dry cell 1.5V for resistance range
Overall dimensions: 210 x 115 x 90mm.
in carrying case, complete with test leads. POST FREE **£15**

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0.1-1-10-100-1000mA. 2.5-10-20-250-500-1000V. AC-DC. Sensitivity AC and DC all ranges except 10V-10,000 Ohm/V. Dimensions 211 x 118 x 75mm. Weight 2.9 lbs. Price complete with steel carrying case and test leads.

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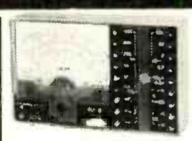
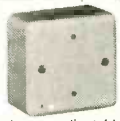


UNIQUE MULTIMETER/ SIGNAL GENERATOR

Taut suspension movement. Simple multimeter combined with audio/I.F. Test Oscillator providing AC and DC Voltage ranges, D.C. current ranges and resistance ranges. 1kHz and 465kHz oscillator output makes the instruments suitable for general tuning of receivers etc.
Scale length: 65mm. D.C. voltage ranges: 0.5, 2.5, 10, 50, 250, 500, 1000V. A.C. voltage ranges: 2.5, 10, 15, 250, 500, 1000V. D.C. current ranges: 0.05, 0.5, 5, 50, 500mA
Sensitivity: 20,000Ω/V. Resistance ranges: 5-1000Ω mid-scale rea ding 50Ω 50Ω 10k; mid-scale reading 500Ω, 500Ω-100kΩ ; mid-scale reading 5kΩ 5kΩ-1mΩ mid-sca le reading 50KΩ.
Accuracy: 5% of F.S.O. Internal battery: 3V dry cell.
Oscillator output: 1kHz squarewave. 465kHz sinewave modulated by 1kHz squarewave signal. Output voltage: 1V minimum.
Overall dimensions: 160 x 97 x 40mm.
in carrying case, complete with test leads. **£7.00 POST FREE**



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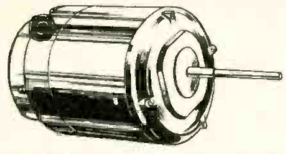
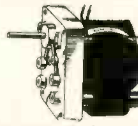


"SLO-SYN" 3-LEAD SYNCHRONOUS STEPPING MOTOR

Type SS15. These fine motors are easily reversed, starting and stopping in less than 5° without electrical or mechanical braking. Simple relay circuit can be applied to give DC., to winding for a maximum holding torque of 300oz/ in with 35v at 0.35amps through winding. For AC. (synchronous) operation at 120v., 50Hz. Speed 60 rpm at 60Hz., 72 rpm. STEPPING. Holding torque at 60 steps per second—100 oz/in. Can be wired to give 100 or 200 steps per revolution with accuracy of 0·1° per step non-cumulative. Torque characteristics can be modified by simple R.C. circuits. Dimensions: dia. 4", body length 4¾", spindle length 2¼" × 3/16" dia. Weight 6½ lbs. BRAND NEW in maker's packing. Offered at less than ⅓ maker's price. **£15**

OPEN FRAME shaded pole GEARED MOTORS



(Dural gear case) 240 AC., 28rpm. NEW HIGH TORQUE, approx. overall size: 3½" × 3½" × 2½"+spindle ½"-dia. as illustrated. £3. P. & P. 30p. Similar to above, 19rpm. £3. P. & P. 30p. 110rpm with pressed steel gear case (similar to above but slightly smaller). £3. P. & P. 30p.

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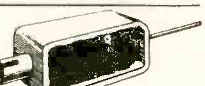
P.S.U. 200-250v. 40/60Hz. Alternative outputs fully variable (variac incorporated). Output 1. 12v at 5a D.C. fully smoothed. Output 2. 12v at 8a D.C., with ripple content. Output 3. 20v at 10a A.C. 2½" x 2½" flush 0-20v D.C. m/c meter. In attractive grey hammer finish case. **In maker's carton. £41.50. Carr. & Pkg. £1.50.**

SHADED POLE MAINS MOTOR

A quality shaded pole motor. Open frame. 3" high × 2½" × 2". Spindle 1" × 3/16". 1,4 20r.p.m. **£1.95** P & P 20p.

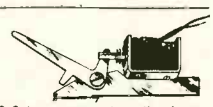
SOLENOIDS by WESTOOL



240AC type MM6. 3lb. pull, 2½"×1"× 1½". Travel 1". **90p** each. P.&P. 10p.

240AC type MM4. 2lb. pull, 1½"×1½"×1". Travel ½" **70p** each. P. & P. 10p. Quantity discounts; 10-50 10%. 50 upwards 25%

MAINS SOLENOID



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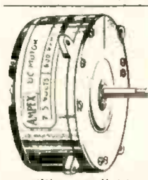

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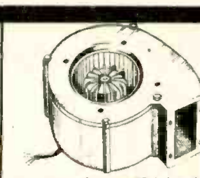

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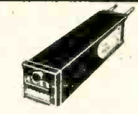

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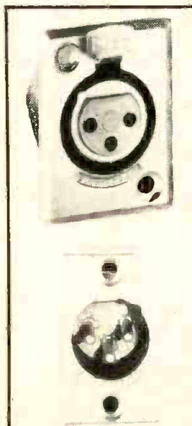

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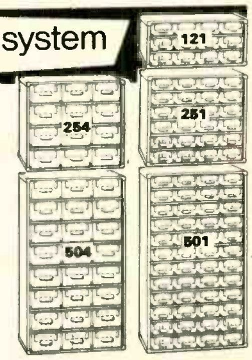

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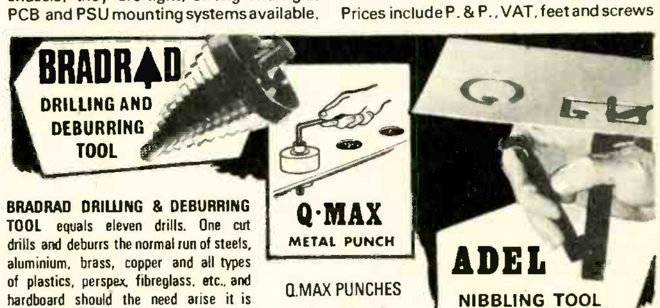

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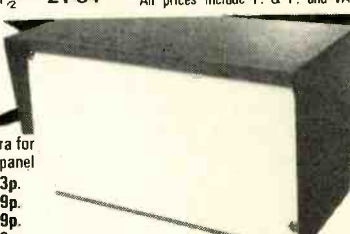

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Prices correct March 1974.

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WW—139 FOR FURTHER DETAILS

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Maintenance Engineers

Data Communications Network

We have two interesting new vacancies, due to continuing rapid expansion in services to memberfirms, for electronics engineers in our Communications Group. The group is responsible for fault-handling on three major networks: one is well-established, with two Argus 400s driving 1700 digi-tv displays in various parts of London; the second, now being commissioned, links 150 Olivetti teleprinters to two DEC PDP 11/40s, to provide a Remote Data Entry (RDE) service for London Members; the third, also being commissioned, extends the Argus system UK-wide via PDP 11s in major centres. Quite exceptionally high service levels are achieved, faults being located and repaired extremely rapidly.

The engineers we require are qualified to at least ONC level, experienced in maintaining data communications systems, and probably aged 25-35. They will work rotating 8 hour shifts between 9 a.m. and 7 p.m.

The Centre Engineer

will record and progress faults, in particular diagnosing their whereabouts and initiating maintenance action. He has a sound knowledge of the principles of tv and data transmission. Starting salary probably £2,250-£2,700.

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will at first work chiefly on the RDE network. He is skilled in rapid fault location, and preferably has some knowledge of the principles of tv transmission. Starting salary probably £1,750-£2,250.

These are permanent career positions with full fringe benefits. To reply please 'phone or write briefly to Ben Mee, The Stock Exchange, London, EC2N 1HP (01-588 2355 ext. 8064).

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The Stock Exchange

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ASSISTANT PROJECT ENGINEER

FOR COLOUR SORTING MACHINES

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Why not ring 01-980 6041 for an informal discussion, or write to:

Mr Ken Hurley,
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Sortex

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For full details post this coupon to:
Mrs P. M. Annesley,
Personnel Branch (P2)
Room 520, Civil Aviation Authority
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London WC2B 6NN
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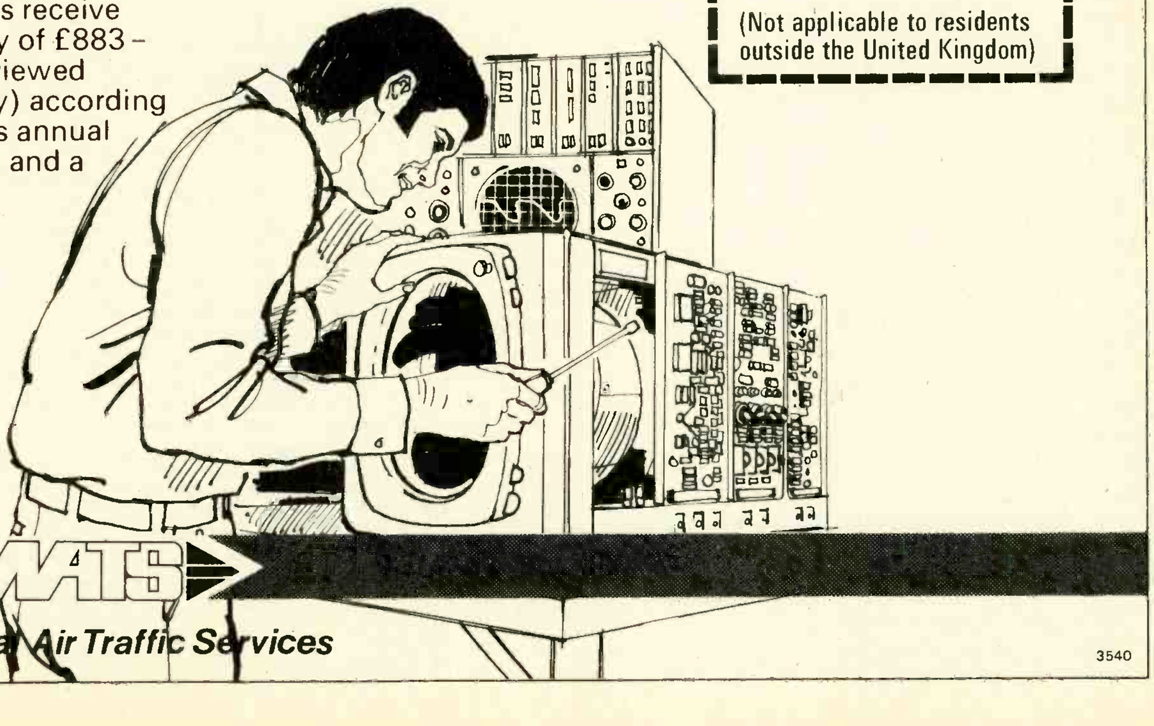
(Not applicable to residents outside the United Kingdom)



NATS
National Air Traffic Services

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Please send me application form for entry as Radio Technician.

Name ____________________

Address ____________________

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NATS

National Air Traffic Services

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Candidates should have a full City and Guilds Technological Certificate and at least five years' experience of V.H.F./F.M. radio; Power line carrier or multi-channel single sideband radio and equipment, and supervisory systems using relay logic/solid state digital techniques.

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[3516

ELECTRONIC EVALUATION ENGINEER

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A vacancy is available in the Engineering Function for an Electronic Evaluation Engineer to provide a technical support service on product evaluation and the supply of factored products. This will involve him in the assessment of performance, construction, safety and suitability of factored products and others and the preparation of written reports. This position will also demand close liaison with suppliers, quality control departments and product planning for the preparation and assistance with the technical specifications required.

Applicants should be educated to HNC or degree level and have had a minimum period of four years project or product experience in Hi-Fi Electronics or a closely related field.

The company's premises are located at Idle, Bradford, convenient for travelling from both Bradford and Leeds and near to the pleasant rural surroundings of the Aire Valley.

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Personnel Officer,
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Bradford Road, Idle,
Bradford BD10 8SF.
Tel: 612552

RANK RADIO INTERNATIONAL

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We're looking for Customer Engineers to carry out, to a high professional standard, all electronic and electromechanical work concerned with installation, modification, refurbishing, preventive and remedial maintenance on UNIVAC equipment both in the UK and Europe.

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Here's a job to put you to the test

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Here in Hastings, we're looking for top-notch senior engineers to join our Test Engineering team. It's a job calling for formal electronics training followed by extensive practical experience of TV test as a Service Engineer, in the Forces or in industry.

If you'd like to put your ability to the test with ITT, we'd like to hear from you. It's an opportunity which, if you have the expertise we are looking for, could take you into the training areas of the Company. Generous additional benefits include pension and sickness schemes and assistance with re-location expenses where appropriate.

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Excellent conditions and benefits include membership of a contributory pension and life insurance scheme.
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The Flying Squad

We require young Electronics Engineers, with HNC or equivalent, who will learn to operate and maintain our advanced and highly sophisticated electronic equipment at transmitting stations throughout the country, bringing independent television and independent local radio into millions of homes.

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You could join us–IBA run a special 18 month training course to give you a comprehensive knowledge of operations and maintenance techniques, plus an additional recognised qualification. To succeed you must be flexible about hours, willing to travel, able to drive and prepared to undertake a demanding training course. We'll pay you a training salary of between £1,461 and £1,851 and on successful completion of your training you will move to £2,253 with progression to £2,880 or more.

Interested? Simply write or 'phone for full details and application forms to:
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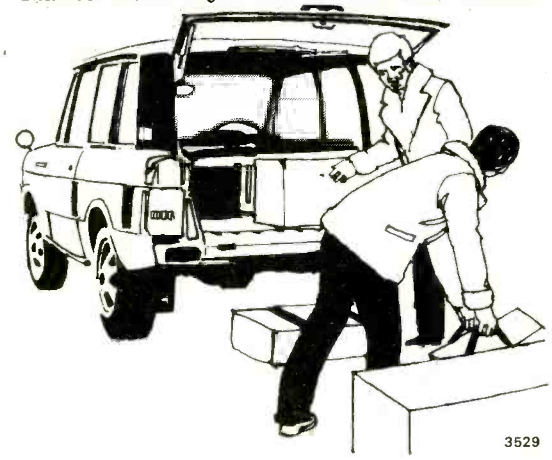
Independent Broadcasting Authority,
Crawley Court, Winchester,
Hants. SO21 2QA. Tel: Winchester 822599.



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SERVICE ENGINEERS

Take on Tomorrow's Technology as an IBM Computer Customer Engineer.

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We'll train you thoroughly to service and maintain medium and large scale systems, data recording, tele-processing and data entry terminals. In fact, your training will be continuous because there will always be something new to learn. Our technology is continually evolving. So as our systems develop so will your engineering techniques.

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[3421

UNIVERSITY OF LIVERPOOL SCHOOL OF EDUCATION

TECHNICIAN (AVA and CCTV)

Invitations are invited for the above post to have overall responsibility for the AVA and CCTV provision in the School

Applicants should be qualified and experienced in the fields of electronics and Audio Visual Aids and be capable of working on their own initiative and supervising other technicians. This is a new post with interesting possibilities for developing new forms of work in the field of Educational Technology. Salary within a range up to £2,382 per annum according to qualifications and experience.

Further particulars and application forms may be obtained from the Registrar, The University, P.O. Box 147, Liverpool, L69 3BX. Quote ref. RV/WW/80663. [3537

Hamilton College of Education

require a

TELEVISION ENGINEER

(COLOUR UNIT)

to join a team engaged in the operation, maintenance and development of the College service. At present the service consists of a two channel colour mobile control room with distribution facilities within the college.

Experience in video tape recorders and/or colour cameras and monitors an advantage.

Normal colour vision and driving licence essential. Annual leave will be 4 weeks.

Salary will be in the range £1530-£2100 (N.J.C. Grade IV, V and VI) depending on qualifications and experience. (Salary scales are at present under review.)

Further information and application forms may be obtained from the College Secretary by telephoning Hamilton 23241, or writing as soon as possible to:

**COLLEGE OF EDUCATION,
Bothwell Road, Hamilton,
Lanarkshire, ML3 0BD.**

[3401

THE BRITISH COUNCIL
QATAR
REGIONAL TRAINING CENTRE, DOHA

AN
INSTRUCTOR IN RADIO AND TELEVISION SERVICING

Candidates, men only, preferably between 28 and 35, should normally be citizens of and permanently resident in the United Kingdom and have a British educational background. They must have relevant C & G FTC, have had approved training as an instructor and at least 5 years' trade experience after training. Some training/teaching experience in a technical institute or recognised work training department is also essential.

SALARY: QRials 2400 (£250 approx.) a month, tax free. Free furnished accommodation or allowance in lieu; car allowance QR400 a month; two months' annual leave, passage paid; free medical service; return air fares. Three year contract, renewable, guaranteed by British Council. 73 AM/132.

Write quoting relevant reference number to THE BRITISH COUNCIL (APPOINTMENTS), 29 BRESSENDEN PLACE, LONDON SW1E 5DD for further particulars and application form to be completed as soon as possible.

[3538

ITN

has a vacancy for a trainee Sound Maintenance Engineer. Applicants should have a good technical background, preferably to 'A' Level standard, and have a keen interest in the practical aspects of sound engineering. Starting salary £1,662 p.a. 4 weeks holiday. Subsidised staff restaurant.

INDEPENDENT TELEVISION NEWS LIMITED
ITN HOUSE, 48 WELLS ST., LONDON W1P 3FE
TEL: 01-637 2424.

3412

Broadcast Television

The following vacancies exist for enthusiastic young engineers to work in our newly equipped studios:

1. **VISION ENGINEER.**
2. **SOUND ENGINEER.**
3. **VIDEOTAPE ENGINEER.**

Previous experience in television preferred but enthusiasm essential.

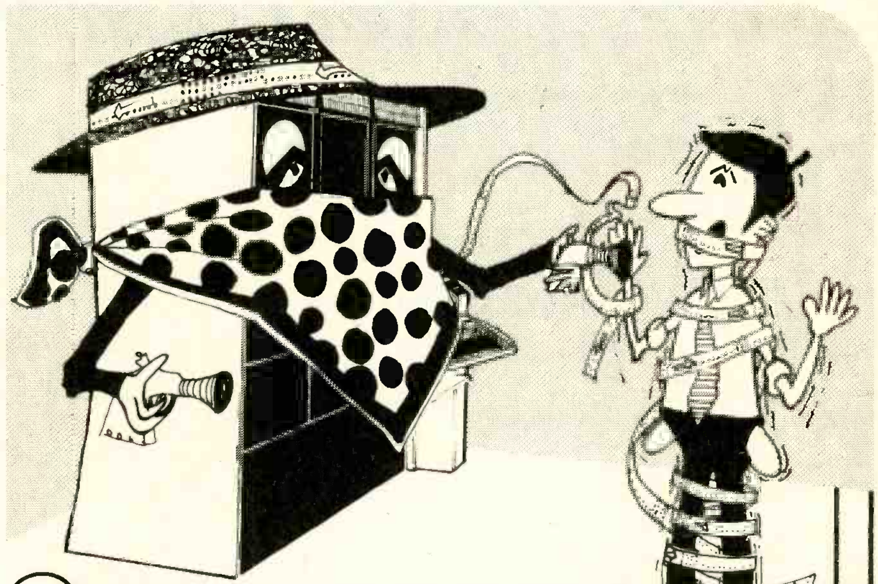
Qualifications: Attending a course leading to HNC or equivalent.

Salary: Commensurate with qualifications and experience. Plus various fringe benefits.

Apply in writing to:

P. Haines, Ewart & Co. (Studio) Ltd., Wandsworth Plain, London, SW18 1ET.

[3515



Computer Field Engineers

Have you got what it takes?

Have you got what it takes to join the world's most successful mini-computer Company?

If you have the ambition to succeed in computer field service and have a good knowledge of digital circuitry, then you may have what it takes. If you also have previous field service experience, particularly on computer products and if you have an H.N.C. or similar qualification, you are more likely to have what it takes.

We are looking for field engineers to work on our world-famous range of PDP mini-computers. We have openings both for site and mobile engineers, located throughout the country but mainly in the South East of England.

The work is varied and challenging, and the rewards are suitably high.

If you are interested, please write or telephone for an application form to our Personnel Department quoting reference WW 122.

DIGITAL EQUIPMENT COMPANY LIMITED
Fountain House, Butts Centre, Reading RG1 7QN. Tel. (0734) 599049

digital the pdp giants

3563

ENGINEERING OPPORTUNITIES
with Europe's largest TV assembly plant

Yes – we're No. 1 in Europe. And to keep it that way, we need a strong, top class team of engineers. Here is your chance to join them. We need . . .

SENIOR ELECTRONIC DESIGN ENGINEERS

who will work on all aspects of electrical design of television receivers. The successful applicants are likely to hold a degree or HNC in Electrical/Electronic Engineering and will have had a minimum of two years' experience in solid-state design, preferably in consumer electronics.

ELECTRONIC DEVELOPMENT ENGINEERS

If you are qualified in RADAR, COMMUNICATIONS, RADIO or TELEVISION, you could be the type of person we are looking for to fill vacancies in our Engineering Liaison Laboratory. Due to continuing expansion of this company, a Development Engineer and a Senior Development Engineer are required.

Normal company benefits apply for the above positions and assistance can be given with re-location expenses. Salary will be negotiated according to qualifications and experience.

Please write or telephone for an application form to Geoff Connolly.

THORN CONSUMER ELECTRONICS (GOSPORT) LTD., Fareham Rd., Gosport PO13 0AU. Tel.: Fareham 6181.

3556

ultra

ELECTRONIC VACANCIES

Engineers

Draughtsmen ● Designers

Service and Test Engineers

Technicians ● Technical Authors

Sales Engineers

£1,600-£5,000 pa

Permanent or Contract

Phone MICHAEL NORTH
01-388 0918
MALLA TECHNICAL STAFF LIMITED
334 Euston Rd., London NW1 3BG

3400

X-ray Field Engineers

Our current expansion programme now calls for experienced electro-mechanical engineers to support our existing field staff. They will become involved in a variety of interesting activities covering the installation, service and maintenance of diagnostic medical X-ray equipment in hospitals.

Progressive opportunities exist in a number of our Branches throughout the UK.

Applicants should be qualified to ONC or City & Guilds equivalent and previous experience on any of the following—X-ray engineering, closed-circuit television, electronics, logic circuitry—would be a distinct advantage.

Good salaries and fringe benefits will be offered to the successful applicants and a company car will be provided as soon as an acceptable stage of proficiency in our product is reached.

For further details and application form please contact:

GEC Medical

Mr. P. B. Blackmore, Personnel Officer, GEC Medical Equipment Limited, East Lane, North Wembley, Middlesex. Tel: 01-904 1288, stating in which area you are interested in working.

3552

THE KINGDOM OF
SAUDI ARABIA

Broadcasting Station Engineers and Technicians

The Ministry of Information of the Kingdom of Saudi Arabia invites applications for service in its MF and HF broadcasting system in the undermentioned posts.

Contracts will be for two years in the first instance, renewable thereafter, and successful applicants will be based in Riyadh, Jeddah or Dammam.

Candidates will be required to provide written proof of their technical competence.

A good knowledge of the English language is required.

The age limit is 55 years.

STATION MAINTENANCE ENGINEERS

Applicants must possess a diploma in Electrical or Telecommunications engineering, equivalent to the British B.Sc. (Eng.), H.N.D. (Higher National Diploma) or H.N.C. (Higher National Certificate) and have had several years' practical experience in the operation, maintenance and supervision of broadcasting stations and studio complexes.

Salary: Minimum 5000 Saudi Arabian Rials per month, subject to negotiation during interview, plus allowances.

STATION MAINTENANCE TECHNICIANS

Applicants must possess a recognised certificate of technical competence equivalent to the British O.N.D. (Ordinary National Diploma) or O.N.C. (Ordinary National Certificate) and have had several years' practical experience in the operation and maintenance and maintenance of broadcasting studios.
of broadcasting stations or in the operation
Salary: Minimum 3000 Saudi Arabian Rials per month, subject to negotiation during interview, plus allowance.

Allowances (all successful candidates). Annual housing allowance equal to two months' salary, or a maximum of SR 8000. Car allowance or SR 300 per month.

Income Tax: Salaries and allowances are subject to Saudi Arabian Income Tax. Details will be given to applicants.

Interviews: Selected applicants will be interviewed in Paris, Brussels, Frankfurt, Amsterdam and Brighton.

Applications: In writing to the Personnel Manager, Preece, Cardew & Rider, of 165/167, Preston Road, Brighton BN1 6AF, Sussex, England who have been instructed to act on behalf of the Ministry of Information, quoting reference GET/PERS./3071.

[3513

The University of Leeds

DEPARTMENT OF PHYSIOLOGY

CARDIOVASCULAR UNIT

Applications are invited for the post of EXPERIMENTAL OFFICER in Electronics. A degree or HNC is required. Responsibilities include PDP12 and PDP8 computers, electronic equipment in three physiological laboratories and three hospital catheter laboratories, and the supervision of four electronics technicians. Salary scale £1563-£2187. Preliminary enquiries may be made to the Director of the Cardiovascular Unit, Department of Physiology, The University, Leeds, LS2 9JT.

Forms of application and further particulars from the Registrar, The University, Leeds LS2 9JT (please quote 43/12/CI).

[3274

When replying to
Box nos
please mention
Wireless World.

CREATIVE DEVELOPMENT ENGINEERS
Up to £3000

If you are keen to develop your career by working for an expanding Company in the forefront of Telecommunications/ Systems Design then read on:

We are looking for young engineers with a degree or HNC in electronics or others with at least two years' experience in the following fields:

- Message Switching—Hardware and Software
- Radio—H.F. and Microwave
- Broadcast—Sound and Vision Transmitters

You will be responsible for the development of the above equipments from initial design through to final production.

The Company is situated in the developing county town of Chelmsford only 35 mins. by train from London. Generous relocation allowances will be paid to successful applicants and assistance with obtaining accommodation is available.

For further information complete the attached coupon and send it to:

Gordon Short,
Marconi Communication Systems Ltd.,
Marconi House, New Street,
CHELMSFORD, Essex, CM1 1PL.
or telephone Chelmsford 53221 Ext. 114.

NAME____________________

ADDRESS____________________

____

AGE______ PRESENT POSITION____________________

Marconi Communication Systems

A GEC-Marconi Electronics Company

3558

Technician Engineer
(Solid State Circuits)

If you know about solid state circuitry read this – then ring us – but you must be experienced in maintenance, design and construction of solid state electronic circuits, preferably in communications and CCTV.

If you are the right man – preferred age range 25/40 – you will share the responsibility for the maintenance of a wide range of sophisticated electronic devices and a radio communications network. Technical competency in your field will lead to additional design and installation responsibilities under guidance of the Company's electro-mechanical research and development group.

The job is based in Central London and starting salary is up to £2,100. If you think you can handle it, **phone 01-405 5200 (reversing charges) to tell us about yourself, and to get more details.**

3573

radio/audio/ tv engineer

QUALITY-CONTROL

The opportunity has arisen at our Liverpool Laboratories for a suitably-qualified engineer to join a small team concerned with the technical appraisal of domestic radio, audio and T.V. products.

This is an especially interesting position involving the examination of samples from the U.K. and abroad. The standards of quality required for inclusion in our Mail Order Catalogues are secured by direct personal contact with our suppliers.

Applicants should be qualified to at least HNC standard, and are unlikely to have less than five years' production experience in the domestic radio and television field, including a close association with design and manufacturing activities. A familiarity with quality-control and inspection procedures would be an added advantage.

An attractive salary will be offered to the successful applicant, together with generous relocation expenses where necessary.

Reply, giving details of yourself and your career to:— John Cordrey, Appointments Manager, Littlewoods, JM Centre, Old Hall Street, Liverpool X.

Littlewoods

3560

RADIO TECHNICIANS

The Ministry of Posts and Telecommunications has vacancies for Radio Technicians at Government Buildings, STANMORE near (Canons Park Underground). Radio Technicians are also liable to be employed at Waterloo Bridge House, Waterloo Road, S.E.1 (opposite Waterloo Station).

- Applicants must be at least 19, have a sound knowledge of electricity and radio combined with 2 years practical workshop experience of maintenance and the use of radio/electronic test gear, and hold GCE 'O' level passes in English Language, Mathematics and/or Physics, or City & Guilds Telecommunications Technician Intermediate Certificate or equivalent qualifications.
- Future prospects of promotion to Telecommunications Technical Officer grades and above.
- Pay—according to age—£1,383 at 19 rising by annual increments to £2,158 plus London Weighting.
- Hours—41 gross, 5 day week.
- Paid Holidays—18 days a year rising to 22 days after 10 years total service, plus public and privilege holidays.

For application forms and interview apply to:—

Miss J. P. Chapman
MINISTRY OF POSTS AND TELECOMMUNICATIONS
Personnel Services Branch (RT)
Room 203, Waterloo Bridge House
Waterloo Road, London SE1 8UA

[3539

At ICN Instruments we are continuing to grow fast in the dynamic field of

NUCLEAR MEDICINE

WE REQUIRE

SERVICE REPRESENTATIVES

in the South East and North Midlands to work with our full range of Scintillation Counters and imaging equipment. Qualifications to the level of H.N.C. in electronics engineering or a background of electronic application in physics or chemistry would be desirable.

The job is demanding with considerable travel involved but will give satisfaction to those who can work independently and with initiative.

Earnings are likely to be in excess of £2,500 per annum plus superannuation scheme and a company Cortina 1600 XL.

MAKE YOUR CHANGE NOW

Telephone or write to:

**The Sales Manager,
ICN Pharmaceuticals (UK) Limited,
Instruments Division,
2 Riverdene Industrial Estate,
Molesey Road, Hersham, Surrey.
Tel: Walton-on-Thames 44441**

[3492

The Middlesex Hospital
London W1N 8AA

Department of Clinical Measurement

Electronic Technician required as soon as possible for work involved in the design, development and maintenance of medical electronic equipment.
Applicants should have experience in the layout and wiring of small signal analogue and digital circuitry and will be part of a team of engineers and technicians.
Opportunities exist for day release for further study.
Salary on Whitley B Scales, Medical Physics Technician III £1,719–£2,211 p.a. plus £126 London Weighting.
Application forms obtainable from the Establishment Officer, The Middlesex Hospital, London W1N 8AA (Tel: 636 8333 Ext. 536).

The Middlesex Hospital

3542

BOTSWANA
ASSISTANT ENGINEER
GRADE I

Required by the Posts and Telecommunications Department to be responsible for an area including rural automatic exchanges, open wire carrier systems, VF telegraphs, some plant and 2 GHz microwave equipment.
Candidates, preferably 30-45 years, must hold the City and Guilds Final Certificate in Telecommunications or an equivalent qualification and have a minimum of five years' experience, excluding training, in a transmission/radio field. Candidates with some knowledge of automatic exchange and subscriber apparatus will be preferred.
Commencing salary including Supplement will be in the range of £2,300 to £3,280. A substantial gratuity is also payable.
Because of lower rates of Income Tax in Botswana, the gross emoluments are roughly equivalent to UK salaries of
£3,450 to £4,550 for a single man
£4,250 to £4,900 for a married man with two children
Other benefits include—Subsidised Accommodation; Holiday Visit Passages; Education Allowances; Free Family Passages; Appointment Grant £100/£200 and Car Loan Normally Payable; 24-36 Month Tour.
The post described is partly financed by Britain's programme of aid to developing countries administered by the Overseas Development Administration of the Foreign and Commonwealth Office.
For further particulars you should apply, giving brief details of experience to

crown agents

M Division, 4 Millbank, London SW1P 3JD, quoting reference number M2K/730428/WF.

[3440

Electronic Test Engineers
Ramsgate or Bracknell
Housing Available

Racal Communications Limited, who are engaged in the design and manufacture of professional communications equipment, have vacancies at their Thanet Division in Ramsgate, Kent for
SENIOR TEST ENGINEERS,
TEST ENGINEERS AND TESTERS
who will be involved in the testing of sophisticated P.C.B. and modular assemblies. A knowledge of transistorized transmitter and receiver techniques is required, and previous experience of production testing would be an advantage.

For the right men these are excellent opportunities to become involved in an ambitious new enterprise.

In addition to the vacancies at our Thanet Division, we also require Test Engineers and Testers at our Company in Bracknell, Berkshire, to work on similar equipments. **Housing may be available both in Bracknell and Ramsgate for suitable applicants.**

These positions command good salaries together with excellent conditions of service including sick pay and pension schemes.

Communicate with Racal

If you are interested, please write, enclosing brief details of previous experience, stating the area preferred, to:

Mr. A. J. Franklin,
Personnel Manager,
Racal Communications Limited,
Western Road, Bracknell,
Berkshire.

RACAL The Electronics Group [3530

HI-FI ENGINEERS

This could be the opportunity you've been looking for. Due to continued expansion we are looking for experienced engineers to join our teams in Liverpool, Manchester and Preston.

You will be fully experienced in servicing a wide range of audio equipment and will be capable of supervising a modern, busy workshop.

Salary negotiable around £1,750.

Assistance with re-location expenses will be given by the company.

HR HARDMAN RADIO

Applications in writing to
The Managing Director
Hardman Radio
33 Dale Street
Liverpool L2 2HF

3551

EMI RECORDS LIMITED

Maintenance Electronic Engineer

EMI

International leaders in Electronics, Records and Entertainments.

Due to the continuing expansion of the Tape Record Division, we wish to appoint two additional Electronic Engineers to work on a double day shift basis.

The Engineers are required primarily to diagnose and rectify faults which occur on a wide range of audio recording equipment. Some of the time, however, will be devoted to new development projects which are being introduced into the Division.

Applications for these positions are invited from Engineers of proven ability (preferably with Hi-Fi experience), who are qualified to at least City and Guilds standard.

If you have a keen interest in audio reproduction and you would like to join a progressive company offering a good basic salary and conditions, please telephone for an application form or write with a brief summary of experience to:

R. Flower, Personnel Officer, EMI Records Limited,
1/3 Uxbridge Road, Hayes, Middlesex. Tel: 01-561 8722 Ext: 176.

3572

COMMUNICATIONS ENGINEERS

WELLINGBOROUGH

Career opportunities offered by Britain's leading communications company to qualified

PAX AND PABX
Estimating and Project Engineers

ALARM & CONTROL
Estimating and Project Engineers

SOUND BROADCASTING
Estimating and Planning Engineers

TECHNICAL AUTHOR

Assistance with relocation to this delightful part of England.

Write or phone H. Hill,
RELIANCE SYSTEMS LTD.,
Turnells Mill Lane, Wellingborough, Northants NN8 2RB. Tel. 093 33 5000.

[3514

GENERAL MANAGER MALAWI

We are seeking an executive capable of managing a well established and profitable radio manufacturing Company within the M.D.C. group.

The company specialises in the manufacture of transistor portables for AM application on M.W. and S.W. Plans are in hand for the use of ICs in the near future.

The applicant should be a good administrator with a knowledge of accounts budgets and financial controls. He will be solely responsible to the Board of Directors for the efficient and profitable operation of the Company. A knowledge of semi-conductor technology as applied to the set making industry would be an advantage.

Salary would be negotiable. Other benefits include a 25% gratuity on the completion of a 3-year contract; passages paid for the Officer, his wife and family if residing outside Malawi, a Company car and house would be provided.

Please apply to MALAWI BUYING AND TRADE AGENTS, Recruitment Section, c/o Berners Hotel, Berners Street, London, W1A 3BE for application form and further particulars quoting reference number B180.

[3564

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR
SCHOOL OF PHYSICAL & MOLECULAR SCIENCES

ELECTRONICS TECHNICIAN GRADE 5

RE-ADVERTISEMENT

Applications are invited for the post of Electronics Technician Grade 5 in the above mentioned School.

The successful applicant would be concerned with the servicing and maintenance of existing electronic equipment for teaching and research and with the development and construction of new specialised equipment.

Applicants should have had several years' practical experience in digital and linear solid state electronics, preferably in industry, coupled with theoretical knowledge to about H.N.C. standard.

Salary at an appropriate point on scale:—
£2,007-£2,382 per annum.

Pension Scheme.

Applications (two copies), giving full details of age, qualifications and experience together with the names and addresses of two referees should be submitted to the Secretary and Registrar, University College of North Wales, Bangor, by not later than the 29th March, 1974.

[3511

SENIOR TEST & SERVICE ENGINEER FOR TELECOMS TEST EQUIPMENT

Applications are invited for the above position. Candidates should possess H.N.C. (electronics), City and Guilds final certificate (telecomms) or equivalent qualifications, and have a minimum of five years applicable experience. A knowledge of digital circuits and basic programming will be a decided advantage.

The successful candidate will become a member of a small group providing service on a wide range of high precision measuring instruments for the telecomms industry. The work will include installation and proof testing of computerised automatic measuring systems at customers' premises.

The position offers a salary in the range of £2400-£2900 with generous annual bonus and a pension scheme. Excellent working conditions for 37½ hour week.

Send application and resume to:

WANDEL & GOLTERMANN (UK) LTD.
40-48 HIGH STREET
ACTON, LONDON, W3
Telephone: 01-992 6791

[3498

ELECTRONICS

Maintenance & Prototype Construction

Reckon you've got a flair for electronics? If so, we'd like to hear from you. We are a highly successful expanding outfit, among the leaders in the field of electronic components. To get the most out of our wide range of new equipment, we need a number of highly skilled technicians who really know what they're doing. There's plenty of work, lots of money to be made, and a secure long-term future, plus good prospects for promotion if you're interested.

For full details call 01-300 9017 at any time (24 hour answer service).
ITT Semiconductors, Footscray, Kent.

Semiconductors ITT

3564

COMPUTER ENGINEERS

your line to success as a computer service engineer

Vacancies exist in the London, Manchester and Liverpool areas for engineers with computer or electronic or electro-mechanical experience. In addition a number of senior vacancies exist for engineers (particularly with teleprocessing experience) who wish to develop their existing management skills. The Company pays attractive salaries together with generous fringe benefits including bonus, car allowance and non-contributory Pension Scheme.
For further details write or telephone.

COMPUTER FIELD MAINTENANCE LTD. *a member of the Computer World Trade Group of Companies.*
99 Bancroft, Hitchin, Hertfordshire Telephone: Hitchin (0462) 51511

3196

COMPUTER ENGINEERING

We require additional Electronic and Electro-Mechanical Engineers, to be involved in the maintenance of medium to large scale digital computing systems.

Training programmes will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City & Guilds or Radio/Radar experience in the Forces.

After training, and in appropriate circumstances, shift allowances will enhance the competitive basic salary, as will our twice yearly bonus. A contributory pension plan includes generous life insurance.

Opportunities also exist for more junior trainees, aged 18 and over, who should have a good standard of education, an aptitude for, and an interest in, mechanics, electronics and computers.

Please write for an application form, Quoting Ref. WW to:— E. J. Young, NCR 1000 North Circular Road, London NW2 7TL.

Plan your future with NCR

3255

CENTRAL ELECTRICITY
GENERATING BOARD
South Eastern Region

DUNGENESS POWER STATION

VACANCY:

INSTRUMENT MECHANIC

Applications are invited for the post of Craftsman (Instruments) at Dungeness Nuclear Power Station, Romney Marsh, Kent.

The successful candidate can earn up to **£45** per week, including productivity bonus payments. This post offers most excellent opportunities for a good Instrument Mechanic to broaden his experience in the field of modern electronics.

Applicants will be considered from candidates with experience of electronic instrumentation and/or closed circuit television.

The employment offers generous holidays with pay (plus one day off with pay each month), sick pay scheme, contributory pension scheme, canteen facilities and Sports & Social Club, etc.

- **A rented council house may be available to a married man living outside the normal daily travel area.**

Applications in writing giving full details of age, experience and career to date, should be sent to:

STATION SUPERINTENDENT, CENTRAL ELECTRICITY GENERATING BOARD, DUNGENESS NUCLEAR POWER STATION, ROMNEY MARSH, KENT, TN29 9PP. To arrive 8th April, 1974, quoting Vacancy No. 5068/74. (WW)

3591

Storno

RADIO COMMUNICATION SYSTEMS

We have vacancies for:

SERVICE TECHNICIANS

for our Service Department based in Camberley. Applicants should be familiar with transmitter/receiver practice and have practical knowledge of radio communications.

ELECTRONIC TEST TECHNICIANS

based in Camberley to work on preparation, development, test and fault finding of special FM/VHF/UHF communications and control systems, preferably with previous experience in radio communications technology and control systems.

FIELD SERVICE TECHNICIANS

in the Greater London area. Applicants should have experience in fault finding and testing of UHF/VHF radio equipment. Current driving licence essential, company vehicle provided.

REPAIR GROUP TECHNICIANS

based in Camberley to work on fault finding and repair of electronic sub-assemblies and main equipments.

SALARIES UP TO £2000 PER ANNUM PLUS OVERTIME.

The Company has much to offer those who are interested in the sophisticated, modern world of radio-telecommunications and who can demonstrate their ability in this field.

Please contact: **The Personnel Officer, Storno Ltd., Frimley Road, Camberley, Surrey. Telephone 0276 29131.**

3592

CIRCUIT DEVELOPMENT ENGINEERS TELEVISION SYSTEMS SALARY RANGE £7,000 (OPEN)

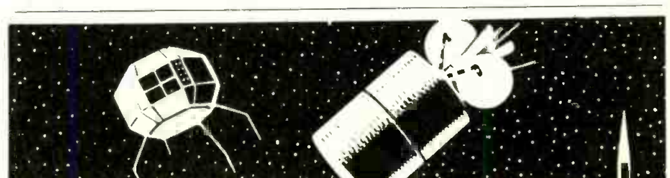
The Grass Valley Group, Inc. (USA), a leading manufacturer of television line and terminal equipment, has immediate openings for highly qualified circuit development engineers. Specifically, we are looking for creative and resourceful people who are capable of carrying ideas through to completed products. Applicants are expected to be familiar with the latest solid state devices and techniques, and preferably should have experience in the design of video switching systems, video processing systems, and possibly digital video systems. Some experience in television studio operations and techniques is also desirable. Educational requirements are a C.E. or a B.Sc. in electronic engineering. A minimum of five years' design experience is required.

If you are interested in a challenging and rewarding career with an expanding company, please airmail a resume of your educational and technical background, work experience, and personal history to William L. Rorden, Chief Engineer, The Grass Valley Group, Inc., P.O. Box 1114, Grass Valley, California 95945, USA. Resumes need not be formal; however, we are interested in learning as much about you and your experience as possible. Immediate consideration will be given and response made to suitable applicants, with a view toward arranging personal interviews in London in early 1974. All resumes will be treated in confidence. References will be required at or prior to the time of interview.

Grass Valley is a small town located in the foothills of the Sierra Nevada mountains in northern California, adjacent to summer resort and ski areas, and 2 1/2 hours from San Francisco.

THE GRASS VALLEY GROUP, INC.

3570



A Long-term future in **BRISTOL**

DRAUGHTSMEN

are required to support our Technology teams who are currently working on a number of new and exciting projects in both our Guided Weapons and Electronics & Space Systems Groups. Applicants must have previous design, detail or layout experience in an electronic or electrical environment. Some experience of printed circuit board layout and design would be desirable for electronics applicants.

Please 'phone or write to:–

**Mr. P. M. Farmer,
Personnel Officer (Ref. GW/231),
British Aircraft Corporation,
Guided Weapons Division,
Filton, Bristol, BS99 7AR.
Tel: Bristol 693831 Ext. 778**

BAC

3561

GUIDED WEAPONS DIVISION

Electronics Engineers

In order to fully meet our future programmes we find it necessary to strengthen our existing design teams and are therefore seeking experienced electronics engineers for positions in one or other of the following design areas.

R.F. Engineering as required in the development of F.M. and A.M. tuners.

Audio engineering as required in the development of tape recorders and high-fidelity amplifiers.

Candidates should be of graduate or equivalent status with proven ability in one of the above areas or a related area.

Good salaries will be offered and the prospects in these expanding teams are excellent. Help can be given with removal expenses where necessary.

Applicants are invited to write or telephone in the first instance for an application form to: Personnel Officer, Decca Radio & Television, Golf Course Lane, Leicester. Tel. 0533 872101 Ext. 54.

DECCA

Electronic Technicians

WALSGRAVE HOSPITAL

Electronic Technicians are required for the Electronics Department dealing with the maintenance of a wide variety of electronic and electro-medical apparatus.

Applicants must possess H.N.C., H.N.D. or O.N.C. in electronics or equivalent City and Guilds Certificate.

General diagnostic maintenance experience in the electronic field is necessary. Training in maintenance of specialised hospital equipment will be given.

Salary scale from £1,719 to £2,211 p.a. Additional payments are made if overtime is required.

Applications stating age, qualifications and experience, together with two referees should be sent to the Group Engineer, Coventry Hospital Management Committee, P.O. Box 92, The Birches, Tamworth Road, Keresley End, Coventry.

Coventry Hospital Management Committee

3553

Avionics Inspector

Due to continued growth and expansion in our Avionics Service Centre, an interesting opportunity exists for an experienced electronic test engineer to join our Quality Control team as Avionics Inspector.

Have You?:

ONC or equivalent.
Practical electronic equipment experience including calibration.
Working knowledge of Ministry and C.A.A. procedures.

If so, you could be the engineer we are seeking.

Attractive salary negotiable from £2,200.
3 weeks' paid annual leave, excellent sickness benefits, and contributory pension scheme.

Please apply immediately for interview:
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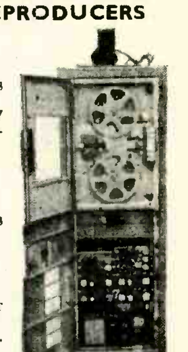

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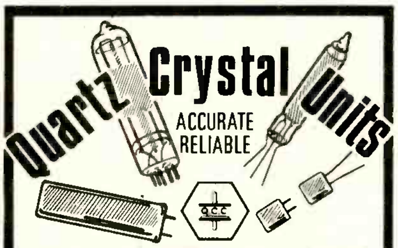

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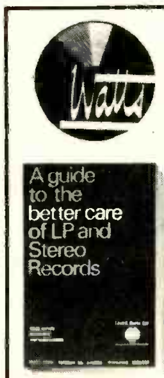

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You can't afford to ignore the new Bradley 234. It's a two-channel, eight digit 100MHz Counter Timer that offers all the facilities you would expect from an expensive instrument – but at the very realistic UK price of £275.

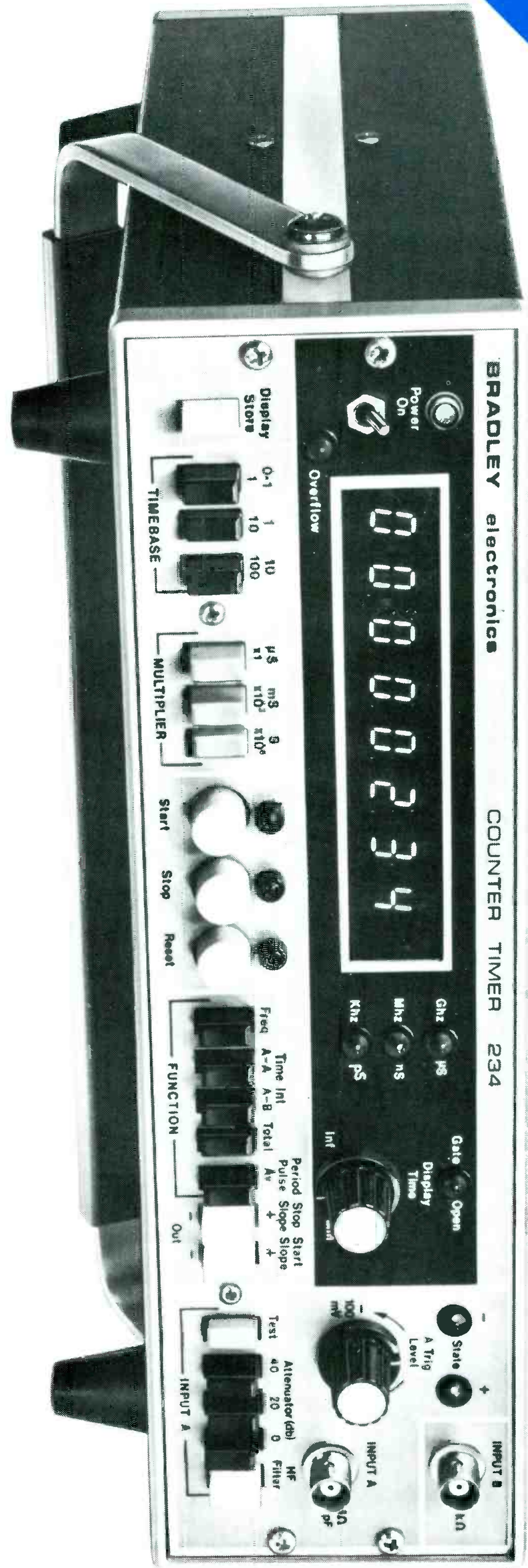
The 234 provides Frequency, Totalise, Period, Period Average, Ratio, Time Interval Average down to 25 ns and Time facilities in a compact and sturdy package. The 10 MHz clock is temperature compensated; alternatively, you can specify, for a moderate extra cost, a high stability clock in a temperature controlled oven. And there's a third 'C' channel for an external clock, or for ratio measurements.

Solid state circuitry incorporates an HF filter which permits low frequency measurements to be made in the presence of high frequency interference.

Other features include display storage and standby mode facility. And the Bradley 234 comes complete with a rugged, impact-resisting case and combination carrying handle and adjustable stand.

To find out more about the 234 Counter Timer, one of the new generation of precision instruments from Bradley, please telephone 01 - 450 7811. Ask for Jim Clarke on Ext. 113. Or drop him a line at the address below.

Price quoted does not include VAT



Our own BCS Certificate is available.

G & E BRADLEY LIMITED,
Electral House, Neasden Lane,
London, NW10 1RR
Telephone: 01-450 7811
Telex: 25583
A Lucas Company

BRADLEY electronics

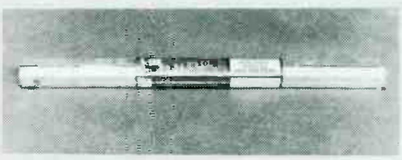
WW—002 FOR FURTHER DETAILS

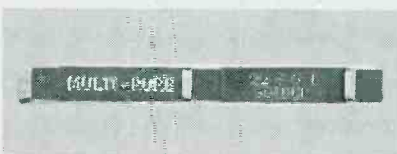
Multicore– the complete answer for printed circuit soldering.

Most printed circuit soldering problems can be avoided by using quality products and seeking quality advice. Naturally, we suggest ours. First, let's talk about quality products.

Extrusol and Multipure.

EXTRUSOL Extruded Bars and MULTI-PURE Cast Bars are made from specially processed ultra high purity solder. EXTRUSOL bars and pellets are protected by plastic film from the moment they are made to the moment they are used. And MULTI-PURE bars are probably the smoothest and brightest solder bars you will ever see.





Ersin Multicore Savbit.

This cored solder has countless uses. For instance, it avoids erosion of copper plating and wires as well as prolonging the life of soldering iron bits.

Liquid Fluxes.

We have a whole family of them, so you're bound to find the right one for your job. One of our latest is Activated RESIN 366 flux, exceptionally fast but non-corrosive and non-conductive.

Right, those are the products. Now for the advice. And we can't really say any more than: if you've a soldering problem or question, call us. We really do have all the answers and the widest range of test equipment.

ROSIN BASE

ERSIN Flux No.	Type	Solids Content w/w	Specifications
0360	non-activated	38%	MIL-F-14256D Type R; DTD 599A DIN 8527 F-SW 31
5381	mildly activated Chloride and Bromide free	25%	MIL-F-14256D Type RMA; DTD 599A
304D	mildly activated	10%	DIN 8527 Type F-SW 32
304W	Halide Free	25%	DTD 599A
PC.21A	activated	38%	DTD 599A; DIN 8527. F-SW 26
PC.25	activated	25%	DTD 599A; DIN 8527. F-SW 26
366	activated (extra fast)	38%	Meet DIN 8511 Type F-SW 26 and
366A-25	activated (extra fast)	25%	pass DTD 599A Corrosion Test
ORGANIC ACID			
PC.101	water base	12%	Water soluble residues must
PC.112	solvent base, fast drying	9.5%	be removed after soldering.
INORGANIC ACID			
ARAX	water base extremely active	40%	Used with most "very difficult to solder" metals. Not for electronics assembly joints.

Solderability Test Instrument.

Already used by major electronic companies throughout the world, this novel instrument saves production costs by controlling solderability of component leads which, unlike a printed circuit, cannot be assessed by a simple "immersion and inspection" test.

Multicore Soldering Chemicals.

We make a complete, compatible range to assist in soldering processes. They clean, protect and preserve.

ERSIN Multicore 5 CORE SOLDER

For full information on these or any other Multicore products, please write on your company's letterhead direct to:

Multicore Solders Limited, Maylands Avenue, Hemel Hempstead, Hertfordshire HP2 7EP.

Tel: Hemel Hempstead 3636. Telex: 82363.