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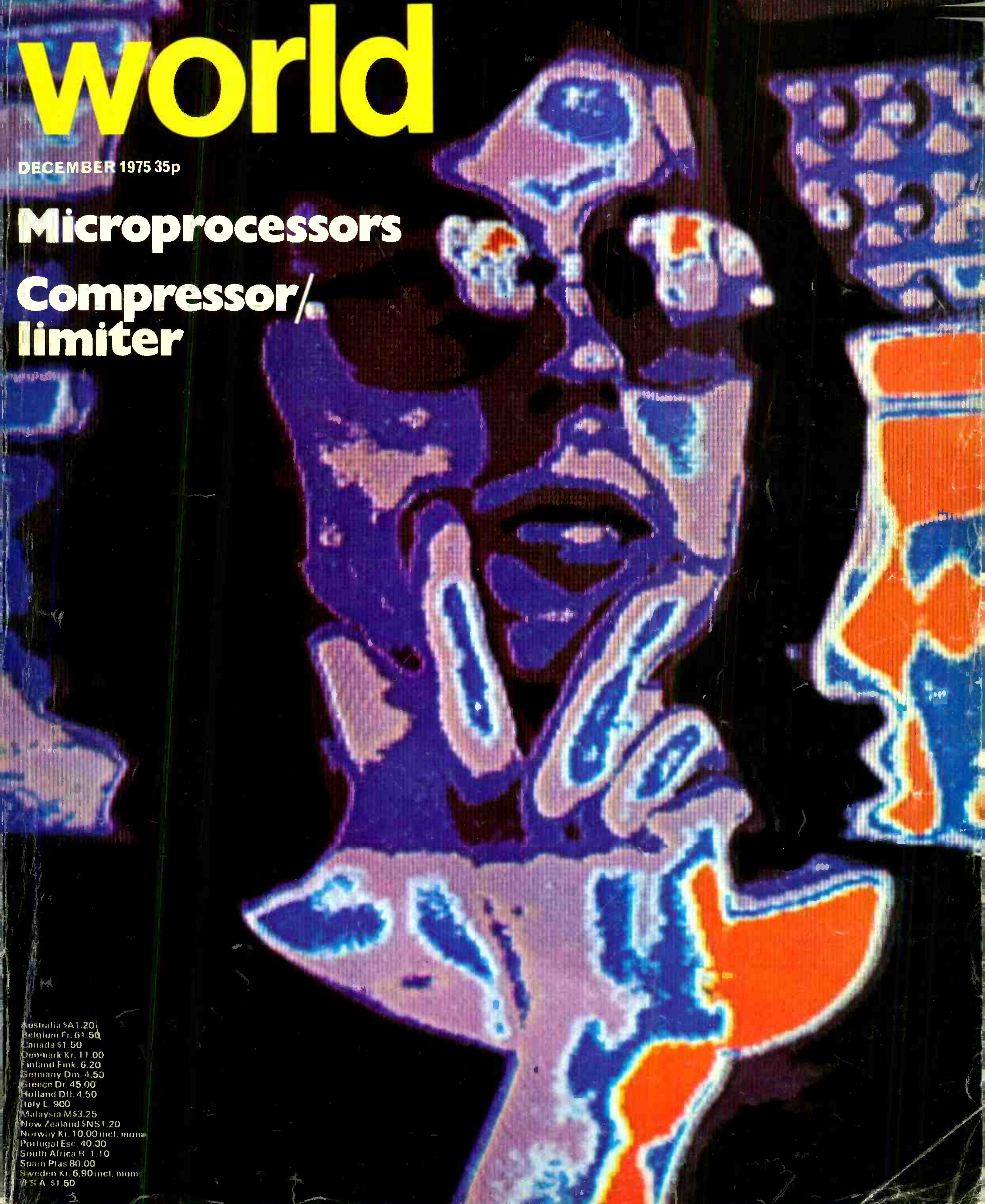

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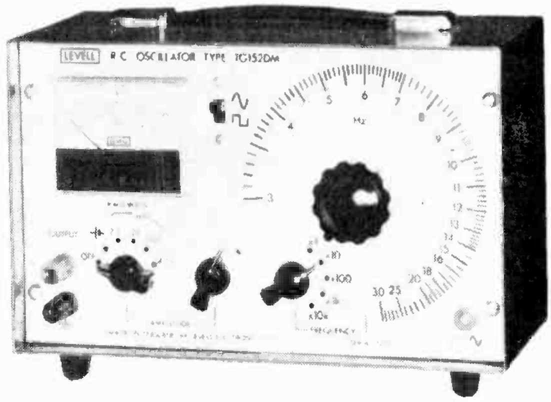

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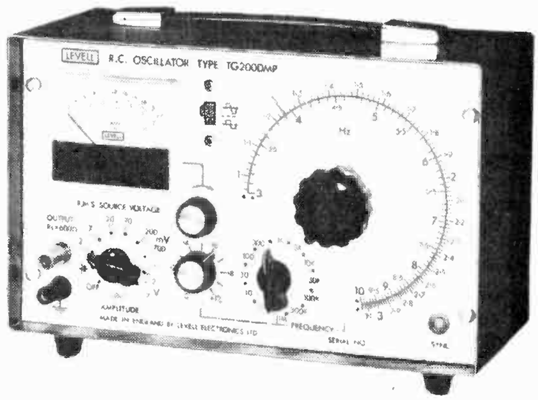

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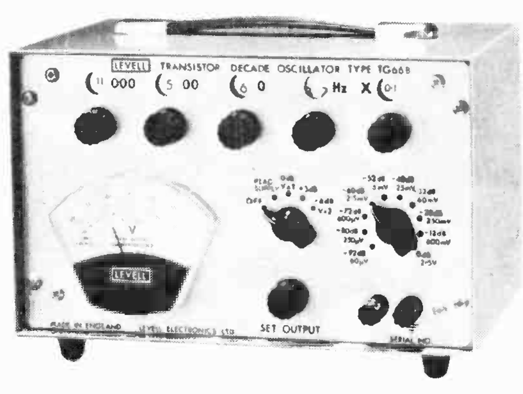

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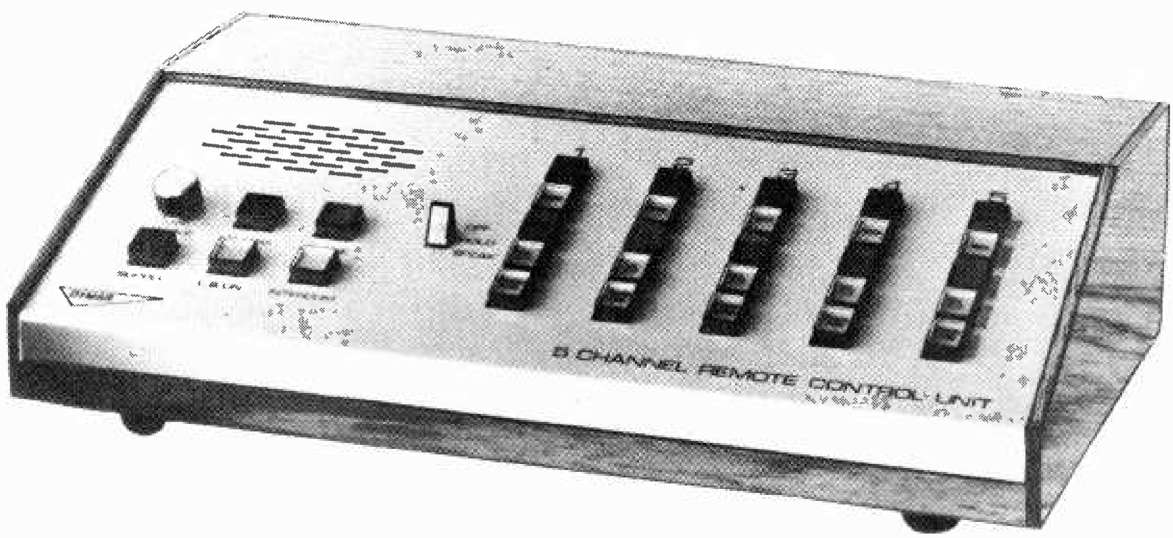

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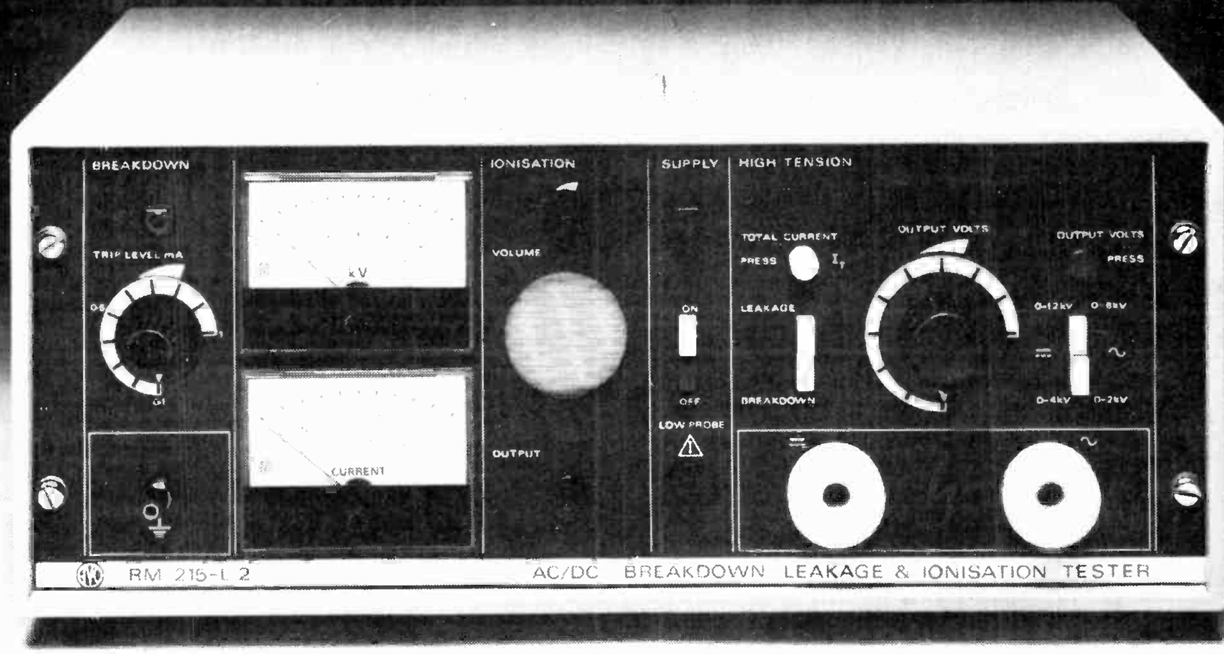

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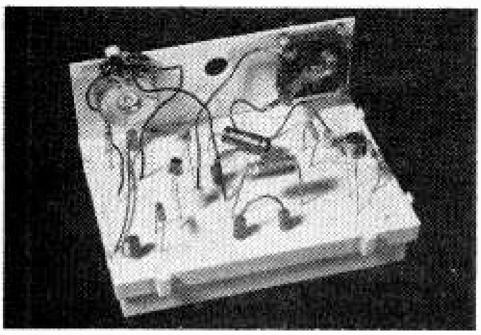

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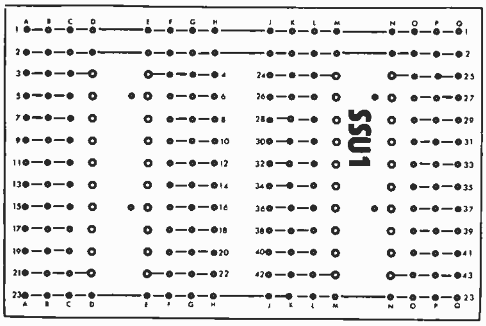

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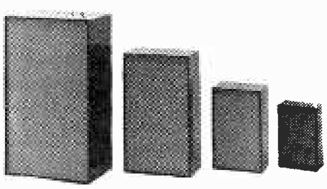

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0.1-100MHz source/detector **SR268**
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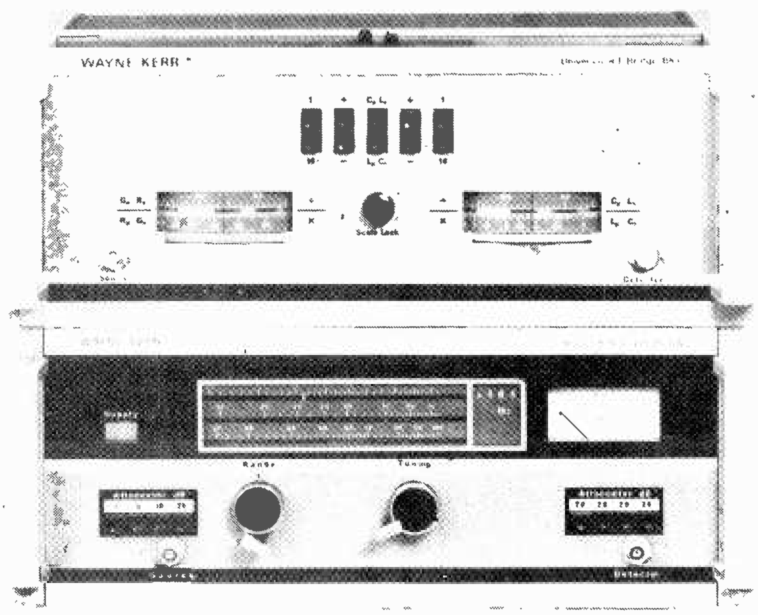

The B602 transformer ratio arm bridge measures impedance in all four quadrants of the complex plane over the frequency range 100kHz to 10MHz. Because of novel features incorporated in the design, values from virtually a short circuit to an open circuit can be measured. This bridge has established a standard of performance and flexibility which is unobtainable from any other radio frequency bridge.

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SPECIFICATION

B602	
Frequency range	100kHz to 10MHz
Accuracy	1% up to 3MHz, 1pF to 10nF 10Ω to 100kΩ 1μH to 10mH
Overall impedance range	1fF to 1mF 100μΩ to 100MΩ (10n℧ to 10k℧) 10pH to 10H
SR268	
Frequency Range	100kHz to 100MHz in 9 bands (SR268L 46.5kHz to 46.5MHz)
Frequency accuracy	2–3% according to band used
Short Term Frequency Stability	0.01%
Output level	0.5–2.0V according to band used
Output attenuator	3, 6, 10, 20 dB additive steps, 75Ω
Input sensitivity for 10% meter deflection	1 to 30μV according to frequency setting
Input attenuator	4 steps of 20 dB, 75Ω
Detector bandwidth	2–3% according to band used

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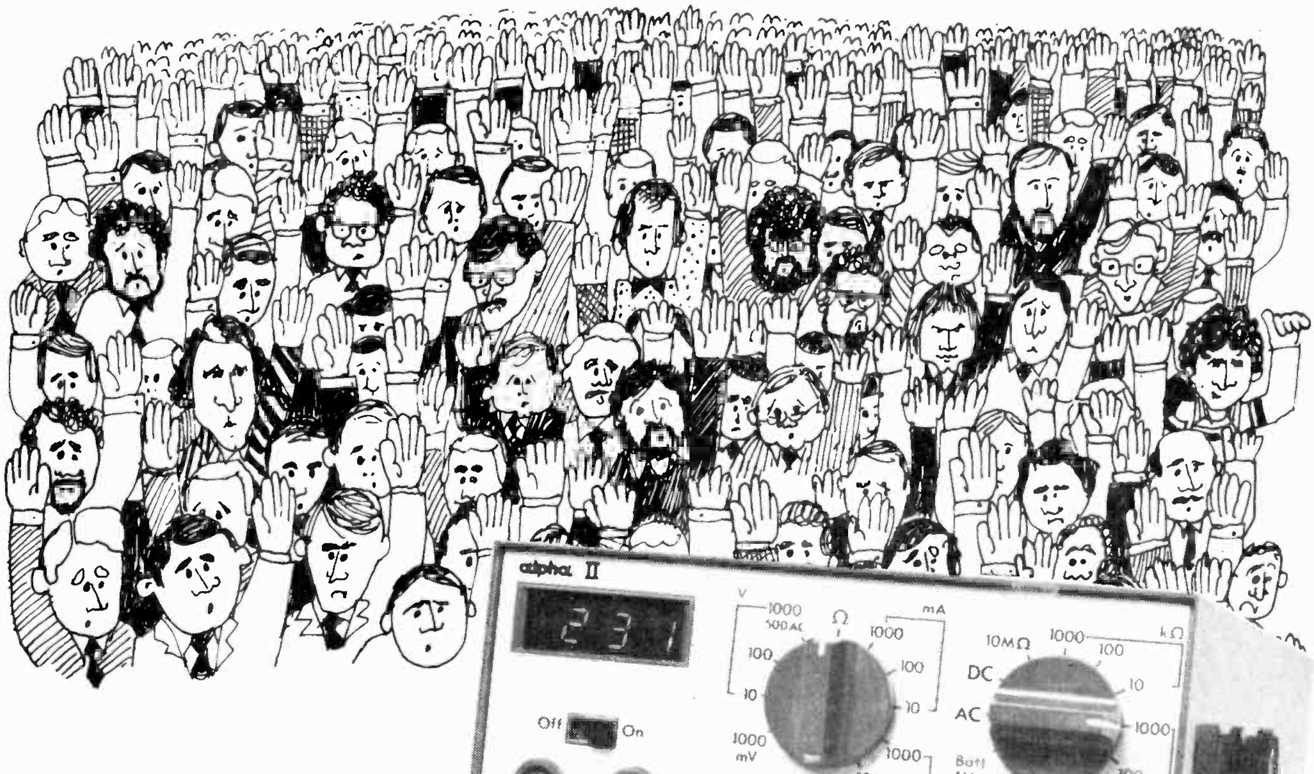

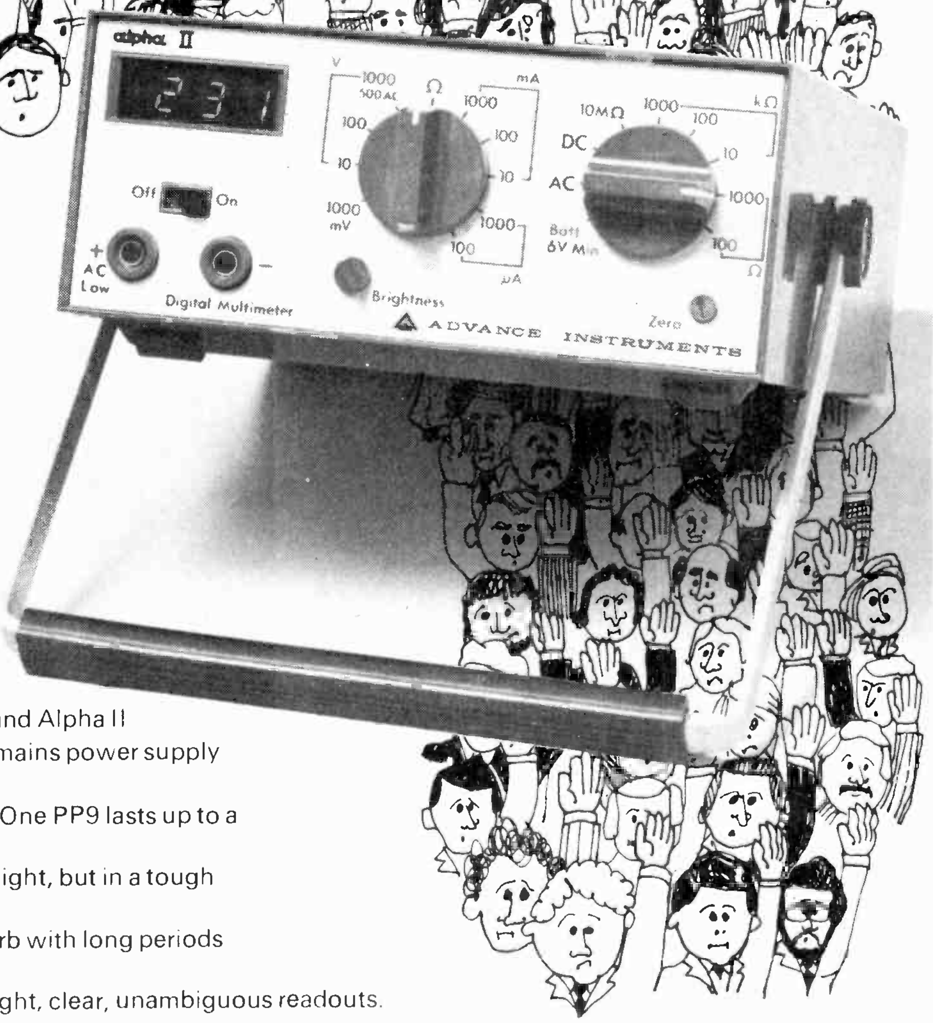

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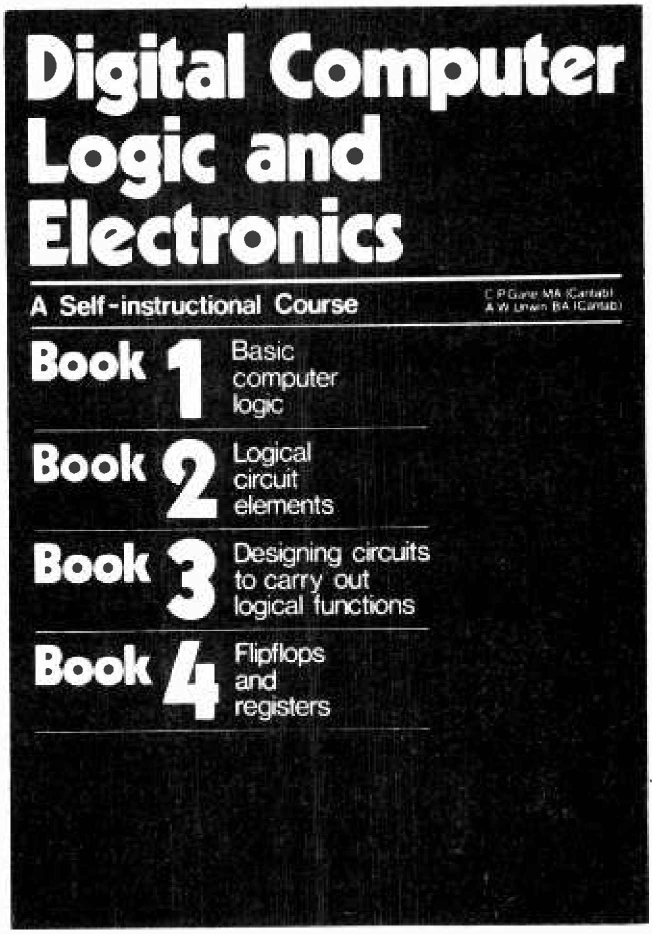

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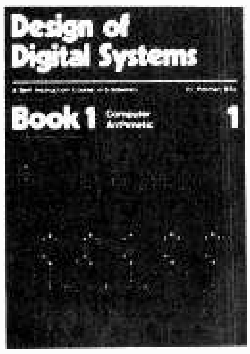

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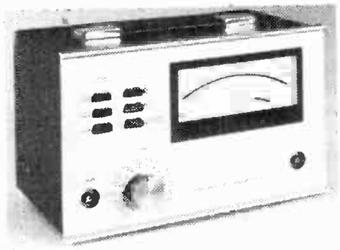

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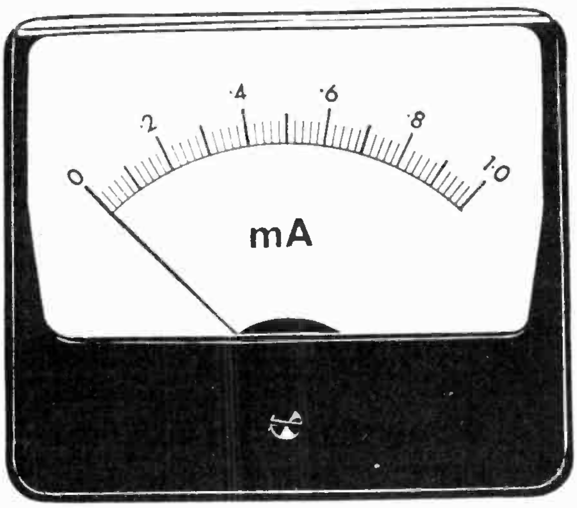

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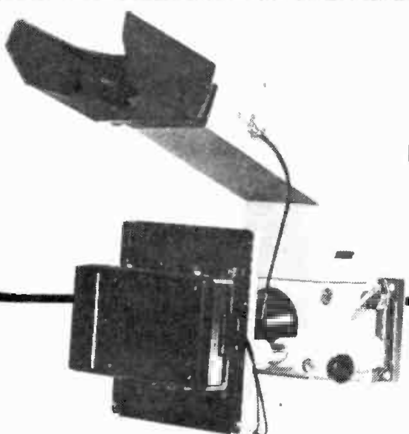

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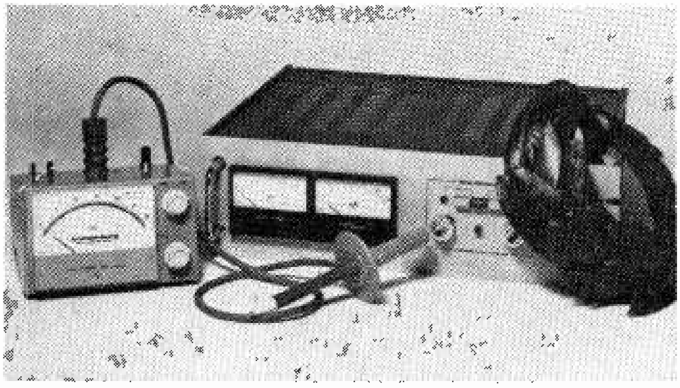
WW—041 FOR FURTHER INFORMATION

brandenburg's Olympian view.



Our Ensign range and HV meters.

Brandenburg produce a wider range of power supplies and associated equipment than any other British manufacturer.

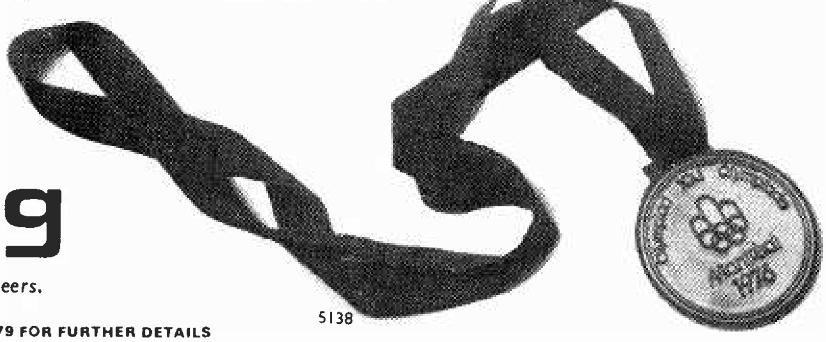
There's our high technology Ensign range of HV power supplies. Featuring the exceptionally high stability level of 10 parts in 10^{-6} at voltage outputs from 3—30kV at 500 µA to 6—60 kV at 250 µA, the Ensign is designed for 19" rack mounting. Operation is from 200—250V r.m.s. 50 H_z supply at ambient temperatures between 0°C and 35°C.

And our HV meters. Designed for accurate measurements of line voltages in the ranges 0—5kV; 0—15kV and 0—30kV at better than 1% accuracy at full scale or 1% f.s.d. Our probe and cable assemblies are available separately.

We at Brandenburg believe Britain does not do enough at or for the Olympic Games. So, as we are British through and through, we thought we would get our industry involved.

Please use our enquiry number and, apart from receiving full information on our Ensign range and meters, it could be the first step in your winning a free trip to the Montreal Olympics. We'll send you an entry form for our Olympian Competition which is, we are sure you'll agree, great fun. Get in training; use your pen now.

Brandenburg Limited,
939 London Road,
Thornton Heath,
Surrey CR4 6JE
England.
Telephone: 01-689 0441.
Telex: 946149



brandenburg

Due to our continued expansion, we have vacancies for sales engineers, development engineers and production personnel.

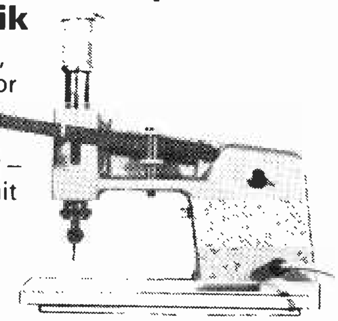
5138

WW 079 FOR FURTHER DETAILS

For printed circuit boards . . .

It pays to know the right drill

KB-2 drilling machine by Kema Elektronik



The KB-2 is a compact, high-speed drill ideal for all precision drilling tasks in workshop or laboratory – especially printed circuit board work. With a 2mm maximum drill diameter, and a 20mm maximum drill depth, it runs at 15,000 rpm with voltage (variable) 220 volts and maximum power 25 VA. Measuring $13\frac{1}{2}$"x $5\frac{1}{2}$"x 10", the KB-2 is Swiss precision engineered, extremely reliable and moderately priced.

For full details, contact:

SPECIAL PRODUCTS DISTRIBUTORS LTD.
81 Piccadilly, London W1V 0HL. (01-629 9556)

WW—011 FOR FURTHER DETAILS

MODEL U-50DX

sanwa MULTI TESTERS

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

6 Months' Guarantee — Excellent Repair Service

MODEL P2B	£11.75	MODEL F80TRD	£26.40
MODEL JP5D	£12.80	MODEL AT45	£23.15
MODEL BX 505	£22.90	MODEL 380CE	£29.12
MODEL YX360TR	£14.90	MODEL N101	£31.85
MODEL U50DX	£16.10	MODEL 460ED	£35.13
MODEL A303TRD	£19.15	MODEL EM800	£74.50
MODEL K30 THD	£24.20	MODEL R1000CB	£75.27

THESE PRICES DO NOT INCLUDE V.A.T.

Cases extra, available for most meters, but not sold separately

Please write for illustrated leaflet of these and other specialised Sanwa meters

SOLE IMPORTERS IN UK

QUALITY ELECTRONICS LTD.
47-49 HIGH STREET, KINGSTON-UPON-THAMES, SURREY. KT1 1LP
Tel: 01-546 4585

WW—014 FOR FURTHER DETAILS

New - Thermostatic - Compact
Fast - Accurate - Self Contained
Adjustable

TC50
Thermostatic Soldering Iron

The new Litesold TC50 thermostatic soldering iron is specially designed for production line use in the electronics industry.

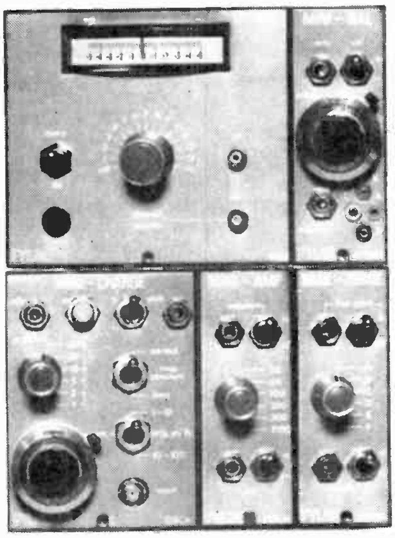
* COMPACT	Only 3″ from tip to handle. Weighs only 2½ oz. without flex. Less tiring to use.
* SELF CONTAINED	Mains version requires no power unit. 24 volt version uses existing soldering iron power units.
* ADJUSTABLE	Simple Allen screw adjustment between 180°C and 420°C whilst running without changing bits.
* ECONOMIC	Better performance at lower cost than many other thermostatic irons.
* FAST	Reaches 350°C in less than 90 secs. Recovery from 300°C to 350°C in 10 secs.
* ACCURATE	Holds set temperature in any attitude with no overshoot.
* VERSATILE	Slip-on long-life bits in 6 shapes and sizes.
* SAFE	Indicator lamp in handle shows operation of control.
* DETAILS	Leaflet giving full details and specification available now.

LIGHT SOLDERING DEVELOPMENTS LTD
97–99, Gloucester Road, Croydon, CRO 2DN. 01–689 0574
346

WW—084 FOR FURTHER DETAILS

FYLDE

TRANSDUCER and RECORDER
AMPLIFIERS and SYSTEMS

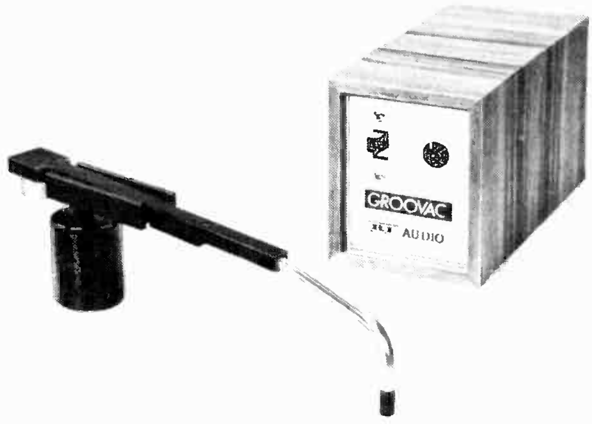


reliable high performance & practical controls. individually powered modules—mains or dc option single cases and up to 17 modules in standard 19″ crates small size—low weight—realistic prices.

FYLDE
Fylde Electronic Laboratories Limited.
49/51 Fylde Road Preston
PR1 2XQ
Telephone 0772 57560

WW—026 FOR FURTHER DETAILS

GROOVAC



vacuum record cleaner

Vacuum cleaning is the best way to remove dust, especially fine dust. Now with the Groovac, vacuum cleaning is available for extracting the particles from inside record grooves which are responsible for record and stylus wear — while your record is playing.

For full details please write to:—

RI AUDIO
Kernick Road, Penryn
Cornwall TR10 9DQ, England
Telephone: Penryn 72753

WW—040 FOR FURTHER DETAILS

ARE YOU HAVING TROUBLE

WITH THE WIRELESS WORLD TUNER?

The kits we supply are fully guaranteed to work, and if trouble should arise we can, and do, put it right. But there are possibly thousands of tuners about which we know nothing, because the parts were not purchased from us. If you have one of these tuners and are having any sort of trouble with its construction or operation, we would like to help. Why? Well, we believe in our design, and know that if it is built correctly it will work, and work better than most. Unfortunately, things are not always as simple as they seem; there were misprints in the article; 'equivalent' devices are not always the same; and a simple dry joint can take a long time to trace. So, if you have built our tuner, or are thinking of doing so, why not write now for your—

FREE TROUBLE-SHOOTING KIT

This includes:
- 11-page article reprint
- Full list of errors, etc.
- Voltage check chart
- Checking routine and
- Diagnostic hints

In fact all you need to know to get it working the way it was intended to work. Please send a S.A.E. size A5 (6 x 8½ min) today, as this offer is only open up to 1st Jan.

If you haven't started yet, why not avoid all possibility of trouble and buy one of our kits. You will get an immediate acknowledgement, prompt delivery ex-stock, a guarantee of success or free repair, in fact a complete after-sales service by the designers.
All our sub-assemblies are available ready built and tested for even less trouble, or you may have a fully assembled tuner with a **five** year guarantee. Send today for full details (S.A.E., please) to:

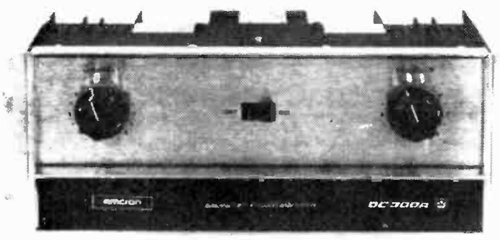
Main Tuner Board Kit	£24.55
Decoder Board Kit	£7.05
Full Tuner Kit	£85.00
Ready built	£102.00
	(+25% VAT)

Icon Design

**33 RESTROP VIEW
PURTON, WILTS., SN5 9DG**

A PEACEFUL CHRISTMAS TO YOU ALL

HIGH POWER DC-COUPLED AMPLIFIER



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

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

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

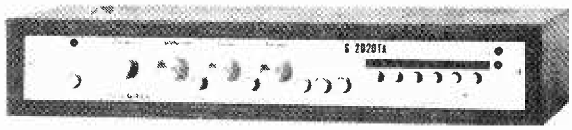
Other models in the range: D60 — 60 watts per channel D150 — 150 watts per channel

MACINNES LABORATORIES LTD

**MACINNES HOUSE, CARLTON PARK INDUSTRIAL ESTATE, SAXMUNDHAM, SUFFOLK IP17 2NL
TEL: (0728) 2262 2615**

S-2020TA STEREO TUNER/AMPLIFIER KIT

NEW PRODUCT

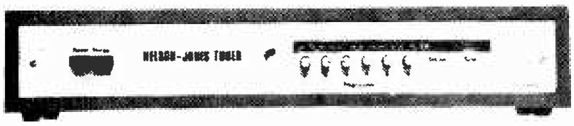


SOLID MAHOGANY CABINET

A high-quality push-button FM Varicap Stereo Tuner combined with a 20W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier: Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc), THD less than 0.1% at 20W into 8 ohms. All sockets, fuses, etc. are PC mounted for ease of assembly. Tuner section: uses Mullard LP1186 module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88–104MHz. 30dB mono S/N @ 1.8μV. THD typ. 0.4%.

PRICE: £47.95 + 99p p&p + VAT.



NELSON-JONES STEREO FM TUNER

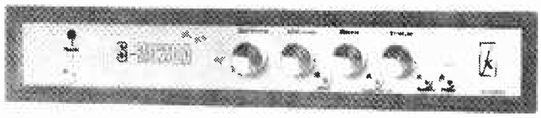
A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.

Brief Spec. Tuning range 88–104MHz. 20dB mono quieting @ 0.75μV. Image rejection—70dB. IF rejection—85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

PRICE: Mono £25.46 + 85p p&p + VAT;
With Portus-Haywood Decoder £31.96 + 85p p&p + VAT;
With ICPL Decoder £29.73 + 85p p&p + VAT.

NEW PRODUCT

S-2020A AMPLIFIER KIT



Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring.

Typ. Spec. 20 + 20W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc). Toroidal mains transformer.

PRICE: £29.95 + 99p p&p + VAT.

STEREO MODULE TUNER

A low-cost Stereo Tuner based on the Mullard LP1186 RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC. Variable INTERSTATION MUTE. PLL stereo decoder IC.

Typ. Spec. Sens. 30dB S/N mono @ 1.8μV. Tuning range 88–104MHz. LED sig. strength indicator. LED Stereo indicator. THD typically 0.4%.

PRICE: Stereo £26.32 + 85p p&p + VAT. Mono £22.40 + 85p p&p + VAT.

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS.

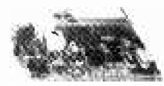
SUB ASSEMBLIES

BASIC NELSON-JONES TUNER

Supplied as a printed circuit board with all components and screening box to build a varicap tuner module. Performance spec as above for complete N-J Tuner. For suitable stereo decoders see below. (Illustrated without screening box.)

PRICE: £12.88 + 25p p&p + VAT.

BASIC MODULE TUNER



Supplied as a printed circuit board with all components and screened Mullard LP1186, to build a mono or stereo tuner module. Performance spec as above for Stereo Module Tuner complete kit.

PRICE: Mono £11.11 + 25p p&p + VAT; Stereo £13.89 + 25p p&p + VAT.

PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER

Mk II version of this design (WW Sept. 1970). The lowest distortion phase-locked stereo decoder kit available (Typ. 0.05% @ N-J Tuner O/P level). Separation 40dB up to 15KHz.
Complete kit comprises PCB and all components, inc. stereo LED.

PRICE: £7.68 + 25p p&p + VAT.

PHASE-LOCKED IC DECODER

Integrated circuit phase-locked stereo decoder based on the MC1310. THD typically 0.3%. Separation 40dB @ 1KHz.

PRICE: £4.27 + 20p p&p + VAT.

PUSH-BUTTON UNIT

The six-position push-button unit used in our tuners and tuner/amp. Each track has the required diode law for stability of tuning. There are approx. 40 turns on each button and there are six separate moving pointers. An AFC disable switch is incorporated with each button. The unit is finished in black with red pointers.

PRICE: £3.00 + 20p p&p + VAT.

Please send SAE for complete lists and specifications.

INTEGREX LIMITED, Portwood Industrial Estate, Church Gresley, Burton-on-Trent, Staffs, DE11 9PT. Tel. Swadlincote (0283 87) 5432. Telex 377106.

WW—055 FOR FURTHER DETAILS

A message for dealers in exclusive high quality audio equipment – everywhere.

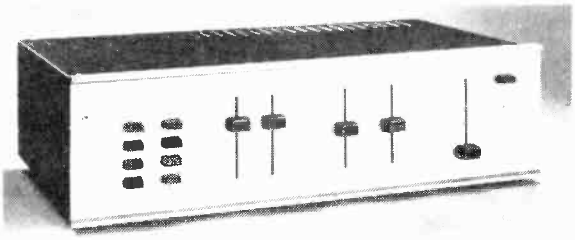
It is now proposed to expand the distribution of RADFORD products by supplying from the factory in BRISTOL direct to franchised dealers outside the United Kingdom.

If you have a discriminating clientele looking for the finest audio equipment and loudspeaker components available, you could profit from a direct RADFORD franchise.

Write today for details and leaflets.

Radford Audio Ltd
Ashton Vale Road
Bristol BS3 2HZ England

RADFORD



ZD22
Stereo Pre-amplifier Control Unit
A stereo pre-amplifier of virtually zero distortion. Inputs for disc, tuner, and two tape machines.
Size 17" x $4\frac{3}{4}$" x 10" deep. £145.00

HD250 Stereo Integrated amplifier
Incorporates ZD22 pre-amplifier with low distortion power amplifier of 50 watts per channel into 4-8 ohms load. Headphone output. Illustrated above.
Size 17" x $4\frac{3}{4}$" x 11". £195.00

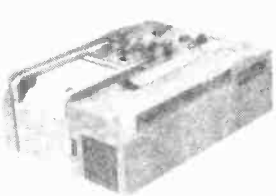
ZD100 Power amplifier
Power output 120 watts in 4 ohms and 75 watts into 8 ohms. Distortion less than 0.004% up to clip level.
Size 17" x $4\frac{3}{4}$" x 13". £175.00

ZD200 Power amplifier
Power output 250 watts into 4 ohms and 150 watts into 8 ohms. Distortion less than 0.004% up to clip level.
Size 17" x 7" x 13". £295.00

WW—052 FOR FURTHER DETAILS

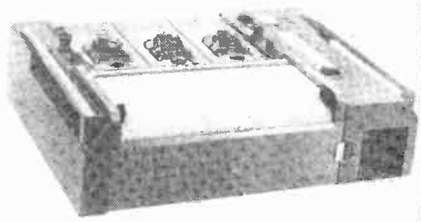
FAST RESPONSE STRIP CHART RECORDERS

Made in USSR



Type H3020-1
Single pen

Type H3020-3
Three-pen



Specification

Basic error 2.5%
Sensitivity . . . . 8mA F.S.D.
Response . . . . 0.2 sec.
Width of each channel 80mm
Chart speeds, selected by push buttons . . . . 0.1–0.2–0.5–1–2.5–5–12.5–25mm/sec.
Chart drive 200-250v 50Hz

Recording: Syphon pen directly attached to moving coil frame, curvilinear co-ordinates

Equipment: Marker pen, Timerpen, Paper footage indicator, 10 rolls of paper, connectors, etc.

Dimensions: H320-1: 285x384x16.5mm
H320-3: 475x384x16.5mm

PRICE: H320-1 £80.00
H320-3 £130.00
Exclusive of VAT

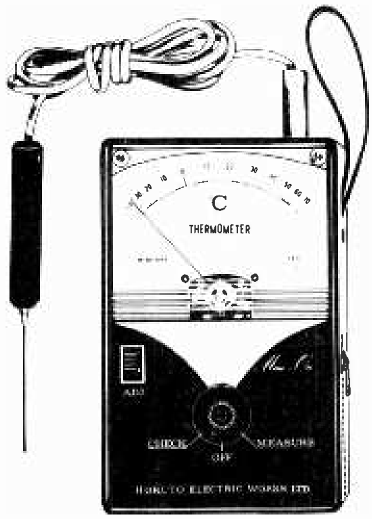
Available for immediate delivery

Z & I AERO SERVICES LTD.

44A WESTBOURNE GROVE, LONDON W2 5SF
Tel. 01-727 5641 Telex: 261306

WW—008 FOR FURTHER DETAILS

ELECTRONIC INDUSTRIAL THERMOMETER



THE MODERN WAY TO MEASURE TEMPERATURE

A Thermometer designed to operate as an Electronic Test Meter. Will measure temperature of Air, Metals, Liquids, Machinery, etc., etc. Just plug-in the Probe, and read the temperature on the large open scale meter. Supplied in zippered vinyl case with transparent front and carrying loop, Probe, and internal 1½ volt standard size battery.

Model "Mini-On 1" measures from — 40°C to + 70°C, price £17.50
Model "Mini-On Hi" measures from + 100°C to + 500°C, price £20.00 (V.A.T. EXTRA)

Write for further details to

HARRIS ELECTRONICS (LONDON),
138 GRAY'S INN ROAD, LONDON. WC1X 8AX
('Phone 01-837 7937)

WW—054 FOR FURTHER DETAILS

FREQUENCY COUNTERS

HIGH PERFORMANCE REASONABLY PRICED ELECTRONIC INSTRUMENTS

TYPE 901

CRYSTAL OVEN
TWO TONE BLUE CASE

£370 **520** MHz

Sensitivity 10mV. Stability 5 parts 10^{10}

301M	32MHz 5 Digit £75		401	32MHz 6 Digit £118
501	32MHz 8 Digit £175		701A	80MHz 8 Digit £195
801A/M	300MHz 8 Digit £295		901M	520MHz 8 Digit £370
801B/M	250MHz 8 Digit £260		Memory versions available if not suffixed M £25 extra	

Start/Stop versions plus £12

Type 101 1MHz 100KHz 10KHz Crystal Standard £80
Type 103 Off/Air Standard £78

SUPPLIERS TO: Ministry of Defence, G.P.O., B.B.C., Government Depts., Crystal Manufacturers and Electronic Laboratories world-wide

R.C.S. ELECTRONICS
NATIONAL WORKS, BATH ROAD
HOUNSLOW, MIDDX. TW4 7EE
Telephone: 01-572 0933/4

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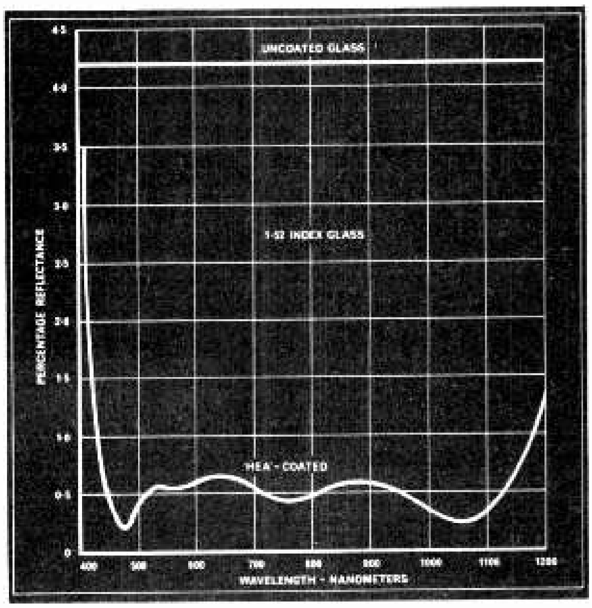
Anti-reflection coatings for high-power laser systems

Check your requirement from this list:

VERY LOW REFLECTIVE COATINGS Reflectance equal to less than 0.05% at specified wavelength.	☐
HIGH-EFFICIENCY REFLECTIVE COATINGS Details on request.	☐
ANTI-REFLECTION WIDE BAND COATINGS Visible to Near Infrared.	☐
POLARISING COATINGS AND BEAMSPLITTERS Details on request.	☐
NARROW BAND FILTERS 0.9 microns and above.	☐



Comparison between OCLI Wide Band 'HEA'-coated and uncoated 1·52 index glass (measured performance)

For more information, send this advertisement to:

OCLI

OCLI Optical Coatings Ltd.,
Hillend Industrial Estate,
Dunfermline, Fife, Scotland KY11 5JE.
Tel Inverkeithing 3631 (038-34 3631).
Telex. 72307

OC-52C

SPANNING EUROPE

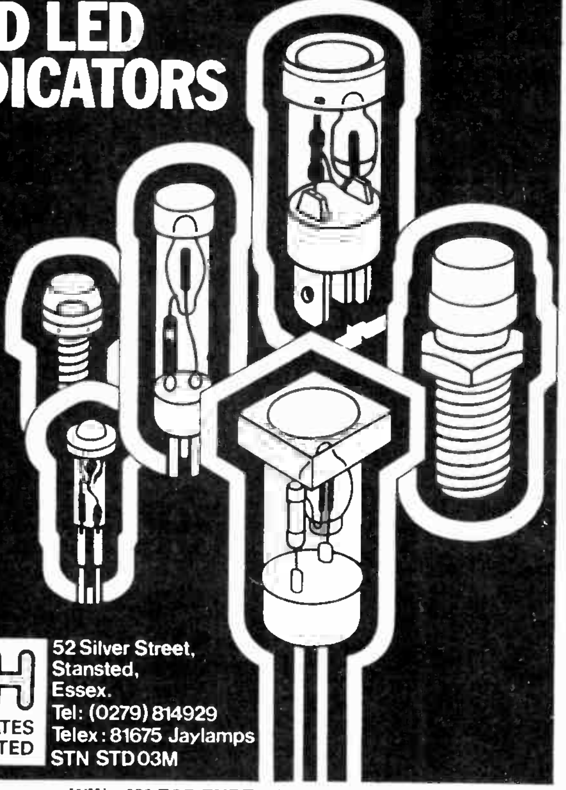
WW—061 FOR FURTHER DETAILS

GRAMPIAN REPRODUCERS LTD. HANWORTH TRADING ESTATE FELTHAM, MIDDLESEX TELEPHONE 01-894 9141

X209

WW—085 FOR FURTHER DETAILS

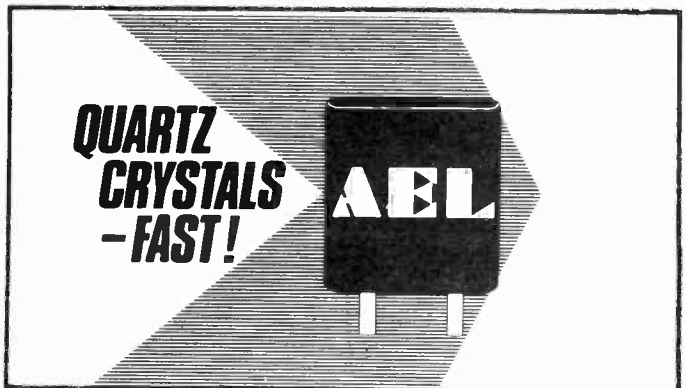
NEON FILAMENT AND LED INDICATORS



JH ASSOCIATES LIMITED

52 Silver Street,
Stansted,
Essex.
Tel: (0279) 814929
Telex: 81675 Jaylamps
STN STD03M

WW—022 FOR FURTHER DETAILS



AEL GATWICK HOUSE, HORLEY, SURREY, ENGLAND
Tel: Horley (02934) 5353
Telex: 87116 (Aerocon Horley) · Cables: Aerocon Telex Horley

WW—048 FOR FURTHER DETAILS

Your choice of Live Sockets-Instantly!

A Lexor DIS-BOARD gives you up to 6 sockets from one power outlet. Portable or permanent fixing, compact units, with safety neon. Over 1,000 socket combinations available from stock. All types of fittings and finishes.

Brochure from
LEXOR DIS-BOARDS LIMITED
Allesley Old Road, Coventry
Telephone 72614 or 72207

WW—047 FOR FURTHER DETAILS

FANTASTIC OFFER—DIGITAL CLOCK KIT SAVE £££s

- Fast building
- Easy to follow instructions
- No knowledge of electronics required
- The most comprehensive kit and instructions you have ever seen

NOW ONLY £12.50
+ £1.50 VAT & p&p

OR READY BUILT & FULLY TESTED ELECTRONIC ASSEMBLY Excl. Case
£11.88 INC.

COMET CLOCK DATA
Size 6¼ × 3 × 2½
Mains Operation
50/60HZ
12/24 hour mode

KIT COMPRISES or separately at:—

		£
1	MOS Clock Chip 12-24 hr option MM5314N	2.95
4	0.63" LED Displays NSN61L	6.60
1	Segment Driver Chip	0.50
1	Pack Resistors, Caps., Transistors, switch	1.60
1	Double Sided Glass Fibre P.C. Board	0.95
1	Double Wound Mains Transformer	1.50
1	Circuit/Assembly Manual	0.50
1	Futuristically styled Case (state colour), Red, Black, White, Mauve, Green, Blue.	4.40

*NB All Prices **INCLUDE** VAT & p&p

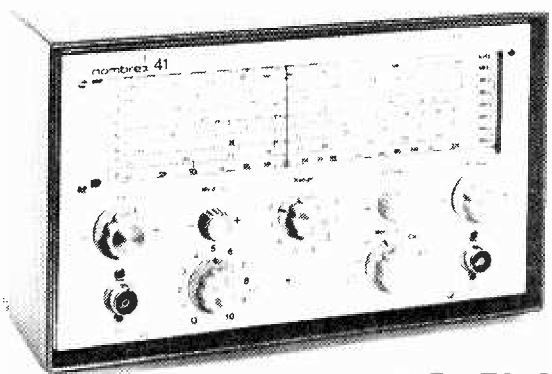
C.W.O. to:

ALL WOOD CASE **70p** EXTRA

Pulse Electronics Ltd

Dept. WW3, 202 Shefford Road, Clifton, Beds.
Tel. Hitchin 0462 814477

nombrex



MODEL 41
R.F. SIGNAL GENERATOR
Price £54.85
PLUS V.A.T.

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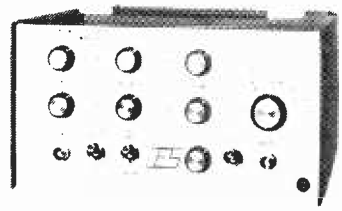

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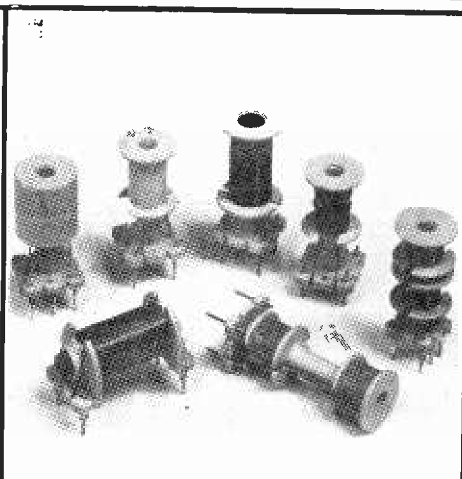

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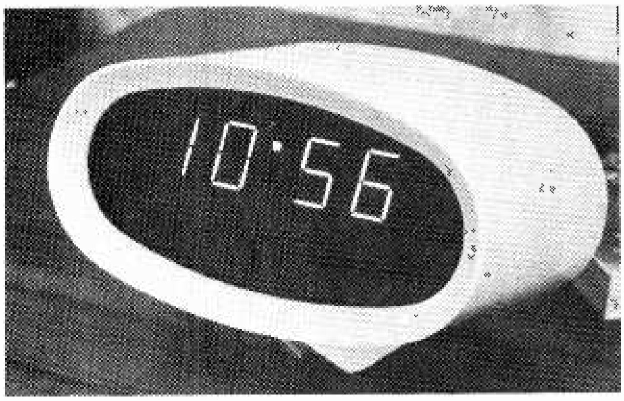

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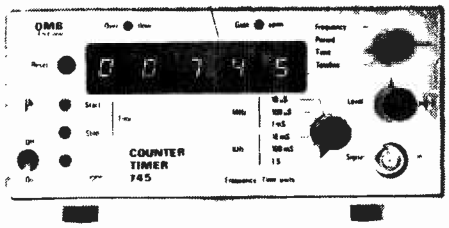

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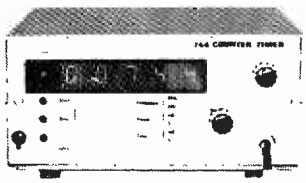

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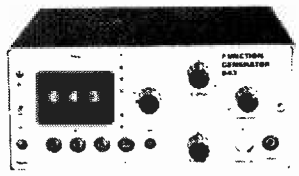

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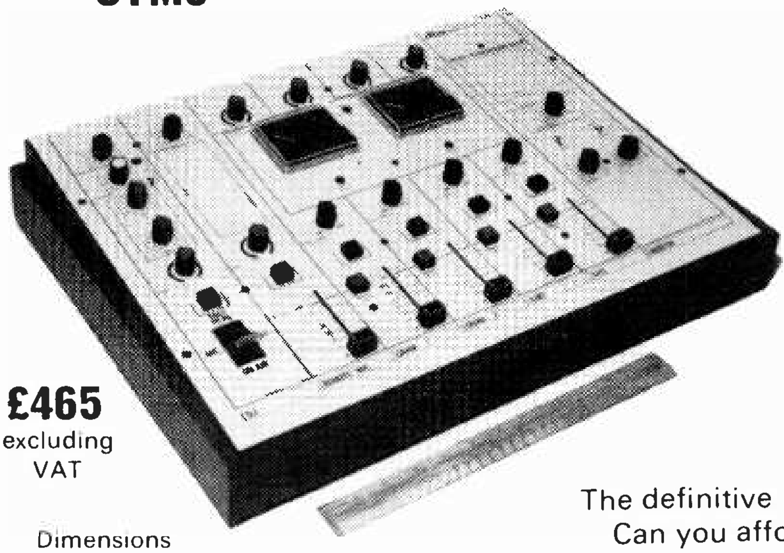
Six Channel Stereo Transmission Mixer (ALICE'S BABY)



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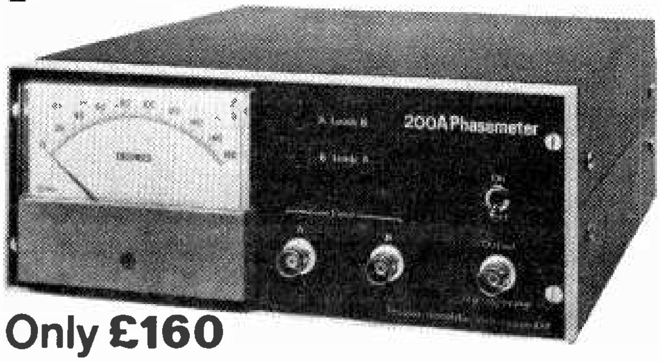

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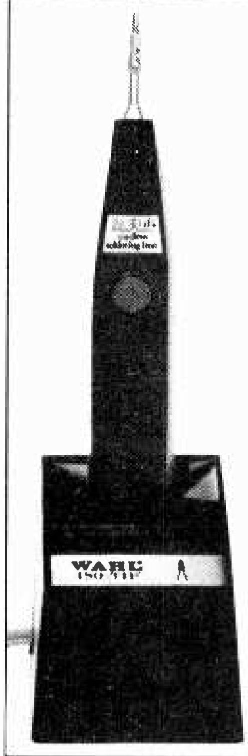

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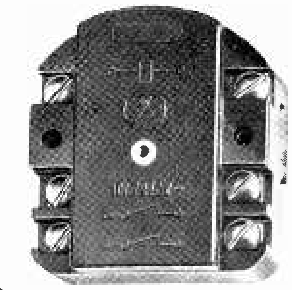

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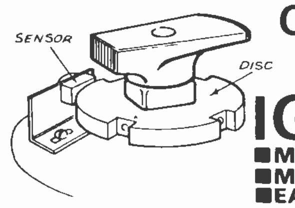

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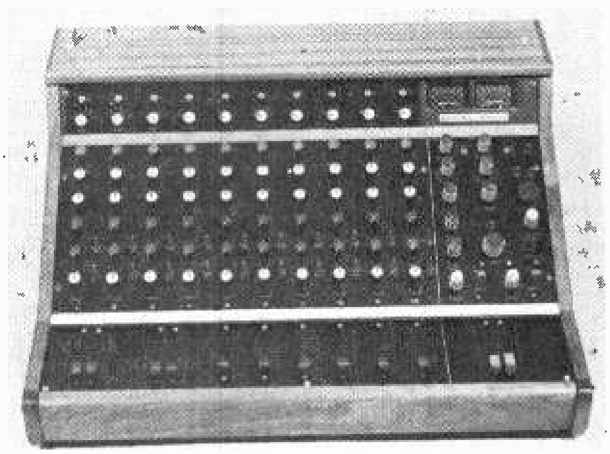

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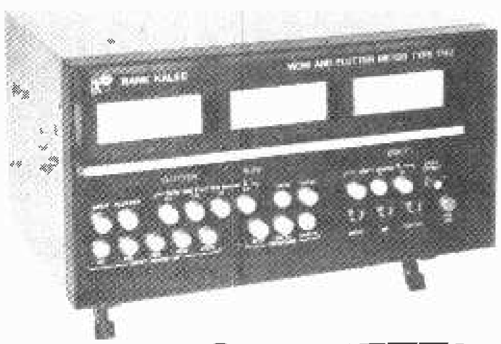

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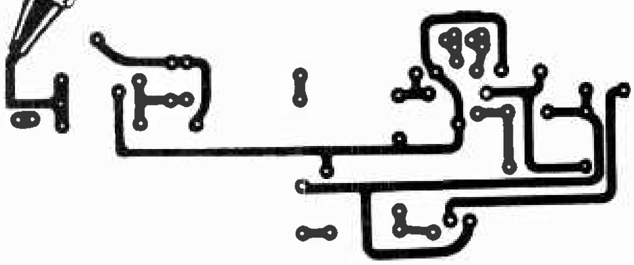

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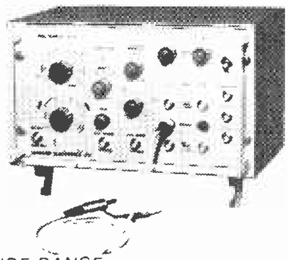

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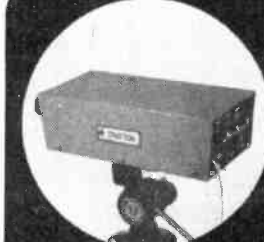

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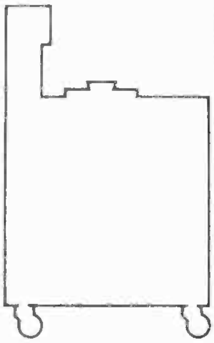

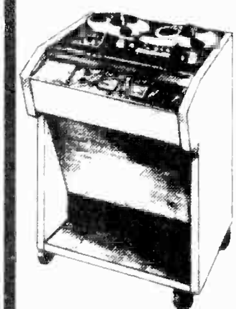

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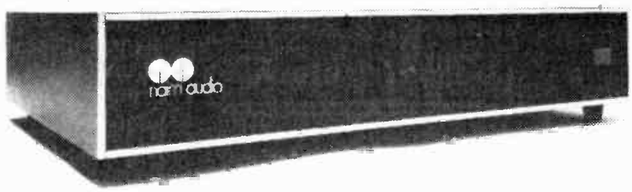

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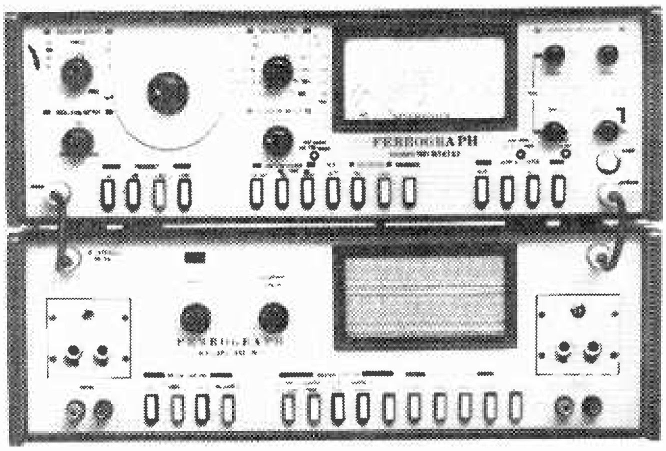

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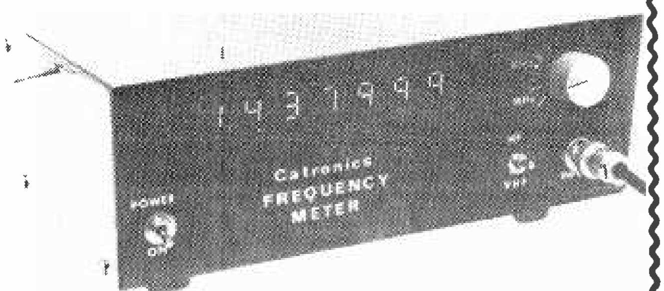

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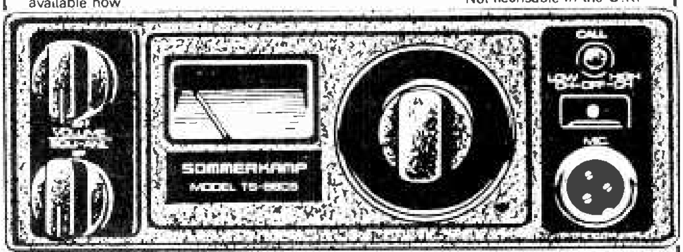

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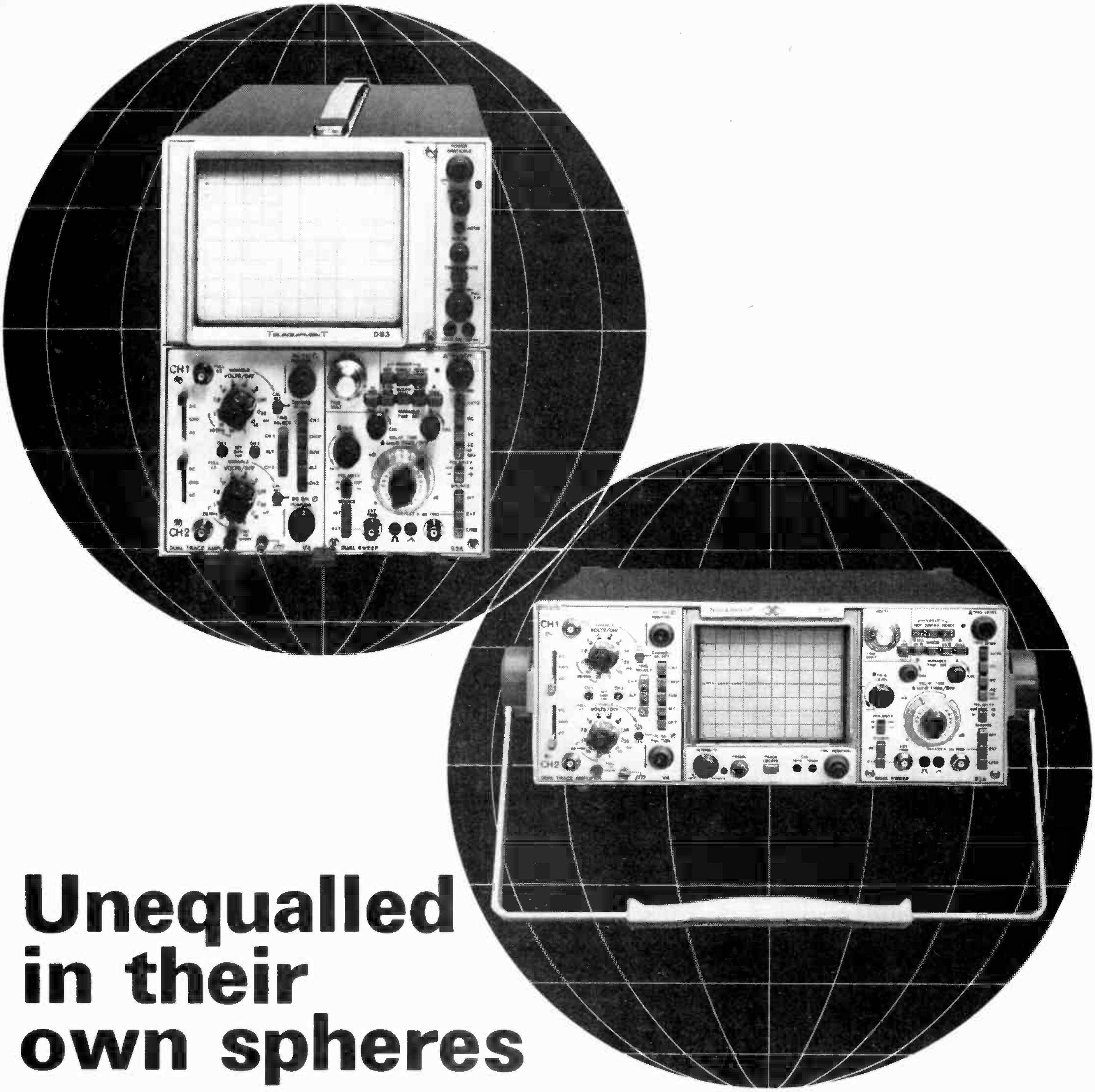

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DECEMBER 1975 Vol 81 No 1480

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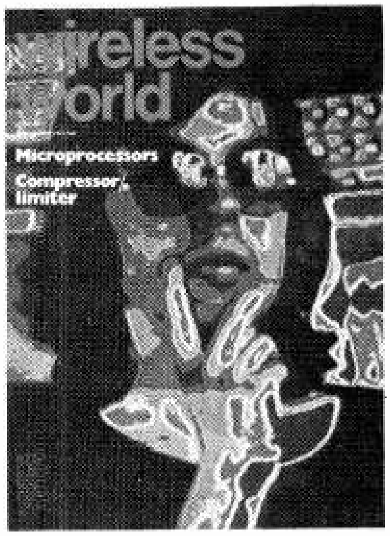

This month's front cover shows a television monitor picture of a human face after digital processing in a video synthesizer made by Electronic Music Studios (London) Ltd.

IN OUR NEXT ISSUE

Phase changes in loudspeakers — are they audible, and do they affect sound quality and stereo image formation?

A-level electronics. Introducing a new tutorial series based on a course that has been on trial in schools for three years.

Television history. On the 50th anniversary of Baird's Royal Institution demonstration a disclosure about his early apparatus.

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A star for India

India is irradiated. Since August 1, an entire sub-continent has been lit with a beam of u.h.f. television signals from a single source, the Applications Technology Satellite ATS-6 now positioned in synchronous orbit over Lake Victoria in East Africa (see Space News, September).

Looking back over 1975, this must surely be the most important project of the year in the application of electronics to human welfare. Important on two counts. Technically, it is the first example of direct broadcasting from a satellite providing coverage of a whole country. (Earlier the ATS-6 had been used for a direct broadcasting experiment in America to isolated communities in Appalachia, the Rocky Mountain region and Alaska.) Socially, it is an ambitious attempt to help the backward, underprivileged people of rural India to understand how they can improve the material conditions of their life. Programmes giving instruction on modern agricultural methods, nutrition, health, hygiene and birth control (as well as other educational and cultural programmes) are being transmitted by All India Radio, via the satellite, to 2400 remote villages in 20 districts spread over the country. There are in fact six clusters of villages, each with about 400 communal receiving stations. Signals on 860MHz from the satellite are picked up by 10ft diameter dish aerials made cheaply of chicken wire, and pass through frequency converters to television sets installed in public buildings for communal viewing.

All this comes, incidentally, just 30 years after Arthur C. Clarke suggested the possibility of direct broadcasting from satellites in his prophetic article "Extra-terrestrial relays" in the October 1945 issue of *Wireless World.*

Unfortunately the Satellite Instructional Television Experiment, as it is called, is indeed just an experiment. It is to last only a year, after which the ATS-6 satellite will be moved on to a new position in the western hemisphere. Considering the enormous problems of rural India – poverty, illiteracy, epidemics, fragmented and inefficient agriculture, all made worse by a caste system which condemns most people to automatic inferiority – it is futile to imagine, as the Indian broadcasters admit, that one year's exposure to television will make any real difference. And for this brief experiment, the expenditure on the ground hardware and facilities has been very high for a poor nation – about £6 million. One year is barely enough to sort out the operating problems, both technical and in the presentation of programmes, let alone derive useful social knowledge from the experiment. It's a pity that NASA, who provided the satellite, could not have been persuaded to leave their vital relay in place for at least another year. One can only echo the expressed hope of All India Radio that this "mammoth" experiment will help to create a "climate for development" in the backward areas of the country. Centuries-old patterns of life and work will not be changed in a few months but expectations may be.

India already has its own scientific satellite, built in Bangalore and launched by the USSR. The need for its own direct broadcasting satellite is much more pressing.

Microprocessors

An introductory discussion of the principles of design, programming and application

by D. E. O'N. Waddington, M.I.E.R.E.

Computer control! These two words conjure up visions of intelligent automatic systems far beyond the reach of us ordinary mortals. Until recently this has been true but it will not be long before microprocessors will be appearing in all sorts of unexpected and even mundane applications. Originally, digital computers were somewhat ponderous and unreliable, using many thousands of thermionic valves, kilo-amps of heater current, were built in large racks and housed in air-conditioned rooms to prevent them from dying of heat exhaustion! This was changed, to a large extent, by the introduction of semiconductor technology. The use of transistors enabled smaller and more efficient computers to be designed, although the need for some form of air conditioning has remained. Silicon integrated circuits allowed further size reduction, as it was now possible to put many logical functions into a very small volume.

This led to the design of the "minicomputer" which is small in size, in comparison with earlier computers, but is usually comparable in performance to much larger machines. A basic form exists which is, in effect, a mini-computer without all the mechanical frills and may even consist of a few, albeit rather large, printed circuit cards. New semiconductor production techniques together with improved quality control are now making true large-scale integration possible so that, although Isaac Asimov's positronic robot is still in the future, the "computer on a chip" has arrived under the alias of Microprocessor. Admittedly, it is not the equal of the large computer or even the mini, but it does represent a new generation of pseudo-intelligent circuits which will change the design and operation of machines ranging from cookers, cars and traffic lights to measuring instruments, automatic landing systems and process control.

One of the main attractions of microprocessors is price. Full size computers can cost tens of thousands of pounds and even minis cost in the order of one to ten thousand. The faster microprocessors cost between £100 and £500 and simple 4-bit machines now cost from £30 to £100, depending on volume and complexity. Prices are still falling, and the new Texas Instruments TMS1000, a one-chip 4-bit machine, primarily intended for calculator type applications but also suitable for use in small control systems, is reputed to cost less than ten dollars. However, this low price applies only to large quantities and does not include the initial charges for the design and manufacture of programming masks, which could be in the order of £10,000. If microprocessors continue to follow the same price trend as most other semiconductor devices, the minimum prices will not be reached for some time yet, so there will probably be substantial price reductions over the next few years.

Before discussing microprocessors in more detail, it is as well to try to answer the question: "What is a computer?". The full definition is very wide ranging but, in the electronics world it has come to mean an electronic machine which is capable of carrying out a set of instructions (programme), either arithmetical or logical, without the need for operator intervention other than to specify which programme is required. In its simplest form, shown in Fig. 1, a computer consists of three main parts; a central processor unit (c.p.u.), a memory or store and input/output ports. The programme or set of instructions which control the operation of the computer is stored in the programme memory and is "read" in sequence by the c.p.u. which carries out each instruction as it is received. The data memory is used to store the data whicn is to be operated on and the c.p.u. can gain access to the locations in this memory either to read the data stored there or to write new information. As a computer is only capable of recognising 1's or 0's it carries out all its operations in binary code, although frequently instructions are in binary-coded octal, decimal or hexadecimal. In order that the computer may serve a useful function it has to be able to communicate and this is done via the input/output ports. Typical inputs are derived from tape-readers, teletypes and trans-

Using microprocessors

One of the prime reasons for using a microprocessor in a control system is its flexibility. Many systems which use these devices could, in theory at least, be made with smaller-scale logic packages in a purpose-designed form, but any changes needed in an operational sequence would involve expensive changes in logic design and printed-circuit layout. Changes in a system using a microprocessor only require a programme change, and the reliability of the system gains from the reduction in the number of integrated circuits.

A typical application for a microprocessor would be the operation of a supermarket cash-point where, together with its input/output devices (keyboard, display, tally-roll printer, etc.), the microprocessor would display the price total, check prices against codes, count the total number of articles, deduct these from stock and inform stock control, dispense change, issue a receipt and send the total to the accounts department.

Possible domestic use of microprocessors includes the control of central heating, taking into account external temperatures, time of day, and internal temperatures desired and achieved. Simulating the occupation of a house when the owner is absent is also a possibility; lights would be switched on and off at relevant times, curtains would be drawn and it is even suggested that the sound of water music could be caused to issue from the bathroom from time to time.

Cars are particularly receptive to microprocessor control. When fed with information derived from sensors on engine temperature, exhaust gas composition, piston position, road speed, engine speed, accelerator depression, road wheel forces, seat belt connexion, etc., the optimum adjustment of mixture and timing to obtain efficient running and least pollution can be maintained, braking can be controlled in such a way as to reduce skidding and the car can be made to refuse to go at all unless the driver has fastened his seat belt. No doubt a breath "sniffer" could also be incorporated in the system.

ducers while outputs may go to line-printers, video display units, control valves, etc.

The basic operating sequence for a computer is as follows: (a) send to the programme memory the address of the instruction to be carried out; (b) read and decode the instruction; (c) implement the instruction. This sequence, illustrated in Fig. 2, is usually known as a machine cycle or micro-cycle and the time taken for its completion is frequently used to define the speed of the computer. This can be misleading as some computers have far more powerful instruction sets than others.

Central processing unit

This description is obviously an over-simplification, so we will look at the architecture (the "in" word used by computer men to describe the layout) of the c.p.u. in more detail as it is this which defines the character of the computer. Fig. 3 shows a typical c.p.u., which is likely to consist of the following main units.

Accumulator register. This usually contains one of the operands to be processed by the arithmetic and logic unit (a.l.u.). A typical instruction could tell the a.l.u. to add the contents of some other register location to the accumulator register and to store the result in the accumulator. Thus the accumulator could be regarded as the main working register into which data and results are written and processed, and from which they are subsequently despatched to memory or output ports.

Programme counter. The instructions which form a programme are stored in the programme storage memory in sequence so that, in order to carry out an operation correctly, the c.p.u. has to keep a count of where it is in the programme. This, then, is the main function of the programme counter. However, programmes frequently contain subroutines which may be called for at any point during the execution of the main programme. Subroutines are sets of instructions used to carry out specific tasks which may be needed several times during the execution of a programme. In a desk calculator type of environment, for example, the calculation of functions such as square, sine, logarithm or root, might each call for a separate subroutine which might, in turn, call for subroutines to add, subtract, multiply and divide. In a control system, the operation of each function might call for a separate subroutine, while the overall operation is unified by a main programme calling for the subroutines as required.

When a jump-to-subroutine instruction occurs in a programme, the address of the next sequential instruction must

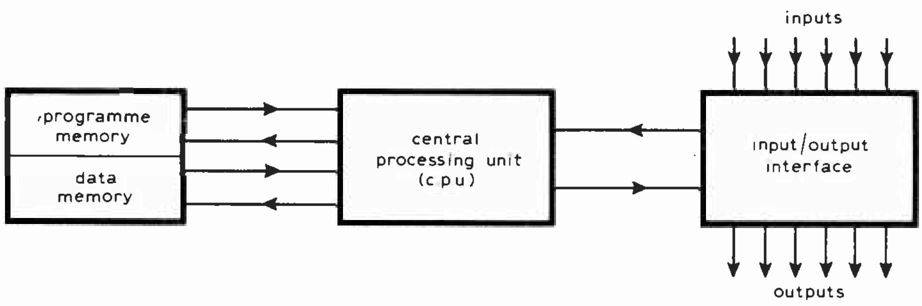


Fig. 1. Basic computer system.

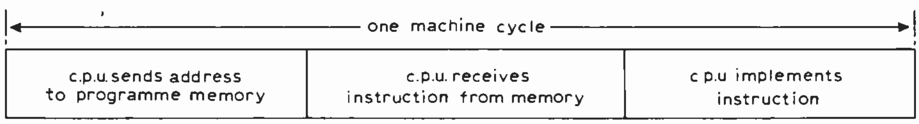


Fig. 2. Computer machine cycle.

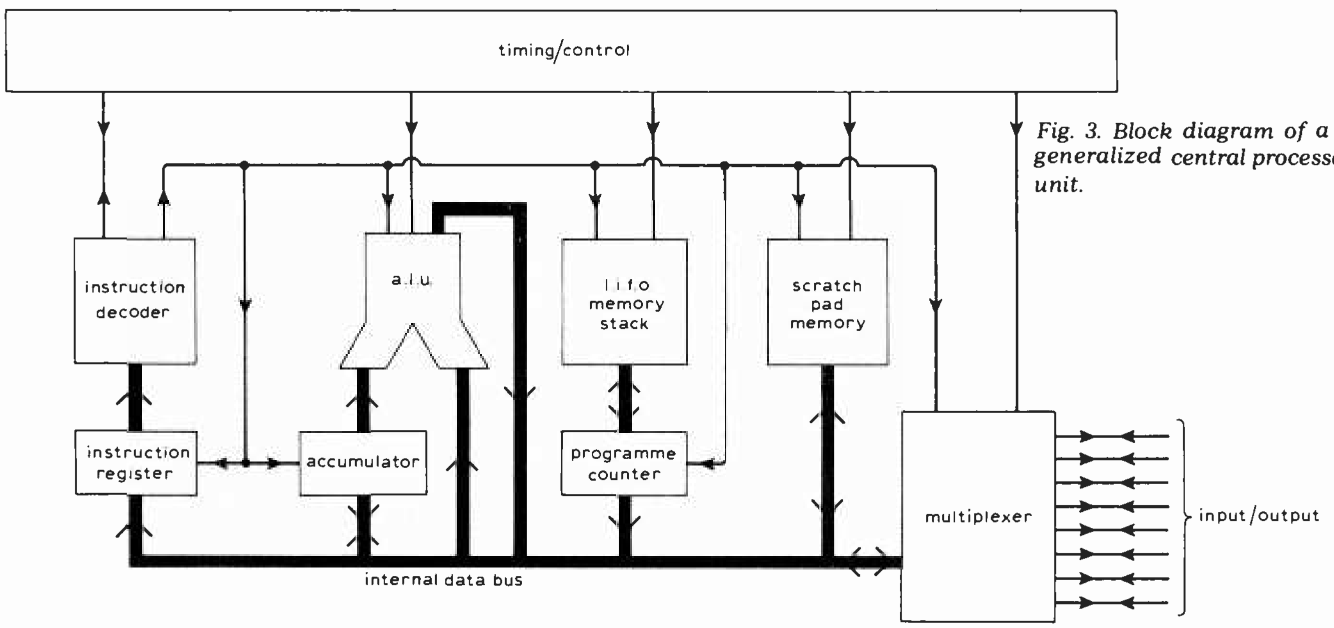


Fig. 3. Block diagram of a generalized central processor unit.

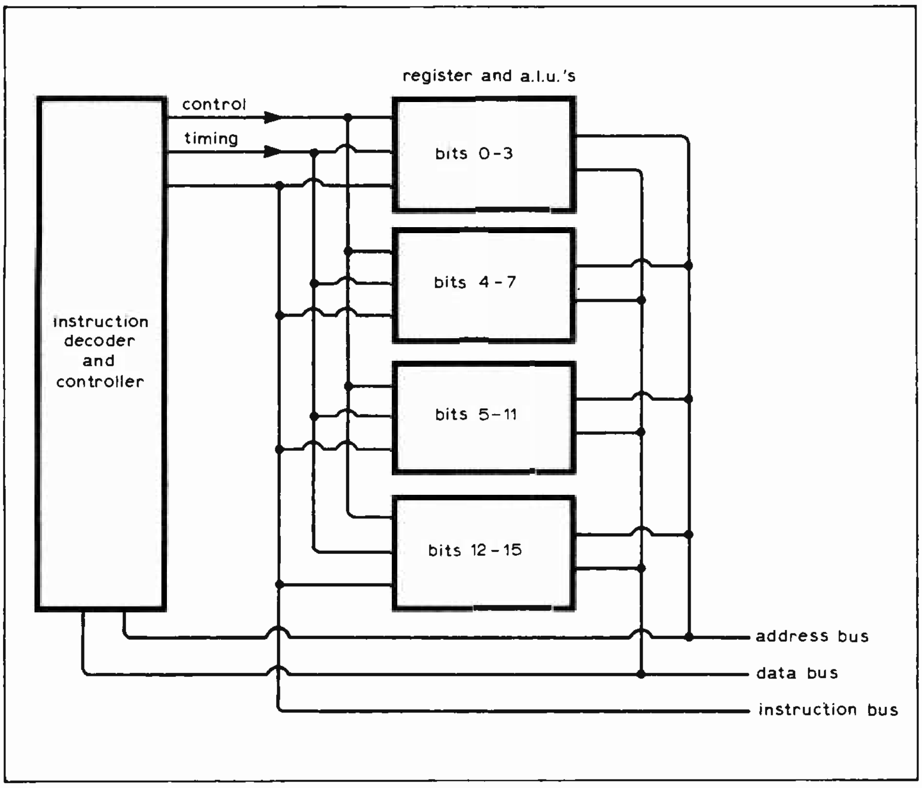


Fig. 4. "Bit slice" c.p.u. configuration.

be stored so that the processor will know where to return at the end of the subroutine, and the address of the first instruction in the subroutine must be inserted into the programme counter. In a microprocessor, this operation is usually done by means of a "push down stack" memory which is also sometimes called a "l.i.f.o." or last-in, first-out memory. Thus the jump-to-subroutine instruction causes the current address to be pushed down one step and the new address is written into the top location. A further jump instruction might cause both of these addresses to be pushed down another step. This occurs when nested subroutines, i.e., subroutines which call for further subroutines, are used. Obviously, the number of subroutines which can be nested before losing the original return address will depend on the depth of the stack, which will vary from one type of microprocessor to the next. At the end of the subroutine the programme "branches back" and the last return address stored is replaced in the programme counter register. This causes the processor to resume its programme from the point immediately following that at which the branch occurred.

Instruction register. When the c.p.u. receives an instruction from memory, it stores it in the instruction register, which holds it for decoding. The length of the instruction will depend on the type of processor. A simple processor, for example, will probably use an 8-bit instruction code. This will give a capacity of up to 256 separate instructions, each of which will consist of a series of 1's and 0's. In practice this is more than sufficient, although some machines use variable-length instruction codes which not only tell the c.p.u. what operation is required, but also specify one or more addresses for fetching data or writing results.

Instruction decoder. The function of this is to decode the instructions and tell the c.p.u. what to do with them — a task which, though appearing formidable, is no more difficult, in principle, than a b.c.d. to 7-segment display decoder, although a different technique is usually used. Generally, the instructions are grouped so that those associated with a particular portion of the c.p.u. have the same "signatures". The four most significant bits in the instruction might be used to define a separate section such as "data transfer", "arithmetic functions" or "logical operations", etc. In this way the decoding can be simplified considerably.

Scratch pad memory. This section is used for all sorts of temporary storage as it is usually more easy to gain access to than the main memory area. One of its main uses in the simpler machines is to store addresses of working memory locations or input/output ports which the c.p.u. will need to use. These addresses can usually be incremented by single instructions so that successive memory locations can be addressed for iterative operations.

Arithmetic/logic unit (a.l.u.). All processors include some form of arithmetic/logic unit which is often known as the a.l.u., although sometimes the registers are included in the description when it is called the r.a.l.u. The a.l.u. is the section which actually performs the computation and it will normally be expected to be able to carry out the following operations as a minimum requirement:

- addition with carry
- subtraction with carry
- left and right shift
- count up/down
- logical AND and OR
- digital word comparison for conditional branching. This may be simple zero/non-zero detection or full word comparison.

More sophisticated a.l.us will include additional functions such as hard-wired multipliers or dividers and more comprehensive logical operations.

As the a.l.u. is based on digital processing techniques, it will carry out all of its operations in binary notation so that the programmer will need to understand binary arithmetic techniques. However some processors which have been designed for calculator type applications will include binary/b.c.d. (binary-coded decimal) conversion instructions.

Clock and control circuitry. The clock generates the timing information for the whole processor system. Its frequency is usually determined by the speed at which the various parts of the c.p.u. can function, although the speed of the memories is also a factor which may have to be taken into account. The actual sequence of events in the c.p.u. is organized by the control circuits. Normally the sequence is fixed, but the control circuit will usually be able to respond to an external request for attention. This is known as an "interrupt" and it will cause the programme to jump to a subroutine which will identify the source of the interruption, service it and return control to the main programme.

These then are the main parts of the c.p.u. In the past they have ranged from several racks of valved equipment down to a single printed-circuit card containing a series of l.s.i./m.s.i. chips. The idea of putting a c.p.u. on a single chip has been around for many years, but for a long time it was not practical. The number of transistors necessary to make a practicable processor is such that a relatively large piece of silicon (about 4mm square) is necessary for the integrated circuit. Both the Intel 8080 and the Motorola 6800 use well over 5000 transistors! Of necessity, this means that unless the crystal slice into which the transistors are to be diffused is perfect, the manufacturing yield will be low and prices correspondingly high. The use of m.o.s. technology has helped the situation considerably, although some small processors using bipolar transistors are now available. Two types of m.o.s. circuit are generally in use; p.m.o.s. which is the least difficult to make and n.m.o.s. which needs tighter production control but which has the advantage that the transistors can be smaller and, as a result, can work at a higher speed.

Most surprisingly it is not the number of transistors which determines the size of the final integrated circuit chip but the amount of interconnection. Usually, the transistors take up less than 10% of the surface area. C.m.o.s. would appear to be an ideal medium for microprocessors as it combines good speed performance with low power consumption. However, it also requires a relatively large area, so that it is not as attractive to make. Nevertheless, at least two manufacturers are now offering c.m.o.s. processors. Bipolar transistor processing, as the oldest-contender in the field of integrated circuits, would appear to be ideal as it has the advantage of the best speed performance. It also, however, has the disadvantage that it uses considerably more power than m.o.s. and this sets an additional limitation on the size of processor which can be made. In order to overcome this, devices known as "bit-slice" processors have appeared. The basic processors are made as two or four bit slices which can be connected in parallel to make up the required word length as in Fig. 4. The major advantage of these processors is speed. They can be designed to have a cycle time of 200ns or less — an order faster than n.m.o.s.

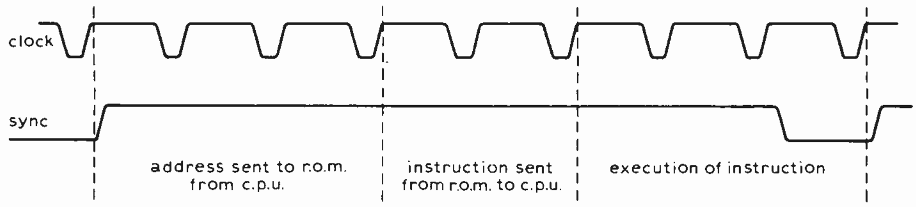


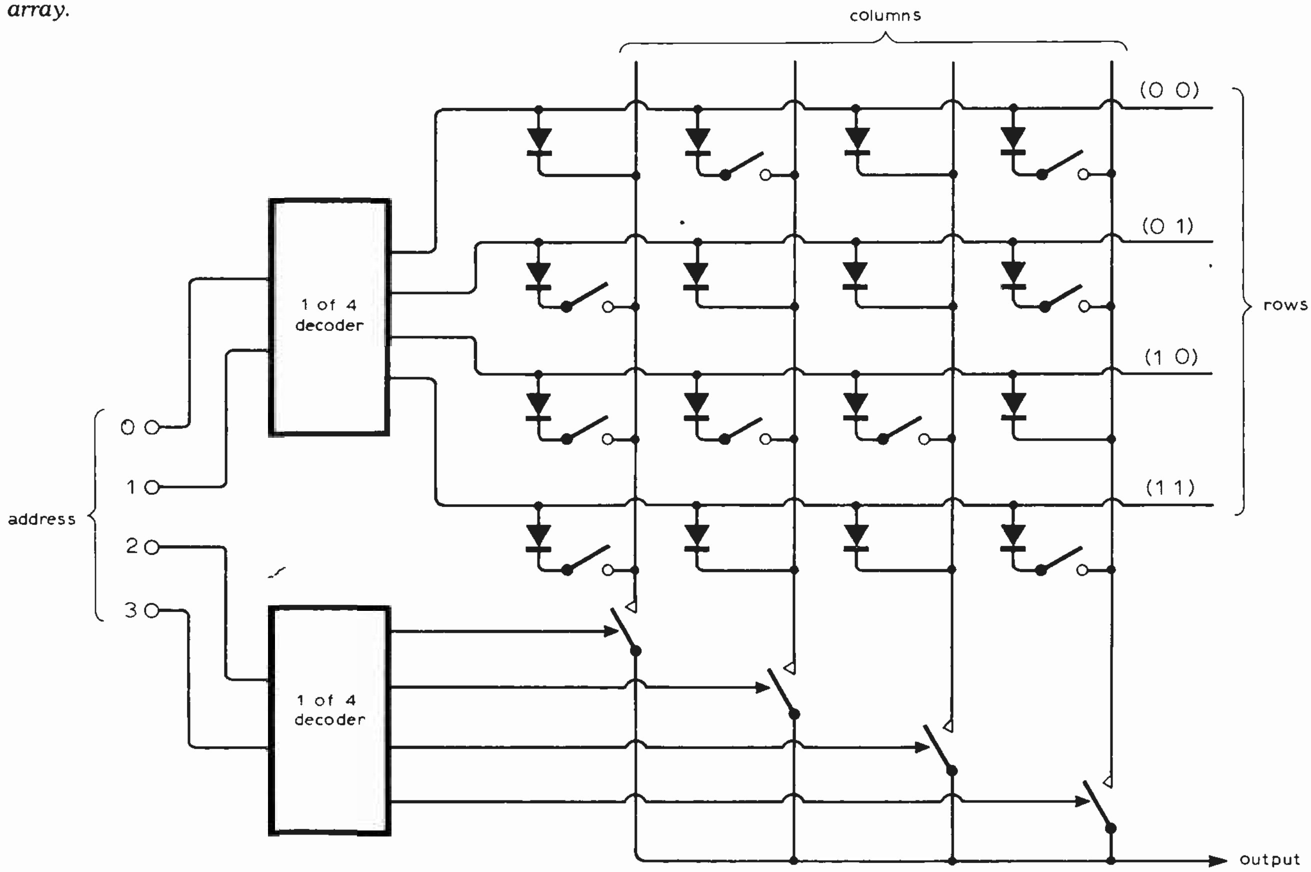
Fig. 5. One machine cycle using a 4-bit bus, illustrating the limitation when compared to higher-capacity buses.

In all processors the number of bits in the bus system is an important factor in determining the effective speed. With a 4-bit bus, addresses can only be sent in 4-bit "nibbles". This means that in order to address 4k (4096) words of store, it will be necessary to send three 4-bit nibbles of address ($4096 = 2^{12}$). If the instructions are each eight bits long it will then take a further two clock cycles to read the instruction. Thus a minimum of five clock cycles is necessary to carry out the first two parts of the machine cycle. It could then take a further three clock cycles to implement the instruction, so that one machine cycle will take eight clock cycles or, with a 1MHz clock, 8 μs as in Fig. 5. However, if the data bus were 12 bits wide, this same operation could be carried out in three or four clock cycles, i.e., twice as fast.

Programme storage

In the past, magnetism has played a great part in computer memories or stores. Core stores are still very widely used, as they have no mechanical

Fig. 6. Basic 4 × 4 read-only memory array.



	(0 0)	(0 1)	(1 0)	(1 1)
0	0 1 0 1	0 1 0 1	0 1 0 1	0 1 0 1
1	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1
2	0 0 0 0	1 1 1 1	0 0 0 0	1 1 1 1
3	0 0 0 0	0 0 0 0	1 1 1 1	1 1 1 1
output	1 0 0 0	0 1 0 1	1 1 0 1	0 0 1 0

moving parts, they are non-volatile, i.e., they retain their information when switched off, and they can be made to occupy a relatively small volume. In fact, for a computer which is to be reprogrammed periodically, they form an ideal storage medium. Most microprocessor systems work with fixed programme control, i.e., the programme need seldom if ever be changed as the processor is dedicated to a single task. For these, core stores are an "overkill" as they require a considerable amount of drive circuitry and provide a facility which will never be used. Thus another kind of store, the read-only memory or r.o.m. is generally used. These consist of logic circuit arrays which can be programmed to give either a 1 or 0 as each location is addressed. Read-only memories can be made in all the various semiconductor technologies. The main differences between these are size, i.e., the number of bits which can be stored, logic levels, reprogrammability and access time. In general bipolar memories are faster than their m.o.s. counterparts, but the latter usually have more capacity.

In its simplest form, a read-only memory is an array of open or closed unidirectional contacts, the state of the contact determining whether the location contains a "1" or a "0". In the 16-bit array shown in Fig. 6, half of the address lines are decoded to energize one of the rows. This activates those column lines which have closed contacts to the selected row. The other address lines are decoded and used to select a column. Thus a selected closed contact will result in a "1" at the output. In a memory for a microprocessor, r.o.ms are usually arranged so that an address selects eight locations in parallel, so that a single address will locate an 8-bit word.

One of the main distinctive features of a r.o.m. is the method by which it is programmed.

Mask-programmable r.o.ms. As implied by the name, these are programmed by a metallization pattern which is either deposited on the surface of the r.o.m. through a mask or selectively etched through a mask. This method of manufacture has a lot to commend it, as the manufacturer can hold stocks of r.o.ms which only need their final masking to provide any memory pattern required. Thus the process of making a r.o.m. need only take the time necessary to produce the final mask and metal pattern. This reduces the time necessary to produce a r.o.m. to about six weeks. However, the disadvantages are that the system designer has no control over the manufacture and there is no room for any error. He must be right!

Electrically-programmable r.o.ms. These fall into two main types; those which, when programmed, cannot be changed and those which can. The first

Table 1

Manufacturer	Advance	Fairchild	General Instruments	Intel	Intel	Intersil	Motorola	MOS Technology	National	National	MOSTEK	Plessey	RCA	Texas Instruments
Type	Two chip	F8	1600	4040	8080	IM6100	M6800	MCS6501	IMP 4	IPC-16A/500D (PACE)	MK5065P	MIPROC	TA6889/90 (COSMAC)	TMS1000
Package	d.i.l.	d.i.l.	d.i.l.	d.i.l.	d.i.l.	d.i.l.	d.i.l.	d.i.l.	3 chip set	d.i.l.	d.i.l.	Printed circuit	two chip	d.i.l.
Number of pins	24 & 28	40	40	24	40		40	40		40	40			4/40
Supply voltages	+5, −12		+5, −12	+5, −12	+5,−6,−12	+5	+5	+5	+5, −12	+5, +3, −12	+5,−5,−12	+5	+5	15
Power	350mW			1W	1W				1W	700mW			60mW	600mW
Clock frequency	55kHz			740kHz	2.083MHz	2MHz	1MHz	1MHz	500kHz	500kHz	1.4MHz		2MHz	400kHz
Phases	2			2	2	1	2	2	4	2	2		1	
Register cycle time		2μs	400ns	10.8μs	2μs	5μs			12μs	2μs		350ns		15μs
Data word (bits)	4	8	16	4	8	12	8	8	4	8/16	8		8	4
Programme word (bits)			16	4	8	12	8	8	4	16	8		8	8
Programme addresses	384	64k	64k	8k	64k	4k	64k	64k	64k	64k	32k		64k	1k
Interrupt		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
d.m.a. ability		✓	✓		✓	✓	✓	✓		✓	✓		✓	
b.c.d. arithmetic	✓	✓		✓	✓		✓	✓	✓	✓				✓
Comments	Manufactured by G.I. to Advance design calculator			Calculator oriented. 4004 is earlier version		c.m.o.s. type compatible with PDP8/E software	Full range of peripheral drivers	Similar to M6800 4 and 16 bit version available soon	8 and 16 bit versions available		Also manufacture F8		c.m.o.s. type	Single chip system includes ROM and RAM

Bit slice microprocessors

Manufacturer	Advanced Micro Devices	Intel	Monolithic Memories	Texas Instruments	Motorola
Type	AM2901	3002	5701/6701	SBP 400	M10800
Technique	Schottky t.t.l.	Schottky t.t.l.	Schottky t.t.l.	I-I	e.c.l.
Cycle time	100ns	100ns	200ns	530ns	55ns
Data word	4	2	4	4	4

type contain some form of fuse which is "blown" by the application of a suitable pulse during the programming process. One type includes links of either nichrome or polysilicon. It is claimed that the latter are more reliable as there is a tendency for nichrome to "grow" back and connect once more. A variant on the fusible link is the shorted-junction where transistors with no physical connection to their bases are diffused into the substrate. By applying a high potential between the collector and emitter, the transistor is forced to break down and a short is formed between the emitter and base, changing the transistor into a diode. This process is a critical one and needs precise control. These p.r.o.ms are all made using bipolar technology.

Two main types of p.r.o.m. are made using m.o.s. transistor arrays. Unlike their bipolar counterparts they are erasable so that they can be reprogrammed, a facility which makes them ideal for development of microprocessor systems. One of the best known types uses f.a.m.o.s. or floating-gate avalanche injection m.o.s. which was introduced in 1971 by Intel. In this type, shown in Fig. 7, a floating gate is induced into the silicon dioxide separating the source and drain of an m.o.s. transistor by applying an excessive voltage to the device. As no discharge path is available for this gate, the charge remains unchanged and it is predicted that if the device is maintained at a temperature of 125°C for 10 years, at least 70% of the charge will remain. At lower temperatures the charge would remain even longer. However, if the device is exposed to strong ultra-violet radiation, the charge may disperse in 5 minutes, when the p.r.o.m. can be reprogrammed. This type is easily recognisable, as the chip is covered by a transparent quartz window.

Another type of m.o.s. p.r.o.m. is known as the e.a.r.o.m. or electrically-alterable r.o.m. Actually, it uses m.n.o.s. in which an additional gate insulation layer of silicon nitride is used. During programming, which is done electrically, a charge is trapped in the gate region and it is possible to sense this charge up to 10^9 times before there is any uncertainty. This is not sufficient for programme storage but, if it is provided as a back up to a read/write memory it may be used to provide a non-volatile store for data. However, it takes an appreciable time, of the order of 2ms, to save data in an e.a.r.o.m. so that these are not in general use.

In addition to the programme storage, a microprocessor system usually contains a memory to store results or data. This is normally known as r.a.m. or random-access memory which, strictly speaking, is a misnomer as the access to r.o.m. may be equally random. It is probably better to call this read/write memory as it is used in this fashion. Just as the amount of r.o.m. used in a system depends on the programme

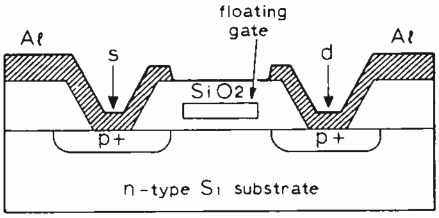


Fig. 7. Cross section through an idealised f.a.m.o.s. transistor.

requirement, the amount of r.a.m. needed will depend on the data storage requirement. R.a.ms consist of arrays of flip-flops which are set or cleared according to the data stored. As with r.o.ms they are made in both bipolar or m.o.s. form. Bipolar devices are generally very much faster but they absorb an appreciable amount of power. M.o.s. r.a.ms may be either static or dynamic: in the former, the data is stored in normal flip-flop type circuits, but in the latter it is stored as electrical charges holding transistors "on" or "off". As the charges leak away gradually, dynamic r.a.ms are refreshed by "clocking" them periodically to replenish the charge.

Programming

Like computers, microprocessors need to be programmed if they are to serve any useful purpose. The processor recognises ones and zeros. However, although a human programmer can learn all the machine codes, it is a very tedious business to try to write a complete programme in machine code. Thus various computer languages have evolved. The simplest type is known as assembly language or assembler code and consists of groups of two, three or four letters, known as mnemonics, which relate directly to the machine codes and describe the instructions. For example:

NOP	no operation
ADD X	add the contents of the register X to the accumulator with carry.
XCH X	exchange the contents of register X with the accumulator.
RD Y	read the contents of register Y into the accumulator.

This type of language is relatively easy to use once all the implications and limitations of each instruction is understood. This is very important as the c.p.u. has no intuition. It can only carry out instructions which it is given and not guess at those which have been left out. In order to convert a programme written in assembly language into machine code, one of two courses is available. The first is to do it very patiently and inefficiently by hand, a procedure which is not recommended for more than about 20 commands. The second is to make use of a programme known as an assembler, which examines the source programme (i.e., assembly language) and converts into machine code. In most machines a "two pass" assembler is used, feeding the source programme to the assembler twice. The first time, the assembler converts the mnemonics to machine code, looks for syntax errors and allocates addresses to the instructions. The second time it fills in all the addresses for the "jump" instructions. Assembly language programming is probably the most efficient when it comes to making the optimum use of memory space and, as such, is most generally used for small to medium sized systems. However, it can be tedious for large programmes, so that high level languages are being developed to allow programmes to be written using a limited English/mathematical vocabulary. One such language is PL/M, which has been developed by Intel for their 8080 system and no doubt other manufacturers are developing their own languages. Programmes written in these languages are then converted into machine code using a programme known as a compiler. Although this method provides a degree of built in "intuition", so that the programmer does not need to worry about all the minor details, compilers do produce programmes which take up to 40% more storage than the corresponding assembly language programme. Another approach is to use an "interpreter" which is a programme which converts the programme to be executed directly into machine code as it is used. As this implies, the processor has to have two programmes built into it, the interpreter and the programme which is to be executed. This approach is only really suitable for very large machines at present but, as microprocessors get "smarter," we may see them with built-in interpreters. Interpreters, however, are inevitably rather slow.

Microprocessor circuits

The first microprocessor was introduced by Intel in 1971 and was a 4-bit machine called the 4004. This was the first of its kind; a 4-bit machine, oriented towards calculators but capable of very much wider application. Shortly it was followed by an 8-bit model, the 8008. The latter has been superseded by the 8080, a n.m.o.s. machine with a 2μs instruction cycle and 70 instructions. The power dissipation is only 600 mW and there is a full range of r.o.ms and r.a.ms, clock and interface receivers and drivers so that a complete system can easily be built. Intel have also introduced the 4040 which is primarily a calculator-oriented machine which has an instruction cycle of 10.2 μs, 47 instructions and which can be used for many other applications.

Some of the types known to me are shown in Table 1.

Meetings
DECEMBER

LONDON

3rd. BKSTS — "Impressions of television and film in the USA and Canada by A. B. Palmer at 19.30 at Thames Television Theatre, 308-316 Euston Rd., NW1.

4th. IEE — Discussion on "Are fibre optics the answer to aircraft signal transmission problems?" at 17.30 at the Royal Aeronautical Society, 4 Hamilton Pl., W1.

4th. IERE — "Dynamic system checkout" by Prof. D. R. Towill at 18.00 at 9 Bedford Sq., WC1.

4th. RTS — "Progress in colour receiver design" by M. F. Bowers at 19.00 at the Conference Suite, London Weekend Television, South Bank TV Centre, Upper Ground, SE1.

5th. IEE — Colloquium on "Communication for the deaf and dumb" at 10.30 at Savoy Pl., WC2.

5th. RI — "Acoustics regained" by Eric A. Ash at 20.45 at The Royal Institution of Great Britain, 21 Albemarle St., W1.

8th. IEE/IERE — Colloquium on "Computer aids to software and system design" at 10.30 at Savoy Pl., WC2.

8th. IEE — Discussion on "Ultra-violet and infra-red curing of printed and coated materials and ultra-violet sterilisation" at 17.30 at Savoy Pl., WC2.

10th. I.Phys./IEE — One-day meeting on "Light detection" at 10.00 at Imperial College, SW7.

10th. IERE — Colloquium on "The electronics of electronic organs" at 14.00 at Engineering Theatre G6, University College, Torrington Pl., WC1.

10th. IEE — "On-line capture and analysis of transient phenomena" by C. Buffam at 18.30 at Savoy Pl., WC2.

10th. BKSTS — "Specialised techniques in television film production" by G. Anderson at 20.30 at NFT2, National Film Theatre, South Bank, Waterloo, SE1.

11th. RTS — The Shoenberg Memorial Lecture on "The history of videotape recording" by J. Roizen at 19.00 at The Royal Institution, Albemarle St., W1.

11th IEETE. — "Electrotechnology in offshore oil fields" by D. S. Townend at 18.00 at the IEE, Savoy Pl., WC2.

12th. IEE — Colloquium on "Technological developments in the fabrication of MOS integrated circuits" at Savoy Pl., WC2.

15th. IEE — "The NPL reference volt" by C. H. Dix at 17.30 at Savoy Pl., WC2.

16th. IEE — Discussion on "Intelligent instruments" at 17.30 at Savoy Pl., WC2.

17th. IEE — "Engineering for biomedical research" by D. Rothwell at 17.30 at Savoy Pl., WC2.

18th. IEE — Colloquium on "Review of digital signal processing" at 9.30 at Savoy Pl., WC2.

18th. IEE — "The development of the Doppler microwave landing system" by K. Kelly at 18.30 at Savoy Pl., WC2.

30th. IEE — "Electronics in crime prevention" by G. Phillips at 14.30 at Savoy Pl., WC2.

31st. IEE — "Electronics in crime prevention" by G. Phillips at 14.30 at Savoy Pl., WC2.

ARBORFIELD

4th. IERE — "Terotechnology" by H. Lukes at 19.30 at the Lecture Theatre, School of Electronic Engineering, R.E.M.E., Arborfield.

BELFAST

2nd. IERE — Discussion on "The role of the engineer in society" at 19.00 at Cregagh Technical College, Montgomery Road.

BIRMINGHAM

10th. RTS — "Optical fibre communications" by M. R. Mathews at 19.00 at the ATV Centre, Broad Street, Birmingham 1.

BLANDFORD

2nd. IERE — "Opto-electronics — illuminating the future" by R. J. Abraham at 18.30 at School of Signals, Blandford Camp.

BOURNEMOUTH

3rd. IEE — "Microprocessor technique" by R. Savage at 19.30 at Durlston Court Hotel.

11th. IEE — A Christmas lecture on "Computers and users" by Peter Clarke at the College of Technology, Lansdowne.

BRISTOL

1st. IEE/IERE — "Open University technology courses — an outsider's view" by Dr S. L. Hurst at 18.00 at Queens Building, Bristol University.

CAMBRIDGE

11th. IEE — One-day seminar on "Unexpected inter-action in electronic equipment" at 10.00 at the University Engineering Dept., Trumpington St.

CARDIFF

10th. IERE/I.Phys. — "Solar energy and its applications" by B. J. Brinkworth at 18.30 at Room 164, Dept. of Chemistry, UWIST.

CHELMSFORD

10th. IERE — "Teletext — information display on the home television receiver" by P. L. Mothersole at 18.30 at the Civic Centre.

COLCHESTER

4th. IEE — "Machine — master or slave of man?" by Prof. M. W. Thring at 18.30 at University of Essex, Wivenhoe Park.

COVENTRY

3rd. IEE — "Computer numerical control of machine tools" by K. W. Norman and I. W. Smith at 18.30 at Lanchester Polytechnic.

DUBLIN

10th. IEE — "The Institution and the future of the Irish branch" by J. L. Dobie at 18.00 at the Physics Theatre, Trinity College.

GLOUCESTER

10th. IEE — "Colour TV — a popular approach" by G. D. Barnes at 19.30 at CEGB Barnwood.

GUILDFORD

10th. IERE — "Aspects of v.h.f. reception" by R. S. Broom at 19.00 at Lecture Theatre 'F', University of Surrey.

LEEDS

9th. IEE — "Automobile electronics" at 18.30 at Leeds University.

16th. IEE — "Computers and communications, convergence or conflict" by J. R. Pollard at 18.30 at Leeds University.

18th. IERE — Colloquium and exhibition on "Microprocessing" at 9.30 at Leeds Polytechnic.

LEICESTER

9th. RTS — "Radio and television interference problems" by F. C. Ward at 19.30 at The Post House, Braunstone Lane East.

LIVERPOOL

1st. IEE — "Artificial vision — past, present and prospect" by P. E. K. Donaldson at 18.30 at the Dept. of Electrical Engineering, Liverpool University.

10th. IERE — "Progress in medical instrumentation" by Dr D. W. Hill at 19.00 at the Dept. of Electrical Engineering and Electronics, University of Liverpool.

LOUGHBOROUGH

10th. IERE/I.Phys. — "Sector scanning sonar" by Dr A. R. Pratt at 19.00 at Lecture Theatre W.O.01, Loughborough University of Technology.

MALVERN

8th. IEE — "Electronic aids for detection and prevention of crime" by G. Phillips at 19.30 at the Winter Gardens.

10th. IERE — "Electronics in seismic exploration" by M. J. Hughes at 19.30 at the Foley Arms Hotel.

MANCHESTER

10th. BKSTS/RTS — "Slide and sound versus cine and sound" by L. E. Slater at 19.00 at Preview Theatre, Granada Television.

11th. IEE/IERE — "Communications in oil rigs" at 17.45 at Renold Building, UMIST.

NEWCASTLE-ON-TYNE

1st. IEE — "Microcomputers — control systems application" by J. Gallacher, at 18.15 at Rm M421 Merz Court, University of Newcastle-on-Tyne.

9th. IERE — 'Practical uses of pattern recognition" by Dr J. R. Parks at 18.00 at YMCA Lecture Theatre, Ellison Place.

PLYMOUTH

11th. IEE — Student papers evening at 19.00 at Plymouth Polytechnic.

SHEFFIELD

11th. IEE — Faraday lecture on "The entertaining electron" by F. H. Steele at 10.30, 14.30 and 19.30 at the City Hall.

SOUTHAMPTON

3rd. IERE/IEE — "Impact of behaviour science in management" by P. Sadler at 18.30 at Southampton Technical College.

STONE, Staffs

8th. IERE/IEE/IPOEE — "My dear Watson" by G. Phillips at 19.00 at the P.O. Training Centre.

SWANSEA

11th. IEE — "Technology aids the police" by G. Phillips at 18.15 at University College of Swansea.

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

Quarter million "Foundations"

With the ninth edition of M. G. Scroggie's "Foundations of Wireless and Electronics" this famous book, from which many engineers have received their grounding in our subject, will have sold a quarter of a million copies. Since it was first published in 1936 the book has been closely associated with *Wireless World* because its author has been a much valued contributor to the journal for the whole of this period (indeed over 50 years) under his own name and as "Cathode Ray".

To commemorate the occasion the publishers of "Foundations", Newnes-Butterworths, have produced two handsome crimson leather-bound gold-embossed copies of the ninth edition. One of these has been presented to the author and the other, autographed by M. G. Scroggie, is to be the prize in a competition open to all buyers of the new edition, just out. Competitors are invited to write an explanation of "why Scroggie's Foundations of Wireless and Electronics is so popular". Details of the competition are given on leaflets inside copies of the new edition.

News of the Month

"A" level electronics

A conference on the pilot "A" level course in electronic systems was recently held at City University by the National Electronics Council in association with the IERE, the IEE, and the Institute of Physics. The course is not intended to be vocational training and will not replace the existing maths and physics courses. "Systems" is the area of interest, in its widest sense, and one gains the impression that electronics is used as an illustration of computer, communication and feedback systems, encountered in any sphere of living, be it biological, mechanical or, one imagines, political and social. Each type of system can be treated as a unit, and taught separately and the course material includes a selection of lecture notes and experimental hardware (an ingenious breadboard particularly caught the eye) designed by a team at the University of Essex, led by Prof. G. B. B. Chaplin. Speakers at the conference included two teachers, G. F. Bevis (Richard Taunton College) and D. Thompson (Welbeck College) who were loud in their praise of the course material, Mr Thompson being particularly encouraging to those teachers present who looked upon electronics with trepidation; he himself, he explained, was until a couple of years ago more at home with a rugby football than an integrated circuit.

IEE's "Factual Salary Survey"

The Council of the Institution of Electrical Engineers, at its meeting on October 2, 1975, endorsed the recommendation of its newly formed Professional Services Board, to undertake a "Factual Salary Survey" beginning January 2, 1976, with the results being produced about six weeks later. The IEE thinks that a survey of this nature is both timely and vital in view of the present inflationary situation and the £6 per week maximum pay increase. The normal questions of age, qualifications, grade of membership and field of employment will be supplemented by questions covering the employment status of IEE members; number employed/unemployed at the beginning of January 1976; number of weeks/months employment during 1975 and if while unemployed the engineer was advised to take part in a government retraining scheme.

TV by tropo-scatter

A television programme has been successfully transmitted via a tropo-scatter communication system across the Mediterranean from Crete in Greece to Dernah in Libya. The 320-km system is capable of transmitting one monochrome television channel and 300 telephone channels. Transmission of television via a long-distance tropo-scatter system has been considered almost impossible due to deep selective fading characteristics in tropo-scatter propagation. Nippon Electric Company has developed a quadruple i.f. combining system to overcome this drawback. The trans-Mediterranean system is connected at Dernah to the border-to-border microwave system, completed by NEC in 1974, running along the Mediterranean Sea from Bengardane in Tunisia to Musaid near the Egyptian border. It will be further linked to microwave systems now being built by NEC in Algeria and Egypt to form a pan-African communications network. The newly completed tropo-scatter system linking Greece and Libya is expected to contribute to the development and furthering of friendly relations between the two countries.

Royal president for IERE

In its 50th year of existence (see News, Oct.) the Institution of Electronic and Radio Engineers has installed as its president a member of the Royal Family, the Duke of Kent. At the end of a wide-ranging presidential address on the applications of electronics, including a look into the future, the Duke sounded a warning about "inherent dangers" to personal liberty in the use of electronic systems for management: "... it will be our task, together with the planners of management systems, to ensure that the privacy of the individual is preserved, that he or she is not reduced to the status of a 'human terminal' in a central management complex. I see great strides in the whole field of 'management' by the electronic devices in the future but I hope also to see an industry profoundly concerned with ensuring preservation of the essential human liberties. The almost limitless scope for extending 'management by electronics' must be accompanied by rigorous safeguards against deliberate or accidental abuse."

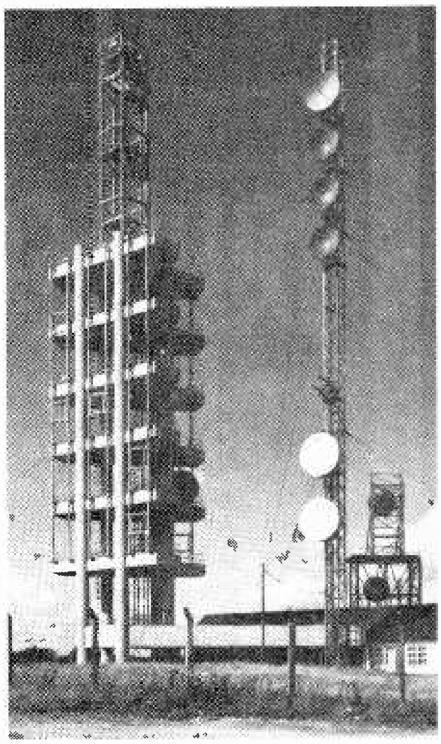
The Duke's cousin Charles, Prince of Wales, has just been made an Honorary Fellow of the IERE.

Facsimile future forecast

"Facsimile transmission over ordinary telephone lines will be much more useful and will play a much more important part in the office of the future than was previously thought. Picture telephones and other video facilities, in which executives can see the person at the other end of the line, do improve the quality of judgments made but they require very expensive telecommunucations links and the extra cost is not justified by the degree of improvement obtained." These are two of the main conclusions of a new research report on the use of telephone facsimile in business which was published at the beginning of October.

The report "Telephone facsimile for business" which is a new and enlarged edition of one published early in 1973, finds that the changes in equipment and practice in the last two or three years have been more substantial than those

To meet increasing demands on telecommunications between the UK and Europe, the Post Office have built a new radio tower to replace the existing guyed mast and tower at their radio relay station near Folkestone. Concrete was chosen as the most suitable material for the 42m high main structure of this 64m high tower.



that had occurred in the previous decade. This means that they have been very substantial indeed because the earlier developments converted facsimile from an expensive, specialised tool suitable only for sending very urgent information such as news photographs and weather charts into a simple, inexpensive one suitable for use on the executive desk of the smallest business. The report costs £29 and is available from Ronald Brown, FREEPOST, Stoke-sub-Hamdon, Somerset TA14 6BR.

Advance in i.c. fabrication

A major advance in the fabrication of integrated circuits has been claimed at Bell Telephone Laboratories by the development of an "electron beam exposure system" known as EBES. By using a beam of electrons to generate the microscopic patterns from which integrated circuits are manufactured, EBES can produce integrated circuit master pattern masks faster, more reliably, with fewer defects and at lower cost than masks made by existing photographic systems. Because electrons have a smaller equivalent wavelength than light, a much "sharper" writing beam can be generated for use in the mask-making process. Circuit design instructions on magnetic tape are fed into the EBES computer which controls both the electron beam and the movable stage on which the mask blank is mounted so that the writing operation is entirely automatic.

Microcircuit copyright lawsuit

General Instrument Microelectronics Ltd have instituted proceedings against the Plessey Company Ltd and their subsidiary LSI (Electronic Systems) Ltd alleging copyright infringement and breach of confidence.

The proceedings stem from Plessey's introduction of certain m.o.s. integrated circuits which GIM claim were copied from their designs. General Microelectronics also assert that Plessey improperly obtained process and design information from several of GIM's former employees.

The first hearing of GIM's application for a temporary injunction restraining Plessey from marketing the microcircuits was heard in the High Court of Justice Chancery Division on October 10, 1975. The circuits in question are Plessey's MP9100 push-button telephone dialler, MP9200 repertory telephone dialler store and MP1013A UAR/T which GIM claim were improperly derived from their AY-5-9100, AY-5-9200, AY-5-1013A respectively.

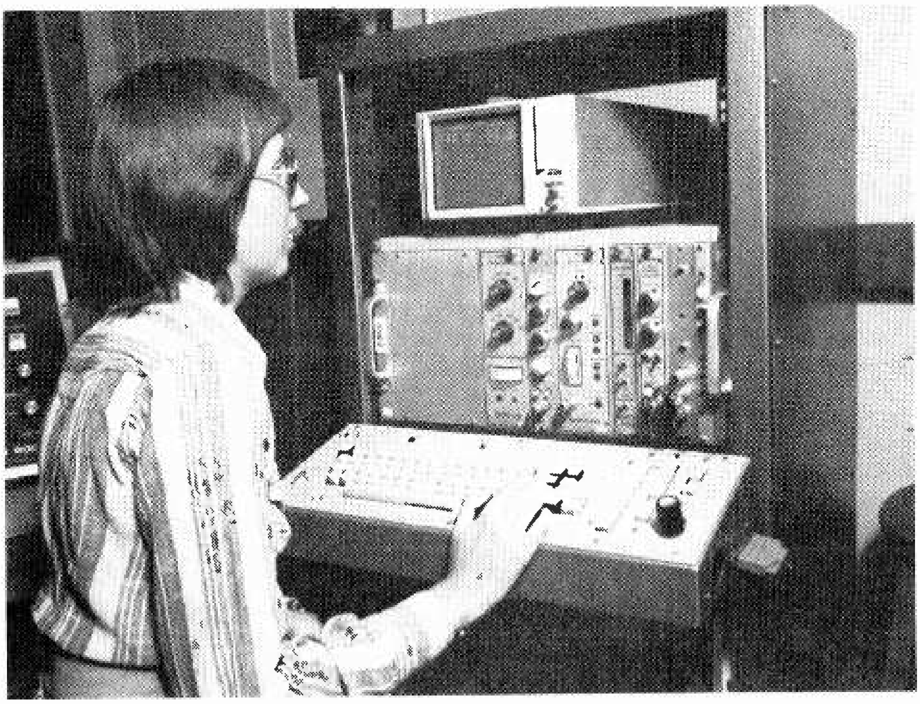
NRDC wants more proposals

Despite the pressures of increased expenditure, interest charges and operating costs, a surplus of £845,000 is recorded by the National Research Development Corporation in its 26th Annual Report published on October 9.

The achievement of this surplus emphasizes the present health of the Corporation. Interest charges of £1.12M have been paid to the Department of Industry, the Corporation's interest relief grant having again been reduced this year to £0.43M.

The effects of the generally depressed state of British industry have inevitably been reflected in the Corporation's development activities during the year ended March 31, 1975. Expenditure on development rose to £3.17M (compared with £2.49M last year) but amounts authorized for investment fell from £5.21M to £4.30M. NRDC state that "Although we can appreciate that companies are reluctant, in the present financial climate, to embark on new development activities, the Corporation is concerned that it is not receiving more proposals for substantial projects involving an appropriate degree of technological innovation."

At Mullard Research Laboratories near Redhill, Surrey, a data communication network has been built which shares the computing power among a number of users distributed within a laboratory building. The results of one experiment can then be used in setting up the next with no need to provide expensive intermediate storage.



Component giants integrate

From November 1, 1975 responsibility for all UK Signetics sales operations will be undertaken by Mullard Ltd. This follows the acquisition of the Signetics Corporation by the United States Philips Trust earlier this year. From the beginning of November the entire Signetics range of digital and linear integrated circuits became part of the range of solid-state devices available from Mullard. This includes the recently announced Signetics 2650 microprocessor and the Mullard LOCMOS4000 series of digital integrated circuits.

Sales of all Signetics i.cs will be the responsibility of a new integrated circuit marketing group being set up within Mullard which will not only be concerned with Signetics products but also with the maintenance and expansion of the sales of all other Mullard industrial i.cs.

According to Bill Everden, general manager of the Mullard Data Processing Division with overall responsibility for the Signetics operation "Under no circumstances do we intend to cause Signetics customers any concern whatsoever. . . . Basically all it means is that instead of contacting the Penge office they will now deal with the same team based in Mullard House."

Indonesian television update

New transmitters, film and processing equipment for the Republic of Indonesia's television authority and radio communications equipment for use by its radio broadcasting authority will be part of an ambitious scheme to expand and update Indonesia's television and broadcasting system. Transmitters and antennas are to be installed at six of the television authority's stations on the islands of Java and Madura as part of a plan to ensure that the majority of inhabitants of the two islands will be able to receive television programmes. At the eastern end of Java, Surabaya, an important city and port, will have its television station's existing low power transmitters replaced by a pair of 10kW v.h.f. transmitters which will radiate more than 100kW of power. Surabaya will then feed three relay stations each supplied with a pair of 1kW v.h.f. transmitters.

The contract for this work has been awarded to Marconi Communication Systems Ltd who will supply the v.h.f. television transmitters. These are self-contained and from their B7103 series of i.f. modulated equipment. Modulation at i.f. has several potential advantages, paramount amongst these being the possibility of applying at i.f. corrections which are asymmetrical about the vision carrier. Emphasis in the design of the series has been placed on the need to reduce the number of valves to a minimum in order to obtain the sort of reliability which is associated with high grade solid-state devices.

Position Location Reporting System seen in use here was developed for the US Marine Corps by Hughes Aircraft Company's ground systems group at Fullerton, California. The set, which weighs 15 pounds, continuously and automatically exchanges information with a master unit back at the command post.

Holographic videodisc

The fifth method of recording video signals on disc (and the first from Japan) has been announced by Hitachi. The recording method is holographic, each frame of the television picture being concentrated in a 1mm diameter hologram on a 12in disc. All three pieces of television information — chrominance, luminance and sound — are superimposed in one hologram, and are "read out" by one laser beam inspected at three different angles. The disc spins at only 6 r.p.m. and can contain 54,000 frames — enough information for 30 minutes playing time in the NTSC standard. This seems to be a playback-only machine and will depend for its success on the supply of programme material. We hope to give more information in a future issue.

Broadcasting for Pakistan villages

Isolated village communities throughout Pakistan are to be provided with news, entertainment and educational programmes broadcast in their own dialect. The low powered broadcasting equipment to be supplied consists of small, self-contained community radio stations, simple to operate and totally self-sufficient in power supply. Until now, many remote country villages in Pakistan have been without any form of radio broadcast communications. The national radio programmes of the Pakistan Broadcasting Corporation could not reach these isolated districts because there was no mains power supply nor any suitable landlines to transmit a programme. The "Village Broadcaster" supplied by Standard Telephones and Cables Pty. is a fully duplicated radio station with two 25kVA diesel generators, two transmitters and two sets of studio desks plus ancillary equipment. Depending on the terrain, a range of 8 to 12 kilometres radius with good quality reception is expected. The contract is part of the Australian Government's aid programme to Pakistan.

Well oiled

An advanced remote control and monitoring system to link Burmah Oil Developments' giant £3000M Thistle "A" drilling platform with the towing and laying vessels during the platform's deployment in the Thistle field is to use a radio communications link between the platform and support vessel during tow out. A cable link will be used as well during the deployment phase. Governing the operation will be the transmission of 150 control signals and the monitoring of over 40 analogue levels and more than 240 indications of platform status. The system, developed by EMI, also includes a unit for attitude measurement during the turnover manoeuvre and an acoustic measuring system for checking leg-to-sea-bed distances during the final touch-down phase. There is complete duplication of the encoding/decoding and radio equipment, with automatic changeover to achieve maximum reliability. Using a 13ft model of the platform, EMI is undertaking extensive tests at its Feltham laboratories which are designed to simulate the radiation patterns that will be encountered. Similarly the entire system will be subjected to full environmental testing with vibration and temperature cycling prior to delivery.

Briefly

5th Salon International "Audiovisuel et Communication." This will be held in Paris from January 24 to 30, 1977. In addition to professional and semi-professional equipment and systems, the Salon will present for the first time "light audiovisual systems". These are intended for a wide public but are of quality suitable for, among other applications, teaching, training, information and commercial promotion.

British radio helps conquer Everest. A Hacker Super Sovereign, RP75MB five-waveband radio was chosen by Chris Bonnington's successful British Everest expedition as its principal portable broadcast receiver.

Computer's Esperanto. Texas Instruments has announced a new micro/minicomputer family with the capability of operating with the same software language throughout, from a microprocessor chip up to the full-size minicomputer.

Current dumping audio amplifier

Output power transistors' non-linearity does not appear in amplifier transfer characteristic

by P. J. Walker

Acoustical Manufacturing Co. Ltd.

If Harold Black did not actually invent negative feedback, he was certainly the first to show a comprehensive understanding of the subject in his famous patent of 1937. Nine years earlier he took out a patent on feed-forward error correction[1]. Relatively small variations on this nearly 50 year old concept have led to the development of a new type of audio output circuit with attractive properties. The circuit was the subject of a paper presented to the 50th convention of the A.E.S. by M. P. Albinson and the writer earlier this year.

An audio power amplifier is required to produce an output signal that differs from the input signal in magnitude only. It must therefore have occurred to every circuit designer that it should be a simple matter to take a portion of the output, compare it with the input to derive an error signal. It is then only necessary to amplify this error signal and add it to the output in the correct amplitude and phase to cancel completely the distortion of the primary amplifier. Of course, one is left with distortion of the error amplifier but being of very low power this can be made negligibly small without much difficulty.

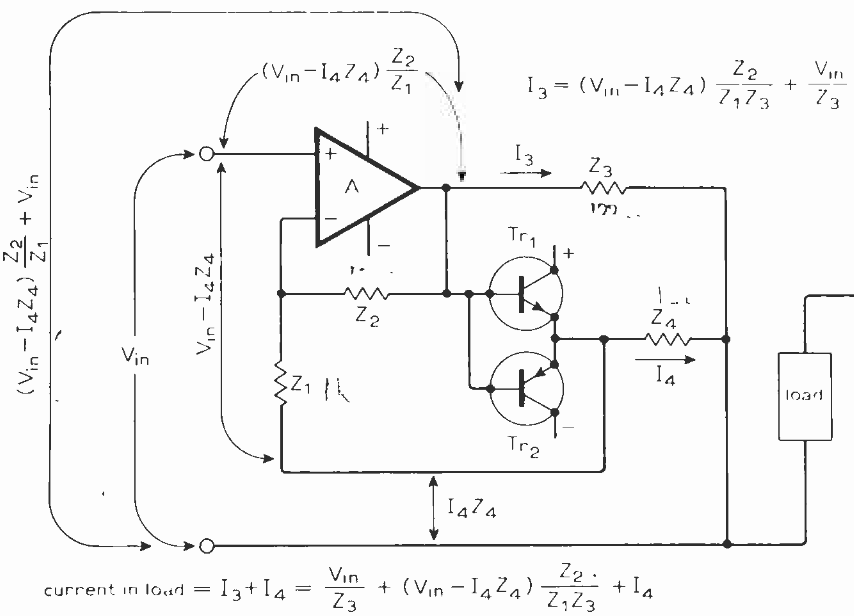
There is a special appeal in feed forward error correction for transistor power circuits. Because of thermal limitations, the output transistors in the majority of audio amplifiers operate in class B, in which alternate output transistors handle the negative and positive signal excursions. The output transistors are carefully biased to obtain a reasonably smooth transition from one to the other. If the bias is insufficient there will be a discontinuity in the transfer characteristic. If the bias is too great, there will be a region of overlap when the mutual conductance will be doubled. The curvature of the characteristic near cut-off precludes there being a perfect bias condition and this is further aggravated by the fact that the junction temperature and hence the bias is a varying factor depending upon both the long term and immediate past history of the programme dynamics. A compromise is selected and overall feedback is applied to obtain an acceptably linear characteristic. Excellent amplifiers have been produced along these lines. Nevertheless, whereas feedback reduces distortion to a small and no doubt negligible amount, feed-forward carries the promise of reducing to zero the distortion of that part of the amplifier over which it is applied. If this is the class B stage, then not only does the distortion itself disappear but all the paraphernalia of quiescent current adjustment and thermal tracking disappears with it.

Feed-forward has only really flourished in areas where stability problems prohibit the use of feedback[2]. In the field of domestic audio amplifiers, it has failed to fire the imagination of all but a few[3]; presumably due to the extra complications and the undoubted practical problems of adding the error channel to the main 'stiff' output in an elegant manner.

If feed-forward is applied within the loop of a feedback amplifier, its stability advantage is necessarily forfeit. Nevertheless, in return, the need for a separate error amplifier can disappear and mutual loading problems disappear with it. A circuit developed on these lines carries an error component bypassing the main output transistors and so largely releasing them of linearity requirements. This technique has become known as 'current dumping' since this is descriptive of the rather mundane functions they are called upon to perform.

The basis of the new approach is shown in Fig. 1. Amplifier A is a small class A amplifier capable of providing the total required output voltage swing but with limited output current capability. Tr_1 and Tr_2 are current dumping transistors which supply the major part of the load current.

Fig. 1. Basic circuit parameters.



It will help in visualising the operation if the impedances are assumed to be resistors of values $Z_1 = 1k$ ohm; $Z_2 = 100k$ ohm; $Z_3 = 100$ ohm; and $Z_4 = 1$ ohm. In the interest of simplicity we have assumed Z_4 to be negligibly small compared to Z_1, and for the time being we will assume that the voltage output of amplifier A is completely defined by the external impedances.

With Tr_1 and Tr_2 turned off, amplifier A will deliver current to the load via Z_3. The current with the values suggested will be 1.01 amps/volt because the second term in the brackets is zero (no I_4 current from the dumpers). When half a volt or thereabouts appears across Z_3, one or other of the dumpers Tr_1 or Tr_2 will begin to turn on and pass some current I_4 into the load. We have selected resistor values such that Z_4Z_2/Z_1Z_3 is unity so that the second term in the expression for the I_3 current is exactly equal and opposite to I_4 (this second term is the feed-forward error correction component). Currents I_3 and I_4 add in the load so that no matter what the magnitude of I_4, the overall mutual conductance remains constant. We can say that any distortion in Tr_1 and Tr_2 produces perturbations in the current I_4 and since this causes the exactly equal and opposite perturbations in I_3, no distortion appears in the load.

Tr_1 and Tr_2 have only one function to perform and that is to dump current into the load sufficiently accurately and sufficiently fast to come to the rescue of the class A amplifier and prevent it from overloading. If this is achieved then the class A amplifier, although it may have considerable gymnastics to perform, will be in complete control of the load current at all times.

Fig. 1 does not look like a practical hi-fi amplifier since its output is constant current and the input is floating relative to the power supply. Nevertheless it is obvious that if the input is returned to the other end of the load all the unique properties of Fig. 1 will still apply though perhaps a little less simple to visualise. This done, we have an amplifier whose output source impedance is Z_4 and Z_3 in parallel.

Two further changes are desirable. A practical amplifier is required to have an internal impedance small compared to the load at audio frequencies and stability requires that the internal loop gain falls with frequency. Both these conditions are met by the use of an inductor for Z_4, a capacitor for Z_2 and resistors for Z_1 and Z_3. The requirement for zero distortion from the dumpers is that Z_4Z_2/Z_1Z_3 is unity at all frequencies of interest. This is achieved if $L = RRC$. Fig. 2 shows the circuit with the modifications carried out. (In order to keep the system operating at all frequencies it is necessary for a resistor in series with the inductor to have a conjugate match with a parallel resistor across the capacitor. This has been omitted for simplicity.)

Fig. 2 begins to look very familiar, in fact just like a conventional amplifier with the biasing removed and a small inductor added. Is this really all that is necessary to produce the perfect amplifier? The answer, of course, is no, not quite; the circuit is over-simplified. We have pushed all the problems back into the class A stage and whilst the distortion would indeed be zero if the class A stage were perfect, this cannot be completely so in practice. We assumed in our analysis that amplifier A was completely controlled by the external impedances, that it had a perfect virtual earth at its input which implied perfect regulation at its output. The effect of departure from this ideal can be assessed by calculation from a deliberate unbalance of the four component bridge, whether this is due to tolerances of any of the components or to inadequate 'stiffness' at the output of amplifier A. With the values shown in Fig. 2, a 5% error in any component value will produce maximum intermodulation products of around 5µV at 1kHz; maximum possible i.m. of 0.01%, the maximum absolute level of these components being some 140dB below full power. Although frequency dependent, it is clear that balance is by no means critical and standard tolerance fixed components can be used without adjusting facilities.

We have said that the dumpers have

Fig. 2. Basic diagram of principal elements.

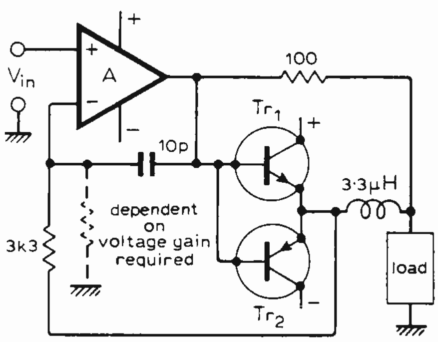
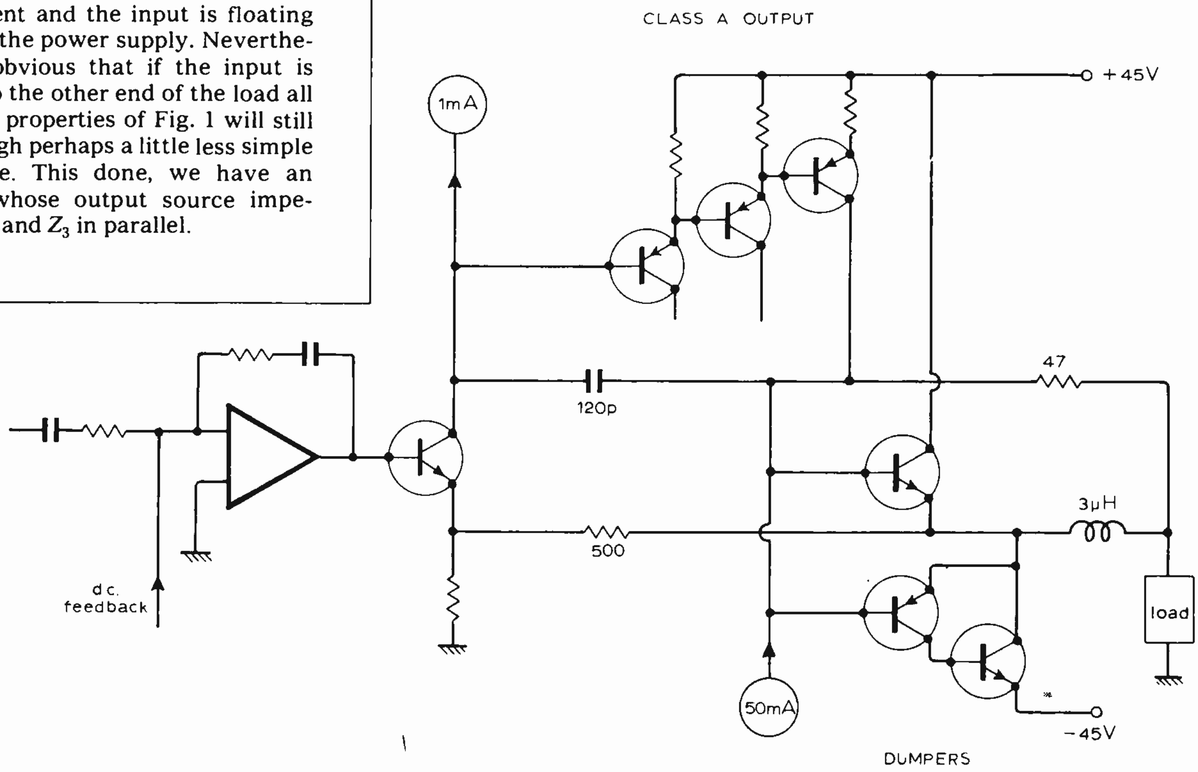
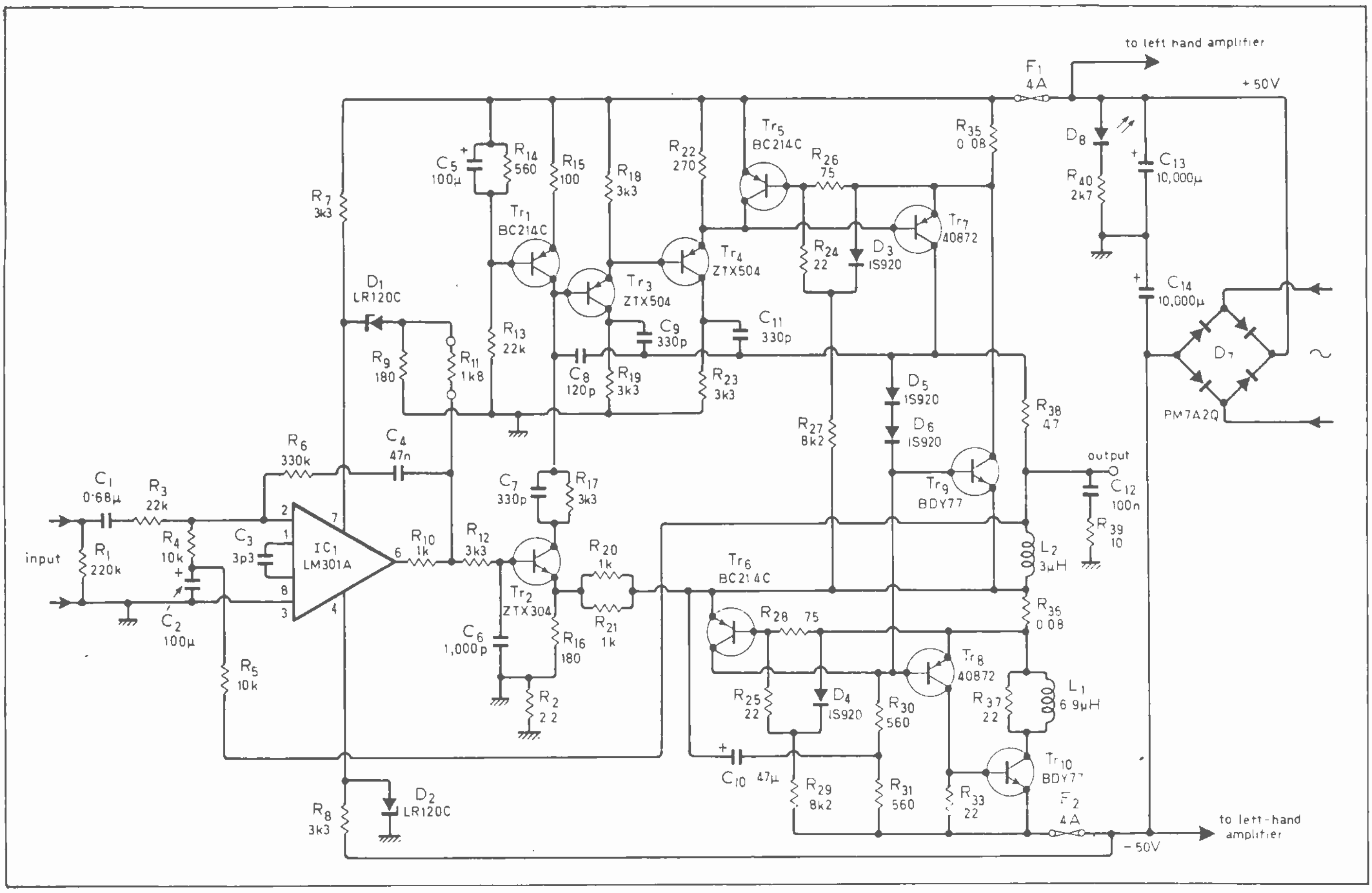


Fig. 3. Simplified diagram showing Class A stage, current dumpers and bridge components.





to be sufficiently fast to come to the rescue of the class A amplifier to prevent its overloading. Clearly they must be sufficiently fast to achieve this over the audio spectrum of the programme. There is, however, nothing whatever to say that they must do so at frequencies outside the audio range provided that steps are taken in the design of the whole amplifier to ensure that any such frequencies that may be present do not embarrass the amplifier performance within the audio range. If the system is properly designed it is possible to use relatively slow devices – inherently more rugged than fast devices – and to show in theory and practice that they will never fail to come to the rescue of the low powered amplifier to any programme. If, however, the criteria are thought to be response to step functions, square waves and other factors not relevant to programme, then of course faster dumpers must be used commensurate with the rise times involved.

Fig. 4. Full circuit diagram. Resistor R_2 is a protective connection provided to ensure earth continuity in the event that Tr_2 and its associated component panel are disconnected from the common earth chassis.

Fig. 4 shows a commercial amplifier circuit (the Quad 405) developed along these lines, Fig. 3 being a simplified diagram to indicate the relevant areas. The class A amplifier serves also as the driver for the top dumper. To counter this extra burden, the class A amplifier is a triple to give a very effective virtual earth. The mid frequency distortion of this amplifier measures about 0.005%, a region where slight component non-linearities etc. tend to deprive such measurements of any true meaning.

An extremely attractive factor of the technique is the complete absence of adjustments or alignment requirements and no thermal problems. Nothing to set up in manufacture and nothing to go out of adjustment during life. One may expect that after several years there will be far less variation, set to set, than is presently realised with most conventional circuits.

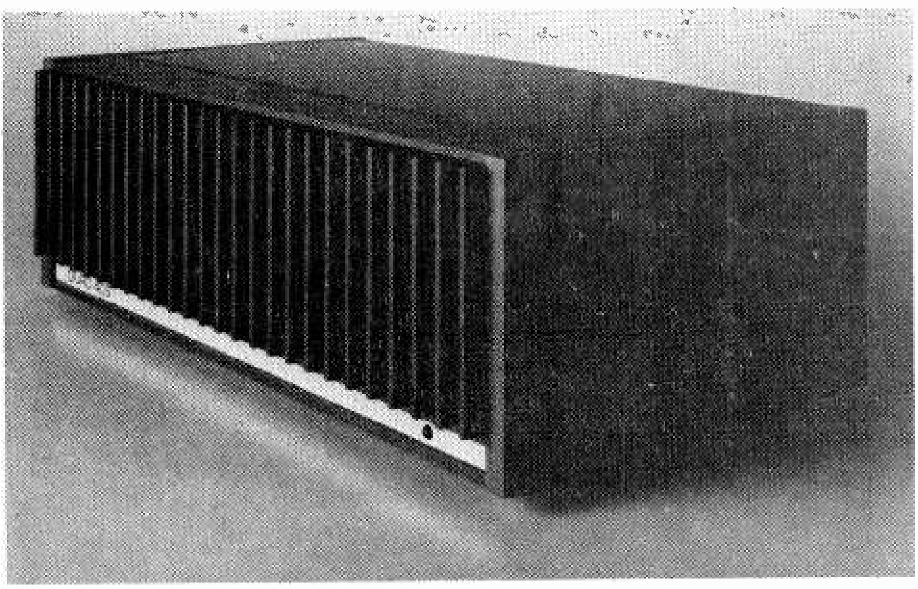


Fig. 5. The Quad 405, a commercial realization of the circuit design.

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1. Black. US Pat. 1,686,792. 9th Oct. 1929.
2. Feedforward error control. *Wireless World*, May 1972, p.232.
3. Sandman, A. M. Reducing amplifier distortion. *Wireless World* October 1974, pp.367-371.

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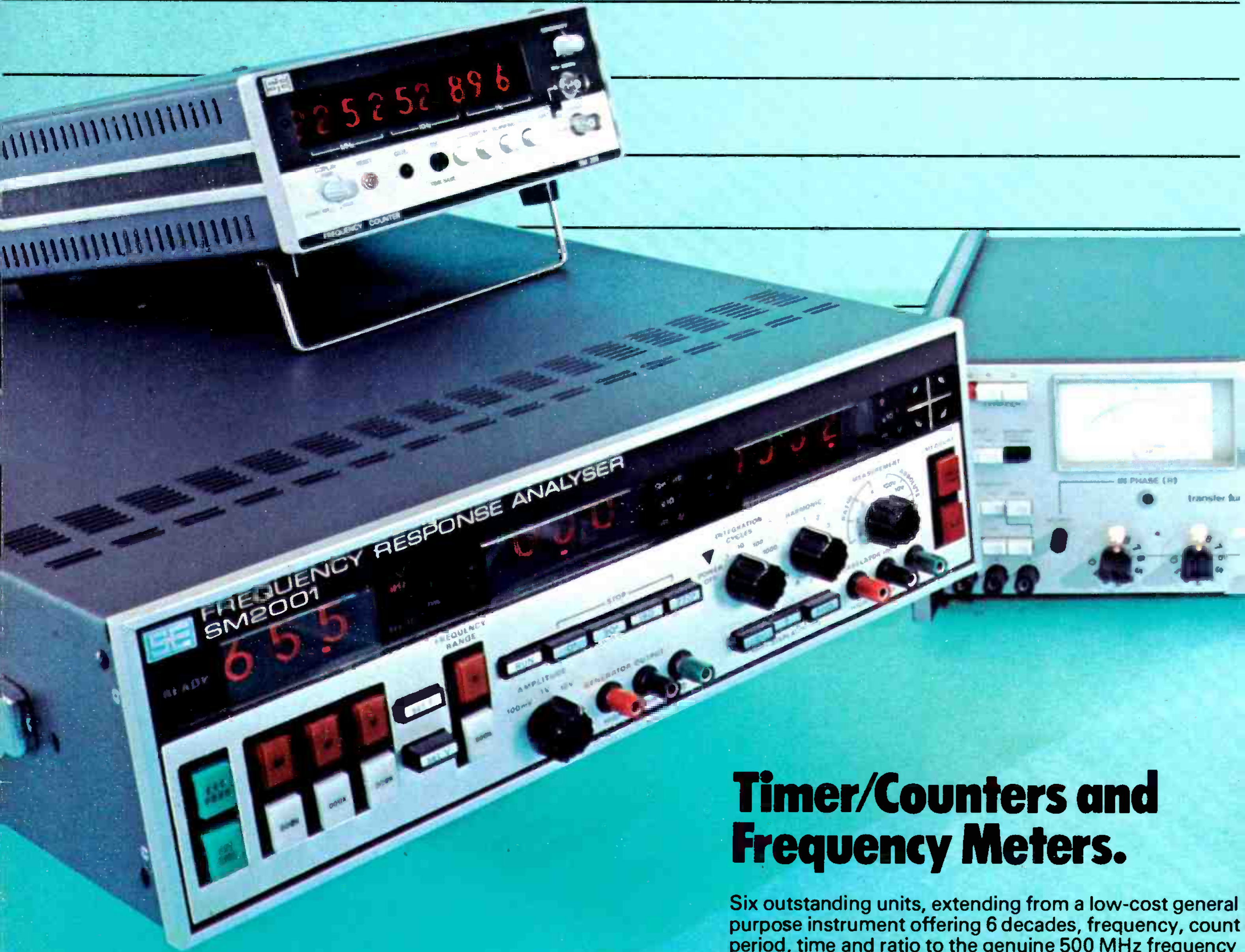

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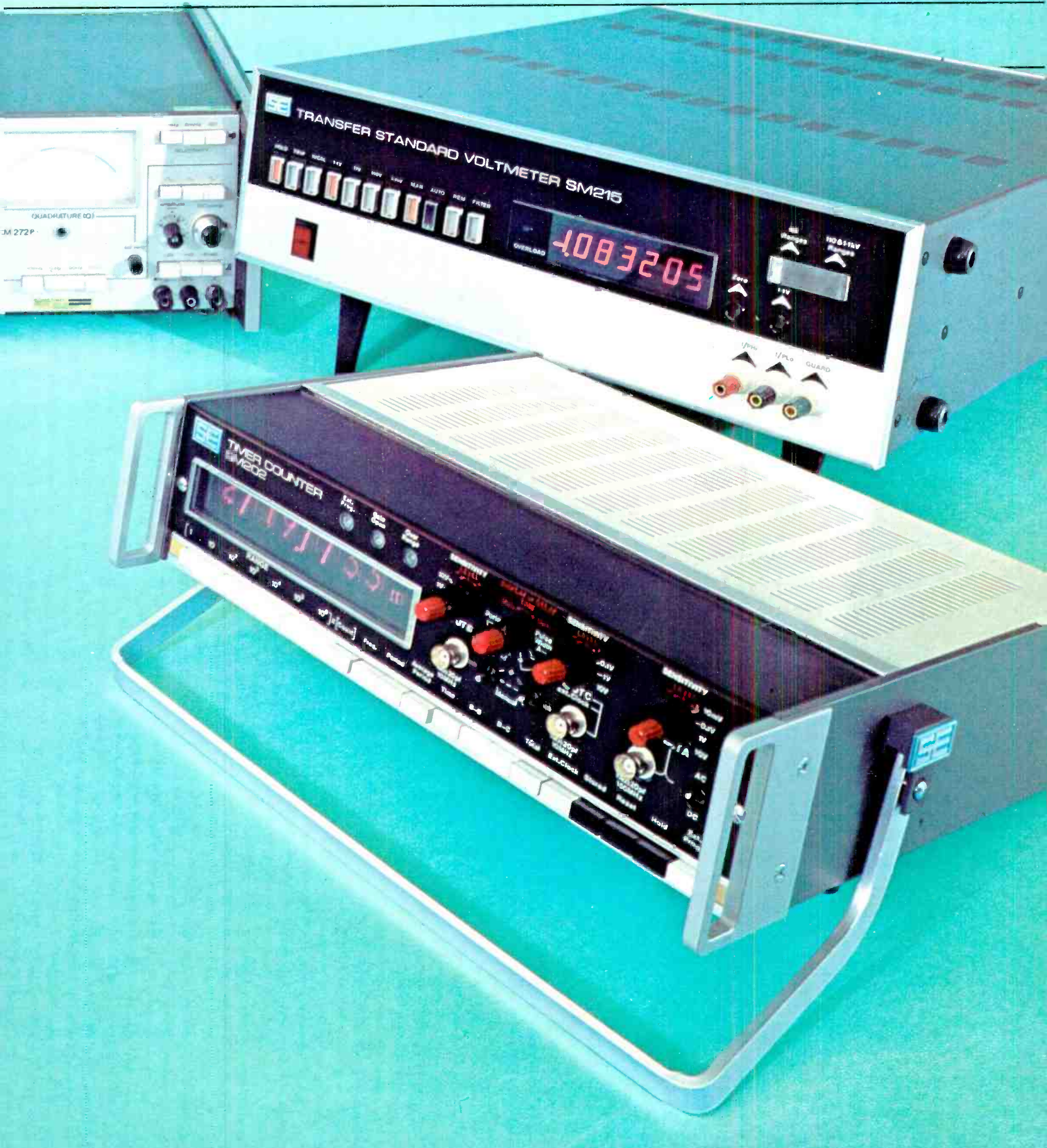


Wireless World Teletext decoder

2—The decoder system

by J. F. Daniels*

This article describes the facilities offered by the Wireless World decoder and also covers, in general terms, the methods of installation in a commercial colour receiver. The problems likely to be encountered with such a project are also discussed.

When contemplating the design of a project as complex as this one, there are many factors which have to be considered. For instance, to build a single Teletext decoder with cost and size virtually no object and expensive test equipment available is comparatively easy, but this is of little interest to the home constructor. What is needed is something which can be built relatively cheaply, can be mounted in a small, attractive cabinet, and can be installed and made to work with only the minimum of adjustments, preferably requiring only a cheap multimeter.

This design will fulfil these requirements. This does assume, however, that the unit is constructed without any wiring errors and with no faulty components – in a unit using around 85 i.cs and their interconnexions, there is some room for error!

Not to be too discouraging at such an early stage, however, it should be pointed out that printed circuit boards will be made available, from normal sources, which should eliminate most wiring error problems. Further, digital i.cs tend to be very reliable, in my experience anyway, as long as they are not obtained from one of the sources of unmarked, untested devices. The use of such i.cs in this project must be strongly discouraged, as even if they appear satisfactory on a d.c. test, they may well be out of tolerance on delay time or fan-out, which could have disastrous effects in some parts of the circuit, where correct delay time through i.cs is an important factor.

For the constructor who has access to an oscilloscope, waveform diagrams will be given at various points in the circuit to help those wishing fully to understand the circuit operation.

It is not intended, in this series of articles, to give full constructional details, and the choice of suitable box, and method of mounting p.c.bs etc. is left to the individual constructor. Details of how the unit may be connected into various types of commercial colour receiver will, however, be fully covered and this should leave only problems of a mechanical nature to the individual.

The cost of the decoder will be in the region of £85, and although this may seem a great deal of money to pay, people who have seen the resulting display of pages on the TV screen agree that the service is well worth while and has great potential for the future. The *Wireless World* decoder will be capable of utilising most of the features currently offered by the system, including display in six colours and white, alphanumeric characters, graphic characters, and flashing display. Two circuit options will be described; one which includes both upper and lower case characters, and another, slightly simpler circuit, with upper case characters only — a worthwhile option for cost conscious contructors. The circuit does not include any form of interpolation (character rounding) because it was thought that the extra cost of about £15-20 was not justified in a discrete-component decoder of this type.

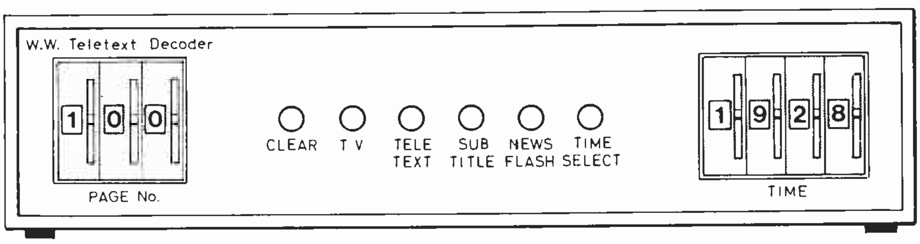
Before going on to describe some problems, which can be encountered when dealing with commercial TV receivers, it is necessary to describe in more detail the performance of the Teletext decoder.

Operation

The decoder can be built into a box measuring about 8.5×10.5×2in, which is a convenient size to rest on top of a normal domestic TV receiver. The power supply is not included in this box for a number of reasons, some electrical, but mainly to keep down the size and heat dissipation in the decoder unit. Space can usually be found in the cabinet of most domestic TV receivers to take the decoder power supply.

The front panel of the decoder carries two sets of thumbwheel switches, and various other function switches. In the latest version, the function switches take the form of a row of pushbuttons as shown in Fig. 1. The bank of three thumbwheel switches are for magazine and page number selection, the one on the left being for magazine number; the other two for page number tens and units. The bank of four thumbwheel switches are for the selection of timed pages. which may only be transmitted for a one-minute period during each day, and therefore require selection by means of time code and storing, for viewing later. The switches can be set to any given time during a 24-hour period, and in this mode of operation a page will only be written into the store at the time shown on the thumbwheel switches. It should be pointed out here that at the time of writing, no pages are being transmitted in this manner, although the operation of the circuitry can easily be checked, because all pages carry time coding information. However, a cost saving of the order of £6 could be made by omitting this facility.

Fig. 1. Suggested front panel layout of the Wireless World *Teletext decoder.*



*Designer of the Teletext decoder

The row of pushbutton switches mainly controls the form of display on the TV screen. The four in the centie are all interlocked, latching pushbuttons, the one of the left is an individually-operating, momentary-action type and the right-hand one is individually latching. The "TV" button merely selects the picture on the screen in the normal manner, although the decoder will still be operative and can store pages in the usual way, ready for instant viewing when the "Teletext" button is pushed. The latter merely replaces the picture with the video output of the decoder and, in this mode, all the normal features of Teletext display are available.

The page header contains a continuously changing time indication in the top right-hand corner, but a fixed page number display — the number of the page selected. When a different page is required on the display, the momentary-action, left-hand button marked "clear" is pushed. This clears all the information from the display except for the page header row, which then starts "rotating" i.e., reading out all the page headers as they are transmitted until the new page number selected is reached, whereupon the new page is read out into the screen.

The next button is marked "subtitle" and is used to select the "insert" mode of operation. When this button is selected, the TV picture is displayed on the screen until the subtitle page, the number of which has been selected on the thumbwheel switches, is detected, when the subtitle message will be read out in a box inserted in the picture. If a new subtitle, or indeed a continuous stream of different subtitles is transmitted, the displayed subtitles will automatically change as they are transmitted. This may be a very useful facility for the future, as subtitles take up very little transmission time in the Teletext waveform, consisting of only a few rows of information. However, at the present time they are only transmitted in test form.

The operation of the "newsflash" button is somewhat similar to the subtitle button, but with an added facility. After selecting the newsflash page number on the thumbwheel switches, the current newsflash — which may have first been transmitted some time ago — is displayed in a box in the TV picture in the normal manner. If, however, the clear button is then pushed, the picture returns to normal, and no data are then displayed until a new newsflash is transmitted, whereupon this is displayed in the usual way in its box. If the current newsflash is required to be seen again, after pushing the clear button, the newsflash button is simply released and reselected.

The next button, marked "time" brings the time-select thumbwheel switches into operation, when the selected page will only be written into the decoder store during the one-minute period displayed on the thumbwheel switches. This page will then be held in the store until either the clear button is depressed or a different mode of operation is selected. This button is not interlocked with the other buttons so that time-selected pages can be written into the store while watching a TV programme — possibly for later reading during the commercials! The time selection facility is not operative when subtitle or newsflash buttons are selected.

No facility is provided for superimposing the complete Teletext display on the picture, as in the author's opinion this gives a meaningless display which makes both the picture and the Teletext display difficult to interpret.

These, then, are the basic facilities offered by the *Wireless World* decoder. Without doubt, as the Teletext system progresses, more facilities will be offered by the service, and it should not be difficult to add extra facilities to the decoder as required.

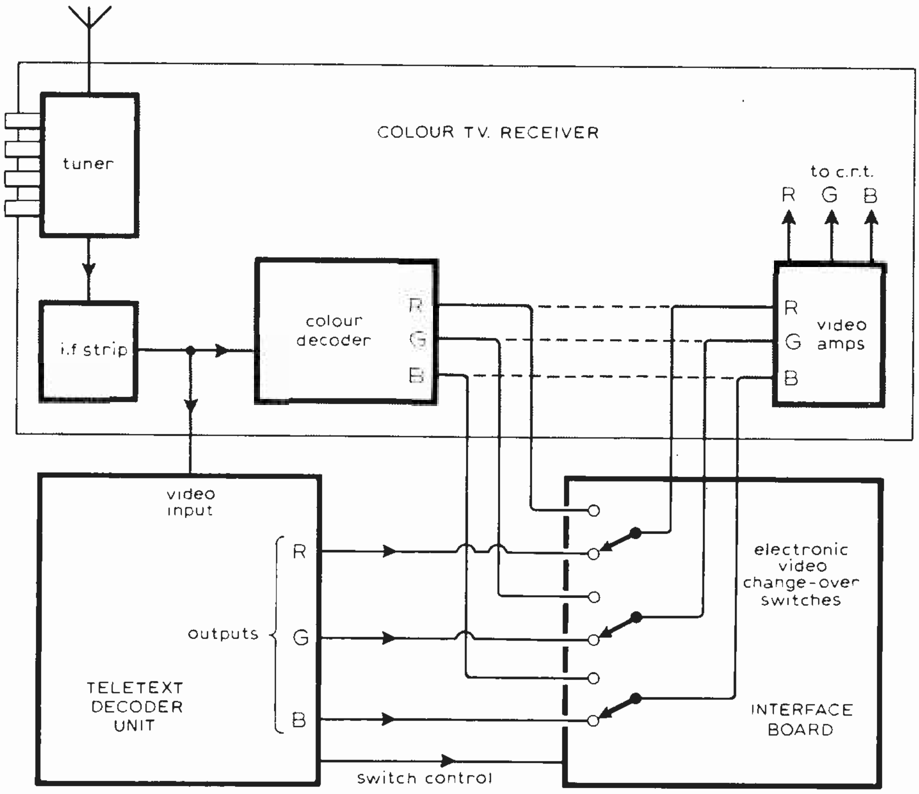
Installation

There is really only one satisfactory way to connect the decoder to a domestic colour receiver if all the facilities described earlier are required, and this is shown in Fig. 2. It can be seen from the diagram that there are only four points of connexion into the set: a feed of composite video from the output of the receiver i.f. strip, and feeds of red, green and blue (or possible R-Y, G-Y and B-Y) to and from the inputs to the receiver video amplifiers. It is possible that a fifth connexion, from the set's flywheel oscillator, will be required if the set is in use in a low signal area and displays a noisy picture, as this can be used to remove horizontal jitter on the Teletext display caused by the noise on the video signal. However, this possibility will be considered later during the circuit description.

The interface board is a small video switch unit, mounted inside the receiver, fairly close to the video amplifiers, and serves to switch electronically between the picture and the Teletext display, when commanded by either the function switches, or by "hole-cutting information from the decoder. The design of this unit will vary slightly, depending on the type of receiver used, some sets having, R, G and B feeds to the video amplifiers and others using colour difference signals (R-Y, G-Y and B-Y). If the facility of putting newsflashes and subtitles in boxes is not required, then this unit could probably be replaced by a three pole change-over relay, controlled solely by the function switches.

This, then, is the only practical way in which a decoder can be installed into an existing TV set, if a coloured display is required and this is the only method that will be described in detail in this series of articles. However, for those who rent a colour set, there is another, somewhat less attractive possibility, shown in Fig. 3. Here, a separate tuner and i.f. strip are used to provide video for the Teletext decoder. The R, G and B outputs of the decoder are then matrixed together, and fed to a u.h.f.

Fig. 2. Suggested method of connexion into a domestic colour receiver, using an interface board containing three simple electronic video switches.



modulator. This in turn feeds the aerial socket of the receiver, which is tuned in to the modulator on an unused channel. This will, of course, only give a monochrome display, but would at least have different shades of grey to represent different transmitted colours.

It is not practical to modulate the decoder display into PAL colour form, partly because of the high cost of a colour coder, but mainly because the results woule be unsatisfactory due to the fact that the bandwidth of the PAL system would be insufficient to cope with the Teletext display waveform.

Data signal

Before starting a description of the decoder block diagram, there are two more important points to be made to prospective constructors. Firstly, there is the question of obtaining a suitably undistorted data signal from the TV receiver.

Distortion of the data waveform can be caused in a number of ways; poor bandwidth or non-linear phase response in the receiver i.f. strip; reflections (ghosting) on the picture, caused either by external multipath interference or aerial mismatching; co-channel interference; and finally noise. All these can cause errors to be made in the data display and, in extreme cases, prevent operation of the decoder at all.

Generally speaking, however, satisfactory results can be expected from the majority of colour sets displaying a ghost-free picture. Noise on the picture, unless of sufficient amplitude to be objectionable, is unlikely to be a problem, as the decoder employs circuits capable of detection and correction of errors caused by noise spikes.

Secondly, the performance of the decoder in the presence of interference in various forms is determined almost solely by the performance of the front end, i.e., the circuitry which separates the data from the video waveform, and converts it into t.t.l.-compatible form. It is proposed to describe first a fairly simple data separator, which is extremely easy to set up and which will be adequate under good reception conditions. This will enable the rest of the digital circuitry to be tested and set up. In a later article a more complex form of data separator will be described which will give an improved performance under adverse signal conditions although it will be rather more difficult to set up initially.

Safety

The most important problem of all is one of safety. If the decoder is to be installed in the manner to be described rather than by using a u.h.f. modulator, as mentioned earlier, then a direct connexion must be made to the receiver chassis, which could under some circumstances be live.

There is only one way to prevent the decoder itself from becoming live, and that is to use a mains isolating transformer in the mains supply to the TV receiver, and I would strongly recommend this course of action for anyone who does not regularly work with live equipment. If, however, the constructor feels absolutely confident that he can carry out the installation without electrocuting himself, then there are two important points to note. The first is to ensure that the receiver chassis is connected to the neutral side of the mains and not the live — this should be a simple matter of connecting the plug the correct way round but it must be checked with a multimeter. The second is to make sure that the decoder cabinet (if made of metal) or any metallic parts on it such as switches, etc. are not connected to the decoder electrical earth.

A three core mains lead must be used, with the earth connexion taken to the decoder cabinet, if this is made of metal. Probably the best solution, though, is to use a wooden cabinet and ensure that the thumbwheel switches and pushbutton switches are suitably insulated from their electrical contacts. The earth connexion should only be made after the decoder has been tested and set up, as it could create a hazard while actually working on the decoder. Of course, after testing is finished, when the earth is connected, protection is ensured against the decoder box becoming live due to faulty insulation.

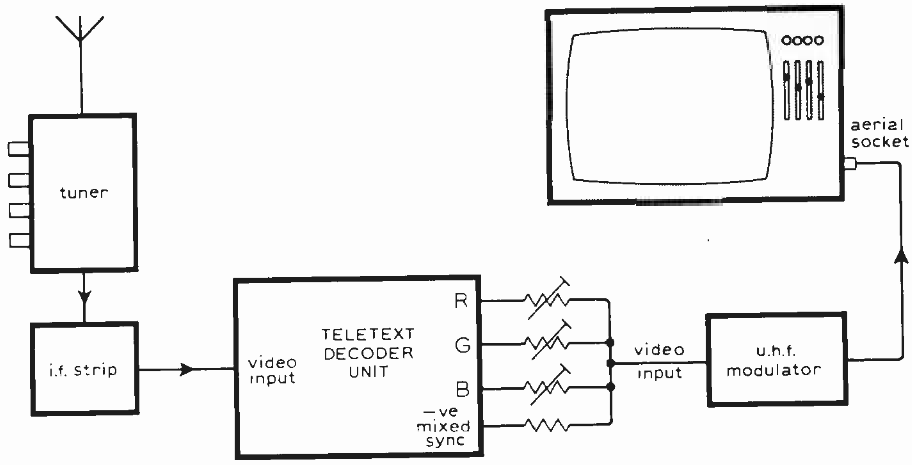


Fig. 3. Alternative arrangements for rented television sets. This has the disadvantage that only a black and white display will be obtained.

Construction

Prototype decoders were constructed on 12 × 7in pieces of ordinary Veroboard 0.1in matrix sheets. There is no reason why this method of construction should not be used, apart from the fact that it is very laborious, and wiring errors can easily be made.

For those who have less time to spare, printed circuits will be available in the form of two large p.c.bs for the digital circuitry, and a smaller p.c.b. for the analogue circuits. The overall size of the unit has been kept down by splitting up the boards in this way.

The large boards measure 9½ × 5½in, and are arranged to mount one above the other, spaced about ½in apart. The analogue board measures 5½ × 3in and is spaced ½in above the digital boards. This gives an overall size for the decoder electronics of about 9½ × 5½ × 1½in. The digital boards, which each hold about 40 i.c.s, are double sided, but for cheapness do not have plated-through holes. The "plating through" process is carried out by the constructor, using tinned copper wire soldered on both sides of the board.

This simplified block diagram in Fig. 4 shows the main functions contained in the decoder, only the main data paths being shown for simplicity. The heart of the circuit is contained in the clock and line divider blocks, and there are many waveforms from these sources which are distributed to the rest of the circuit blocks. This initial description is only intended as a guide to circuit operation, so that an overall picture can be obtained, before starting a detailed description of each circuit block.

The function of the analogue board is to take the composite wide-band video signal from the receiver i.f. strip, and produce from it t.t.l.-compatible mixed syncs, data, and clock waveforms. The single clock line includes the outputs of two clock generators, one derived from the incoming data, and another free-running oscillator used during the display time. Switching between the oscillators is achieved by using a waveform from the line divider circuits, which switches from the display oscillator to the "data locked" oscillator during part of the field blanking interval (between lines 10 and 20). The free-running oscillator has a preset frequency adjustment which controls the width of the Teletext display, and is also triggered by a line blanking wavefrom to ensure that it starts up in the same phase at the start of each television line.

Clock and data waveforms from the analogue board are fed to the serial-to-parallel converter, which in turn feeds the data latches and the framing-code detector. The output of the framing code detector is used to reset the clock dividers, and a ÷8 clock waveform is in turn used to operate the data latches.

It should be explained at this point that the clock and line dividers perform the dual role of data aquisition and data display dividers, and this constitutes quite a saving in circuit components.

Bits 1-7 from the data latches are fed straight to the inputs of the data store, while all eight bits are fed to the parity checker and Hamming-code corrector. The output of the Hamming corrector consists of bits 2, 4, 6 and 8, suitably corrected in the case of a single error, and also an output which indicates an even number of errors. If an even error is detected during a row address group, then the even error output of the Hamming corrector is used to inhibit any data from being written into the store on this row.

Bits 2, 4, 6 and 8 from the Hamming corrector are fed to the row and page recognition circuitry, and also to the line divider circuits. The line divider circuits count line syncs during the display period, but when data lines are detected during field blanking, the counters are preset to the correct row number, indicated by the Hamming-corrected bits. The five-bit row-address output of the line dividers is fed, together with the six-bit column-address output of the clock dividers, to the code convertor circuit. ("Column address" refers to the 40 vertical character columns and "row address" to the 24 horizontal character rows.)

The divider circuits are both arranged so that the data on these eleven wires is correct during both data aquisition and data display, and this obviates the necessity of complicated switching in the address inputs to the store. The code convertor is required for the following reason: the 1024-bit random-access memories are arranged in a 32 × 32 matrix which can, of course, be addressed in any of its store positions by a 10-bit address input. Our display matrix, though, is arranged in a 40×24 pattern as previously described, and this requires an 11-bit (6 + 5) code to address each individual position. However, there are many unused positions which can be addressed by the 11-bit code and by a suitable rearrangement of the addresses, the 11-bit code can be reduced to 10 bits, without actually losing any of the 40 × 24 matrix positions. A simple calculation showing that 40 multiplied by 24 comes to less than 1024 indicates this possibility.

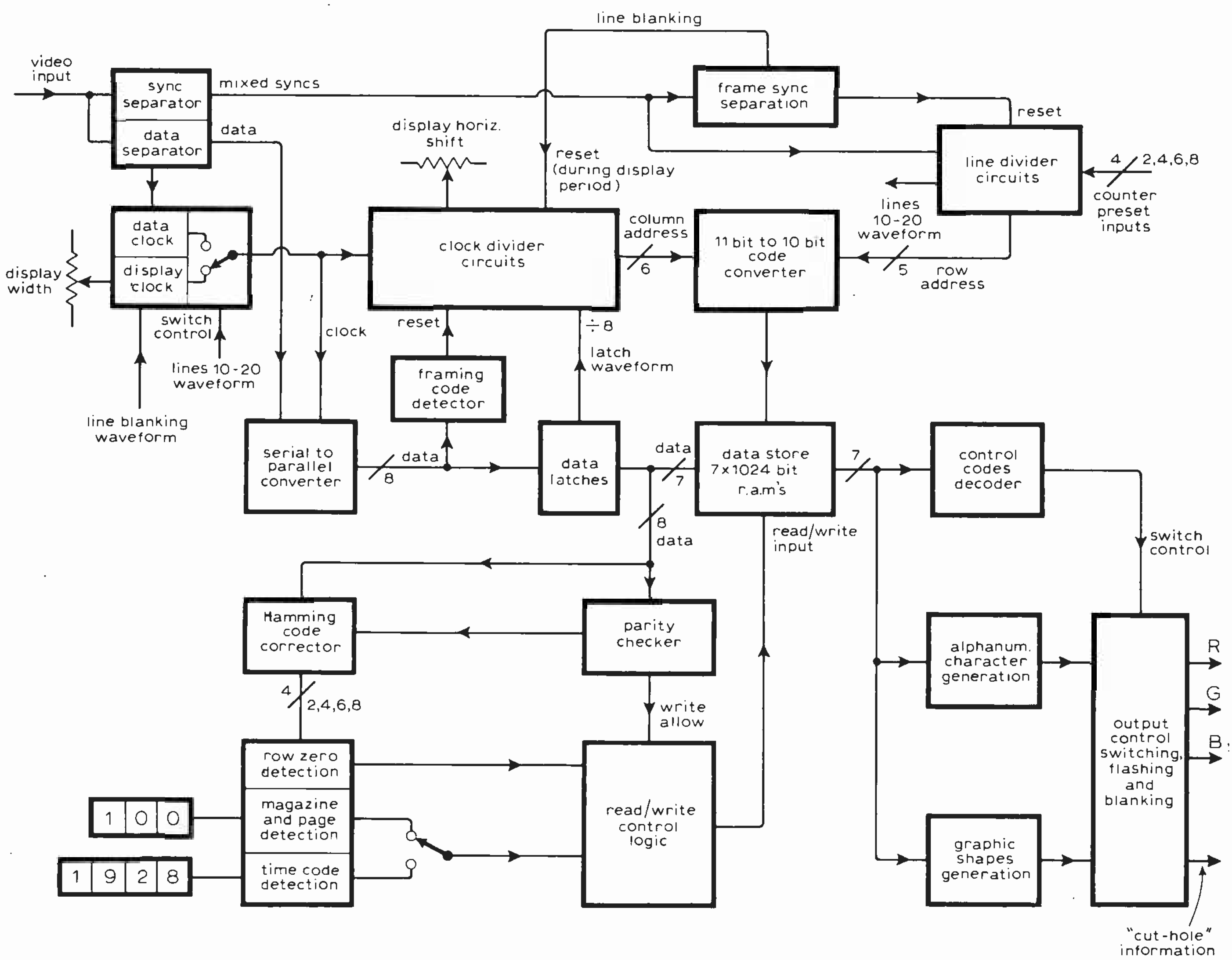
Fig. 4. Teletext decoder simplified block schematic.

The data store consists of seven 1024-bit random-access memories, addressed in parallel – one for each of the seven bits of data. The other input to the store is the read/write input. This input is normally in the read condition, when data already in the store is read out onto the screen, but changes to the write condition during Teletext data lines 17 and 18, when instructed to do so by the read/write control logic.

The seven-bit output of the data store is fed in parallel to three circuit blocks, as shown. Alphanumeric characters and graphic characters are generated for each of the 960 display positions on the screen. The control codes decoder decides which will actually be displayed, what colour it should be, and whether or not it ought to be flashing or boxed. It does this by suitable switching in the output control unit, which also blanks control characters.

This, then, is a necessarily brief introduction to the *Wireless World*. Teletext decoder. In the following articles, detailed descriptions of each of the circuit blocks will be given, with waveform diagrams and explanations where these are relevant. Finally, circuits will be given for various types of "interface" board.

(To be continued)



Applying "magnetic Ohm's law" to permanent magnets

by P. E. K. Donaldson
Medical Research Council

The entertaining article last year by M. G. Sçroggie in which he replaces the notion of e.m.f. by a counter electric field ("What is e.m.f.?", August 1974 issue) reminded me forcibly of another area in which a motive force is inclined to be consigned to limbo: the application of the "magnetic Ohm's law" to magnetic circuits excited by a permanent magnet. The textbooks follow a well-worn path in defining magnetomotive force as the line integral of a magnetizing force, but then press quickly on to consider a magnetic circuit excited by a coil carrying a current, developing the familiar relation

$$\text{flux} = \frac{\text{m.m.f.}}{\text{total circuit reluctance}}$$

which parallels neatly the even more familiar

$$\text{current} = \frac{\text{e.m.f.}}{\text{total circuit resistance}}$$

perhaps leaving the student with the notion that m.m.f. is something made only by a coil carrying a current.

What does happen to a magnetic circuit if the electromagnet is replaced by a permanent magnet? Is the "magnetic Ohm's law" model still relevant? The textbooks are maddeningly inexplicit on this point, but seem in general to abandon the notion, switching abruptly to an "ad hoc" graphical solution to find the flux in the permanent magnet case. "Cathode Ray" (*Wireless World*, February 1973) evidently believes in m.m.f. for permanent magnets, but uses the graphical solution. Another author[1] states clearly that, in the absence of a wound coil, "the m.m.f. in the circuit is zero," and concludes that a flux is able to exist because the reluctance of the permanent magnet is negative. Now this is perfectly legitimate; it is analogous to looking at the terminals of the dotted box in Fig. 1 and concluding that, since there is a p.d. of 1.4V between them, and a current of 0.1A flowing in at the negative terminal and out at the positive, the box must contain a resistance of −14 ohms. But I feel sure it is more useful to think of a real cell as an e.m.f. in series with an internal (positive) resistance, and would like to suggest, in the magnetic case, that it is useful to think of a real permanent magnet as a m.m.f. in series with an internal (positive) reluctance.

Choosing a ceramic magnetic material for the conveniently constant reluctance such materials have, we find for Mullard[2] Magnadur 1 that the B–H curve cuts the $B=0$ axis at $H=-140\times10^3$ ampere turns/metre, the $H=0$ axis at $B=210$ milliwebers/metre^2 and is straight between. Plotting this data for a magnet of length $l=3$ cm and a cross-section $A=4$ cm^2 gives us Fig. 2. If the magnet were to be immersed in a very highly reluctant medium, there can be no flux, $\phi=0$, so the working point is α. Because there is no flux, the "open circuit" magnetic potential difference will give the m.m.f.; in this case 4.2×10^3 ampere-turns. If the magnet were immersed in a very high−μ (low-reluctance) medium, the magnet would be short-circuited, there can be no magnetic potential difference, the working point is β and the short-circuit flux is 8.4×10^{-5} webers. The internal reluctance (cf. Fig. 1) is given by

$$\frac{\text{open-circuit m.m.f.}}{\text{short-circuit flux}} = 5\times10^7\,\frac{\text{ampere-turns}}{\text{weber}}$$

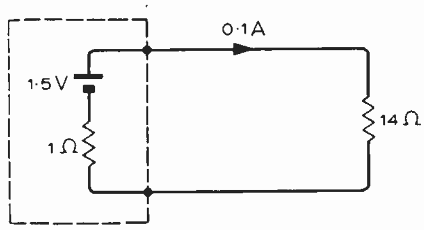


Fig. 1 Electrical circuit analogy for a permanent magnet with negative reluctance: the box can be said to contain a resistance of −14 ohms.

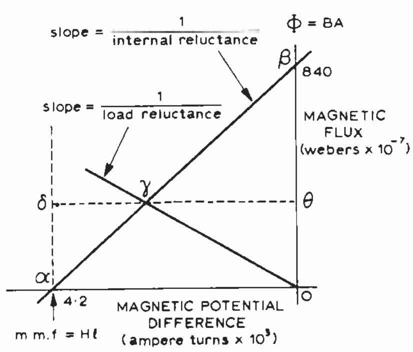


Fig. 2 Plot of magnetic flux against magnetic potential difference for a ceramic magnetic material.

These two quantities, m.m.f. and internal reluctance, entirely characterize the magnet.

In general the working point will be between α and β, at some point γ, where O γ is a load line representing the reluctance of the air-gap, pole pieces etc.:

$$\frac{l_1}{A_1\mu_1} + \frac{l_2}{A_2\mu_2} \;\ldots\ldots$$

The flux is given by

$$\frac{\text{m.m.f}}{\text{load reluctance} + \text{internal reluctance}}$$

$$= \frac{4.2\times10^3 \text{ ampere-turns}}{\dfrac{l_1}{A\mu_1} + \dfrac{l_2}{A_2\mu_2} \ldots + 5\times10^7\,\dfrac{\text{ampere-turns}}{\text{weber}}}$$

If the only significant load is an air gap 0.5 cm long and of cross-section 1 cm^2, then its reluctance is

$$\frac{l}{A\mu_0} = \frac{0.5\times10^{-2}}{10^{-4}\times4\pi\times10^{-7}} = \frac{1.25}{\pi}\times10^8$$

$$= 4\times10^7\,\frac{\text{ampere-turns}}{\text{weber}}$$

and the flux is

$$\frac{4.2\times10^3}{4\times10^7+5\times10^7} = 4.7\times10^{-5}\text{ weber}$$

or 4,700 "lines" or maxwells.

The distance $\delta\gamma$ is the magnetic potential dropped in the internal reluctance of the magnet, leaving $\gamma\theta$ available for pushing flux through the external load. When the load reluctance is equal to the internal reluctance, γ bisects α β and the product Hl,BA is maximal. For a given magnet, that is, lA fixed, we have therefore the well-known $(BH)_{max.}$ condition ("Cathode Ray," *Wireless World*, February 1973, p. 73) for optimum use of the magnetic material. We see that the condition corresponds to conditions for maximum power transfer in the analogous electrical case.

It seems that some useful insights are to be had by pushing the "magnetic Ohm's law" notion into the realm of permanent magnetism. Is there a catch to it, or have I been looking in the wrong books? Oh, and let nobody say that the graphical solution, rather than the simple Ohm's law solution, is necessitated by the fact that, for many permanent magnet materials, the reluctance is not very constant, but is a function of H (or B). The β of a bipolar transistor is not very constant either, being a function of I_c. But the concept of β is far too useful to be discarded on that account. And so, it seems to me, are the m.m.f. and internal reluctance of a permanent magnet.

References

1. Bennet, G. A. G., *Electricity & Modern Physics*, Edward Arnold, 1971.
2. Mullard Ltd data sheet, *Permanent Magnets*, March 1971.

Letters to the Editor

TELEVISION TUNER DESIGN

I am writing to advise you and forewarn potential constructors of D. C. Read's television tuner (Oct., Nov., Dec.) that the design, as shown, with the Mullard ELC1043 varicap tuner, will not be suitable for use in those areas served by group C/D or E transmitters. The tuning voltage is derived from an 11V line and therefore the varicap tuner cannot be tuned above channel 50, some 24V being required to reach channel 68. Indeed, the values shown for resistors R_{89} to R_{97} inclusive preclude the tuner from being used even on group B, for the potentiometers R_{90}, R_{93} and R_{96} will allow channels 21 to 26, 23 to 29, and 33 to 40, respectively, to be tuned. These will be satisfactory for the Crystal Palace transmissions but different component values may be required for some group A or any group B transmitters. A mechanical tuner will be required if coverage of the whole u.h.f. television spectrum is required.

It would also be helpful if Mr Read could advise which version of the ELC1043 is required, as there have been six versions: the two models in current production, the ELC1043/05 and ELC1043/06, have differing i.f. coil arrangements which may require alteration to the matching components C_5 and R_3 to optimise the response shape. I am also advised that early versions of the ELC1043, as are currently available from many discount dealers, had an i.f. output which was not isolated from the 12V supply, which might result in R_3 expiring along with the i.f. coil in the tuner.

P. A. Moore,
London E3.

Mr Read replies:
I am indebted to Mr Moore for his timely reminder that television channel numbers and radiated frequencies in use move ever upward towards the limit of Band V and that some changes (even additions) to the tuner circuit published in Part 1 of the article would be necessary to receive signals from the newer transmitters. To allay Mr Moore's possible suspicion that we who live in the shadow of the Crystal Palace transmitter had forgotten everyone else, I refer him to steps 2 and 11a of the line-up procedure in Part 4 which deal with this aspect of construction, specifically relating it to a curve (Fig. 21) showing tuning voltage against channel numbers/frequencies for the ELC1043 and ELC 1043/05 modules. Re-stated briefly, the point is made that the published circuit will enable reception up to channel 50; for channels 51 to 68 one or two extra zener diodes are needed in the Tr_{20} collector circuit to provide up to 22.5 V for the tuning supply.

At the time of writing it seems that channel 69 is being reserved for the "Fourth Programme" transmissions ready for when (and if) the Government decides on allocation. The highest-numbered channel at present in use is 67, which is allocated to the IBA transmitter at Henley. In the event that a tuner is required to receive channel 67, and also happens to have an ELC1043 or an ELC1043/05 version with a characteristic at the top of the manufacturer's quoted spread (see Fig. 21), the necessary extra tuning voltage — perhaps 25V — could be obtained by bypassing the MC7824CP (IC_3) regulator and driving the Tr_{19}/Tr_{20} circuit directly from the 30V rail, using an extra zener diode.

Regarding the specific version of the tuner module to be used, I am similarly grateful for the information from Mr Moore, particularly his point about the lack of i.f. output isolation on early models; I had not previously heard of this. In reply, it is simply necessary to say that: (i) as indicated in the parts list (Part 3), the u.h.f. module fitted to the prototype tuners was coded ELC1043, i.e. *without* suffix numbers; the ELC1043/05 version should be suitable but has yet to be tried; and (ii) if one of the early un-isolated u.h.f. tuners is to be used, the only modification required will be to break the copper track leading from the i.f. output roundel on the board and to bridge the break with a small disc ceramic capacitor (e.g. 2.2nF).

AUDIO AMPLIFIER LOAD SPECIFICATION

Since amplifier specifications rarely call for any "wattless" output capability and since loudspeakers are not required to reflect a purely resistive load, it is not surprising that some amplifiers of excellent paper specification fail to live up to their promise when auditioned.

The situation has deteriorated in recent years because of the indiscriminate use of voltage-dependent current limiting. $V-I$ limiting restricts the amplifier's ability to cope with the reactive component of the load but it does enable faster output transistors to be safely used, with the implied assumption of a "better" specification.

I would like to suggest that a power amplifier must be capable of providing its full output *voltage* without exceeding its specified distortion when loaded by $R \pm jX$, where R is the rated load for which the amplifier is designed and X is any value from zero to several times R.

In practice only a single additional measurement is really necessary. Set up the amplifier in the usual way to measure power output and distortion just below clipping into the resistive load R. Then, without changing the input level, a reactance equal to R at the frequency of measurement is added in series with the R. The distortion at the amplifier output terminals should not increase.

The choice of $R \pm jX$ seems to me a reasonable compromise because it is the form of the load of any single moving-coil speaker and it is very representative of the load imposed by the majority of loudspeaker systems. It allows a sensible degree of $V-I$ limiting in the amplifier. (Constant voltage to $R \pm jX$ implies that the amplifier shall be able to deliver half peak current at zero volts.)

There are a few loudspeakers (our ESL is one) which place a more severe load on the amplifier than their rated impedance implies. However, the prudent loudspeaker designer will only allow this to happen in areas of the frequency band where full power is unlikely to occur on programme.

Meeting the requirement outlined in this letter is no real hardship for amplifier or loudspeaker designer and can result in nothing but better sound for the listener.

P. J. Walker,
Acoustical Mfg. Co. Ltd.,
Huntingdon.

The following is an invited response to Mr Walker's letter. Other invited comments will be published later.

I applaud Mr Walker's letter as a useful and correct attempt to arrive at a standard to be agreed and achieved by loudspeaker and power amplifier designers. As a target the notion of a load $R \pm jX$ where the magnitude of X varies from 0 to ∞ is suitable.

However, in the present world loudspeakers tend not to be so well behaved and the amplifier designer is obliged to consider more stringent loads. I would suggest that a power amplifier of rated load impedance R ohms should maintain its performance into loads of $R/2$ and $R//jX$, i.e. $(jR-X)/XR$. This requires, of course, twice the resistive load current and a zero voltage current sink of rated peak current. This is not of course an ideal state of affairs and is only necessary because monitor quality loudspeakers are not designed to Mr Walker's suggested impedance limits and do not always exhibit the defects outside the speech band.

In the second paragraph of his letter it is suggested that $V-I$ limiting is a device for enabling fast transistors to be used with reduced reactive power capability. There is an economic factor not made clear; there is no reason for $V-I$ limiting, particularly delayed limiting, to deteriorate the performance of the power amplifier, nor is there any reason why this should preclude the use of fast or slow devices. All that is important is the time nature of the $V-I$ limiting and the $V-I$ co-ordinates used, bearing in mind the loads already discussed. Of course, faster transistors e.g. triple-diffused devices, may need to be used in larger numbers and because they are already more expensive than the rugged single diffused or epi-base parts a given $V-I$ characteristic will cost more with the faster part. Whether or not this actually improves the specification or the performance is too dependent on the circuit and too complicated to discuss here.

How do we propose to achieve this standard?

J. R. Stuart,
Boothroyd/Stuart and Partners,
Cambridge.

ANALOGUE vs DIGITAL READOUT

Your editorial on analogue versus digital measuring instruments in the July issue strikes a chord in my thought which I should like to express. My home laboratory has only analogue meters for d.c. and low frequency a.c.; and with 1-2% or 3-4% moving iron types for a.c., and a few 1% d.c. meters, I try to stay that close to true voltages and currents over a fairly wide range. Every five years or so I purchase a (British-made) standard cell and check over my d.c. instruments, assisted by a Wheatstone bridge and sufficient precision resistors to set up a potentiometer. But I am not unaware of the relatively-phenomenal accuracies of the digital multimeters available for a few hundred dollars; in fact, I read all the advertisements, wondering when I will jump that way. What stops me is their evident limited life at their initial accuracy, unless re-calibrated. Decades pass, and my analogue meters (when properly treated) continue to live up to the standard cell checks and other means of calibration I am able to borrow.

What use would it be to me to have a meter that would display impressive rows of digits, when after a year or so it may have drifted way beyond my modest, but dependable, 1%, and thereby require re-calibration to a degree of accuracy entirely out of reach of the home laboratory, budget-wise? And I am not at all anti-digital; my "upstairs" scientific calculator uses reverse Polish logic, while my "downstairs" ditto employs algebraic logic with two pairs of nested parentheses. I could hardly be happy without both of them, technically speaking. I would be interested to hear comments from experts on digital multimeters which might help to resolve my doubts.

F. A. B. Smith,
Washington DC,
USA.

CONTROLLING STAGE LIGHTING

I have read with very great interest the letter from Paul M. Hodgson in the October issue on the amateur's problem in using triacs for stage lighting. The points he made on using triacs with T class lamps were extremely relevant and enlightening. However, he is misinformed on the point that these triacs are not available on the British market.

Allen Bennett components Ltd (Orgreave Crescent, Sheffield S13 9NR) supply a range of triacs up to 50 amps r.m.s. on-state current which are extremely reliable and at a price between £5 and £10 each. I have approached the company and have received the assurance that if any bona fide amateur group who are building their own stage lighting equipment would write to the company they are prepared to supply these triacs at a much reduced price.

C. D. Naylor,
Sheffield.

ELECTRODYNAMICALLY INDUCED E.M.F.

For those readers who are interested in the continuing discussion of "electrodynamically induced e.m.f." (Letters, Feb., May, July, Sept., Oct. 1975) which was prompted by your earlier two-part series on electricity and magnetism and who would like to augment their general understanding of electromagnetic theory, I would like to recommend the lucid paper by Professor Chen-To Tai entitled, "On the Presentation of Maxwell's Theory" (*Proc. IEEE*, Aug. 1972).

This important contribution identifies some typical ambiguities found in most textbooks on the subject, explains their origins and resolves them in a scholarly way. However one has become acquainted with electromagnetic theory, Professor Tai's paper is indeed both a necessary and enlightening supplement.

Douglas H. Preis,
Harvard University,
USA.

The continuing controversy concerning electrodynamically induced e.m.f., as expressed by the letters from Dr Smith and Mr Masson in your September 1975 issue, prompts me to refer once again to my relevant correspondence in your May 1975 issue. This is in broad agreement with Colin Masson's suggestion that only a relativistic consideration is satisfactory; but I must disagree with Mr Masson's statement that the electric field seen from the aeroplane is as real as the earth's magnetic field itself. Such a statement is at variance with one of the two axioms upon which Einstein based the special theory of relativity, namely that uniform and non-rotational velocity of a system cannot be detected within that system, and is in fact meaningless.

In contrast, the first reference of my May 1975 letter postulates relative motion between a conductor and the system within which the conductor e.m.f. is to be detected as a basic requirement for electrodynamic induction of e.m.f. in the conductor. Perhaps "Cathode Ray" will also accept my note of disagreement as being equally valid for his footnote in your September issue, with rotation discounted in the interest of simplicity.

John Gray,
College of Technology,
Belfast.

"THE CONSULTANTS"

We have read with great interest the contribution by Mr Dwyer in the November issue on the subject of consultants.

It is a source of considerable dismay to us that there are several points which can be regarded as little short of gross misrepresentation — not only regarding the activities of our own company, Angus McKenzie Facilities Limited, but also those of several of our highly respected colleagues also mentioned in the article.

One specific source of concern to us is the very superficial discussion of fees, which most unjustly gave the impression that the better established audio consultants charged exorbitant fees, with the sole justification of personal greed for big houses and fast cars! In order to maintain a high standard of instrumentation to avoid Mr Raymond Cooke's true picture of some "consultants with just an Avo with a bent needle", the capital investment involved in a properly organised and equipped audio laboratory runs well into tens of thousands, and the feeblest level of schoolboy accountancy points to the need to amortizing this high level of expenditure. In our own concern, for example, we have had to re-equip with approaching £10,000 worth of capital gear over the last 12 months in order to keep the standard of our test equipment at least one step ahead of the increasingly more sophisticated products which we are called upon to assess. Our particular rates of charge are by no means rigid and depend upon facilities and personnel required to complete the job of work — the article made no reference to the fact that as a firm we are not a "one-man-band"; there are indeed six of us regularly employed with extra staff enrolled as necessary for work calling for more hands.

Our second major worry is with regard to the holding of shares in companies in the audio industry. It can hardly be construed as a sin for an investor to have shares in any particular large public company in any industry — and the Managing Director, Mr McKenzie, is by no means unique in holding a relatively small proportion of his shares in major electrical companies. The point which Mr McKenzie was endeavouring to put over was that our existence depends entirely upon our being unbiased and being seen to be such and that we are most prepared to disclose any associations financial or otherwise with clients; the same state of affairs we know to be true of others amongst our respected colleagues.

Finally we would request that such an apparently irresponsibly composed article receive closer scrutiny before publication in order to maintain the very high standard and integrity of reporting to which we have previously been accustomed in *Wireless World* and also to avoid the upset which has been caused to ourselves and undoubtedly to more than a few of our colleagues.

A. P. B. Faulkner,
Angus McKenzie Facilities Ltd,
London, N3.

Mr Dwyer replies:

Consultants seem to find no difficulty in expressing the inestimable advantages of using their services, as Mr McKenzie well knows. Therefore, if I attempt to tell readers what to look out for if they are thinking of employing a consultant, what I have to do is to try to discover the pitfalls. I feel sure that Angus McKenzie, for whom I have the highest regard, would not countenance the design, or even the use, of a digital or analogue system which fed merely the non-errors in the output back to the input, for such a system would be unstable. Yet he is not alone among electronics engineers in being willing to entertain just such an idea in relation to examination of his own activities by the press and others.

As I pointed out in the article, PATS charge about the same as Angus McKenzie Facilities and yet they support a staff of 100, many of them Ph.Ds, as well as a laboratory and office complex covering several thousand square feet. The capital employed would be many times that employed by Mr McKenzie's company. That part of the article alluded to by Mr Faulkner merely said that consultants who have large houses and expensive cars must be successful, yet they still resent competition from university departments. I find this resentment puzzling, but I said nothing about greed, nor did I mean to imply it.

I had no intention when I started the article of mentioning anyone's shareholdings, since normally these are are the business of no-one but the person concerned. That is why I did not ask Mr McKenzie about this when I first interviewed him. But in subsequent interviews with others it was put to me that holding shares in a company might prejudice a consultant in favour of pushing the client in the direction of that company's products. I felt I could not write the article without touching on the subject and so I 'phoned Mr McKenzie to ask him about it. I knew that he had in the past been annoyed by remarks he said had been made about his shareholdings and thought it a good opportunity to make clear exactly what his position was. The morality of the thing is his concern. I made it clear in the article that he would tell clients of his shareholdings.

With reference to John Dwyer's article "The consultants" in the November issue, it was stated that B & W employed consultants and as implied I should like to absolutely deny this and would point out that we have a staff of five engineers in the Research and Development Department and the only outside services we call on are for styling and visual design and climatic testing for reliability of components, the two consultants being Pentagram Design Partnership, 61 North Wharf Road, London W2, and Yarsley Research Laboratories Limited, The Street, Ashtead, Surrey.

John Bowers,
B & W Loudspeakers,
Worthing,
Sussex.

INSULATION TESTERS

Mr King's reply (October Letters) to my letter in the March issue shows he quite missed my point. Far from suggesting that d.c. testing of a.c. circuits was ridiculous, I wanted to imply that the Americans were only just beginning to do it – with this "new product".

I would, however, apologise for using the name "Megger" to describe the instrument illustrated, which still looks to me very like the genuine Megger we have, and which has given yeoman service almost every day for many years. We could not manage without these tests. How could anyone?

J. G. C. Fox,
Royal Postgraduate Medical School,
London, W12.

RAILWAY FAIL-SAFE?

Mr Anderton, in his interesting article on railway electronics (August issue), reproduced an example of supposedly fail-safe circuitry. The design included a traditional two transistor astable, but did not show any provision for recovering from the stable state in which both transistors are hard on. Such a state can be reached when the power is turned on. The probability of this event depends largely on the match of transistor gains, a parameter which changes with time and temperature.

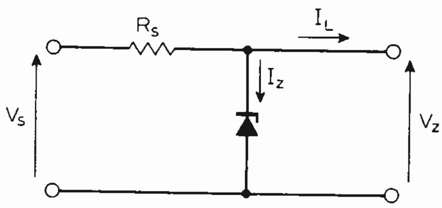
I hope that human safety does not depend on this circuit.

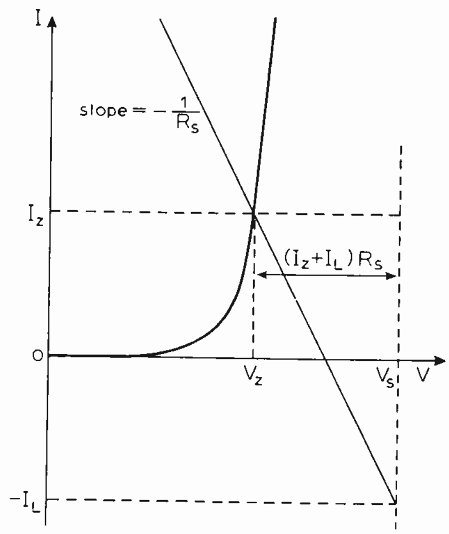
I would also question the use of high value resistors and capacitors in timing circuits. The 15μF unit, which must be a plastic film type if the quoted 5% accuracy is to be maintained, probably costs as much as the other fifty components together, and five times as much as a single integrated circuit which could perform the whole timing function.

David Cockerell,
New York,
USA.

ZENER DIODE LOAD LINE

In the case of a zener-regulated supply, students often have difficulty in relating zener voltage and current to input voltage and output current. The following simple graphical construction clar-





ifies the interrelation between these quantities. From Kirchhoff's law:

$$V_s = V_z + (I_z + I_L)R_s$$

A load line of slope $-1/R_s$ is drawn through the point $(V_s, -I_L)$. Its intersection with the zener diode characteristic gives the operating point. It is immediately obvious how changes in V_s and I_L affect V_z and I_z.

N. H. Sabah,
American University of Beirut,
Lebanon.

Interference from pocket calculators

Electromagnetic radiation tests on three commercial instruments

by Charles Thomas Ristorcelli

Postgraduate School, US Navy

This article reports an investigation into the near field electromagnetic interference caused by pocket calculators. American regulations on permissible levels of interference from portable electronic equipment are reviewed, then the results of measurements on three pocket calculators are presented. Results indicate that near field radiation levels are sufficiently large to make questionable the unrestricted operation of a pocket calculator in an electromagnetically sensitive environment, such as an aircraft flight deck. A simple and inexpensive way of eliminating the interference is suggested.

Electromagnetic interference caused by portable electronic equipment is receiving attention in many circles, including the US Department of Defense, because of the profusion of devices such as calculators, digital test instruments and digital processors which are being used in modern electronic systems. Of particular interest is the possibility of interference to electronic sensors from these devices in electromagnetically sensitive areas such as aircraft flight decks, especially if the operation of a digital device causes r.f. emissions of significant magnitude in the near field. This increased interest is not limited to United States agencies alone, as is demonstrated by the following excerpt:

"A Word To The Wise"

Recent tests by the Canadian Department of Communications have established that handheld calculators cause a degree of interference in a.d.f. signals when the calculator is operated in close proximity to the a.d.f. antennas. It is not necessary that operations be performed on the calculator, only that the calculator be turned on.

Pilots should be aware of this and use a.d.f. indications cautiously when handheld electronic calculators are being used in the cockpit."

The only US government regulation establishing permissible e.m. interference levels for pocket calculators is expressed in Article 15.7.(c) of the Rules and Regulations of the Federal Communications Commission:

"That in any event the total electromagnetic field produced at any point distance of 157,000/f (kHz) (equivalent to $\lambda/2\pi$) from the apparatus shall not exceed 15 microvolts per meter."

This regulation is applicable to all "miscellaneous" electronic equipment, that is, equipment not specifically designed for the purpose of radiation of electromagnetic energy.

Another American organization which establishes guidelines pertaining to r.f. emission from portable electronic equipment, with emphasis on equipment to be used aboard aircraft, is the Radio Technical Commission for Aeronautics at Washington, DC.* The following excerpt from a RTCA report emphasizes the nature of the problem:

"Unfortunately, detailed factual data upon which to base precise limits for the levels of r.f. energy which can be permitted to radiate from portable equipment are not available. However, safety considerations and general experience with r.f. interference problems indicate that the levels of radiated r.f. energy from portable electronic devices should be at least 6dβ below those which cause malfunction of airborne electronic equipment during the tests conducted by the FAA. On this basis, the maximum level of permissible r.f. energy emission from any portable electronic device operated aboard aircraft in flight should not exceed the following values within the frequency bands indicated:

Frequency	Maximum emission
110 kHz	3.5 μV/m at 64 cm
350 kHz	1.8 μV/m at 64 cm
1750 kHz	1.7 μV/m at 64 cm
10.0 MHz	1.15 μV/m at 64 cm
18.0 MHz	0.63 μV/m at 64 cm"

Theory. The following derivation from classical electromagnetic theory is provided as a mathematical basis for understanding the terms "near field" and "far field" in these studies.

* RTCA is not an official agency of the US Government. It is a co-operative association of government, aeronautical industry, and telecommunications agencies. Its objectives are the resolution of aeronautical-telecommunications problems through mutual agreement.

For an elementary electric dipole of vanishingly small length relative to the wavelength λ of its conducted current, the electric field at an observation point $P_{(X,Y,Z)}$ in the spherical co-ordinate system, as a function of angular displacement θ from the z axis, is given by Fig. 1(a):

$$E_\theta = -\frac{IdB_0^2}{2\pi}\sqrt{\frac{\mu}{\epsilon}}\sin\theta\left|\frac{1}{jB_0r}+\frac{1}{(jB_0r)^2}+\frac{1}{(jB_0r)^3}\right|e^{-jB_0r}$$

where: I = conducted current; B_0 = free space phase constant; d = dipole length; μ = permeability of free space; ϵ = permittivity of free space; and r = radial distance from dipole centre.

For the case where $B_0r \ll 1$ the expression given above may be simplified to read:

$$E_\theta = -\frac{IdB_0^2}{2\pi}\sqrt{\frac{\mu}{\epsilon}}\sin\theta\left|\frac{1}{(jB_0r)^3}\right|e^{-jB_0r} \quad (1)$$

whereas for the case $(B_0r) \gg 1$ a similar simplification yields:

$$E_\theta = -\frac{IdB_0^2}{2\mu}\sqrt{\frac{\mu}{\epsilon}}\sin\theta\left|\frac{1}{(jB_0r)}\right|e^{-jB_0r} \quad (2)$$

Expressions (1) and (2) are commonly considered the near field and far field electromagnetic radiation terms, respectively. Similar derivations for all other electromagnetic field components are possible.

Consider the ratio

$$\frac{E_{\theta\,\text{near field}}}{E_{\theta\,\text{far field}}} = \frac{1}{B_0^2r^2} = \frac{1}{\mu\epsilon\omega^2r^2}$$

where $\omega = 2\pi f$. If a unity value for the above ratio is chosen as a convenient indicator of the radial distance r at which a crossover between the near field and far field radiation components applies, then r may be expressed as

$$r=\frac{\lambda}{2\pi} \qquad (3)$$

The ratio given by expression (3) is the radial distance chosen by the FCC in establishing the permissible interference levels described by article 15.7.(c) of FCC regulations.

The emphasis in this investigation was to determine the interference levels from near field measurements during the operation of three different portable calculators. The models chosen were two Texas Instruments SR-50 calculators and one Hewlett-Packard HP-45. The reasons for choosing these calculators were their availability, and the fact that their light emitting diode displays are blanked during the performance of certain calculations. The desirability of this feature will be explained later.

Two possible sources of electromagnetic interference believed associated with the operation of a pocket calculator are: strobing of data into the l.e.d. display; and digital switching operations associated with the streams of pulses found in all operating digital devices. The digital switching operations are believed to provide the broadband r.f. emissions when the calculator is in operation. If streams of symmetrical pulses such as shown in Fig. 1(b) are assumed in these switching operations, Fourier analysis of the waveform leads to the following Fourier coefficients in frequency domain:

$$C_k=\sum_{k=-\infty}^{=+\infty}\frac{V}{\pi k}\sin\frac{k\omega_0(a)}{2};$$
$$(k=0,\pm 1,\pm 2,\ldots)$$

These coefficients may be associated with the power spectrum of the pulse stream. If we assume a fundamental frequency of 100kHz for the calculator functions, the broadband nature of the possible radiated interference is immediately apparent.

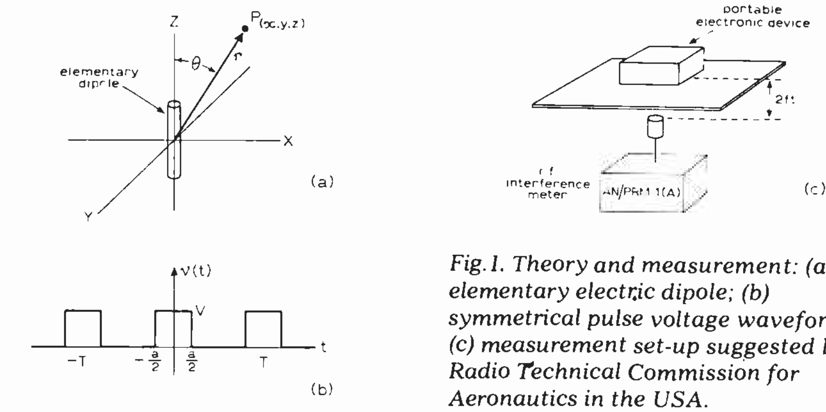


Fig. 1. Theory and measurement: (a) an elementary electric dipole; (b) symmetrical pulse voltage waveform; (c) measurement set-up suggested by Radio Technical Commission for Aeronautics in the USA.

Measurement procedures. The measurements in this investigation were performed according to the method suggested by RTCA, except that a radio frequency interference meter type AN/PRM-1(A) was substituted for the 390-ohm terminated valve-voltmeter suggested by RTCA (Fig. 1(c)). The frequencies of interest are those in the 110-1750 kHz band because of their importance to long range navigation systems.

The measurements obtained have been examined with the following questions in mind:

- Can the calculator's emission of e.m. interference be attributed principally to the l.e.d. display strobing, or to the internal processing? It was consideration of this question that made the chosen calculators desirable, because while the devices perform certain mathematical functions such as the determination of large factorials the l.e.d. display remains blanked, allowing measurement of interference levels associated with the internal processing.
- Can unusual r.f. emission patterns be detected during performance of certain calculator functions?
- Is there a difference between the levels of interference from the two makes of calculator which may indicate certain construction features preferable in order to eliminate, or reduce, electromagnetic radiation?

Operating modes. The calculator operating modes used to measure their interference levels as indicated in the graphs and tables are defined as:

Display. The constant pi (3.141592654) was displayed, providing measurement of emitted r.f. energy when l.e.d. display data strobing was in progress.

Undefined. Division by zero was performed to provide measurement of r.f. energy emitted with a pulsating display.

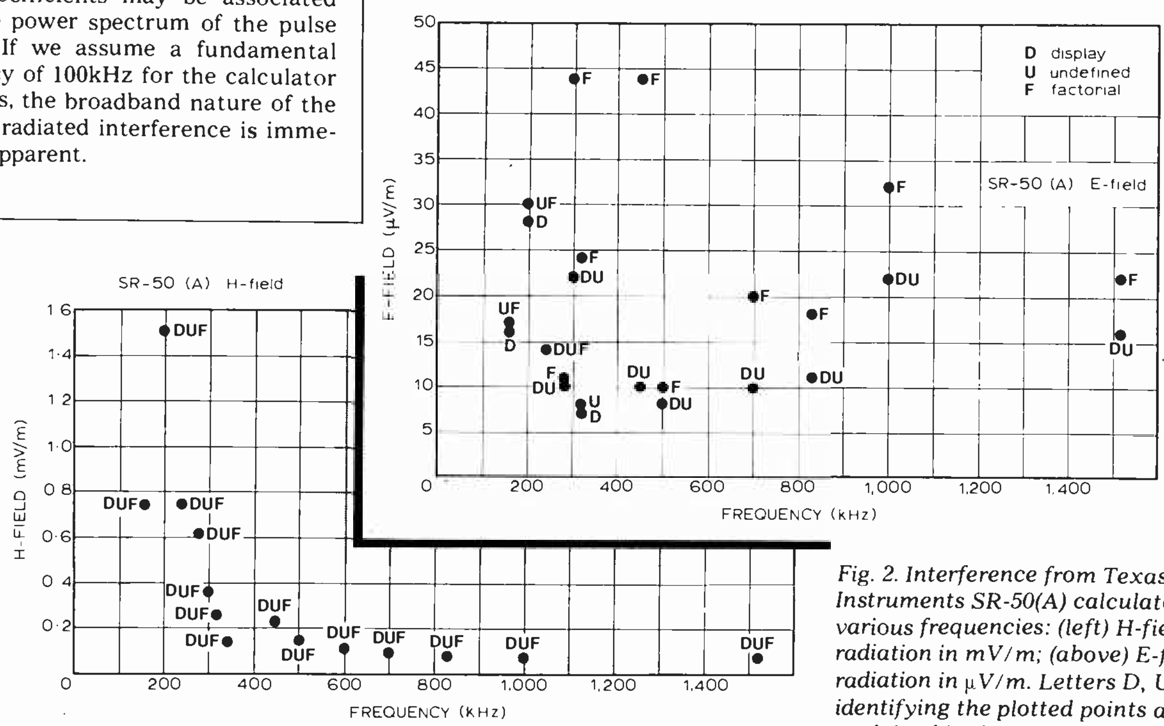


Fig. 2. Interference from Texas Instruments SR-50(A) calculator at various frequencies: (left) H-field radiation in mV/m; (above) E-field radiation in μV/m. Letters D, U and F identifying the plotted points are explained in the text.

Table 1: H-field interference levels from three calculators (μV/m at 64cm). Operating modes: D — display, U — undefined, F — factorial

	Texas Instruments SR-50 (A)				Texas Instruments SR-50 (B)				Hewlett-Packard HP-45			
	operating mode				operating mode				operating mode			
frequency (MHz)	ambient noise (μV/m)	D (μV/m)	U (μV/m)	F (μV/m)	ambient noise (μV/m)	D (μV/m)	U (μV/m)	F (μV/m)	ambient noise (μV/m)	D (μV/m)	U (μV/m)	F (μV/m)
0.160	62.0	750.0	750.0	750.0	90.0	240.0	300.0	310.0	135.0	9000.0	1050.0	1050.0
0.200	60.0	1500.0	1500.0	1500.0	90.0	450.0	630.0	510.0	120.0	2700.0	585.0	150.0
0.240	90.0	750.0	750.0	750.0	90 0	150.0	300.0	210.0	90.0	600.0	420.0	420.0
0.280	75.0	600.0	600.0	600.0	60.0	60 0	110.0	60.0	90.0	2100.0	360.0	120.0
0.300	75.0	360.0	360.0	360.0	70.0	240.0	300.0	210.0	60.0	3000.0	225 0	90.0
0.320	60.0	225.0	225.0	225.0	30.0	30.0	60.0	100.0	45.0	600.0	150.0	60.0
0.340	60.0	150.0	150.0	150.0	45.0	60 0	100.0	45.0	45.0	1050.0	180.0	240.0
0.450	60.0	210.0	210.0	210.0	60.0	1500 0	720.0	2100.0	60.0	1500.0	180.0	60.0
0.500	60.0	165.0	165.0	165.0	60.0	70.0	1800 0	80.0	55 0	600.0	150.0	55.0
0.600	54.0	126.0	126.0	126.0	60.0	65 0	90.0	75 0	60.0	660.0	80.0	60.0
0.700	54.0	105.0	105.0	105.0	48.0	75 0	90.0	120 0	55.0	2850.0	300.0	600.0
0.830	20.0	35.0	35.0	35.0	20.0	200.0	140.0	240.0	20.0	450.0	60.0	20.0
1.000	20.0	30.0	30.0	30.0	20.0	120.0	90.0	190.0	20.0	175.0	60.0	20.0
1.520	20.0	45.0	45.0	45.0	20.0	100.0	70 0	120 0	20.0	80.0	30.0	20.0
2.100	40.0	40.0	40.0	40.0	40.0	100.0	130.0	100.0	40.0	160.0	50.0	60.0

Table 2: E—field interference levels from three calculators (μV/m at 64cm). Operating modes: D — display, U — undefined, F — factorial

	Texas Instruments SR-50 (A)				Texas Instruments SR-50 (B)				Hewlett-Packard HP-45			
	operating mode				operating mode				operating mode			
frequency (MHz)	ambient noise (μV/m)	D (μV/m)	U (μV/m)	F (μV/m)	ambient noise (μV/m)	D (μV/m)	U (μV/m)	F (μV/m)	ambient noise (μV/m)	D (μV/m)	U (μV/m)	F (μV/m)
0.160	3.0	16.0	17.0	17.0	2.0	12.0	11 0	50.0	3.0	20.0	160.0	28.0
0.200	3.0	28.0	30.0	30.0	2.0	6.0	6.0	6.0	3.0	11.0	20.0	18.5
0.240	3.0	14.0	14.0	14.0	1.8	5.5	4.0	8.0	3.0	11.0	12.0	6.0
0.280	3.0	10.0	10.0	11.0	2.0	4.5	4.0	9.0	2.9	11.0	12.0	6.0
0.300	3.0	22.0	22.0	44.0	2.5	5.0	4.5	19.0	3.0	180.0	180.0	200.0
0.320	3.0	8.0	7.0	24.0	4.1	7.5	7.0	14.0	3.0	100.0	80.0	100.0
0.340	3.0	9.0	9.0	32.0	4.0	6.0	6.0	6.0	3.0	70.0	120.0	70.0
0.450	3.0	10.0	10.0	44.0	2.0	4.0	4 5	5.0	3.0	24.0	60.0	20.0
0.500	3.2	8.0	8.0	10.0	2.0	6 0	7 0	16 0	3.0	100.0	180.0	110.0
0.600	3.2	9.5	9.5	11.0	1.9	3 5	3.0	10.0	3.0	16.0	18.0	16.0
0.700	3.2	10.0	10.0	20.0	2.0	4 0	4.0	5.0	3.2	100.0	240.0	120.0
0.830	4.0	11.0	11.0	18.0	2.0	10.0	8.0	14 0	4.0	10.0	44.0	8.0
1.000	6.0	22.0	22.0	32.0	2.0	4.0	4.0	8 0	3 6	6.0	55.0	10.0
1.520	5.7	16.0	16.0	22.0	2 0	2.0	3.0	5.0	3 9	9.0	80.0	9.0
2.100	5.7	6.0	6.0	9.5	1 0	2.0	2 0	4.0	2.0	4.0	20.0	4.0

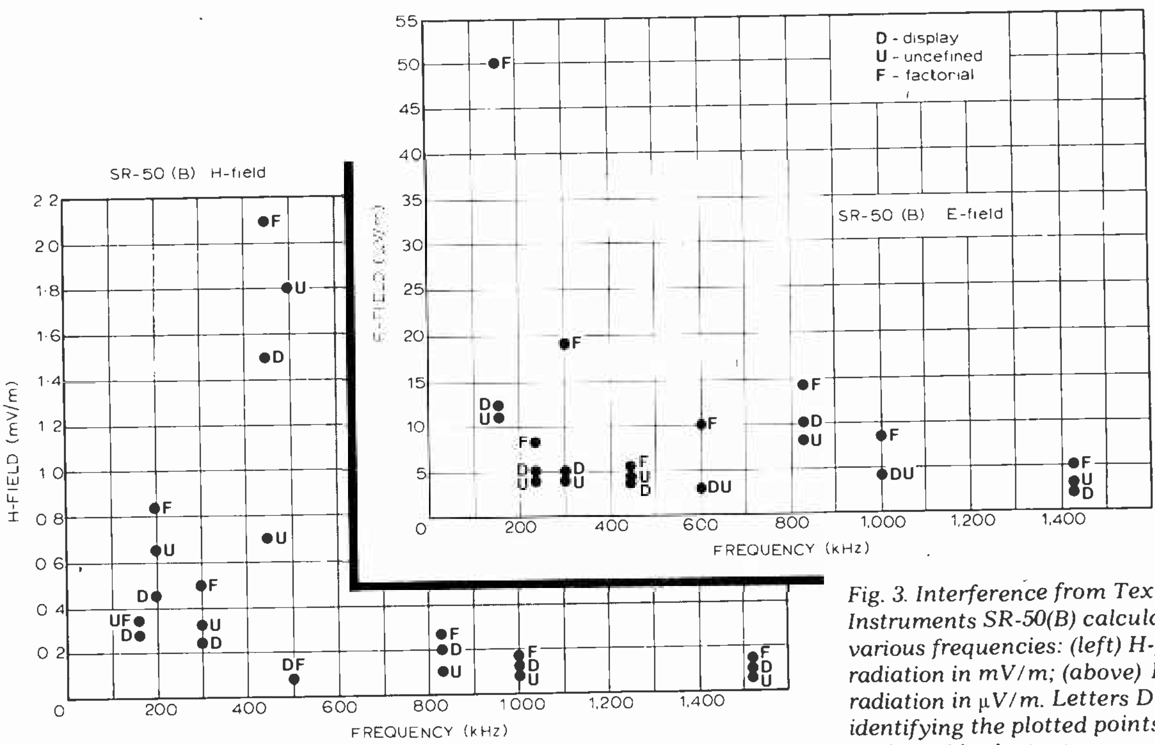


Fig. 3. Interference from Texas Instruments SR-50(B) calculator at various frequencies: (left) H-field radiation in mV/m; (above) E-field radiation in μV/m. Letters D, U and F identifying the plotted points are explained in the text.

Factorial. 69! was calculated. In this manner the display was blanked for approximately 4 seconds, allowing the measurement of emitted r.f. as a result of the internal digital processing.

The frequencies for measurement were randomly chosen. The r.f. energy emission was not confined to discrete frequencies, however, but was observed to cover a very broad spectrum. The non-automated measuring technique prevented a continuous measurement of interference vs. frequency, thus making necessary a discrete set of measurements. The results of all measurements are listed in the tables and selected data are presented graphically in Figs. 2, 3 and 4.

Conclusions. As expected before the measurements were performed, the levels of e.m. interference detected as a result of the calculator operations were below the limits established by the FCC for such interference. However, these limits address the interference detected at a range $r = \lambda/2\pi$, a distance which our theoretical development indicates is a crossover point for near vs. far field considerations. In the near field the measurements indicate a level of interference which exceeds the limits suggested by RTCA for electromagnetically sensitive environments such as aircraft in flight.

From the above considerations it seems advisable to re-examine the regulations establishing permissible interference levels from portable electronic equipment. The fact that significant levels of interference are present in the near field of an operating portable calculator becomes a problem only if the environment in which the device is operated cannot safely tolerate the interference. If instances of this problem are identified, then either restrictions on the use of portable calculators may be imposed, or a cure for the radiated interference must be found (a possible solution is offered below):

The E-field interference intensity measurements associated with the operation of the SR-50 calculators would indicate that the resulting interference levels are principally caused by the internal digital processing in the strobing of the l.e.d. display. This type of interference should be expected from any digital processor, and the power level of the interference should be directly related to the power levels found within the device.

The measurements indicated that for near field considerations the interference levels associated with the H-field electromagnetic components are orders of magnitude greater than those associated with the E-field. Further investigation may reveal that this phenomenon is a result of component layout within the caclulator, permitting circular current flows to create a "loop antenna" radiation effect.

As a subject of amusing interest, the AN/PRM-1(A) r.f. interference meter provides the operator with an audio output for monitoring purposes, and the interference signals resulting from operation of the calculators presented significantly different "audio signatures" as a function of calculator brand. The differences were sufficiently pronounced to allow the meter operator to identify the calculator brand name from the audio output.

Finally, a means was sought which would reduce the levels of interference emitted from these calculators. Some form of shielding seemed a likely solution, and this approach was briefly examined. The calculators were surrounded by one sheet of aluminium kitchen foil and then operated in the various modes described above. The shielding proved so effective that the r.f. interference meter was then only capable of detecting the ambient noise level of electromagnetic radiation. This suggests that, at least where portable calculators are concerned, perhaps either selectively or collectively as a general cure, providing a foil or other type of shield around the interior of the calculator case would eliminate the possibility of interference from these devices in environments where it cannot safely be tolerated.

Reference

1. United States Department of the Navy, *Approach, The Naval Aviation Safety Review*, December 1974, p.28. Washington, United States Government Printing Office, 1974-635 022/7.

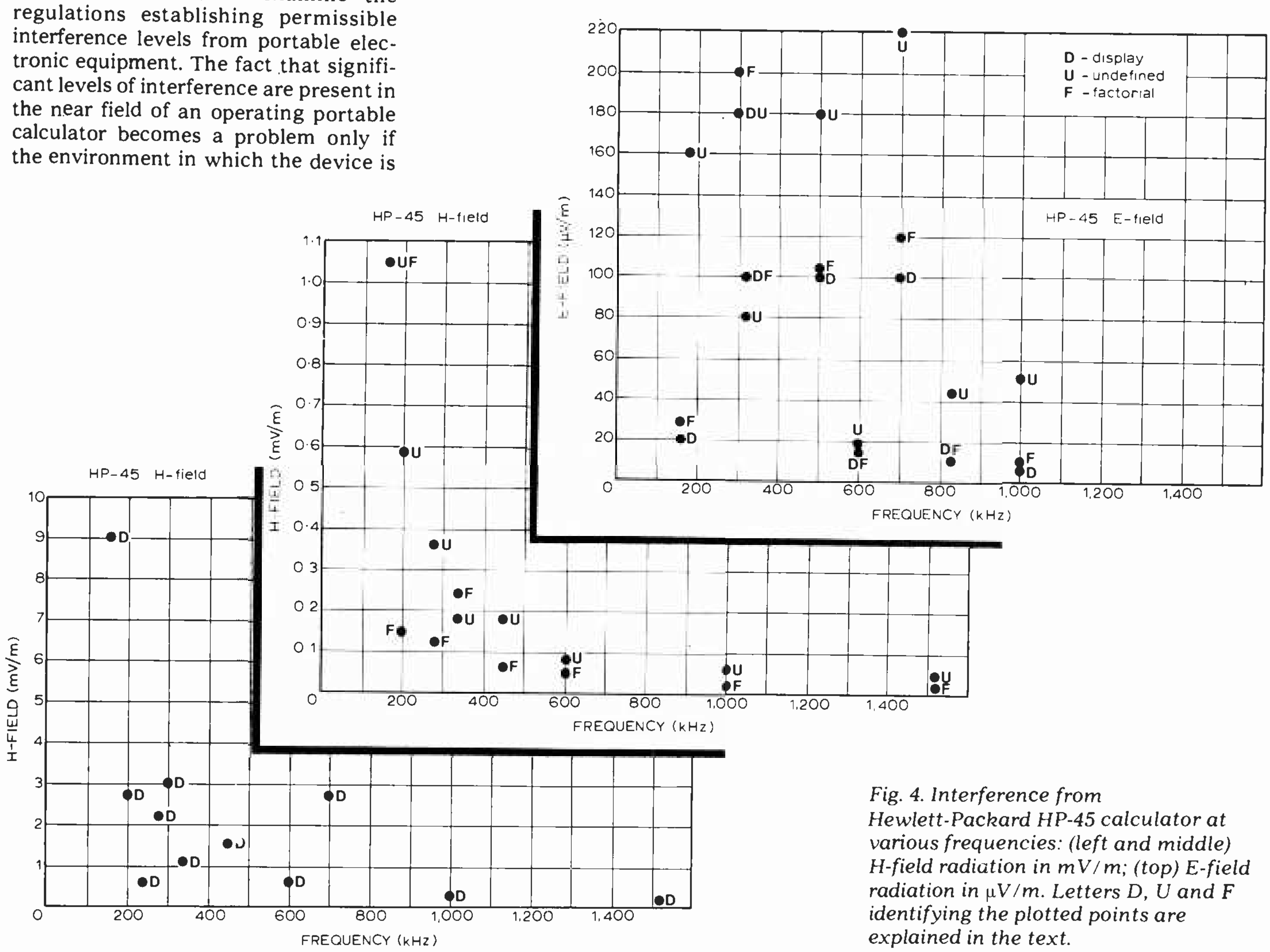
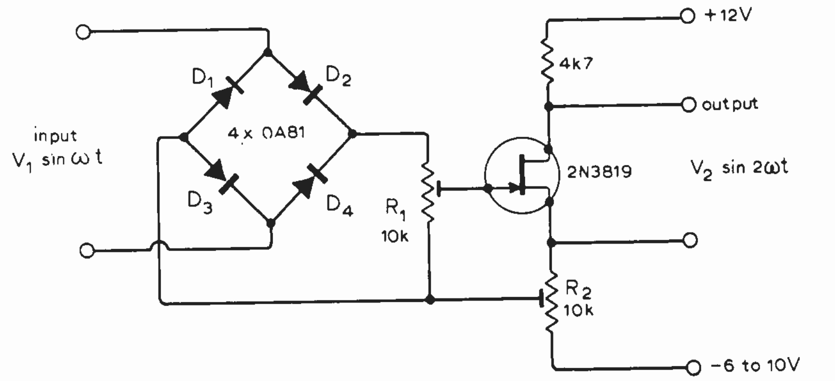


Fig. 4. Interference from Hewlett-Packard HP-45 calculator at various frequencies: (left and middle) H-field radiation in mV/m; (top) E-field radiation in µV/m. Letters D, U and F identifying the plotted points are explained in the text.

Circuit Ideas



Frequency doubler

This circuit was devised to show that theory can be put into practice; we hope that readers may find other uses for it. The theory is simply the trigonometric identity $\frac{1}{2}(1+\cos 2\theta)=\cos 2\theta$. Replacing θ by ωt produces a frequency doubler. Probably the easiest way of obtaining a square law characteristic, at least over half the input range, is to use a f.e.t. because the drain current is determined by

$$I_d=(1-\frac{V_{gs}^2}{V_p^2}).\,I_{dss}\ \text{for}\ |V_{gs}|\leqslant|V_p|.$$

In practice, $D_{1,2,3,4}$ ensure that a positive-going pulse is applied to the f.e.t. gate so that the device operates with a square law effect on both cycles ($\cos^2\theta = |\cos\theta|^2$).

Potentiometer R_1 is adjusted to operate the device at the correct input level, a compromise between overloading and a good output.

Potentiometer R_2 sets the f.e.t. to just-cut-off under no-signal conditions, which operates the device in the square law region. The potentiometers may be adjusted, while the device is in operation, with the use of an oscilloscope or t.h.d. monitor to obtain minimal distortion. Correctly set up, the harmonic content of the output for a sine wave input can be made to approach that of the input. It will of course considerably distort any other input waveform. The circuit shown performed well up to about 10kHz, but this could probably be bettered with good construction and higher speed diodes.

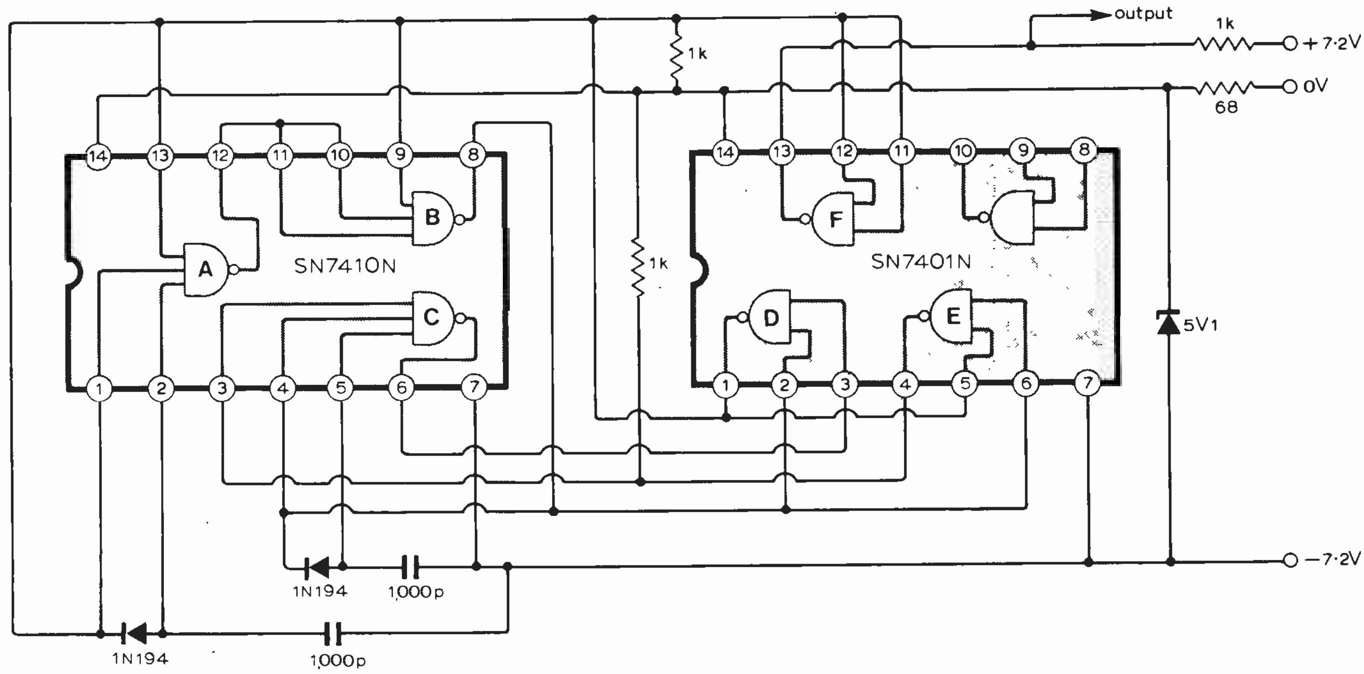
R. Williams & J. Dunne
Brentwood School,
Essex.

Clock generator for electronic calculators

The *Wireless World* desk calculator (Sept./Oct. 1972) uses a hybrid thick-film integrated circuit for its clock generator. An alternative, and inexpensive (around 50p) way of producing the clock waveform is by means of two readily available t.t.l. integrated circuits, as shown.

NAND gates A, B, C, D and E are connected to form a free-running multivibrator, with a self starting gate, C, to ensure that the clock waveform is available as soon as the supply is applied to the calculator-chip. The multivibrator output (gate D) swings approximately from −7.2 to −2.1V, and this signal is applied to the input of a voltage level changing gate, F, which is an open-collector type having its output connected to +7.2V via a 1kΩ resistor. When the input to F is −7.2V (logical O) this gate is effectively an open circuit and its corresponding output is +7.2V. Alternatively, when the input to F is −2.1V (logical 1) this gate is effectively a short-circuit and its corresponding output is −7.2V. Therefore the output swings between +7.2 and −7.2V at approximately 320kHz for a 1000 pF capacitor. This frequency was found to be satisfactory in practice.

T. J. Terrell,
Preston Polytechnic.



Linear current/rotation control

In the circuit described, the current through a linear potentiometer is made a linear function of the rotational angle of the potentiometer. Consider the circuit of Fig. 1, in which

$$i_1(R_1+R_2+R_3+R_4)=i(R_3+R_4).$$

The linear relationship between angle of turn and current i_1 is achieved by making current i constant and by using a double potentiometer for R_1 and R_4, connected so that $R_1 + R_4$ is constant and equal to the value of the potentiometer R, therefore

$$i_1=\frac{i}{R+R_2+R_3}(R+R_3-R_1)$$

showing the linear relationship between current i_1 and the variable resistance R_1. Because R_1 has a maximum value of R the ratio of maximum to minimum current is

$$\frac{i_{1\ max}}{i_{1\ min}}=\frac{R+R_3}{R_3}$$

This ratio may be altered by adjusting R_3.

For any setting of the potentiometer, current i_1 is proportional to i so the latter may be adjusted to set up a particular $i_{1\ max}$ or $i_{1\ min}$. Appropriate adjustment of both i and R_3 allows setup of $i_{1\ max}$ and $i_{1\ min}$. In designing a practical circuit we must allow for the voltage across the arms (assuming still that $v_1 = v_2$):

$$v-v_1=i_1(R_1+R_2)$$

$$=\frac{i}{R+R_2+R_3}(R_1+R_2)(R+R_3-R_1)$$

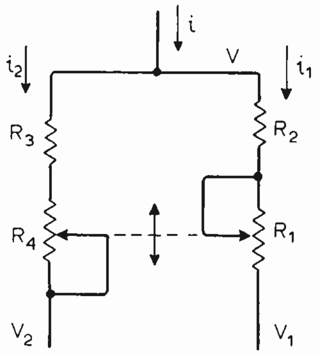


Fig. 1

which is dependent upon angle of rotation and is at maximum

$$(v-v_1)_{max}=\frac{i(R+R_2+R_3)}{4}$$

Shown in Fig. 2 is a practical circuit in which the current i_1 is used to charge capacitor C which is periodically discharged by the unijunction transistor when the trigger voltage is reached. Because the charging time is inversely proportional to charge current, the frequency of the output sawtooth is proportional to current i_1 and hence to the potentiometers angle of rotation. The setup sequence is:

Adjust potentiometer to give maximum frequency sawtooth and adjust preset R_5 to give the required maximum frequency.

Set potentiometer to the other extreme and adjust preset R_3 to give the required minimum frequency.

The sequence may need repeating because the two adjustments are coupled. The preset R_6 is adjusted to setup working voltages, and in a final design may be replaced by a fixed resistor.

A multi-way switch can be included to select different R_5 and C values.

Andrew Armit,
Clifton,
Bedfordshire.

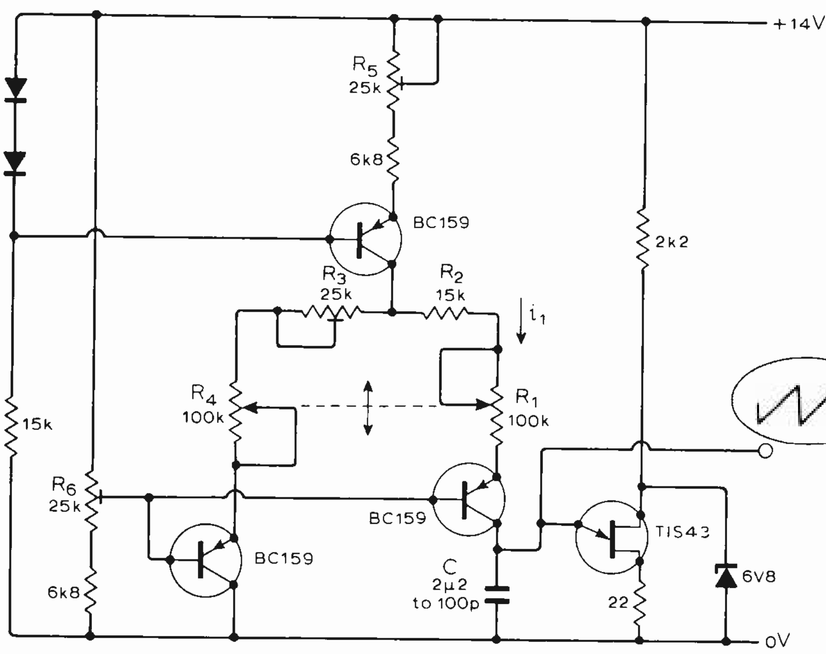
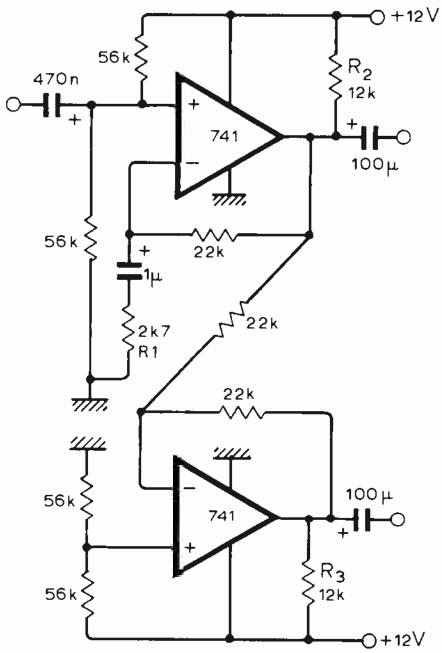
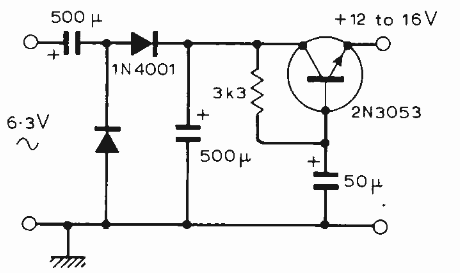


Fig. 2

Balanced output amplifier

This low-cost amplifier provides a low impedance balanced output from an unbalanced input. The modest power supply requirements can be met by a voltage doubler and filter working from a valve filament supply; this enables a balanced output to be added to a valve preamplifier. In the original design 741





amplifiers were used but similar types such as the LM307 or dual 741 (747) can be used. Response is flat from 10Hz to 20kHz and the distortion is less than 0.1% at 800Hz + 20dBm into a 600ohm load. Crossover distortion is minimized by the addition of R_2, and R_3. The gain is 20dB but can be reduced by increasing R_1.

K. D. James,
Dunedin,
New Zealand.

Contributors to Circuit Ideas are urged to say what is new or improved about their circuit early in the item, preferably in the first sentence.

Advances in microwaves

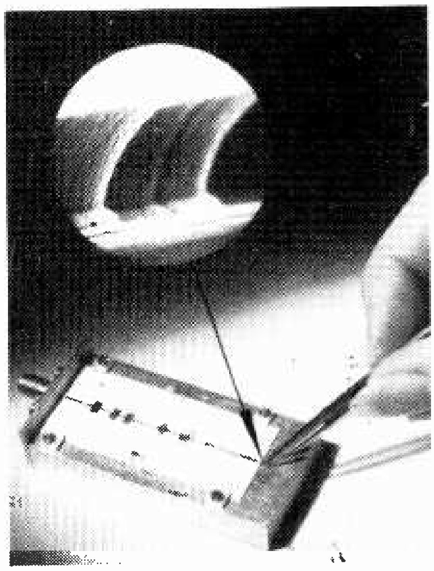
5th European microwave conference held last September in Hamburg is reported by M. W. Hosking, author of the Realm of Microwaves articles

This conference has grown in size over the years and also in composition, starting as a biennial event held first in London in 1969, then in Stockholm in 1971 where it was amalgamated with the Microwave and Optical Generation and Amplification Conference (MOGA), Brussels in 1973, and Montreaux in 1974. From 1974 the conference became associated with an organised exhibition and is now the largest microwave event of its kind.

In recognition of the advances being made in opto-electronics, together with the use of the laser and infra-red sources in communications, Prof. H. G. Unger's invited paper on optical waveguides gave a very comprehensive survey of this vital area of technology. There are two main areas of development, one being the types of transmission line suitable for the design of components and interconnections, and the other being long-distance waveguide. In the first category, the most widely-used type of transmission line is the film guide. This consists of a thin dielectric film on top of a dielectric substrate of lower refractive index. A trapped light wave then propagates down the thin film in a zig-zag fashion by total internal reflection at the boundaries. Phase conditions can exist for both low and high-order modes but, as the attenuation losses arise from general dispersion and scattering at film imperfections, the higher order modes suffer greater loss. Transparent glass-film guide with suitable boron and silicon doping can provide low-order mode losses of less than 1dB/cm and a value of 0.04dB/cm has been achieved.

Instead of coating the complete substrate, the film can be made as a narrow raised or recessed strip and can still provide total internal reflection at the side walls. This looks very similar in section to the microstrip type of microwave transmission line and, in fact, many of the design principles can be used directly to fabricate beam splitters, directional couplers, filters and other passive components.

A laser beam can be coupled into and out of the film guide by various types of coupler. One efficient method is to form a series of grating strips in the film which, with proper phase design, will radiate a coherently scattered beam into the guide. Another technique, the prism coupler, consists of bringing a slab of different refractive index material into close proximity with the film guide. An evanescent mode is set up in the gap which in turn excites a plane wave in the prism and, for the correct laser intensity distribution, can vary efficiently couple out power.



Microstrip pulsed Trapatt oscillator producing about 100W peak power at 2.5GHz with 32.5% efficiency. Key circuit element is a matching low-pass filter. Inset shows the device mesa structure. (Mullard Research Laboratories).

For long-distance signal transmission, single-mode fibres are used consisting of a central core and a slightly lower refractive index cladding. The wave is confined by total internal reflection and parameters are adjusted so that usually only the dominant HE_{11} mode propagates. Fibres with a graded index of refraction, decreasing from the centre outwards, are being developed to reduce signal dispersion and high-silica fibres have been made with 1dB/km loss and less than 1ns/km pulse dispersion.

This is still a new and rapidly expanding area and many problems remain to be overcome in circuit design and basic technology. Not least is the interconnection of optical fibres which individually range in diameter from about 10^{-2}mm to 10^{-1}mm.

In the design of array antennas, commonly-used individual elements are the half-wave dipole and radiating slot and most attention is paid to the overall radiation pattern, together with problems of mutual coupling. In a paper presented by A. Clavin of Hughes Aircraft, a basic improvement in the design of the individual array element was described, consisting of a conventional slot radiator with two short wires placed one either side and normal to the slot. The total radiation pattern is a combination of a slot plus an array of two dipoles (monopole plus image). By adjusting the phase of excitation of the wires by their length and spacing, the slot pattern can be modified. In particular, its endfire radiation can be cancelled, with the result that the E-plane pattern of the element can be made equal to the H-plane slot pattern. The new element thus has a symmetrical radiation pattern. Beamwidth was increased by bending over the top of each wire to form an inverted-L. Practical results with an array of these new elements at X-band have shown a reduction in mutual coupling, elimination of back radiation, general improvement in sidelobe structure and a slight increase in gain.

Complementary to the radiating aperture side of phase array antennas was a session devoted to the heart of the system — the microwave phase-shifter circuitry itself. This, as usual, splits into the two areas of ferrite and p-i-n diode devices where the competition still exists for the best low weight, low loss and low cost device. On the ferrite side the papers were mainly theoretical and included a useful survey of the properties and performance of dual-mode reciprocal phasers. A further advance in the design of high power, low loss p-i-n diode phase shifters was reported from ITT in the form a 4-bit (22.5°, 45°, 90°, 180°) device on a sapphire substrate capable of handling 440 watts at a 17dB insertion loss level.

On the solid-state oscillator and amplifier front, one of the most rapidly advancing areas is that of the microwave field-effect transistor This device is already competing strongly on noise performance with microwave mixer diodes and looks likely to offer higher c.w. powers and higher efficiency than Impatt devices. In a paper read by J. A. Angus of Plessey, results on some designs of GaAs power m.e.s.f.e.t.s. were presented. Using some novel gate and drain configurations, a four-cell, 2 μm gate device gave 700mW of c.w. power output at 3GHz with 6dB gain and 25% efficiency. A six-cell f.e.t. of slightly different geometry and a 3.5μm gate length gave 1.3 watt at 2GHz with 6.2dB gain and 32% efficiency. With multiple-cell devices already reported as giving saturated output powers of this order at X-band (8 to 12GHz), f.e.t. development over the next few years should prove to be very interesting.

At the low-noise end of the scale, an impressive GaAs m.e.s.f.e.t. amplifier was described by C. A. Liechti *et al.* of Hewlett Packard. Operating in the 11.7 to 12.2GHz satellite communication band, the three-stage amplifier using 1 μm gate chips on a microstrip circuit gave a noise figure of 5.3dB with 18dB gain. This compares very favourably indeed with achievable mixer figures. On cooling to 40°K, the noise figure improved to 1.6dB (130°K noise temperature) and the gain increased to 31dB. Considering that uncooled and cooled parametric amplifiers provide about 150°K and 50°K respectively of noise figure, improved performance of this type of m.e.s.f.e.t. is expected to provide keen competition.

Acoustic-wave technology is another area wherein steady progress is being made and a paper from France by P. Hartemann of Thomson-CSF described a range of surface-wave components produced on lithium niobate and quartz substrates. Operating in the region of 1000MHz, a range of wide-band delay lines, filters and oscillators had been constructed. One of the main technological advances was the production of transducer patterns with linewidths down to 0.3 μm. The Royal Radar Establishment continues its world leadership in bulk acoustic-wave technology and T. M. Mason described the design of a complete delay module containing delay line, amplifiers, p-i-n switches, circulators and power supplies. Spinel ($MgAl_2O_4$) crystal formed the delay line and the module operated at 1000MHz with a 3dB bandwidth of 500MHz, 22 μs delay and unity gain.

Finally, a session this year was devoted to the biological effects of microwaves. The most apparent and obvious effect of microwave power has always been the absorption of energy by living tissue, leading to heating. However, in experiments on animals, nervous system effects, blood cell production and glandular performance have all proved to be influenced by microwave exposure. On the cheerful side, there appears to be no definite evidence of attributable health defects among microwave workers. But a disturbing inconsistency prevails in that the USSR specifies 0.01 to 1mW/cm$_2$ as a safe power density whilst the USA specifies 10mW/cm^2.

This, the second year of a combined conference and exhibition, was well supported in terms of exhibitors with over 100 companies being represented on stands. Components of all sorts were on show ranging from connectors to integrated sub-systems and semiconductor devices. A full range of instruments was also present, including advanced sweep generators, power monitors and spectrum analysers. There never appeared to be much danger of being trampled underfoot by visitors to the exhibition and a light attendance was confirmed by many of the people on the stands. However, a general comment was that those that did attend were serious visitors and several reported fresh business openings.

The 1976 European Microwave Conference will be held from 14 to 17 September at the Pallazzo di Congressi in Rome with Professor Peitro de Santis as chairman. Particular attention will be paid to microwave acoustics and integrated optics.

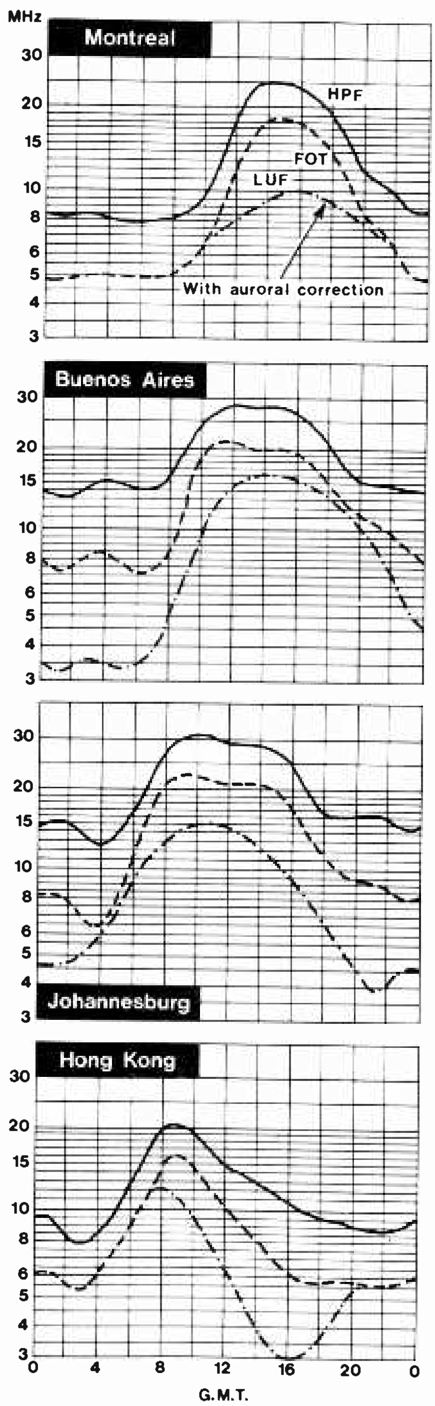
"Facsimile scanner"
We regret that an error occurred in the diagram of Fig. 5, p.460, in the October issue. The two 1kΩ resistors should be returned to the gate inputs, not to 5V. This biases the gates in the "linear" part of their characteristic and ensures starting.

"Transmitter power amplifier design"
We regret that it has been necessary to postpone publication of the fourth, and final part of this series.

HF predictions

Ionospheric absorption or skywave loss is greater during winter than in summer months. This is known as the winter anomaly as it is the opposite effect to that deduced from simple reasoning of the seasonal changes in sun/Earth relationship.

The high absorption is continuously present over a large area for several days and then shifts to another area, for example Europe to Western Russia. This results in short routes having "patchy" conditions and long routes having day-to-day variations in signal strength about four times greater than during summer. However, with the availability of higher frequencies (compare this month's Montreal chart with that for June) winter daytime communication is overall better than that experienced during summer.



High resolution satellite cloud cover pictures

Report from a unique ground receiving station

by P. E. Baylis

University of Dundee

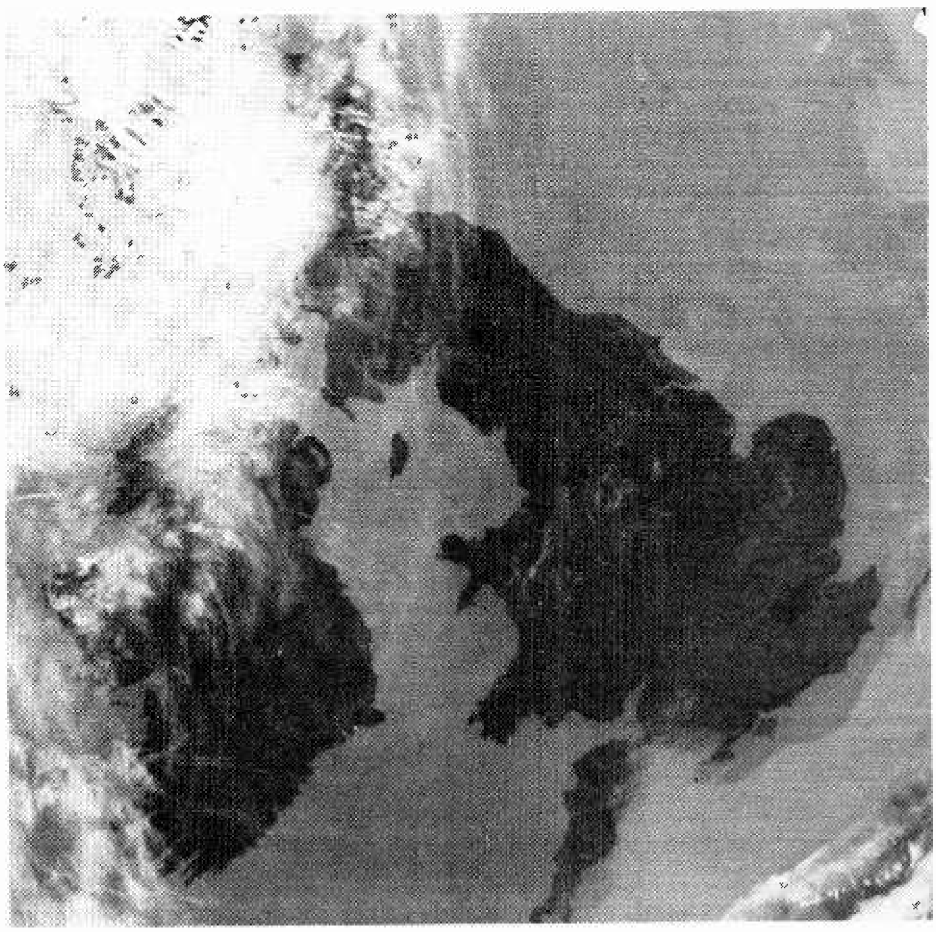
The Department of Electrical Engineering and Electronics, University of Dundee has recently completed the construction of a ground receiving station for the acquisition of Very High Resolution Radiometer (VHRR) cloud cover picture data from the American NOAA satellites. It is thought to be the only station in the UK with this capability. This type of data transmission is similar to that on 137.5 and 137.62MHz from the low resolution scanning radiometers on the same spacecraft. The chief difference lies in the nearly ten-fold increase in resolution and consequent hundred-fold increase in data rate. The VHRR scanning rate is 400 lines of visible and 400 lines of infra red channel per minute, time multiplexed. The resolution of both channels is 0.9km. The analogue signal from the radiometer which has a video bandwidth of 35kHz, frequency modulates a 99kHz subcarrier with peak deviation of ±29kHz. The subcarrier frequency modulates the main carrier of 1697.5MHz with peak deviation of ±300kHz. Total r.f. bandwidth is approximately 1MHz and the transmitter power is 5W (+37dBm).

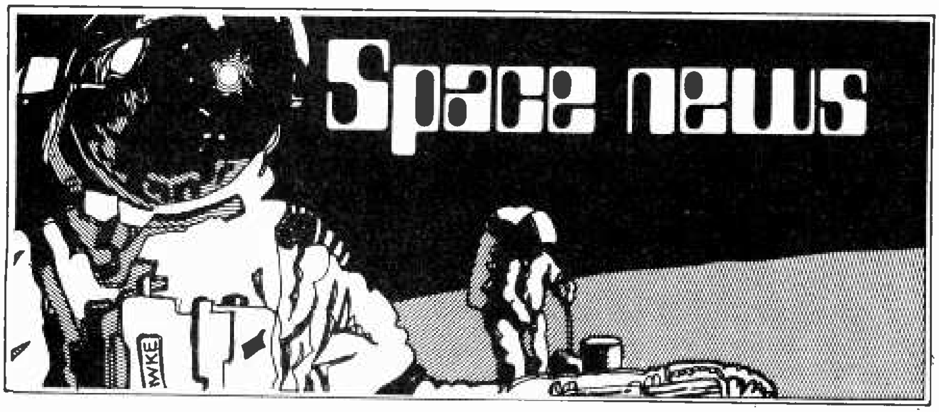
The Dundee receiver front end consists of a two stage transistor preamplifier, balanced diode mixer and first i.f. mounted at the focus of a 12ft diameter fully steerable parabolic reflector antenna. Local oscillator power is derived from a v.h.f. crystal controlled oscillator followed by a power amplifier, a times—12 varactor multiplier and an interdigital bandpass filter fabricated in triplate configuration from p.c.b. The first i.f. is at 137MHz so that it can be fed into existing v.h.f. satellite equipment for the reception of APT (Automatic Picture Transmission) compatible WE-FAX type transmissions from either Meteosat or SMS when they become available in the future. The low noise two stage transistor preamplifier was fabricated from microstrip on three 2 × 2in alumina substrates and has a noise figure of approximately 3dB. The transistors are type 35876E, made by Hewlett Packard. It is mounted in a sealed tube bolted on to the back of a 5in diameter circular waveguide primary feed at the reflector focus. Right hand circular polarization is transmitted by the spacecraft so the circular waveguide contains a polarizer to convert from circular to linear before the probe transition into a coaxial feed to the receiver. Matching into the first transistor is for optimum noise. A bandpass filter is included in the preamplifier to attenuate the second channel and discourage local v.h.f. mobile signals which are frequently over 70dB stronger than the satellite signals.

When the satellite is at an elevation of 5° the slant range is 2180 miles and the space loss $(\lambda/4\pi R)^2$ is −169dB. With a receiver n.f. of 3dB and bandwidth 1MHz the resultant predemodulator carrier/noise ratio is 14dB assuming the gain of the 12ft reflector antenna to be 33.7dB (55% aperture efficiency). In fact, the receiver will produce usable data from horizon to horizon.

The remaining parts of the receiver are quite conventional. A second mixer, manually tuned v.f.o. and 10.7MHz second i.f. amplifier are followed by a bandpass limiter and phase lock discriminator. Doppler shift has a maximum of ±25kHz so a.f.c. to the second l.o. is included. A separate i.f. is used to drive an S meter and to produce a signal for the possible implementation of auto-track at some future date.

Satellite NOAA 4, orbit no 2313, date 19.5.75, time 09.40, height 31km.

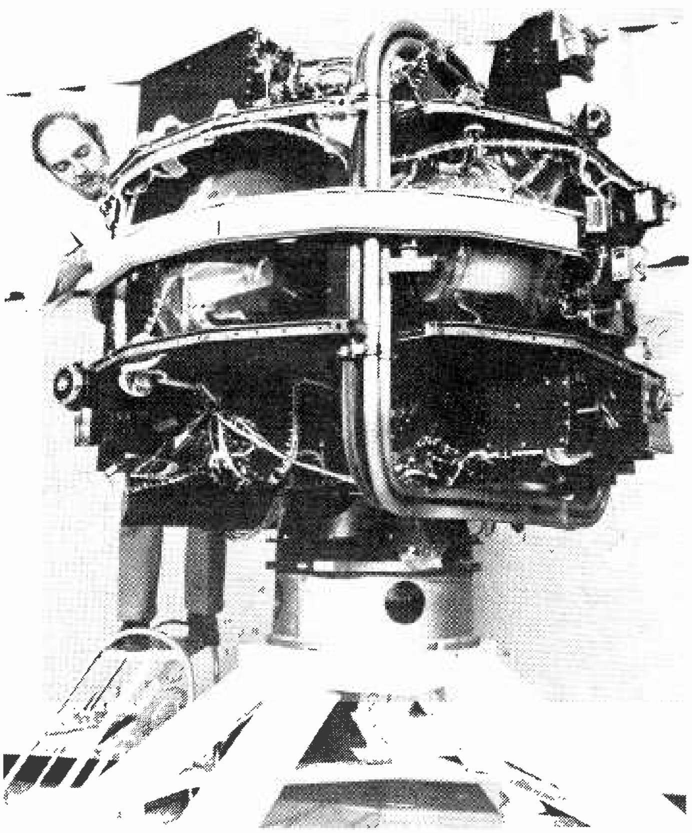




ESA's first satellite

The first satellite to be launched by the new European Space Agency (ESA) was placed in orbit on August 9, 1975 from the Western Test Range, California. A scientific satellite designed to study extraterrestrial gamma-radiation, COS-B is the eighth satellite developed by European industry for ESA's predecessor, the European Space Research Organization. COS-B carries a single payload which can be considered as a remotely-controlled astronomical laboratory designed to study radiation emitted from known and assumed sources of gamma rays. The payload has been assembled by six institutes in France, Germany, Italy, Netherlands.

The experiment electronics unit plays a central role in the payload in that it generates and accepts most of the internal payload signals and controls the flow of data from the sub-systems to the telemetry encoder. These signals consist of time, position and energy data produced by gamma and pulsar synchronizer events in the sub-systems of the payload. A built-in inflight test sequencer generates four main programmes which are capable of testing and calibrating other parts of the payload according to a preset pattern. Other functions of the experiment electronics are concerned with basic interpretation of data produced by the spark chamber. The objective of this chamber is the accurate measurement of the arrival direction of gamma quanta in the energy range from 30MeV to above 3GeV. Tracks of electron-positron pairs produced when gamma quanta in this energy range pass through conversion plates are traced out in the chamber by sparks produced by applied high voltage fields. The position co-ordinates of the sparks generated are stored on ferrite cores and from there are transferred to a buffer memory for telemetering to ground.



Installing an ozone sounding instrument on NASA's Atmosphere Explorer-E satellite that will be investigating the possibility of ozone depletion in the stratosphere.

Radar probes Ganymede

Jupiter's largest moon, Ganymede, has been probed by radar for the first time and found to have a rougher surface than the inner planets. The big Jovian satellite, slightly larger than the planet Mercury, is considerably rougher than Mercury, Mars or Venus, the most likely possibility for the surface being rocky and/or metallic material embedded in a top layer of ice. The Ganymede test over a distance of 600 million kilometres was conducted on six nights, employing the 64-metre antenna at the NASA-Jet Propulsion Laboratory deep space network tracking station at Goldstone, California. The finding is particularly interesting in view of verification by Pioneer 10 and 11 flybys that Jupiter itself is gaseous with no solid surface that could sustain a radar echo.

The material on Ganymede is probably meteoric in origin. Ganymede scatters to Earth 12 per cent of the power expected from a conducting sphere of the same size and distance. Roughness is made evident in this experiment by the presence of echoes away from the centre of the disc. A perfectly smooth disc would reflect only a glint from the centre. A rough one reflects power from the entire disc. A 400-kilowatt beam of microwaves with a wavelength of 12.6cm was directed at Ganymede.

Mars probe launched

America's most ambitious unmanned space venture is underway with the launch during August and early September of two Viking spacecraft. The year long 815-million-kilometre journey will culminate with the landing of an automated laboratory on the surface of Mars in the summer of 1976. The instrument-laden craft will take pictures and conduct a detailed scientific examination of the planet, including a search for life. Viking 2 will arrive at Mars seven weeks after Viking 1. Each will divide into an orbiter and lander vehicles. The main orbiter communications system is a two-way S-band, radio link providing Earth command, radio tracking and scientific data return. This link uses either a steerable 1.5m high-gain dish antenna or an omni-directional low-gain antenna. Transmission rates at S-band vary from 8.3 to 33.3 bits per second for engineering data to 2,000 to 16,000 bits per second for Lander and Orbiter science data. The radio science investigations will make use of Orbiter and Lander communications equipment to measure Mars' gravitational field, determine its axis of rotation, measure surface properties, conduct certain relativity experiments and pinpoint the locations of both Landers on Mars. An X-band radio link will be used to study charged ion and electron particles.

Television tuner design — 3

Construction and sound-only version

by D. C. Read, B.Sc.

Parts 1 and 2 of this article dealt with important aspects of the tuner design, particularly where it differs from the more conventional arrangements, explained circuit operation, and gave oscillograms to illustrate typical performance. Description continues with constructional points and modifications for a vaned-capacitor-tuned version and a sound-only unit. Part 4 will detail alignment and use of an optocoupler for mains isolation.

To help readers build the tuner, a component location diagram, provided with the printed-circuit board* carries important information concerning specific processes in construction; the uses of this diagram are explained below.

Inspection of the printed-circuit board will show that it has an earth plane covering the whole of the component side; there are also a number of "earth-plane" zones on the wiring side, and it is esential that in the course of wiring-in components these zones are connected through to the main earth plane.

Each of the points at which a through connection must be made (before mounting near-by components) is indicated in the location diagram by a small triangle; at such points on the board, a short wire link is passed through the hole provided and firmly soldered to both sides. Most, but not all, of the large squares representing inductors in the drawing are flanked by triangles. In these instances, the links ensure that the screening-can lugs and the associated wiring-side zones are properly connected to earth. Sometimes, as with resistors R_5 and R_{56}, a through connection can be arranged simply by feeding the component lead itself through the board and soldering this on each side.

*Board diagram is available from the editorial office, together with location diagram. Drilled boards are available from the address given in the components list.

Several of the through connection points are associated with short sections of copper track which are needed:

- on the wiring side of the board, to provide earth connections for C_{59}, C_{65}, L_{18}, Tr_7 and IC_2. Both pins 4 of the 8-pin d.i.l. packaged SN72748P and the SN72741P (See Fig.14) require an earth; these two i.cs replace the SN72747 shown in Fig.2.
- on the component side of the board, to complete the 24-volt supply rail circuit. These are shown in the diagram as broken lines across the top of C_{35} and along the edge of the board below R_{25} and R_{26}.

Two other symbols used in the location diagram to indicate particular aspects of construction are:

- a diagonal cross drawn at one end of some components. This shows that the appropriate connecting "leg" in each instance has to be shortened and bent so that it can be soldered directly to the earth plane (on the component side).
- a square, which shows the position of a monitor point, provided with stand-off resistor for oscilloscope measurement.

In addition to the copper-track links already mentioned, a long wire link must be fitted to carry the a.g.c. circuit output to the Tr_1/Tr_2 i.f. stage. The two points which require this interconnection are terminated in copper "pads" on the board; one of these is beneath C_{65} (the large 1μF component to the right of the u.h.f. module) and the other is marked "a.g.c." (at the junction of C_{13} and R_6). A further long wire link is needed if the group-delay equalizer has been omitted from the circuit. This is required to join the output of the Tr_4/Tr_5 stage to the input of Tr_6/Tr_7, and runs from R_{28} to C_{34}.

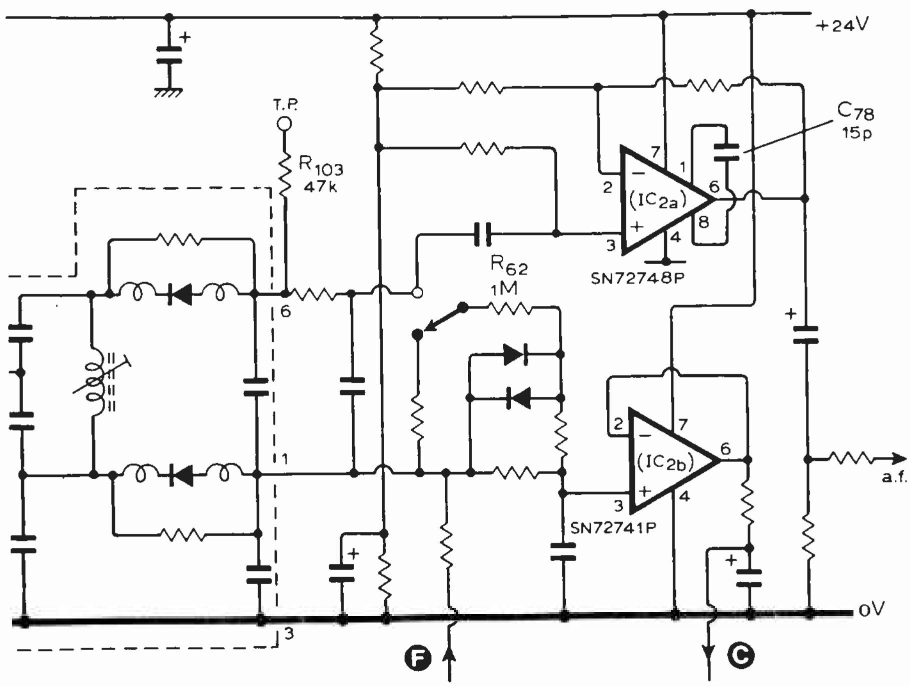


Fig. 14. Changes and corrections to the sound/a.f.c. circuit given in Fig. 2 (Part 1). Separate components in the IC_{2a} and IC_{2b} positions take advantage of better noise performance available from the SN72748P acting as the audio output amplifier.

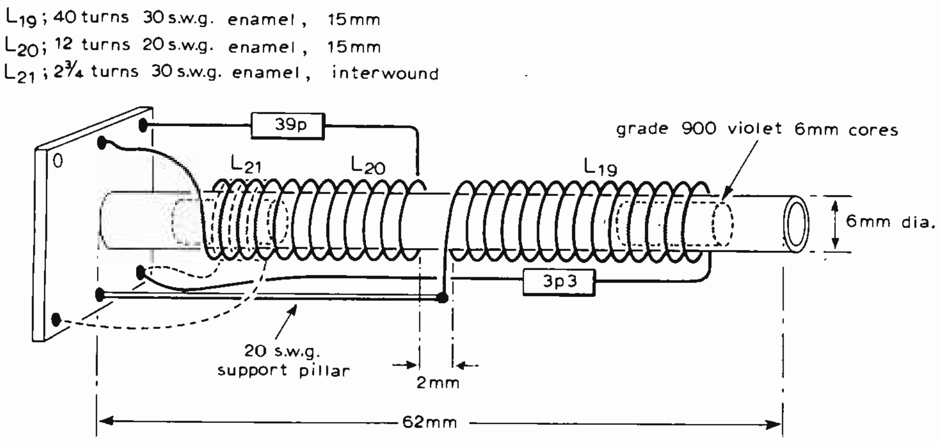


Fig 15. Dimensions and form of $L_{19}/L_{20}/L_{21}$ coil construction.

In the circuit of Fig. 2 the following components were omitted: C_{77}, which should decouple the junction of R_1 and R_2 to earth, C_{40}, which should decouple Tr_9 base to earth, R_{108}, which should be in series with the tuning voltage line at point F, and R_{109}, which feeds the sound a.f.c. discriminator output on pin 6 to a test point.

Pre-assembly of inductor circuits

In addition to winding the coils (see parts list), further assembly work is required for some inductors before they are mounted on the circuit board. In most instances, these sub-assemblies are formed simply by adding a capacitor which is mounted inside the screening can in one of the two ways outlined below. Construction of the $L_{19}/L_{20}/L_{21}$ assembly and of the L_{18} discriminator circuit, however, is more involved, and requires separate description.

For the more simple inductors the choice of construction depends on whether the inductor and its associated capacitor are in series or parallel. For series combinations use diagonally opposing base pins; from Fig.2 and the parts list it can be seen that L_1, L_3, L_{11} and L_{13} need to be assembled in this way. Inductors L_7, L_{14}, L_{15} and L_{17} are parallel-connected to their capacitors and wired to adjacent base pins. Inductors L_8, L_9, L_{10} and L_{12} also have parallel capacitors, and as the Neosid type E-2 formers used for these have an off-centre stack, there is room for the added component inside the can. But for these components it is just as convenient to solder the capacitors across the inductor connection pins which will be proud on the wiring side of the board.

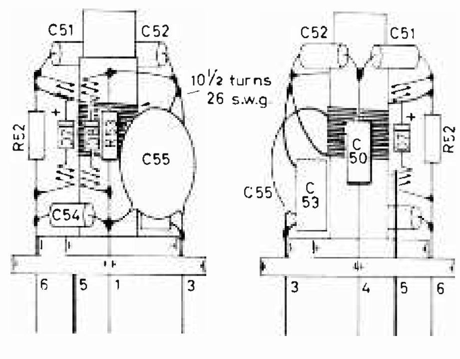
As explained more fully elsewhere, proper operation of the sound trap/sound take-off circuit obtains when phase cancellation occurs precisely at the sound carrier (i.f.) frequency, and this in turn depends on the degree of coupling between L_{19} and the L_{20}/L_{21} pair. Fig.15 shows how the three coils are wound on the common former and are connected to associated capacitors C_{19} and C_{20}. Typical dimensions for the coils and their spacing are also given. To facilitate a change in spacing which may be advantageous during adjustment of the circuit as described in step 7 of the line-up instructions (part 4), the upper coil can be wound over a paper tube wrapped round the former stack, and subsequently fixed by a coating of Denfix or clear Bostic when the optimum coupling conditions have been established by measurement.

Rigid construction of the discriminator assembly (L_{18} and components enclosed by broken lines in Fig.2) before installation on the board is essential: any change in circuit parameters here, such as might be caused by relative movement, could spoil the performance of the tuner.

Two views of the coil and its associated circuitry are given in Fig.16, which shows diagrammatically the assembly from opposite corners of the former base. The assembly should be built up in three stages, as detailed below.

- Insert an 18 s.w.g. wire through hole 5 in the former base, solder it to the metal insert and cut it so that it reaches nearly to the top of the stack; this wire simply acts as a support and is not part of the circuit. Wind the 10⅓-turn coil as shown and temporarily secure the ends by wrapping them round the support wire so that the coil turns are held tightly in position. Completely coat the coil in cement (Denfix) and leave overnight to dry thoroughly.
- Free the coil ends and cut back the support wire to a length roughly as in the drawing. Now connect and arrange into the positions shown, resistors R_{52} and R_{53}, ceramic capacitors C_{53} and C_{55}, and diodes D_7 and D_8, each with leads formed into miniature coils as explained in part 1. Cover these components with cement, making sure that wiring points to which the remaining capacitors will be soldered are kept clear. Leave the assembly to dry.
- Finally, connect C_{50}, C_{51}, C_{52} and C_{54} so that they are held in position as firmly as possible but do not cement them because the polystyrene dielectric might then be dissolved.

Fig. 16. Opposing views of L_{18} assembly identifying associated components and their positions.



The assembly is then connected into the circuit, (making sure that pin numbers on the base correspond with those marked on the board) where it is held by means of 6BA screws in the tapped holes provided. The screening can is added later and held separately by 6BA screws and nuts passing through two more holes in the board.

Tuning-voltage supply arrangements

The later steps in the line-up procedure, to be given in part 4, require reception of a transmitted signal, and therefore the switched voltages available from the tuning supply circuit (shown in part 1) must be pre-set to the appropriate values for the required transmissions. Values given for the fixed resistors feeding the pre-set controls R_{90}, R_{93}, R_{96} are suitable for the London area (Crystal Palace) transmitter; for other localities, these values will have to be changed as follows.

From Fig. 17 the tuning voltages which correspond to the channels chosen. If a wanted channel has a number more than 45 to 50, add one or two 5.6-volt zener diodes in series with those at D_{12} and D_{13} to increase the tuning supply-rail voltage. Calculate new fixed-resistor values (for R_{89}/R_{91}, R_{92}/R_{94}, etc), taking the current through each resistor chain to be 0.5mA, so that suitable voltages are then available for final adjustment by the pre-sets to the precise values found above.

Current from Tr_{20} through the zener circuit should be held at about 6.5mA to give the required zero temperature coefficient of the zeners. Therefore, the resistance of each pre-set control divider chain must be increased to maintain a total supply to the four chains of about 2mA. The increase will be up to, say, 40kΩ for a 22V rail with each variable changed to 10kΩ to give the same control range.

For added convenience of operation, push-button units can be obtained (from Manor Supplies) in which each button also actuates a separate multi-turn variable resistor and a common

From Canada's largest manufacturer of video monitors, Bell & Howell present the extensive Electrohome range.

Questions to ask before buying a video monitor

It's an impressive number of models but what about the performance?

The performance price ratio is equally impressive – perhaps the best in the CCTV business. More than 80% of the screen has a resolution capability greater than 1,000 lines and on the large monitors the minimum brightness in the white area is 130ft lamberts (under accepted test conditions). Other features include high video input impedance and external sync input.

I need a large screen. For what application has Electrohome's 23 in monitor been designed?

The long-term reliability of the EVM23 and EVM23AG make either ideal for surveillance systems in banks, factories and department stores. They are equally at home in the message centres of the world's airports, in schools and broadcast studios. Both models have a durable outer casing and the EVM23AG has a special tube face to reduce reflections – important where lights or windows may reflect on to the screen. Lockable front panels make them ideal for unattended locations.

What about mounting? I need the utmost flexibility.

There is no problem. Electrohome have wall and ceiling mount assemblies that allow a monitor to be swivelled or tilted about its centre of gravity. For mobile work like presentations and exhibitions there is an adjustable stand to support the EVM23 at four different heights – 63in, 55½in, 54in, and 46½in. If your requirement is for rack mounting versions, all sizes below 23in are available in rack mount options.

How do I decide the screen size to suit my application and do Electrohome have a complete range?

Screen size depends largely on viewing distance and available space. If the minimum viewing distance is 10ft then you should use a large monitor – 17in or above. At closer distances or where space is limited a 9in or 11in screen may be more suitable. If you intend TV to teach or persuade, avoid the mistake of sacrificing visual impact for the sake of economy. Electrohome's range is one of the most comprehensive available with seven different sizes from 9in to 25in (two in colour).

What facilities do Electrohome's small screen monitors offer?

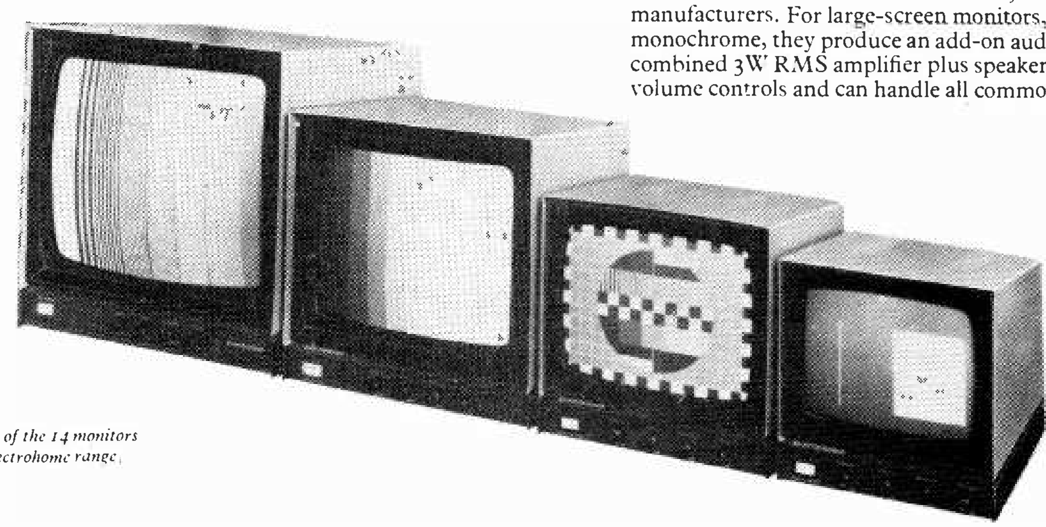
To complement this outstanding specification we have not forgotten the importance of switchable A-B inputs, switchable underscan, DC restoration and good geometry. Also the wide input sensitivity range and the input ground which can be 'floated' will look after less favourable operating conditions. Input power requirement is also tolerant within 95–130V 185–265V, 50 60Hz.

When should I use a colour monitor?

We'll ask a question which will help you decide. Everything you show on TV will be shown with a purpose. Will colour help to achieve that purpose? If so, use colour – and choose an Electrohome colour monitor because, simply, you cannot make a better choice. (This is only part of the answer to a complex question which we would enjoy discussing with you in proper depth.)

What about audio? You have convinced me that the video signal is first-class, but I need to hear the sound.

Electrohome haven't overlooked audio, like some manufacturers. For large-screen monitors, both colour and monochrome, they produce an add-on audio pod with a combined 3W RMS amplifier plus speaker unit. It has tone and volume controls and can handle all common audio inputs.



Just four of the 14 monitors in the Electrohome range

Bell & Howell A-V Ltd.,
Freepost, Wembley, Middlesex HA0 1BR
(no stamp required).

BELL & HOWELL

More questions? Write to us for the address of your nearest Bell & Howell Video Centre. You'll get the answers in the most convincing way possible – by seeing and hearing how Electrohome's monitors perform.

Specifications: the Electrohome monitor range from Bell & Howell

Models	Screen size	Specification	Individual features
EVM-910 (freestanding) **EVM-910R** (rack mounted) **EVM-910R2** (double rack mounted)	9in (21.7cm) $38in^2$ ($245cm^2$)	Input sensitivity 0.25V – 4V pp composite or separate sync. signal (sync. negative). Resolution in excess of 1,000 lines in central 80% of display area at 5ft lamberts; more than 860 lines at 30ft lamberts brightness; capability 55ft lamberts in white area of test pattern (23 in monitor 130ft lamberts). EHT regulation, switchable scan size, selectable black level clamp and 15Mhz bandwidth $\mp$3dB. Operating temperature 0-50°C, humidity 0-98% non-condensing.	2 composite video inputs or 1 video blanked input plus sync.
EVM-1110 (free standing) **EVM-1110R** (rack mounted)	11in (26.3cm) $61in^2$ ($393.5cm^2$)		
EVM-1410 (free standing) **EVM-1410R** (rack mounted)	14in (32.2cm) $82in^2$ ($529cm^2$)		
EVM-1710 (free standing) **EVM-1710R** (rack mounted)	17in (41.3cm) $149in^2$ ($961cm^2$)		
EVM-23	23in (57.5cm) $282in^2$ ($1819.3cm^2$)		Lockable control cover
EVM-23AG	23in (57.5cm) $282in^2$ ($1819.4cm^2$)		Special tube face to reduce reflections. Lockable control cover
ECV-19P (colour)	19in (48.26cm) $185in^2$ ($1193.25cm^2$)	Input sensitivity 0.5V – 2V pp composite or separate sync. signal (sync. negative). D.C. restoration: keyed clamp back porch maintains black level shift to less than 2% of peak luminance from 10% to 90% APL. Colour temperature: 6500°K. Continuously adjustable to 9300°K.	Lockable control cover
ECV-25P (colour)	25in (62.5cm) $315cm^2$ ($2032cm^2$)		

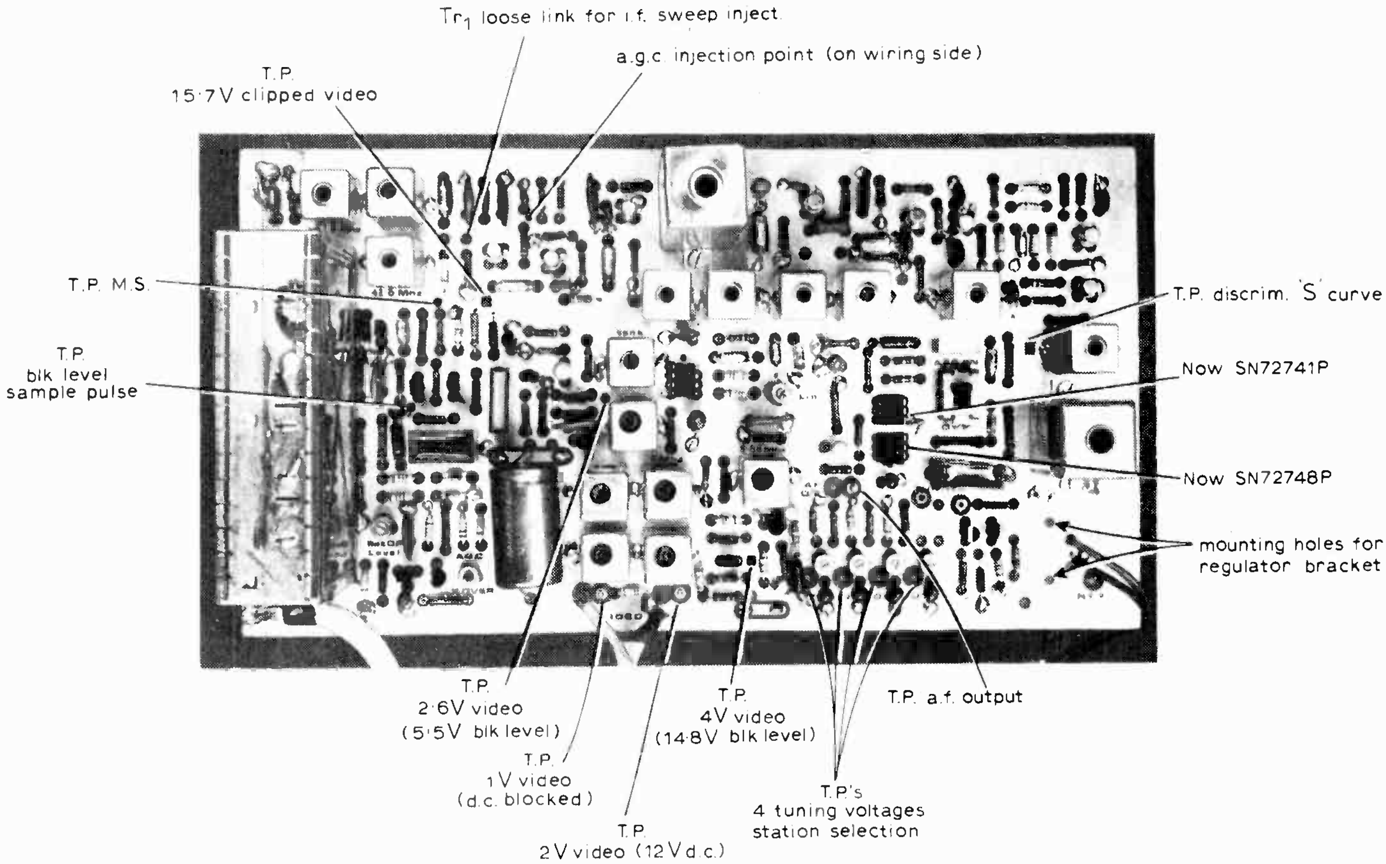
Accessories for EVM-23, ECV-19P and ECV-25P

ECM-2	Ceiling mount
EWM-1	Wall mount
EVSA-2	Speaker/amplifier pod. 3W RMS amplifier available for large monochrome and colour monitors.
EPC-1	Pulse-Cross kit. Allows VTR users to optimise tracking and tape tension (EVM-23 only).

BELL & HOWELL

WW—087 FOR FURTHER DETAILS


IF THE NAKAMICHI CAN CAPTURE HIM, THINK WHAT IT'LL DO FOR BEETHOVEN.
Most portable cassette decks are quite happy recording the odd pop song.
But give them something truly challenging, and you soon realize their shortcomings. Fine, if you're content to be unambitious. But at Nakamichi we think you should be able to record any sound you want. Which is the reason why we produced the Nakamichi 550.
From a mouse squeak to the triumphant sounds of Beethoven, you can record it all on a Nakamichi 550.
Its peak level meters have a range of 45dB. Its signal-to-noise ratio is more than 60dB. Its microphone inputs have a dynamic range of 125dB.
Wider ranges than any other portable cassette deck in the world.
And that's not all. The 550 is also the only portable cassette deck with 3 microphone inputs. And a tape end alarm with pre-set timer.
The only one too, with a button that shows how much of your cassette you've used.
And Nakamichi's exclusive record/playback head. And it's the only one with a battery life that can give you up to 15 hours continuous playing.
When you try the Nakamichi 550, you'll know why it costs £236+ VAT.
Suddenly, other portable cassette decks look like toys.
NAKAMICHI
THE WORLD'S MOST VERSATILE PORTABLE CASSETTE DECK
Natural Sound Systems Limited.
Strathcona Road, North Wembley, Middx. HA9 8QL. 01-904 0141
Nakamichi 550



Photograph of component side of board showing approximate positions of test points and the signals they carry. When completed, the board is fitted on pillars into the bottom of a U-section aluminium sheet screen which covers the whole of the wiring side and extends above the components.

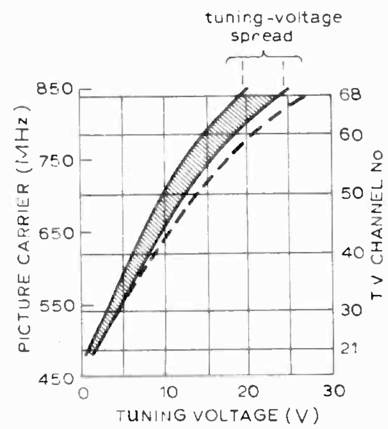


Fig. 17. Broken line indicates tuning voltage versus frequency and channel number for ELC1043 u.h.f. tuner. Shaded area shows spread quoted for the ELC1043/05.

a.f.c.-inhibit switch. When a button is pressed, it can then be rotated, acting as a fine-tuning control, to give any voltage up to the maximum available.

The pre-set variables in these units have resistance values around 50kΩ, and hence draw a much smaller current that the control chains specified in the published tuner circuit. To compensate for this, the standing zener current must again be adjusted to 6.5mA, in this instance by adjusting the value of R_{88} feeding Tr_{20} emitter (an increase in value causes a decrease in current).

MODIFICATIONS

Vaned-capacitor module

Although varicap-operated u.h.f. tuner circuits such as the Mullard ELC1043/05 used here are very convenient, especially for remote-control arrangements, they do have disadvantages, mainly in that they are prone to spurious phase modulation.

The ELC1043 circuit principally consists of four half-wave tuned lines in cascade, each with a fixed capacitor at one end and a capacitance diode at the other acting as the control variable responding to the separately-applied tuning voltage (which is push-button switched and includes a slowly-varying a.f.c. correction signal). The incoming r.f. signal, with its main spectral components as illustrated in Fig. 18, passes through these lines superimposed on the direct control voltage; the varicap diodes can thus be affected by amplitude changes in the vision carrier envelope as well as by the control-voltage.

Thus, if the incoming vision carrier amplitude is very high, it causes detectable sympathetic changes in the resonance of the lines, and hence variations in the phase of their output. In practice, the rate of phase change will be mainly at the 50-Hz field frequency (2 fields = 1 picture) which predominates at the low end of the spectrum. Such phase variation does not usually affect the a.m. picture information (unless a phase-locked-loop demodulator is being used), but it does interfere with the sound because it is detected as frequency modulation. Given a sufficiently large phase variation, the result is the well-known sound 'buzz.'

This type of interference may be prevented by suitably arranging the r.f./i.f. a.g.c. overlap (see Fig. 13 in part 2) to give as small an r.f. signal amplitude as possible. But if the amplitude is reduced too much, the signal-to-noise performance is degraded.

To test the relative merits of varicap and vaned-capacitor u.h.f. tuners, and especially to sample the possible improvements in tuner performance with regard to the problem mentioned above, a second circuit to this overall design was constructed but with the varicap module replaced by a "mechanical" module taken from a commercial receiver and connected to the board by means of flying leads. (The component used was a Mullard type AT6382 –41–PB.)

Extensive tests were carried out, using locally-generated r.f. feeds as well as 'off-air' signals and with both high

Components

Resistors

qty	value	reference
Mullard MR25 metal film ±2% 0.4W, or equivalent metal film ±5% 0.25W.		
1	10	107[1]
2	47	13, 18
1	75	88
9	100	11, 41, 45, 47, 50, 51, 58, 66, 108
3	150	31, 32, 68
2	180	3, 14
1	300	4
1	390	8
3	470	6, 48, 74
2	750	2[5], 28
1	820	46
8[2]	1k	1, 7, 9, 20, 102, 104, 105
3	1.5k	25, 29, 30
2	1.8k	77, 79
2	2k	26, 91[3]
2	2.2k	5, 67[4]
3	3.3k	27, 40, 106
1	3.6k	22
1	4.3k	94[3]
4	4.7k	24, 59, 63, 70
1	5.6k	67[7]
2[2]	6.2k	95
1	6.8k	21
6	10k	10, 39, 55, 56, 64, 73
1	11k	97[3], 3, 5
1	12k	84
1	13k	92[3]
1	15k	43
1	16k	89[3]
2	18k	23, 71
6	22k	16, 34[5], 44, 49, 86, 87
4	33k	37, 38, 42, 81
1	39k	12
3	47k	35, 36, 103[6]
5	100k	15, 33, 52, 53, 82
Mullard MR30 metal film or equivalent ±5% 0.25W		
3	150k	72, 80, 85
1	220k	61, 65
1	270k	69
2	470k	54, 101
1	560k	57
2	1M	62[5], 75
Erie carbon ±5% 0.33W		
1	1.5M	62[8]
2	2.2M	60, 76[5]
Carbon potentiometer		
1	2k	see note 2
Cermet potentiometers		
1	500	19
1	1k	78
4	5k	90, 93, 96, 99
1	10k	17
1	50k	83

Notes:
1. Used with MC7824CP regulator.
2. One used for a.g.c. test point.
3. For London transmissions.
4. Used when D_9 is used.
5. Changed value from that shown in Fig. 2 (part 1).
6. Additional component to those in Fig. 2 (see text).
7. Used when D_9 is not used.
8. Used with mechanical vane tuner, see inset Fig. 2.

Capacitors

qty	value	reference
	0.5p	inter-track on p.c.b.
Erie tubular ceramic NO33AD		
2	2.2p	41, 53
2	3.3p	8, 19
polystyrene ±2% 125V (Suflex, Salford, Lemco)		
1	10p	23[1]
1	12p	50
2	15p	78[4]
3[2]	20p	49
1	22p	32
3	27p	30, 39, 42
4	33p	6, 26[6], 44, 62
2	39p	20[4], 29
2	51p	51, 52
1	68p	33
3	100p	22, 28, 54
1	120p	56
2	150p	5, 64
1	200p	31
1	220p	46
1	470p	24
1	680p	21[4]
3	1n	7, 11, 14
disc ceramic ±25% 500V Erie K7004/831		
11	2.2n	13, 15, 16, 18, 37, 40[6] 43, 45, 47, 48, 76[3]
5	10n K7004/811	9, 12, 17, 66, 38
8	100n K7004/811/T/30V	1-4, 27, 55, 68, 77[5]
polyester metallized ±10% 100 or 250V (Mullard)		
1	10n type 344 41103	58
1	330n type 344 25334	63
2	1µ type 344 25105	59, 65
tantalum ±20% Union Carbide or RS Components		
1	4.7µ 35V	61
9	10µ 25V	25, 36, 60, 67, 70-73[4,5], 75
1	22µ 15V	57
2	47µ 6V	34, 74
electrolytic, Erie, Mullard or equivalent		
1	150µ 25V	69[4]
1	1000µ 25V	35

Notes
1. Removed when c.r.o. connected.
2. One used for C_5 a.o.t., another to resonate L_{16} in test procedure.
3. Used with regulator.
4. Changed value from that shown in Fig 2.
5. Additional component to those in Fig. 2 (see text.
6. Shown as C_{36} in Fig. 2, part 1.
7. The 22µF/15V tantalum capacitors may be retained for channels requiring less than 15V

Semiconductor devices

qty	type	reference
diodes		
4	1N916	7, 8, 15, 16
2	AAZ13 or OA47	5, 6
1	BZY88 C3V3	14
2	BZY88 C5V1	10, 11
5[1]	BZY88 C5V6	2-4, 12, 13
1	BZY88 C12V	1
1	BZY88 C16V	9
transistors		
1	BF167	2
7	BF173	1, 3, 8-12
3	2N3904 or BC107-8-9	4, 6, 15
8	2N3906 or BCY70-1-2	5, 7, 13, 14, 17-20
1	2N3819	
integrated circuits		
1	MC1330P 8-pin d.i.l. (Motorola)	1
1	SN72748P 8-pin d.i.l. (Motorola)	2a } change of device from that of Fig. 2
1	SN72741P 8-pin d.i.l. (Motorola)	2b } change of device from that of Fig. 2
1	MC7824CP (optional)	3

1. Up to three extra zener diodes are needed for higher tuning voltages.

Inductors (all require cans)	**reference**
Neosid 4mm dia. 6mm leg spacing 18mm tall, grade 900 violet core (µ=11), Neosid or equivalent	
15 turns 26s.w.g.	
8 turns 34s.w.g.	2
30 turns 34s.w.g.	3
40 turns 40s.w.g.	4
5¼ turns 26s.w.g.	6
9 turns 26s.w.g.	7
4 off, 11 turns 26s.w.g. 6mm dia.	14-17
10 turns 26s.w.g. 35mm tall	18 (Fig. 16)
See Fig. 15 for detail. 62mm tall	19-21
Neosid E2 assemblies	
9½+9½ turns 16/48 litz pile wound	8
18 turns 16/48 litz pile wound	9
33+33 turns 16/48 litz pile wound	10
27 turns 16/48 litz pile wound	11
19+19 turns 16/48 litz pile wound	12
31 turns 16/48 litz pile wound	13

Other parts

u.h.f. tuner Mullard ELC1043. (If ELC1043/05 is used drill extra hole in board next to test point position.)
a.f.c. switch 1pole 2way
photocoupler Mullard CNY48
printed board (available at £6 inclusive from M. R. Sagin, 11 Villiers Road, London NW2, together with component location diagram).
Kits, or parts separately, including a sound-only version, are available from Manor Supplies, 172 West End Lane, London NW6 1SD, telephone 01-794 8751.
Vision monitor used with prototype was Decca CS2240/L, costing about £280 including 8% v.a.t.

and low incoming levels. From these tests, it was evident that the performance benefits – as distinct from possible financial ones – were not as marked as expected.

The first main improvement was in signal-to-noise — of 3 to 4dB — obtained from transmissions received at high aerial-strength (e.g. the signal from a transmitter at 'line-of-sight' distance). Reception conditions as beneficial as this, however, are the exception rather than the rule; generally, the limiting factor in respect of noise performance is already realized as a function of received signal level, and the signal-to-noise figure which can be achieved using a varicap-tuned front end is the best possible given that input level. Hence, the noise cannot be further reduced by changing the input circuit to one using a vaned capacitor.

The second main improvement was discussed earlier regarding r.f./i.f. a.g.c. overlap setting. Remember, with low r.f. but high i.f. gain, the problem is r.f.-circuit mixer noise whereas with gain conditions reversed, the result is buzz-on-sound. Higher r.f. levels could be permitted in the mechanical tuner so allowing greater level range to be accommodated between the onset of adverse effects. But, except in places where reception conditions for wanted stations are greatly different (or change considerably with time), this extra range is of no particular advantage because the a.g.c. circuit can so easily be set for a satisfactory compromise which includes the highest and lowest levels normally received.

Under certain conditions, then the different operating characteristics of mechanical tuners could be useful in obtaining the best possible video signal-to-noise figure. Added to this is the saving in component cost which would be made if a mechanical module were already to hand or cheaply available.

In choosing such a module, check that it includes a varicap diode for a.f.c. correction. For constructors who wish to take up this option, therefore, the necessary circuit changes have been detailed in Fig. 2. They involve the small differences in value for C_5 (which could accommodate the capacitance introduced by about 6 inches of connecting cable), R_3, the alternative a.f.c. circuit catching diodes as detailed by the inset diagram in Fig. 2, Tr_{19} and Tr_{20} plus, R_{87} to R_{100} and associated capacitors with the zener diodes omitted.

Sound-only tuner

Some readers may wish, at least initially, to build only those parts of the circuit necessary for producing a sound signal; the vision side could be added at a later date. The circuit changes necessary are as follows. Referring separately to the four sections of circuitry in Fig. 2

—**top section** — retain except for R_9, Tr_3 and L_4. The i.f. output from C_{14} is then connected directly to the emitter of Tr_8, via a short wire link on the wiring side of the board.

—**second section** — omit entirely (C_{17} to C_{35}, R_{13} to R_{33} etc).

—**third section** — retain all this section, making sure R_{34} is 22kΩ, not as incorrectly shown in Fig. 2, and incorporating the changes to the sound and a.f.c. output circuits already called for.

—**bottom section** — omit the part up to the R_{80}/R_{81} divider, retaining all the circuit including, and to the right of, C_{66}. The temporary divider chain marked 'a.g.c. test' in Fig. 2 becomes a permanent part of the circuit and is used to set the gain of the sound-only tuner.

Line-up of this simplified tuner is very easy and details will be given subsequently.

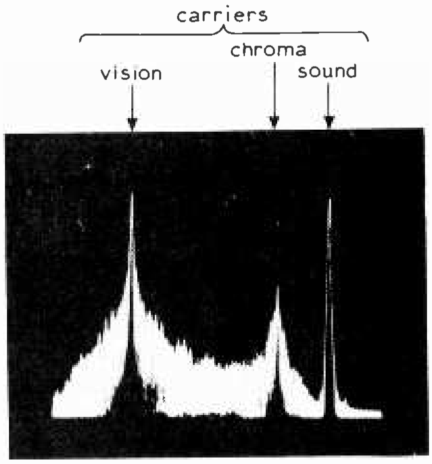


Fig. 18. Spectrum of r.f. television transmission showing distribution and relative energy content of side bands about the vision carrier (left), the colour subcarrier (centre), and the sound carrier (right).

Announcements

Allen-Bradley Electronics Ltd, Pilgrimsway, Bede Industrial Estate, Jarrow have announced that they are to phase out production at Jarrow of the **"Morganite"** range of carbon composition resistors, the last of their important products supplied to the consumer goods sector.

National Semiconductor U.K. Ltd, 19 Goldington Road, Bedford MK40 3LF has formed a new group to produce **electronic subsystems**. Known as The Module Products Group, it will produce modules to meet the needs of home appliances, entertainment systems, automotive products, telecommunications and miltary equipment.

Reaching decisions on the technical merits of introducing **hybrid microelectronics** into equipment, assessing alternative approaches, estimating likely costs and identifying the right suppliers can be difficult problems for electronic equipment designers and manufacturers. Now available is a comprehensive, independent report dealing with these problems which has just been completed by the Electronics Technology Department of the Electrical Research Association Ltd, Cleeve Road, Leatherhead, Surrey KT22 7SA.

Plasro Plastics Ltd, 38 Wates Way, Mitcham, Surrey now offer a service for the manufacture of **control knobs.** These can be produced in any thermosetting or thermoplastic material with hot foiled or paint infilled legend, metal inserts and bright trimmed discs.

Sifam Ltd, Accessories Division, Torquay, Devon has appointed Townsend Coates Ltd, Lunsford Road, Leicester, stockists and distributors for the Sifam range of professional collet knobs.

Bosch Ltd has changed its company name to **Robert Bosch Ltd,** P.O. Box 166, Rhodes Way, Watford, Herts.

As a result of a six-year research programme the Allen Clark Research Centre of the Plessey Company Ltd at Caswell, near Towcester, Northants has now established a complete facility for the design and production of **surface acoustic wave** devices to customers' requirements.

Electroplan Ltd, P.O. Box 19, Orchard Road, Royston, Herts, has been appointed sole UK distributor for the **"Powercube"** range of power supplies manufactured by Integrated Photomatrix.

Amateur Computer Club, 7 Doordells, Basildon, Essex has commenced the design and construction of a low cost computer which appears in a series of articles in the club's newsletter. Membership to the ACC costs £1 and details of the club's activities can be obtained from the above address.

Guest International Ltd, Redlands, Coulsdon, Surrey CR3 2HT, is establishing manufacturing facilities for **carbon film resistors.**

Books Received

Radio Construction for Amateurs by R. H. Warring is a plain-man's guide to understanding and (hopefully) building a receiver. The book contains 27 working circuit designs ranging from a simple crystal set to a f.e.t. receiver and i.c. amplifier. Transistor circuitry is used in all the discrete designs and the text is supplemented with pictorial diagrams for the identification of components. Price £2. Pp. 120 (paperback). Pitman Publishing Ltd, 39 Parker Street, London WC2B 5PB.

Videotape Recording by Joseph F. Robinson is aimed at providing a readable exposition for readers with a basic engineering knowledge. The book starts with chapters on tape recording principles and basic requirements of videotape recording. Having gently led the reader up the video path, broadcast and c.c.t.v. formats, f.m. theory, signal systems, and servo-mechanisms are discussed. The book concludes with chapters on errors and correction, cassettes and cartridges, editing, magnetic video discs and slow motion techniques. Pp. 303. Price £5.75. Focal Press Ltd, 31 Fitzroy Square, London W1P 6BH.

Radio and Line Transmission A (second edition) by D. C. Green. This is a textbook covering the second-year requirements of the telecommunication technicians' course. The contents have been revised to include chapters on f.e.ts and i.cs. and omit those dealing with aerials and power supplies. A number of new questions have also been added to the exercises at the end of each chapter. Price £4.00. Pp. 318. Pitman Publishing Ltd, 39 Parker Street, London WC2B 5PB.

World of Amateur Radio

Amateur radio on Oracle

Amateur radio information is now frequently transmitted on the experimental Oracle Teletext service (London region only except when London programmes are networked) on the ITV channel. A multiple-page (often up to 5 pages transmitted sequentially on page 167) provides, typically, details of Oscar 6 and Oscar 7 orbits, information on beacon and repeater stations, and news items. An introduction states: "These pages of information are being transmitted as a service to radio amateurs who have access to, or have built, Oracle decoders." The service was initiated and is being updated by members of the London Weekend Television Radio Club (G4AOT). It is hoped to include h.f. propagation information.

More countries with novice licences

The Australian Post Office, with the full support of the Wireless Institute of Australia, has now begun issuing "novice licences" to applicants who pass a simple theory examination and a 5 w.p.m. Morse test. The licence permits the use of crystal-controlled transmitters between 3525-3575, 21125-21200 and 26960-27230 kHz with up to 10 watts input (double sideband) or 30 watts p.e.p. single sideband. Licences cost $A6 plus $A2 examination fee, half the usual cost of an Australian amateur licence. Purpose of the new facility is to allow applicants "to engage in radio as a hobby on a restricted basis and gain the knowledge and experience necessary to qualify for a normal licence".

Holland is introducing shortly a "D-licence" (communicators) which allows the holder to operate on six crystal-controlled channels in the 144MHz band using n.b.f.m. for fixed or mobile operation with a maximum input of 20 watts. It will be issued to people over 18 years old who have passed a simple technical examination. The Dutch society VERON opposes what it believes is "an ill-considered plan" in conflict with the aims and definition of the amateur service. It would seem that the introduction of the D-licence is linked with efforts to suppress illegal use in Holland of the 27MHz "citizens band".

The Federal Republic of Germany is making it possible for youngsters between 14 and 18 years old to obtain revocable amateur licences; these permit operation of club stations (under supervision) and, after reaching 16 years, home stations under normal regulations.

Repeater problems

Although a number of v.h.f. and u.h.f. repeater stations are now licensed and operational in the United Kingdom, there appears to be some dissatisfaction with the way in which the Home Office is regulating these facilities. In particular the ruling that v.h.f. repeaters must normally be spaced at least 100 miles apart is provoking the criticism that little or no account is being taken of the topography: an example is the turning down of the proposed Dover repeater although the area it would cover is screened by hills from the London repeater service area. One result is the recent formation of a UK Repeater Users' Council to act as a ginger group.

ARRL opposes Docket 20282

The American Radio Relay League in its official submission on the proposed "restructuring" of the amateur radio service criticises FCC Docket 20282 on the grounds that "Whilst idealistic in its goals, it is so unrealistic and potentially diversive as to be unworkable". The ARRL however favours some more moderate revision and improvement of the present licence structure. Instead of the suggested Morse-code-free "communicator" licence, the League puts forward a new suggestion: the idea that applicants should have "familiarity with the Morse code without requiring the ability to send or receive at any speed".

"Amateur radio" ARRL comments "has reached its present high level of technical excellence under a licensing philosophy based upon learning by doing — there must be a balance between the attractiveness of an entry level licence and the motivation of those entering to advance to higher grades".

In view of the recent resignation of Mr A. Prose Walker, W4BW, chief of the FCC Amateur and Citizens Division, it may well mean that FCC will revise its proposals and that some of the more controversial elements of the restructuring will be dropped altogether.

In brief

With Oscar 6 now in its fourth year of operational service, it is available for use on ascending orbits on Mondays, Thursdays and Saturdays and on descending orbits on Sundays. Oscar 7, one-year-old on November 19, is available for general use daily except Wednesdays when orbits are reserved for special experiments. It is not necessary to use more than 80 watts effective radiated power for Oscar communication and excessive power harms the batteries. . . . A supplementary instruction guide to the use of the London v.h.f. repeater, covering recently-added facilities, is available under the title "GB3LO what you hear and why" from Richard Street, UKFM Group (London), "Code 12", 3 White Ledges, London W13 8JB. Price 7p plus large stamped-addressed envelope; add 5p for a copy of the original "GB3LO without tears" and change address to "Code 23".... According to William Orr, W6SAI, the original prototype of the famous HRO communications receivers was given the factory designation "HOR" standing for "Hell of a rush" and finally rechristened HRO just in time for its first announcement in the December 1934 issue of *QST*. Over 10,000 HRO receivers were manufactured during World War II (many of them still in use)... World Radio Club – broadcast on the BBC's World Service – has recently enrolled its 23,000th member... Address of Rev. G. C. Dobbs (G3RJV) who is secretary of the G-QRP Club and produces the newsletter "Sprat" devoted to low power radio communication is now 8 Redgates Court, Calverton, Nottingham NG14 6LR... Several instances of Sporadic E propagation extending up to beyond 144 MHz occurred during the Summer but an outstanding example in the United States was the "fantastic day" of July 20th when widespread Sporadic E lasted many hours on 144 MHz... Customs & Excise in turning down RSGB efforts to reduce VAT on amateur radio equipment admit the educational value of amateur radio but nevertheless state that "their considered view is that the activities of ham radio operators are essentially of a recreational nature" – clearly the Customs do not set much store by "learning by doing"... Winner of the 1975 BERU contest for British Commonwealth stations was Yuri Blanarovich, VE3BMV who made over 400 contacts. Leading British station was that of Al Slater, G3FXB who was a close second in a hard fought contest that has encouraged the RSGB Contest Committee to retain many of the features of the "BERU" contest for 1976 after originally deciding that a complete overhaul was needed... RSGB president for 1976 will be Dr E. J. Allaway, MB, ChB, MRCS, LRCP, G3FKM who for many years has been a noted enthusiast for long-distance operation on the h.f. bands. Membership of the Society at the end of July totalled just over 18,500 of which 1,827 were overseas members. In the year to the end of June 1975, the Society overspent its income by a staggering £18,000 (less a £5,000 VAT refund) which the treasurer says is "the worst year in our history".

PAT HAWKER, G3VA

High-quality compressor/limiter

A variable law, low distortion attenuator incorporating second harmonic cancellation circuitry

by D. R. G. Self, B.A.

University of Sussex

Compression and limiting play an increasingly important role in the resources of a modern sound studio. The conventional function of signal level control is to avoid overload, but it can be used in the realm of special effects. To date, however, relatively few designs for high-fidelity compressor/limiters have been published.

The main design problem is the voltage-controlled attenuator, v.c.a., which increases attentuation of the input signal in response to a voltage from a control loop as shown in Fig. 1. In limiting, this circuit block continuously monitors the peak output level from the v.c.a. and acts to maintain an almost constant level if it exceeds a threshold value, or, in compression, allows it to increase more slowly than the v.c.a. input signal. This is illustrated in Fig. 2., which shows the input-amplitude/output-amplitude characteristic for both compression and limiting. Note that limiting makes use of a much tighter slope to ensure that the output voltage cannot exceed the chosen limit, and that the threshold (point of onset of attenuation) takes place at a higher level than for compression.

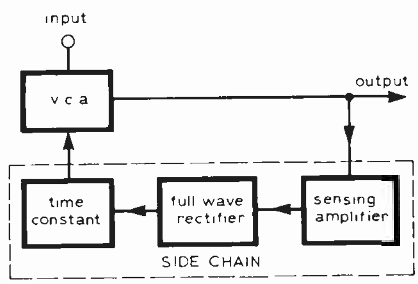


Fig. 1. Voltage-controlled attenuator with d.c. control loop.

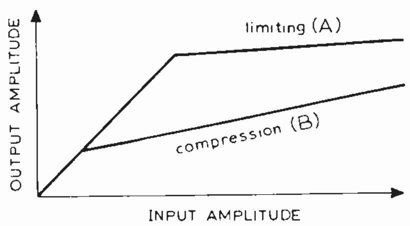


Fig. 2. Amplitude characteristics for compression and limiting—the last-mentioned uses an almost zero slope to prevent the output exceeding a preset level.

Traditionally, studio-quality compressor/limiters (as the two functions are so similar it is logical to produce a system that can be used for either compression or limiting) used one of two types of v.c.a. Either the audio signal was chopped at an ultrasonic frequency by a variable mark/space square wave – which requires complex circuitry and careful filtering of the audio output to avoid beats with tape-recorder bias frequencies – or it was attenuated by an electronic potential divider, one arm of which was a photoresistor, the control signal being applied via a small filament bulb. The last-mentioned has disadvantages because photoresistors are non-linear devices, therefore noticeable distortion is introduced into the audio signal, and the thermal inertia of the bulb filament limits the speed of attenuation onset.

Most moden compression systems use field-effect transistor operated below pinch-off as a voltage-variable resistance in a potential divider. This technique has many advantages; it is a simple, cheap, and fast-acting configuration that can provide an attenuation variable between 0 and 45dB. The only problem is that an f.e.t. is a square-law device, and tends to generate a level of second-harmonic distortion that increases rapidly with signal amplitude. A typical arrangement is shown in Fig. 3 – R_2, R_3 and C_2 allow the source of the f.e.t. to be set at a d.c. level above ground, so that a control-voltage that moves positive with respect to ground can be used, to avoid level-shifting problems in the control loop. This d.c. level is isolated from the input and output by C_1.

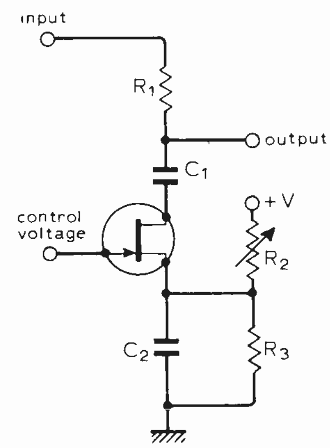


Fig. 3. Basic v.c.a. circuit providing up to 45dB of attenuation. This configuration introduces second-harmonic distortion which is greatest at 6dB of attenuation.

The distortion introduced by this circuit is at its worst for the 6dB attenuation condition, because at this point the drain-source resistance equals R_1, and the maximum power level exists in the f.e.t. Table 1 shows the level of second-harmonic distortion introduced into a sine-wave signal of 100mV r.m.s. amplitude, under the 6dB attenuation condition, for three different f.e.t. types. Measurements were made with a Marconi TF2330 wave analyser, higher-orders of harmonic distortion proved to be negligible amplitude in all cases. These measurements were made on one sample of each type of f.e.t. and, because production spreads are large, the results should be treated with some caution. However, it is clear that these levels of distortion are unacceptable for high-quality applications.

Fortunately, a technique* exists for reducing f.e.t. distortion to manageable levels, if the control-voltage is applied to the f.e.t. gate and summed with a signal consisting of one-half the voltage from drain to source, then the distortion level is dramatically lowered. The configuration in Fig. 4 shows a simple way of realising this; the signal fraction fed back is not critical and 10% resistors can be used for R_4 and R_5. Surprisingly, this distortion cancellation procedure leaves the attenuation/control-voltage characteristic almost unchanged. Table 1 shows the new maximum distortion values for 100mV r.m.s. input. (Note that the maximum no longer occurs at 6dB attentuation, but at a point that varies with the f.e.t. type, where cancellation is least effective.) From these results the 2N5457 and 2N5459 are superior, the 2N5459 was used in the final version of the v.c.a.

To determine appropriate signal levels in the v.c.a., measurements were made of maximum distortion generated, ie the v.c.a. was set to 2dB attenuation, against r.m.s. input voltage; results are shown in Table 2. The question now arises as to whether this distortion performance is adequate for a high-quality compressor/limiter. There is no general agreement as to the amount of second harmonic distortion that can be introduced into a program signal before it becomes aurally detectable, but 0.1% is a figure that is quoted. This means that the permissible input voltage to the v.c.a. would be restricted to below 100mV r.m.s. In practice, however, the attenuation level will be constantly changing, and because distortion level peaks fairly sharply with attenuation change, this level of distortion will only be present for a very small percentage of the time. In any case, second harmonic distortion alone has a relatively low "objectionability factor". The proof of the pudding is in listening to the compressor output signal; inputs of music around 200mV r.m.s. produced no trace of audible distortion. (Good class A power amplifiers and headphones were used for monitoring).

The control loop consists of an amplifier which senses the v.c.a. output level. A full-wave rectification system is normal practice because program waveforms have positive and negative peaks that can vary by as much as 8dB, and an 8dB uncertainty in the output level is usually unacceptable. A time-constant arrangement is used with the rectification circuit to control the attack and decay rates.

The output sensing amplifier in the system is a non-inverting op-amp which allows a high input impedance because the output impedance of the v.c.a. stage reaches a maximum of about 39kΩ at zero attenuation. The full-wave rectification system consists of a transistor phase-splitter driving two op-amp precision-rectifier stages in antiphase. The principle of a precision rectifier is illustrated in Fig. 5. The rectifying element is placed in the feedback loop of an op-amp, so that the effect of the forward voltage drop on the output voltage is divided by the open-loop gain. During positive half-cycles, if the input voltage exceeds the d.c. level stored on the capacitor C, the op-amp output swings positive and C is charged through diode D until its stored voltage is equal to the input voltage. Thus C takes up a voltage across it equal to that of the positive peak of the input signal. During negative half-cycles, and while the input is less than the voltage on C during positive half-cycles, the op-amp saturates negatively and D remains firmly reverse-biased. Obviously this is only a half-wave rectification circuit, the

Table 1. Second-harmonic distortion level introduced into a sine-wave of 100mV r.m.s.

Device	2N3819	2N5457	2N5459
2 nd harmonic at −6dB	13%	10%	8.9%
2nd harmonic with cancellation attenuation shown	0.39% 2dB	0.12% 10dB	0.12% 2dB

Table 2. Maximum distortion generated by various input voltages at 2dB attenuation.

Input (mV, r.m.s.)	2nd harmonic (%)
20	0.005
50	0.10
100	0.12
200	0.19
500	0.34
1,000	0.56

Table 3. Prototype calibration data and compression ratios

VC_2 (V)	Threshold (mV, pk)	Compression ratio
2.9	10	2.3
3.5	20	5.1
5.0	50	10
6.7	100	20
8.5	200	35
9.8	500	50

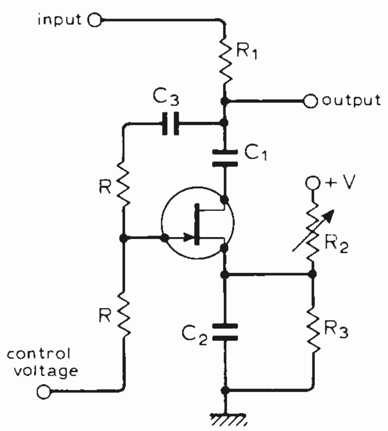


Fig. 4. Standard circuit technique for reducing f.e.t. distortion by summing half of the drain/source voltage with the control voltage.

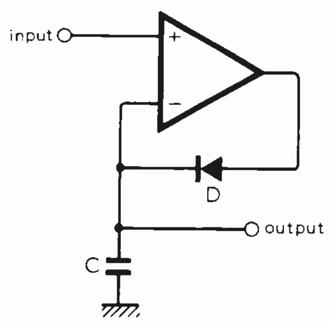


Fig. 5. Basic precision rectifier circuit where the rectifying element is in the feedback loop of an op-amp.

full-wave version uses two of these driven in antiphase, and charging a common capacitor. A resistance through which the charging currents flow determines the attack time, and another in parallel with C defines the decay time-constant.

The complete circuit is shown in Fig. 6. The v.c.a. is essentially as described above and the attenuation threshold is set by the variable resistance R_2. As the resistance is increased the level of control voltage required for attenuation to begin is reduced, and the system's input/output characteristic moves smoothly from A to B on Fig. 2. The threshold decreases and the compression slope becomes less flat as the system turns slowly from a limiter into a compressor by the manipulation of a single control. The output sensing amplifer consists of IC_1 and has a gain of 19 over the audio band. This is rolled off to unity at d.c. by C_5. Transistor Tr_2 and its associated components form a conventional phase-splitter driving IC_2 and IC_3, the precision rectifiers. The rectifier circuitry is more complex than implied above, three modifications have been made improve the performance. Firstly, IC_2 and IC_3 charge C_9 via current amplifier stages Tr_5 and Tr_6 otherwise the current-limited 741 outputs would be unable to provide enough current for the faster attack times (less than 1mS). Secondly, the feedback loop from C_9 to the inverting unputs of IC_2 and IC_3 is completed via a f.e.t. source-follower. Without this, C_9 would be loaded by the two 741 inputs, and this would severely limit the maximum decay times available. Incorporating the source-follower allows decay times of several minutes by using large resistance values for R_{27}. The conventional source-follower has a large negative offset voltage and is unusable in this application because due to their rectifying action IC_2 and IC_3 are unable to provide a voltage on C_9 that is negative of ground. This would be required to allow the source-follower output to be at ground when there is no input to the rectifers. However, if a modified source-follower is used, with a constant-current source and resistance combination in the source circuit, the offset voltage can be varied on either side of zero by manipulation of R_{24} which varies the driving current. The offset voltage is arranged to be plus 0.3V, to allow a large safety margin for thermal variations, component ageing, etc. This means that under no-signal conditions C_9 takes up a standing quiescent voltage of plus 0.3V. The effect of this is taken up in the calibration of R_2.

The third modification is the addition of R_{21}, D_3, and R_{22}, D_4. These two networks prevent IC_2 and IC_3 from saturating negatively, during negative half-cycles of their input voltage, by allowing local negative feedback through D_3 and D_4. This limits the negative excursion of the IC outputs to

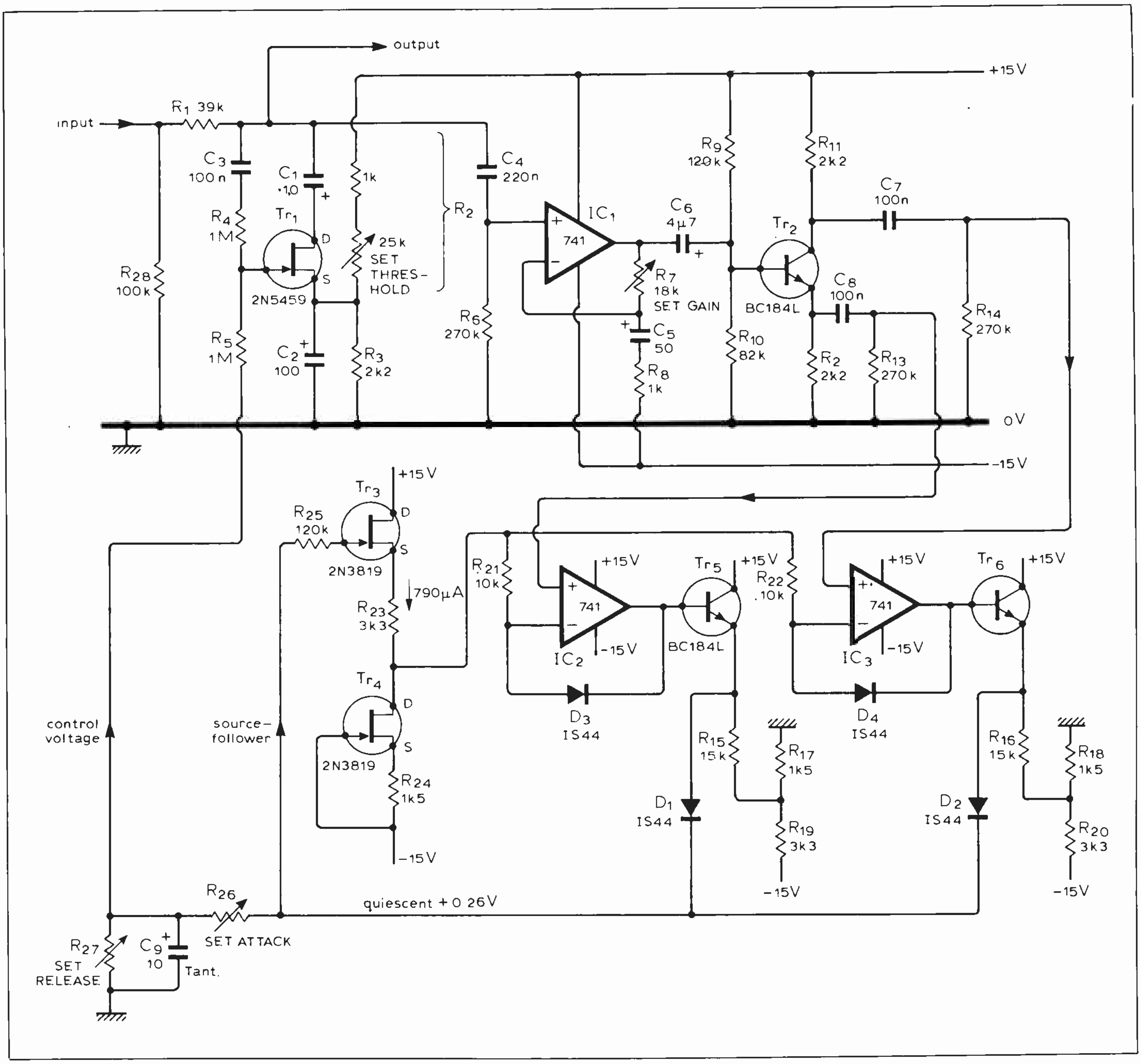


Fig. 6. Complete circuit where the output is taken directly from the v.c.a.—this may be buffered for loads greater than 100kΩ.

about two Volts. The prevention of saturation is necessary because the recovery time of the 741s causes the frequency response of the precision rectifier circuit to drop off at about 1kHz. The addition of the anti-saturation networks provides a frequency response that starts to fall off significantly above about 12kHz which is ample for our purposes as program signals have very little energy content above this frequency.

The final part of the circuit defines the attenuation time constants. Resistor R_{26} sets the attack time constant and R_{27} the decay time constant; these can range between zero and 1MΩ(220μs and 10s) for R_{26}, and 1kΩ and infinity(10mS and 20min) for R_{27}. They can be either switched or variable resistances, depending on the range of variation required.

The circuit in Fig. 6 shows the compressor output being taken directly from the v.c.a. This is only suitable if the minimum load to the output is greater than 100kΩ, otherwise the v.c.a. attenuation characteristic will be distorted by excessive loading. If lower resistance loads are to be driven a buffer amplifier stage must be interposed. The IC_1 amplifier stage is suitable for most applications, and its gain is $(R_7+R_8)/R_8$. For the unity gain case R_8 & C_5 can be eliminated and R_7 replaced by a direct connexion.

The compressor should be driven from a reasonably low impedance output (less than 5kΩ).

Construction is straightforward; the layout is not critical and the prototype was assembled on 0.1in matrix Veroboard. To set up the circuit R_{24} is adjusted so that the voltage across C_9 is about plus 0.3V with no signal input. The value required will vary due to production spreads in the f.e.t.s. To calibrate R_2 it is necessary to relate the level of input signal at which attenuation commences, with the voltage across C_2. This can be done with an oscilloscope, or preferably an a.f. milivoltmeter. As a guide the calibration data for the prototype is shown in Table 3, along with the values of the compression ratio (number of dBs the input must increase by to increase the output by 1dB). This data must be regarded as only a guide. It is worth noting that as the controlling factor setting the compression/limiting function is the voltage acrss C_2 R_2 could be replaced by a 1kΩ resistor connected to a remote voltage source.

The compressor/limiter is quite straightforward in use, provided a few points are kept in mind. Firstly, if it is being used in the limiting mode to prevent overload of a subsequent device, the fastest possible attack time should be used, to catch fast transients, and a fast decay time (say 100ms; $R_{27} = 10k\Omega$), to allow the system to recover rapidly when the transient has passed. Secondly, if a noisy programme signal is being compressed a long decay time should be employed, otherwise the noisy background will be faded up during quiet passages, and the familiar compressor "breathing noises" will be heard. Finally, signals with a large v.l.f. content should be avoided or filtered, otherwise v.l.f. modulation of the signal will result, if a fast decay time is in use.

If a stereo compressor/limiter is constructed from two of the systems described above it is necessary to gang together R_2, R_{26}, and R_{27} between the two channels. A direct connexion between the non-grounded sides of the two C_9s is also needed. It might be necessary to select matched f.e.ts to avoid stereo image shift during compression, due to differing attenuation characteristics in the two v.c.as. A well-smoothed p.s.u. providing ±15V should be used to power the compressor/limiter.

Components list

$IC_{1,2,3}$	741	
$Tr_{2,5,6}$	BC184L or equivalent	
Tr_1	2N5459	
$Tr_{3,4}$	2N3819	
$D_{1,2,3,4}$	IS44 or low-leakage equivalent	
R_1	39k	
R_2	25k variable, with 1k in series	
R_3	2.2k	
$R_{4,5}$	1M	
R_6	270k	
R_7	18k	
R_8	1k	
R_9	120k	
R_{10}	82k	All resistors
$R_{11,12}$	2.2k	(except R_2) ¼W
$R_{13,14}$	270k	
$R_{15,16}$	15k	
$R_{17,18}$	1.5k	
$R_{19,20}$	3.3k	
$R_{21,22}$	10k	
R_{23}	3.3k	
R_{24}	see text	
R_{25}	120k	
$R_{26,27}$	see text	
R_{28}	100k	
C_1	10µF 25V electrolytic	
C_2	100µF 25V electrolytic	
C_3	100nF 250V polyester	
C_4	220nF 250V polyester	
C_5	50µF 40V electrolytic	
C_6	4.7µF 40V electrolytic	
$C_{7,8}$	100nF 250V polyester	
C_9	10µF 16V tantalum bead	

Printed circuit boards

Wireless World has arranged a supply of stereo glass fibre p.c.bs. One off price is £3 inclusive; make cheques or postal orders payable to M. R. Sagin, 11 Villiers Road, London NW2.

"Electronic circuit calculations simplified"

We apologize that once again it has been necessary to postpone publication of Part 6 of this series, on LC circuits. The seventh, and final, part will be on active devices.

Literature Received

A British Standard, BS E 9111, on the quality assessment of low-power, fixed-value, non-wirewound resistors has recently been published, being the English text of a European Standard CEEC 40 100, with additions. Copies are available from BSI Sales Department, 101 Pentonville Road, London N1 9ND at £2.70.

Television distribution equipment from Wolsey is briefly described in their new short-form catalogue, available from Wolsey Electronics, Cymmer Road, Porth, Mid Glamorgan WW401

Full descriptions of a range of analogue and digital thermometers, recorders and associated equipment, thermocouples and application information are given in a new catalogue from Comark Electronics Ltd, Brookside Avenue, Rustington, Sussex BN16 3LF WW402

Moore Reed have sent two new leaflets, which give technical data and general descriptions of the company's ranges of stepping motors and rotary contact encoders. The leaflets contain useful descriptions of general interest on each of the classes of device. Moore Reed & Company Ltd, Walworth, Andover, Hants SP10 5AB..... WW404

The Annual Report and Accounts of the Independent Broadcasting Authority are now published, giving details on the financial position, technical developments, programmes and programming, advertising and engineering information. The Report is obtainable from H.M. Stationery Office or booksellers at £1.00.

General transducer techniques are described and specific information is given relating to a range of transducers for the measurement of pressure, displacement, acceleration and force in a new brochure from Sales Department, S.E. Labs (EMI) Ltd, Feltham, Middx. The publication is entitled "A guide to your transducer requirements" .. WW405

We have received a copy of the new catalogue of gears from Davall, which, in addition to data on a vast range of gear products, contains a technical section providing tabular information, conversions, glossary and bibliography. Davall Gear Company Ltd, Welham Green, Hatfield, Herts AL9 7JB WW406

Hewlett-Packard have prepared an eight-page guide to their range of optoelectronic devices, including red, green and yellow l.e.ds, alphanumeric displays and opto-couplers. P.i.n. diodes are also included. The brochure is obtainable from GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks WW407

Self-balancing chart recorders which use fan-fold chart paper and feature ±1% accuracy, the SM range from Channel Electronics can provide up to six-point dotting with colour and a wide range of speeds. Channel Electronics (Sussex) Ltd, Cradle Hill Industrial Estate, Seaford, Sussex BN25 3JE WW408

A brochure on the E.E.V. range of travelling-wave tubes is now available, which gives descriptions of t.w.ts for high-capacity microwave links, including 10W and 20W types working at 4, 6, 8 and 11GHz. E.E.V., Chelmsford, Essex CM1 2QU...... WW409

A book on the design and use of heat pipes has been produced by Solek. Costing £17.50, the publication includes information on the theory and design of heat pipes, testing, wick materials and applications in 300 pages. The price includes one 12in, ⅜in diameter heat pipe with its data sheet. Solek Ltd, 16 Hollybush Lane, Sevenoaks, Kent........ WW410

Unitrode have published a 32-page semiconductor selection guide which presents information, in tabular form, on rectifying devices, transistors, diodes and i.cs. There is also a section on reliability, a list of application notes and mechanical details. Walmore Electronics Ltd, 11-15 Betterton Street, Drury Lane, London WC2 9BS........... WW411

We have received a copy of Pye Ether's new brochure on their range of transducers for industrial measurement. Descriptions are offered of devices for the electrical measurement of displacement, pressure, force, acceleration, vibration, speed, torque and temperature, and associated signal-conditioning, display and recording equipment is illustrated. Pye Ether Ltd, Caxton Way, Stevenage, Herts...................... WW412

Highland Electronics have sent us a leaflet on an over-voltage trip circuit breaker, designed to operate within 2% of the setting in four ranges centred on 25V d.c., 50V d.c., 118V a.c. and 242V a.c. Contact rating of load-switching controls is 50A at 250V a.c. Highland Electronics Ltd., 33-41 Dallington Street, London EC1V 0BD WW413

A booklet from Fairhurst Instruments forms an introduction to a logic tutor and Karnaugh mapper, describing the construction and use of the equipment. It is available, on payment of 15p for postage and packing, from Fairhurst at Dean Court, Woodford Road, Wilmslow, Cheshire WW414

A booklet from Marconi presents specifications and applications information on two precision signal sources, employing signal generators and associated digital synchronizers, with which frequencies locked in 10Hz steps to 88MHz and 100MHz steps up to 520MHz can be generated at crystal stabilities. Marconi Instruments Ltd, St. Albans, Herts AL4 0JN WW415

Speed detection alternative

An alternative method of speed detection on the roads has been proposed, based on the Doppler effect in vehicular noise.* The method correlates the noise frequency spectrum as the vehicle approaches an observer with the spectrum as it moves away. The results of empirical investigation demonstrate that the Doppler shift can be extracted from a motor vehicle's noise and related to the vehicle's speed. Although sources of inaccuracy are significant at lower speeds, a resolution of ±5% was easily achieved at 60 m.p.h. Such a technique might be found useful in large scale traffic speed and density monitoring systems and may prove to be practical with the use of dedicated mini- or micro-processors. A single computation centre could simultaneously serve a large number of inexpensive microphone sensors. There is considerable interest in computer controlled traffic systems, and it's possible that the acoustic speed measuring technique could become economically competitive with the widely used radar method.

*Jakus, K. & Coe, D. S. "Speed Measurement Through Analysis of the Doppler Effect in Vehicular Noise," *IEEE Trans. on Vehicular Technology*, Vol. VT-24, Aug. 1975.

New Products

Test meter
The LT 801 is a small multimeter with the unusual feature that the meter movement lifts to an inclined angle to improve viewing. Fifteen switched ranges are available together with three current ranges. The meter is 20kΩ/V and is overload protected. Alternating voltages from 10V to 1kV f.s.d. may be measured, together with direct voltages from 5V to 2.5kV, f.s.d. Two resistance scales are offered with 50kΩ, f.s.d. and 5MΩ f.s.d. West Hyde Developments Ltd, Ryefield Crescent, Northwood, Middlesex HA6 1NN.
WW 301 for further details

Cartridge heated soldering iron
The Quick-Shot soldering iron is designed for us in situations where no power supply is available. The iron bit encloses a replaceable cartridge of "thermit" compound which, when fired by a spring loaded pin in the handle, generates about 10,000 calories of heat, raising the bit temperature to over 860°F in a few seconds. Soldering temperatures are maintained for 8 to 10 minutes.

The cartridge is non-inflammable and non-explosive and produces no sparks or chemical fumes during use. A range of copper bits are available. Tele-production Tools Ltd, 28B Hamlet Court Road, Westcliff-on-Sea, Essex.
WW 302 for further details

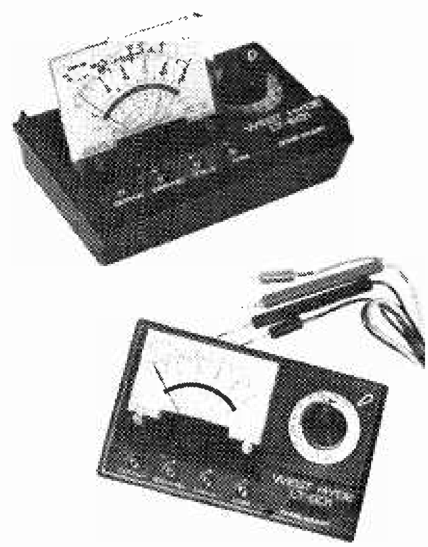
Static inverter
Designed primarily for aircraft use, the ATR500 is a static inverter rated at 500VA and generates 200V, three phase, 400Hz from a 28V d.c. source. The system comprises two 250VA inverters, a master and a slave, mounted in a tray which interconnects them to give a 3-phase output. The output voltage regulation is 4% worst case with a typical figure of 2%. Up to 167VA load may be applied to each phase with a power factor of one for unbalanced loads and 0.7 for balanced loads. Industrial Instruments Ltd, Stanley Road, Bromley, Kent BR2 9JF.
WW 303 for further details

Pico and micro-fuses
Pico fuses are 3/32in × 9/32in and weigh approximately 1/5g. Available in fusings from 62mA to 15A these are designed for use in circuits below 125V. They have a ceramic body hermetically sealed by a heat-shrunk transparent sleeve and are made with two lead configurations. Type 275 have tinned copper axial leads for direct soldering and type 276 have tinned copper radial leads either for soldering or plugging into AMP type tubular receptacles.

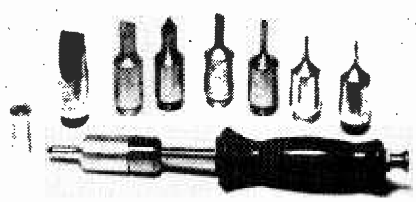
Microfuses are plug-in types and are available in 24 fusings from 2mA up to 5A. Designed to have a very fast fusing action, the short-circuit interruption capacity is 10kA d.c. at 125V. Seven types of holders are available including p.c.b. mounting, panel mounting and indicating types. G. E. Electronics (London) Ltd, Eardley House, 182/4 Campden Hill Road, Kensington, London W8 7AS.
WW 304 for further details

P.m. synchronous motors
The range of Memotrace motors is based on a permanent magnet face rotor design, offering ungeared torque ratings from 80-3000g-cm in a variety of options. At 50Hz the motors will operate synchronously at 250, 375 or 500 r.p.m. with gear heads available for a wider range of speeds from 10 r.p.m. The single coil construction type have a random initial starting direction, but will automatically reverse when driven against a mechanical end stop. The double coil, capacitor start motors are directionally controllable and provide greater torque, a stepping mode by d.c. pulsing the winding and variable speed operation also from d.c. pulses. Unimatic Engineers Ltd, Granville Road Works, 122 Granville Road, Cricklewood, London NW2 2LN.
WW 305 for further details

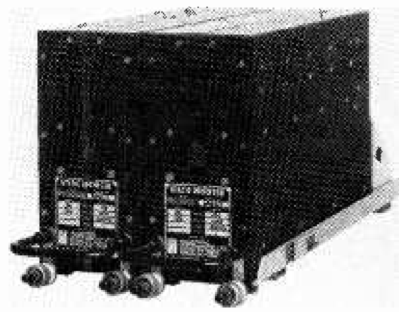
Sound level meter
The PSI 203A is a data-logging sound level meter with a total of 72dB linear dynamic range. The meter is designed to meet the IEC 179 Standard and can be fitted with filters for either octave band or other analysis. Weighting characteristics such as the three standard A, B and C curves are incorporated with an externally fitted option of a D weighting filter. Three dynamic responses may be selected, slow, fast or impulse. Normally supplied with a 1in micro-



WW 301 for further details



WW 302 for further details



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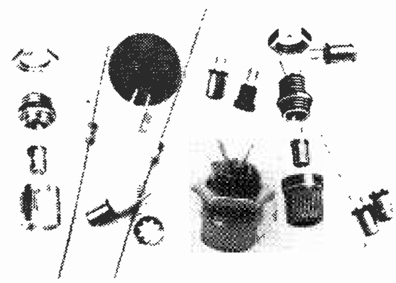
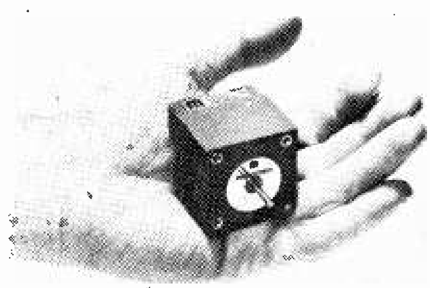


WW 304 for further details



WW 305 for further details

phone, the meter can also be fitted with 0.5in or 0.25in capsules, permitting measurements up to 40kHz. A linear d.c. output is provided for connexion to a recorder, with a dynamic range of 0 to 3.5V d.c. Power is supplied from either five 1.5V primary or NiCd rechargeable cells or an accessory a.c. power unit. A wide range of optional accessories is also available. Castle Associates, Redbourn House, North Street, Scarborough, Yorkshire YO11 1DE.
WW 306 for further details

Real-time analyzer

Two real-time spectrum analyzers have been announced by Wessex, the distributors for Rockland Systems. These are the FFT 512/S and the FFT 512/C. The former is a single-channel analyzer using fast Fourier transform techniques to calculate 512 spectral lines of which only 400 are displayed. In addition thirty one-third octave filters from 25Hz to 20kHz are optionally available together with a selectable mode enabling two 200-line analyses to be made and simultaneously displayed. Either digital or analogue data can be accepted and an analogue display and digital data output are provided.

The display is in the form of a 10 × 8cm c.r.t. with cursor readout built in. Real-time analysis to 5kHz is offered as a standard, but an extension to 10kHz is offered as an option. The Model 512/C cross-channel adaptor provides for the combination of two 512/S units to perform cross-channel analysis. Wessex Electronics Ltd, Stover Trading Estate, Yate, Bristol BS17 5QP.
WW 307 for further details

NiCd charger module

An extended range of modular chargers is available ex-stock from Electroplan. These units provide true constant current operation and are available with output currents ranging from 10mA to 400mA with up to 10 cells being simultaneously charged in a series connexion. Two case sizes are offered, this being dependent upon the power output. Electroplan Ltd, P.O. Box 19, Orchard Road, Royston, Herts SG8 5HH.
WW 308 for further details

Anti-static plastic

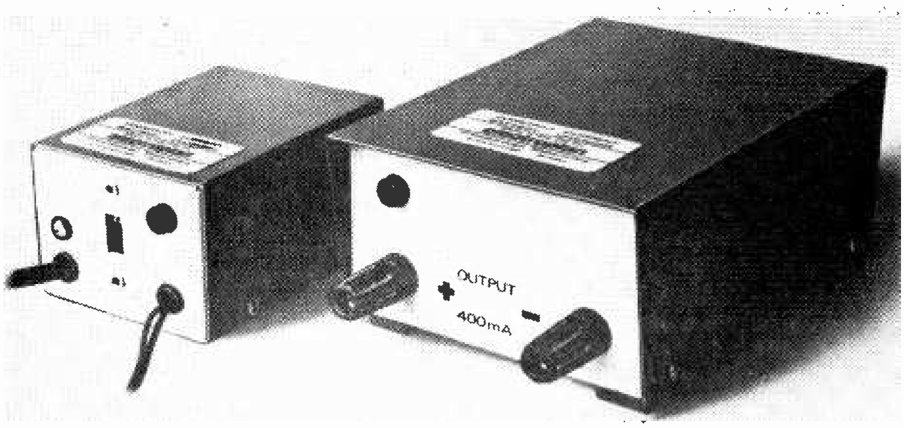
A range of anti-static plastic products are being offered by Dage Intersem. These include plastic and foam packages for the transportation and storage of c.m.o.s. devices and assembled boards, together with anti-static plastic sheeting for work tops, trays etc, and grounding straps for use with either the plastic sheeting or for use by production line staff. Dage Intersem Ltd, Haywood House, Pinner, Middlesex.
WW 309 for further details

Extractor tool

The user of l.s.i. circuits is often faced with the problem of extracting these 24, 36 or 40 pin d.i.p. packages from a tight socket. The l.s.i. extractor tool is a simple stainless steel device with a vinyl coated handle designed to make this task easier. Rastra Electronics Ltd,, 275-281 King Street, Hammersmith, London W6 9NF.
WW 310 for further details

D.i.p. boards

A range of high density d.i.p. cards have been introduced by Vero. Initially they have been introduced in two versions, the international card size of 114.3 × 165.1mm and the Eurocard size of 100 × 160mm. The former has forty three 2.54mm pitch gold plated contacts on both sides and will accept a maximum of thirty six, 14 or 16 pin i.cs. The Eurocard will take a 64 way indirect



WW 308 for further details

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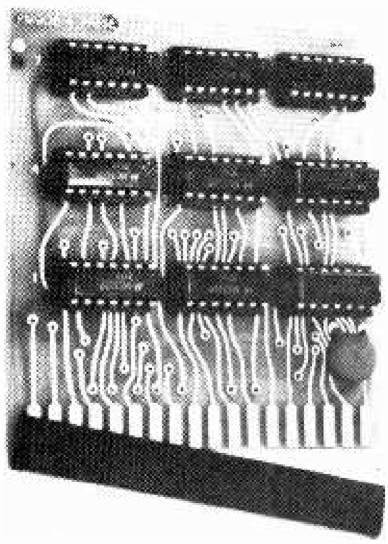
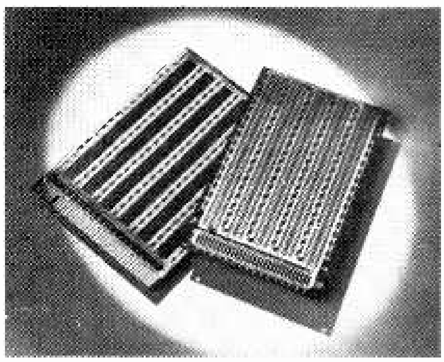


WW 309 for further details



WW 311 for further details

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WW — 057 FOR FURTHER DETAILS

The Black Watch – using the unique Sinclair-designed state-of-the-art IC.

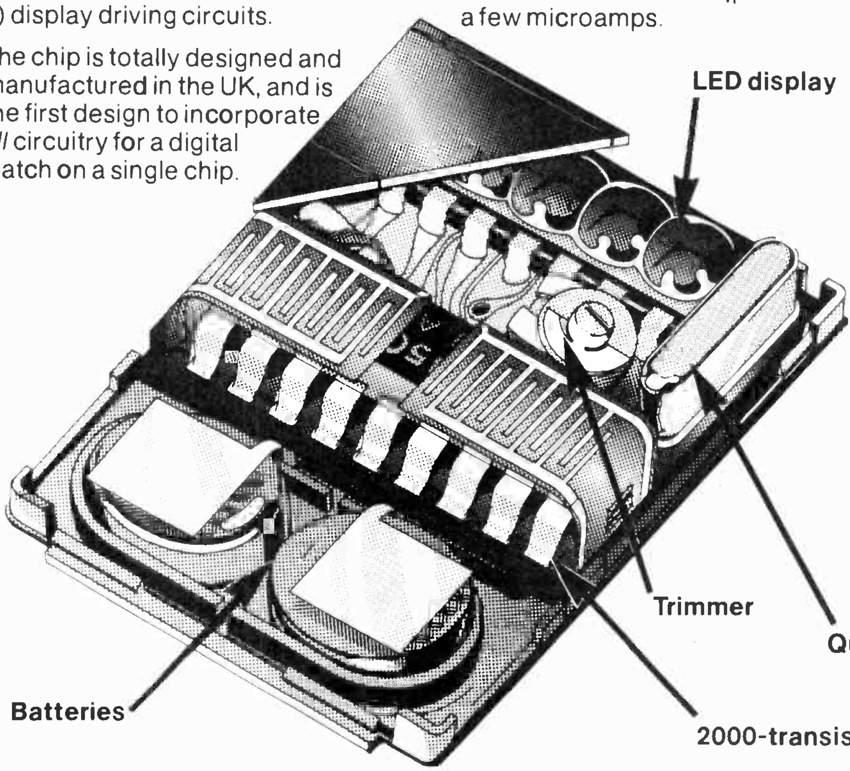
The chip...
The heart of the Black Watch is a unique IC designed by Sinclair and custom-built for them using state-of-the-art technology – integrated injection logic.

This chip of silicon measures only 3 mm x 3 mm and contains over 2000 transistors. The circuit includes

a) reference oscillator
b) divider chain
c) decoder circuits
d) display inhibit circuits
e) display driving circuits.

The chip is totally designed and manufactured in the UK, and is the first design to incorporate *all* circuitry for a digital watch on a single chip.

...and how it works
A crystal-controlled reference is used to drive a chain of 15 binary dividers which reduce the frequency from 32,768 Hz to 1 Hz. This accurate signal is then counted into units of seconds, minutes, and hours, and on request the stored information is processed by the decoders and display drivers to feed the four 7-segment LED displays. When the display is not in operation, special power-saving circuits on the chip reduce current consumption to only a few microamps.



Complete kit £17.95!

The kit contains

1. printed circuit board
2. unique Sinclair-designed IC
3. encapsulated quartz crystal
4. trimmer
5. capacitor
6. LED display
7. 2-part case with window in position
8. batteries
9. battery-clip
10. black strap (black stainless-steel bracelet optional extra – see order form)
11. full instructions for building and use.

All you provide is a fine soldering iron and a pair of cutters. If you've any queries or problems in building, ring or write to the Sinclair service department for help.

Take advantage of this no-risks, money-back offer today!
The Sinclair Black Watch is fully guaranteed. Return your kit within 10 days and we'll refund your money without question. All parts are tested and checked before despatch – and correctly-assembled watches are guaranteed for one year. Simply fill in the FREEPOST order form and post it – today!

Price in kit form: £17.95 (inc. black strap, VAT, p&p).

sinclair

Sinclair Radionics Ltd,
London Road, St Ives,
Huntingdon, Cambs., PE17 4HJ.
Tel: St Ives (0480) 64646.
Reg. no: 699483 England. VAT Reg. no: 213 8170 88.

To: Sinclair Radionics Ltd, FREEPOST, St Ives, Huntingdon, Cambs., PE17 4BR.

Please send me Total £

.... (qty) Sinclair Black Watch kit(s) at £17.95 (inc. black strap, VAT, p&p). ....

.... (qty) black stainless-steel bracelet(s) at £2.00 (inc. VAT, p&p). ....

* I enclose cheque for £................................, made out to Sinclair Radionics Ltd and crossed.

* Please debit my *Barclaycard/Access/American Express account number

....

Name ______________________________

Address ______________________________

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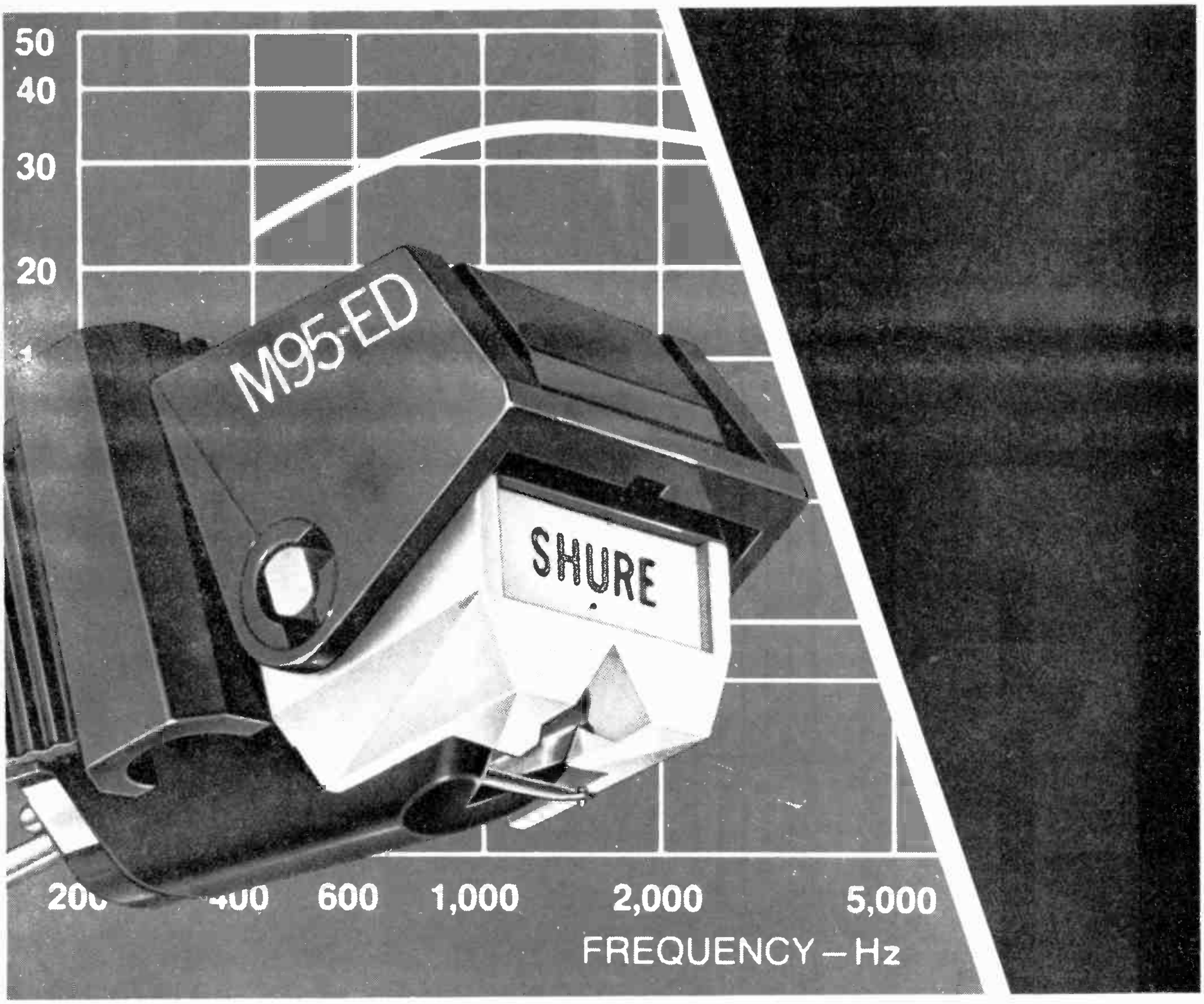
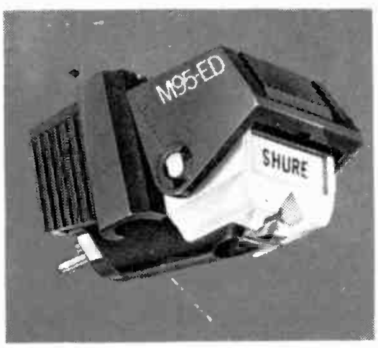
Please print. FREEPOST – no stamp required. *Delete as required



M95ED: A Significant Technological Innovation



Shure now introduces a superb, moderately priced pick-up cartridge with a performance second only to the renowned V-15 Type III. The technologically advanced electromagnetic structure with a newly designed pole-piece virtually eliminates hysteresis loss. The frequency response from 20 to 20,000 Hz remains essentially flat. Operating at extremely light tracking forces of between ¾ and 1½ grams, the exceptional trackability of the M95ED enables it to trace the very high recorded velocities encountered on many modern recordings with the result that in addition to providing faithful reproduction of the recorded sound, stylus and record wear are reduced to minimum proportions. The M95ED: A notable addition to the Shure range with a performance never before available at such a competitive price.

Shure Electronics Limited
Eccleston Road, Maidstone ME15 6AU
Telephone: Maidstone (0622) 59881

SHURE®

WW—018 FOR FURTHER DETAILS

connector to DIN 41612 specification and will accept a maximum of thirty 14 or 16 pin packages.

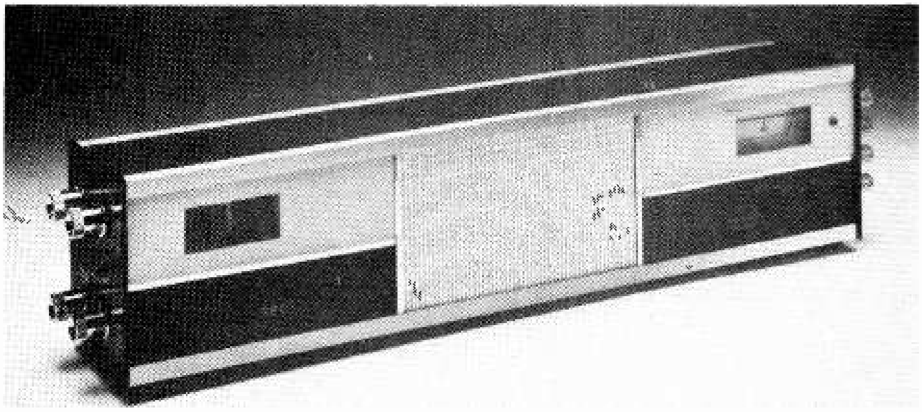
The copper pattern is carried on three separate planes, two voltage planes on the wiring side and a ground plane on the component side. Interconnection of devices is either through soldering or by wire wrapping. Vero Electronics Ltd, Industrial Estate, Chandlers Ford, Eastleigh, Hants.

WW 311 for further details

Centre fed dipole

The CD95/3 is a single dipole claimed to produce the same 3dB gain in a single dipole, that is normally obtained from a stacked and phased two way system. Frequency range is from 70-480MHz with maximum gain between 165 and 175MHz. Impedance is 50Ω, and the v.s.w.r. better than 1.5:1. Radiomasts Ltd, Pond Wood Close, Moulton Park, Northants.

WW 312 for further details



WW 313 for further details

Audio-video receiver

This unit features a three day digital timer/clock and is designed to be used in conjunction with video cassette recorders. Up to 72 hrs pre-selection of record start with a one-minute accuracy is available for periods up to 9 hrs 57 minutes. Tuning is effected without the use of a monitor, by using a combination of an l.e.d. display and the integral monitor loudspeaker. Video and audio outputs are available from off-air u.h.f. transmissions together with a switched mains outlet. Power supply is 200-240V, 50Hz, with a standby battery for the digital timer/clock. Radio Rentals Contracts Ltd, Apex House, Twickenham Road, Feltham, Middlesex TW13 6JQ.

WW 313 for further details

Solid State Devices

Names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

M.o.s. drivers

The AM0026 and AM0056 are two dual high-speed clock drivers for use in large m.o.s. memory systems. They consist of two independent circuits suitable for driving loads of high capacitance and providing clock pulse widths down to 125ns. Both standard and Shottky t.t.l. input levels are accepted and converted to m.o.s. compatible outputs. Output current drive is rated to 1.5A and output voltage swing up to 20V. The devices are identical in all but one respect, the AM0056 having a V^{BB} terminal to provide a higher voltage to the output stage.

Advance Micro Devices Inc.

WW 350 for further details

Dual op-amp

The Harris HA-2655 features, in each half, a minimum slew rate of 2V/μs, a minimum full-power bandwidth of 30kHz and a ± 13V output voltage swing. The slew rate capability is maintained typically above 4V/μs even when supply voltages are permitted to drop to ±3V. The average input offset voltage drift is said to be 8μV/βC and the maximum offset current 60nA. Minimum input resistance is 5MΩ.

GDS Sales Ltd

WW 351 for further details

Tuner diodes

The ZC100 Series are a range of variable capacitance tuner diodes claimed to provide a high Q at low cost. The devices are encapsulated in the standard E-line package. Sets of devices with matched parameters are obtainable and also a selection based on parameter tolerance.

Ferranti

WW 352 for further details

Microwave transistor

A family of Class A amplifying microwave transistors has been introduced by AEI. These devices make use of an overlay emitter structure and the high power versions incorporate emitter ballast resistors. The series comprises three types, the DC5621, 5623 and 5631 with gains of 9dB, 8dB and 7.5dB respectively and 1dB gain compression points of 60mW, 150mW and 300mW, measured at 2GHz.

AEI Semiconductors

WW 353 for further details

Germanium power transistors

A series of germanium power transistors with peak current capabilities of 25A at up to 80V have been introduced by the American company, Germanium Power Devices Corp. Designed as p-n-p transistors and for use in a wide variety of switching and analogue situations they are designated 2N575 and 2N575A and are available in a standard MT-7 package.

Germanium Power

WW 354 for further details

Yellow, orange, red l.e.ds

Twelve high intensity discrete l.e.ds are now available from Vitality. Available in yellow, orange, red and green, the devices have intensities ranging up to 45mcd and viewing angles from a spot for backlighting, a 24° dispersion for directional indicators to 65β for general panel uses. All the l.e.ds are encapsulated in cylindrical packs with 0.75in tin-plated leads.

Vitality

WW 355 for further details

Suppliers

Advance Micro Devices Inc., 901 Thompson Place, Sunnyvale, California 94086, U.S.A.

GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Bucks.

Ferranti Ltd, Electronic Components Division, Gem Mill, Chadderton, Oldham, Lancs.

AEI Semiconductors Ltd, Carholme Road, Lincoln, LN1 1SG.

Germanium Power Devices Corp., P.O. Box 65, Shawsheen Village Station, Andover, Ma. 01810, U.S.A.

Instruments in Bloomsbury

In the present economic uncertainty, instrument manufacturers can hardly be blamed for appearing less than complacent about the coming year. The development which must have been undertaken before the situation began to worsen is now, however, bearing fruit in the shape of a variety of new equipment from a large number of manufacturers, who anticipate that the new crop will modify recessive tendencies to manageable proportions. New equipment shown at the 15th EPG electronic instruments exhibition in London takes full advantage of semiconductor developments to achieve a high degree of automatic operation and superlative performance. But the introduction at the less complicated end of the market is equally worthwhile.

Scopex showed two new single-beam oscilloscopes, both continuing the company's policy of simplicity in design and operation. The 4S-6 has a reduced cost and performance specification, compared with the earlier models, and is intended for use in schools and servicing roles. It is evident that very careful thought has been applied to the controls, the result being a horizontal sweep controlled in time, trigger level, trigger polarity and internal/external trigger selection by two knobs and a 4mm switching socket. Bandwidth is 6MHz and the maximum sweep is 1cm/μs — a little slow for the bandwidth. The other instrument, the IS-10, is a 1-in-tube, 10MHz instrument, which is smaller than the standard car radio. The front panel is 5¼×2⅜ inches and the unit weighs just over 3lb.

Among the customary exoticism at the **Tektronix** stand were the DM40 and DM43 digital add-on units for time measurements when used in conjunction with the 465 and 475 portable oscilloscopes. Time measurement is carried out by selecting the two points by means of a bright-up spot with the delay-time position control. Time between the two is then displayed digitally on the add-on unit, which can also be used independently of the oscilloscope for voltage, resistance and temperature measurement.

The 314 portable storage oscilloscope, also shown by Tektronix, possesses a bistable storage screen with a four-hour viewing time. Sensitivity is 1 div/mV at 10MHz (1 division is 0.25in). Maximum sweep speed is 10 div/μs and a full complement of triggering and dual-beam switching modes is provided. The unit can be powered by a.c. mains, by 24V d.c. at 800mA or 12V d.c. at 1.6A.

Oscilloscopes newly introduced by **Dynamco** are the 7500 and 8500. The former is a mains/battery portable instrument with a bandwidth of 0-40MHz at 0.1 cm/mV (1 cm/mV at 5MHz) sweep delay (which operates in the "mixed" mode) and gated trigger. It is a dual-trace unit with the same general approach as the older Dynamco types, but has no facilities for plug-in X and Y modules. This does help to keep costs down and is sensible in a general-purpose instrument with a specification high enough to be useful in the majority of applications. A rather more advanced specification was adopted for the 8500, which is a 100MHz unit, reverting to the more conventional shape from the long, low look previously used by Dynamco. It boasts an extremely fast timebase (5ns/cm with magnifier in use) and delayed sweep. Sensitivity of the dual-channel Y amplifier is 0.1cm/mV or 1cm/mV at 40MHz. Both instruments possess sufficient signal delay to enable leading pulse edges to be seen.

The development of digital measuring instruments continues to advance rapidly, the pace being determined, to a large extent, by the integrated-circuit designer rather than the instrument engineer, although there will always be the ingenious method of sailing round limitations instead of battering through them. The **EIP** Autohet digital frequency meter, for instance, is capable of measuring frequencies up to 18GHz with a basic 300MHz counter. This instrument, shown by **Dana,** uses three different techniques to cover the band, that employed from 20Hz to 300MHz being straightforward counting, with either 50Ω or 1MΩ input impedance. From 100MHz to 850MHz, a divide-by-four prescaler precedes the counter, while at higher frequencies a heterodyne approach is used. The 10MHz crystal oscillator used for the gating circuitry is also used to phase-lock a 200MHz oscillator, which feeds an yttrium-iron-garnet comb filter. This produces a series of harmonics of 200MHz and is automatically tuned, selecting successive harmonics until one of them, when mixed with the unknown signal, generates a frequency within the range of the counter. The converter circuit, which step-tunes the filter, provides information to the display on which harmonic was selected and the heterodyne frequency is added to this. Operation is completely automatic, once the correct input is chosen, and the method of measurement confers the advantage that a high degree of f.m. will not affect the result.

A digital method of generating a variety of waveforms (sinusoid as standard) is used by **Farnell** in the DSG1 digital signal generator, which covers the range of 10^4Hz to 10^5Hz. The frequency of a multivibrator is phase-locked to a crystal oscillator for stability and the square-wave ouput is used as the clock, addressing a read-only memory. The r.o.m. is programmed to contain the waveshape of interest (other programmes are available) in 120 steps, giving a minimum of 0.1% harmonic distortion at mid frequencies. T.h.d. figures rise to 0.3% and 1.5% at top and bottom of the frequency range. The clock waveform and a square wave at twice this frequency are provided at a separate output. A feature of this method of signal generation is that two such instruments can be run together to provide a precise phase relationship.

Carrying this approach several steps further the **Fluke** 601DA (£1650) is a signal synthesizer, covering 10Hz to 11MHz at a resolution of 0.1Hz and a stability of better than 3 p.p.m. after one year. A microprocessor is used to programme the unit with up to ten frequencies, modulation modes and output levels, controlled by push-button. The unit is interfaced for use with automatic test systems.

The use of digital methods in voltage measurement are in use at comparatively less advanced levels of work than was the case a few years ago, two new examples being shown by Advance and Farnell. Both are digital multimeters, designed for general use in the sort of work that ordinary moving-coil test meters were, and still are, used but with greater resolution and accuracy. The **Advance** DMM7 uses p.m.o.s. large-scale i.cs to provide direct voltage measurement from 199.9mV full scale to 1200V full scale, at an accuracy of 0.1%±0.05% f.s.d. and a c.m.r.r. of more than 120dB at 50Hz; alternating voltage in the same ranges; direct current from 199.9μA f.s.d. to 1999mA and resistance from 199.9Ω f.s.d. to 19.99MΩ. **Farnell's** DM131 is a similar type of instrument, but offers auto-ranging and temperature measurement from −55°C to +125°C at a resolution of 0.1°C.

Turning to communications, the automatic modulation meter Type 9008, shown by **Racal**, is able to measure amplitude modulation depth or frequency deviation without the critical manual tuning process and level-setting that is a common feature to these instruments. The carrier frequency range is 1.5MHz - 2GHz, tuned completely automatically, and levels from 5mV r.m.s. to 1V r.m.s. can be accepted, depending on frequency. The level of signal is also adjusted automatically if it lies within the acceptable range. Mod. depths up to 100% f.s.d. in six ranges and deviations of up to 100kHz in eight ranges (50Hz - 30kHz) can be displayed.

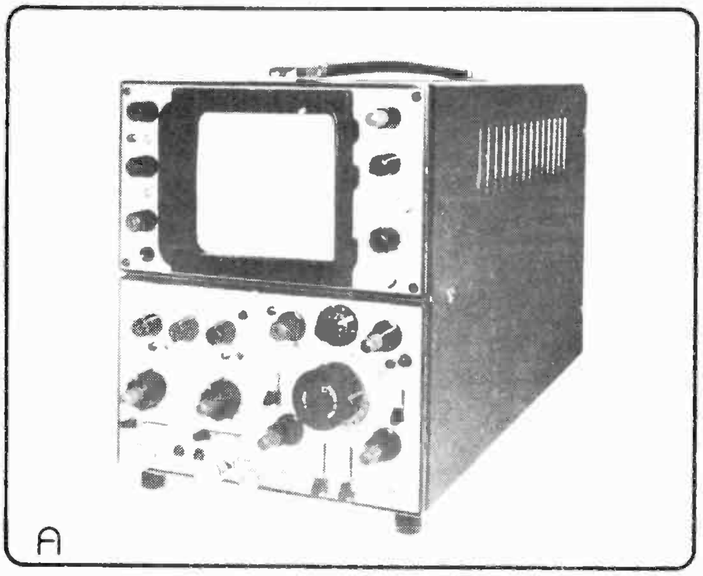
A similar instrument was on the **Marconi Instruments** stand, the TF2304, which covers 25-1000MHz and accepts modulation frequencies (a.m. and f.m.) of 50Hz to 9kHz.

Even more impressively automatic in operation is the OA2090C white noise test set by **M.I.,** for the measurement of noise-power ratio, channel power and signal-to-noise ratio in multi-channel, frequency-multiplex communications systems. The set consists of a noise generator and receiver, which can be used separately, covering the frequency range 6kHz to 12.36MHz. The generator contains a programmable filter unit with plug-in filters, which is remotely selectable, as is the output level. Selection of a band-stop filter in the generator automatically selects the receiver bandpass frequency, and several functions on the generator (filter switching, noise on/off) can be controlled from the receiver.

As an example of the analogue equipment on show, **Racal** had the 9301 — a true r.m.s. millivoltmeter for the range 10kHz to 1.5GHz at 1mV fullscale. It is a sampling type, which converts the product of the sampling process to the r.m.s. value, giving correct readings in the presence of distortion. Remote programming has been provided.

High-power signals for r.f. testing are provided by the **AIL** model 446, which puts out 70W in the range 10kHz-2.5GHz by means of plug-in r.f. sections. Up to 1000MHz, frequency calibration is by means of a five-digit l.e.d. display, while frequencies above this point are dial-calibrated. Load mismatch protection is incorporated and there is metering for both forward and reflected power.

A: Dynamco 8500 100MHz oscilloscope. B: Advance digital multimeter. C: Scopex 1S-10 miniature oscilloscope. D: Racal true r.m.s. millivoltmetre. E: Farnell digital multimeter. F: Racal modulation meter.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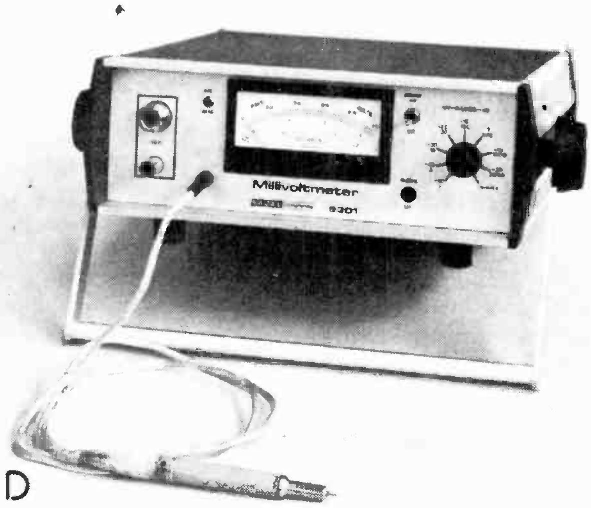

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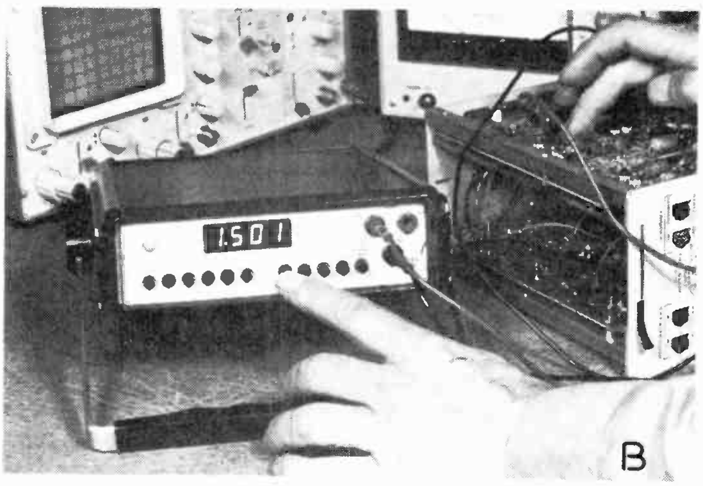

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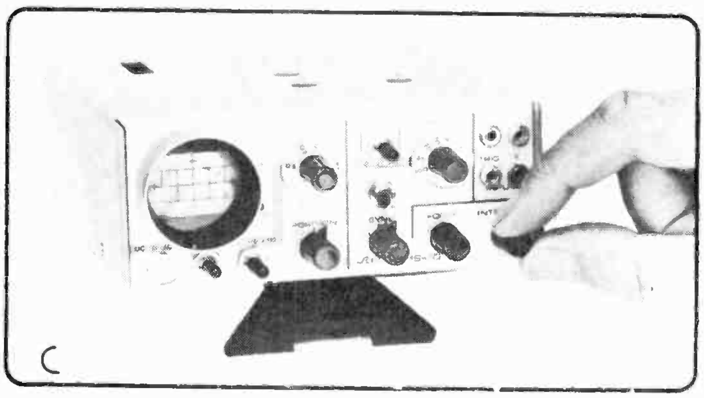
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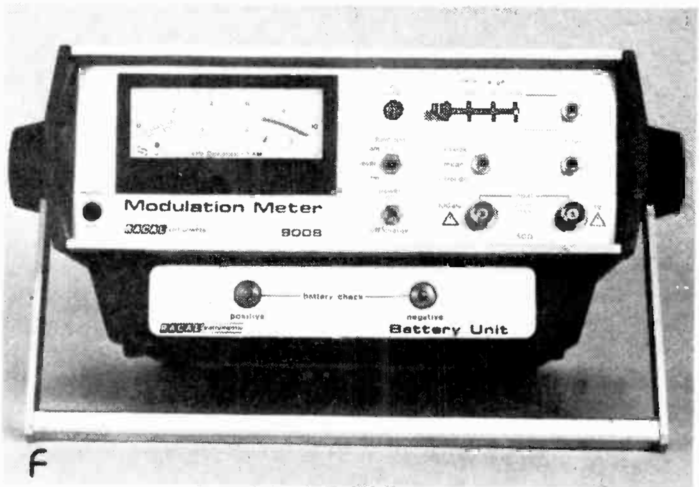

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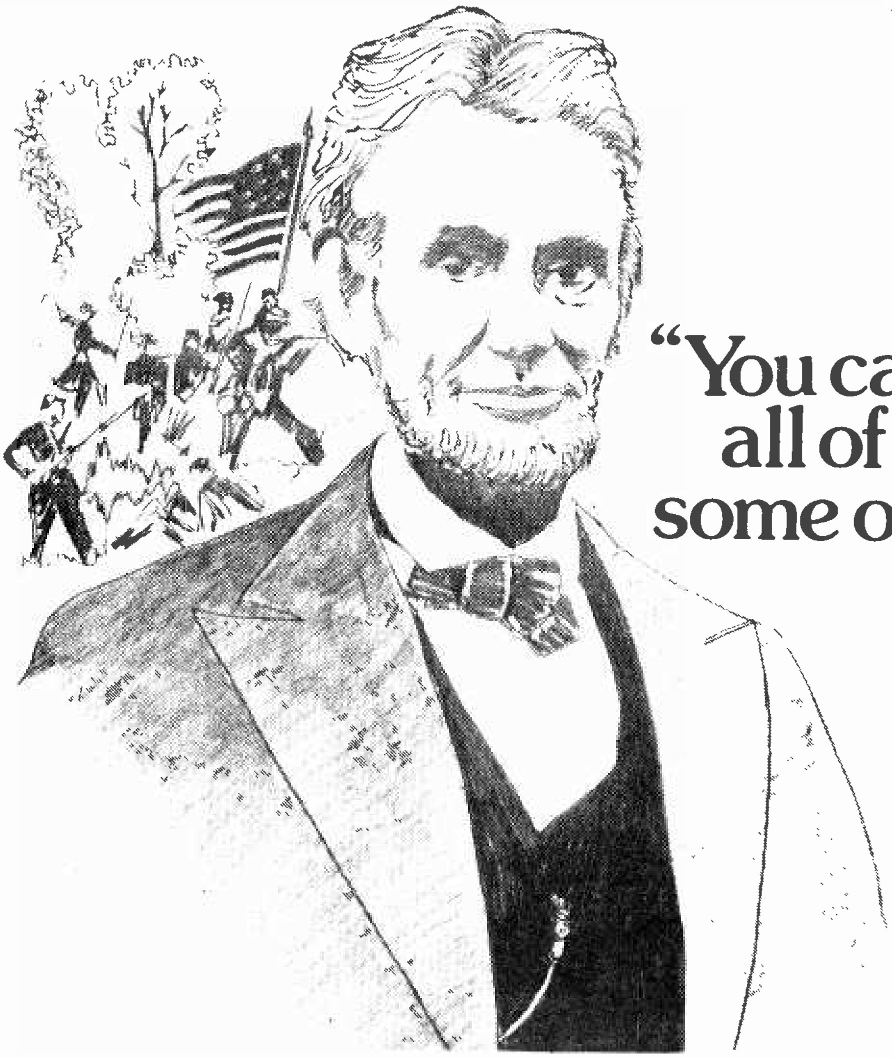
Abraham Lincoln
1809-1865



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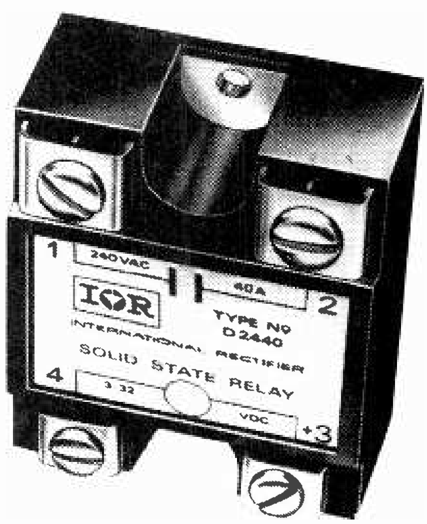

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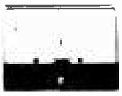

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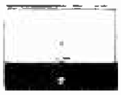

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100uA	£4 95	300V AC	£4 90
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50 0 50uA	£4 95		
100 0 100uA	£4 90		
1mA	£4 75		
1A DC	£4 75		
5A DC	£4 75		
20V DC	£4 75		
50V DC	£4 75		
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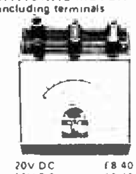

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1A DC	£8 40	5V 15V DC	£9 50
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5V DC	£8 40		
10V DC	£8 40		
15V DC	£8 40		

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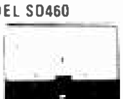

50uA	£3 85	5V DC	£3 65
100uA	£3 80	10V DC	£3 65
200uA	£3 75	20V DC	£3 65
500uA	£3 70	50V DC	£3 65
50 0 50uA	£3 80	300V DC	£3 65
100 0 100uA	£3 75	15V AC	£3 80
1mA	£3 65	300V AC	£3 80
5mA	£3 65	VU Meter	£4 65
10mA	£3 65		
50mA	£3 65		
100mA	£3 65		
500mA	£3 65		
1A DC	£3 65		
5A DC	£3 65		
10A DC	£3 65		

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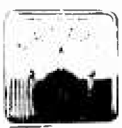

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500uA	£3 10	50V DC	£3 05
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100 0 100uA	£3 30	150V DC	£3 10
500 0 500uA	£3 05	300V DC	£3 10
1mA	£3 05	500V DC	£3 15
1 0 1mA	£3 05	750V DC	£3 15
2mA	£3 05	15V AC	£3 15
5mA	£3 05	50V AC	£3 15
10mA	£3 05	150V AC	£3 15
20mA	£3 05	300V AC	£3 15
50mA	£3 05	500V AC	£3 30
100mA	£3 05	5 Meter 1mA	£3 50
150mA	£3 05	VU Meter	£4 10
200mA	£3 05		
300mA	£3 05		
500mA	£3 05		
750mA	£3 05		
1A DC	£3 05		
2A DC	£3 05		
5A DC	£3 05		
10A DC	£3 05		
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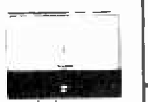

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100uA	£4 65	20V DC	£4 50
200uA	£4 60	50V DC	£4 50
500uA	£4 55	300V DC	£4 50
50 0 50uA	£4 65	15V DC	£4 60
100 0 100uA	£4 60	300V AC	£4 60
1mA	£4 50	VU Meter	£5 60
5mA	£4 50		
10mA	£4 60		
50mA	£4 50		
100mA	£4 50		
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500uA	£3 30	VU Meter	£4 30
50 0 50uA	£3 50	1A AC	£3 25*
100 0 100uA	£3 45	5A AC	£3 25*
500 0 500uA	£3 25	10A AC	£3 25*
1mA	£3 25	20A AC	£3 25*
5mA	£3 25	30A AC	£3 25*
10mA	£3 25		
50mA	£3 25		
100mA	£3 25		
500mA	£3 25		
1A DC	£3 25		
5A DC	£3 25		
10V DC	£3 25		
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50V DC	£3 25		
300V DC	£3 25		

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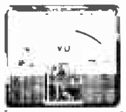

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200uA	£5 90	300V DC	£5 75
500uA	£5 80	15V AC	£5 85
50 0 50uA	£5 95	300V AC	£5 85
100 0 100uA	£5 90	5 Meter 1mA	£6 65
500 0 500uA	£6 65	VU Meter	£7 10
1mA	£5 75	1A AC	£5 75*
1 0 1mA	£5 75	5A AC	£5 75*
5mA	£5 75	10A AC	£5 75*
10mA	£5 75	20A AC	£5 75*
50mA	£5 75	30A AC	£5 75*
100mA	£5 75		
500mA	£5 75		
1A DC	£5 75		
5A DC	£5 75		
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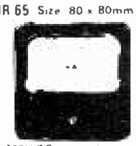
50 0 50uA	£3 85	5A AC	£3 65*
100 0 100uA	£3 70	10A A	£3 65*
1mA	£3 65	20A AC	£3 65*
5mA	£3 65	30A AC	£3 65*
10mA	£3 65		
50mA	£3 65		
100mA	£3 65		
500mA	£3 65		
1A DC	£3 65		
5A DC	£3 65		
10V DC	£3 65		
20V DC	£3 65		
50V DC	£3 65		
300V DC	£3 65		
15V AC	£3 75		
300V AC	£3 75		

BAKELITE MODEL MR 65 Size 80 x 80mm



25uA	£5 80	300V DC	£3 95
50uA	£4 40	30V AC	£3 95*
100uA	£4 35	50V AC	£3 95*
500uA	£4 05	150V AC	£3 95*
50 0 50uA	£4 35	300V AC	£3 95*
100 0 100uA	£4 30	500V AC	£3 95*
500 0 500uA	£3 95	VU Meter	£5 20*
1mA	£3 95	1A AC	£3 95*
1 0 1mA	£3 95	5A AC	£3 95*
5mA	£3 95	10A AC	£3 95*
10mA	£3 95	20A AC	£3 95*
50mA	£3 95	30A AC	£3 95*
100mA	£3 95	50A AC	£3 95*
500mA	£3 95	500mA AC	£3 95
1A DC	£3 95	50mV DC	£4 15
2A DC	£3 95	100mV DC	£4 15
5A DC	£3 95		
10A DC	£3 95		
15A DC	£3 95		
30A DC	£3 95		
50A DC	£4 20		
5V DC	£3 95		
10V DC	£3 95		
15V DC	£3 95		
20V DC	£3 95		
50V DC	£3 95		
150V DC	£3 95		

EDGWISE MODEL PE70
Size 90 x 34mm

50uA	£4 55
100uA	£4 50
200uA	£4 45
500uA	£4 30
50 0 50uA	£4 50
100 0 100uA	£4 45
1mA	£4 25
10V DC	£4 25
300V DC	£4 35
VU Meter	£5 50

CLEAR PLASTIC MODEL MR 65P
Size 86 x 78mm

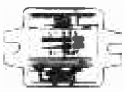
50uA	£4 35	300V DC	£4 10
100uA	£4 25	15V AC	£4 20
200uA	£4 20	50V AC	£4 20
500uA	£4 15	150V AC	£4 20
50 0 50uA	£4 25	300V AC	£4 20
100 0 100uA	£4 20	500V AC	£4 30
500 0 500uA	£4 10	5 Meter 1mA	£4 85
1mA	£4 10	VU Meter	£5 20
1 0 1mA	£4 10	1A AC	£4 10*
5mA	£4 10	5A AC	£4 10*
10mA	£4 10	10A AC	£4 10*
50mA	£4 10	20A AC	£4 10*
100mA	£4 10	30A AC	£4 10*
500mA	£4 10	50A AC	£4 10
1A DC	£4 10	50mA AC	£4 10*
5A DC	£4 10	100mA AC	£4 10*
10A DC	£4 10	200mA AC	£4 10*
15A DC	£4 10	500mA AC	£4 10*
20A DC	£4 20		
30A DC	£4 25		
50A DC	£4 10		
5V DC	£4 10		
10V DC	£4 10		
15V DC	£4 10		
20V DC	£4 10		
50V DC	£4 10		
150V DC	£4 10		

POSTAGE / PACKING & INSURANCE 15p

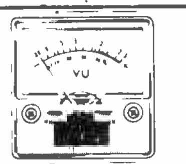
240° Wide Angle 1mA METERS

MW1 6 60 x 60 mm
£7 00P P & Ins 15p
MW1 8 80 x 80mm
£7 45P & P ins 15p

BATTERY LEVEL PANEL INDICATOR



18mm
18mm Panel mounting
OUR PRICE 95p P P & Ins 15p Discounts for quantity



VU METER TYPE 3
250uA Size 33mm 20mm
£1.55 P P & Ins 15p

REDUCED TO CLEAR
YAMABISHI VARIABLE VOLTAGE TRANSFORMERS
Excellent quality at low cost Input 230V 50/60Hz Output 0–260V
MODEL S260 BENCH MOUNTING

		P P & Ins
1A	£7 30	£1 50
2 5A	£10 35	£1 50
5A	£12 95	£1 50
8A	£19 45	£1 50
10A	£23 75	£1 50
12A	£25 90	£1 50
20A	£60 45	£1 50
25A	£64 75	£1 50
40A	£73 40	£1 50

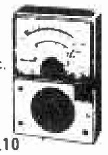
MODEL C7202EN

20 000 o p v DC
10 000 o p v AC
Mirror Scale
5 25 50 250 500 1000 2500 V DC
10 50 100 500 1000 V AC DC Resistance · 10 1000 30Ω centre scale DC Current 50uA 2 5mA 250mA 20 to · 68 dB
OUR PRICE £7 50 P P & Ins 30p

U4323 MULTIMETER

20,000opv. Simple unit with audio/IF oscillator. Suitable for general receiver tuning. Ranges 0.5/2.5/10/50/250/500/1000V DC 2.5/10/15/250/500/1000V AC 0.05/0 5 5 50 500mA DC Resistance x 10 x 100, x 1 000, x 10 000 (50Ω 500Ω, 5kΩ, 50kΩ centre scale) Battery operated Size 160 x 97 x 40mm. Supplied in carrying case complete with test leads.
OUR PRICE £8.60P P & Ins 60p

HIOKI 730X



30,000 opv Overload protection 6 30 60 300/500 1200V DC. 12 60/120/600 1200V AC. 60 μA/30mA 300mA 2K/200K 2 Meg Ohm. 10 to 63dB
OUR PRICE £8.10
P P & Ins 30p

TMK 200 MULTIMETER KIT

Build yourself a quality 20000 opv multimeter and save money Complete kit with meter scale movement and rotary range selector ready mounted in cabinet All parts, batteries test prods and instructions Ranges 0 0 6 6 30 120 600 1200V D C 0 6 30 120 600 1200V A C Current 0 0 6 6 60 600mA Resistance 0 10 100K 1 10 Meg ohms Decibels 20 to + 63db Size 90 x 150 x 35mm
OUR PRICE £9.65P P & Ins 30p

MODEL C7208FM

30 000 opv DC
15 000 opv AC
6 3 15 60 300 600 1200V DC 6 30 120 600 1200V AC
DC Resistance x 1, x 10 x 100 x 1000 (50Ω centre scale)
DC Current 30uA 3 30 600mA 20 to + 63dB
OUR PRICE £9.65 P P & Ins 30p

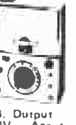
U4324 MULTIMETER
High sensitivity.

20,000opv. Ranges. 0.6/1.2/3/12/30/60/120/600/1200V DC. 3/6/15/60/150/300/600/900V AC. Current. 0.06/0.6/6/60/500mA/3A DC. 0.3/3/30/300mA/3A AC. Resistance 25/500 ohms/0.5/5/50/500k ohms/5 Mohms. Decibels −10 to +12dB. Size 167 x 98 x 63mm. Supplied complete with test leads, spare diode and instructions.
OUR PRICE £10.60P P & Ins 60p

U91 Clamp VOLT AMMETER

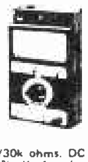
For measuring AC voltage and current without breaking circuit. Ranges 300/600V AC. Current. 10/25/100/250/500A. Accuracy 4%. Size 283 x 94 x 36mm. Complete with carrying case, leads and fuses.
OUR PRICE £15.10P P & Ins 60p

HIOKI 750X VOLT-OHM-MILLIAMETER



43 ranges. 0–0 3/0 6/1 5/3/6/12/30/60/150/300/600/1,200V DC 0–3/6/15/30/60/120/300/600/1,200V AC. Current 0–30/60uA/1.5/3/15/30/150/300 mA/6/12A. Resistence 0–3/300k/3/30Mohms Decibels 10 to +17dB. Output 0 3/6/15/30/60/120/300V Accuracy ± 3% DC, ± 4% AC Sensitivity 50,000 opv DC, 5,000 opv AC 4 inch meter Built in protection Size 57 x 102 x 153mm
OUR PRICE £12.90P P & Ins 60p

U4312 MULTIMETER



extremely sturdy instrument for general electrical use. 667opv. 0/0.3/1.5/7.5/30/60/150/300/600/900V DC & 75mV 0/0.3/1.5/7.5/30/60/150/300/600/900V AC. 0/300uA/1 5/6/15/150/60/600mA/1/1.5/6A DC 0/1.5/6/15/60/150/600mA/1.5/6A AC. 0/200/3k/30k ohms. DC accuracy 1%. AC 1.5% Knife edge pointer, mirror scale Complete with sturdy metal carrying case, leads and instructions.
OUR PRICE £11.60P P & Ins 60p

ALL PRICES INCLUDE VAT

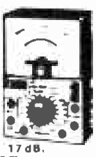
MODEL 500

30,000 opv with overload protection. Mirror scale. 0/0.5/2.5/10/25A 100/250/500/1000V DC. 0/2.5/10/25/100/250/500/1000V AC. 0/50uA/5/50/500mA. 12A DC. 0/60k/6 meg/60 megohms.
OUR PRICE £15.05P P & Ins 60p

TMK MODEL TW50K

46 ranges, mirror scale. 50k/V DC 50k/V AC. DC Volts: 0.125/0.25/1.25/2.5/5/10/25/50/125/250/500/1000, AC Volts 1.5/3/5/10/25/50/125/250/500/1000. DC current 25/50uA/2.5/5/25/50/250/500mA/5/10A. Resistence 10k/100k/1 Meg/10 Meg ohms. −20 to +81.5dB.
OUR PRICE £13.50P P & Ins 60p

MODEL AF.105 VOM

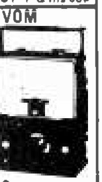


50,000 opv Mirror scale Meter · protection. 0 3/3 12 60 120 300/600/1200V DC. 0/6 30 120/300/600 1200V DC. 0 30μA 6 60/300 mA 12 Amp. 0 10K 1m/10m 100 Meg Ohms 20 to 17 dB.
OUR PRICE £13.50P P & Ins 60p

U4317 MULTIMETER

High sensitivity instrument for field and laboratory work. Knife edge pointer, 86mm, mirror scale. Overload protection Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000 V DC. 0.5/2.5/10/25/50/100/250/500/1000V AC. Current: 50uA/0.5/1/5/10/50/250mA/1/5A DC. 0.25/0.5/1/5/10/50/250mA/1/5A AC. Resistance: 0.5/10/100/200 ohms/1/3/30/300k ohms. Decibels: −5 to +10dB Battery operated. Size: 210 x 115 x 90mm. Supplied in carrying case complete with leads.
OUR PRICE £18.35P P & Ins 60p

MODEL AS.100D VOM

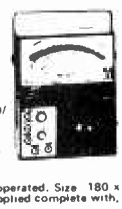


100,000 opv. Mirror scale Built-in meter protection. 0 3 12 60 120 300 600 1200V DC. 0 6 30 120 300 600V AC. 0 10μA 6 60 300mA 12 Amp 0 2K 200K 2M 200 Meg Ohm 20 to 17 dB
OUR PRICE £18.90P P & Ins 60p

370WTR MULTIMETER

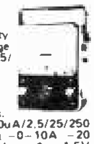
Features AC current ranges. 20,000opv 0/0 5/2 5/10/50/250/500/1000V DC 0/2.5/10/50/250/500/1000V AC 0/50uA/1/10/100 mA/1/10A DC. 0/100mA/1/10A AC. 0/5k/50k/500k/5 Meg/50 Meg Decibels −20 to +62dB.
OUR PRICE £21.50P P & Ins 60p

KAMODEN 360 MULTIMETER



High sensitivity DC 100kohm/V AC 10kohm/V 5" mirror scale, overload protected Ranges 0.5/2 5/10/50/250/1000V DC. 5/10/50/250/1000V AC. Current 0.01mA/0.5/5/50/500mA/10A. Resistance 0.1/1/10/100 ohms/1/10/100k ohms/10/100M ohms. Decibels −20 to +62dB. Battery operated. Size 180 x 140 x 80mm. Supplied complete with, test leads etc
OUR PRICE £18.90P P & Ins 60p

Model HT100B4 MULTIMETER



Overload protected, shock proof circuits 9.5uA Meter with mirror scale Sensitivity 100kV Polarity change switch Ranges 0.5/2 5/1 /50/250/500/1,000 Volts DC 2.5/10/50/250/1,000 Volts AC DC resistence 0–20/200k/2/20 Meg. ohms. DC current – 10/250uA/2.5/25/250 mA/10A. AC current −0–10A −20 to +62dB Operates from 2 x 1.5V batteries. Size 180 x 134 x 79mm.
OUR PRICE £21.50P P & Ins 60p

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KAMODEN 72.200 Multitester
High sensitivity tester. 200,000 opv. Overload protected. Mirror scale. Ranges – 0/.06/.3 3/30/120/600/ 1200V DC. 0/3 12/60/300/11200 V AC. 0/6uA/ 1.2mA/120mA/ 600mA/12A DC 0/12A AC, −20 to +63dB. 0/2k/200k/ 2 Meg/200 Megohms
OUR PRICE £24.30p P & Ins 60p

KAMODEN HM720B FET VOM
Input impedence 10 Megohms. Ranges – 0/.25/1/2.5/10/50/ 1000V DC. 0/2.5/10 50/250/1000V AC. 0/25uA/2.5/25/250 mA DC. 0/5k/50k/500k/5 M 500 Megohms
OUR PRICE £24.30 P P & Ins 60p

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 £4.55 P P & Ins 60p

MODEL TE20 RF SIGNAL GENERATOR
Six bands, 120kHz – 260MHz. Dual output RF terminals. Separate variable audio output. Accuracy ± 2%. Audio output to 8V. Power requirements 105–125V, 220–240V AC. Size 193 x 265 x 150mm. Complete with test leads etc.
OUR PRICE £20.45p P & Ins 60p

KAMODEN TT35 TRANSISTOR TESTER
High quality instrument to test reverse leak current and DC current. Amplification factor of NPN, PNP, diodes, transistors, SCR's etc. 4" square clear scale meter. Operates from internal batteries. Complete with instructions, leads carrying handle.
OUR PRICE £18.90 P P & Ins 60p

S100TR MULTIMETER TRANSISTOR TESTER
100 000opv. Mirror scale. Overload protection. 0/0.12/ 0.6/3/12/30/120/ 600V DC. 0/6/30/ 120/600V AC. 0/12/600uA/12/ 300mA/6/12A DC 0/10k/1 Meg/ 100 Meg. −20 to +50dB. 0.01 0.2 MFD
Transistor tester measures Alpha, Beta and ICO. Complete with instructions, batteries and leads.
OUR PRICE £22.65p P & Ins 60p

C15 PULSE OSCILLOSCOPE
For display of pulsed and periodic wave forms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1–25; HOR. AMP. Band width. 500kHz. Sensitivity ay 100kHz VRMS/mm 0.3–25. Preset triggered sweep 1–3000usec. Free running 20–200 kHz in nine ranges. Calibrator pips. 220 x 360 x 430mm. 115–230V AC.
OUR PRICE £47.50 P. P & Ins £1.50

U4341 Multimeter & Transistor Tester
27 ranges. 16,700opv. Overload protected. Ranges 0.3/1.5/6/ 30/60/150/300/900V DC. 1.5/7.5/30/150/ 300/750V AC. Current 0.06/0.6/ 6/60/600mA DC. 0.3/3/30/300mA AC. Resistance 0.06/ 0.6/2/6/20/60/200k ohms/2 Mohms. Battery operated. Supplied complete with probes, leads and steel carrying case. Size 115 x 215 x 90mm.
OUR PRICE £11.85p P & Ins 60p

TE 200 RF SIGNAL GENERATOR
Accurate wide range signal generator covering 120 kHz 500 MHz on 6 bands. Directly calibrated. Variable R.F. attenuator audio output. Xtal socket for calibration. 220 240V a.c. Brand new with instructions. Size 140mm x 215mm x 170mm.
OUR PRICE £24.30 P P & Ins 60p

LB4 TRANSISTOR TESTER
Tests PNP or NPN transistors. Audio indication. Operates on two 1.5V batteries. Complete with instructions etc.
OUR PRICE £4.85 P P & Ins 20p

TE22 SINE SQUARE WAVE AUDIO GENERATOR
Sine 20cps to 200kHz on 4 bands. Square 20 cps to 30 kHz. Output impedence 5000 Ohms. 200/250V AC operation. Supplied brand new guaranteed, with instruction manual and leads.
OUR PRICE £26.90p P & Ins 60p

ARF 300 AF/RF SIGNAL GENERATOR
All transistorised compact fully portable. AF sine wave 18Hz to 220 kHz. AF square wave 18Hz to 100k Hz. Output Square/ Sine wave 10V. P.P RF 100kHz to 200MHz. Output 1V maximum. 220/240V AC operation. Complete with instructions and leads.
OUR PRICE £40.50p P & Ins 60p

SINCLAIR DM2 DIGITAL MULTIMETER
Will measure AC and DC volts, AC and DC current and resistance in a total of 20 ranges. The large light emitting diode display will read up to 1999 and automatically indicate polarity. Indication of positive and negative overload is also provided. The instrument is fitted with a combined carrying handle and bench stand and sockets are provided for the connection of an external power supply.
RANGES
DC VOLTS 1v 10 100v 1000v
AC VOLTS 1v 10v 100v 1000v
DC CURRENT 1mA 10mA 100mA 1000mA
AC CURRENT 1mA 10mA 100mA 1000mA
RESISTANCE 1k 10k 100k 1000k
OUR PRICE £63.70 P P & Ins 50p

TRANSISTORISED L C R A C BR 8 MEASURING BRIDGE
A new portable bridge offering excellent range and accuracy at low cost. Resistance 6 ranges 0.1 ohm 11.1 megohm. 1 Inductance 6 ranges 1 microhenry 111 henries. 2 Capacity 6 ranges 10pf 1110 mfd. 2 Turns Ratio 6 ranges 1 1 1000 1 11100. 1 Bridge Voltage at 1 000cps. Operated from 9 volt battery. 100 micro-amp meter indication. Size 7¾ x 5 x 2
OUR PRICE £29.70 P P & Ins 60p

SINCLAIR Project 80 Modules

240 Power Amp	£5.60	P P & Ins 15p
260 Power Amp	£6.95	P P & Ins 15p
Stereo 80 Pre Amp	£13.10	P P & Ins 15p
Active Filter Unit	£7.40	P P & Ins 15p
FM Tuner	£13.10	P P & Ins 15p
Stereo Decoder	£8.40	P P & Ins 15p
PZ5 Power Supply	£4.65	P P & Ins 30p
PZ6 Power Supply	£8.40	P P & Ins 30p
PZ8 Power Supply	£7.90	P P & Ins 30p
Transformer for PZ8	£5.10	P P & Ins 30p

WALKIE TALKIES
SKYFON NV7
Super low cost transmitter receivers 100MW with call buzzer and on off volume control. 7 transistors. Telescopic rod antenna.
OUR PRICE £43.60 per PAIR P P & Ins 50p
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MINIATURE ORGAN MUSIC MASTER AM100
Spanning nearly two octaves including semi tones. This instrument will give hours of enjoyment to all the family. Beautifully finished. The Keyboard range can be adjusted to be in tune with any instrument. Operates from internal 9V battery. Fitted with on off switch, vibrato switch, earphone socket and external 9V D.C. socket. Size 229mm x 127mm x 64mm.
OUR PRICE £9.95 P P & Ins 50p

SAVE £14.00
ELIZABETHAN 8 LZ-1
8 Track Stereo Player Home. 8 Track player with automatic and manual programme change and illuminated channel indicators for use with your hi-fi system. Size 7¾ w x 12 D x 2¾ h. List Price £28.90
OUR PRICE £14.90 P P & Ins £1.35

ALL PRICES INCLUDE VAT

SENN-SOUND 4-CHANNEL ADAPTOR
Simple couple this unit to your existing stereo amplifier and add a pair of speakers and enjoy the realism of the concert hall.
OUR PRICE £4.95 P P & Ins £1.35

BELTEK C6260 CAR AM FM RADIO & 8 TRACK CARTRIDGE PLAYER
12v Neg earth, has tone and balance controls, cartridge programme indicator, automatic head cleaning and comes complete with installation kit, suppressors and instructions. (No cartridge included)
OUR PRICE £22.50 P P & Ins £1.35

FANTAVOX FMT1 STEREO FM TUNER
9v Battery operated FM Stereo Tuner with AFC FM88 108 MHz. Seven section telescopic aerial. Edgewise Tuning and volume controls. Size only 151 x 66 x 108mm. Socket for external power supply. Simple connections.
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SINCLAIR PROJECT 805
Now available at special low LASKYS prices the famous project 805 no solder amplifier kit. Included are all necessary wires, push-on connectors, P80 pre amp, two Z40 power boards giving 12w rms, PZ5 power supply and a comprehensive manual. List Price £49.93
OUR PRICE £17.50 P P & Ins £1.65

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EXCLUSIVE TO LASKYS

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LSH20 Individual volume controls. Mono stereo switch 40-19,00 Hz 8 ohms.
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LSH30 Individual tone and volume controls. Mono stereo switch 30-20,000 Hz 8 ohms.
OUR PRICE £10.50 P P & Ins 30p
LSH40 Two way speaker system. Individual volume controls 20-20,000 Hz 8 ohms.
OUR PRICE £12.95 P P & Ins 30p

AUDIOTRONIC DIGITAL CLOCK RADIOS
ADC22 24-hour clock radio covering MW FM wave bands. 60 minute sleep timer, timer. Choice of Grey or White cabinet.
OUR PRICE £17.50 P P & Ins £1.00
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OUR PRICE £19.95 P P & Ins £1.00

AUDIOTRONIC ACD 770D
Cassette Deck with Dolby. Twin VU meters, program counter, DIN and phono input outputs, level slider controls in sleek black brushed aluminium and teak. Freq response 40 12kHz on normal tape and 40 16kHz on CrO² tape. W F 0.2 and with the Dolby Noise Reduction System in a signal to noise ratio of 57dB.
OUR PRICE £79.95 P P & Ins £1.65

AUDIOTRONIC HIGH ENERGY LOW NOISE CASSETTES

MODEL	5	10	15
C60LN	£3.59	£6.80	£9.64
C90LN	£5.13	£9.72	£13.77
C120LN	£6.15	£11.66	£16.52

p p & Ins 15p per order

AUDIOTRONIC LOW NOISE CASSETTES

MODEL	5	10	15
C60	£2.05	£3.88	£5.50
C90	£2.81	£5.34	£7.57
C120	£3.59	£6.80	£9.64

AUDIOTRONIC MODEL ATM5
Jewel movement, attractively moulded case with edgwise ohms adjustment. Ranges 0.3/15/150/ 300/1200V AC. (2500 opv) 0.6/30/ 300/600V DC. (5000 opv) 0.300 uA/0.300mA DC. Resistance x 10 & x 100. −10 to +16dB. Supplied with battery test leads and data booklet. Size 121 x 73 x 29mm.
OUR PRICE £5.40 P P & Ins 25p

AUDIOTRONIC AHA101 Stereo Headphone Amplifier
All silicon transistor amplifier operates from magnetic, ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery. INPUTS 5mV and 100mV. OUTPUT 50mV per channel.
OUR PRICE £10.65p P & Ins 30p

AUDIOTRONIC Model ATM1
Top value 1,000 opv pocket multi-meter. Ranges 0/10/50/250/1,000 volt AC and DC. DC current 0.1mA/ 100mA. Resistence 0/150k ohms. Decibels −10 to +22dB. Size 90 x 60 x 28mm. Complete with test leads.
OUR PRICE £4.60 P P & Ins 25p

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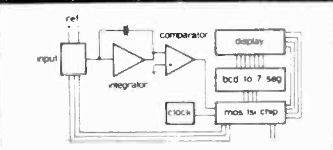

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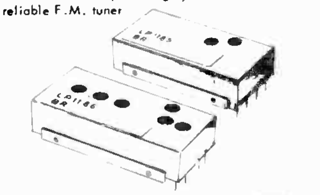

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I1 250 mA
Pd 200 mW
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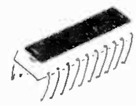
LINE-O-LIGHT



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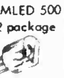

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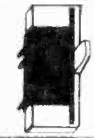

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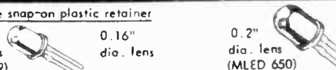

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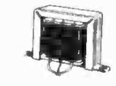

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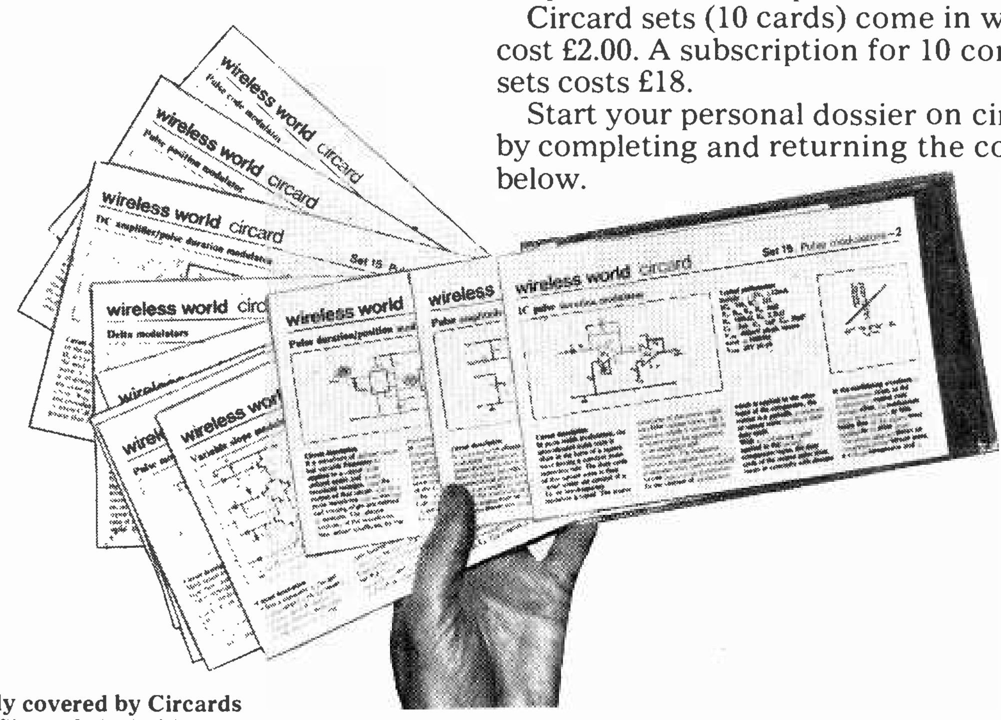
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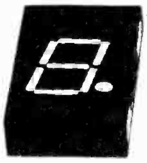

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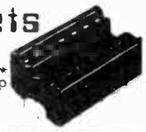

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BC 108	0.090	0.113	2N 2218A	0.220	0.275
BC 108A	0.130	0.163	2N 2219	0.220	0.275
BC 108B	0.130	0.163	2N 2219A	0.220	0.275
BC 108C	0.140	0.175	2N 2221	0.180	0.225
BC 109	0.090	0.113	2N 2221A	0.210	0.263
BC 109B	0.140	0.175	2N 2222	0.200	0.250
BC 109C	0.140	0.175	2N 2222A	0.250	0.313
BC 184(K)	0.120	0.150	2N 2904	0.190	0.238
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BC 212B(K)	0.110	0.138	2N 2906	0.170	0.213
BC 213C(K)	0.110	0.138	2N 2906A	0.170	0.213
BC 214B(K)	0.110	0.138	2N 2907	0.220	0.275
BCY 71	0.220	0.275	2N 2907A	0.240	0.300
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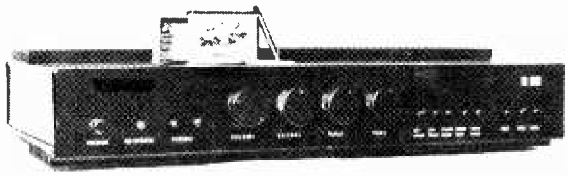

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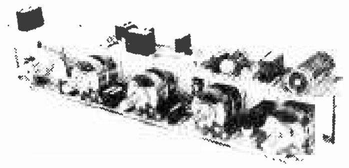

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*We incorporate the Quilter modification which is most important as it reduces distortion and increases the bass and treble control range

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NAS0164W	400V	40
NAS0164X	400V	.38
NAS0166W	600V	.50
NAS0166X	600V	.48

6AMP ISOLATED TAB

NAS0651W	100V	.65
NAS0651X	100V	.65
NAS0652W	200V	.61
NAS0652X	200V	.61
NAS0654W	400V	.72
NAS0654X	400V	.70
NAS0656W	600V	.88
NAS0656X	600V	.76

10AMP ISOLATED TAB

NAS1001W	100V	.72
NAS1001X	100V	.72
NAS1002W	200V	.78
NAS1002X	200V	.78
NAS1004W	400V	1.09
NAS1004X	400V	1.04
NAS1006W	600V	1.36
NAS1006X	600V	1.36

3.5AMP CLIPPED TAB

NAS0351W	100V	.52
NAS0351X	100V	.52
NAS0352W	200V	.56
NAS0352X	200V	.56
NAS0354W	400V	.68
NAS0354X	400V	.67
NAS0356W	600V	.85
NAS0356X	600V	.84

8.5AMP ISOLATED TAB

NAS0851W	100V	.68
NAS0851X	100V	.68
NAS0852W	200V	.76
NAS0852X	200V	.76
NAS0854W	400V	.88
NAS0854X	400V	.85
NAS0856W	600V	1.10
NAS0856X	600V	1.06

15 AMP ISOLATED TAB

NAS1501W	100V	1.05
NAS1501X	100V	.95
NAS1502W	200V	1.02
NAS1502X	200V	1.02
NAS1504W	400V	1.51
NAS1504X	400V	1.48
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Devices with Internal Trigger have "W" suffix. "X" denotes Standard Triac

THYRISTORS

1.6AMP TO5 ●

NAS006P	50PVV	.25
NAS006Q	100PIV	.28
NAS006R	200PIV	.31
NAS006S	400PIV	.40
NAS006T	600PIV	.52

4AMP ISOLATED TAB

NAS106P	50PIV	.26
NAS106Q	100PIV	.30
NAS106R	200PIV	.36
NAS106S	400PIV	.57
NAS106T	600PIV	.90

6AMP ISOLATED TAB

NAS206P	50PIV	.37
NAS206Q	100PIV	.42
NAS206R	200PIV	.50
NAS206S	400PIV	.77

8AMP ISOLATED TAB

NAS306P	50PIV	.41
NAS306Q	100PIV	.47
NAS306R	200PIV	.59
NAS306S	400PIV	.85

16AMP ISOLATED TAB

NAS806P	.50
NAS806Q	.58
NAS306R	.73
NAS806S	1.15

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TAA263	TO18	62	● TBA810AS	1.08	● 741	8 Pin	.35
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CD4019AE	0.46	CD4037AE	0.78	CD4055AE	1.08	CD4078BE	0.18	OC04585BE	1.45
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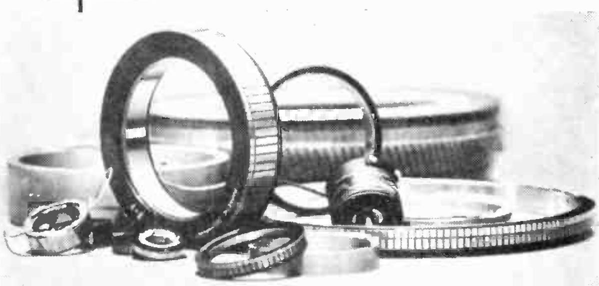

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Ref. No.	VA (Watts)	£	P&P p
07*	20	4.10	58
149	60	4.69	72
150	100	5.33	85
151	200	8.54	1.12
152	250	10.32	1.41
153	350	12.47	1.41
154	500	14.33	1.61
155	750	21.94	BRS
156	1000	30.51	BRS
157	1500	34.89	BRS
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Ref. No.	AMPS 12v	AMPS 24v	£	P&P p
111	0.5	0.25	1.54	28
213	1.0	0.5	1.86	58
71	2	1	2.41	58
18	4	2	2.97	72
70	6	3	4.43	72
108	8	4	5.09	85
72	10	5	5.50	85
116	12	6	5.80	97
17	16	8	7.48	97
115	20	10	10.91	1.61
187	30	15	14.20	1.41
226	60	30	17.67	BRS

50 VOLT RANGE

SECONDARY TAPS 0-19-25-33-40-50V

Ref. No.	Amps.	£	P&P p
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103	1.0	3.55	72
104	2.0	4.95	85
105	3.0	6.10	97
106	4.0	7.98	1.12
107	6.0	12.71	1.25
118	8.0	13.53	1.61
119	10.0	17.75	BRS

30 VOLT RANGE

SECONDARY TAPS 0-12-15-20-25-30V

Ref. No.	Amps	£	P&P p
112	0.5	1.90	58
79	1.0	2.52	72
3	2.0	3.77	72
20	3.0	4.70	85
21	4.0	5.56	85
51	5.0	6.73	97
117	6.0	7.52	1.12
88	8.0	10.20	1.25
89	10.0	10.36	1.41

60 VOLT RANGE

SECONDARY TAPS 0-24-30-40-48-60V

Ref. No.	Amps	£	P&P p
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126	1.0	3.68	72
127	2.0	5.33	85
125	3.0	7.90	97
123	4.0	9.19	1.41
40	5.0	10.25	1.25
120	6.0	12.07	1.41
121	8.0	15.75	BRS
122	10.0	19.40	BRS
189	12.0	20.26	BRS

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Ref. No.	VA (Watts)	AUTO TAPS	£	P&P p
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64	75	0-115-210-240	3.05	72
4	150	0-115-210-220-240	4.33	72
66	300		6.11	85
67	500	" "	9.36	1.25
84	1000	" "	14.36	1.61
93	1500	" "	19.02	BRS
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73	3000	" "	36.84	BRS

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1000	250	26.31	BRS
2000	252	44.12	BRS

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212	1A 1A	0-6, 0-6	1.93	46
13	100	9-0-9	1.56	25
235	330, 330	0-9, 0-9	1.64	25
207	500, 500	0-8-9, 0-8-9	2.02	51
208	1A 1A	0-8-9, 0-8-9	3.07	58
236	200, 200	0-15, 0-15	1.56	25
214	300, 300	0-20, 0-20	2.03	58
221	700 (DC)	20-12-0-12-20	2.38	58
206	1A 1A	0-15-20, 0-15-20	3.63	72
203	500, 500	0-15-27, 0-15-27	3.15	72
204	1A 1A	0-15-27, 0-15-27	4.14	72
S112	500	12, 15, 20, 24, 30	1.97	58

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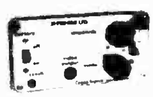

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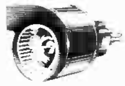
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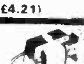
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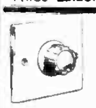
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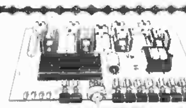
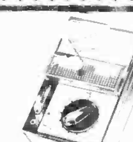
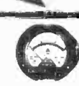
750W Solid State Fader, with three functions: Manual fade. Auto fade-up. Auto fade-down. Automatic cycling up and down. Functions selected with three position rocker switch. Two ranges of cycling for Flashing or Slow blending. Ready built module 6" x 3" glass fibre board incorporating 10 amp TRIAC. Two or more modules for top quality colour blending and flashing effects. PRICE **£15.00**. Post 65p.

SQUAD LIGHT

A new conception in light control. Four channels each capable of handling 750 watts of spotlights, floodlights, or dozens of small mains lamps. Seven programs all speed controlled plus flash modulation, effectively giving 14 different displays. Makes sound-to-light obselete. Completely electrically and mechanically noise free. Can be used on same circuit as radio mikes or sensitive amplifiers. A whole new range of lighting effects possible with astounding results. Already in use in London's foremost theatres, night clubs and discos. Conforms to all R.F.I. tests, including Common Market regulations. Supplied in tough, well designed case with embossed front panel. Price only **£60.00**. Post 75p. S.A.E. (Foolscap) for further details.

WHY PAY MORE?!

MULTI RANGE METER. A.C. volts 2.5-500. D.C. volts 2.5-500 (Sensitivity 2000Ω/V DC & AC). DC current 0/1/10/100 mA. Ohms range. Sturdy compact moving coil instrument with 21 ranges, dimensions 120x 80x 44mm. Weight 0.32 kg. SERVICE TRADING CO. Price **£5.00**. Post 50p. (Total price inc. VAT & Post **£5.94**).

METERS NEW

90mm Diameter.
Type 65C5. 2A D.C. M/C. 5A D.C. M/C. 10A D.C. M/C. 20A D.C. M/C.
Type 62T2. 1A A.C. M/I. 20A A.C. M/I. 300V A.C. M/I. ALL ABOVE **£2.50**. Post 30p.
Type 65L5. 300V A.C. R/M/C. **£2.75**. Post 30p.

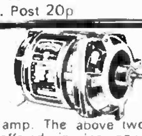
VAT VAT AT 8% MUST BE ADDED TO ALL ORDERS FOR THE TOTAL VALUE OF GOODS INCLUDING POSTAGE UNLESS OTHERWISE STATED

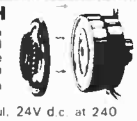
GEARED MOTOR

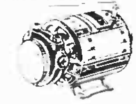
230/240 volt A.C. smooth, powerful, continuously rated. Two types. 32 r.p.m. or 110 r.p.m. Either type **£4.75**. Post 50p.

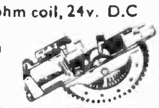
REVERSIBLE MOTOR
General Electric. 230v A.C. 1,600 r.p.m. 0.25 amp. Complete with anti-vibration mounting bracket and capacitor. O/A size 110mm x 95mm. Spindle 5/16" dia. 20mm long. Ex-equipment tested. **£3.00**. Post 50p.

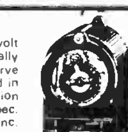
20 r.p.m. GEARED MOTOR
230/240 volt 20 r.p.m. motor. **£1.00**. Post 20p.

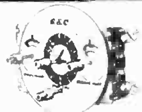
BODINE TYPE N.C.I. GEARED MOTOR

(Type 1) 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 **£6.25**. Post 75p or less transformer **£3.75**. Post 65p.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines, etc. etc.

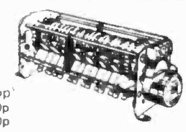
BENDIX MAGNETIC CLUTCH

A superb example of Electro-mechanics! The main body is in two sections. The coil section is fixed and has a ⅜in. sleeve. The drive section rotating on the outer perimeters. The uniting plate has ⅜in. ID bearing concentric with main section and 18-tooth cog wheel.
When energized transmission is extremely powerful. 24V d.c. at 240 MA. OUR PRICE JUST £2.50. Post 45p.

ROTARY VACUUM AIR COMPRESSOR AND PUMP

Carbon vane, oil-less. 100/115V A.C. 1/12 h.p. motor. 50/60 cycle. 2875/3450 r.p.m. 20" vacuum. 1.25 c.f.m. 10 p.s.i. (approx. figures). New unused surplus stock, with elect. connection data. Fraction of maker's price **£12.00**. Post £1.00. Suitable transformer £3.50. Post 50p.

UNISELECTOR SWITCHES—NEW

4 BANK 25 WAY FULL WIPER 25 ohm coil, 24v. D.C operation **£6.90**. Post 50p.
6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. **£7.90**. Post 50p.
8 BANK 25 WAY FULL WIPER
24 v. D.C. operation **£9.50**. Post 65p.

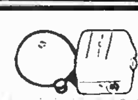
TIME SWITCH

'Horstmann' Type V Mk II Time Switch. 200/250 volt A.C. Two on/two off every 24 hours, at any manually pre-set time. 30 amp contacts. 36-hour spring reserve in case of power failure. Day omitting device. Fitted in heavy high impact case, with glass observation window. Built to highest Electricity Board spec. individually tested. Price **£7.75**. Post 50p. (Total inc. VAT £8.91.)

A.C. MAINS TIMER UNIT

Based on an electric clock with 25 amp single pole switch which can be preset for any period up to 12 hrs. ahead to switch on for any length of time, from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets, etc. Attractive satin copper finish. Size 135 mm x 130 mm x 60 mm. Price **£2.25**. Post 40p. (Total inc. VAT & Post **£2.87**.)

PROGRAMME TIMERS

230/240 Volt A.C. 15 RPM Motors. Each cam operates a c/o micro switch. Ideal for lighting effects, animated displays etc. Ex equipment tested, similar to illustration.
2 cam model 15 r.p.m. **£2.00** post 35p
4 cam model 15 r.p.m. **£2.50** post 40p
8 cam model 20 r.p.m. **£4.75** post 60p
8 cam model each cam fully adjustable. 6 r.p.m. Mfg. by Magnetic Devices. **£7.50**. Post 60p.

POWER RHEOSTATS

New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10, 25, 100, 150, 250, 500, 1k, 1.5k ohm **£1.70**. Post 20p. **50 WATT** 1, 5, 10, 25, 50, 100, 500, 1k ohm **£2.10**. Post 25p. **100 WATT** 1/10/25/50/100/250/500/1k/1.5k/2.5k/5k ohm, **£3.30**. Post 35p.
Black Silver Skirted knob calibrated in Nos. 1-9. 1¼ in. dia. brass bush. Ideal for above Rheostats, 22p ea.

'GENTS' 6" ALARM BELL

200/250 volt AC/DC. **Brand New.** Price **£5.00**. Post 75p (illus.). **VAT 25%.**

'STC' 6" RED ALARM BELL
Brand New. Price: **£4.00**. Post 50p. **24/48V DC. VAT 25%**

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Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8 in., W. 4 in., H. 6 in., weight 6 lb.
500 VOLTS 500 megohms **£30.00**. Post 80p.
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	£		£		£		£
A1065	1.25	ECL82	0.35	GZ37	1.00	PY33	0.60
AR8	0.55	ECL83	0.70	KT66	2.50	PYRO	0.40
ATP4	0.50	ECL86	0.50	KT88	3.85	PY81	0.40
B12H	3.00	EF36	0.65	MH4	0.75	PY82	0.40
CY31	0.50	EF37A	1.20	ML6	0.65	PY83	0.40
DAF96	0.55	EF40	0.75	OA2	0.45	PY88	0.45
DF96	0.55	EF41	0.65	OB2	0.45	PY500	1.00
DK96	0.70	EF80	0.30	PABC80	0.40	PY800	0.45
DL92	0.40	EF83	1.25	PC97	0.50	PY801	0.50
DL96	0.60	EF85	0.35	PC900	0.50	QQV03-10	
DY86/87	0.40	EF86	0.35	PCC84	0.40		1.40
DY802	0.45	EF89	0.30	PCC85	0.40	QQV06-40A	
E88CC/01	1.20	EF92	0.50	PCC89	0.50		8.00
E180CC	0.70	EF95	0.40	PCC189	0.60	R19	0.75
E182CC	1.25	EF183	0.35	PCF80	0.40	SC1/400	3.00
EA50	0.40	EF184	0.35	PCF82	0.40	SC1/600	5.00
EABC80	0.40	EFL200	0.75	PCF84	0.60	SP61	0.75
EAF42	0.75	EL34	0.70	PCF86	0.60	TT21	5.00
EB91	0.30	EL36	0.60	PCF200	0.75	U25	0.85
EBC33	1.00	EL37	1.80	PCF201	0.75	U26	0.75
EBC41	0.75	EL41	0.80	PCF801	0.55	U27	0.65
EBF80	0.40	EL81	0.60	PCF802	0.50	U191	0.75
EBF83	0.50	EI82	0.55	PCF805	0.90	U801	0.75
EBF89	0.40	EL84	0.30	PCF806	0.75	UABC80	0.40
EC52	0.35	EL85	0.60	PCF808	0.90	UAF42	0.65
ECC81	0.40	EL86	0.45	PCH200	0.80	UBC41	0.60
ECC82	0.35	EL90	0.45	PCL81	0.55	UBF80	0.40
ECC83	0.35	EL504	0.80	PCL82	0.40	UBF89	0.40
ECC84	0.35	EM31	0.60	PCL83	0.65	UBL1	1.00
ECC85	0.40	EM80	0.55	PCL84	0.45	UBL21	0.70
ECC86	0.90	EM84	0.40	PCL86	0.50	UCC85	0.45
ECC88	0.50	EM87	1.00	PCL805	0.60	UCF80	0.75
ECC189	0.70	EY51	0.45	PFL200	0.70	UCH42	0.75
ECF80	0.40	EY81	0.45	PL36	0.60	UCH81	0.45
ECF82	0.40	EY86	0.40	PL81	0.50	UCL82	0.45
ECF801	0.75	EY88	0.50	PL82	0.45	UCL83	0.65
ECH35	1.40	EZ40	0.70	PL83	0.45	UF41	0.70
ECH42	0.80	EZ41	0.75	PL84	0.45	UF80	0.35
ECH81	0.35	EZ80	0.30	PL504	0.80	UF85	0.45
ECH83	0.45	EZ81	0.30	PL508	1.00	UF89	0.50
ECH84	0.45	GY501	0.75	PL509	1.35	UL41	0.70
ECL80	0.55	GZ34	0.70	PL802	1.75		

A lot of these valves are imported and prices vary for each delivery so we reserve the right to change prices for new stock when unavoidable

	£		£		£		£		£		£
UL84	0.40	3A4	0.60	6AL5	0.30	6AX5GT	1.00	6C6	0.50	6J7G	0.40
UY41	0.45	3BP1	7.00	6AL5W	0.55	6B7	0.70	6CB6	0.50	6K6GT	0.80
VR105/30	0.45	3D6	0.40	6AM6	0.60	6BA6	0.35	6CH6	1.45	6K7	0.55
VR150/30	0.45	3S4	0.40	6AN8	0.45	6BE6	0.40	6CL6	0.75	6K7G	0.30
X61M	1.40	3V4	0.85					6D6	0.55	6K8GT	0.50
X66	0.65	5B 254M	4.50					6EA8	0.85	6K25	1.00
Z800U	2.70	5B255M	4.50					6F7	1.10	6L6	1.90
Z801U	2.70	5R4GY	1.10					6F8G	0.75	6L6G	0.60
Z900T	1.20	5U4G	0.50					6F23	0.90	6L7G	0.40
1A3	0.55	5V4G	0.55					6F32	0.75	6SA7	0.50
1L4	0.25	5Y3GT	0.60					6F33	3.50	6SA7GT	0.40
1R5	0.40	5Z3	0.80	6AQ5	0.45	6BG6G	0.90	6H6	0.40	6SC7GT	0.40
1S4	0.30	5Z4GT	0.55	6AQ5W	0.70	6BJ6	0.65	6J4WA	1.25	6SG7	0.50
1T4	0.30	6AB7	0.60	6AS6	0.80	6BQ7A	0.60	6J5	0.65	6SJ7	0.55
1X2A	0.75	6AC7	0.60	6AT6	0.60	6BR7	1.20	6J5GT	0.50	6SJ7GT	0.35
1X2B	0.75	6AH6	0.70	6AU6	0.40	6BW6	1.00	6J6	0.30	6SK7	0.55
2D21	0.50	6AK5	0.40	6AV6	0.45	6BW7	1.00	6J7	0.60	6SL7GT	0.50
2K25	9.00	6AK8	0.40	6AX4GT	0.75	6C4	0.40				

VAT
Please add 25% to all orders

TRANSISTORS, DIODES etc.

AC113	AF178	BSY38	OAZ200	OC206	2N3054
AC126	AF186	BSY95A	OC22	SX754	2N3055
AC127	AF239	BYZ16	OC25	ZR11	2N3391
AC128	AFZ12	CRS1/10	OC26	ZR21	2N3638A
AC176	ASY26	CRS1/20	OC28	1N23A	2N3730
ACY18	ASY27	CRS1/30	OC29	1N25	2N3819
ACY19	ASY28	CRS1 40	OC35	1N32A	2N4038
ACY20	BC108	CRS3/10	OC36	1N38A	2N4058
ACY39	BC118	CRS3/20	OC42	1N43	2N4061
ACY40	BC119	CRS3/30	OC44	1N70	2N4785
AD149	BC136	CRS3/40	OC45	1N277	2N5295
AD161	BC137	CRS25/C25	OC70	1N415C	3N128
AD162	BC148A	GET115	OC73	1N4148	3N154
ADZ11	BC172	GET116	OC78	2N456A	3N159
ADZ12	BC172A	GEX66	OC780	2N708	2S303
AF114	BC212A	NKT222	OC81	2N918	2082
AF115	BCY31	OA5	OC82	2N1304	40250
AF116	BCY33	OA47	OC820	2N1305	40251
AF117	BCY72	OA70	OC820M	2N1307	40310
AF118	BF115	OA71	OC83	2N1309	40668
AF124	BF167	OA73	OC139	2N2062	
AF125	BF185	OA79	OC140	2N2147	
AF126	BFY51	OA91	OC170	2N2411	
AF127	BFY52	OA200	OC172	2N2989	
AF139	BSY27	OA202	OC200	2N3053	

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6SN7GT	0.50	30C17	1.00
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6X5GT	0.50	30FL14	0.90
6Y6G	0.90	30L15	0.95
6Z4	0.65	30L17	0.95
6-30L2	0.90	30P12	1.00
7B7	0.80	30P19	1.00
7Y4	0.80	30PL1	0.95
9D6	0.40	30PL13	1.10
11E2	6.00	30PL14	1.10
12A6	0.55	35L6GT	0.75
12AT6	0.45	35W4	0.50
12AT7	0.40	35Z4GT	0.70
12AU7	0.35	50C5	0.80
12AV6	0.50	50C06G	1.10
12AX7	0.35	75	1.00
12BA6	0.45	75C1	0.75
12BE6	0.50	76	0.75
12BH7	0.50	78	0.70
12C8	0.55	80	0.75
12E1	3.50	85A2	0.75
12K5	1.10	723a/b	9.00
12K7GT	0.50	803	6.00
12K8GT	0.70	805	14.00
12Q7GT	0.70	807	0.65
12SA7GT	0.70	813	6.50
12SG7	0.55	866A	1.20
12SJ7	0.55	931A	6.00
12Y4	0.40	954	0.50
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19AQ5	0.65	956	0.50
19G3	8.00	957	0.50
19G6	6.60	1305	0.20
19H5	14.00	1629	0.70
20P3	0.60	2051	1.00
20P4	1.10	5933	3.00
25L6GT	0.70	6057	0.75
30C15	1.00	6060	0.70

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6064	0.60
6065	1.00
6067	0.70
6080	2.30
6146	3.35
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9002	0.50
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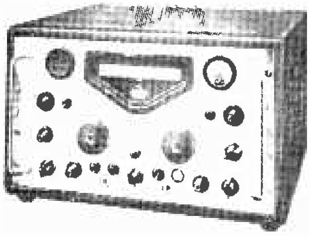
VALVES AND TRANSISTORS
Telephone enquiries for valves, transistors, etc., retail 749 3934, trade and export 743 0899.



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Models RA17, RA17 Mk II, RA 17L, RA17W, RA117E, in condition from working "as seen" to brand new in cabinets Prices on application
DIVERSITY SWITCH TYPE MA168B. solid state **£45.00.**
RA98A SSB ADAPTOR. P.O.A.

KAHN SSB ADAPTOR MODEL RSSB 62 1B Designed for receivers with 455 500kHz I F (eg Collins 51J, AR88D etc) at 100mV (max) input Features Electronic A.F.C carrier frequency diversity to combat fading 20 sec R C memory to maintain tuning during severe fading individual carrier meters nuvistors low distortion production demo dulator Full spec & P O A

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PLUG-IN UNITS
G—20 MHz differential 50MV-20V.
D—High gain differential 1MV-50V.

CT 480 SIGNAL GENERATOR 70KMc/s to 12KMc/s **£160**

DIGITAL VOLTMETER DM 2003 1kV peak input, 2v to 1kV **£75.**

TECHNICAL MATERIAL CORP:
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BOONTON FM/AM SIGNAL GENERATOR TYPES 202E & 202H. 54-216 MHz in two ranges complete with separate power supply unit **£275.**

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Few left, only **£110.**

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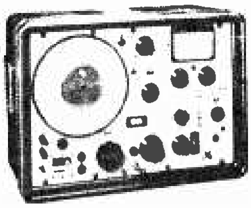

TF144H SIGNAL GEN. Freq. range 10 KHz-72 MHz, R.F. output 2µV to 2V at 50 ohms 400 and 1000 Hz internal mod. Limited qty. only available. Full spec. and price on request.

TF 526B OSCILLATOR AND DETECTOR UNIT £50·00.

TF 1226B, TF1225A, TF 577A. WHITE NOISE TEST SET £185·00. Full spec. on request.

TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. freq. 10Hz to 100kHz, pulse width 0·1 to 100µ sec., delay —1·5 to +3000µ sec., rise time 30N sec. **SPEC. TM 6600/S.** As for TF1400S except pulse width 0·5 to 25µ sec., delay 0 to +300µ sec. £175

TF 893 AUDIO OUTPUT METERS £55.

NOISE GENERATOR TF1053 (CT207). Range 100 600MHz Noise factor up to 150 (21 7db) at 75 ohms Audio power up to 500MW **£95.**
MARCONI TF893 AUDIO OUTPUT METERS Price on application

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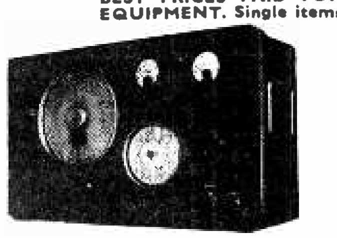
MS 111D DANISH PRODUCTION SIGNAL GENERATOR 10Kc — 110Mc **£150.**

BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT. Single items or quantities. Private or Industrial.



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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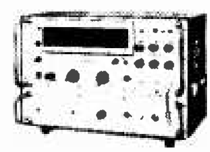
CT 160 Valve Characteristic meter **£55.**
CT410 Noise Generator **£30.**

RACAL UNIVERSAL COUNTER/TIMER SA550 (CT488)



8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc, Full spec. on request. £145.

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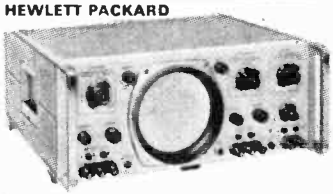

Model 130C 200μV/cm Oscilloscope. This scope is a versatile all purpose instrument for laboratory, production line, industrial process measurements and medical applications. The outputs of rf detectors, strain gauges, transducers, and other low level devices may be viewed directly without preamplification. The Model 130C is easy to operate even by inexperienced personnel. Specification: Time Base: Range — 1 μs/cm to 5 s/cm, 21 ranges in a 1,2,5 sequence, accuracy ± 3%, vernier provides continuous adjustment between steps and extends the 5 s/cm step to at least 12.5 s/cm. Automatic triggering (baseline displayed in the absence of an input signal). Vertical and horizontal amplifiers. Bandwidth: d.c. coupled, dc to 500 KHz; ac coupled (input), 2 Hz to 500 KHz, ac coupled (amplifier), 25 Hz to 500 KHz at 0.2 mV/cm deflection factor ... **£175**

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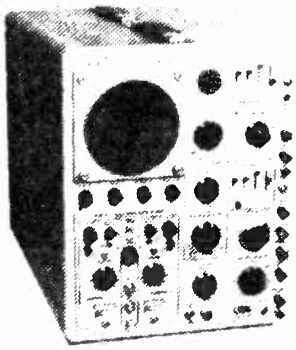
ROBAND R050 DC — 25 MHz c/w 5c Plug Dual Trace. Rue Time 13 n secs 50mV/cm min sensitivity, 5" display. Superb condition ... **£220**



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MAIN FRAMES ONLY
546 ... **£275**
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Plug ins available include
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Types available cx1441, cx1443, cx1444. DC-15 MHz, 5" Display. Portable. Good condition.

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OUR PRICE ... **£49.50**

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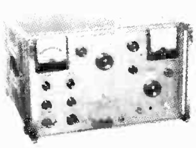
Megger Series II 250V ... **£12**
Megger Series III Mk. 3 250V ... **£20**
Megger 250V ... **£20**

SIGNAL SOURCES

FM AM SIGNAL GENERATOR TYPE 202H



This superb generator in grade one condition, F.M., A.M., C.W. & pulse coverage 54 to 216MHz. Used to testing and calibration of F.M. receiving systems, V.H.F., T.V., Mobile and general Communications. Freq. range 54-216MHz ÷ 2 Bands. R.F. stability 0.01%. R.F. output 0.1 μV-0.2V. V.S.W.R. 1.2. Signal to noise ratio 50dB below 10KHz. Dimensions 16¾" x 10¼" x 18⅜".

PRICE NEW OVER £1,000!
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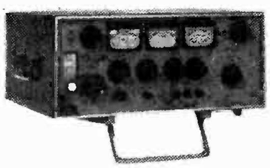

Phase/AM Signal Generator TF 2003. 0.4-12 MHz. Bargain price — super condition ... **£150**

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TF 801D/1s ... **£350-£600**
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R.C. OSCILLATOR TF 1370 ... **£90**

LEVELL Decade Oscillator TG 66A (new condition) ... **£40**
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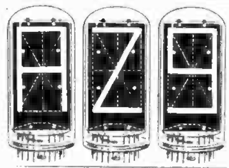

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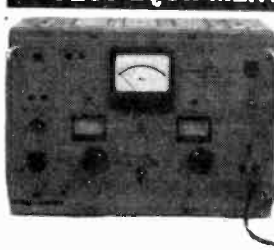

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Beckman	7246/5019	10	50 ohm	£2.00
Bourns	35005-2-500	10	50 ohm	£1.95
Bourns	35005	10	1K	£2.00
Beckman	A/S303	10	5K	£1.00
Beckman	72212/5	10	10K	£2.00
Relcon	0710-1-1-001A	10	10K	£2.00
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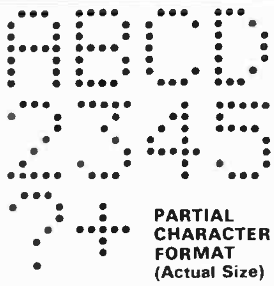
Full applications data is available, giving all necessary information.



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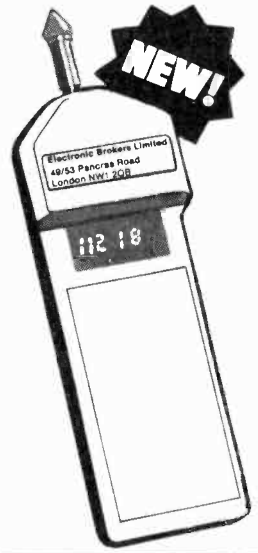

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Pulleys • Anything that rotates

SPECIFICATION

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RANGE	1 to 19999
INDICATOR	Red Luminescent
BATTERIES	4 "A" cells
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MEASURING TIME	1 Second
ON-OFF SWITCH	Push Button
ACCURACY	.01 of 1% ± 1 Digit
WEIGHT	Approx. 15 oz.

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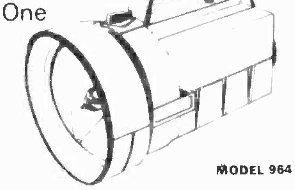

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STROBOSCOPIC FLASH RATE—200 to 6,000 flashes per minute
TACHOMETER SPEED RATE—200 to 6,000 R.P.M.
ACCURACY—3% better
CALIBRATION—At 3,600 F.P.M. against any known synchronous speed — 7200, 3600, 1800, 1200, 900 RPM, etc.
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POWER—220 VOLTS 50/60 Hz 22 watts

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Only £89.50

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- Four ranges 0-1,000, 3,000, 10,000, 30,000 RPM
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- Push-button reading
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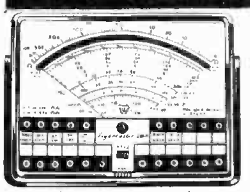
SPECIFICATIONS
Photocell: Photo transistor. **Lamp: GE No.** 222X. **Batteries:** One 5.4 V type TR-134R. Except Model B 912. **Accuracy:** 1½% of full scale. **Meter:** Shock-proof movement, large clear-face dial. **Calibration:** From any fluorescent light 50 to 60 cycles. **Dimensions:** 5⅛" (130.0 mm) wide, 7½" (190.0 mm) high, 2½" (63.5 mm) deep.

Carrying case **£12.50**

MULTIMETERS



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V Output 5 ranges: 1.5V, 10V, 50V, 250V, 1,000V
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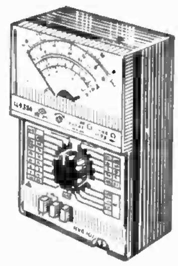

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1N935	2	2N3906	8	BC131	4	BD607	2	MC1312P	1	MJE520	3	74155	1
1N938A	1	2N4059	1	BC136	3	BD608	2	MC1314P	1	MJE2955	1	74174	1
1N3323RB	1	2N5089	5	BC137	3	BF121	4	MC1315P	1	MJE3055	2	74196	1
1N3595	3	2N5128	5	BC153	6	BF125	4	MC1357P	1	ML1537	1	74H87	1
1N4392	3	2N5447	10	BC157	8	BF153	2	ME0411	2	MP8113	2	7485	1
1N5398	15	2N5485	2	BC170A	3	BF160	3	ME0414	10	MPS6571	3	74122	1
2N1304	3	2N5591	1	BC171	3	BF222	4	ME0462	2	MPSA05	6	SW6432N	2
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2N2726	2	AC122	3	BC208A	6	BF395C	8	ME1002	1	MZ1000-22	4	TIP29A	1
2N2905A	3	AC175K	2	BC214K	6	BF395D	8	ME4003	3	SD4	3	TIP30B	2
2N2907	2	AC193K	1	BC261	5	BFX37	2	ME4102	10	SE7055	1	TIP31A	1
2N2926	1	AC194K	3	BC261A	4	BFY57	4	ME4104	11	7406	5	TIP42A	1
2N3053	5	AF239	3	BC268A	8	BU105	1	ME6101	3	7412N	5	TIS60M	2
2N3252	5	BA163	1	BCY21	8	BUY24	1	ME6102	4	7420	2	TIS61	3
2N3508	3	BC113	6	BD117	2	CA3029	1	ME8001	5	7425	2	SN72741N	2
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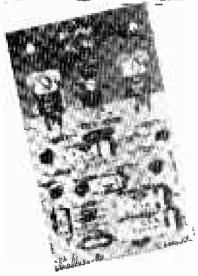

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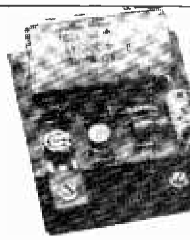

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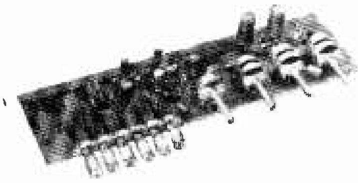

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100 which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

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Comprising: 2 x AL60, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets.
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Comprising: Teak veneered cabinet size 16¾" x 11½" x 3¾", other parts include aluminium chassis, heatsink and front panel bracket, plus bar panel and appropriate sockets, etc.
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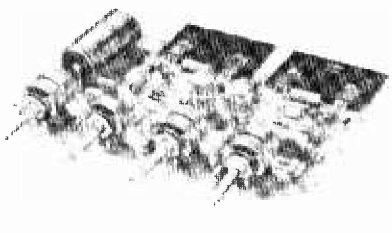

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7 + 7 WATTS R.M.S.

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This with only the addition of a transformer or overwind, will produce a high quality audio unit suitable for use with a wide range of inputs, i.e. high quality ceramic pickup, stereo tuner, stereo tape deck, etc.

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5019

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The work involves close contact with patients. It will include care, use and maintenance of intensive care equipment and sophisticated monitoring systems both in the Unit and throughout the hospital

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Applications stating age, qualifications and previous experience together with the names of two referees to the **Sector Administrator, Leicester General Hospital, Gwendolen Road, Leicester LE5 4PW.** Closing date: 24th November, 1975.

5013

Leicestershire Health Service

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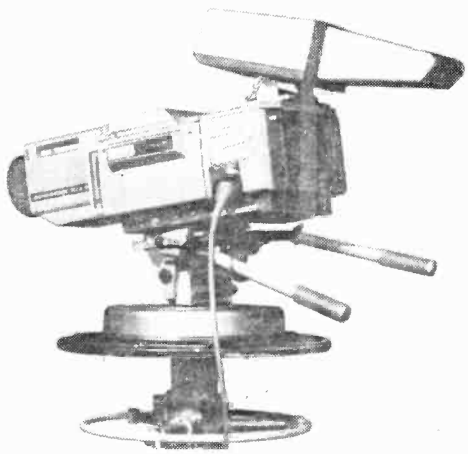

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Please apply in writing for interview, giving details of age, marital status, qualification (if any), experience to date and current salary to:

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Duties will be concerned with servicing, calibration, design and construction of electronic equipment used in obstetrics, paediatrics and associated laboratories.

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Salary Scale (Medical Physics Technician Grade III) £2,931-£3,834.

Please write to the Personnel Officer, Queen Elizabeth Hospital, Edgbaston, Birmingham 15, for further particulars and application forms

4993

The Polytechnic of North London

Department of Chemistry

Applications are invited for the following appointment:

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required immediately by the spectroscopy laboratories of the Department. The main duties will involve the maintenance and development of electronic instrumentation. Applicants should have practical experience in electronics but specific knowledge of spectroscopic instruments is not essential.

Normally candidates should hold C & G/IST Ordinary Certificate, ONC or C & G Part 2 (or equivalent) in Electronics subjects, and have seven years' experience.

Salary Scale: Grade 4 £2247-£2628 plus £411 London Allowance.

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(4978)

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UNIVERSITY OF GLASGOW

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Complete involvement from basic development through to responsibility for manufacturing continuity with particular emphasis on specific custom design and engineering of medium capacity multiplex systems. Necessary experience level is around 6 years and experience of RF techniques above 2GHz is helpful.

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Please indicate any company to whom you do not wish to apply.

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The salary offered would depend upon experience and qualification on appointment and would be between £2202 p.a. and £2394 p.a. It would also rise by £96 p.a. to a maximum of £2682 p.a. Salaries under review. Satisfactory trainees could expect to be selected within two years for more senior Laboratory Technician posts.

Requests for further information and application forms to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA, quoting reference 75.E.4056.WW, and enclosing addressed foolscap envelope. Application forms to be returned by 14 days after publication.

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CITY OF LONDON POLYTECHNIC

ELECTRONICS TECHNICIAN I

GRADE 3

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Further information on the above post can be obtained by an application in writing to the Head of Department of Psychology, City of London Polytechnic, Calcutta House, Old Castle Street, London, E1 7NT. 5017

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SERVICE AND INSTALLATION ENGINEERS

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We are looking for adaptable self-reliant engineers who are prepared to spend periods of up to approximately 3 months overseas. The successful candidates will have a good knowledge of semi-conductors circuitry, be qualified to at least ONC standard and will preferably have worked on such equipment as modern high-power radar systems.

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(GRADE 4)

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The Personnel Manager, Motorola Limited, Chesford Grange, Warrington, Cheshire, WA1 4RG. Tel. Warrington 52306. (4981)

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Grade II and Grade IV

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Apply to Personnel, Guy's Hospital, London SE1 9RT. Telephone 01-407 7600 Extn. 3462.

(4967

UNIVERSITY OF LEICESTER

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(Grade 5)

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Good conditions of appointment including generous holidays, superannuation and sick leave schemes. Salary (under review) not less then £2439 p.a. rising to £2895 p.a. Subject to qualifications and/or practical experience an appointment can be made above the minimum of the scale.

Applications in writing should be sent as soon as possible to Professor R. D. Peacock, Department of Chemistry, The University, Leicester LE1 7RH

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SCHOOL OF MOLECULAR SCIENCES

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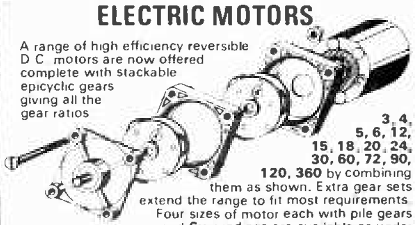

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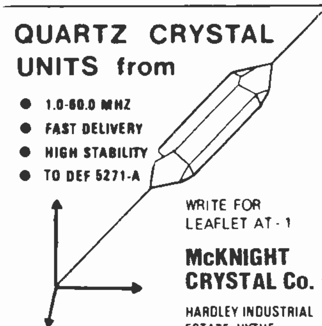

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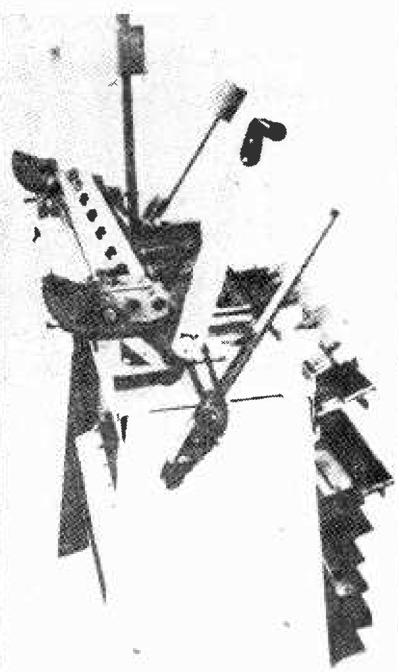

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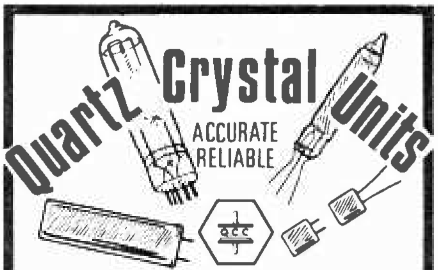

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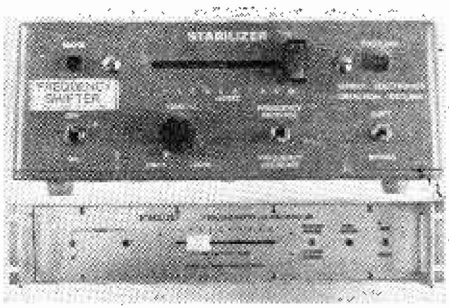

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0.22μF	33	16	64p	1.0μF	82p	62p	52p
0.25μF	33	16	67p	2.2μF	96p	75p	61p
0.47μF	33	19	80p	4.7μF	£1.62	£1.13	94p
0.5μF	33	19	87p	6.8μF	£1.96	£1.38	£1.13
0.68μF	50.8	19	93p	10μF	£2.40	£1.95	£1.64
1.0μF	50.8	19	£1.03	15μF	£3.22	£2.79	£2.24
2.0μF	50.8	25.4	£1.44	22μF	£4.28	£3.68	£3.08

***TANTALUM BEAD CAPACITORS** — Values available: 0.1, 0.22, 0.47, 1.0, 2.2, 4.8, 6.iμF at 15V/25V or 35V, 10μF at 16V/20V or 25V; 22.0μF at 6V or 16V; 33 0μF at 6V or 10V; 47.0μF at 3V or 6V; 100.0μF at 3V. ALL at **10p** each. 10 for **95p**, 50 for **£4.**

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AD149	40p	BCY72	12p	*2N2926O	11p
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AF239	38p	BF115/167	22p	2N3054	65p
BC107/8/9	9p	BF173	24p	2N3055	50p
*BC114	12p	BF178	26p	2N3702/ 3704	11p
*BC147/8/9	10p	BF184	22p	*TIP30A	52p
*BC153/154	12p	*BF194/195*	12p	TIP31A	55p
*BC157/8/9	12p	*BF196/197*	12p	TIP32A	64p
BC177	18p	BF200	27p	TIP3055	55p
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*BC183/183L	11p	BFY50/51/52	20p	NE555	61p
*BC184/184L	12p	BFX84/86/88	20p	741C	32p
*BC212/212L	14p	BFX85	26p	ZN414	£1.15
*BC213/213L	11p	BR101	41p	SN76013ND	£1.50
*BC214/214L	11p	GET872	25p		
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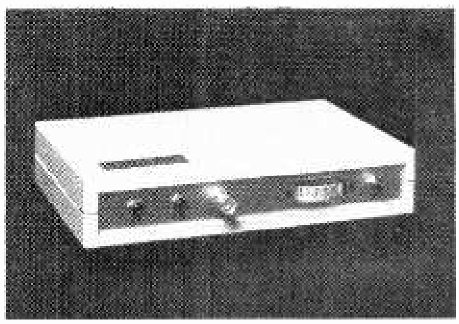

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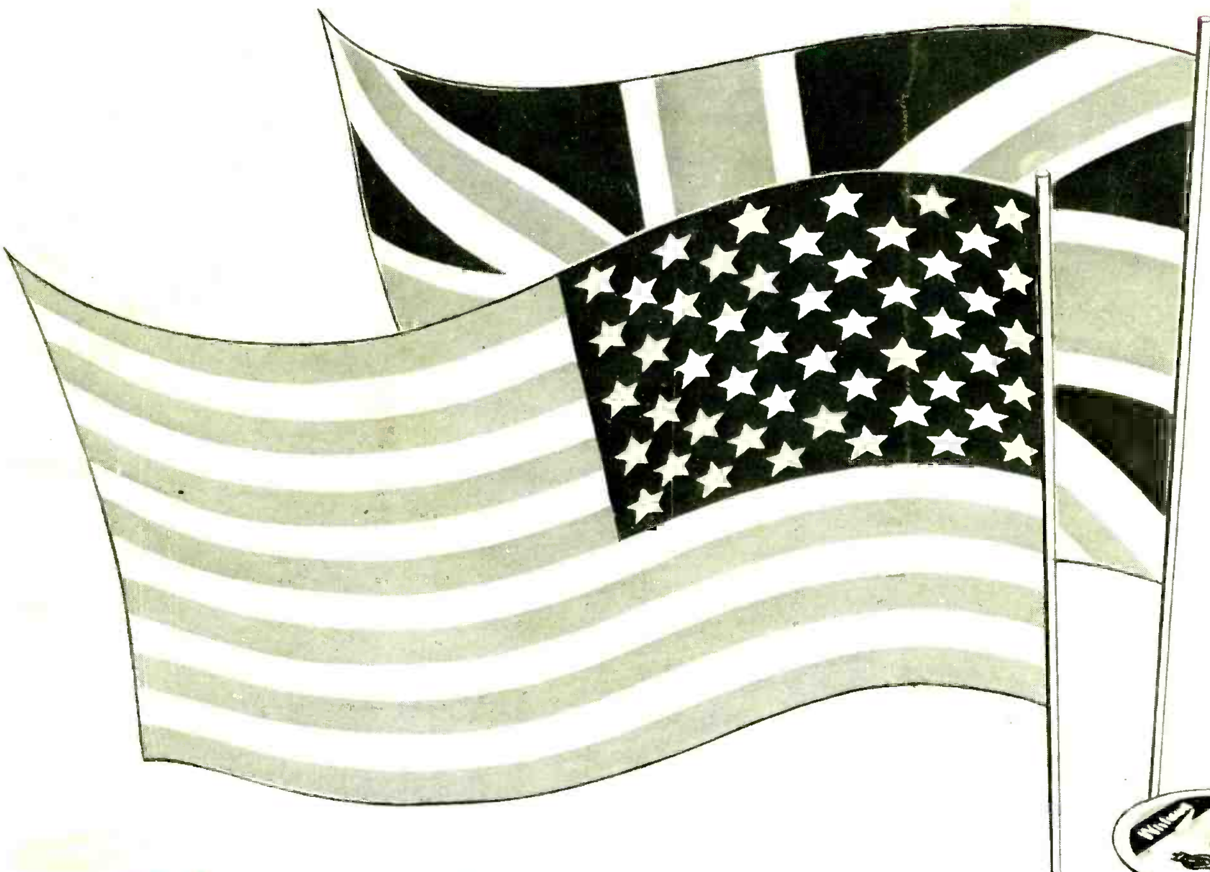

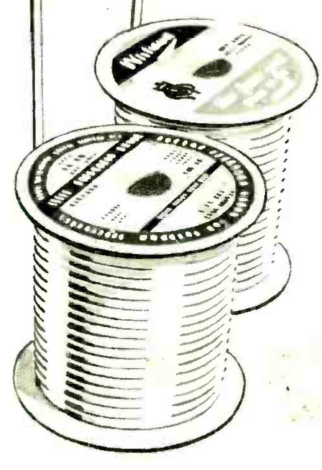

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